1) Aarts, J. and Berg, M. “A tale of two hospitals: a sociotechnical appraisal of the introduction of computerized physician order entry in two Dutch hospitals” Medinfo **11**(Pt 2): 999-1002. (2004)

Abstract: 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

2) Aarts, J. and Berg, M. “Same systems, different outcomes--comparing the implementation of computerized physician order entry in two Dutch hospitals” Methods of Information in Medicine **45**(1): 53-61. (2006)

Abstract: OBJECTIVES: To compare the outcome of the implementation of computerized physician order entry (CPOE) systems in two Dutch hospitals. METHODS: Qualitative research methods, including interviews in both hospitals, observations of system in use, observations of staff meetings and document analysis were used to understand the implementation of CPOE. The transcribed texts and implementation documents were analyzed for relevant concepts. The transcripts and field notes were analyzed using a heuristic success and failure model with medical work as the primary focus. RESULTS: Occasions that determined the outcome of the implementation were classified according to factors that may influence the success or failure of implementing systems. CONCLUSIONS: The themes and patterns that emerged from the data helped validate the concept of medical work as the primary focus of our analysis model; in addition the concept of a support base necessary to accept changes in medical work that result from introducing CPOE may help to understand the different implementation outcomes.

3) Aarts, J., Doorewaard, H. and Berg, M. “Understanding implementation: the case of a computerized physician order entry system in a large Dutch university medical center” Journal of the American Medical Informatics Association **11**(3): 207-16. (2004)

Abstract: Most studies of the impact of information systems in organizations tend to see the implementation process as a "rollout" of technology, as a technical matter removed from organizational dynamics. There is substantial agreement that the success

of implementing information systems is determined by organizational factors. However, it is less clear what these factors are. The authors propose to characterize the introduction of an information system as a process of mutual shaping. As a result, both the technology and the practice supported by the technology are transformed, and specific technical and social outcomes gradually emerge. The authors suggest that insights from social studies of science and technology can help to understand an implementation process. Focusing on three theoretical aspects, the authors argue first that the implementation process should be understood as a thoroughly social process in which both technology and practice are transformed. Second, following Orlikowski's concept of "emergent change," they suggest that implementing a system is, by its very nature, unpredictable. Third, they argue that success and failure are not dichotomous and static categories, but socially negotiated judgments. Using these insights, the authors have analyzed the implementation of a computerized physician order entry (CPOE) system in a large Dutch university medical center. During the course of this study, the full implementation of CPOE was halted, but the aborted implementation exposed issues on which the authors did not initially focus.

4) Abookire, S. A., Teich, J. M., Sandige, H., Paterno, M. D., Martin, M. T., Kuperman, G. J. and Bates, D. W. “Improving allergy alerting in a computerized physician order entry system” Proceedings / AMIA Annual Symposium: 2-6. (2000)

Abstract: Computerized physician order entry has been shown to reduce the frequency of serious medication errors. Decision support tools such as alerting functions for patient medication allergy are a key part of these applications. However, optimal performance requires iterative refinement. As systems become increasingly complex, mechanisms to monitor their performance become increasingly critical. We analyzed trend data obtained over a five-year period that showed decreasing compliance to allergy alert functions within computerized order entry. Many medication-allergy pairs were being consistently overridden. Renewal policies affecting reordering narcotics also contributed heavily to this trend. Each factor revealed a system-wide trend that could result in suggestions for policy or software change. Monitoring trends such as these is very important to maintain software correctness and ensure user trust in alerting systems, so users remain responsive to computerized alerts.

5) Achtmeyer, C. E., Payne, T. H. and Anawalt, B. D. “Computer order entry system decreased use of sliding scale insulin regimens” Methods of Information in Medicine. **41**(4): 277-81. (2002)

Abstract: OBJECTIVES: Despite evidence documenting their ineffectiveness, sliding scale insulin is a commonly used regimen for glucose management for hospitalized patients with diabetes mellitus. At the Veterans Affairs Puget Sound Medical Center, where computer order entry has been mandated, we tested the hypothesis that an

evidence-based minimal intervention order (supplemental insulin only when fasting serum glucoses exceeded 400 mg/dl) would decrease the use of sliding scale insulin orders. METHODS: Using a computerized order entry system, providers were initially offered a traditional sliding scale order or their own ad hoc orders for glycemic control of inpatients. After 34 weeks providers were offered a third option; a "minimal intervention order" with supplemental insulin only for glucose > 400 mg/dl. We extracted all regular insulin orders and performed a retrospective review of insulin sliding scale orders written between December 1, 1998 and November 16, 1999. We compared the frequency of traditional insulin sliding scale orders before and after the introduction of the minimal intervention order. RESULTS: Nearly all orders in the first 34 weeks were traditional insulin sliding scales. We found a significant decrease in the number of traditional insulin sliding scale orders in the 16 weeks after the introduction of a computerized quick-order for minimal intervention, from 978/1007 (97.1%) to 254/398 (63.8%) ($P < 0.001$). CONCLUSIONS: A simple, evidenced-based quick-order in a computer order entry system rapidly and significantly reduced use of sliding scale insulin regimens for glycemic control of inpatients.

6) Ahmad, A., Teater, P., Bentley, T. D., Kuehn, L., Kumar, R. R., Thomas, A. and Mekhjian, H. S. “Key attributes of a successful physician order entry system implementation in a multi-hospital environment” Journal of the American Medical Informatics Association **9**(1): 16-24. (2002)

Abstract: The benefits of computerized physician order entry have been widely recognized, although few institutions have successfully installed these systems. Obstacles to successful implementation are organizational as well as technical. In the spring of 2000, following a 4-year period of planning and customization, a 9-month pilot project, and a 14-month hiatus for year 2000, the Ohio State University Health System extensively implemented physician order entry across inpatient units. Implementation for specialty and community services is targeted for completion in 2002. On implemented units, all orders are processed through the system, with 80 percent being entered by physicians and the rest by nursing or other licensed care providers. The system is deployable across diverse clinical environments, focused on physicians as the primary users, and accepted by clinicians. These are the three criteria by which the authors measured the success of their implementation. They believe that the availability of specialty-specific order sets, the engagement of physician leadership, and a large-scale system implementation were key strategic factors that enabled physician-users to accept a physician order entry system despite significant changes in workflow.

7) Ali, N. A., Mekhjian, H. S., Kuehn, P. L., Bentley, T. D., Kumar, R., Ferketich, A. K. and Hoffmann, S. P. “Specificity of computerized physician order entry has a significant effect on the efficiency of workflow for critically ill patients” Critical Care Medicine **33**(1): 110-4. (2005)

Abstract: 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.

8) Almond, M., Gordon, K., Kent, J. R., Jones, B. W., Nice, S. W. and Dhillon, S. "The effect of the controlled entry of electronic prescribing and medicines administration on the quality of prescribing, safety and success of administration on an acute medical ward" British Journal of Healthcare Computing & Information Management **2002 Mar; 19**(2): 41-2. (2002)

Abstract: There is a need to reduce the frequency of adverse drug events arising from prescribing and drug-administration errors. It is perceived that this can be achieved by the implementation of electronic prescribing and medicines administration with clinical decision support. We investigated the effect of the implementation of a commercial, integrated, prescribing, administration and stock control system with clinical decision support in a controlled, prospective manner on a general medical ward. Its impact on the quality of medicine administration was evaluated over three months. We were also interested in the effect on the clinical efficiency of the ward and the need for education and training in the use of an electronic integrated prescribing and medicines-administration system. The results demonstrated that the proportion of medicines administered successfully rose from 90% on the existing paper-based system to 95% on the electronic system ($p<0.001$). The clinical pharmacist identified errors in 12% of paper prescriptions with 1% of administrations being deferred as a consequence of unclear prescribing or lack of administration details. All electronic prescribing ultimately passed clinical checks (94% after one or fewer modifications) and was always clear at the point of administration. The time taken for prescribing and medicines administration

increased significantly, administration time doubling. A marginal improvement in wasted or returned medicines occurred. Implementation of a commercial, electronic, prescribing and medicines-administration system therefore improved the quality of prescribing and safety of medicines administration. The system was introduced into an acute setting with naive electronic prescribers and those responsible for administration in a safe manner over a relatively short time scale. The cost in staff time to achieve this improvement in clinical safety was significant, however.

9) Anderson, J. G. “Evaluation in health informatics: computer simulation” Computers in Biology & Medicine **32**(3): 151-64. (2002)

Abstract: The evaluation of complex medical informatics applications involves not only the information system, but also its impact on the organizational environment in which it is implemented. In instances where these applications cannot be evaluated with traditional experimental methods, computer simulation provides a flexible approach to evaluation. The construction of a computer simulation model involves the development of a model that represents important aspects of the system under evaluation. Once validated, the model can be used to study the effects of variation in system inputs, differences in initial conditions and changes in the structure of the system. Three examples are discussed, namely, a wide-area health care network, physician order entry into a hospital information system, and the use of an information system designed to prevent medical errors that lead to adverse drug events in hospitals.

10) Anderson, J. G., Jay, S. J., Anderson, M. and Hunt, T. J. “Evaluating the potential effectiveness of using computerized information systems to prevent adverse drug events” Proceedings / AMIA Annual Symposium: 228-32. (1997)

Abstract: In this study a dynamic computer simulation model is used to estimate the effectiveness of various information systems applications designed to detect and prevent medication errors that result in adverse drug events (ADEs). The model simulates the four stages of the drug ordering and delivery system: prescribing, transcribing, dispensing and administering drugs. In this study we simulated interventions that have been demonstrated in prior studies to decrease error rates. The results demonstrated that a computerized information system that detected 26% of medication errors and prevented associated ADEs could save 1,226 days of excess hospitalization and $1.4 million in hospital costs annually. Those results suggest that such systems are potentially a cost-effective means of preventing ADEs in hospitals. The results demonstrated the importance of viewing adverse drug events from a systems perspective. Prevention efforts that focus on a single stage of the process had limited impact on the overall error rate. This study suggests that system-wide changes to the drug-ordering and delivery system are required to significantly reduce adverse drug events in a hospital setting.

11) Anderson, J. G., Jay, S. J., Anderson, M. and Hunt, T. J. “Evaluating the Capability of Information Technology to Prevent Adverse Drug Events: A Computer Simulation Approach” J Am Med Inform Assoc **9**(5): 479-490. (2002)

Abstract: Background: The annual cost of morbidity and mortality due to medication errors in the U.S. has been estimated at $76.6 billion. Information technology implemented systematically has the potential to significantly reduce medication errors that result in adverse drug events (ADEs). Objective: To develop a computer simulation model that can be used to evaluate the effectiveness of information technology applications designed to detect and prevent medication errors that result in adverse drug effects. Methods: A computer simulation model was constructed representing the medication delivery system in a hospital. STELLA, a continuous simulation software package, was used to construct the model. Parameters of the model were estimated from a study of prescription errors on two hospital medical/surgical units and used in the baseline simulation. Five prevention strategies were simulated based on information obtained from the literature. Results: The model simulates the four stages of the medication delivery system: prescribing, transcribing, dispensing, and administering drugs. We simulated interventions that have been demonstrated in prior studies to decrease error rates. The results suggest that an integrated medication delivery system can save up to 1,226 days of excess hospitalization and $1.4 million in associated costs annually in a large hospital. The results of the analyses regarding the effects of the interventions on the additional hospital costs associated with ADEs are somewhat sensitive to the distribution of errors in the hospital, more sensitive to the costs of an ADE, and most sensitive to the proportion of medication errors resulting in ADEs. Conclusions: The results suggest that clinical information systems are potentially a cost-effective means of preventing ADEs in hospitals and demonstrate the importance of viewing medication errors from a systems perspective. Prevention efforts that focus on a single stage of the process had limited impact on the overall error rate. This study suggests that system-wide changes to the medication delivery system are required to drastically reduce mediation errors that may result in ADEs in a hospital setting.

12) Andrews, T., DiFrancesco, M. and Gilliam, M. “Putting CPOE to work” Nursing Management **2003 Oct; IT Solutions**: 12. (2003)

Abstract: Explore relevant selection, implementation, and usage guidelines from nurse leaders who've played pivotal roles in computerized provider order entry (COE) rollout within their facility.

13) Anonymous “Top-priority actions for preventing adverse drug events in hospitals. Recommendations of an expert panel” American Journal of Health-System Pharmacy **53**(7): 747-51. (1996)

Abstract:

14) Anonymous “Computerized provider order entry systems” Health Devices **30**(9-10): 323-59. (2001)

Abstract: Computerized provider order entry (CPOE) systems are designed to replace a hospital's paper-based ordering system. They allow users to electronically write the full range of orders, maintain an online medication administration record, and review changes made to an order by successive personnel. They also offer safety alerts that are triggered when an unsafe order (such as for a duplicate drug therapy) is entered, as well as clinical decision support to guide caregivers to less expensive alternatives or to choices that better fit established hospital protocols. CPOE systems can, when correctly configured, markedly increase efficiency and improve patient safety and patient care. However, facilities need to recognize that currently available CPOE systems require a tremendous amount of time and effort to be spent in customization before their safety and clinical support features can be effectively implemented. What's more, even after they've been customized, the systems may still allow certain unsafe orders to be entered. Thus, CPOE systems are not currently a quick or easy remedy for medical errors. ECRI's Evaluation of CPOE systems--conducted in collaboration with the Institute for Safe Medication Practices (ISMP)--discusses these and other related issues. It also examines and compares CPOE systems from three suppliers: Eclipsys Corp., IDX Systems Corp., and Siemens Medical Solutions Health Services Corp. Our testing focuses primarily on the systems' interfacing capabilities, patient safeguards, and ease of use. [References: 54]

15) Anonymous “CPOE, bedside technology, and patient safety: a roundtable” American Journal of Health System Pharmacy. (2003)

Abstract: Proceedings of a roundtable discussion held on December 10, 2002, during the ASHP Midyear Clinical Meeting, Atlanta, GA. Participating in the discussion were Mark Neuenschwander, President, The Neuenschwander Company, Bellevue, WA; Steven S. Rough, M.S., Director of Pharmacy, University of Wisconsin Hospital and Clinics, Madison; Shabir M. Somani, Director of Pharmacy Services, University of Washington Academic Medical Center, Seattle, and Associate Professor and Vice-Chair, Department of Pharmacy, University of Washington, Seattle; John VanEeckhout, Pharm.D., Vice President,Clinical Services, Child Health Corporation of America, Shawnee Mission, KS; and Billy W. Woodward, Executive Director, Department of Pharmacy, Scott & White Health System, Temple, TX.
The views presented here are those of the participants and do not necessarily represent those of their affiliated organizations.

16) Anton, C., Nightingale, P. G., Adu, D., Lipkin, G. and Ferner, R. E. “Improving prescribing using a rule based prescribing system” Quality & Safety in Health Care **13**(3): 186-90. (2004)

Abstract: OBJECTIVE: To test the hypothesis that the prescribing behaviour of doctors would improve after having experience with a computerised rule based prescribing system. DESIGN: A prospective observational study of changes in prescribing habits resulting from the use of a computerised prescribing system in (1) a cohort of experienced users compared with a new cohort, and (2) a single cohort at the beginning and after 3 weeks of computer aided prescribing. SETTING: 64 bed renal unit in a teaching hospital. INTERVENTION: Routine use of a computerised prescribing system by doctors and nurses on a renal unit from 1 July to 31 August 2001. MAIN OUTCOME MEASURES: Number of warning messages generated by the system; proportion of warning messages overridden; comparison between doctors of different grades; comparison by doctors' familiarity with the system. RESULTS: A total of 51,612 records relating to 5995 prescriptions made by 103 users, of whom 42 were doctors, were analysed. The prescriptions generated 15,853 messages, of which 6592 were warning messages indicating prescribing errors or problems. Doctors new to the system generated fewer warning messages after using the system for 3 weeks (0.81 warning messages per prescription v 0.42 after 3 weeks, $p = 0.03$). Doctors with more experience of the system were less likely to generate a warning message (Spearman's rho = -0.90, $p = 0.04$) but were more likely to disregard one (Spearman's rho = -1, $p<0.01$). Senior doctors were more likely than junior doctors to ignore a warning message. CONCLUSIONS: Doctors are influenced by the experience of using a computerised prescribing system. When judged by the number of warning messages generated per prescription, their prescribing improves with time and number of prescriptions written. Consultants and registrars are more likely to use their clinical judgement to override warning messages regarding prescribed drugs.

17) Aranow, M. “What works: clinical information systems. Order entry rules. Healthcare enterprise achieves physician acceptance, reduced medication errors and improved patient outcomes through CIS and CPOE technology” Health Management Technology. **23**(7): 34, 38. (2002)

Abstract:

18) Armstrong, C. W. “AHA Guide to Computerized Physician Order-Entry Systems”: 50. (2000)

Abstract:

19) Armstrong, E. P. and Chrischilles, E. A. “Electronic prescribing and monitoring are needed to improve drug use” Archives of Internal Medicine **160**(18): 2713-4. (2000)

Abstract:

20) Asaro, P. V., Sheldahl, A. L. and Char, D. M. “Embedded guideline information without patient specificity in a commercial emergency department computerized order-entry system” Academic Emergency Medicine **13**(4): 452-8. (2006)

Abstract: BACKGROUND: Clinical practice guidelines and computerized provider order entry (CPOE) have potential for improving clinical care. Questions remain about feasibility and effectiveness of CPOE in the emergency department (ED). However, successful implementations in other settings typically incorporate decision support functions that are lacking in many commercially available ED information systems. OBJECTIVES: To compare acute coronary syndrome (ACS) guideline compliance before and after implementation of a locally implemented ACS guideline, first on paper and then in a commercially available ED information system without patient-specific clinical decision support. METHODS: Clinical data were abstracted retrospectively on patients seen before and after introduction of paper and, subsequently, CPOE versions of ACS guideline-based order-sets. Order-set use was determined. Risk category assignments were made retrospectively using guideline criteria and compliance with the guideline regarding beta-blockers, heparin, and aspirin was determined. Association between order-set use and compliance was determined. RESULTS: The authors found increasing use of order-sets over the period of study. However, there was poor association between the order-sets used and risk stratification category. Some association between ED beta-blocker use and use of CPOE order-sets was found, but there was no improvement in overall compliance with any of the guideline recommendations. CONCLUSIONS: Adherence to an ACS guideline did not improve with implementation of a commercial ED information system without provision for patient-specific decision support. This suggests that the lack of patient-specific decision-support functionality in most current ED information system products may hamper progress in the development of effective decision support.

21) Ash, J., Gorman, P., Lavelle, M., Lyman, J. and Fournier, L. “Investigating physician order entry in the field: lessons learned in a multi-center study” Medinfo **10**(Pt 2): 1107-11. (2001)

Abstract: The progress of studies by this team of researchers concerning computerized physician order entry (POE), beginning with a mail survey and moving to qualitative multi-center studies, is reviewed, with emphases on lessons learned and future directions. While mail surveys were appropriate to answer initial research questions about diffusion of POE in the U.S., multiple qualitative methods became the methods of choice for answering more complex questions. Results of the latter include

articulation of multiple perspectives on both positive and negative aspects of POE and a description of what may be important for successful implementation of POE in the future. The present economic environment of hospitals may be inhibiting widespread diffusion of POE, not only because of the direct cost, but also indirectly by affecting relations with practitioners. Analysis of successful past implementations can provide guidance when the time is right.

22) Ash, J. S., Berg, M. and Coiera, E. “Some unintended consequences of information technology in health care: the nature of patient care information system-related errors.[see comment]” Journal of the American Medical Informatics Association **11**(2): 104-12. (2004)

Abstract: Medical error reduction is an international issue, as is the implementation of patient care information systems (PCISs) as a potential means to achieving it. As researchers conducting separate studies in the United States, The Netherlands, and Australia, using similar qualitative methods to investigate implementing PCISs, the authors have encountered many instances in which PCIS applications seem to foster errors rather than reduce their likelihood. The authors describe the kinds of silent errors they have witnessed and, from their different social science perspectives (information science, sociology, and cognitive science), they interpret the nature of these errors. The errors fall into two main categories: those in the process of entering and retrieving information, and those in the communication and coordination process that the PCIS is supposed to support. The authors believe that with a heightened awareness of these issues, informaticians can educate, design systems, implement, and conduct research in such a way that they might be able to avoid the unintended consequences of these subtle silent errors.

23) Ash, J. S., Fournier, L., Stavri, P. Z. and Dykstra, R. “Principles for a successful computerized physician order entry implementation” AMIA. Annual Symposium Proceedings/AMIA Symposium. (2003)

Abstract: To identify success factors for implementing computerized physician order entry (CPOE), our research team took both a top-down and bottom-up approach and reconciled the results to develop twelve overarching principles to guide implementation. A consensus panel of experts produced ten Considerations with nearly 150 sub-considerations, and a three year project using qualitative methods at multiple successful sites for a grounded theory approach yielded ten general themes with 24 sub-themes. After reconciliation using a meta-matrix approach, twelve Principles, which cluster into groups forming the mnemonic CPOE emerged. Computer technology principles include: temporal concerns; technology and meeting information needs; multidimensional integration; and costs. Personal principles are: value to users and tradeoffs; essential people; and training and support. Organizational principles include: foundational underpinnings; collaborative project management; terms, concepts and connotations;

and improvement through evaluation and learning. Finally, Environmental issues include the motivation and context for implementing such systems.

24) Ash, J. S., Gorman, P. N. and Hersh, W. R. “Physician order entry in U.S. hospitals” Proceedings / AMIA Annual Symposium: 235-239. (1998)

Abstract: OBJECTIVE: Determine the percent of U.S. hospitals where computerized physician order entry (POE) is available and the extent of its use. METHODS: A survey was sent to a systematic sample of 1,000 U.S. hospitals asking about availability of POE, whether usage is required, percent of physicians using it, and percent of orders entered by computer. RESULTS: About 66% do not have POE available. Of the 32.1% that have it completely or partially available, 4.9% require its usage, over half report usage by under 10% of physicians, and over half report that fewer than 10% of orders are entered this way. Analysis of comments showed that many hospitals have POE available for use by non-physicians only, but that they hope to offer it to physicians after careful planning. CONCLUSION: Most U.S. hospitals have not yet implemented POE. Complete availability throughout the hospital is rare, very few require its use, low percentages of physicians are actual users, and low percentages of orders are entered this way. On a national basis, computerized order entry by physicians is not yet widespread

25) Ash, J. S., Gorman, P. N., Hersh, W. R., Lavelle, M. and Poulsen, S. B. “Perceptions of house officers who use physician order entry” Proceedings / AMIA Annual Symposium: 471-5. (1999)

Abstract: OBJECTIVE: Describe the perceptions of housestaff physicians about their experience using computerized physician order entry (POE) in hospitals. METHODS: Qualitative study using data from participant observation, focus groups, and both formal and informal interviews. Data were analyzed by three researchers using a grounded approach to identify patterns and themes in the texts. RESULTS: Six themes were identified, including housestaff education, benefits of POE, problems with POE, feelings about POE, implementation strategies, and the future of POE. CONCLUSION: House officers felt that POE assists patient care but may undermine education. They found that POE works best when tailored to fit local and individual workflow. Implementation strategies should include mechanisms for engaging housestaff in the decision process.

26) Ash, J. S., Gorman, P. N., Lavelle, M. and Lyman, J. “Multiple Perspectives on Physician Order Entry” Proceedings / AMIA Annual Symposium: 27-31. (2000)

Abstract: Objective: Describe the complex interplay of perspectives of physicians, administrators, and information technology staff regarding computerized physician order

entry (POE) in hospitals.
Methods: Linstone's Multiple Perspectives Model provided a framework for organizing the results of a qualitative study done at four sites. Data from observation, focus groups, and formal and informal interviews were analyzed by four researchers using a grounded approach.
Results: It is not a simple matter of physicians hating POE and others loving it. The issues involved are both complex and emotional. All groups see both positive and negative aspects of POE.
Conclusion: The Multiple Perspectives Model was useful for organizing a description to aid in understanding all points of view. It is imperative that those implementing POE understand all views and plan implementation strategies accordingly.

27) Ash, J. S., Gorman, P. N., Lavelle, M., Payne, T. H., Massaro, T. A., Frantz, G. L. and Lyman, J. A. "A cross-site qualitative study of physician order entry" Journal of the American Medical Informatics Association. **10**(2): 188-200. (2003)

Abstract: OBJECTIVE: To describe the perceptions of diverse professionals involved in computerized physician order entry (POE) at sites where POE has been successfully implemented and to identify differences between teaching and nonteaching hospitals. DESIGN: A multidisciplinary team used observation, focus groups, and interviews with clinical, administrative, and information technology staff to gather data at three sites. Field notes and transcripts were coded using an inductive approach to identify patterns and themes in the data. MEASUREMENTS: Patterns and themes concerning perceptions of POE were identified. RESULTS: Four high-level themes were identified: (1) organizational issues such as collaboration, pride, culture, power, politics, and control; (2) clinical and professional issues involving adaptation to local practices, preferences, and policies; (3) technical/implementation issues, including usability, time, training and support; and (4) issues related to the organization of information and knowledge, such as system rigidity and integration. Relevant differences between teaching and nonteaching hospitals include extent of collaboration, staff longevity, and organizational missions. CONCLUSION: An organizational culture characterized by collaboration and trust and an ongoing process that includes active clinician engagement in adaptation of the technology were important elements in successful implementation of physician order entry at the institutions that we studied.

28) Ash, J. S., Gorman, P. N., Lavelle, M., Stavri, P. Z., Lyman, J., Fournier, L. and Carpenter, J. "Perceptions of physician order entry: results of a cross-site qualitative study" Methods of Information in Medicine **42**(4): 313-23. (2003)

Abstract: OBJECTIVE: To identify perspectives of success factors for implementing computerized physician order entry (POE) in the inpatient setting. DESIGN: Qualitative study by a multidisciplinary team using data from observation, focus groups, and both formal and informal interviews. Data were analyzed using a grounded approach to

develop a taxonomy of patterns and themes from the transcripts and field notes. RESULTS: A taxonomy of ten high level themes was developed, including 1) separating POE from other processes, 2) terms, concepts, and connotations, 3) context, 4) tradeoffs, 5) conflicts and contradictions, 6) collaboration and trust, 7) leaders and bridgers, 8) the organization of information, 9) the ongoing nature of implementation, and 10) temporal concerns. CONCLUSION: The identified success factors indicate that POE implementation is an iterative and difficult process, but informants perceive it is worth the effort.

29) Ash, J. S., Gorman, P. N., Seshadri, V. and Hersh, W. R. "Computerized physician order entry in U.S. hospitals: results of a 2002 survey.[see comment]" Journal of the American Medical Informatics Association **11**(2): 95-9. (2004)

Abstract: OBJECTIVE: To determine the availability of inpatient computerized physician order entry in U.S. hospitals and the degree to which physicians are using it. DESIGN: Combined mail and telephone survey of 964 randomly selected hospitals, contrasting 2002 data and results of a survey conducted in 1997. MEASUREMENTS: Availability: computerized order entry has been installed and is available for use by physicians; inducement: the degree to which use of computers to enter orders is required of physicians; participation: the proportion of physicians at an institution who enter orders by computer; and saturation: the proportion of total orders at an institution entered by a physician using a computer. RESULTS: The response rate was 65%. Computerized order entry was not available to physicians at 524 (83.7%) of 626 hospitals responding, whereas 60 (9.6%) reported complete availability and 41 (6.5%) reported partial availability. Of 91 hospitals providing data about inducement/requirement to use the system, it was optional at 31 (34.1%), encouraged at 18 (19.8%), and required at 42 (46.2%). At 36 hospitals (45.6%), more than 90% of physicians on staff use the system, whereas six (7.6%) reported 51-90% participation and 37 (46.8%) reported participation by fewer than half of physicians. Saturation was bimodal, with 25 (35%) hospitals reporting that more than 90% of all orders are entered by physicians using a computer and 20 (28.2%) reporting that less than 10% of all orders are entered this way. CONCLUSION: Despite increasing consensus about the desirability of computerized physician order entry (CPOE) use, these data indicate that only 9.6% of U.S. hospitals presently have CPOE completely available. In those hospitals that have CPOE, its use is frequently required. In approximately half of those hospitals, more than 90% of physicians use CPOE; in one-third of them, more than 90% of orders are entered via CPOE.

30) Ash, J. S., Lyman, J., Carpenter, J. and Fournier, L. "A diffusion of innovations model of physician order entry" Proceedings / AMIA Annual Symposium: 22-6. (2001)

Abstract: OBJECTIVE: To interpret the results of a cross-site study of physician order

entry (POE) in hospitals using a diffusion of innovations theory framework. METHODS: Qualitative study using observation, focus groups, and interviews. Data were analyzed by an interdisciplinary team of researchers using a grounded approach to identify themes. Themes were then interpreted using classical Diffusion of Innovations (DOI) theory as described by Rogers [1]. RESULTS: Four high level themes were identified: organizational issues; clinical and professional issues; technology implementation issues; and issues related to the organization of information and knowledge. Further analysis using the DOI framework indicated that POE is an especially complex information technology innovation when one considers communication, time, and social system issues in addition to attributes of the innovation itself. CONCLUSION: Implementation strategies for POE should be designed to account for its complex nature. The ideal would be a system that is both customizable and integrated with other parts of the information system, is implemented with maximum involvement of users and high levels of support, and is surrounded by an atmosphere of trust and collaboration.

31) Ash, J. S., Sittig, D. F., Seshadri, V., Dykstra, R. H., Carpenter, J. D. and Starvi, P. Z. “Adding insight: a qualitative cross-site study of physician order entry” Medinfo **11**(Pt 2): 1013-7. (2004)

Abstract: The research questions, strategies, and results of a six-year qualitative study of computerized physician order entry implementation (CPOE) at successful sites are reviewed over time. The iterative nature of qualitative inquiry stimulates a consecutive stream of research foci which, with each iteration, add further insight into the overarching research question. A multidisciplinary team of researchers studied CPOE implementation in four organizations using a multi-method approach to address the question "what are the success factors for implementing CPOE?" Four major themes emerged after studying three sites; ten themes resulted from blending the first results with those from a fourth site; and twelve principles were generated when results of a qualitative analysis of consensus conference transcripts were combined with the field data. The study has produced detailed descriptions of factors related to CPOE success and insight into the implementation process.

32) Ash, J. S., Sittig, D. F., Seshadri, V., Dykstra, R. H., Carpenter, J. D. and Stavri, P. Z. “Adding insight: a qualitative cross-site study of physician order entry” International Journal of Medical Informatics **74**(7-8): 623-8. (2005)

Abstract: The research questions, strategies, and results of a 7-year qualitative study of computerized physician order entry implementation (CPOE) at successful sites are reviewed over time. The iterative nature of qualitative inquiry stimulates a consecutive stream of research foci, which, with each iteration, add further insight into the overarching research question. A multidisciplinary team of researchers studied CPOE implementation in four organizations using a multi-method approach to address the

question "what are the success factors for implementing CPOE?" Four major themes emerged after studying three sites; ten themes resulted from blending the first results with those from a fourth site; and twelve principles were generated when results of a qualitative analysis of consensus conference transcripts were combined with the field data. The study has produced detailed descriptions of factors related to CPOE success and insight into the implementation process.

33) Ash, J. S., Stavri, P. Z., Dykstra, R. and Fournier, L. “Implementing computerized physician order entry: the importance of special people” International Journal of Medical Informatics **69**(2-3): 235-50. (2003)

Abstract: OBJECTIVE: To articulate important lessons learned during a study to identify success factors for implementing computerized physician order entry (CPOE) in inpatient and outpatient settings. DESIGN: Qualitative study by a multidisciplinary team using data from observation, focus groups, and both formal and informal interviews. Data were analyzed using a grounded approach to develop a taxonomy of patterns and themes from the transcripts and field notes. RESULTS: The theme we call Special People is explored here in detail. A taxonomy of types of Special People includes administrative leaders, clinical leaders (champions, opinion leaders, and curmudgeons), and bridgers or support staff who interface directly with users. CONCLUSION: The recognition and nurturing of Special People should be among the highest priorities of those implementing computerized physician order entry. Their education and training must be a goal of teaching programs in health administration and medical informatics.

34) Ash, J. S., Stavri, P. Z. and Kuperman, G. J. “A Consensus Statement on Considerations for a Successful CPOE Implementation” J Am Med Inform Assoc **10**(3): 229-234. (2003)

Abstract: In May of 2001, thirteen experts on computerized provider order entry (CPOE) from around the world gathered at a 2-day conference to develop a consensus statement on successful CPOE implementation. A qualitative research approach was used to generate and validate a list of categories and considerations to guide CPOE implementation.

35) Aydin, C. E. and Forsythe, D. E. “Implementing computers in ambulatory care: implications of physician practice patterns for system design” Proceedings / AMIA Annual Symposium: 677-81. (1997)

Abstract: This paper presents pre-implementation data from the internal medicine division of a large physician group practice scheduled to implement an electronic medical record (EMR). Data were gathered through short-term participant observation

and interviews. Findings indicate that (1) most physicians anticipate enough benefits to be willing to use the system; (2) computers must be accessible, easy to log into, and provide for physician movement and interrupted sessions; (3) many physicians are concerned about losing eye contact with patients; (4) it is unrealistic to expect even good typists to enter their own long notes; (5) staged implementation, with order entry introduced first, may help physicians adapt gradually; and (6) training should include protected time for instructional sessions for physicians, simulated patient encounters to help physicians adapt their practice patterns, and tutors available to answer questions in the clinical setting.

36) Baghdasarian, S. B., Gordon, S. M. and Yen-Lieberman, B. "Evaluation and interventions to reduce errors in HIV-2 testing" Journal for Healthcare Quality. **24**(6): 23-5, 61. (2002)

Abstract: When patients are evaluated for human immunodeficiency virus (HIV) infection, the possibility of HIV type 2 (HIV-2) infection should be considered in individuals who may have acquired infection in West Africa or from an individual from that area. A 45.6% error rate in HIV-2 test ordering was observed among patients at the Cleveland Clinic Foundation, this was attributed in large part to the order entry screen, which may have confused ward clerks who were entering HIV testing ordered by clinicians. Modification of the order entry screen and consultation with clinical laboratory personnel for diagnostic HIV-2 testing were effective in reducing the rate of errors tenfold, to 4.3%.

37) Ball, M. J. and Douglas, J. V. "IT, patient safety, and quality care" Journal of Healthcare Information Management **16**(1): 28-33. (2002)

Abstract: The growing understanding of medical errors as systemic in nature underscores the importance of analyzing and redesigning systems. Best practices in medication safety that promise rapid payback include computerized physician order entry, ongoing tracking and benchmarking, and the creation by leadership of nonpunitive environments where this new culture of safety can thrive. [References: 66]

38) Ball, M. J. and Douglas, J. V. "Redefining and improving patient safety" Methods of Information in Medicine. **41**(4): 271-6. (2002)

Abstract: OBJECTIVES: The Institute of Medicine (IOM) has focused attention on patient safety in the United States. Other countries share these concerns. METHODS: Governmental agencies and professional organizations are redefining approaches to safety, calling upon the use of information and communication technology as an enabler and expanding the range of evidence admissible in documenting success. RESULTS:

Efforts to understand medical errors have used retrospective chart review, incident reporting, and computerized surveillance; the result is an evolving picture of the number, nature, and cause of errors. Approaches used to prevent errors include computerized physician order entry, decision support tools, computerized monitoring, and evidence-based practice; varying levels of evidence document their success. CONCLUSIONS: Technology offers challenging capabilities, not simple solutions. New evidence and new tools demand new approaches and attention to human factors. [References: 37]

39) Ball, M. J., Garets, D. E. and Handler, T. J. "Leveraging information technology towards enhancing patient care and a culture of safety in the US" Methods of Information in Medicine **42**(5): 503-8. (2003)

Abstract: OBJECTIVES: To heighten awareness about the critical issues currently affecting patient care and to propose solutions based on leveraging information technologies to enhance patient care and influence a culture of patient safety. METHODS: Presentation and discussion of the issues affecting health care today, such as medical and medication-related errors and analysis of their root causes; proliferation of medical knowledge and medical technologies; initiatives to improve patient safety; steps necessary to develop a culture of safety; introduction of relevant enabling technologies; and evidence of results. RESULTS AND CONCLUSION: Medical errors affect not only mortality and morbidity, but they also create secondary costs leading to dissatisfaction by both provider and patient. Health care has been slow to acknowledge the benefits of enabling technologies to affect the quality of care. Evaluation of recent applications, such as the computerized patient record, physician order entry, and computerized alerting systems show tremendous potential to enhance patient care and influence the development of a culture focused on safety. They will also bring about changes in other areas, such as workflow and the creation of new partnerships among providers, patients, and payers.

40) Ball, M. J., Weaver, C. and Abbott, P. A. "Enabling technologies promise to revitalize the role of nursing in an era of patient safety" International Journal of Medical Informatics **69**(1): 29-38. (2003)

Abstract: The application of information technology (IT) in health care has the potential to transform the delivery of care, as well as the health care work environment, by streamlining processes, making procedures more accurate and efficient, and reducing the risk of human error. For nurses, a major aspect of this transformation is the refocusing of their work on direct patient care and away from being a conduit of information and communication among departments. Several of the technologies discussed, such as physician order entry and bar code technology, have existed for years as standalone systems. Many others are just being developed and are being integrated into complex clinical information systems (CISs) with clinical decision support

at their core. While early evaluation of these systems shows positive outcome measurements, financial, technical, and organizational hurdles to widespread implementation still remain. One major issue is defining the role nurses, themselves, will play in the selection and implementation of these systems as they become more steeped in the knowledge of nursing informatics. Other challenges revolve around issues of job satisfaction and the attraction and retention of nursing staff in the midst of a serious nursing shortage. Despite these concerns, it is expected that, in the long run, the creation of an electronic work environment with systems that integrate all functions of the health care team will positively impact cost-effectiveness, productivity, and patient safety while helping to revitalize nursing practice.

41) Banet, G. A., Jeffe, D. B., Williams, J. A. and Asaro, P. V. “Effects of implementing computerized practitioner order entry and nursing documentation on nursing workflow in an emergency department” Journal of Healthcare Information Management **20**(2): 45-54. (2006)

Abstract: Nurses'perceptions of effective use of their time are critical to the successful implementation of information system changes. We examined the effects of implementing computerized practitioner order entry and nursing documentation in our emergency department with an anonymous survey of nurses and repeated time-motion studies. Emergency care nurses were positive about effects of CPOE, reporting needing less time to complete medication, laboratory, and radiology orders and less time spent clarifying orders. Their perceptions of time spent were congruent with observations from time-motion studies where combined computer-and-paper time and direct-patient-care time did not change significantly. Nurses also reported supplementing template options with free text, and those who were more comfortable using computers reported supplementing template options more often than their counterparts, suggesting that assessments of users' expertise in computer use may influence their ability to maximize their use of the functionality of emergency department information systems.

42) Bansal, P., Aronsky, D., Talbert, D. and Miller, R. A. “A computer based intervention on the appropriate use of arterial blood gas” Proceedings / AMIA Annual Symposium: 32-6. (2001)

Abstract: OBJECTIVE: To evaluate impact of a computer-based intervention on arterial blood gas (ABG) usage in an intensive care setting. DESIGN: Retrospectively examined, via mixed group analysis, the effects of the intervention on ABG usage in the intensive care unit (ICU). SUBJECTS: Included all clinicians who placed ABG orders in an ICU using the computerized physician order-entry system, as well as controls in non-order entry units. METHODS: Computer-based intervention presenting ordering clinician with patient s previous ABG values and limiting forward duration of tests ordered. Study spanned 12 weeks, 5 weeks pre-intervention and 7-weeks post-intervention. Of 8 ICUs, intervention implemented in 6, not implemented in 2. Data analyzed using the repeated

measure ANOVA. RESULTS: Physicians entered <40% ABG orders. 376 ABGs per week processed pre-intervention, 387 per week post. Results nonsignificant with a p= 0.09. Orders placed declined from 1039 per week, Jan 2000 to 662 per week, April 2001. DISCUSSION: Study did not demonstrate significant change; limited power. Need longer study periods. Impact improved in the future by targeting physician users and tailoring intervention to specific work flow pattern of high utilization units.

43) Barlow, S., Johnson, J. and Steck, J. “The economic effect of implementing an EMR in an outpatient clinical setting” Journal of Healthcare Information Management. **18**(1): 46-51. (2004)

Abstract: Central Utah Multi-Specialty Clinic, a 59-physician group with practices in nine locations treating 200,000 active patients, documented the economic impact of implementing an electronic medical record. During the one-year period of the study, the clinic experienced direct reductions in spending and increases in revenue of more than $952,000 compared with the prior year, and anticipates cumulative savings of more than $8.2 million over the next five years.

44) Bates, D. W. “Frequency, consequences and prevention of adverse drug events” Journal of Quality in Clinical Practice **19**(1): 13-7. (1999)

Abstract: Iatrogenic injuries are important because they are frequent and many may be preventable; those caused by therapeutic drugs are among the most frequent. While medication errors are common, most have little potential for harm. However, some errors, such as giving a patient a drug to which they have a known allergy, are more likely to cause injury. Error theory provides insights into the changes required to reduce medication error injury rates. Data from the Adverse Drug Event (ADE) Prevention study suggest that most serious errors occur at the ordering and dispensing stages, while another, smaller, proportion occur at the administration stage. These data suggest that physician computer-order entry, where physicians write orders on-line with decision support, including patient-specific information and alerts about potential problems, has the potential to significantly reduce the number of serious medication errors.

45) Bates, D. W. “Using information technology to reduce rates of medication errors in hospitals” BMJ **320**(7237): 788-791. (2000)

Abstract:

46) Bates, D. W. “John M. Eisenberg Patient Safety Awards. Research: David W. Bates, MD, MSc, Brigham and Women's Hospital. Interview by Steven Berman”

Joint Commission Journal on Quality Improvement. **28**(12): 651-9, 633. (2002)

Abstract: Dr Bates discusses the challenges and rewards of computerized physician order entry and other information technology applications and describes current work in improving medication safety across clinical settings.

47) Bates, D. W. "Computerized physician order entry and medication errors: Finding a balance. (CPOE and the facilitation of medication errors)" Journal of Biomedical Informatics **38**(4): 259-261. (2005)

Abstract:

48) Bates, D. W., Boyle, D. L. and Teich, J. M. "Impact of computerized physician order entry on physician time" Proceedings / AMIA Annual Symposium: 996. (1994)

Abstract: We examined the effect of computerized physician order entry on housestaff time use patterns, using time motion techniques. For both medical and surgical house officers, writing orders on the computer took about twice as long ($p < 0.001$), or 44 minutes for medical and 73 minutes for surgical house officers. Medical house officers recovered about half this time because some administrative tasks--e.g. looking for charts--were made easier. Within types of orders, sets of stereotyped orders took much less time with order entry, but one-time orders took longer. We have since developed strategies to make it easier to enter one-time orders

49) Bates, D. W., Boyle, D. L., Vander Vliet, M. B., Schneider, J. and Leape, L. "Relationship between medication errors and adverse drug events" Journal of General Internal Medicine **10**(4): 199-205. (1995)

Abstract: OBJECTIVE: To evaluate the frequency of medication errors using a multidisciplinary approach, to classify these errors by type, and to determine how often medication errors are associated with adverse drug events (ADEs) and potential ADEs. DESIGN: Medication errors were detected using self-report by pharmacists, nurse review of all patient charts, and review of all medication sheets. Incidents that were thought to represent ADEs or potential ADEs were identified through spontaneous reporting from nursing or pharmacy personnel, solicited reporting from nurses, and daily chart review by the study nurse. Incidents were subsequently classified by two independent reviewers as ADEs or potential ADEs. SETTING: Three medical units at an urban tertiary care hospital. PATIENTS: A cohort of 379 consecutive admissions during a 51-day period (1,704 patient-days). INTERVENTION: None. MEASUREMENTS AND MAIN RESULTS: Over the study period, 10,070 medication orders were written, and 530 medications errors were identified (5.3 errors/100 orders), for a mean of 0.3

medication errors per patient-day, or 1.4 per admission. Of the medication errors, 53% involved at least one missing dose of a medication; 15% involved other dose errors, 8% frequency errors, and 5% route errors. During the same period, 25 ADEs and 35 potential ADEs were found. Of the 25 ADEs, five (20%) were associated with medication errors; all were judged preventable. Thus, five of 530 medication errors (0.9%) resulted in ADEs. Physician computer order entry could have prevented 84% of non-missing dose medication errors, 86% of potential ADEs, and 60% of preventable ADEs. CONCLUSIONS: Medication errors are common, although relatively few result in ADEs. However, those that do are preventable, many through physician computer order entry.

50) Bates, D. W., Cohen, M. S., Leape, L. L., Overhage, J. M., Shabot, M. M. and Sheridan, T. “Reducing the Frequency of Errors in Medicine Using Information Technology” Journal of the American Medical Informatics Association **8**: 299-308. (2001)

Abstract: BACKGROUND: Increasing data suggest that error in medicine is frequent and results in substantial harm. The recent Institute of Medicine report (LT Kohn, JM Corrigan, MS Donaldson, eds: To Err Is Human: Building a Safer Health System. Washington, DC: National Academy Press, 1999) described the magnitude of the problem, and the public interest in this issue, which was already large, has grown. GOAL: The goal of this white paper is to describe how the frequency and consequences of errors in medical care can be reduced (although in some instances they are potentiated) by the use of information technology in the provision of care, and to make general and specific recommendations regarding error reduction through the use of information technology. RESULTS: General recommendations are to implement clinical decision support judiciously; to consider consequent actions when designing systems; to test existing systems to ensure they actually catch errors that injure patients; to promote adoption of standards for data and systems; to develop systems that communicate with each other; to use systems in new ways; to measure and prevent adverse consequences; to make existing quality structures meaningful; and to improve regulation and remove disincentives for vendors to provide clinical decision support. Specific recommendations are to implement provider order entry systems, especially computerized prescribing; to implement bar-coding for medications, blood, devices, and patients; and to utilize modern electronic systems to communicate key pieces of asynchronous data such as markedly abnormal laboratory values. CONCLUSIONS: Appropriate increases in the use of information technology in health care- especially the introduction of clinical decision support and better linkages in and among systems, resulting in process simplification-could result in substantial improvement in patient safety.

51) Bates, D. W., Kuperman, G. J., Jha, A., Teich, J. M., Orav, E. J., Ma'luf, N., Onderdonk, A., Pugatch, R., Wybenga, D., Winkelman, J., Brennan, T. A.,

Komaroff, A. L. and Tanasijevic, M. J. “Does the computerized display of charges affect inpatient ancillary test utilization?” Archives of Internal Medicine **157**(21): 2501-8. (1997)

Abstract: BACKGROUND: The computerized display of charges for ancillary tests in outpatients has been found to affect physician-ordering behavior, but this issue has not been studied in inpatients. OBJECTIVE: To assess whether the computerized display of charges for clinical laboratory or radiological tests affected physician-ordering behavior. PATIENTS AND METHODS: Two prospective controlled trials, randomized by patient, were performed. Each trial included all medical and surgical inpatients at 1 large teaching hospital during 4 and 7 months: 3536 intervention and 3554 control inpatients in the group with clinical laboratory tests, and 8728 intervention and 8653 control inpatients in the group with radiological tests. The intervention consisted of the computerized display of charges for tests at the time of ordering. MAIN OUTCOME MEASURES: The number of clinical laboratory and radiological tests ordered per admission and the charges for these tests. RESULTS: For the clinical laboratory tests, during a 4-month study period, patients in the intervention group had 4.5% fewer tests ordered, and the total charges for these tests were 4.2% lower, although neither difference was statistically significant. Compared with historical controls from the same 4-month period a year before, the charges for the tests per admission had decreased 13.3%, but the decrease was temporally correlated with a restriction of future ordering of tests, and not with the introduction of the display of charges. For the radiological tests, during a 7-month period, the intervention group had almost identical numbers of tests ordered and charges for these tests. CONCLUSIONS: The computerized display of charges had no statistically significant effect on the number of clinical laboratory tests or radiological procedures ordered or performed, although small trends were present for clinical laboratory tests. More intensive interventions may be needed to affect physician test utilization.

52) Bates, D. W., Kuperman, G. J., Rittenberg, E., Teich, J. M., Fiskio, J., Ma'luf, N., Onderdonk, A., Wybenga, D., Winkelman, J., Brennan, T. A., Komaroff, A. L. and Tanasijevic, M. “A randomized trial of a computer-based intervention to reduce utilization of redundant laboratory tests” American Journal of Medicine **106**(2): 144-50. (1999)

Abstract: PURPOSE: To determine the impact of giving physicians computerized reminders about apparently redundant clinical laboratory tests. SUBJECTS AND METHODS: We performed a prospective randomized controlled trial that included all inpatients at a large teaching hospital during a 15-week period. The intervention consisted of computerized reminders at the time a test was ordered that appeared to be redundant. Main outcome measures were the proportions of clinical laboratory orders that were canceled and the proportion of the tests that were actually performed. RESULTS: During the study period, there were 939 apparently redundant laboratory tests among the 77,609 study tests that were ordered among the intervention (n = 5,700 patients) and control (n = 5,886 patients) groups. In the intervention group, 69% (300 of

437) of tests were canceled in response to reminders. Of 137 overrides, 41% appeared to be justified based on chart review. In the control group, 51% of ordered redundant tests were performed, whereas in the intervention group only 27% of ordered redundant tests were performed (P <0.001). However, the estimated annual savings in laboratory charges was only $35,000. This occurred because only 44% of redundant tests performed had computer orders, because only half the computer orders were screened for redundancy, and because almost one-third of the reminders were overridden. CONCLUSIONS: Reminders about orders for apparently redundant laboratory tests were effective when delivered. However, the overall effect was limited because many tests were performed without corresponding computer orders, and many orders were not screened for redundancy.

53) Bates, D. W., Kuperman, G. J. and Teich, J. M. "Computerized physician order entry and quality of care" Quality Management in Health Care **2**(4): 18-27. (1994)

Abstract: In automated physician order entry systems, physicians enter orders directly on the computer. Compared with manual systems, advantages are that orders are legible, transcription is eliminated, the writer can be identified, and orders can rapidly be routed to their destinations. But most importantly, physician order entry allows order checking and provision of decision support to the orderer in real time. Disadvantages are that systems developed to date have been slower than pen and paper and they represent a major process change so that implementation is time-consuming and requires patience both on the part of the users and the developers.

54) Bates, D. W., Kuperman, G. J., Wang, S., Gandhi, T., Kittler, A., Volk, L., Spurr, C., Khorasani, R., Tanasijevic, M. and Middleton, B. "Ten commandments for effective clinical decision support: making the practice of evidence-based medicine a reality" Journal of the American Medical Informatics Association **10**(6): 523-30. (2003)

Abstract: While evidence-based medicine has increasingly broad-based support in health care, it remains difficult to get physicians to actually practice it. Across most domains in medicine, practice has lagged behind knowledge by at least several years. The authors believe that the key tools for closing this gap will be information systems that provide decision support to users at the time they make decisions, which should result in improved quality of care. Furthermore, providers make many errors, and clinical decision support can be useful for finding and preventing such errors. Over the last eight years the authors have implemented and studied the impact of decision support across a broad array of domains and have found a number of common elements important to success. The goal of this report is to discuss these lessons learned in the interest of informing the efforts of others working to make the practice of evidence-based medicine a reality.

55) Bates, D. W., Leape, L. L., Cullen, D. J., Laird, N., Petersen, L. A., Teich, J. M., Burdick, E., Hickey, M., Kleefield, S., Shea, B., Vander Vliet, M. and Seger, D. L. "Effect of computerized physician order entry and a team intervention on prevention of serious medication errors" JAMA **280**(15): 1311-6. (1998)

Abstract: CONTEXT: Adverse drug events (ADEs) are a significant and costly cause of injury during hospitalization. OBJECTIVES: To evaluate the efficacy of 2 interventions for preventing nonintercepted serious medication errors, defined as those that either resulted in or had potential to result in an ADE and were not intercepted before reaching the patient. DESIGN: Before-after comparison between phase 1 (baseline) and phase 2 (after intervention was implemented) and, within phase 2, a randomized comparison between physician computer order entry (POE) and the combination of POE plus a team intervention. SETTING: Large tertiary care hospital. PARTICIPANTS: For the comparison of phase 1 and 2, all patients admitted to a stratified random sample of 6 medical and surgical units in a tertiary care hospital over a 6-month period, and for the randomized comparison during phase 2, all patients admitted to the same units and 2 randomly selected additional units over a subsequent 9-month period. INTERVENTIONS: A physician computer order entry system (POE) for all units and a team-based intervention that included changing the role of pharmacists, implemented for half the units. MAIN OUTCOME MEASURE: Nonintercepted serious medication errors. RESULTS: Comparing identical units between phases 1 and 2, nonintercepted serious medication errors decreased 55%, from 10.7 events per 1000 patient-days to 4.86 events per 1000 (P=.01). The decline occurred for all stages of the medication-use process. Preventable ADEs declined 17% from 4.69 to 3.88 (P=.37), while nonintercepted potential ADEs declined 84% from 5.99 to 0.98 per 1000 patient-days (P=.002). When POE-only was compared with the POE plus team intervention combined, the team intervention conferred no additional benefit over POE. CONCLUSIONS: Physician computer order entry decreased the rate of nonintercepted serious medication errors by more than half, although this decrease was larger for potential ADEs than for errors that actually resulted in an ADE.

56) Bates, D. W., Miller, E. B., Cullen, D. J., Burdick, L., Williams, L., Laird, N., Petersen, L. A., Small, S. D., Sweitzer, B. J., Vander Vliet, M. and Leape, L. L. "Patient risk factors for adverse drug events in hospitalized patients. ADE Prevention Study Group" Archives of Internal Medicine **159**(21): 2553-60. (1999)

Abstract: BACKGROUND: Adverse drug events (ADEs) are common in hospitalized patients, but few empirical data are available regarding the strength of patient risk factors for ADEs. METHODS: We performed a nested case-control study within a cohort that included 4108 admissions to a stratified random sample of 11 medical and surgical units in 2 tertiary care hospitals during a 6-month period. Analyses were conducted on 2 levels: (1) using a limited set of variables available for all patients using computerized data available from 1 hospital and (2) using a larger set of variables for the case

patients and matched controls from both hospitals. Case patients were patients with an ADE, and the matched control for each case patient was the patient on the same unit as the case patient with the most similar prevent length of stay. Main outcome measures were presence of an ADE, preventable ADE, or severe ADE. RESULTS: In the cohort analysis, electrolyte concentrates (odds ratio [OR], 1.7), diuretics (OR, 1.7), and medical admission (OR, 1.6) were independent correlates of ADEs. Independent correlates of preventable ADEs in the cohort analysis were low platelet count (OR, 4.5), antidepressants (OR, 3.3), antihypertensive agents (OR, 2.9), medical admission (OR, 2.2), and electrolyte concentrates (OR, 2.1). In the case-control analysis, exposure to psychoactive drugs (OR, 2.1) was an independent correlate of an ADE, and use of cardiovascular drugs (OR, 2.4) was independently correlated with severe ADEs. For preventable ADEs, no independent predictors were retained after multivariate analysis. CONCLUSIONS: Adverse drug events occurred more frequently in sicker patients who stayed in the hospital longer. However, after controlling for level of care and preevent length of stay, few risk factors emerged. These results suggest that, rather than targeting ADE-prone individuals, prevention strategies should focus on improving medication systems.

57) Bates, D. W., Teich, J. M., Lee, J., Seger, D., Kuperman, G. J., Ma'Luf, N., Boyle, D. and Leape, L. “The impact of computerized physician order entry on medication error prevention” Journal of the American Medical Informatics Association **6**(4): 313-21. (1999)

Abstract: BACKGROUND: Medication errors are common, and while most such errors have little potential for harm they cause substantial extra work in hospitals. A small proportion do have the potential to cause injury, and some cause preventable adverse drug events. OBJECTIVE: To evaluate the impact of computerized physician order entry (POE) with decision support in reducing the number of medication errors. DESIGN: Prospective time series analysis, with four periods. SETTING AND PARTICIPANTS: All patients admitted to three medical units were studied for seven to ten-week periods in four different years. The baseline period was before implementation of POE, and the remaining three were after. Sophistication of POE increased with each successive period. INTERVENTION: Physician order entry with decision support features such as drug allergy and drug-drug interaction warnings. MAIN OUTCOME MEASURE: Medication errors, excluding missed dose errors. RESULTS: During the study, the non-missed-dose medication error rate fell 81 percent, from 142 per 1,000 patient-days in the baseline period to 26.6 per 1,000 patient-days in the final period ($P < 0.0001$). Non-intercepted serious medication errors (those with the potential to cause injury) fell 86 percent from baseline to period 3, the final period ($P = 0.0003$). Large differences were seen for all main types of medication errors: dose errors, frequency errors, route errors, substitution errors, and allergies. For example, in the baseline period there were ten allergy errors, but only two in the following three periods combined ($P < 0.0001$). CONCLUSIONS: Computerized POE substantially decreased the rate of non-missed-dose medication errors. A major reduction in errors was achieved with the initial version of the system, and further reductions were found with

addition of decision support features.

58) Bell, D. S., Cretin, S., Marken, R. S. and Landman, A. B. “A conceptual framework for evaluating outpatient electronic prescribing systems based on their functional capabilities” Journal of the American Medical Informatics Association **11**(1): 60-70. (2004)

Abstract: OBJECTIVE: Electronic prescribing (e-prescribing) may substantially improve health care quality and efficiency, but the available systems are complex and their heterogeneity makes comparing and evaluating them a challenge. The authors aimed to develop a conceptual framework for anticipating the effects of alternative designs for outpatient e-prescribing systems. DESIGN: Based on a literature review and on telephone interviews with e-prescribing vendors, the authors identified distinct e-prescribing functional capabilities and developed a conceptual framework for evaluating e-prescribing systems' potential effects based on their capabilities. Analyses of two commercial e-prescribing systems are presented as examples of applying the conceptual framework. MEASUREMENTS: Major e-prescribing functional capabilities identified and the availability of evidence to support their specific effects. RESULTS: The proposed framework for evaluating e-prescribing systems is organized using a process model of medication management. Fourteen e-prescribing functional capabilities are identified within the model. Evidence is identified to support eight specific effects for six of the functional capabilities. The evidence also shows that a functional capability with generally positive effects can be implemented in a way that creates unintended hazards. Applying the framework involves identifying an e-prescribing system's functional capabilities within the process model and then assessing the effects that could be expected from each capability in the proposed clinical environment. CONCLUSION: The proposed conceptual framework supports the integration of available evidence in considering the full range of effects from e-prescribing design alternatives. More research is needed into the effects of specific e-prescribing functional alternatives. Until more is known, e-prescribing initiatives should include provisions to monitor for unintended hazards.

59) Berger, R. G. and Kichak, J. P. “Computerized physician order entry: helpful or harmful?[see comment]” Journal of the American Medical Informatics Association **11**(2): 100-3. (2004)

Abstract: Computerized physician order entry (CPOE) is touted as a major improvement in patient safety, primarily as a result of the Institute of Medicine's 1999 report on medical errors and the subsequent formation of the "Leapfrog Group" of companies to preferentially direct their employees' health care to those institutions that install such systems (as part of directives that "Leapfrog" feels will improve patient care). Although the literature suggests that such systems have the potential to improve patient outcomes through decrease of adverse drug events, actual improvements in

medical outcomes have not been documented. Installation of such systems could actually increase the number of adverse drug events and result in higher overall medical costs, particularly in the first few years of their adoption.

60) Bergeron, B. P. “Medical errors: computers are no panacea” Journal of Medical Practice Management **21**(1): 31-4. (2005)

Abstract: Increased patient loads, time pressures, and heightened public awareness of medical errors are forcing many physicians and clinical administrators to consider acquiring computerized physician order entry (CPOE) systems and clinical information systems. The recent revelation that CPOE systems can facilitate medical errors, however, is a call to physicians to remain vigilant despite the new technologies. By attending to specific data-capture and data-access errors associated with clinical information systems, physicians can minimize errors associated with clinical information systems and maximize the potential benefits to their patients.

61) Beuscart-Zephir, M. C., Pelayo, S., Degoulet, P., Anceaux, F., Guerlinger, S. and Meaux, J. J. “A usability study of CPOE's medication administration functions: impact on physician-nurse cooperation” Medinfo **11**(Pt 2): 1018-22. (2004)

Abstract: Implementation of CPOE systems in Healthcare Institutions has proven efficient in reducing medication errors but it also induces hidden side-effects on Doctor-Nurse cooperation. We propose a usability engineering approach to this problem. An extensive activity analysis of the medication ordering and administration process was performed in several departments of 3 different hospitals. Two of these hospitals are still using paper-based orders, while the 3rd one is in the roll-out phase of medication functions of its CPOE system. We performed a usability assessment of this CPOE system. The usability assessment uncovered usability problems for the entry of medication administration time scheduling by the physician and revealed that the information can be ambiguous for the nurse. The comparison of cooperation models in both situation shows that users tend to adopt a distributed decision making paradigm in the paper-based situation, while the CPOE system supports a centralized decision making process. This analysis can support recommendation for the re-engineering of the Human-Computer Interface.

62) Bierstock, S., Kanig, S. P. and Marcus, E. “Computerized physician order entry systems and medication errors.[comment]” Jama **294**(2): 178-9. (2005)

Abstract:

63) Bindels, R., de Clercq, P. A., Winkens, R. A. and Hasman, A. “A test ordering system with automated reminders for primary care based on practice guidelines” International Journal of Medical Informatics **58-59**: 219-33. (2000)

Abstract: In this article we describe a real-time automated reminder system that has been developed to change Family Physicians' (FP) test ordering behavior. The system focuses on the appropriateness of test requests. We aim at using the system as a substitute for written feedback by human experts. The reminder system consists of a knowledge base, an order entry system and modules to provide passive and active support in the form of reminders to FPs. The system generates critical comments about the rationality of the test requests at the moment the FP orders a test that is not in line with national or regional guidelines. For the first validation of the knowledge base we compared the comments of a human expert to the comments of the reminder system on three random samples of test requests. The overall agreement in the subsequent validation rounds was 46, 60 and 69%. The corrections made in the knowledge base after each validation round resulted in a reminder system with 149 reminders concerning various medical problems. Due to the corrections in the knowledge base the reminder system reacts better over the subsequent validation rounds.

64) Birkmeyer, C. M., Lee, J., Bates, D. W. and Birkmeyer, J. D. “Will electronic order entry reduce health care costs?” Effective Clinical Practice. **5**(2): 67-74. (2002)

Abstract: Since the release of the Institute of Medicine's report "To err is human,"1 there has been growing interest in electronic order entry as a tool for reducing medication errors in hospitalized patients. With electronic order entry, clinicians place orders through computer workstations linked to databases containing patient-specific clinical information and error-prevention software. A number of studies have demonstrated the potential of these systems to substantially reduce medication errors.2-4 As a result, the Leapfrog Group, a large consortium of private and public purchasers, is advocating implementation of electronic order entry at hospitals caring for its more than 30 million employees and beneficiaries.5 According to their estimates, electronic order entry would prevent over 500,000 serious medication errors in the United States if fully implemented nationwide.6 While few dispute the potential for electronic order entry to reduce medication errors, many question whether hospitals can afford it. Electronic order entry requires that hospitals make substantial investments in information technology; implementation also requires a considerable commitment of clinician time and its related costs. Although many point to savings likely to be achieved from reduced errors and increased efficiency, the economic benefits of electronic order entry have not been carefully considered. In this article, we categorize the costs and savings associated with electronic order entry from the hospital's perspective. Although the data are insufficient to calculate the financial "bottom line" for hospitals, we quantify costs and savings as much as possible.

65) Bizovi, K. E., Beckley, B. E., McDade, M. C., Adams, A. L., Lowe, R. A., Zechnich, A. D. and Hedges, J. R. "The effect of computer-assisted prescription writing on emergency department prescription errors" Academic Emergency Medicine **9**(11): 1168-75. (2002)

Abstract: OBJECTIVE: To determine whether computer-assisted prescription writing reduces the frequency of prescription errors in the emergency department (ED). METHODS: A pre-post retrospective analysis was used to compare errors between handwritten (HW) and computer-assisted (CA) ED prescriptions. Prescriptions were reviewed for pharmacist clarifications. A clarification was defined as an error if missing information, incorrect information, incorrect dose, non-formulary medication, or illegibility was the reason for clarification. The HW and CA error rates were compared using odds ratios (ORs) with 95% confidence intervals (95% CIs). RESULTS: During the pre-intervention period, there were 7,036 patient visits with 2,326 HW ED prescriptions filled for 1,459 patients. There were 91 clarifications, with a rate of 3.9%. There were 54 HW errors, for an error rate of 2.3%. During the post-intervention period, there were 7,845 patient visits with 1,594 CA prescriptions filled for 1,056 patients. There were 13 clarifications, with a clarification rate of 0.8%, and 11 errors, for a CA error rate of 0.7%. The CA prescriptions were substantially less likely to contain an error [OR 0.31 (95% CI = 0.10 to 0.36)] or to require pharmacist clarification [OR 0.19 (95% CI = 0.10 to 0.36)] than were the HW prescriptions. CONCLUSIONS: Computer-assisted prescriptions were more than three times less likely to contain errors and five times less likely to require pharmacist clarification than handwritten prescriptions.

66) Bobb, A., Gleason, K., Husch, M., Feinglass, J., Yarnold, P. R. and Noskin, G. A. "The epidemiology of prescribing errors: the potential impact of computerized prescriber order entry" Archives of Internal Medicine **164**(7): 785-92. (2004)

Abstract: BACKGROUND: Adverse drug events (ADEs) are the most common cause of injury to hospitalized patients and are often preventable. Medication errors resulting in preventable ADEs most commonly occur at the prescribing stage. OBJECTIVES: To describe the epidemiology of medication prescribing errors averted by pharmacists and to assess the likelihood that these errors would be prevented by implementing computerized prescriber order entry (CPOE). METHODS: At a 700-bed academic medical center in Chicago, Ill, clinical staff pharmacists saved all orders that contained a prescribing error for a week in early 2002. Pharmacist investigators subsequently classified drug class, error type, proximal cause, phase of hospitalization, and potential for patient harm and rated the likelihood that CPOE would have prevented the prescribing error. RESULTS: A total of 1111 prescribing errors were identified (62.4 errors per 1000 medication orders), most occurring on admission (64%). Of these, 30.8% were rated clinically significant and were most frequently related to anti-infective medication orders, incorrect dose, and medication knowledge deficiency. Of all verified prescribing errors, 64.4% were rated as likely to be prevented with CPOE (including 43% of the potentially harmful errors), 13.2% unlikely to be prevented with CPOE, and 22.4% possibly prevented with CPOE depending on specific CPOE system

characteristics. CONCLUSIONS: Prescribing errors are common in the hospital setting. While CPOE systems could improve practitioner prescribing, design and implementation of a CPOE system should focus on errors with the greatest potential for patient harm. Pharmacist involvement, in addition to a CPOE system with advanced clinical decision support, is vital for achieving maximum medication safety.

67) Bogucki, B., Jacobs, B. R. and Hingle, J. “Computerized reminders reduce the use of medications during shortages” Journal of the American Medical Informatics Association **11**(4): 278-80. (2004)

Abstract: Medication shortages pose serious problems in health care. This study examines the impact of a computer-based reminder in addressing a national methylprednisolone shortage. An alert was designed and implemented in a computerized order entry platform at a children's hospital. The alert informed physicians of the shortage and provided an alternative prescribing pathway. Data regarding the number and type of parenteral corticosteroid prescriptions were collected for a one-month period before and after the alert was implemented. The alert resulted in a 55% relative reduction in methylprednisolone use and an average reduction of more than three orders each day. Dexamethasone and hydrocortisone, the recommended alternative medications, increased in use by 12% and 49%, respectively. The alert resulted in a $36,552 annualized cost reduction to the institution. Similar alert applications have great potential for effectively altering physician prescribing behavior.

68) Broverman, C. A., Clyman, J. I., Schlesinger, J. M. and Want, E. “Clinical decision support for physician order-entry: design challenges” Proceedings / AMIA Annual Symposium: 572-576. (1996)

Abstract: We report on a joint development effort between ALLTEL Information Services Health Care Division and IBM Worldwide Healthcare Industry to demonstrate concurrent clinical decision support using Arden Syntax at order-entry time. The goal of the partnership is to build a high performance CDS toolkit that may be easily customized for multiple health care enterprises. Our work uses and promotes open technologies and health care standards while building a generalizable interface to a legacy patient-care system and clinical database. This paper identifies four areas of design challenges and solutions unique to a concurrent order-entry environment: the clinical information model, the currency of the patient virtual chart, the granularity of event triggers and rule evaluation context, and performance

69) Burke, J. P. and Pestotnik, S. L. “Antibiotic use and microbial resistance in intensive care units: impact of computer-assisted decision support” Journal of Chemotherapy **11**(6): 530-5. (1999)

Abstract: As part of our integrated hospital information system (the HELP system), we developed computer-assisted decision support programs for antimicrobial prescribing that are available at bedside terminals throughout our 520-bed community hospital. Recently, options have been added to allow direct physician order entry of anti-infective agents in the shock-trauma intensive care unit (STRICU). Physicians prescribed the computer-suggested regimens for 46% but followed the suggested dose and interval for 93% of the orders during a 1-year study period. In comparison to a 2-year pre-intervention period, improved drug selection and reductions in adverse drug events and costs were seen. Antimicrobial resistance patterns for nosocomial gram-negative isolates remained stable or improved in the STRICU over an 11-year period of computer-assisted antibiotic management. We conclude that strategies for optimizing antimicrobial prescribing have the potential to stabilize resistance and reduce costs by encouraging heterogeneous prescribing patterns, use of local antimicrobial susceptibility patterns to inform empiric drug selection, and reduced "tonnage" of antibiotic use.

70) Butler, J., Speroff, T., Arbogast, P. G., Newton, M., Waitman, L. R., Stiles, R., Miller, R. A., Ray, W. and Griffin, M. R. “Improved compliance with quality measures at hospital discharge with a computerized physician order entry system” American Heart Journal **151**(3): 643-53. (2006)

Abstract: BACKGROUND: Most measures used to assess the quality of care of hospitalized patients with congestive heart failure (CHF) and acute myocardial infarction (AMI) involve discharge medications and instructions. Implementation of disease-specific computerized physician order entry (CPOE) discharge tools may improve compliance with these measures. METHODS: We studied 286 versus 290 AMI and 595 versus 656 CHF discharges in the pre-CPOE (July 2001 to June 2002) and CPOE (October 2002 to September 2003) periods, respectively. Compliance with chosen quality measures (aspirin and beta-blocker use for AMI, ejection fraction determination and discharge instructions for CHF, and angiotensin-converting enzyme inhibitor use, and smoking cessation counseling for both) was assessed. RESULTS: Compliance with recommended discharge medications was high at baseline and did not change significantly. Smoking cessation counseling (43% vs 1% for CHF and 62% vs 21% for AMI) and discharge instructions for CHF (56% vs 3%) improved significantly in the CPOE period. Overall, 63% of patients with CHF and AMI in the CPOE period were discharged using the tools. Compliance with prescription of recommended medications was 100% among eligible patients when CPOE was used; however, this improvement was due entirely to better documentation of contraindications in the CPOE period. The actual proportion of patients who received discharge prescriptions between the pre-CPOE and CPOE periods did not change: beta-blockers (85% vs 84%), angiotensin-converting enzyme inhibitor for AMI (77% vs 76%), and for CHF (56% vs 61%). However, nonmedication measures significantly improved when CPOE was used. CONCLUSIONS: Implementation of a CPOE discharge tool improved compliance with selected quality measures in patients with AMI and CHF. Effective methods of rapid implementation and acceptance of these tools by providers require further study.

71) Caldas, A. E. “Success Factors in the Implementation of Patient Care Information Systems” Toward an Electronic Patient Record '95 **2**: 8-13. (1995)

Abstract:

72) Carpenter, J. D. and Gorman, P. N. “What's so special about medications: a pharmacist's observations from the POE study” Proceedings / AMIA Annual Symposium: 95-9. (2001)

Abstract: Observations from a multi-site observational study of physician order entry (POE) confirm that implementing POE is problematic, and suggest that implementing medication order entry is particularly difficult. A pharmacist participating in the study group sought to answer the question: What makes medications different? Analysis of themes specific to medication POE in this study's large data set was undertaken using a grounded theory approach. Emerging themes in the data are explored and include: (1) order complexity and the consequences of error; (2) impacts on professional roles; (3) prescribing needs in different settings; and (4) technology impact on medication administration. Awareness of potential roadblocks and lessons learned from previous implementation attempts should help organizations considering medication POE to optimize their own strategies.

73) Caudill-Slosberg, M. and Weeks, W. B. “Case study: identifying potential problems at the human/technical interface in complex clinical systems” American Journal of Medical Quality **20**(6): 353-7. (2005)

Abstract: Many who would like to improve patient safety in health care have advocated for the widespread adoption of computerized physician order entry and electronic medical records. However, unforeseen consequences of this new technology may put patients at greater risk of harm, not less. The authors present a clinical scenario that demonstrates system vulnerabilities in the interface between humans and such technology. Furthermore, the authors suggest that managers could anticipate these vulnerabilities by using techniques such as cause-and-effect analysis or failure mode and effect analysis, both before the installation of electronic medical records and as ongoing surveillance mechanisms. The case study demonstrates that adoption of technology is not a quick fix to the patient safety issue; proactive and ongoing efforts to address the human factors issues raised by the introduction of new technology will be required to prevent patient harm.

74) Chan, W. “Increasing the success of physician order entry through human factors

engineering" Journal of Healthcare Information Management **16**(1): 71-9. (2002)

Abstract: Even though the success of a physician order entry (POE) system depends on meeting physicians' needs, no studies of POE systems report using standard, formal methods for assessing physician needs and how to design the best technology to meet those needs. To increase the chance of a successful POE implementation, the article proposes that techniques from the field of human factors engineering (HFE) be used to enhance the interaction between technology and the physicians. [References: 61]

75) Chapman, F. "Computer-based Patient Record (CPR) The Business Point of View" Toward an Electronic Patient Record '95 **2**: 360-364. (1995)

Abstract: As CPR comes of age, its implementation has become one of the moset cost/benefit justified investments you can make for your medical practice. Billing and scheduling system have long provided productivity for COST. Now CPR offs productivity for REVENUE. A 10 percent enhancement of physician productivity has become more significant that a reduction in FTE clerical support shifting focus to physician rather than staff productivity. To the more conservative and "already productive" physician, CPR can be fully cost justified on clerical and paper savings alone.

76) Chen, P., Tanasijevic, M. J., Schoenenberger, R. A., Fiskio, J., Kuperman, G. J. and Bates, D. W. "A computer-based intervention for improving the appropriateness of antiepileptic drug level monitoring" American Journal of Clinical Pathology. **119**(3): 432-8. (2003)

Abstract: We designed and implemented 2 automated, computerized screens for use at the time of antiepileptic drug (AED) test order entry to improve appropriateness by reminding physicians when a potentially redundant test was ordered and providing common indications for monitoring and pharmacokinetics of the specific AED. All computerized orders for inpatient serum AED levels during two 3-month periods were included in the study. During the 3-month period after implementation of the automated intervention, 13% of all AED tests ordered were canceled following computerized reminders. For orders appearing redundant, the cancellation rate was 27%. For nonredundant orders, 4% were canceled when information on specific AED monitoring and pharmacokinetics was provided. The cancellation rate was sustained after 4 years. There has been a 19.5% decrease in total AED testing volume since implementation of this intervention, despite a 19.3% increase in overall chemistry test volume. Inappropriateness owing to repeated testing before pharmacologic steady state was reached decreased from 54% of all AED orders to 14.6%. A simple, automated, activity-based intervention targeting a specific test-ordering behavior effectively reduced inappropriate laboratory testing. The sustained benefit supports the idea that computerized interventions may durably affect physician behavior. Computerized

delivery of such evidence-based boundary guidelines can help narrow the gap between evidence and practice.

77) Cheng, C. H., Goldstein, M. K., Geller, E. and Levitt, R. E. “The Effects of CPOE on ICU workflow: an observational study” AMIA. Annual Symposium Proceedings/AMIA Symposium. (2003)

Abstract: 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.

78) Chertow, G. M., Lee, J., Kuperman, G. J., Burdick, E., Horsky, J., Seger, D. L., Lee, R., Mekala, A., Song, J., Komaroff, A. L. and Bates, D. W. “Guided medication dosing for inpatients with renal insufficiency” JAMA **286**(22): 2839-44. (2001)

Abstract: CONTEXT: Usual drug-prescribing practices may not consider the effects of renal insufficiency on the disposition of certain drugs. Decision aids may help optimize prescribing behavior and reduce medical error. OBJECTIVE: To determine if a system application for adjusting drug dose and frequency in patients with renal insufficiency, when merged with a computerized order entry system, improves drug prescribing and patient outcomes. DESIGN, SETTING, AND PATIENTS: Four consecutive 2-month intervals consisting of control (usual computerized order entry) alternating with intervention (computerized order entry plus decision support system), conducted in September 1997-April 1998 with outcomes assessed among a consecutive sample of 17 828 adults admitted to an urban tertiary care teaching hospital. INTERVENTION: Real-time computerized decision support system for prescribing drugs in patients with renal insufficiency. During intervention periods, the adjusted dose list, default dose amount, and default frequency were displayed to the order-entry user and a notation was provided that adjustments had been made based on renal insufficiency. During control periods, these recommended adjustments were not revealed to the order-entry user, and the unadjusted parameters were displayed. MAIN OUTCOME MEASURES: Rates of appropriate prescription by dose and frequency, length of stay, hospital and pharmacy costs, and changes in renal function, compared among patients with renal insufficiency who were hospitalized during the

intervention vs control periods. RESULTS: A total of 7490 patients were found to have some degree of renal insufficiency. In this group, 97 151 orders were written on renally cleared or nephrotoxic medications, of which 14 440 (15%) had at least 1 dosing parameter modified by the computer based on renal function. The fraction of prescriptions deemed appropriate during the intervention vs control periods by dose was 67% vs 54% (P<.001) and by frequency was 59% vs 35% (P<.001). Mean (SD) length of stay was 4.3 (4.5) days vs 4.5 (4.8) days in the intervention vs control periods, respectively (P =.009). There were no significant differences in estimated hospital and pharmacy costs or in the proportion of patients who experienced a decline in renal function during hospitalization. CONCLUSIONS: Guided medication dosing for inpatients with renal insufficiency appears to result in improved dose and frequency choices. This intervention demonstrates a way in which computer-based decision support systems can improve care.

79) Chin, H. L. “Implementation of the Computer-Based Patient Record in Kaiser Permanente's Northwest Region: Real Life Experiences” Toward an Electronic Patient Record '96 **1**: 20-23. (1996)

Abstract:

80) Chin, H. L. and Krall, M. “Implementation of a comprehensive computer-based patient record system in Kaiser Permanente's Northwest Region” MD Computing **14**(1): 41-45. (1997)

Abstract: Clinicians use this system to document encounters, code diagnoses and procedures, maintain problem lists, order lab and radiology and send prescriptions electronically. Also supports patient-specific messages and referrals between medical providers. Article describes strategy and experience.

81) Chin, H. L. and Wallace, P. “Embedding guidelines into direct physician order entry: simple methods, powerful results” Proceedings / AMIA Annual Symposium: 221-5. (1999)

Abstract: Drs Chin and Wallace of Kaiser Permanente Northwest Region has implemented a comprehensive outpatient computer-based patient record (CPR). Using this system, clinicians electronically order laboratory tests, radiology tests, and prescriptions. Clinicians also use this comprehensive CPR to document encounters, code diagnoses and procedures, maintain problem lists, and to send patient-specific messages and referrals to other medical providers. Healthcare for our entire membership of 440,000 covered lives is now provided through this system and 2 over black square]; [1 and 2 over black square]]. Implementation of a comprehensive CPR with direct physician order-entry provides the opportunity to embed guidelines into the

ordering process. This article describes the underlying theme and various simple but effective methods we use to embed guidelines into the ordering process. Our experience demonstrates the powerful effect of these simple methods to reduce unnecessary variation and to reduce cost while maintaining or improving the quality of care delivery.

82) Chin, T. L. “Winning support for physician order entry” Health Data Management **7**(5): 54-6, 60, 62-3. (1999)

Abstract:

83) Choi, S. S., Jazayeri, D. G., Mitnick, C. D., Chalco, K., Bayona, J. and Fraser, H. S. “Implementation and initial evaluation of a Web-based nurse order entry system for multidrug-resistant tuberculosis patients in Peru” Medinfo **11**(Pt 1): 202-6. (2004)

Abstract: Socios En Salud uses directly observed therapy to treat a majority of the multidrug-resistant tuberculosis in Peru. The nurses play an important role in this community-based model as the patients' primary care givers. Since nurses, rather than physicians, are involved in patients' daily care, we developed a nurse-order entry system to test whether such a system would improve the accuracy and quality of medication data. We compared regimen information from patient electronic medical records, paper charts and pharmacy records. After a two-month training period on the new system, we conducted the trial for 52 days in two of Lima's six geographic treatment areas, and re-reviewed the three sources of medication data. We measured the error rates after the trial period and found there was no significant difference in the control group's (Lima Este), error rate (8.6% vs. 6.9%, P=0.66) after the trial. The intervention group (Lima Callao), however, showed a significant drop in the error rate (17.4% vs. 3.1%, P=0.0074) after the same time interval. Additionally, the nurse expressed satisfaction with the order entry system and its ease of use. The decrease in error rates and user satisfaction regarding the system are promising measures of our order entry system's success.

84) Churgin, P. G. “Successful Implementation of Computerized Patient Records in Clinical Practice” Toward an Electronic Patient Record '96 **1**: 15-19. (1996)

Abstract:

85) Clark, F. and Kimmerly, W. “Case study: a health check-up for the corporate IT department” Journal of Healthcare Information Management. **18**(1): 59-64. (2004)

Abstract: As advances such as the electronic charting, closed-loop medication safety, physician order entry, consumer portals, electronic collaboration, and wireless access become the norm, central IS organizations are finding it difficult to keep pace. This challenge is exacerbated by declining margins, severe cost pressures, increased regulation, and added public scrutiny. Is your centralized IS organization healthy enough to meet the challenges presented by today's complex, demanding, dynamic healthcare delivery environments? How do you know? What factors do you consider?

86) Coleman, R. W. “Translation and interpretation: the hidden processes and problems revealed by computerized physician order entry systems” Journal of Critical Care **19**(4): 279-82. (2004)

Abstract: Even the most basic computerized physician order entry systems can reduce medication error rates, improve the quality, and decrease the costs of medical care. Routine tasks such as decryption, triage, transcription, and transmission are eliminated or streamlined, reducing the source and likelihood of human errors. Translation of physician intent into actual orders requires more advanced computer systems with sophisticated algorithms built-in. Further, adding an interpretative function to understand and transmit orders that could have subtly different meanings will be challenging. Extensive analysis and the cooperative efforts of multidisciplinary teams will be required to add incremental value to computerized physician order entry systems.

87) Collins, C. D., Pedersen, C. A., Schneider, P. J., Miller, A. S., Sierawski, S. J. and Roux, R. K. “Effect on amphotericin B lipid complex use of a clinical decision support system for computerized prescriber order entry” American Journal of Health System Pharmacy **61**(13): 1395-9. (2004)

Abstract:

88) Cordero, L., Kuehn, L., Kumar, R. R. and Mekhjian, H. S. “Impact of computerized physician order entry on clinical practice in a newborn intensive care unit” Journal of Perinatology **24**(2): 88-93. (2004)

Abstract: OBJECTIVE: To study the impact of computerized physician order entry (CPOE) on selected neonatal intensive care unit (NICU) practices. DESIGN: Retrospective review. SETTING: Nursing units in an academic health system where CPOE has been implemented in adult services since 2000 and in the NICU since 2002. STUDY POPULATION: Data from 111 very-low-birth-weight (VLBW) infants born consecutively within 6 months before and 100 VLBW infants born within 6 months after the implementation of CPOE were evaluated. The study is based on pre- and post-

CPOE comparisons in medication error rates and on the initiation to completion time intervals for pharmacy orders and radiology procedures. The specific data subsets that were compared included caffeine and gentamicin. Radiology turn-around time (order to image display) for the first chest and abdominal X-ray taken following endotracheal intubation and/or umbilical catheter placement was studied. RESULTS: Statistically significant ($p<0.01$) reductions were seen in medication turn-around times for the loading dose of caffeine in pre-CPOE (n=41, mean 10.5+/-9.8 SD hours) and post-CPOE (n=48, mean 2.8+/-3.3 SD hours). After CPOE implementation, the percentage of cases during each period where caffeine was administered before 2 and 3 hours increased from 10 to 35% and 12 to 63%, respectively. Accuracy of gentamicin dose at the time of admission for 105 (pre-CPOE) and 92 (post-CPOE) VLBW infants was determined. In the pre-CPOE period, 5% overdosages, 8% underdosages, and 87% correct dosages were identified. In the post-CPOE, no medication errors occurred. Accuracy of gentamicin dosages during hospitalization at the time of suspected late-onset sepsis for 31 pre- and 28 post-CPOE VLBW infants was studied. Gentamicin dose was calculated incorrectly in two of 31 (6%) pre-CPOE infants. No such errors were noted in the post-CPOE period. Radiology response time decreased significantly from the pre-CPOE (n=107, mean 42+/-12 SD minutes) to post-CPOE (n=95, mean 32+/-16 SD minutes). CONCLUSION: The implementation of CPOE in our NICU resulted in a significant reduction in medication turn-around times and medication errors for selected drugs, and a decrease in ancillary service (radiology) response time. In spite of the complexities of medication orders in pediatric populations, commercially available software programs for CPOE can successfully be adjusted to accommodate NICU needs and to beneficially impact clinical practice.

89) Corley, S. T. “Electronic prescribing: a review of costs and benefits” Topics in Health Information Management **24**(1): 29-38. (2003)

Abstract: Electronic prescribing tools are currently available but most medical practices are not using them. The literature was reviewed for data on adverse drug events and the expected dollar savings that could occur if these events were prevented. In addition to cost savings from improved patient safety, the effect of these systems on formulary compliance and drug cost savings was examined. Improved physician, nurse, and staff efficiencies were calculated using time trial comparisons between a paper system of handling prescription refills and a representative electronic prescribing system. The conclusion is made that electronic prescribing software is cost-effective for all size practices with a more rapid return on investment in larger practices. Copyright (C) 2003 by Aspen Publishers, Inc.

90) Cornia, P. B., Amory, J. K., Fraser, S., Saint, S. and Lipsky, B. A. “Computer-based order entry decreases duration of indwelling urinary catheterization in hospitalized patients” American Journal of Medicine. **114**(5): 404-7. (2003)

Abstract:

91) Cotter, C. M. “Computerized physician order entry from a chief information officer perspective” Journal of Critical Care **19**(4): 283-9. (2004)

Abstract: 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.

92) Cox, P. M., Jr., D'Amato, S. and Tillotson, D. J. “Reducing medication errors” American Journal of Medical Quality **16**(3): 81-6. (2001)

Abstract: This article describes initiatives one institution developed to improve systems for detecting and preventing adverse medication events. Our discussion focuses on issues regarding the frequency and incidence of medication errors, the trials of traditional versus anonymous incident reporting, and the efforts to improve systems rather than placing blame and punishment on individuals. Initiatives such as improved documentation of pediatric patient weights and hepatic and renal function, increase of direct physician order entry into our Medical Information System (MIS), elimination of nonemergent verbal orders, and new and improved MIS ordering matrices (incorporating medical protocols and pathways) have led to more rational and efficient practices. Improved error prevention and critical incident review have identified on-going opportunities for improvement. Although the direct impact on patient outcomes is not yet measurable, numerous positive results have allowed for improved clinical decision making, streamlining of processes, increased regulatory compliance, and a positive culture change.

93) Cutler, D. M., Feldman, N. E. and Horwitz, J. R. “U.S. adoption of computerized physician order entry systems” Health Affairs **24**(6): 1654-63. (2005)

Abstract: Computerized physician order entry (CPOE) has been shown to reduce preventable, potential adverse events. Despite this evidence, fewer than 5 percent of U.S. hospitals have fully implemented these systems. We assess empirically alternative reasons for low CPOE implementation using data from various sources. We find that

CPOE is related to hospital ownership and teaching status; government and teaching hospitals are much more likely than other hospital types are to invest in CPOE. Hospital profitability is not associated with CPOE investment. Although greater diffusion of CPOE is needed, it might have to await continuing publicity efforts and substantial reimbursement system changes.

94) Davenport, T. H. and Glaser, J. “Just-in-time delivery comes to knowledge management” Harvard Business Review. **80**(7): 107-11, 126. (2002)

Abstract: Like all primary care physicians, Dr. Bob Goldszer must stay on top of approximately 10,000 different diseases and syndromes, 3,000 medications, 1,100 laboratory tests, and many of the 400,000 articles added each year to the biomedical literature. That's no easy task. And it is, quite literally, a matter of life and death. The Institute of Medicine's 1999 report, To Err Is Human, suggests that more than a million injuries, and 90,000 deaths are attributable to medical errors annually. Something like 5% of hospital patients have adverse reactions to drugs, another study reports, and of those, 43% are serious, life threatening, or fatal. Many knowledge workers have problems similar to Dr. Goldszer's (though they're usually less life threatening). No matter what the field, many people simply can't keep up with all they need to know. In the early years of knowledge management, companies established knowledge networks and communities of practice, built knowledge repositories, and attempted to motivate people to share knowledge. But each of these activities involved a great deal of additional labor for knowledge workers. A better approach, say the authors, is to bake specialized knowledge into the jobs of highly skilled workers. Partners HealthCare has started to embed knowledge into the technology that doctors use in their jobs so that consulting it is no longer a separate activity. Now when Dr. Goldszer orders medicine or a lab test, the order-entry system automatically checks his decision against a massive clinical database as well as the patient's own medical record. Knowledge workers in other fields could likewise benefit from a just-in-time knowledge-management system tailored to deliver the right supporting information for the job at hand.

95) Davidson, E. J. and Chismar, W. G. “Planning and managing computerized order entry: a case study of IT-enabled organizational transformation” Topics in Health Information Management **19**(4): 47-61. (1999)

Abstract: This article uses a model for technology-enabled organizational transformation to analyze a case study of computerized order entry at a medium-sized, urban hospital. The hospital achieved initial goals for direct order entry by physicians and improvements in patient care and is now using the system to implement disease management policies. The authors use the model to examine decisions and actions that facilitated or constrained effective implementation of the system and discuss the model's implications for managing implementation of computerized order entry technologies in health care systems.

96) Dawe, U., Warnock-Matheron, A. and Ross, S. “Mapping the future of hospital information systems: priorities for nursing applications” Computers in Nursing **11**(2): 61-6. (1993)

Abstract: The purpose of this study was to determine the value of computerized applications to nurse users in a large acute-care university-affiliated hospital. A hospital information system has been in place since 1983. A convenience sample of 77 staff nurses and 33 nurse managers from various clinical areas rated the benefits for decision making and patient care of approximately 19 existing automated applications, and prioritized for future acquisition, approximately 40 applications not currently available. Results of the study revealed that of the applications currently automated, respondents ranked the applications of results reporting, order entry, nursing station census, and message switching as most useful for decision making and patient care. Applications identified as high priorities for future acquisition were on-line charting, automated medication record, and enhanced results reporting.

97) De Ville, K. A. “The ethical and legal implications of handheld medical computers” Journal of Legal Medicine **22**(4): 447-66. (2001)

Abstract:

98) Del Fiol, G., Rocha, B. H., Kuperman, G. J., Bates, D. W. and Nohama, P. “Comparison of two knowledge bases on the detection of drug-drug interactions” Proceedings / AMIA Annual Symposium: 171-5. (2000)

Abstract: This paper describes a drug ordering decision support system that helps with the prevention of adverse drug events by detecting drug-drug interactions in drug orders. The architecture of the system was devised in order to facilitate its use attached to physician order entry systems. The described model focuses in issues related to knowledge base maintenance and integration with external systems. Finally, a retrospective study was performed. Two knowledge bases, developed by different academic centers, were used to detect drug-drug interactions in a dataset with 37,237 drug prescriptions. The study concludes that the proposed knowledge base architecture enables content from other knowledge sources to be easily transferred and adapted to its structure. The study also suggests a method that can be used on the evaluation and refinement of the content of drug knowledge bases.

99) Del Fiol, G., Rocha, R. A., Bradshaw, R. L., Hulse, N. C. and Roemer, L. K. “An XML model that enables the development of complex order sets by clinical

experts" IEEE Transactions on Information Technology in Biomedicine **9**(2): 216-28. (2005)

Abstract: Medication errors are significant and well-known problems in health care. Despite the evidence supporting the use of computerized physician order entering (CPOE) to help reduce medication errors, only a small number of hospitals in the U.S. have successfully implemented a CPOE system. Different authors have indicated that the utilization of order sets derived from best-practice standards can reduce medication errors and improve physicians' acceptance of CPOE systems. However, a variety of issues related to the development and continuous maintenance of best-practice order sets still need to be understood. This paper presents a model that supports an order set development process driven by clinical experts. Model requirements and details are presented and discussed.

100) Dexter, P. R., Perkins, S., Overhage, J. M., Maharry, K., Kohler, R. B. and McDonald, C. J. "A computerized reminder system to increase the use of preventive care for hospitalized patients" New England Journal of Medicine **345**(13): 965-70. (2001)

Abstract: BACKGROUND: Although they are effective in outpatient settings, computerized reminders have not been proved to increase preventive care in inpatient settings. METHODS: We conducted a randomized, controlled trial to determine the effects of computerized reminders on the rates at which four preventive therapies were ordered for inpatients. During an 18-month study period, a computerized system processed on-line information for all 6371 patients admitted to a general-medicine service (for a total of 10,065 hospitalizations), generating preventive care reminders as appropriate. Physicians who were in the intervention group viewed these reminders when they were using a computerized order-entry system for inpatients. RESULTS: The reminder system identified 3416 patients (53.6 percent) as eligible for preventive measures that had not been ordered by the admitting physician. For patients with at least one indication, computerized reminders resulted in higher adjusted ordering rates for pneumococcal vaccination (35.8 percent of the patients in the intervention group vs. 0.8 percent of those in the control group, P<0.001), influenza vaccination (51.4 percent vs. 1.0 percent, P< 0.001), prophylactic heparin (32.2 percent vs. 18.9 percent, P<0.001), and prophylactic aspirin at discharge (36.4 percent vs. 27.6 percent, P<0.001). CONCLUSIONS: A majority of hospitalized patients in this study were eligible for preventive measures, and computerized reminders significantly increased the rate of delivery of such therapies.

101) Dexter, P. R., Perkins, S. M., Maharry, K. S., Jones, K. and McDonald, C. J. "Inpatient computer-based standing orders vs physician reminders to increase influenza and pneumococcal vaccination rates - A randomized trial" Jama **292**(19): 2366-2371. (2004)

Abstract: Context Computerized reminder systems increase influenza and pneumococcal vaccination rates, but computerized standing order systems have not been previously described or evaluated. Objective To determine the effects of computerized physician standing orders compared with physician reminders on inpatient vaccination rates. Design, Setting, and Patients Randomized trial of 3777 general medicine patients discharged from 1 of 6 study wards during a 14-month period (November 1, 1998, through December 31, 1999) composed of 2 overlapping influenza seasons at an urban public teaching hospital. Interventions The hospital's computerized physician order entry system identified inpatients eligible for influenza and pneumococcal vaccination. For patients with standing orders, the system automatically produced vaccine orders directed to nurses at the time of patient discharge. For patients with reminders, the computer system provided reminders to physicians that included vaccine orders during routine order entry sessions. Main Outcome Measure Vaccine administration. Results During the approximately 6 months of the influenza season, 50% of all hospitalized patients were identified as eligible for influenza vaccination. Twenty-two percent of patients hospitalized during the entire 14 months of the study were found eligible for pneumococcal vaccination; Patients with standing orders received an influenza vaccine significantly more often (42%) than those patients with reminders (30%) (P.001). Patients with standing orders received a pneumococcal vaccine significantly more often (51%) than those with reminders (31%) (P.001). Conclusions Computerized standing orders were more effective than computerized reminders for increasing both influenza and pneumococcal vaccine administration. Our findings suggest that computerized standing orders should be used more widely for this purpose.

102) DiFrancesco, M. and Andrews, T. “Alamance Regional Medical Center improves patient safety with CPOE” Journal of Healthcare Information Management **18**(1): 18-23. (2004)

Abstract: While it is widely written that advanced clinical information systems can help healthcare organizations reduce adverse medical events and increase patient safety, Alamance Regional Medical Center (ARMC) has proven that it truly does. ARMC chose Eclipsys' Sunrise Clinical Manager for its ability to provide knowledge-based clinical decision support and its alert capabilities at the time of order entry. Since its organization-wide rollout in summer 2000, ARMC has been using the computerized physician order entry (CPOE) system with widespread success and has transformed the care delivery process.

103) Dinning, C., Branowicki, P., O'Neill, J. B., Marino, B. L. and Billett, A. “Chemotherapy error reduction: a multidisciplinary approach to create templated order sets” Journal of Pediatric Oncology Nursing **22**(1): 20-30. (2005)

Abstract: More than 48,000 newly diagnosed cancer patients can expect to have some adverse events related to their care each year. Historically, 20% of these adverse events have been medication related, and two thirds have been thought to be preventable. Since the majority of these errors occurred during the order writing process, the prioritized changes made at the joint pediatric program for Children's Hospital, Boston, and Dana-Farber Cancer Institute have been the initiation of templated orders and the development of a computerized order entry system. The goal of this initiative was to decrease errors related to chemotherapy administration by creating legible, complete, clearly defined order sets, and at the same time, to make order writing and reviewing more efficient. Chemotherapy templates were created using a consistent format and a rigorous multidisciplinary review process. Each order set includes the following: identification of the patient and cycle of chemotherapy to be given, criteria necessary to receive chemotherapy, chemotherapy orders with modifications if appropriate, and supportive care orders. Templated order sets have reduced the duplication of work efforts by significantly reducing the number of changes made during the order verification process; orders are more complete, and standardization has occurred.

104) Doolan, D. F. and Bates, D. W. “Computerized physician order entry systems in hospitals: mandates and incentives” Health Affairs. **21**(4): 180-8. (2002)

Abstract: Concerns with health care quality and medical errors are evident in media reports and research studies. A number of studies have demonstrated that computerized physician order entry (CPOE) can reduce medication error rates. In response, the California government and the Leapfrog Group have called for hospitals to implement CPOE for medications. However, few hospitals now use CPOE. Barriers include the large investment needed and the state of commercial CPOE systems. We argue that government, employers, and insurers should share the costs of CPOE and should fund further research into its benefits and means of implementation.

105) Dunbar, C. N. “Safety first: writing's on the wall” Nursing Spectrum **5**(4 ref). (2004)

Abstract: Computerized physician order entry system reduces errors, saves time, and improves patient care.

106) Dworkin, L. A., Krall, M., Chin, H., Robertson, N., Harris, J. and Hughes, J. “Experience using radio frequency laptops to access the electronic medical record in exam rooms” Proceedings / AMIA Annual Symposium: 741-4. (1999)

Abstract: Kaiser Permanente, Northwest, Portland, OR evaluated the use of laptop

computers to access our existing comprehensive Electronic Medical Record in exam rooms via a wireless radiofrequency (RF) network. Eleven of 22 clinicians who were offered the laptops successfully adopted their use in the exam room. These clinicians were able to increase their exam room time with the patient by almost 4 minutes (25%), apparently without lengthening their overall work day. Patient response to exam room computing was overwhelmingly positive. The RF network response time was similar to the hardwired network. Problems cited by some laptop users and many of the eleven non-adopters included battery issues, different equipment layout and function, and inadequate training. IT support needs for the RF laptops were two to four times greater than for hardwired desktops. Addressing the reliability and training issues should increase clinician acceptance, making a successful general roll-out for exam room computing more likely.

107) Dykstra, R. “Computerized physician order entry and communication: reciprocal impacts” Proceedings / AMIA. Annual Symposium.: 230-4. (2002)

Abstract: Participant observation, focus group and oral history techniques were used to collect data from four distinctly different sites across the U.S. Data were examined initially to identify success factors for computerized physician order entry (CPOE) implementation. These data, reexamined for communication issues, revealed significant impacts on communication channels and relationships unanticipated by the implementers. Effects on physician-nurse interactions, pharmacy roles, and patient communications that vary by time and location were noted. The importance of robust bi-directional information channels between administration and staff was demonstrated to be potentially "mission-critical." The recommendation for implementers is "Plan to be surprised." Careful planning and pre-work are important but, no matter how much an institution prepares for the upheaval of CPOE, unforeseen consequences are inevitable. The presence of a prepared and capable implementation support group is essential.

108) Eisenberg, F. and Barbell, A. S. “Computerized physician order entry: eight steps to optimize physician workflow” Journal of Healthcare Information Management **16**(1): 16-8. (2002)

Abstract:

109) Endoh, A., Minato, K., Komori, M., Inoue, Y., Nagata, S. and Takahashi, T. “Quantitative comparison of human computer interaction for direct prescription entry systems” Medinfo **8**(Pt 2): 1101-5. (1995)

Abstract: An objective and quantitative method is described for evaluating human-computer interaction (interface) in a direct prescription entry system. This method is based on a GOMS model and represented by a tree structure. Three different interfaces

at university hospitals were compared by this evaluation method, and the differences among them were measured.

110) Eskew, A., Geisler, M., O'Connor, L., Saunders, G. and Vinci, R. “Enhancing patient safety: clinician order entry with a pharmacy interface” Journal of Healthcare Information Management **16**(1): 52-7. (2002)

Abstract: The electronic pharmacy interface is the unique aspect of Boston Medical Center's new clinician order entry system, which electronically transmits clinicians' orders to the laboratory, radiology, and pharmacy. The interface and several other enhancements create a platform for clinicians that provides for efficiency, standardization, documentation compliance, and most important, improved patient safety.

111) Fabrey, R. H. “Physician computer order entry in a hospital setting” Physician Executive **22**(4): 31-3. (1996)

Abstract:

112) Ferren, A. L. “Gaining MD buy-in: physician order entry” Journal of Healthcare Information Management **16**(2): 66-70. (2002)

Abstract: Computerized physician order entry (CPOE) eliminates illegible handwriting, reduces medical errors, and improves patient care. The administration, medical staff, nursing, and health information systems departments of a community teaching hospital cooperated to achieve organization-wide use of its CPOE system.

113) Finch, E. and Mayne, C. “Thinking beyond CPOE to integrated IT strategy and management” Journal of Healthcare Information Management. **18**(1): 24-9. (2004)

Abstract: There is a tremendous amount of pressure driving organizations to implement computerized provider order entry. To unlock the greatest value, a more enterprise-wide strategic approach to healthcare IT is needed.

114) FitzHenry, F., Kiepek, W. T., Shultz, E. K., Byrd, J., Doran, J. and Miller, R. A. “Implementing outpatient order entry to support medical necessity using the patient's electronic past medical history” Proceedings / AMIA. Annual

Symposium.: 250-4. (2002)

Abstract: Physician order entry is difficult to implement, both in inpatient and outpatient settings. Such systems must integrate conveniently into clinical workflows, and provide sufficient benefit to offset the burden of system use. For outpatient order entry, significant advantages can accrue when systems incorporate medical necessity guidelines - improved billing and adherence to governmental policies. The authors developed and implemented an outpatient order entry system that utilizes an electronically accessible history of patient, provider, and clinic-related diagnoses in assisting providers (when possible and appropriate) to select compliant justifications for tests and procedures. The pilot implementation site, active for more than six months, has been the Vanderbilt University Page Campbell Cardiology Clinic, with 34 providers.

115) Fitzpatrick, J. and Koh, J. S. "If you build it (right), they will come: the physician-friendly CPOE. Not everything works as planned right out of the box. A Mississippi hospital customizes its electronic order entry system for maximum use by physicians" Health Management Technology **26**(1): 52-3. (2005)

Abstract:

116) Flanagan, J. R. and Walker, K. P. "Tracking vaccine compliance in a primary care setting: online history, reminders, order entry, and charting" Proceedings / AMIA Annual Symposium: 760-4. (1999)

Abstract: In a new primary care setting with three medical disciplines participating, a vaccine history and order entry system was implemented along with other online documentation systems as the primary documentation tools for the clinic. Reminders were generated based upon a set of algorithms consistent with 1998 nationally accepted vaccine guidelines. Vaccine compliance data were analyzed for the entire population cared for in this setting for a 6 month period. Rates of compliance with national recommendations for eight key vaccine groups were calculated based on the online data. Trends in the rates of compliance, interpreted within limitations, showed statistically and clinically significant improvements. The immunization application accomplished several goals: accurate history and patient-specific recommendations, online ordering of vaccines or serum products, online charting of administration that, in turn, automatically maintained the vaccine history.

117) Fortescue, E. B., Kaushal, R., Landrigan, C. P., McKenna, K. J., Clapp, M. D., Federico, F., Goldmann, D. A. and Bates, D. W. "Prioritizing strategies for preventing medication errors and adverse drug events in pediatric inpatients" Pediatrics. **111**(4 Pt 1): 722-9. (2003)

Abstract: OBJECTIVES: Medication errors in pediatric inpatients occur at similar rates as in adults but have 3 times the potential to cause harm. Error prevention strategies in this setting remain largely untested. The objective of this study was to classify the major types of medication errors in pediatric inpatients and to determine which strategies might most effectively prevent them. METHODS: A prospective cohort study was conducted of 1020 patients who were admitted to 2 academic medical centers during a 6-week period in April and May 1999. Medication errors were characterized by subtype. Physician raters evaluated error prevention strategies and identified those that might be most effective in preventing errors. RESULTS: Of 10 778 medication orders reviewed, 616 contained errors. Of these, 120 (19.5%) were classified as potentially harmful, including 115 potential adverse drug events (18.7%) and 5 preventable adverse drug events (0.8%). Most errors occurred at the ordering stage (74%) and involved errors in dosing (28%), route (18%), or frequency (9%). Three interventions might have prevented most potentially harmful errors: 1) computerized physician order entry with clinical decision support systems (76%); 2) ward-based clinical pharmacists (81%); and 3) improved communication among physicians, nurses, and pharmacists (86%). Interrater reliability of error prevention strategy assignment was good (agreement: 0.92; kappa: 0.82). CONCLUSIONS: Of the assessed interventions, computerized physician order entry with clinical decision support systems; ward-based clinical pharmacists; and improved communication among physicians, nurses, and pharmacists had the greatest potential to reduce medication errors in pediatric inpatients. Development, implementation, and assessment of such interventions in the pediatric inpatient setting are needed.

118) Foster, R. A. and Antonelli, P. J. “Computerized physician-order entry: are we there yet?” Otolaryngologic Clinics of North America. **35**(6): 1237-43, vii. (2002)

Abstract: Computerized physician-order entry (CPOE) is a system of hardware and software through which a physician enters orders directly into a computer rather than writing them on paper. The advantages of CPOE include order legibility, improved response time, reduction in adverse drug reactions, reduced cost of care, and improved patient outcomes. The maturation of mobile computing platforms, graphical user interfaces, and wireless technologies are making CPOE more practical for both outpatient and inpatient care. Significant barriers to the implementation of CPOE include the reluctance of physicians to change existing practices, doubt about the possible benefits, increased front-end time to enter orders, and system cost.

119) Frank, G., Lawless, S. T. and Steinberg, T. H. “Improving physician communication through an automated, integrated sign-out system” Journal of Healthcare Information Management **19**(4): 68-74. (2005)

Abstract: Communication failures among physicians are a leading cause of medical errors. The resident sign-out sheet is the primary tool used by house staff to facilitate

the sign-out process. The resident sign-out sheet is a structured report, with patient-specific information including demographics, such a patient's name, age, sex, room number, and attending physician; problem list; medications; and allergies. Some physicians use handwritten notes to keep track of this information, while others use freestanding word processor or database programs. In a previous study, the authors described serious inaccuracies in a manually updated word-processor based resident sign-out sheet used by pediatric residents at a tertiary-care children's hospital. An automated and integrated sign-out system (AISS) was subsequently developed that retrieves pertinent patient information from a computerized provider order entry (CPOE) system. The AISS generates a resident sign-out sheet, which includes demographic information, weight, current medications, allergies, and diet orders, as well as optional free-text information. The AISS has proven to be enormously popular, increasing physician acceptance of CPOE throughout the organization. This paper discusses lessons learned, including technical, design, and workflow aspects of an integrated resident sign-out sheet. The authors recommend that all future commercial CPOE systems incorporate physician sign-out tools such as the one described in this article.

120) Franklin, M. J., Sittig, D. F., Schmiz, J. L., Spurr, C. D., Thomas, D., O'Connell, E. M. and Teich, J. M. “Modifiable templates facilitate customization of physician order entry” Proceedings / AMIA Annual Symposium: 315-9. (1998)

Abstract: Physician order entry is a key factor in improving the quality of healthcare, while simultaneously reducing its cost. This paper describes an editor, a database, and a run-time system for creating and executing highly customized, user modifiable, order entry templates. The system allows non-programmers to create new order entry templates rapidly. Over the past 18 months, the templates have been used on over 2500 patients to enter over 40,000 separate orders.

121) Galanter, W. L., DiDomenico, R. J. and Polikaitis, A. “Preventing exacerbation of an ADE with automated decision support” Journal of Healthcare Information Management. **16**(4): 44-9. (2002)

Abstract: This case demonstrates that, despite physician disregard of appropriate expert system warnings during computerized physician order entry, the distribution of alert "override" warnings to non-physician members of the clinical team can help avert adverse drug events.

122) Galanter, W. L., Didomenico, R. J. and Polikaitis, A. “A trial of automated decision support alerts for contraindicated medications using computerized physician order entry” Journal of the American Medical Informatics Association **12**(3): 269-74. (2005)

Abstract: BACKGROUND: Automated clinical decision support has shown promise in reducing medication errors; however, clinicians often do not comply with alerts. Because renal insufficiency is a common source of medication errors, the authors studied a trial of alerts designed to reduce inpatient administration of medications contraindicated due to renal insufficiency. METHODS: A minimum safe creatinine clearance was established for each inpatient formulary medication. Alerts recommending cancellation appeared when a medication order was initiated for a patient whose estimated creatinine clearance was less than the minimum safe creatinine clearance for the medication. Administration of medications in patients with creatinine clearances less than the medication's minimum safe clearance were studied for 14 months after, and four months before, alert implementation. In addition, the impact of patient age, gender, degree of renal dysfunction, time of day, and duration of housestaff training on the likelihood of housestaff compliance with the alerts was examined. RESULTS: The likelihood of a patient receiving at least one dose of contraindicated drug after the order was initiated decreased from 89% to 47% ($p < 0.0001$) after alert implementation. Analysis of the alerts seen by housestaff showed that alert compliance was higher in male patients (57% vs. 38%, $p = 0.02$), increased with the duration of housestaff training ($p = 0.04$), and increased in patients with worsening renal function ($p = 0.007$). CONCLUSION: Alerts were effective in decreasing the ordering and administration of drugs contraindicated due to renal insufficiency. Compliance with the alerts was higher in male patients, increased with the duration of housestaff training, and increased in patients with more severe renal dysfunction.

123) Galanter, W. L., Polikaitis, A. and DiDomenico, R. J. “A trial of automated safety alerts for inpatient digoxin use with computerized physician order entry” Journal of the American Medical Informatics Association **11**(4): 270-7. (2004)

Abstract: OBJECTIVE: Automated clinical decision support (CDS) has shown promise in improving safe medication use. The authors performed a trial of CDS, given both during computerized physician order entry (CPOE) and in response to new laboratory results, comparing the time courses of clinician behaviors related to digoxin use before and after implementation of the alerts. DESIGN: Alerts were implemented to notify of the potential risk from low electrolyte concentrations or unknown digoxin or electrolyte concentrations during CPOE. Alerts were also generated in response to newly reported hypokalemia and hypomagnesemia in patients given digoxin. MEASUREMENTS: Clinician responses to the alerts for six months were compared with responses to similar situations for six months prior to implementation. RESULTS: During CPOE, checking for unknown serum values increased after implementation compared with control at one hour: 19% vs. 6% for digoxin, 57% vs. 9% for potassium, and 40% vs. 12% for magnesium as well as at 24 hours ($p < 0.01$ for all comparisons). Electrolyte supplementation increased with newly reported hypokalemia and hypomagnesemia after implementation at one hour: 35% vs. 6% and 49% vs. 5% for potassium and magnesium, respectively, as well as at 24 hours ($p < 0.01$ for all comparisons). During CPOE, supplementation for hypokalemia was not improved,

whereas supplementation for hypomagnesemia improved at one hour ($p < 0.05$). CONCLUSION: Overall, the alerts improved the safe use of digoxin. During CPOE, alerts associated with missing levels were effective. For hypokalemia and hypomagnesemia, the alerts given during CPOE were not as effective as those given at the time of newly reported low electrolytes.

124) Gardner, R. M., Pryor, T. A. and Warner, H. R. “The HELP hospital information system: update 1998” International Journal of Medical Informatics **54**(3): 169-82. (1999)

Abstract: The HELP hospital information system has been operational at LDS Hospital since 1967. The system initially supported a heart catheterization laboratory and a post open heart Intensive Care Unit. Since the initial installation the system has been expanded to become an integrated hospital information system providing services with sophisticated clinical decision-support capabilities to a wide variety of clinical areas such as laboratory, nurse charting, radiology, pharmacy, etc. The HELP system is currently operational in multiple hospitals of LDS Hospital's parent health care enterprise--Intermountain Health Care (IHC). The HELP system has also been integrated into the daily operations of several other hospitals in addition to those at IHC. Evaluations of the system have shown: (1) it to be widely accepted by clinical staff; (2) computerized clinical decision-support is feasible; (3) the system provides improvements in patient care; and (4) the system has aided in providing more cost-effective patient care. Plans for making the transition from the 'function rich' HELP system to more modern hardware and software platforms are also discussed.

125) Geiger, G. and Derman, Y. D. “Methodology for evaluating physician order entry (POE) implementations” Journal of Evaluation in Clinical Practice **9**(4): 401-8. (2003)

Abstract: The body of physician order entry (POE) implementations literature uses statistical evaluation methods to demonstrate changes in specified variables after POE implementation. To understand and manage the holistic impact of POE on the health care institution, a methodology that utilizes feedback to guide the POE implementation towards the satisfaction of stakeholder objectives is presented. Stakeholders jointly define quantitative and qualitative metrics for their objectives, establish target value vectors for the metrics that represent acceptable implementation outcomes and specify evaluation milestones. These are used to compare pre- and post-POE implementation clinical performance, enabling a socio-technical feedback-improvement cycle. A case study is provided to illustrate how the methodology is being used at Sunnybrook and Women's College Health Science Centre in Toronto, Canada.

126) Geissbuhler, A. and Grande, J. F. “Embedding a Web-Browser in an Order entry System to Improve the Distributed Meintenance of Decision-Support Resources” Proceedings / AMIA Annual Symposium: 939. (1997)

Abstract:

127) Geissbuhler, A. and Miller, R. A. “A new approach to the implementation of direct care-provider order entry” Proceedings / AMIA Annual Symposium: 689-693. (1996)

Abstract: Successful implementation of direct computer-based care-provider order entry traditionally relies on one of two different approaches development from scratch or installation of a commercial product. The former requires extensive resources; the latter, by its proprietary nature, limits extension of the system beyond capabilities supplied by the vendor. This paper describes an intermediate approach using the association of a locally-developed and controlled set of distributed microcomputer based applications and a commercial, mainframe-based order entry application used as an order transaction processing system. This combination provides both an intuitive user interface and a platform for implementing clinical decision-support tools

128) Geissbuhler, A. and Miller, R. A. “Clinical application of the UMLS in a computerized order entry and decision-support system” Proceedings / AMIA Annual Symposium: 320-4. (1998)

Abstract: Vanderbilt University Medical Center uses the UMLS as a dictionary, an interlingua, and a knowledge source within the WizOrder system. WizOrder provides direct care-provider order entry and integrated clinical decision-support capabilities. Linking the two functions enables efficient decision-support during the "normal" workflow of care providers, at the point where decisions are made. WizOrder uses the UMLS as a dictionary to encode free-text entries into controlled vocabularies such as ICD9. As an interlingua, the UMLS provides mapping between vocabularies, allowing to translate patient-specific information to MeSH terms and perform automated literature retrieval. WizOrder uses the tables of co-occurring concepts and the Semantic Network to provide sensible lists of potential drug interactions and adverse drug reactions, and generate fully-formed MEDLINE queries for PubMed.

129) Geissbuhler, A. and Miller, R. A. “Distributing knowledge maintenance for clinical decision-support systems: the "knowledge library" model” Proceedings / AMIA Annual Symposium: 770-4. (1999)

Abstract: The maintenance of knowledge-rich clinical decision-support systems is challenging, in particular in the complex setting of a large academic medical center.

Distributing the maintenance tasks to the source of expertise can address scalability, accuracy and currency issues. It also helps to foster a more global sense of ownership among the system users. The knowledge maintenance model must provide processes and tools to deal with a wide range of stakeholders (resident and attending physicians, consulting specialists, other care providers, case managers, ancillary departments), with knowledge embedded in legacy departmental systems, and with the continuous evolution of the content and form of the knowledge base. We describe and illustrate the "knowledge library" model in use at Vanderbilt University Medical Center for the distributed maintenance of the integrated knowledge base that drives the WizOrder clinical decision-support, physician order entry, and notes capture system.

130) George, D. and Austin-Bishop, N. “Error rates for computerized order entry by physicians versus nonphysicians” American Journal of Health System Pharmacy **60**(21): 2250-2. (2003)

Abstract:

131) Gettinger, A., Lee, J., Dulac, D. E., Turpin, E. H. and Johnson, P. A. “Workflow Improvements from use of Wireless Technology:The Dartmouth-Hitchcock Experience.” Proceedings / AMIA Annual Symposium: 1017. (2000)

Abstract: Wireless technology via laptops allows practitioners to access clinical information and enter data without being tied to fixed workstations. We evaluated the impact of wireless technology at Dartmouth-Hitchock Medical Center (DHMC). Eight physicians were given laptops that enabled them to access the clinical information system without fixed stations. Among a subset of these eight physicians, the dissemination of wireless technology resulted in rise in the percentage of directly entered notes from 14% to 86%.

132) Giannone, G. “Computer-supported weight-based drug infusion concentrations in the neonatal intensive care unit” CIN: Computers, Informatics, Nursing **23**(2): 100-5. (2005)

Abstract: This article addresses the development of a computerized provider order entry (CPOE)-embedded solution for weight-based neonatal drug infusion developed during the transition from a legacy CPOE system to a customized application of a neonatal CPOE product during a hospital-wide information system transition. The importance of accurate fluid management in the neonate is reviewed. The process of tailoring the system that eventually resulted in the successful development of a computer application enabling weight-based medication infusion calculation for neonates within the CPOE information system is explored. In addition, the article provides guidelines on how to customize a vendor solution for hospitals with neonatal

intensive care unit. [References: 14]

133) Giuse, D. A. “Provider order entry with integrated decision support: from academia to industry” Methods of Information in Medicine. **42**(1): 45-50. (2003)

Abstract: OBJECTIVES: To describe the evolution of a provider order entry system with integrated decision support, from a research prototype to full implementation at one academic center, and finally to a commercial product. METHODS: Describe the institutional environment and planning process in which the system originated. Highlight the historical evolution of the provider entry system, and analyze its system architecture and functionality. Describe the requirements for successful design and deployment both within a single health care organization and as part of a commercial product line. RESULTS: Over a period of eight years the system evolved from a research prototype to a fully integrated order entry system in routine use on most inpatient units of a large academic medical center. Around 12,000 orders are entered every day into the computer system; 70% of those are entered directly by the responsible physician. The system embeds best-of-care practice guidelines, and is used to reduce resource utilization by limiting unnecessary testing and suggesting more effective or less costly therapeutic replacements. The system was recently acquired by a large HIS software vendor and is being rapidly implemented at numerous customer sites. CONCLUSIONS: Large-scale development or deployment of complex health information systems requires considerable organizational agreement and resources, as well as close attention to iterative system design that explicitly includes constant feedback from the user community. The transformation of such a system from a single-site success to a widely deployed product requires convergence of resources and needs.

134) Goldblum, O. M. “Electronic prescribing: criteria for evaluating handheld prescribing systems and an evaluation of a new, handheld, wireless wide area network (WWAN) prescribing system” Dermatology Online Journal **7**(1): 1. (2001)

Abstract: OBJECTIVE: The objectives of this study were: 1) to establish criteria for evaluating handheld computerized prescribing systems; and 2) to evaluate out-of-box performance and features of a new, Palm Operating System (OS)-based, handheld, wireless wide area network (WWAN) prescribing system. The system consisted of a Palm Vx handheld organizer, a Novatel Minstrel V wireless modem, OmniSky wireless internet access and ePhysician ePad 1.1, the Palm OS electronic prescribing software program. DESIGN: A dermatologist familiar with healthcare information technology conducted an evaluation of the performance and features of a new, handheld, WWAN electronic prescribing system in an office practice during a three-month period in 2000. System performance, defined as transmission success rate, was determined from data collected during the three-month trial. Evaluation criteria consisted of an analysis of features found in electronic prescribing systems. METHODS: All prescriptions written for all patients seen during a three-month period (August - November, 2000) were eligible

for inclusion. Prescriptions written for patients who intended to fill them at pharmacies without known facsimile receiving capabilities were excluded from the study. The performance of the system was evaluated using data collected during the study. Criteria for evaluating features of electronic prescribing systems were developed and used to analyze the system employed in this study. RESULTS: During this three-month trial, 200 electronic prescriptions were generated for 132 patients included in the study. Of these prescriptions, 92.5 percent were successfully transmitted to pharmacies. Transmission failures resulted from incorrect facsimile numbers and non-functioning facsimile machines. Criteria established for evaluation of electronic prescribing systems included System (Hardware & Software), Costs, System Features, Printing & Transmission, Formulary & Insurance, Customization, Drug Safety and Security. CONCLUSION: This study is the first effort to establish comprehensive criteria for evaluating handheld prescribing systems and to evaluate the performance and features of a handheld, electronic prescribing system. The results demonstrated that the evaluated system: 1) was simple to install; 2) successfully interfaced with a commonly used practice management system; 3) was user-friendly and easy to operate; 4) offered a robust variety of standard features; and, 5) resulted in a high rate of success for transmitting electronic prescriptions. The criteria established for the evaluation of features of an electronic prescribing system can be used to critically evaluate the performance and features of other handheld and personal computer-based electronic prescribing systems.

135) Goldstein, M. K., Hoffman, B. B., Coleman, R. W., Tu, S. W., Shankar, R. D., O'Connor, M., Martins, S., Advani, A. and Musen, M. A. “Patient safety in guideline-based decision support for hypertension management: ATHENA DSS” Proceedings / AMIA Annual Symposium: 214-8. (2001)

Abstract: The Institute of Medicine recently issued a landmark report on medical error.1 In the penumbra of this report, every aspect of health care is subject to new scrutiny regarding patient safety. Informatics technology can support patient safety by correcting problems inherent in older technology; however, new information technology can also contribute to new sources of error. We report here a categorization of possible errors that may arise in deploying a system designed to give guideline-based advice on prescribing drugs, an approach to anticipating these errors in an automated guideline system, and design features to minimize errors and thereby maximize patient safety. Our guideline implementation system, based on the EON architecture, provides a framework for a knowledge base that is sufficiently comprehensive to incorporate safety information, and that is easily reviewed and updated by clinician-experts.

136) Gorman, P. N., Lavelle, M. B. and Ash, J. S. “Order creation and communication in healthcare” Methods of Information in Medicine **42**(4): 376-84. (2003)

Abstract: OBJECTIVES: The aim of this paper is to examine the adequacy of the

concept of Physician Order Entry (POE) as a model for clinical systems, and to suggest an alternative understanding of the order creation and communication process. METHODS: The study is based on an interpretative analysis of POE as a model for clinical systems and the results of our recent fieldwork. RESULTS: Observations from our recent fieldwork suggest that orders, like patient care in general, emerge from interactions among patients, physicians, nurses, family members, and others, employing a variety of technologies and information resources in the process. Orders as we have observed them originate, are negotiated, and are carried out in a dynamically evolving group with fluctuating membership and shifting role responsibilities. Furthermore, orders by themselves represent only a partial picture of what is done for the patient. CONCLUSION: We argue that information systems are more likely to be helpful if they accommodate and facilitate POE as a multidisciplinary collaboration effort and fit better into the larger system of patient care.

137) Gottlieb, J. “The long and winding road to computerized physician order entry. Massive, 8-year project to bring CPOE to Thomas Jefferson University Hospital is nearly complete” Physician Executive **30**(2): 30-5. (2004)

Abstract:

138) Gouveia, W. A., Shane, R. and Clark, T. “Computerized prescriber order entry: power, not panacea” American Journal of Health-System Pharmacy. **60**(18): 1838. (2003)

Abstract:

139) Goverman, I. L. “Orienting health care information systems toward quality: how Group Health Cooperative of Puget Sound did it” Joint Commission Journal on Quality Improvement **20**(11): 595-605. (1994)

Abstract: BACKGROUND: Group Health Cooperative of Puget Sound (GHC), a large staff-model health maintenance organization based in Seattle, is redesigning its information systems to provide the systems and information needed to support its quality agenda. PLANNING PROCESS: Long-range planning for GHC's information resources was done in three phases. In assessment, interviews, surveys, and a benchmarking effort identified strengths and weaknesses of the existing information systems. We concluded that we needed to improve clinical care and patient management systems and enhance health plan applications. In direction setting, we developed six objectives (for example, approach information systems in a way that is consistent with quality improvement principles). Detailed planning was used to define projects, timing, and resource allocations. MAJOR EFFORTS: Some of the most important efforts in the resulting five-year plan include the development of (1) a computerized patient record; (2) a provider-based clinical workstation for access to

patient information, order entry, results reporting, guidelines, and reminders; (3) a comprehensive set of patient management and service quality systems; (4) reengineered structures, policies, and processes within the health plan, supported by a complete set of integrated information systems; (5) a standardized, high-capacity communications network to provide linkages both within GHC and among its business partners; and (6) a revised oversight structure for information services, which forms partnerships with users. CONCLUSIONS: A quality focus ensured that each project not only produced its own benefits but also supported the larger organizational goals associated with "total" quality.

140) Gray, M. D. and Felkey, B. G. “Computerized prescriber order-entry systems: evaluation, selection, and implementation” American Journal of Health System Pharmacy **61**(2): 190-7. (2004)

Abstract:

141) Grissinger, M. and Globus, N. J. “How technology affects your risk of medication errors” Nursing **34**(1): 36-41. (2004)

Abstract:

142) Grundmeier, R. and Johnson, K. “Housestaff attitudes toward computer-based clinical decision support” Proceedings / AMIA Annual Symposium: 266-70. (1999)

Abstract: OBJECTIVE: To measure housestaff attitudes towards computer-based decision support and their threshold for having CDSS messages displayed. DESIGN: 770 self-administered surveys were distributed to housestaff physicians. RESULTS: 209 surveys were returned. 63% of respondents agreed or strongly agreed that CDSS would improve quality of care, while 52% agreed or strongly agreed that it would decrease adverse drug events. Respondents were neutral regarding the impact of CDSS on productivity and on their autonomy. Sixty percent approved of a reminder to consider surgical consultation in a patient with abdominal pain, while 88% approved of alerts about hypokalemia. Respondents felt both reminders should be triggered when their PPV exceeded 67%. Attitudes toward POE correlated positively with attitudes toward CDSS (Pearson's rho 0.56; $p < 0.0001$). Respondents who were dissatisfied with POE had a higher threshold PPV for seeing reminders. CONCLUSION: The majority of housestaff favor the implementation of a CDSS. Housestaff with favorable POE experiences were more likely to endorse CDSS, and those with negative POE experience were more likely to oppose it. The results suggest that a carefully designed CDSS with rules constructed to exceed a threshold PPV would be accepted by housestaff.

143) Guchelaar, H. J. and Kalmeijer, M. D. “The potential role of computerisation and information technology in improving prescribing in hospitals” Pharmacy World & Science **25**(3): 83-7. (2003)

Abstract: For physicians, prescribing of drugs is one of the most common actions in daily practice. In the continuum prescribing, dispensing, administration and use of drugs, failures may occur and can lead to patient harm. The use of computerised physician order entry systems is subject to much discussion regarding medication error reduction. This commentary analyses the issues where such systems can contribute to improved care.

144) Han, Y. Y., Carcillo, J. A., Venkataraman, S. T., Clark, R. S., Watson, R. S., Nguyen, T. C., Bayir, H. and Orr, R. A. “Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system” Pediatrics **116**(6): 1506-12. (2005)

Abstract: OBJECTIVE: In response to the landmark 1999 report by the Institute of Medicine and safety initiatives promoted by the Leapfrog Group, our institution implemented a commercially sold computerized physician order entry (CPOE) system in an effort to reduce medical errors and mortality. We sought to test the hypothesis that CPOE implementation results in reduced mortality among children who are transported for specialized care. METHODS: Demographic, clinical, and mortality data were collected of all children who were admitted via interfacility transport to our regional, academic, tertiary-care level children's hospital during an 18-month period. A commercially sold CPOE program that operated within the framework of a general, medical-surgical clinical application platform was rapidly implemented hospital-wide over 6 days during this period. Retrospective analyses of pre-CPOE and post-CPOE implementation time periods (13 months before and 5 months after CPOE implementation) were subsequently performed. RESULTS: Among 1942 children who were referred and admitted for specialized care during the study period, 75 died, accounting for an overall mortality rate of 3.86%. Univariate analysis revealed that mortality rate significantly increased from 2.80% (39 of 1394) before CPOE implementation to 6.57% (36 of 548) after CPOE implementation. Multivariate analysis revealed that CPOE remained independently associated with increased odds of mortality (odds ratio: 3.28; 95% confidence interval: 1.94-5.55) after adjustment for other mortality covariables. CONCLUSIONS: We have observed an unexpected increase in mortality coincident with CPOE implementation. Although CPOE technology holds great promise as a tool to reduce human error during health care delivery, our unanticipated finding suggests that when implementing CPOE systems, institutions should continue to evaluate mortality effects, in addition to medication error rates, for children who are dependent on time-sensitive therapies.

145) Handler, J. A., Feied, C. F., Coonan, K., Vozenilek, J., Gillam, M., Peacock, P. R., Jr., Sinert, R. and Smith, M. S. “Computerized physician order entry and online decision support. proceedings of the 2004 AEM Consensus Conference on Emergency Medicine Informatics [held in Orlando, Florida]” Academic Emergency Medicine **11**(11): 1135-41. (2004)

Abstract: Computerized physician order entry (CPOE) and decision support systems (DSS) can reduce certain types of error but often slow clinicians and may increase other types of error. The net effect of these systems on an emergency department (ED) is unknown. The consensus participants combined published evidence with expert opinion to outline recommendations for success. These include seamless integration of CPOE and DSS into systems and workflow; ensuring access to Internet-based and other online support material in the clinical arena; designing systems specifically for the ED and measuring their impact to ensure an overall benefit; ensuring that CPOE systems provide error and interaction checking and facilitate weight- and physiology-based dosing; using interruptive alerts only for the highest-severity events; providing a simple, vendor-independent interface for institutional customization of CPOE alert thresholds; maximizing the use of automated systems and passive data capture; and ensuring the widespread availability of CPOE and DSS using secure wireless and portable technologies where appropriate. Decisions regarding CPOE and DSS in the ED should be guided by the ED chair or designee. Much of what is believed to be true regarding CPOE and DSS has not been adequately studied. Additional CPOE and DSS research is needed quickly, and this research should receive funding priority. DSS and CPOE hold great promise to improve patient care, but not all systems are equal. Evidence must guide these efforts, and the measured outcomes must consider the many factors of quality care.

146) Haruki, Y., Ogushi, Y., Okada, Y., Kimura, M., Kumamoto, I. and Sekita, Y. “Status and perspective of hospital information systems in Japan” Methods of Information in Medicine **38**(3): 200-6. (1999)

Abstract: Questionnaire surveys were sent to hospital managers, designed to shape the policy for future hospital information systems in Japan. The answers show that many hospitals use dedicated management systems, especially for patient registration and accounting, and personnel, food control, pharmacy and financial departments. In many hospitals, order-entry systems for laboratory tests and prescriptions are well developed. Half of the hospitals have patient databases used for inquiries of basic patient information, history of outpatient care and hospital care. The most obvious benefit is the reduction of office work, due to effective hospital information system. Many hospital managers want to use the following sub systems in the future for automatic payment, waiting time display, patient records search, automatic prescription verification, drug side-effect monitoring, and graphical display of patient record data.

147) Hasman, A., Safran, C. and Takeda, H. “Quality of health care: informatics foundations. [Review] [52 refs]” Methods of Information in Medicine. **42**(5): 509-18. (2003)

Abstract: OBJECTIVE: To discuss in what ways computer systems can contribute to the quality of healthcare and on which principles of informatics successful systems are based. METHODS: Part of the information was obtained via a literature search and part is based on the knowledge of the authors. RESULTS: The results of the literature search are reported. The answers to the questions whether decision support is useful and which factors determine its success, the foundations of computerized guidelines systems and applications of physician order entry and medical risk management are presented. CONCLUSIONS: Despite many publications concerning diagnostic support systems their use in clinical practice is limited. Reminder systems do appear to have an impact on health outcomes. Standards for guideline models are being developed for effective sharing of guidelines across systems. Electronic patient records and physician order entry systems are useful aids in medical risk management. [References: 52]

148) Hawkins, H. H., Hankins, R. W. and Johnson, E. “A computerized physician order entry system for the promotion of ordering compliance and appropriate test utilization” Journal of Healthcare Information Management **13**(3): 63-72. (1999)

Abstract: Emergency physicians diagnose and treat patients for clinical situations, making sure each patient is triaged in a stable and safe condition for appropriate further treatment. A process-oriented approach is required; physicians must rapidly assess each patient's condition, identify and obtain the most useful information, and bring the patient to appropriate treatment and stability. Radiology is a heavily used information source in this context, providing on demand a wide variety of imaging procedures. The marketplace demands that the healthcare industry address issues of utilization and cost. Although medicine has exploited computers for imaging, education, billing, and scheduling, it is in a relatively early phase of the use of information technology to improve clinical decision making and service to internal customers. An information management model that enhances collaboration among clinical colleagues while applying evolving clinical technology is needed. A system for gatekeeping, changing physician behavior, collecting data for clinical research, and improving clinical processes should evolve from the model. A joint effort of the radiology (RD) and emergency (ED) departments at the University of Cincinnati Medical Center (UCMC), the project described here investigated ways to achieve these results by capturing an unambiguous test order as it is placed by an ED caregiver and integrating decision support information into the test selection and ordering process. The article discusses the design and implementation phases of the project. It focuses on problems in the previous system, behavioral influences on their solutions, the development of a computer-assisted system and implementation strategies, and the evaluation of the first phase of implementation.

149) Hegedus, S. M. “Computerized physician order entry systems and medication errors.[comment]” Jama **294**(2): 180-1. (2005)

Abstract:

150) High, S. and Rowe, J. “When LIS meets HIS: refining the design of an order entry process” Healthcare Informatics **11**(8): 46-8, 50. (1994)

Abstract:

151) Hillman, J. M. and Given, R. S. “Hospital implementation of computerized provider order entry systems: results from the 2003 leapfrog group quality and safety survey” Journal of Healthcare Information Management **19**(4): 55-65. (2005)

Abstract: A critical element of The Leapfrog Group's strategy for advancing improvements in healthcare is its ongoing survey of hospital patient safety and quality improvement activities, including computerized provider order entry (CPOE) systems. This survey is distinct from other surveys of CPOE adoption because individual hospital responses are publicly disseminated. Furthermore, this survey offers an opportunity to explore the drivers of hospital CPOE adoption before financial incentives for patient safety proliferate, as well as an opportunity to compare the characteristics of participating and non-participating hospitals. Results from the 2003 survey show that only 3.7 percent of the 842 participating hospitals located in The Leapfrog Group's targeted regions had fully implemented a CPOE system consistent with the Leapfrog standard, although 92 percent reported at least planned or partial implementation of a CPOE system. While prior research suggests that a hospital's financial condition should be positively correlated with decisions to invest in CPOE, the analysis generally failed to detect such a relationship.

152) Hobbs, C. F. and Hardinge, T. T. “Using the nursing process to implement a Y2K computer application” Journal for Nurses in Staff Development - JNSD **16**(5): 227-31. (2000)

Abstract: Because of the coming year 2000, the need was assessed to upgrade the order entry system at many hospitals. At Somerset Medical Center, a training team divided the transition into phases and used a modified version of the nursing process to implement the new program. The entire process required fewer than 6 months and was relatively problem-free. This successful transition was aided by the nursing process, training team, and innovative educational techniques.

153) Horsky, J., Kaufman, D. R., Oppenheim, M. I. and Patel, V. L. “A framework for analyzing the cognitive complexity of computer-assisted clinical ordering” Journal of Biomedical Informatics **36**(1-2): 4-22. (2003)

Abstract: Computer-assisted provider order entry is a technology that is designed to expedite medical ordering and to reduce the frequency of preventable errors. This paper presents a multifaceted cognitive methodology for the characterization of cognitive demands of a medical information system. Our investigation was informed by the distributed resources (DR) model, a novel approach designed to describe the dimensions of user interfaces that introduce unnecessary cognitive complexity. This method evaluates the relative distribution of external (system) and internal (user) representations embodied in system interaction. We conducted an expert walkthrough evaluation of a commercial order entry system, followed by a simulated clinical ordering task performed by seven clinicians. The DR model was employed to explain variation in user performance and to characterize the relationship of resource distribution and ordering errors. The analysis revealed that the configuration of resources in this ordering application placed unnecessarily heavy cognitive demands on the user, especially on those who lacked a robust conceptual model of the system. The resources model also provided some insight into clinicians' interactive strategies and patterns of associated errors. Implications for user training and interface design based on the principles of human-computer interaction in the medical domain are discussed.

154) Horsky, J., Kaufman, D. R. and Patel, V. L. “The cognitive complexity of a provider order entry interface” AMIA. Annual Symposium Proceedings/AMIA Symposium. (2003)

Abstract: Computer-based provider order entry (POE) can reduce the frequency of preventable medical errors. However, overly complex interfaces frequently pose a challenge to users and impede clinical efficacy. We present a cognitive analysis of clinician interaction with a commercial POE system. Our investigation was informed by the distributed resources model, a novel approach designed to describe the dimensions of user interfaces that introduce unnecessary cognitive complexity. This approach characterizes the relative distribution of user's internal representations and external representations embodied in the system or environmental artifacts. The research consisted of two component analyses: a modified cognitive walkthrough evaluation and a simulated clinical ordering task performed by seven physicians. The analysis revealed that the configuration of resources placed unnecessarily heavy cognitive demands on the user, especially those who lacked a robust conceptual model of the system. The resources model was also used to account for patterns of errors produced by clinicians.

155) Horsky, J., Kaufman, D. R. and Patel, V. L. “Computer-based drug ordering: evaluation of interaction with a decision-support system” Medinfo **11**(Pt 2): 1063-7. (2004)

Abstract: Provider order entry systems (POE) often incorporate active decision-support component for drug dosing. The efficacy of automated alerts that suggest dose amounts to the clinician in real time depends in part on how well they are timed to fit into the decision process and on their representational structure. We have conducted a cognitive evaluation of an interaction with a POE system that offered active decision support for heparin dosing with the goal of characterizing its effectiveness and opportunities for error. Two researchers completed a cognitive walk-through of an ordering task based on a clinical scenario. In addition, seven clinicians were asked to enter a set of orders in an experiment using the same scenario. The analysis revealed that users without a solid conceptual knowledge of the ordering system followed patterns of inefficient interactive behavior resulting in delays and some errors. Physicians often did not take full advantage of automatic dose computation provided by a decision support component and used it largely as reference. The calculated dose was not perceptually salient in the generated alert and required users to engage in meaning interpretation of the displayed information. Better visual presentation of the alert message would likely result in faster and less cognitively demanding interaction.

156) Horsky, J., Kuperman, G. J. and Patel, V. L. “Comprehensive analysis of a medication dosing error related to CPOE” Journal of the American Medical Informatics Association **12**(4): 377-82. (2005)

Abstract: This case study of a serious medication error demonstrates the necessity of a comprehensive methodology for the analysis of failures in interaction between humans and information systems. The authors used a novel approach to analyze a dosing error related to computer-based ordering of potassium chloride (KCl). The method included a chronological reconstruction of events and their interdependencies from provider order entry usage logs, semistructured interviews with involved clinicians, and interface usability inspection of the ordering system. Information collected from all sources was compared and evaluated to understand how the error evolved and propagated through the system. In this case, the error was the product of faults in interaction among human and system agents that methods limited in scope to their distinct analytical domains would not identify. The authors characterized errors in several converging aspects of the drug ordering process: confusing on-screen laboratory results review, system usability difficulties, user training problems, and suboptimal clinical system safeguards that all contributed to a serious dosing error. The results of the authors' analysis were used to formulate specific recommendations for interface layout and functionality modifications, suggest new user alerts, propose changes to user training, and address error-prone steps of the KCl ordering process to reduce the risk of future medication dosing errors.

157) Horsky, J., Zhang, J. and Patel, V. L. “To err is not entirely human: Complex technology and user cognition. (CPOE and the facilitation of medication errors)”

Journal of Biomedical Informatics **38**(4): 264-266. (2005)

Abstract:

158) Hsieh, T. C., Kuperman, G. J., Jaggi, T., Hojnowski-Diaz, P., Fiskio, J., Williams, D. H., Bates, D. W. and Gandhi, T. K. “Characteristics and consequences of drug allergy alert overrides in a computerized physician order entry system.[see comment]” Journal of the American Medical Informatics Association **11**(6): 482-91. (2004)

Abstract: OBJECTIVE: The aim of this study was to determine characteristics of drug allergy alert overrides, assess how often they lead to preventable adverse drug events (ADEs), and suggest methods for improving the allergy-alerting system. DESIGN: Chart review was performed on a stratified random subset of all allergy alerts occurring during a 3-month period (August through October 2002) at a large academic hospital. MEASUREMENTS: Factors that were measured were drug/allergy combinations that triggered alerts, frequency of specific override reasons, characteristics of ADEs, and completeness of allergy documentation. RESULTS: A total of 6,182 (80%) of 7,761 alerts were overridden in 1,150 patients. In this sample, only 10% of alerts were triggered by an exact match between the drug ordered and allergy listed. Physicians' most common reasons for overriding alerts were "Aware/Will monitor" (55%), "Patient does not have this allergy/tolerates" (33%), and "Patient taking already" (10%). In a stratified random subset of 320 patients (28% of 1,150) on chart review, 19 (6%) experienced ADEs attributed to the overridden drug; of these, 9 (47%) were serious. None of the ADEs was considered preventable, because the overrides were deemed clinically justifiable. The degree of completeness of patients' allergy lists was highly variable and generally low in both paper charts and the CPOE system. CONCLUSION: Overrides of drug-allergy alerts were common and about 1 in 20 resulted in ADEs, but all of the overrides resulting in ADEs appeared clinically justifiable. The high rate of alert overrides was attributable to frequent nonexact match alerts and infrequent updating of allergy lists. Based on these findings, we have made specific recommendations for increasing the specificity of alerting and thereby improving the clinical utility of the drug allergy alerting system.

159) Huang, Y. W., Chen, W. H., Wu, H. J., Chien, H. Y., Lin, T. Y., Chiang, H. H., Huang, T. M. and Lin, C. L. “Learning curve of a new hospital laboratory. The monitoring of computer-generated turnaround time of laboratory tests in an emergency department” Clinical Chemistry & Laboratory Medicine **41**(10): 1373-8. (2003)

Abstract: Learning curves have been described for different health technologies, mainly new surgical or diagnostic procedures, but learning curves for a new hospital's laboratory procedures have not been systematically studied. To monitor the timeliness (turnaround time) of stat tests from the Emergency Department as a marker of

laboratory quality and to address the issue of a learning curve for procedures performed in a new hospital laboratory, we employed a computerized system for collecting data of turnaround time (from order entry to result verification) on stat tests from the Emergency Department of a newly opened (July 24, 2000) 471-bed general hospital. The data collection operates without user intervention. We evaluated the turnaround times of stat complete blood count and biochemistry tests from August 2000 to December 2001. Results show that it took 6 to 12 months before the turnaround times reached a plateau, we believe that this is the learning curve of a new hospital laboratory. Computer-generated turnaround times for Emergency Department stat tests appear to be a useful tool for monitoring the quality of laboratory tests and can demonstrate the learning curve of a new hospital laboratory.

160) Hughes, L., Adaskin, E., Dreidger, M., Kennedy, L., McLean, M., McMorris, D., McMullan, P., Rapko, H., Rowluk, J. and Sinha, L. “Impact of computerization on nursing: automated order entry, care planning, and implications for recruitment” Canadian Journal of Nursing Administration **6**(2): 14-8. (1993)

Abstract: Very few empirical studies have been completed which verify the actual benefits of automation for nursing. This article provides an overview of the results and implications of five research studies undertaken at a Canadian Hospital to ascertain the impact of computerization on selected aspects of nursing. These studies found that nurses perceived few positive benefits for direct care givers when order entry, results reporting and care planning were automated. This article will be of particular interest to nurse administrators who are embarking on automation within their hospitals.

161) Hulgan, T., Rosenbloom, S. T., Hargrove, F., Talbert, D. A., Arbogast, P. G., Bansal, P., Miller, R. A. and Kernodle, D. S. “Oral quinolones in hospitalized patients: an evaluation of a computerized decision support intervention” Journal of Internal Medicine **256**(4): 349-57. (2004)

Abstract: OBJECTIVE: To determine whether a computerized decision support system could increase the proportion of oral quinolone antibiotic orders placed for hospitalized patients. DESIGN: Prospective, interrupted time-series analysis. SETTING: University hospital in the south-eastern United States. SUBJECTS: Inpatient quinolone orders placed from 1 February 2001 to 31 January 2003. INTERVENTION: A web-based intervention was deployed as part of an existing order entry system at a university hospital on 5 February 2002. Based on an automated query of active medication and diet orders, some users ordering intravenous quinolones were presented with a suggestion to consider choosing an oral formulation. MAIN OUTCOME MEASURE: The proportion of inpatient quinolone orders placed for oral formulations before and after deployment of the intervention. RESULTS: There were a total of 15 194 quinolone orders during the study period, of which 8962 (59%) were for oral forms. Orders for oral quinolones increased from 4202 (56%) before the intervention to 4760

(62%) after, without a change in total orders. In the time-series analysis, there was an overall 5.6% increase (95% CI 2.8-8.4%; P < 0.001) in weekly oral quinolone orders due to the intervention, with the greatest effect on nonintensive care medical units. CONCLUSIONS: A web-based intervention was able to increase oral quinolone orders in hospitalized patients. This is one of the first studies to demonstrate a significant effect of a computerized intervention on dosing route within an antibiotic class. This model could be applied to other antibiotics or other drug classes with good oral bioavailability.

162) Hume, M. “Changing hospital culture, systems reduces drug errors” Executive Solutions for Healthcare Management **2**(4): 1, 4-9. (1999)

Abstract:

163) Hume, M. “Computer-aided drug selection can sharply cut adverse events” Quality Letter for Healthcare Leaders **11**(3): 10-2. (1999)

Abstract: Intermountain Health Care and Brigham and Women's Hospital both have invested millions of dollars and countless hours in powerful computer systems that aid physicians' drug choices. One expert says he doesn't see how other hospitals can afford not to do the same.

164) Hwang, J. I., Park, H. A. and Bakken, S. “Impact of a physician's order entry (POE) system on physicians' ordering patterns and patient length of stay” International Journal of Medical Informatics. **65**(3): 213-23. (2002)

Abstract: OBJECTIVE: To investigate the impact of a physician's order entry (POE) system on physicians' ordering patterns and patient length of stay. DESIGN: Prospective time series study at pre-POE, 3 months and 6 months after POE at a tertiary teaching hospital in Korea. The study period was from June 1999 to May 2000. MEASUREMENTS: The number of orders (doctor's, PRN, medication, changed, canceled orders), number of tests (complete blood count, chemistry, chest X-ray, stat laboratory, serum electrolytes tests), appropriateness and length of patient stay were measured through chart review of 171 in-patients (liver disease, renal disease, gastrectomy, simple mastectomy). RESULTS: The number of doctors' orders, PRN, and medication orders significantly increased after POE. The numbers of changed and canceled orders were not significantly different between pre- and post-POE. The number of stat lab tests significantly decreased after POE. There was no change in appropriateness of patients' hospital stay between pre- and post-POE. Length of stay significantly decreased (P=0.049). CONCLUSION: POE contributed to improving the quality of care in two ways: improvement of auditability by recording the medical services for patients in more precise and transparent manner, and more appropriate utilization of resources by decreasing the number of stat diagnostic tests and length of

stay.

165) Ikeda, M., Hayashi, E. and Yamauchi, K. “Model analysis of time duration in a medication order entry system with attention to do-medication orders” Computers in Biology & Medicine **24**(6): 473-83. (1994)

Abstract: To investigate the relative time length needed for a medication computer order entry in comparison with the handwritten prescription system, we made a model, focusing our attention on the "do-medication order entry function." In the model analysis, we conducted a statistical analysis using the Nagoya University Hospital Information System. From the results and our model, if the time needed to make one (drug) item medication order entry is less than 1.9-3.0 times the time needed for handwriting one item prescription, computer order entry is faster on average.

166) Johnson, V. R., Hummel, J., Kinninger, T. and Lewis, R. R. “Immediate steps toward patient safety” Healthcare Financial Management. **58**(2): 56-61. (2004)

Abstract: Patient safety should be a fundamental element in any hospital's philosophy, mission, and vision. Use of barcode point-of-care technology (BPOC) to reduce medication errors is a patient-safety approach that hospitals can implement within a short time frame and obtain immediate benefits. Advantages of BPOC are that it is intuitive, cost-effective, and conducive to improved patient satisfaction.

167) Johnston, D., Pan, E. and Walker, J. “The value of CPOE in ambulatory settings” Journal of Healthcare Information Management. **18**(1): 5-8. (2004)

Abstract:

168) Jones, J. L. “Implementing computerized prescriber order entry in a children's hospital” American Journal of Health System Pharmacy **61**(22): 2425-9. (2004)

Abstract:

169) Jones, S. and Moss, J. “Computerized provider order entry: strategies for successful implementation” Journal of Nursing Administration **36**(3): 136-9. (2006)

Abstract: An estimated 522,000 serious medication errors can be eliminated in the United States each year through the use of computerized provider order entry.

However, the implementation of computerized provider order entry is being slowed down by resistance from clinicians, particularly physicians. Nurses understand the work of physicians and are in a unique position to help overcome their resistance and smoothen the transition to computerized provider order entry. The authors outline the strategies for nurses to increase organizational acceptance during the process of computerized provider order entry implementation. [References: 17]

170) Kalmeijer, M. D., Holtzer, W., van Dongen, R. and Guchelaar, H. J. "Implementation of a computerized physician medication order entry system at the Academic Medical Centre in Amsterdam" Pharmacy World & Science **25**(3): 88-93. (2003)

Abstract: In the period 1997-2001 the Academic Medical Centre in Amsterdam implemented the computerized physician medication order entry (CPmOE) system Medicator. This article describes several important aspects of this program: technological architecture, features, implementation project, authentication and training, continuous support, human resource investments, route of prescription, logistics and administration. Furthermore important advantages and disadvantages of the CPmOE system are discussed. Advantages mainly concern patient safety and drug logistics, while disadvantages are related to access to a computer, user friendliness of the software and printer problems.

171) Kamal, J., Rogers, P., Saltz, J. and Mekhjian, H. "Information warehouse as a tool to analyze Computerized Physician Order Entry order set utilization: opportunities for improvement" AMIA. Annual Symposium Proceedings/AMIA Symposium. (2003)

Abstract: A Computerized Physician order entry (CPOE) system was successfully implemented at the Ohio State University Medical Center (OSUMC) in February 2000. The electronic entry and use of order sets is designed to standardize patient care and improve efficiency and patient safety. To evaluate the effectiveness of the CPOE system and to maximize its benefits, one needs to easily access and analyze the data. Since the CPOE system is not equipped to support such on demand analysis, the data from the system is extracted daily into the OSUMC's Information Warehouse (IW). This allows the CPOE data to be linked with other clinical and financial patient information in the IW to provide detailed and comprehensive analysis. Our focus in this paper is the use of the IW as a tool to analyze order set usage patterns and the opportunities such analysis provides for improvements in education, resource utilization and patient care.

172) Kaplan, B. "Reducing barriers to physician data entry for computer-based patient records" Topics in Health Information Management **15**(1): 24-34. (1994)

Abstract: Physician data entry and use of clinical workstations is one barrier to computer-based patient records (CPRs). Often, clinicians do not understand the potential benefits of CPRs. For the benefits to be realized, however, clinical personnel must use the workstations for both data entry and retrieval. The article reviews recent experience with physicians' direct data entry. It summarizes benefits that clinicians have realized from such systems and also disincentives to their use. It concludes by discussing implementation strategies for enhancing the benefits and reducing the barriers. [References: 54]

173) Karow, H. S. “Creating a culture of medication administration safety: laying the foundation for computerized provider order entry” Joint Commission Journal on Quality Improvement. **28**(7): 396-402. (2002)

Abstract: BACKGROUND: Computerized provider order entry (CPOE) systems are recognized as an effective tool for reducing preventable adverse drug events; however, implementation is a complex process that involves much more than installing new software. The literature addresses the use of these systems in large tertiary care hospitals and university settings; yet there is little information on their implementation and use in smaller hospitals. Beaver Dam Community Hospital, a small, rural hospital, set about laying the foundation for implementing CPOE. Actions were taken in terms of context (the culture and attitude, acceptance, and importance regarding the change), process (roles, workflow, and policies relating to the change), and content (how-to, such as procedural steps and rules). USE OF THE RAPID-CYCLE IMPROVEMENT PROCESS: The team elected to use the rapid-cycle improvement process for implementation to allow it to move ahead quickly, adjusting changes as necessary for maximum success. Each change was considered an individual Plan-Do-Check-Act cycle, with its own action plan and measurement for successful implementation. PLANNING ACTUAL IMPLEMENTATION: The Patient Safety Committee has begun the planning of actual implementation--Phase II. Issues addressed include how to phase in the system--in which units to bring up first, how to structure the transitional period, how to redesign workflow, and how to plan role changes. SUMMARY: The changes already implemented contribute to medication safety and are important from that perspective alone, without the use of CPOE. The addition of an electronic system will enhance the organization's ability to provide safe, accurate medication administration.

174) Karsh, B. “Beyond usability: designing effective technology implementation systems to promote patient safety” Quality & Safety in Health Care **13**(5): 388-94. (2004)

Abstract: Evidence is emerging that certain technologies such as computerized provider order entry may reduce the likelihood of patient harm. However, many technologies that should reduce medical errors have been abandoned because of

problems with their design, their impact on workflow, and general dissatisfaction with them by end users. Patient safety researchers have therefore looked to human factors engineering for guidance on how to design technologies to be usable (easy to use) and useful (improving job performance, efficiency, and/or quality). While this is a necessary step towards improving the likelihood of end user satisfaction, it is still not sufficient. Human factors engineering research has shown that the manner in which technologies are implemented also needs to be designed carefully if benefits are to be realized. This paper reviews the theoretical knowledge on what leads to successful technology implementation and how this can be translated into specifically designed processes for successful technology change. The literature on diffusion of innovations, technology acceptance, organisational justice, participative decision making, and organisational change is reviewed and strategies for promoting successful implementation are provided. Given the rapid and ever increasing pace of technology implementation in health care, it is critical for the science of technology implementation to be understood and incorporated into efforts to improve patient safety.

175) Kaushal, R., Barker, K. N. and Bates, D. W. “How can information technology improve patient safety and reduce medication errors in children's health care? [see comments.]” Archives of Pediatrics & Adolescent Medicine **155**(9): 1002-7. (2001)

Abstract: BACKGROUND: Medication errors are common, costly, and injurious to patients. OBJECTIVE: To review the role of information technology in decreasing pediatric medication errors in both inpatient and outpatient settings. DESIGN: We performed a literature review of current information technology interventions. RESULTS: Several types of information technology will likely reduce the frequency of medication errors, although insufficient data exists for many technologies, and most available data come from adult settings. Computerized physician order entry with decision support substantially decreases the frequency of serious inpatient medication errors in adults. Certain other inpatient information technologies may be beneficial even though less evidence is currently available. These include computerized medication administration records, robots, automated pharmacy systems, bar coding, "smart" intravenous devices, and computerized discharge prescriptions and instructions. In the outpatient setting, where adherence is especially important, personalized Web pages and World Wide Web-based information have substantial potential. CONCLUSIONS: Medication errors are an important problem in pediatrics. Information technology interventions have great potential for reducing the frequency of errors. The magnitude of benefits may be even greater in pediatrics than in adult medicine because of the need for weight-based dosing. Further development, application, evaluation, and dissemination of pediatric-specific information technology interventions are essential. [References: 45]

176) Kaushal, R. and Bates, D. W. (2001). Computerized Physician Order Entry (CPOE) with Clinical Decision Support Systems (CDSSs). Evidence

Report/Technology Assessment No. 43, Making Health Care Safer: A Critical Analysis of Patient Safety Practices, AHRQ Publication No. 01-E058). W. M. Tierney**:** 59-69.

Abstract:

177) Kaushal, R. and Bates, D. W. “Information technology and medication safety: what is the benefit?” Quality & Safety in Health Care. **11**(3): 261-5. (2002)

Abstract: Medication errors occur frequently and have significant clinical and financial consequences. Several types of information technologies can be used to decrease rates of medication errors. Computerized physician order entry with decision support significantly reduces serious inpatient medication error rates in adults. Other available information technologies that may prove effective for inpatients include computerized medication administration records, robots, automated pharmacy systems, bar coding, "smart" intravenous devices, and computerized discharge prescriptions and instructions. In outpatients, computerization of prescribing and patient oriented approaches such as personalized web pages and delivery of web based information may be important. Public and private mandates for information technology interventions are growing, but further development, application, evaluation, and dissemination are required.

178) Kaushal, R., Bates, D. W., Landrigan, C., McKenna, K. J., Clapp, M. D., Federico, F. and Goldmann, D. A. “Medication errors and adverse drug events in pediatric inpatients” JAMA **285**(16): 2114-20. (2001)

Abstract: CONTEXT: Iatrogenic injuries, including medication errors, are an important problem in all hospitalized populations. However, few epidemiological data are available regarding medication errors in the pediatric inpatient setting. OBJECTIVES: To assess the rates of medication errors, adverse drug events (ADEs), and potential ADEs; to compare pediatric rates with previously reported adult rates; to analyze the major types of errors; and to evaluate the potential impact of prevention strategies. DESIGN, SETTING, AND PATIENTS: Prospective cohort study of 1120 patients admitted to 2 academic institutions during 6 weeks in April and May of 1999. MAIN OUTCOME MEASURES: Medication errors, potential ADEs, and ADEs were identified by clinical staff reports and review of medication order sheets, medication administration records, and patient charts. RESULTS: We reviewed 10 778 medication orders and found 616 medication errors (5.7%), 115 potential ADEs (1.1%), and 26 ADEs (0.24%). Of the 26 ADEs, 5 (19%) were preventable. While the preventable ADE rate was similar to that of a previous adult hospital study, the potential ADE rate was 3 times higher. The rate of potential ADEs was significantly higher in neonates in the neonatal intensive care unit. Most potential ADEs occurred at the stage of drug ordering (79%) and involved incorrect dosing (34%), anti-infective drugs (28%), and intravenous medications (54%). Physician reviewers judged that computerized physician order entry could potentially have prevented 93% and ward-based clinical pharmacists 94% of

potential ADEs. CONCLUSIONS: Medication errors are common in pediatric inpatient settings, and further efforts are needed to reduce them.

179) Kaushal, R., Jha, A. K., Franz, C., Glaser, J., Shetty, K. D., Jaggi, T., Middleton, B., Kuperman, G. J., Khorasani, R., Tanasijevic, M., Bates, D. W. and Brigham and Women's Hospital, C. W. G. “Return on investment for a computerized physician order entry system.[see comment]” Journal of the American Medical Informatics Association **13**(3): 261-6. (2006)

Abstract: OBJECTIVE: Although computerized physician order entry (CPOE) may decrease errors and improve quality, hospital adoption has been slow. The high costs and limited data on financial benefits of CPOE systems are a major barrier to adoption. The authors assessed the costs and financial benefits of the CPOE system at Brigham and Women's Hospital over ten years. DESIGN: Cost and benefit estimates of a hospital CPOE system at Brigham and Women's Hospital (BWH), a 720-adult bed, tertiary care, academic hospital in Boston. MEASUREMENTS: Institutional experts provided data about the costs of the CPOE system. Benefits were determined from published studies of the BWH CPOE system, interviews with hospital experts, and relevant internal documents. Net overall savings to the institution and operating budget savings were determined. All data are presented as value figures represented in 2002 dollars. RESULTS: Between 1993 and 2002, the BWH spent $11.8 million to develop, implement, and operate CPOE. Over ten years, the system saved BWH $28.5 million for cumulative net savings of $16.7 million and net operating budget savings of $9.5 million given the institutional 80% prospective reimbursement rate. The CPOE system elements that resulted in the greatest cumulative savings were renal dosing guidance, nursing time utilization, specific drug guidance, and adverse drug event prevention. The CPOE system at BWH has resulted in substantial savings, including operating budget savings, to the institution over ten years. CONCLUSION: Other hospitals may be able to save money and improve patient safety by investing in CPOE systems.

180) Kaushal, R., Shojania, K. G. and Bates, D. W. “Effects of computerized physician order entry and clinical decision support systems on medication safety: a systematic review” Archives of Internal Medicine. **163**(12): 1409-16. (2003)

Abstract: BACKGROUND: Iatrogenic injuries related to medications are common, costly, and clinically significant. Computerized physician order entry (CPOE) and clinical decision support systems (CDSSs) may reduce medication error rates. METHODS: We identified trials that evaluated the effects of CPOE and CDSSs on medication safety by electronically searching MEDLINE and the Cochrane Library and by manually searching the bibliographies of retrieved articles. Studies were included for systematic review if the design was a randomized controlled trial, a nonrandomized controlled trial, or an observational study with controls and if the measured outcomes were clinical (eg, adverse drug events) or surrogate (eg, medication errors) markers. Two reviewers

extracted all the data. Discussion resolved any disagreements. RESULTS: Five trials assessing CPOE and 7 assessing isolated CDSSs met the criteria. Of the CPOE studies, 2 demonstrated a marked decrease in the serious medication error rate, 1 an improvement in corollary orders, 1 an improvement in 5 prescribing behaviors, and 1 an improvement in nephrotoxic drug dose and frequency. Of the 7 studies evaluating isolated CDSSs, 3 demonstrated statistically significant improvements in antibiotic-associated medication errors or adverse drug events and 1 an improvement in theophylline-associated medication errors. The remaining 3 studies had nonsignificant results. CONCLUSIONS: Use of CPOE and isolated CDSSs can substantially reduce medication error rates, but most studies have not been powered to detect differences in adverse drug events and have evaluated a small number of "homegrown" systems. Research is needed to evaluate commercial systems, to compare the various applications, to identify key components of applications, and to identify factors related to successful implementation of these systems. [References: 63]

181) Kawamoto, K. and Lobach, D. F. “Clinical decision support provided within physician order entry systems: a systematic review of features effective for changing clinician behavior” AMIA. Annual Symposium Proceedings/AMIA Symposium. (2003)

Abstract: Computerized physician order entry (CPOE) systems represent an important tool for providing clinical decision support. In undertaking this systematic review, our objective was to identify the features of CPOE-based clinical decision support systems (CDSSs) most effective at modifying clinician behavior. For this review, two independent reviewers systematically identified randomized controlled trials that evaluated the effectiveness of CPOE-based CDSSs in changing clinician behavior. Furthermore, each included study was assessed for the presence of 14 CDSS features. We screened 10,023 citations and included 11 studies. Of the 10 studies comparing a CPOE-based CDSS intervention against a non-CDSS control group, 7 reported a significant desired change in professional practice. Moreover, meta-regression analysis revealed that automatic provision of the decision support was strongly associated with improved professional practice (adjusted odds ratio, 23.72; 95% confidence interval, 1.75-infiniti). Thus, we conclude that automatic provision of decision support is a critical feature of successful CPOE-based CDSS interventions. [References: 23]

182) Keillor, A. and Morgenstern, D. “Computerized physician order entry systems and medication errors.[comment]” Jama **294**(2): 180-1. (2005)

Abstract:

183) Khorasani, R. “Computerized physician order entry and decision support: improving the quality of care” Radiographics **21**(4): 1015-8. (2001)

Abstract:

184) Kilbridge, P. M., Welebob, E. M. and Classen, D. C. “Development of the Leapfrog methodology for evaluating hospital implemented inpatient computerized physician order entry systems” Quality & Safety in Health Care **15**(2): 81-4. (2006)

Abstract: The 1999 Institute of Medicine report raised public awareness of the frequency and cost of adverse drug events in medicine. In response, in November 2000 a coalition of healthcare purchasers announced the formation of the Leapfrog Group, an organization dedicated to making "great leaps forward" in the safety and quality of health care in America. Their first target-computerized physician order entry (CPOE)-was selected specifically for its potential to reduce harm to patients from medications. The Leapfrog inpatient CPOE standard included a requirement that the organization operating CPOE should demonstrate via a test that their inpatient CPOE system can alert physicians to at least 50% of common serious prescribing errors. This paper outlines the development of this test which evaluates the ability of implemented CPOE systems to prevent the occurrence of medication errors that have a high likelihood of leading to adverse drug events. A framework was developed to include 12 different categories of CPOE based decision support that could prevent prescribing errors leading to adverse drug events. A scoring system was developed based on the known frequency and severity of adverse drug events. Simulated test patients and accompanying simulated test medication orders were developed to evaluate the ability of a CPOE system to intercept prescribing errors in all 12 decision support categories. The test was validated at a number of inpatient sites using both commercially available and custom developed CPOE systems. A web based application was developed to allow hospitals to self-administer the evaluation.

185) Kim, G. R., Chen, A. R., Arceci, R. J., Mitchell, S. H., Kokoszka, K. M., Daniel, D. and Lehmann, C. U. “Error reduction in pediatric chemotherapy: computerized order entry and failure modes and effects analysis” Archives of Pediatrics & Adolescent Medicine **160**(5): 495-8. (2006)

Abstract: OBJECTIVE: To implement and evaluate the impact of computerized provider order entry (CPOE) on reducing ordering errors in pediatric chemotherapy. DESIGN: Before-and-after study from 2001 to 2004. SETTING: Pediatric Oncology in an academic medical center. INTERVENTION: Implementation of a CPOE system guided by multidisciplinary failure modes and effects analysis into pediatric chemotherapy. MAIN OUTCOME MEASURES: Completion data on chemotherapy steps of high morbidity/mortality potential if missed (as determined by attending oncologists) from 1259 pre-CPOE paper and 1116 post-CPOE pediatric chemotherapy orders. RESULTS: After CPOE deployment, daily chemotherapy orders were less likely to have improper dosing (relative risk [RR], 0.26; 95% confidence interval [CI], 0.11-

0.61), incorrect dosing calculations (RR, 0.09; 95% CI, 0.03-0.34), missing cumulative dose calculations (RR, 0.32; 95% CI, 0.14-0.77), and incomplete nursing checklists (RR, 0.51; 95% CI, 0.33-0.80). There was no difference in the likelihood of improper dosing on treatment plans and a higher likelihood of not matching medication orders to treatment plans (RR, 5.4; 95% CI, 3.1-9.5). CONCLUSION: Failure modes and effects analysis-guided CPOE reduced ordering errors in pediatric chemotherapy and provided data for further improvements.

186) King, W. J., Paice, N., Rangrej, J., Forestell, G. J. and Swartz, R. “The effect of computerized physician order entry on medication errors and adverse drug events in pediatric inpatients” Pediatrics. **112**(3 Pt 1): 506-9. (2003)

Abstract: OBJECTIVE: Computerized physician order entry (CPOE) has the potential to reduce patient injury resulting from medication errors. We assessed the impact of a CPOE system on medication errors and adverse drug events (ADEs) in pediatric inpatients. DESIGN: A retrospective cohort study. SETTING: Tertiary care pediatric hospital. PARTICIPANTS: Pediatric inpatients on 3 medical and 2 surgical wards. INTERVENTION: CPOE system implemented on 2 medical wards and compared with 1 medical and 2 surgical wards that continued to use hand written orders. OUTCOME MEASURES: Rate of medication error and ADEs before and after CPOE implementation. RESULTS: In 6 years, a total of 804 medication errors were identified with 18 ADEs, resulting in patient injury among 36 103 discharges and 179 183 patient days. The overall medication error rate (MER) was 4.49 per 1000 patient days. Before the introduction of CPOE, the MERs of the intervention versus control wards were indistinguishable (ratio = 0.93; 95% confidence interval [CI] = 0.76, 1.13). After the introduction of CPOE, the MER was 40% lower on the intervention than on the control wards (ratio = 0.60; 95% CI = 0.48, 0.74). On average, 490 patient days are required to see the benefit of one less medication error using CPOE. We did not demonstrate a similar effect of CPOE for ADEs (ratio of rate ratios = 1.30; 95% CI 0.47, 3.52). CONCLUSIONS: The introduction of a commercially available physician computer order entry system was associated with a significant decrease in the rate of medication errors but not ADEs in an inpatient pediatric population.

187) Kini, N. and Savage, B. “CPOE primer” Physician Executive **30**(2): 20-6. (2004)

Abstract: If you don't already have it, get ready for it. Computerized physician order entry (CPOE) is most likely coming your way. Discover some of the ifs, ands and buts of identifying and implementing a CPOE systems.

188) Kinnaird, D., Cox, T. and Wilson, J. P. “Unclaimed prescriptions in a clinic with computerized prescriber order entry.” American Journal of Health-System

Pharmacy **60**(14): 1468-70. (2003)

Abstract: Unclaimed prescriptions in a clinic with computerized prescriber order entry medication compliance is an integral part of successful drug therapy. Prescriptions that have been written by a health care provider and filled at a pharmacy but unclaimed by the patient represent noncompliance and resource waste. Several studies have delineated reasons for unclaimed drugs in the institutional ambulatory care pharmacy setting. Financial or cost considerations have been reported to account for 9-19% of instances of patients not picking up their prescriptions. The U.S. Army Health Clinic (USAHC) in Vicenza, Italy, serves the U.S. military population stationed in Italy, eligible retired U.S. service members, and family members residing in the area. Pharmacy staff checked patient profiles of patients not picking up a prescription in six categories of essential medications to determine if the patient already had been taking the medication and, if so, whether the new prescription involved a dosage change.

189) Kirkley, D. “Not whether, but when: gaining buy-in for computerized clinical processes” Journal of Nursing Administration. **34**(2): 55-8. (2004)

Abstract:

190) Kitzmiller, R., Hunt, E. and Sproat, S. B. “Adopting best practices: "Agility" moves from software development to healthcare project management” CIN: Computers, Informatics, Nursing **24**(2): 75-82; quiz 83-4. (2006)

Abstract: It is time for a change in mindset in how nurses operationalize system implementations and manage projects. Computers and systems have evolved over time from unwieldy mysterious machines of the past to ubiquitous computer use in every aspect of daily lives and work sites. Yet, disconcertingly, the process used to implement these systems has not evolved. Technology implementation does not need to be a struggle. It is time to adapt traditional plan-driven implementation methods to incorporate agile techniques. Agility is a concept borrowed from software development and is presented here because it encourages flexibility, adaptation, and continuous learning as part of the implementation process. Agility values communication and harnesses change to an advantage, which facilitates the natural evolution of an adaptable implementation process. Specific examples of agility in an implementation are described, and plan-driven implementation stages are adapted to incorporate relevant agile techniques. This comparison demonstrates how an agile approach enhances traditional implementation techniques to meet the demands of today's complex healthcare environments. [References: 11]

191) Knight, A. M., Kravet, S. J., Harper, G. M. and Leff, B. “The effect of computerized provider order entry on medical student clerkship experiences”

Journal of the American Medical Informatics Association **12**(5): 554-60. (2005)

Abstract: OBJECTIVE: To describe medical students' attitudes toward placing orders during training, and the effect of computerized provider order entry (CPOE) on their learning experiences. DESIGN: Prospective, controlled study of all 143 Johns Hopkins University School of Medicine students who began the Basic Medicine clerkship between March 2003 and April 2004 at one of three teaching hospitals: one using CPOE, one paper orders, and one that began using CPOE midway through this study. MEASUREMENTS: Survey of students at the start and after the first month of the clerkship. RESULTS: Ninety-six percent of students responded. Students expressed a desire to place 100% of orders for their patients. Ninety-five percent of students believed that placing orders helps students learn what tests and treatments patients need. Eighty-four percent reported that being unavailable due to conferences and teaching sessions was a significant barrier to participating in the ordering process. Students at hospitals using CPOE reported placing significantly fewer of their patients' follow-up orders compared to students at hospitals using paper orders (25% vs. 50%, $p < 0.01$) and were more likely to report that their resident or intern did not want them to enter orders (40% vs. 16%, $p < 0.01$). Comparisons of students at hospitals using CPOE to each other showed that these differences were attributable to one of the hospitals. Thirty-two percent of students at both hospitals using CPOE reported that the extra length of time required for housestaff to review their orders in the computer was a significant barrier. CONCLUSION: Hospitals need to ensure that the educational potential of medical students' clinical experiences is maximized when implementing CPOE.

192) Koppel, R. “Computerized physician order entry systems: the right prescription?” LDI Issue Brief **10**(5): 1-4. (2005)

Abstract: Policymakers increasingly urge the use of information technology to improve the quality and efficiency of health care. In particular, computerized physician order entry (CPOE) is emphasized for its ability to reduce prescribing errors inherent in paper-based systems. This Issue Brief summarizes research that sounds a cautionary note about the potential for computerized systems to facilitate medication errors, as well as reduce them.

193) Koppel, R., Localio, A. R., Cohen, A. and Strom, B. L. “Neither panacea nor black box: Responding to three Journal of Biomedical Informatics papers on computerized physician order entry systems. (CPOE and the facilitation of medication errors)” Journal of Biomedical Informatics **38**(4): 267-269. (2005)

Abstract:

194) Koppel, R., Metlay, J. P., Cohen, A., Abaluck, B., Localio, A. R., Kimmel, S. E. and Strom, B. L. “Role of computerized physician order entry systems in facilitating medication errors.” Jama **293**(10): 1197-203. (2005)

Abstract: 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.

195) Koppel, R., Metlay, J. P., Cohen, A., Abaluck, B., Localio, A. R., Kimmel, S. E. and Strom, B. L. “Role of computerized physician order entry systems in facilitating medication errors.[COMMENTS from JAMA]” Jama **29**(2): 178-181. (2005)

Abstract:

196) Kramer, J., Laing, T., Fendrick, M. and Rhodes, S. “Evaluation of the Effect of Mobile Computers on Physician Acceptance of an Online Order Entry System.” Proceedings / AMIA Annual Symposium: 1051. (2000)

Abstract: Online order entry systems have the capability to decrease order errors and

therefore complications due to adverse drug events. However, many order systems are difficult to use, awkward to use, or are unavailable in locations where care is provided. Greater access to computers, using wireless handheld computing devices, may improve acceptance and usability of the COES. This study evaluated mobile computer technology as a mechanism to increase physician willingness to transition to a computerized order entry system, COES.

197) Krampera, M., Venturini, F., Benedetti, F., Oliani, A., Carolei, S., Visco, C., Aqel, H., Pizzolo, G. and Scroccaro, G. "Computer-based drug management in a bone marrow transplant unit: a suitable tool for multiple prescriptions even in critical conditions" British Journal of Haematology **125**(1): 50-7. (2004)

Abstract: Drug prescription or administration errors are the most common causes of adverse events for hospital patients. Computer-based systems can be effective in reducing these errors. The aim of this study was to assess whether computer-based systems are easily exploitable even in critical conditions. The oral and handwritten system for drug management was completely replaced by a computer-based system in our bone marrow transplant unit, chosen because: (i) the intensive treatments could test the efficiency of the system; (ii) the very frequent occurrence of complications and emergencies could test the flexibility of the system; and (iii) the pre-existing system could be used as comparison. From May to November 2002, 41 patients were repeatedly admitted to undergo high-dose chemotherapy, autologous/allogeneic stem cell transplantation or because of severe complications. In 27 consecutive admissions, 2264 drug prescriptions (average, 29 drugs/patient admission) and 36 786 drug administrations (39.8/patient/d) were carried out. Despite the large number of procedures, the computerized system effectively replaced the oral and handwritten transmission of information among medical staff, pharmacists and nurses, and lowered the error risks. In addition, it contributed to medical updating through warnings on potential problems in case of multiple drug prescriptions, and gave the pharmacy a valuable tool to monitor drug use.

198) Kuperman, G. J., Cooley, T., Tremblay, J., Teich, J. M. and Churchill, W. "Decision support for medication use in an inpatient physician order entry application and a pharmacy application" Medinfo **9**(Pt 1): 467-71. (1998)

Abstract: Studies have shown that adverse drug events are common, expensive, and due to causes that can be remedied by information technologies. At our institution we have developed a physician order entry application and a pharmacy application designed to decrease the risk of such adverse drug events. In this paper, we describe the applications, with attention to the clinical decision support features present in each. We also describe the manner in which the two applications interact.

199) Kuperman, G. J., Gandhi, T. K. and Bates, D. W. “Effective drug-allergy checking: methodological and operational issues” Journal of Biomedical Informatics **36**(1-2): 70-9. (2003)

Abstract: Adverse drug events cause a large number of injuries, and adverse events caused by medications administered in the face of known allergies represent an important preventable cause of patient harm. Computerized systems can effectively prevent reactions due to known allergies, but building an effective allergy prevention feature is challenging and presents many interesting informatics issues that have both methodological and operational implications. In this paper, we present the experiences from one large delivery system in delivering allergy-related decision support, discuss some of the different approaches that we have used, and then propose a future approach. We also discuss the methodological, behavioral, and operational issues that have arisen which have a major impact on success. Key factors in drug-allergy checking include storing patient allergy data in a single common repository, representing allergy data using suitable terminologies and creating groups of allergies for inferencing purposes, being judicious about which allergy warnings to display, conveying the reaction that the patient has experienced when exposed to the drug to inform the provider of the importance of the warning, and perhaps most important, implementing strategies to optimize the likelihood that allergy information will be entered.

200) Kuperman, G. J. and Gibson, R. F. “Computer physician order entry: benefits, costs, and issues” Annals of Internal Medicine. **139**(1): 31-9. (2003)

Abstract: Several analyses have detected substantial quality problems throughout the health care system. Information technology has consistently been identified as an important component of any approach for improvement. Computerized physician order entry (CPOE) is a promising technology that allows physicians to enter orders into a computer instead of handwriting them. Because CPOE fundamentally changes the ordering process, it can substantially decrease the overuse, underuse, and misuse of health care services. Studies have documented that CPOE can decrease costs, shorten length of stay, decrease medical errors, and improve compliance with several types of guidelines. The costs of CPOE are substantial both in terms of technology and organizational process analysis and redesign, system implementation, and user training and support. Computerized physician order entry is a relatively new technology, and there is no consensus on the best approaches to many of the challenges it presents. This technology can yield many significant benefits and is an important platform for future changes to the health care system. Organizational leaders must advocate for CPOE as a critical tool in improving health care quality.

201) Kuperman, G. J., Teich, J. M., Gandhi, T. K. and Bates, D. W. “Patient safety and computerized medication ordering at Brigham and Women's Hospital” Joint Commission Journal on Quality Improvement **27**(10): 509-21. (2001)

Abstract: BACKGROUND: Medications are important therapeutic tools in health care, yet creating safe medication processes is challenging for many reasons. Computerized physician order entry (CPOE), one important way that technology can be used to improve the medication process, has been in place at Brigham and Women's Hospital (BWH; Boston) since 1993. CPOE AT BWH: The CPOE application, designed and developed internally by the BWH information systems team, allows physicians and other clinicians to enter all patient orders into the computer. Physicians enter 85% of orders, with the remainder entered electronically by other clinicians. CPOE AND SAFE MEDICATION USE: The CPOE application at BWH includes several features designed to improve medication safety--structural features (for example, required fields, use of pick lists), enhanced workflow features (order sets, standard scales for insulin and potassium), alerts and reminders (drug-drug and drug-allergy interaction checking), and adjunct features (the pharmacy system, access to online reference information). RESULTS AT BWH: Studies of the impact of CPOE on physician decision making and patient safety at BWH include assessment of CPOE's impact on the serious medication error and the preventable adverse drug event rate, the impact of computer guidelines on the use of vancomycin, the impact of guidelines on the use of heparin in patients at bed rest, and the impact of dosing suggestions on excessive dosing. CONCLUSION: CPOE and several forms of clinical decision support targeted at increasing patient safety have substantially decreased the frequency of serious medication errors and have had an even bigger impact on the overall medication error rate. [References: 36]

202) Leape, L. L., Berwick, D. M. and Bates, D. W. “What practices will most improve safety? Evidence-based medicine meets patient safety” Jama. **288**(4): 501-7. (2002)

Abstract:

203) Leape, L. L., Kabcenell, A. I., Gandhi, T. K., Carver, P., Nolan, T. W. and Berwick, D. M. “Reducing adverse drug events: lessons from a breakthrough series collaborative” Joint Commission Journal on Quality Improvement **26**(6): 321-31. (2000)

Abstract: BACKGROUND: In January 1996, 38 hospitals and health care organizations (for a total of 40 hospitals) in the United States came together in an Institute for Healthcare Improvement (IHI; Boston) Breakthrough Series collaborative to reduce adverse drug events-injuries related to the use or nonuse of medications. METHODS: The participants were taught the Model for Improvement, a method for rapid-cycle change and evaluation, and were then coached on how to identify their own problem areas and develop changes in practice for rapid-cycle testing. These changes could be implementation of one or more known medication error prevention practices or new practices developed. RESULTS: During a 15-month period the 40 hospitals conducted a total of 739 tests of changes. Process changes accounted for 63% of the

cycles; the remainder consisted of preliminary data gathering, consensus-building, or education cycles. Eight types of changes were implemented by seven or more hospitals, with a success rate of 70%. These changes included non-punitive reporting, ensuring documentation of allergy information, standardizing medication administration times, and implementing chemotherapy protocols. DISCUSSION: Success in making significant changes was associated with strong leadership, effective processes, and appropriate choice of intervention. Successful teams were able to define, clearly state, and relentlessly pursue their aims, and then chose practical interventions and moved early into changing a process. They did not spend months collecting data before beginning a change. Changes that were most successful were those that attempted to change processes, not people. Health care organizations committed to patient safety need not regard current performance limits as inevitable.

204) Lee, F., Teich, J. M., Spurr, C. D. and Bates, D. W. “Implementation of physician order entry: user satisfaction and self-reported usage patterns” Journal of the American Medical Informatics Association **3**(1): 42-55. (1996)

Abstract: OBJECTIVES: To evaluate user satisfaction, correlates of satisfaction, and self-reported usage patterns regarding physician order entry (POE) in one hospital. DESIGN: Surveys were sent to physician and nurse POE users from medical and surgical services. RESULTS: The users were generally satisfied with POE (mean = 5.07 on a 1 to 7 scale). The physicians were more satisfied than the nurses, and the medical staff were more satisfied than the surgical staff; satisfaction levels were acceptable (more than 3.50) even in the less satisfied groups. Satisfaction was highly correlated with perceptions about POE's effects on productivity, ease of use, and speed. POE features directed at improving the quality of care were less strongly correlated with satisfaction. The physicians valued POE's off-floor accessibility most, and the nurses valued legibility and accuracy of POE orders most. Some features, such as off-floor ordering, were perceived to be highly useful and reported to be frequently used by the physicians; while other features, such as "quick mode" ordering and personal order sets, received little self-reported use. CONCLUSIONS: Survey of POE users showed that satisfaction with POE was good. Satisfaction was more correlated with perceptions about POE's effect on productivity than with POE's effect on quality of care. Physicians and nurses constitute two very different types of users, underscoring the importance of involving both physicians and nonphysicians in POE development. The results suggest that development efforts should focus on improving system speed, adding on-line help, and emphasizing quality benefits of POE

205) Lee, Y. L., Hsu, C. Y., Hsieh, D. and Li, Y. C. “Development and deployment of a web-based physician order entry system” International Journal of Medical Informatics **62**(2-3): 135-42. (2001)

Abstract: The computer-based Physician Order Entry System (POES) has been

employed in many clinical institutes in Taiwan. Most of the POES systems are developed in the two-tier client-server architecture, and a large portion of the systems are constructed on a mainframe or even a single PC.The exponential growth of the Internet has had a tremendous impact on our society in recent years. In consideration of the future user interface and system architecture, we have developed a three-tier web-based Physician Order Entry System and successfully deployed it in the Wang-Fang Hospital in Taipei.The system is the first POES based on three-tier and World Wide Web (WWW) in Taiwan. The system provides the Subjective, Objective, Assessment, and Plan (SOAP) structure for the physician to enter subject, object, diagnoses, medicine dosage, treatment and laboratory test request, and prints out the prescription and necessary document. The doctor can also retrieve the patient's medical record on the system. One of the special characteristics of the system is its personalized design. The doctor can define their own diagnosis, medicine and treatment database and any combination of these to facilitate their clinical work.The system has been reviewed since February 1999. The result shows that the clinical procedure has become more efficient, and the chances of omission have been reduced. The system is very stable and the Open Database Connectivity (ODBC) database access did not show any delay in the network. Since we have incorporated many new web-programming techniques, the progress of the techniques will improve the system performance in the future.

206) Lehman, M. L., Brill, J. H., Skarulis, P. C., Keller, D. and Lee, C. “Physician Order Entry impact on drug turn-around times” Proceedings / AMIA Annual Symposium: 359-63. (2001)

Abstract: This paper describes a study of the impact of Physician Order Entry (POE) on pharmacy order turn-around times. The study looked at two surgical services, Neurosurgery and Transplant, of a large Midwestern academic medical center. Pharmacy orders were followed in these units from the time a physician wrote an order to the time the patient received the medication. The first part of the study tracked pharmacy orders for a two-month period before the implementation of POE and the second part of the study tracked pharmacy orders for a two-month period after POE had been implemented. The pre- and post-POE pharmacy turn-around times were compared. It was expected that the data would show a substantial decrease in pharmacy order turn-around times. Our study did, in fact, show a significant reduction in this turn-around-time.

207) Levick, D. and Lukens, H. “Computerized physician order entry systems and medication errors.[comment]” Jama **294**(2): 179-80. (2005)

Abstract:

208) Levick, D., Lukens, H. F. and Stillman, P. L. “You've led the horse to water, now

how do you get him to drink: managing change and increasing utilization of computerized provider order entry" Journal of Healthcare Information Management **19**(1): 70-5. (2005)

Abstract: Community hospitals served by predominately private-practice physicians face difficult challenges in implementing computerized provider order entry (CPOE), but there are techniques and incentives that can be employed to change physician behavior Various techniques were used to increase CPOE utilization at Lehigh Valley Hospital, a three-campus, 750-bed tertiary community hospital in eastern Pennsylvania. Those techniques included presenting studies supporting CPOE as a way to improve patient care, recognizing support with small trinkets, providing individual access to computers, adding clinical decision support, and bringing peer pressure to bear Ultimately, financial compensation for the educational time required to learn to use and become proficient with the system was employed and had the greatest impact on behavior Measuring utilization of the CPOE system with data extracted from the hospital's clinical information system, CPOE utilization by physicians increased to 57 percent from 35 percent after a financial compensation program was initiated. Utilization declined to 42 percent several months after completing the first phase of the program and increased to 54 percent after a second phase was initiated.

209) Lieder, T. R. "Computerized prescriber order entry changes pharmacists' roles" American Journal of Health-System Pharmacy **58**(10): 846, 851. (2001)

Abstract: Pharmacist David F. Gregory had heard the rumor. "They're going to [computerized] physician order entry. They don't need pharmacists anymore." But several years after a computerized prescriber order-entry (CPOE) system started spreading across Vanderbilt University Medical Center in Nashville, where Gregory is manager of pediatric pharmacy services, pharmacists are far from obsolete. "Our workload has not decreased," he said. "It's just shifted into a different focus."

210) Lipton, H. L., Miller, R. H. and Wimbush, J. J. "Electronic prescribing: ready for prime time?" Journal of Healthcare Information Management. **17**(4): 72-9. (2003)

Abstract: Escalating drug expenditures and the prevalence of medication errors have prompted calls for drug cost control and quality improvement. E-prescribing promises to address these concerns. This study aims to describe the benefits and costs of eRx as assessed by key industry stakeholders, identify the components of a needed electronic prescribing infrastructure and the barriers to its completion, and identify potential public and private policies and initiatives that could encourage the development of an EPI and hasten eRx adoption among stakeholders.

211) Liu, Z., Sakurai, T., Orii, T., Iga, T. and Kaihara, S. “Evaluations of the prescription order entry system for outpatient clinics by physicians in the 80 university hospitals in Japan” Medical Informatics & the Internet in Medicine **25**(2): 123-32. (2000)

Abstract: We investigated the evaluations of the prescription order entry system by the physicians who are the direct users of this system. Questionnaires were sent to 400 staff physicians of 80 medical school affiliated hospitals, out of which 76% responded. Among the respondents, 48 per cent are making use of the computerized outpatient prescription order entry system, and 52 per cent are not. The result shows 78% of the physicians are in favor of the prescription order entry system; the most dissatisfied opinion of the physicians toward the system was that the input took too much time thus reduced the communication with the patient. Physicians who are using the system seemed to favor the system more than the physicians who are not using it.

212) Lovis, C., Chapko, M. K., Martin, D. P., Payne, T. H., Baud, R. H., Hoey, P. J. and Fihn, S. D. “Evaluation of a Command-line Parser-based Order Entry Pathway for the Department of Veterans Affairs Electronic Patient Record” Journal of the American Medical Informatics Association **8**(5): 486-498. (2001)

Abstract: Objective: To improve and simplify electronic order entry in an existing electronic patient record, the authors developed an alternative system for entering orders, which is based on a command- interface using robust and simple natural-language techniques. Design: The authors conducted a randomized evaluation of the new entry pathway, measuring time to complete a standard set of orders, and users' satisfaction measured by questionnaire. A group of 16 physician volunteers from the staff of the Department of Veterans Affairs Puget Sound Health Care System-Seattle Division participated in the evaluation. Results: Thirteen of the 16 physicians (81%) were able to enter medical orders more quickly using the natural-language-based entry system than the standard graphical user interface that uses menus and dialogs (mean time spared, 16.06 4.52 minutes; P=0.029). Compared with the graphical user interface, the command--based pathway was perceived as easier to learn (P<0.01), was considered easier to use and faster (P<0.01), and was rated better overall (P<0.05). Conclusion: Physicians found the command- interface easier to learn and faster to use than the usual menu-driven system. The major advantage of the system is that it combines an intuitive graphical user interface with the power and speed of a natural-language analyzer.

213) Lovis, C. and Payne, T. H. “Extending the VA CPRS electronic patient record order entry system using natural language processing techniques” Proceedings / AMIA Annual Symposium: 517-21. (2000)

Abstract: An automated practitioner order entry system was recently implemented at

the VA Puget Sound Health Care System. Since the introduction of this system, we have experienced various problems, among them an increase in time required for practitioners to enter orders. In order to improve usability and acceptance of the order entry, an alternate pathway was built within CPRS that allows direct natural language based order entry. Implementation of the extension in CPRS has been made possible because of the three layers CPRS architecture and its strong object oriented models. This paper discusses the advantages and needs for a natural language based order entry system and its implementation within an existing order entry system.

214) Lyons, S. S., Tripp-Reimer, T., Sorofman, B. A., Dewitt, J. E., Bootsmiller, B. J., Vaughn, T. E. and Doebbeling, B. N. “VA QUERI informatics paper: information technology for clinical guideline implementation: perceptions of multidisciplinary stakeholders” Journal of the American Medical Informatics Association **12**(1): 64-71. (2005)

Abstract: OBJECTIVE: This multisite study compared the perceptions of three stakeholder groups regarding information technologies as barriers to and facilitators of clinical practice guidelines (CPGs). DESIGN: The study settings were 18 U.S. Veterans Affairs Medical Centers. A purposive sample of 322 individuals participated in 50 focus groups segmented by profession and included administrators, physicians, and nurses. Focus group participants were selected based on their knowledge of practice guidelines and involvement in facility-wide guideline implementation. MEASUREMENTS: Descriptive content analysis of 1,500 pages of focus group transcripts. RESULTS: Eighteen themes clustered into four domains. Stakeholders were similar in discussing themes in the computer function domain most frequently but divergent in other domains, with workplace factors more often discussed by administrators, system design issues discussed most by nurses, and personal concerns discussed by physicians and nurses. Physicians and nurses most often discussed barriers, whereas administrators focused most often on facilitation. Facilitators included guideline maintenance and charting formats. Barriers included resources, attitudes, time and workload, computer glitches, computer complaints, data retrieval, and order entry. Themes with dual designations included documentation, patient records, decision support, performance evaluation, CPG implementation, computer literacy, essential data, and computer accessibility. CONCLUSION: Stakeholders share many concerns regarding the relationships between information technologies and clinical guideline use. However, administrators, physicians, and nurses hold different opinions about specific facilitators and barriers. Health professionals' disparate perceptions could undermine guideline initiatives. Implementation plans should specifically incorporate actions to address these barriers and enhance the facilitative aspects of information technologies in clinical practice guideline use.

215) Manser, A. J. “Computerised physician order entry: Strategic issues for Australian hospital pharmacists” Australian Journal of Hospital Pharmacy **26**(6):

664-667. (1996)

Abstract: The introduction of computerised physician order entry will provide opportunities for hospital pharmacists to take a leadership role in the development and implementation of these systems. This paper discusses some of the strategic issues and problems associated with computerised physician order entry and looks at some of the specific pharmacist-related issues that may arise. Strategic issues addressed include extent and scope, leadership and ownership, nature and security, inputs and the ongoing development of these systems.

216) Markert, D. J., Haney, P. J. and Allman, R. M. “Effect of computerized requisition of radiology examinations on the transmission of clinical information” Academic Radiology **4**(2): 154-6. (1997)

Abstract: RATIONALE AND OBJECTIVES: The authors developed a method to evaluate the availability and accuracy of clinical data proffered by clinicians when ordering radiologic examinations with a computer order-entry system. METHODS: Two thousand consecutive clinical indications for a spectrum of pediatric imaging studies were scrutinized for accuracy by means of computerized chart review, verbal communication with clinical attending staff, and reference to surgical and laboratory results. The indications were classified as appropriate, incorrect, misleading, or incomplete. RESULTS: Of the 2,000 stated indications, 1,464 (73%) provided a reasonable, if minimal, amount of clinical information; however, in 376 (19%) cases the diagnosis or proximate indication was incorrect, in 108 (5%) cases the data were incomplete, and in 52 (3%) cases the information was misleading. CONCLUSION: Computer order-entry systems can improve the transmission of clinical information but they allow misinformation to be provided.

217) Marshalek, G. and Casey, S. “Pain-free CPOE. Following the right protocol is a critical step for encouraging physician adoption” Health Management Technology. **24**(2): 24-7. (2003)

Abstract:

218) May, E. L. “The case for bar coding: better information, better care--and better business” Healthcare Executive. **18**(5): 8-13. (2003)

Abstract: Bar coding, pervasive in almost all other industries, has been slow to infiltrate the healthcare setting. for years, disparate systems, a lack of standardization, and an absence of significant market incentives have hindered healthcare providers, IT vendors, and drug manufacturers alike in adopting bar coding technology. But thanks to a proposed FDA rule issued last Spring, bar coding is is edging its way to the top of

many IT priority lists. By mid-2004, the final rule should be passed, which will require all drugmakers to bar code prescription drug products at the unit dose level. The bar code will identify the drug, manufacture, strength of the medication, and dosage.

219) Mayer, T. “E-prescribing hits the medical world: what physicians need to know to get the right technology” Journal of Medical Practice Management **17**(2): 103-5. (2001)

Abstract: Electronic prescribing is an emerging technology that allows physicians to write appropriate, legible, and safe prescriptions quickly and easily, using a handheld computer unit linked to their office computer. The early physician adapters using this innovation had little objective information upon which to base their choice, so cost was their main criterion. Now, a variety of vendors and options are available, so the discriminating physician is able to select the electronic prescribing system most complementary to his or her practice's needs and unique style.

220) McConnell, T. “Safer, cheaper, smarter. Computerized physician order entry promises to streamline and improve healthcare delivery” Health Management Technology **22**(3): 16-8. (2001)

Abstract:

221) McDonald, C. J., Overhage, J. M., Tierney, W. M., Dexter, P. R., Martin, D. K., Suico, J. G., Zafar, A., Schadow, G., Blevins, L., Glazener, T., Meeks-Johnson, J., Lemmon, L., Warvel, J., Porterfield, B., Cassidy, P., Lindbergh, D., Belsito, A., Tucker, M., Williams, B. and Wodniak, C. “The Regenstrief Medical Record System: a quarter century experience” International Journal of Medical Informatics **54**(3): 225-53. (1999)

Abstract: Entrusted with the records for more than 1.5 million patients, the Regenstrief Medical Record System (RMRS) has evolved into a fast and comprehensive data repository used extensively at three hospitals on the Indiana University Medical Center campus and more than 30 Indianapolis clinics. The RMRS routinely captures laboratory results, narrative reports, orders, medications, radiology reports, registration information, nursing assessments, vital signs, EKGs and other clinical data. In this paper, we describe the RMRS data model, file structures and architecture, as well as recent necessary changes to these as we coordinate a collaborative effort among all major Indianapolis hospital systems, improving patient care by capturing city-wide laboratory and encounter data. We believe that our success represents persistent efforts to build interfaces directly to multiple independent instruments and other data collection systems, using medical standards such as HL7, LOINC, and DICOM. Inpatient and outpatient order entry systems, instruments for visit

notes and on-line questionnaires that replace hardcopy forms, and intelligent use of coded data entry supplement the RMRS. Physicians happily enter orders, problems, allergies, visit notes, and discharge summaries into our locally developed Gopher order entry system, as we provide them with convenient output forms, choice lists, defaults, templates, reminders, drug interaction information, charge information, and on-line articles and textbooks. To prepare for the future, we have begun wrapping our system in Web browser technology, testing voice dictation and understanding, and employing wireless technology.

222) Meadows, G. and Chaiken, B. P. "Computerized physician order entry: a prescription for patient safety" Nursing Economics. **20**(2): 76-7, 87. (2002)

Abstract: Clinician adoption of CPOE/CDS solutions is crucial to helping caregivers reduce medical errors and enhance patient safety. The LeapFrog Group CPOE/CDS report can be a helpful guide, but as clinicians concerned about the quality of health care and the well-being of our patients, we must play an active role in the successful adoption of these solutions by: 1. Making sure that your institution is committed to having the appropriate people involved in the entire process, including nurse leaders. 2. Selecting a vendor that has the knowledge and clearly understands the importance of implementing this type of system. 3. Ensuring that your organization is selecting a system that actually meets the criteria defined by the LeapFrog Group.

223) Mekhjian, H., Saltz, J., Rogers, P. and Kamal, J. "Impact of CPOE order sets on lab orders" AMIA. Annual Symposium Proceedings/AMIA Symposium **931**. (2003)

Abstract: Introduction of the computerized physician order (CPOE) is intended to promote best practices, decrease practice variation among practitioners, and optimize the utilization of resources consistent with evidence based practice guidelines. Implicit in the use of CPOE is the assumption that the use of order sets might decrease utilization of resources such as the ordering of unnecessary laboratory tests. Conversely compliance with practice guidelines may necessitate ordering of certain tests that are deemed to be consistent with the good practice of medicine. In order to develop an understanding of these issues, we compared the utilization of laboratory orders prior to and following implementation of order sets in CPOE. In addition, we analyzed the impact of CPOE on the timely placement of certain orders based on critical levels of some laboratory results, in this instance potassium.

224) Mekhjian, H. S., Kumar, R. R., Kuehn, L., Bentley, T. D., Teater, P., Thomas, A., Payne, B. and Ahmad, A. "Immediate benefits realized following implementation of physician order entry at an academic medical center" Journal of the American

Medical Informatics Association. **9**(5): 529-39. (2002)

Abstract: OBJECTIVE: To evaluate the benefits of computerized physician order entry (POE) and electronic medication administration record (eMAR) on the delivery of health care. DESIGN: Inpatient nursing units in an academic health system were the setting for the study. The study comprised before-and-after comparisons between phase 1, pre-implementation of POE (pre-POE) and phase 2, post-implementation of POE (post-POE) and, within phase 2, a comparison of POE and the combination of POE plus eMAR. Length of stay and cost were compared pre- and post-POE for a period of 10 to 12 months across all services in the respective hospitals. MEASUREMENTS: Comparisons were made pre- and post-POE for the time intervals between initiation and completion of pharmacy (pre-POE, n=46; post-POE, n=70), radiology (pre-POE, n=11; post-POE, n=54), and laboratory orders (without POE, n=683; with POE, n=1,142); timeliness of countersignature of verbal order (University Hospitals [OSUH]: pre-POE, n=605; post-POE, n=19,225; James Cancer Hospital (James): pre-POE, n=478; post-POE, n=10,771); volume of nursing transcription errors (POE with manual MAR, n=888; POE with eMAR, n=396); length of stay and total cost (OSUH: pre-POE, n=8,228; post-POE, n=8,154; James: (pre-POE, n=6,471; post-POE, n=6,045). RESULTS: Statistically significant reductions were seen following the implementation of POE for medication turn-around times (64 percent, from 5:28 hr to 1:51 hr; p<0.001), radiology procedure completion times (43 percent, from 7:37 hr to 4:21 hr; p<0.05), and laboratory result reporting times (25 percent, from 31:3 min to 23:4 min; p=0.001). In addition, POE combined with eMAR eliminated all physician and nursing transcription errors. There were 43 and 26 percent improvements in order countersignature by physicians in OSUH and James, respectively. Severity-adjusted length of stay decreased in OSUH (pre-POE, 3.91 days; post-POE, 3.71 days; p=0.002), but not significantly in James (pre-POE, 3.68 days; post-POE, 3.61 days; p=0.356). Although total cost per admission decreased significantly in selected services, it did not change significantly across either institution (OSUH: pre-POE, 5,697 dollars; post-POE, 5,661 dollars; p=0.687; James: pre-POE, 6,427 dollars; post-POE, 6,518 dollars; p=0.502). CONCLUSION: Physician order entry and eMAR provided the framework for improvements in patient safety and in the timeliness of care. The significant cultural and workflow changes that accompany the implementation of POE did not adversely affect acuity-adjusted length of stay or total cost. The reductions in transcription errors, medication turn-around times, and timely reporting of results supports the view that POE and eMAR provide a good return on investment.

225) Mellin, A. “E-prescribing: an opportunity for process re-engineering” Health Management Technology. **23**(1): 42, 44, 47. (2002)

Abstract:

226) Meyer, G. S. and Massagli, M. P. “The forgotten component of the quality triad: can we still learn something from "structure"?” Joint Commission Journal on

Quality Improvement. **27**(9): 484-93. (2001)

Abstract: BACKGROUND: Quality assessment was founded on structural measures, such as accreditation status of facilities, credentialing of providers, and type of provider. Recent efforts in measures development have focused on processes and outcomes because research has suggested that structural measures are not strong markers of the quality of care at the health plan or provider levels. Nevertheless, the literature on the quality of health care contains a number of examples illustrating the potential application of structural measures to the assessment of quality. The continued development of measures of structure-which would at least measure aspects of the physical environment, working conditions, organizational culture, and provider satisfaction--may be helpful because generalizing from studies of process and outcome requires specification of the conditions under which these linkages are found. A ROAD MAP FOR MEASURES DEVELOPMENT: The Leapfrog Group of large purchasers has promoted the application of three patient safety "leaps" that are, in essence, structural measures: the use of computerized physician order entry, the selective referral of patients to high-volume providers for certain procedures, and the availability of board-certified critical care specialists in intensive care units. Structural measures, like process and outcomes measures, face the same challenges of standardization, reliability, validity, and portability. Field testing of potential measures will be required to examine the feasibility and added value of these measures in real-world settings. CONCLUSION: Research to date suggests that a new cadre of structural measures of health care quality, which have largely been overlooked in the recent measures development boom, have the potential to fill in important gaps in our ability to assess quality. [References: 51]

227) Meyer, K. E., Altamore, R., Chapko, M., Miner, M., McGann, M., Hill, E., Van Duesen-Lucas, C., Bates, M., Weir, C. and Lincoln, T. “The need for a thoughtful deployment strategy: evaluating clinicians' perceptions of critical deployment issues” Medinfo **9**(Pt 2): 854-8. (1998)

Abstract: This paper presents data collected from 899 clinicians across three Department of Veterans Affairs (VA) medical centers where existing terminal-based architecture was being replaced with client-server architecture. Surveys were conducted with physicians (n = 184), nurses (n = 355) and other clinicians (n = 360) gathering user characteristics and their perceptions of five deployment issues (e.g. adequacy of technical and institutional support and perceptions of the soon-to-be-implemented clinical workstation). Mean scores for the five deployment issues for all clinicians indicates perceptions are somewhat neutral. However, when data is analyzed according to job classification, significant (p = 0.05) differences in perceptions were noted among groups of clinicians (e.g., physicians and registered nurses). Results of analyzing data grouped by VA site (n = 3) indicates significant (p = 0.05) differences exist among sites in clinicians' perceptions of the deployment issues. A thoughtful deployment strategy including an in-depth assessment of clinician users by job classification and by location may produce important information, critical to the successful deployment of new

technologies, in very large health management institutions.

228) Miller, R. A., Gardner, R. M., Johnson, K. B. and Hripcsak, G. “Clinical decision support and electronic prescribing systems: a time for responsible thought and action.[comment]” Journal of the American Medical Informatics Association **12**(4): 403-9. (2005)

Abstract:

229) Miller, R. A., Waitman, L. R., Chen, S. and Rosenbloom, S. T. “The anatomy of decision support during inpatient care provider order entry (CPOE): empirical observations from a decade of CPOE experience at Vanderbilt” Journal of Biomedical Informatics **38**(6): 469-85. (2005)

Abstract: The authors describe a pragmatic approach to the introduction of clinical decision support at the point of care, based on a decade of experience in developing and evolving Vanderbilt's inpatient "WizOrder" care provider order entry (CPOE) system. The inpatient care setting provides a unique opportunity to interject CPOE-based decision support features that restructure clinical workflows, deliver focused relevant educational materials, and influence how care is delivered to patients. From their empirical observations, the authors have developed a generic model for decision support within inpatient CPOE systems. They believe that the model's utility extends beyond Vanderbilt, because it is based on characteristics of end-user workflows and on decision support considerations that are common to a variety of inpatient settings and CPOE systems. The specific approach to implementing a given clinical decision support feature within a CPOE system should involve evaluation along three axes: what type of intervention to create (for which the authors describe 4 general categories); when to introduce the intervention into the user's workflow (for which the authors present 7 categories), and how disruptive, during use of the system, the intervention might be to end-users' workflows (for which the authors describe 6 categories). Framing decision support in this manner may help both developers and clinical end-users plan future alterations to their systems when needs for new decision support features arise.

230) Milstead, J. A. “Leapfrog Group: a prince in disguise or just another frog?” Nursing Administration Quarterly. **26**(4): 16-25. (2002)

Abstract: Executive directors, presidents, chief executive officers of some of the principal nursing organizations, and other nurse leaders in the United States were interviewed to ascertain their reactions to the recommendations of the Leapfrog Group, a coalition of more than 90 companies that employ large numbers of workers in the United States. The Leapfrog Group is concerned with patient safety and was formed in response to the Institute of Medicine's report on health care errors. Three

recommendations for urban hospitals focus on computerized physician order entry, evidence-based hospital referral, and the use of intensivists.

231) Miranda, D., Fields, W. and Lund, K. “Lessons learned during 15 years of clinical information system experience” Computers in Nursing. **19**(4): 147-51. (2001)

Abstract: This article describes lessons learned during an initial intensive care unit point-of-care clinical information system implementation and subsequent expansions to other units and hospitals in a multihospital healthcare delivery system. Although the implementation and expansions were primarily successful, lessons learned include developing a broad base of support, making decisions through consensus, addressing conflict when it occurs, keeping user expectations realistic, preparing for the change process, implementing the computer information system in stages, challenging existing work processes, viewing the implementation as a process, and choosing a project leader with outstanding communication and group process skills in addition to technical skills.

232) Morrissey, J. “Eye on info. Trying to go beyond order entry” Modern Healthcare. **31**(46): 34-6. (2001)

Abstract: Focuses on the Vanderbilt clinical-care information technology software offered by McKesson Information Solutions. Budget of the company for the research and development of the product; Capabilities and applications of the software; Details of the testing of the commercialized Vanderbilt system at Providence Health System in Portland, Oregon.

233) Morrissey, J. “An info-tech disconnect. Even as groups such as Leapfrog push IT as an answer to quality issues, doctors and executives say, 'not so fast'” Modern Healthcare. **33**(6): 6-7, 36-8, 40 passim. (2003)

Abstract: The future is now. A new wave of information technology is gaining wide support outside the hospital industry as a solution to medication errors and patient-safety lapses. But in our survey of information system trends, most firms say they aren't operating or launching a physician order-entry system for drugs or treatments. Consultant Steven Roth, left, says recent examples of disasters have warded off many healthcare executives.

234) Murff, H. J. and Kannry, J. “Physician Satisfaction with Two Order Entry Systems” Journal of the American Medical Informatics Association **8**(5): 499-511.

(2001)

Abstract: Objectives: In the wake of the Institute of Medicine report, To Err Is Human: Building a Safer Health System (LT Kohn, JM Corrigan, MS Donaldson, eds; Washington, DC: National Academy Press, 1999), numerous advisory panels are advocating widespread implementation of physician order entry as a means to reduce errors and improve patient safety. Successful implementation of an order entry system requires that attention be given to the user interface. The authors assessed physician satisfaction with the user interface of two different order entry systems--a commercially available product, and the Department of Veterans Affairs Computerized Patient Record System (CPRS). Design and Measurement: A standardized instrument for measuring user satisfaction with physician order entry systems was mailed to internal medicine and medicine-pediatrics house staff physicians. The subjects answered questions on each system using a 0 to 9 scale. Results: The survey response rates were 63 and 64 percent for the two order entry systems. Overall, house staff were dissatisfied with the commercial system, giving it an overall mean score of 3.67 (95 percent confidence interval [95%CI], 3.37-3.97). In contrast, the CPRS had a mean score of 7.21 (95% CI, 7.00-7.43), indicating that house staff were satisfied with the system. Overall satisfaction was most strongly correlated with the ability to perform tasks in a "straightforward" manner. Conclusions: User satisfaction differed significantly between the two order entry systems, suggesting that all order entry systems are not equally usable. Given the national usage of the two order entry systems studied, further studies are needed to assess physician satisfaction with use of these same systems at other institutions.

235) Murray, M. D., Harris, L. E., Overhage, J. M., Zhou, X. H., Eckert, G. J., Smith, F. E., Buchanan, N. N., Wolinsky, F. D., McDonald, C. J. and Tierney, W. M. “Failure of computerized treatment suggestions to improve health outcomes of outpatients with uncomplicated hypertension: results of a randomized controlled trial” Pharmacotherapy **24**(3): 324-37. (2004)

Abstract: STUDY OBJECTIVE: To assess the effects of evidence-based treatment suggestions for hypertension made to physicians and pharmacists using a comprehensive electronic medical record system.
DESIGN: Randomized controlled trial with a 2 x 2 factorial design of physician and pharmacist interventions, which resulted in four groups of patients: physician intervention only, pharmacist intervention only, intervention by physician and pharmacist, and intervention by neither physician nor pharmacist (control).
SETTING: Academic primary care internal medicine practice.
SUBJECTS: Seven hundred twelve patients with uncomplicated hypertension.
MEASUREMENTS AND MAIN RESULTS: Suggestions were displayed to physicians on computer workstations used to write outpatient orders and to pharmacists when filling prescriptions. The primary end point was generic health-related quality of life. Secondary end points were symptom profile and side effects from antihypertensive drugs, number of emergency department visits and hospitalizations, blood pressure

measurements, patient satisfaction with physicians and pharmacists, drug therapy compliance, and health care charges. In the control group, implementation of care changes in accordance with treatment suggestions was observed in 26% of patients. In the intervention groups, compliance with suggestions was poor, with treatment suggestions implemented in 25% of patients for whom suggestions were displayed only to pharmacists, 29% of those for whom suggestions were displayed only to physicians, and 35% of the group for whom both physicians and pharmacists received suggestions (p=0.13). Intergroup differences were neither statistically significant nor clinically relevant for generic health-related quality of life, symptom and side-effect profiles, number of emergency department visits and hospitalizations, blood pressure measurements, charges, or drug therapy compliance.
CONCLUSION: Computer-based intervention using a sophisticated electronic physician order-entry system failed to improve compliance with treatment suggestions or outcomes of patients with uncomplicated hypertension.

236) Murray, M. D., Loos, B., Tu, W., Eckert, G. J., Zhou, X.-H. and Tierney, W. M. "Effects of Computer-based Prescribing on Pharmacist Work Patterns" J Am Med Inform Assoc **5**(6): 546-553. (1998)

Abstract: Abstract Objective: To measure the effect of computer-based outpatient prescription writing by internal medicine physicians on pharmacist work patterns. Design: Work sampling at a hospital-based outpatient pharmacy. Data were collected from pharmacists wearing silent, random-signal generators before and after the implementation of computer-based prescribing. Measurements: The type of work performed by pharmacists (activity), the reason for their work (function), and the people they contacted (contact) were measured. Results: Total staff hours and prescriptions handled were similar before and after computer-based prescribing. Pharmacists recorded 4,687 observations before and 4,735 observations after implementation of computer-based outpatient prescription writing. After implementation, pharmacists spent 12.9 percent more time correcting prescription problems, had 3.9 percent less idle time, and spent 2.2 percent less time in discussions with others. Pharmacists also spent 34.0 percent less time filling prescriptions, 45.8 percent more time in problem-solving activities involving prescriptions, and 3.4 percent less time providing advice. Over 80 percent of pharmacist time was spent working alone both before and after computer-based outpatient prescription writing. Conclusion: Computer-based prescribing results in major changes in the type of work done by hospital-based outpatient pharmacists and in the reason for their work and small changes in the people contacted during their work.

237) Myers, T. F., Venable, H. H. and Hansen, J. A. "Computer-enhanced neonatology practice evolution in an academic medical center. NICU Clinical Effectiveness Task Force" Journal of Perinatology **18**(6 Pt 2 Su): S38-44. (1998)

Abstract: The U.S. health care system is evolving as a result of market-place forces that demand optimal medical outcomes, cost effectiveness, and improved customer service. These demands may be in conflict with the mission of an academic neonatal intensive care unit (NICU). For more than 5 years, we have used computer-enhanced clinical practice evolution to improve quality while reducing costs. The multidisciplinary NICU Clinical Effectiveness Task Force used the Quality/Cost Improvement Cycle in an evidenced-based, data-driven approach to clinical practice change. Merger of the Neonatal Clinical Database permitted birth weight-specific cost reporting. Specific practice patterns in the Pharmacy, Clinical Laboratory, Respiratory Therapy, and Radiology cost centers were targeted for improvement based on the medical literature. Customized interactive physician order-entry pathways were created within the existing medical ordering module of the Medical Information System. Birth weight-specific neonatal survival rates were unchanged. A dramatic reduction in neonatal medication errors from 3.2 to 0.6 errors per 1000 patient days occurred. Changes in targeted clinical practices were documented. A substantial decrease in average total hospital cost per infant and average length of stay was demonstrated for infants whose birth weights were less than 1001 gm. In conclusion, clinical practices can be changed while outcomes are improved and cost is reduced in an academic NICU through implementation of computer-enhanced clinical practice evolution. There are many remaining questions regarding the best neonatal practices to optimize outcome and minimize cost.

238) Nadzam, D. M. and Macklis, R. M. “Promoting patient safety: is technology the solution?” Joint Commission Journal on Quality Improvement **27**(8): 430-6. (2001)

Abstract: BACKGROUND: On April 30, 2001, the Cleveland Clinic Foundation and Cleveland Clinic Health System Quality Institute sponsored a 1-day conference focused on technology in patient safety. PATIENT SAFETY-A CALL TO ACTION: Kenneth W. Kizer focused on ten high-priority patient safety strategies identified by the National Quality Forum-including implementing recognized "safe practices", recognizing and dealing with professional misconduct, and supporting efforts to create a nonpunitive environment for health care error reporting. CULTURAL IMPLICATIONS OF INTRODUCING NEW TECHNOLOGY: Randolph A. Miller described a computerized clinician order-entry system used to provide decision support, reduce excess test ordering, introduce cost savings, and meet regulations for inpatient radiology and cardiology tests. USING BAR CODES TO ELIMINATE MEDICATION ERRORS: Jeff Ramirez reported on the Veterans Health Administration's use of bar coding technology for point-of-care validation of medication administration, which has resulted in improvements in response time; the efficiency of the dispensing, delivery, and administration process; and patient care. HOW TO MAKE COMPUTERS TEAM PLAYERS: The knowledge base exists to design computers as team players that expand human expertise and help health care practitioners better create safety. Yet David D. Woods challenged the audience to anticipate the changing shape of iatrogenic risk as a result of increasing dependence on automation in health care. TECHNOLOGY

AND MEDICATION SYSTEMS: Mark Neuenschwander spoke about automating various steps within the medication use system, through computerized prescriber order entry and bedside scanning. FUTURE TECHNOLOGICAL POSSIBILITIES: Charles Denham suggested how technology may aid health care professionals in their care of patients, such as in using predictive modeling to identify the risks of therapeutic intervention.

239) Nebeker, J. R., Hoffman, J. M., Weir, C. R., Bennett, C. L. and Hurdle, J. F. “High rates of adverse drug events in a highly computerized hospital” Archives of Internal Medicine **165**(10): 1111-6. (2005)

Abstract: BACKGROUND: Numerous studies have shown that specific computerized interventions may reduce medication errors, but few have examined adverse drug events (ADEs) across all stages of the computerized medication process. We describe the frequency and type of inpatient ADEs that occurred following the adoption of multiple computerized medication ordering and administration systems, including computerized physician order entry (CPOE). METHODS: Using explicit standardized criteria, pharmacists classified inpatient ADEs from prospective daily reviews of electronic medical records from a random sample of all admissions during a 20-week period at a Veterans Administration hospital. We analyzed ADEs that necessitated a changed treatment plan. RESULTS: Among 937 hospital admissions, 483 clinically significant inpatient ADEs were identified, accounting for 52 ADEs per 100 admissions and an incidence density of 70 ADEs per 1000 patient-days. One quarter of the hospitalizations had at least 1 ADE. Of all ADEs, 9% resulted in serious harm, 22% in additional monitoring and interventions, 32% in interventions alone, and 11% in monitoring alone; 27% should have resulted in additional interventions or monitoring. Medication errors contributed to 27% of these ADEs. Errors associated with ADEs occurred in the following stages: 61% ordering, 25% monitoring, 13% administration, 1% dispensing, and 0% transcription. The medical record reflected recognition of 76% of the ADEs. CONCLUSIONS: High rates of ADEs may continue to occur after implementation of CPOE and related computerized medication systems that lack decision support for drug selection, dosing, and monitoring.

240) Neilson, E. G., Johnson, K. B., Rosenbloom, S. T., Dupont, W. D., Talbert, D., Giuse, D. A., Kaiser, A., Miller, R. A. and Resource Utilization, C. “The impact of peer management on test-ordering behavior.[see comment]” Annals of Internal Medicine **141**(3): 196-204. (2004)

Abstract: BACKGROUND: Laboratory testing of hospitalized patients, although essential, can be expensive and sometimes excessive. Attempts to reduce unnecessary testing have often been difficult to implement or sustain. OBJECTIVE: Use of peer management through a resource utilization committee (RUC) to favorably modify test-ordering behavior in a large academic medical center. DESIGN: Interrupted time-series

study. SETTING: Medical center with inpatient care provider order entry (CPOE) system and database of ordered tests. PARTICIPANTS: Predominantly housestaff physicians but all clinical staff (attending physicians, housestaff, medical students, nurses, advance practice nurses, and other clinical staff) at Vanderbilt University Hospital who used CPOE systems. INTERVENTION: The RUC analyzed the ordering habits of providers during previous years and made 2 interventions by modifying software for the CPOE system. The committee first initiated a daily prompt in the system that asked providers whether they wanted to discontinue tests scheduled beyond 72 hours. After evaluating this first intervention, the committee further constrained testing options by unbundling serum metabolic panel tests (sodium, potassium, chloride, bicarbonate, glucose, blood urea nitrogen, and creatinine tests) into single components and by reducing the ease of repeating targeted tests (including electrolyte, blood urea nitrogen, creatinine, and glucose tests; electrocardiography; and portable chest radiography). MEASUREMENTS: Pre- and postintervention volumes of tests; proportion of patients with abnormal targeted chemistry levels after 48 hours; rates of repeated admission, transfer to intensive care units, and mortality; adjusted coefficient of variation for test ordering; and length of stay. RESULTS: Voluntary reduction of testing beyond 72 hours (first intervention) decreased orders for metabolic panel component tests by 24% ($P = 0.02$) and electrocardiograms by 57% ($P = 0.006$) but not orders for portable chest radiographs. Prospective constraints on recurrent test ordering with panel unbundling (second intervention) produced an additional decrease of 51% for metabolic panel component tests ($P < 0.001$) and 16% for portable chest radiographs ($P = 0.03$). Incidence of patients with abnormal targeted blood chemistry levels after 48 hours decreased after the intervention ($P = 0.02$). Postintervention-adjusted coefficients of variation decreased for metabolic panel component tests ($P = 0.03$) and electrocardiography ($P = 0.04$). Rates of (adjusted) monthly readmission, transfers to intensive care units, hospital length of stay, and mortality were unchanged. LIMITATIONS: Other activities occurring during the time period of the interventions might have influenced some test-ordering behaviors, and we assessed effects on only a limited number of commonly ordered tests. CONCLUSIONS: Peer management reduced provider variability by addressing the imperfect ability of clinicians to rescind testing in a timely manner. Hospitals with growing health care costs can improve their resource utilization through peer management of testing behaviors by using CPOE systems.

241) Nemeth, C. and Cook, R. “Hiding in plain sight: What Koppel et al. tell us about healthcare IT. (CPOE and the facilitation of medication errors)” Journal of Biomedical Informatics **38**(4): 262-263. (2005)

Abstract:

242) Newby, D. A., Fryer, J. L. and Henry, D. A. “Effect of computerised prescribing on use of antibiotics.[comment]” Medical Journal of Australia. **178**(5): 210-3. (2003)

Abstract: OBJECTIVES: To examine whether the use of current prescribing software systems might raise rates of repeat prescribing, with a consequent increase in use of antibiotics in the community. DESIGN AND SETTING: A prospective audit of consecutive prescriptions for amoxycillin, cefaclor, roxithromycin and amoxycillin/clavulanate presented to community pharmacies in the Hunter region of New South Wales and a follow-up survey of people who received a repeat prescription, October to November 2000. MAIN OUTCOME MEASURES: The frequency of repeat prescription ordering on computer-generated and handwritten prescriptions; the proportion of people who filled their repeat prescription. RESULTS: Data were collected for 1667 prescriptions presented to 35 pharmacies; 126 people who received repeat prescriptions completed the survey. The rate of repeat prescription ordering on computer-generated prescriptions was 69%, compared with 40% for handwritten prescriptions (odds ratio, 3.3; 95% CI, 2.6-4.2). Computer-generated repeat prescriptions were as likely to be filled as hand-written prescriptions (61% and 69%, respectively). CONCLUSIONS: The default settings on computerised prescribing packages result in a significant increase in the use of antibiotics. We estimate these settings result in about 500 000 additional prescriptions being filled annually in Australia for the four antibiotics in the study.

243) Nightingale, P. G., Adu, D., Richards, N. T. and Peters, M. “Implementation of rules based computerised bedside prescribing and administration: intervention study” BMJ **320**(7237): 750-3. (2000)

Abstract: OBJECTIVES: To implement and assess a rules based computerised prescribing system with the aim of improving the safety of prescriptions and the administration of drugs. DESIGN: Analysis of performance of computerised system plus questionnaire survey of users. SETTING: 64 bed renal unit in a teaching hospital. Intervention: Introduction of the system into routine clinical use. MAIN OUTCOME MEASURES: Number of attempted prescriptions cancelled by the system; proportion of warning messages overridden; users' comparisons of the system with conventional procedures. RESULTS: Between October 1998 and August 1999 the system cancelled 58 (0.07%) out of 87 789 prescriptions on the grounds of clinical safety. In addition, 427 (57%) attempted prescriptions generating high level warnings and 1257 (8%) generating low level warnings were not completed. In a user survey 82% (31/38) of doctors and nurses considered the system to be an improvement on conventional procedures. CONCLUSIONS: The system has contributed to safety and patient care. All prescriptions are complete and legible, and transcription errors have been eliminated. The system assists clinicians when they are writing a prescription by making available information on patients. The system supports clinical decision making and has been well received by doctors, nurses, and pharmacists.

244) Niinimaki, J. and Forsstrom, J. “Approaches for certification of electronic prescription software” International Journal of Medical Informatics **47**(3): 175-

182. (1997)

Abstract: The proper management of drug treatment is essential, since adverse drug reactions are common reasons of hospitalizations. Expenditure on drug therapy has also been growing faster than any other aspect of health care in many countries. Savings and quality improvements in drug treatment could be achieved with computerised prescribing. In this paper, the architecture of an electronic prescription system is described in the light of software certification and registration. An electronic prescription system is an example of a system supporting shared care and therefore it should be person based, integrated, secure and confidential and data should be shared among health care institutions. The system architecture shares the idea of a virtual patient record and a smart card will be used as a key to prescription data located on the network. The certification and registration of medical software is a difficult and costly procedure. Ensuring the quality of software can be based on; certification of development process, voluntary evaluation, and post-market surveillance. Voluntary evaluation practice would be a precious toot for both the customers and software developers, and it would also be an invaluable source of information in terms of developing new software.

245) Nold, E. G. “Trends in health information systems technology” American Journal of Health-System Pharmacy **54**(3): 269-74. (1997)

Abstract: Major trends in health information systems technology are described. The new paradigm for information systems is integrated, patient-centered computing. The computer system and files are designed around information-capture needs along the continuum of care instead of around charge capture or inventory. The need for patient information in the future will not be limited to the health system but will extend to work sites and homes. Health systems will move to full client-server architecture, higher-speed data transmission, and greater network capacity. Computing standards will be instituted nationwide. With changes in the economics of health care, physician order-entry systems are inevitable. Many health systems and system vendors are making progress in achieving the computer-based patient record (CPR); health systems will require the CPR if they are to be truly integrated. Trends in health care and health care information technology will require that pharmacists innovate and adapt as never before.

246) North, D. “Controlling the costs of antibiotic resistance” Clinical Therapeutics **15**(Suppl A): 3-11. (1993)

Abstract: Excessive and inappropriate use of antibiotics in hospitals contributes to the development of antibiotic resistance and to increased hospital costs. Denver's three major teaching hospitals have developed a multifaceted approach that has curbed inappropriate antibiotic prescribing and reduced costs for antibiotic purchases. A joint

antibiotic-use committee with representatives from each hospital's pharmacy and therapeutics committee developed a single antibiotic formulary for systemically active antibacterial agents, based on simplicity, clinical efficacy, previous use patterns, local resistance patterns, and relative cost. This formulary includes primary agents, ordered at the prescriber's discretion; secondary agents, ordered only for an approved condition; and restricted agents, which had been used excessively or inappropriately in the past, and are now dispensed only after consultation with infectious disease specialists. A computerized antibiotic order-entry program at the Denver V.A. Medical Center requires all physicians to enter antibiotic requests through a centralized computer system. Drug utilization is evaluated using data collected from the computer data base and in vitro data from the microbiology laboratory. In addition, appropriate antibiotic prescribing and infection control practices are taught in an education program for physicians, nurses, and other health care workers.

247) O'Connell, E. M., Teich, J. M., Pedraza, L. A. and Thomas, D. “A comprehensive inpatient discharge system” Proceedings / AMIA Annual Symposium: 699-703. (1996)

Abstract: Our group has developed a computer system that supports all phases of the inpatient discharge process. The system fills in most of the physician's discharge order form and the nurse's discharge abstract, using information available from sign-out, order entry, scheduling, and other databases. It supplies information for referrals to outside institutions, and provides a variety of instruction materials for patients. Discharge forms can be completed in advance, so that the patient is not waiting for final paperwork. Physicians and nurses can work on their components independently, rather than in series. Response to the system has been very favorable.

248) O'Connor, A. B., Lang, V. J. and Quill, T. E. “Eliminating analgesic meperidine use with a supported formulary restriction” American Journal of Medicine **118**(8): 885-9. (2005)

Abstract: PURPOSE: Meperidine is a commonly used analgesic despite unique disadvantages compared with other opioid analgesics. The objective of this study was to measure the effects of a meperidine formulary restriction on the prescribing of parenteral opioid analgesics. MATERIALS AND METHODS: The study was performed at a single 750-bed tertiary care teaching hospital in Rochester, NY. The formulary restriction limited meperidine to use exclusively for rigors or procedural sedation and was supported by an educational initiative and a computerized order entry system. Independent computerized pharmacy records were used to capture all doses of parenteral morphine, meperidine, and hydromorphone administered to patients in the emergency department or on a medical or surgical inpatient floor during data-collection periods. Baseline data were collected during two 3-day periods before the formulary restriction; then comparison data were collected during three 3-day periods over 15

months after the formulary restriction. RESULTS: The number of administered doses of meperidine per day decreased from 37.5 (20.8% of parenteral opioid doses before the restriction) to 0.22 (0.1% of parenteral opioid doses, P =.001). The total number of opioid doses and morphine doses given did not change, whereas the number of hydromorphone doses increased significantly postrestriction, from 16.0 doses per day (8.9% of total) to 59.7 doses per day (29.5%) (P =.009). CONCLUSION: Meperidine formulary restriction, supported by an educational program and computerized order entry, effectively eliminated analgesic meperidine use. Hydromorphone use increased proportionately to offset the decreased use of meperidine.

249) Oates, R. M. D. “Implementing An Electronic Medical Record in The Ambulatory Setting” Toward an Electronic Patient Record '96 **2**: 595-600. (1996)

Abstract: Lay the foundation, create the vision or mission statement; Work flow, Data flow, Practice profile; Manage expectations early; Inventory and Evaluation of your currrent system; Patient encounter note or record of visit data elements; Peopleware; Communicate; Implementation process; Set goals, Educate and motivate, Develop user surveys, Identify and address barrirers and plan actions to meet goals, Evaluate and select EMR Vendors - general issues, Implementation schedule - general to do list; Evolutionary process.

250) Ohsfeldt, R. L., Ward, M. M., Schneider, J. E., Jaana, M., Miller, T. R., Lei, Y. and Wakefield, D. S. “Implementation of hospital computerized physician order entry systems in a rural state: feasibility and financial impact” Journal of the American Medical Informatics Association **12**(1): 20-7. (2005)

Abstract: OBJECTIVE: The aim of this study was to estimate the costs of implementing computerized physician order entry (CPOE) systems in hospitals in a rural state and to evaluate the financial implications of statewide CPOE implementation. METHODS: A simulation model was constructed using estimates of initial and ongoing CPOE costs mapped onto all general hospitals in Iowa by bed quantity and current clinical information system (CIS) status. CPOE cost estimates were obtained from a leading CPOE vendor. Current CIS status was determined through mail survey of Iowa hospitals. Patient care revenue and operating cost data published by the Iowa Hospital Association were used to simulate the financial impact of CPOE adoption on hospitals. RESULTS: CPOE implementation would dramatically increase operating costs for rural and critical access hospitals in the absence of substantial costs savings associated with improved efficiency or improved patient safety. For urban and rural referral hospitals, the cost impact is less dramatic but still substantial. However, relatively modest benefits in the form of patient care cost savings or revenue enhancement would be sufficient to offset CPOE costs for these larger hospitals. CONCLUSION: Implementation of CPOE in rural or critical access hospitals may depend on net increase in operating costs. Adoption of CPOE may be financially infeasible for these small hospitals in the absence

of increases in hospital payments or ongoing subsidies from third parties.

251) Oliven, A., Michalake, I., Zalman, D., Dorman, E., Yeshurun, D. and Odeh, M. “Prevention of prescription errors by computerized, on-line surveillance of drug order entry” International Journal of Medical Informatics **74**(5): 377-386. (2005)

Abstract: Aims: The present study was undertaken to quantify the impact of computerized drug order entry system (CDOE) connected to the patients' database, on the incidence and type of prescription errors (PEs) in the medical service, and to delineate the causes for remaining errors.Methods: Drug orders were reviewed daily by a physician-reviewer, in a department of internal medicine that used for more than 3 years a CDOE (CDOEdept), and in a similar department in which drug orders were handwritten (HWdept). PEs were divided into those not related to the individual patient (type 1 PEs), and PEs resulting from drug-laboratory, drug-disease, and drug-allergy interactions (type 2 PEs).Results: Ten thousand and two hospitalization days were evaluated. The incidence of type 1 PEs was 5.21 and 1.36 per 100 hospitalization days in the HWdept and CDOEdept, respectively ($p < 0.0001$). Type 2 PEs were more common, 7.20 and 3.02 per 100 hospitalization days in the HWdept and CDOEdept, respectively ($p < 0.0001$), and about 75% of them were due to few drug-laboratory interactions. Most of the remaining errors in the CDOEdept were due to inadequate adjustment of drugs and doses to renal function, or failure to perform adequate changes when new laboratory results became available.Conclusions: We conclude that linkingthe CDOE with few, specific, laboratory results has a large impact on the prevention of PEs. Combining the CDOE with a drug-laboratory alert system is expected to further reduce the incidence of PEs.

252) Oliven, A., Michalake, I., Zalman, D., Dorman, E., Yeshurun, D. and Odeh, M. “Prevention of prescription errors by computerized, on-line surveillance of drug order entry” International Journal of Medical Informatics **74**(5): 377-86. (2005)

Abstract: AIMS: The present study was undertaken to quantify the impact of computerized drug order entry system (CDOE) connected to the patients' database, on the incidence and type of prescription errors (PEs) in the medical service, and to delineate the causes for remaining errors. METHODS: Drug orders were reviewed daily by a physician-reviewer, in a department of internal medicine that used for more than 3 years a CDOE (CDOEdept), and in a similar department in which drug orders were handwritten (HWdept). PEs were divided into those not related to the individual patient (type 1 PEs), and PEs resulting from drug-laboratory, drug-disease, and drug-allergy interactions (type 2 PEs). RESULTS: Ten thousand and two hospitalization days were evaluated. The incidence of type 1 PEs was 5.21 and 1.36 per 100 hospitalization days in the HWdept and CDOEdept, respectively ($p<0.0001$). Type 2 PEs were more common, 7.20 and 3.02 per 100 hospitalization days in the HWdept and CDOEdept,

respectively (p<0.0001), and about 75% of them were due to few drug-laboratory interactions. Most of the remaining errors in the CDOEdept were due to inadequate adjustment of drugs and doses to renal function, or failure to perform adequate changes when new laboratory results became available. CONCLUSIONS: We conclude that linking the CDOE with few, specific, laboratory results has a large impact on the prevention of PEs. Combining the CDOE with a drug-laboratory alert system is expected to further reduce the incidence of PEs.

253) Oppenheim, M. I., Vidal, C., Velasco, F. T., Boyer, A. G., Cooper, M. R., Hayes, J. G. and Frayer, W. W. “Impact of a computerized alert during physician order entry on medication dosing in patients with renal impairment” Proceedings / AMIA. Annual Symposium.: 577-81. (2002)

Abstract: Computerized assistance to clinicians during physician order entry can provide protection against medical errors. However, computer systems that provide too much assistance may adversely affect training of medical students and residents. Trainees may rely on the computer to automatically perform complex calculations and create appropriate orders and are thereby deprived of an important educational exercise. An alternative strategy is to provide a critique at the completion of an order, requiring the trainee to enter the entire order but displaying an alert if an error is made. While this approach preserves the educational components of order-writing, the potential for errors exists if the computerized critique does not induce clinicians to correct the order. The goal of this study was to determine (a) the frequency with which errors are made by trainees in an environment in which renal dosing adjustment calculation for antimicrobials are done by the system after the user has entered an order, and (b) the frequency with which prompts to clinicians regarding these errors leads to correction of those orders.

254) Oren, E., Shaffer, E. R. and Guglielmo, B. J. “Impact of emerging technologies on medication errors and adverse drug events” American Journal of Health-System Pharmacy. **60**(14): 1447-58. (2003)

Abstract: Published evidence on the effects of computerized physician order entry (CPOE), automated dispensing machines (ADMs), bar coding, and computerized medication administration records (CMARs) on medication errors and adverse drug events (ADEs) were reviewed. Emerging technologies have been recommended as potential mechanisms for reducing medication errors. Critical evaluations of the impact of these new technologies on medication errors and other adverse outcomes are lacking. PubMed was searched to identify all peer-reviewed publications linking four technologies (CPOE, ADMs, bar coding, and CMARs) with reductions in medication errors and ADEs and secondary endpoints. All controlled studies that assessed the impact of the technologies were evaluated. The appropriateness of the use of these technologies was also examined. Few studies were identified that evaluated the

technologies' impact on these endpoints. Of the evaluated technologies, CPOE was the most studied; however, investigations were limited to selected medical centers. The appropriateness of use of the technologies was evaluated even more infrequently. A literature review revealed a paucity of controlled, generalizable studies confirming the benefits of technologies intended to reduce medication errors and ADEs. Very little evidence on the appropriateness of the use of these technologies was found. [References: 59]

255) Ostbye, T., Moen, A., Erikssen, G. and Hurlen, P. “Introducing a module for laboratory test order entry and reporting of results at a hospital ward: an evaluation study using a multi-method approach” Journal of Medical Systems **21**(2): 107-117. (1997)

Abstract:

256) Overhage, J. M., Middleton, B., Miller, R. A., Zielstorff, R. D. and Hersh, W. R. “Does national regulatory mandate of provider order entry portend greater benefit than risk for health care delivery? The 2001 ACMI debate. The American College of Medical Informatics” Journal of the American Medical Informatics Association **9**(3): 199-208. (2002)

Abstract: The 2001 debate of the American College of Medical Informatics focused on the proposition that national regulatory mandate of computer-based provider order entry (CPOE), to take effect by the end of 2005, portends greater benefit than risk for health care delivery. Both sides accepted that provider order entry offers potential benefit. Those supporting the proposition emphasized public safety, noting that payers have little economic incentive to pay for quality and that a mandate would force vendors to improve the usability and value of their systems. They argued that the mandate would align the economic incentives to finally allow CPOE to be widely adopted. Those opposing the proposition emphasized the risks resulting from a mandate, including the direct implementation costs, the logistic issues of implementation, and the cost of failed implementations. They also noted the potential for errors introduced by the systems themselves and the fact that the safety and utility of commercially available CPOE products have yet to be proved.

257) Overhage, J. M., Perkins, S., Tierney, W. M. and McDonald, C. J. “Controlled trial of direct physician order entry: effects on physicians' time utilization in ambulatory primary care internal medicine practices” Journal of the American Medical Informatics Association **8**(4): 361-71. (2001)

Abstract: OBJECTIVE: Direct physician order entry (POE) offers many potential benefits, but evidence suggests that POE requires substantially more time than

traditional paper-based ordering methods. The Medical Gopher is a well-accepted system for direct POE that has been in use for more than 15 years. The authors hypothesized that physicians using the Gopher would not spend any more time writing orders than physicians using paper-based methods. DESIGN: A randomized controlled trial of POE using the Medical Gopher system in 11 primary care internal medicine practices. MEASUREMENTS: The authors collected detailed time use data using time motion studies of the physicians and surveyed their opinions about the POE system. RESULTS: The authors found that physicians using the Gopher spent 2.2 min more per patient overall, but when duplicative and administrative tasks were taken into account, physicians were found to have spent only 0.43 min more per patient. With experience, the order entry time fell by 3.73 min per patient. The survey revealed that the physicians believed that the system improved their patient care and wanted the Gopher to continue to be available in their practices. CONCLUSIONS: Little extra time, if any, was required for physicians to use the POE system. With experience in its use, physicians may even save time while enjoying the many benefits of POE.

258) Overhage, J. M., Tierney, W. M., Zhou, A. and McDonald, C. J. “A Randomized Trial of "Corollary Orders" to Prevent Errors of Omission” Journal of the American Medical Informatics Association(4): 364-375. (1997)

Abstract: Objective: Errors of omission are a common cause of systems failures. Physicians often fail to order tests or treatments needed to monitor/ameliorate the effects of other tests or treatments. The authors hypothesized that automated, guideline-based reminders to physicians, provided as they wrote orders, could reduce these omissions.
Design: The study was performed on the inpatient general medicine ward of a public teaching hospital. Faculty and housestaff from the Indiana University School of Medicine, who used computer workstations to write orders, were randomized to intervention and control groups. As intervention physicians wrote orders for 1 of 87 selected tests or treatments, the computer suggested corollary orders needed to detect or ameliorate adverse reactions to the trigger orders. The physicians could accept or reject these suggestions.
Results: During the 6-month trial, reminders about corollary orders were presented to 48 intervention physicians and withheld from 41 control physicians. Intervention physicians ordered the suggested corollary orders in 46.3% of instances when they received a reminder, compared with 21.9% compliance by control physicians ($p < 0.0001$). Physicians discriminated in their acceptance of suggested orders, readily accepting some while rejecting others. There were one third fewer interventions initiated by pharmacists with physicians in the intervention than control groups.
Conclusion: This study demonstrates that physician workstations, linked to a comprehensive electronic medical record, can be an efficient means for decreasing errors of omissions and improving adherence to practice guidelines.

259) Ozdas, A., Speroff, T., Waitman, L. R., Ozbolt, J., Butler, J. and Miller, R. A. “Integrating "best of care" protocols into clinicians' workflow via care provider order entry: impact on quality-of-care indicators for acute myocardial infarction” Journal of the American Medical Informatics Association **13**(2): 188-96. (2006)

Abstract: OBJECTIVE: In the context of an inpatient care provider order entry (CPOE) system, to evaluate the impact of a decision support tool on integration of cardiology "best of care" order sets into clinicians' admission workflow, and on quality measures for the management of acute myocardial infarction (AMI) patients. DESIGN: A before-and-after study of physician orders evaluated (1) per-patient use rates of standardized acute coronary syndrome (ACS) order set and (2) patient-level compliance with two individual recommendations: early aspirin ordering and beta-blocker ordering. MEASUREMENTS: The effectiveness of the intervention was evaluated for (1) all patients with ACS (suspected for AMI at the time of admission) (N = 540) and (2) the subset of the ACS patients with confirmed discharge diagnosis of AMI (n = 180) who comprise the recommended target population who should receive aspirin and/or beta-blockers. Compliance rates for use of the ACS order set, aspirin ordering, and beta-blocker ordering were calculated as the percentages of patients who had each action performed within 24 hours of admission. RESULTS: For all ACS admissions, the decision support tool significantly increased use of the ACS order set (p = 0.009). Use of the ACS order set led, within the first 24 hours of hospitalization, to a significant increase in the number of patients who received aspirin (p = 0.001) and a nonsignificant increase in the number of patients who received beta-blockers (p = 0.07). Results for confirmed AMI cases demonstrated similar increases, but did not reach statistical significance. CONCLUSION: The decision support tool increased optional use of the ACS order set, but room for additional improvement exists.

260) Pallin, D., Lahman, M. and Baumlin, K. “Information technology in emergency medicine residency-affiliated emergency departments” Academic Emergency Medicine **10**(8): 848-52. (2003)

Abstract: OBJECTIVES: To describe acquisition and implementation of information technology (IT) in U.S. emergency medicine (EM) residency-affiliated emergency departments (EDs), including automatic medication error checking. METHODS: This was a survey of all U.S. EM residencies active in September 2000. Respondents specified whether specific IT tools had been "acquired" and "implemented fully." EDs were categorized according to primary versus affiliated training site, trauma level, and census. Numbers of "yes" responses were compared according to ED type (Kruskal-Wallis test, p < or = 0.05 significant). RESULTS: Of 121 residency programs, data were obtained from 93 (77%) for a total of 149 EDs. The percentages of EDs that reported full implementation for each technology are as follows: medication error checking, 7%; medication order entry, 18%; nonmedication orders, 7%; clinical documentation, 21%; old electrocardiograms, 62%; laboratory results, 84%; radiography order entry, 62%; image retrieval, 29%; radiologists' interpretations, 67%; cardiology reports, 62%; pathology reports, 70%; surgical reports/dictations, 60%; triage, 34%; tracking, 46%;

electronic reference materials, 56%; registration, 84%; accounts, 72%; patient management software package, 20%; voice recognition, 7%. Trauma centers reported more IT tools than nontrauma centers (p = 0.01), and primary training sites reported fewer IT tools than affiliated EDs (p = 0.027). CONCLUSIONS: Incorporation of IT is not uniform in EDs where EM residents train. Acquisition of effective IT tools varies, and implementation lags behind acquisition. Fully implemented IT for medication error checking was reported in 7% of EDs; an additional 12% had acquired IT without implementing it fully.

261) Papshev, D. and Peterson, A. M. “Electronic prescribing in ambulatory practice: promises, pitfalls, and potential solutions” American Journal of Managed Care **7**(7): 725-36. (2001)

Abstract: OBJECTIVE: To examine advantages of and obstacles to electronic prescribing in the ambulatory care environment. DATA SOURCES: MEDLINE and International Pharmaceutical Abstract searches were conducted for the period from January 1980 to September 2000. Key words were electronic prescribing, computerized physician order entry, prior authorization, drug utilization review, and consumer satisfaction. In September 2000, a public search engine (www.google.com) was used to find additional technical information. In addition, pertinent articles were cross-referenced to identify other resources. DATA EXTRACTION: Articles, symposia proceedings, and organizational position statements published in the United States on electronic prescribing and automation in healthcare are cited. DATA SYNTHESIS: Electronic prescribing can eliminate the time gap between point of care and point of service, reduce medication errors, improve quality of care, and increase patient satisfaction. Considerable funding requirements, segmentation of healthcare markets, lack of technology standardization, providers' resistance to change, and regulatory indecisiveness create boundaries to the widespread use of automated prescribing. The potential solutions include establishing a standardizing warehouse or a router and gaining stakeholder support in implementation of the technology. CONCLUSIONS: Electronic prescribing can provide immense benefits to healthcare providers, patients, and managed care. Resolution of several obstacles that limit feasibility of this technology will determine its future. [References: 35]

262) Pare, G. “Implementing clinical information systems: a multiple-case study within a US hospital” Health Services Management Research. **15**(2): 71-92. (2002)

Abstract: The rapid movement of information technologies into health care organizations has raised managerial concern regarding the capability of today's institutions to satisfactorily manage their introduction. Indeed, several health care institutions have consumed huge amounts of money and frustrated countless people in wasted information systems implementation efforts. Unfortunately, there are no easy answers as to why so many health informatics projects are not more successful. The

aim of this study is to provide a deeper understanding of clinical information systems implementation. The research reported in this paper focuses on building a theory of the dynamic nature of the implementation process, that is, the how and why of what happened. The general approach taken was inspired by the work of Eisenhardt (1989) on building theories from case study research. We examined the implementation process, use and consequences of three distinct clinical information systems at a large tertiary care teaching hospital. A series of four research propositions reflecting the dynamic nature of the implementation process are offered as each of the three cases are analyzed. Findings add a number of new perspectives and empirical insights to the existing body of knowledge in the fields of IT implementation and medical informatics.

263) Pare, G., Sicotte, C. and Jacques, H. “The effects of creating psychological ownership on physicians' acceptance of clinical information systems” Journal of the American Medical Informatics Association **13**(2): 197-205. (2006)

Abstract: OBJECTIVE: Motivated by the need to push further our understanding of physicians' acceptance of clinical information systems, we propose a relatively new construct, namely, psychological ownership. We situated the construct within a nomological net using a prevailing and dominant information technology adoption behavior model as a logical starting point. DESIGN: A mail survey was sent to the population of users of a regional physician order entry (POE) system aimed at speeding up the transmission of clinical data, mainly laboratory tests and radiology examinations, within a community health network. MEASUREMENTS: All scales, but one, were measured using previously validated instruments. For its part, the psychological ownership scale was developed using a multistage iterative procedure. RESULTS: Ninety-one questionnaires were returned to the researchers, for a response rate of 72.8%. Our findings reveal that, in order to foster physicians' adoption of a clinical information system, it is important to encourage and cultivate a positive attitude toward using the new system. In this connection, positive perception of the technology's usefulness is crucial. Second, results demonstrate that psychological ownership of a POE system is positively associated with physicians' perceptions of system utility and system user friendliness. Last, through their active involvement and participation, physicians feel they have greater influence on the development process, thereby developing feelings of ownership toward the clinical system. CONCLUSION: Psychological ownership's highly significant associations with user participation and crucial beliefs driving technology acceptance behaviors among physicians affirm the value of this construct in extending our understanding of POE adoption.

264) Park, R. W., Shin, S. S., Choi, Y. I., Ahn, J. O. and Hwang, S. C. “Computerized physician order entry and electronic medical record systems in Korean teaching and general hospitals: results of a 2004 survey” Journal of the American Medical Informatics Association **12**(6): 642-7. (2005)

Abstract: OBJECTIVE: To determine the availability of computerized physician order entry (CPOE) and electronic medical record (EMR) systems in teaching and general hospitals in the Republic of Korea. DESIGN: A combined mail and telephone survey of 283 hospitals. MEASUREMENTS: The surveys assessed the availability of CPOE and EMRs in the hospitals, as well as inducement, participation, and saturation regarding CPOE use by physicians. RESULTS: A total of 122 (43.1%) hospitals responded to the survey. The complete form of CPOE was available in 98 (80.3%) hospitals. The use of CPOE was mandatory in 92 (86.0%) of the 107 hospitals that responded to the questions regarding the requirement of CPOE use. In 85 (79.4%) of the hospitals in which CPOE was in use, more than 90% of physicians used the system. In addition, physicians entered more than 90% of their total orders through CPOE in 87 (81.3%) hospitals. In contrast, a complete EMR system was available in only 11 (9.0%) of the hospitals. CONCLUSION: Of the teaching and general hospitals in the Republic of Korea that responded to the survey, the majority (80.3%) have CPOE systems, and a complete EMR system is available in only 9%.

265) Park, W. S., Kim, J. S., Chae, Y. M., Yu, S. H., Kim, C. Y., Kim, S. A. and Jung, S. H. “Does the physician order-entry system increase the revenue of a general hospital?” International Journal of Medical Informatics **71**(1): 25-32. (2003)

Abstract: OBJECTIVE: The purpose of this study was to examine whether the physician order-entry system (POE) could increase the outpatient and inpatient revenue of hospitals. METHOD: We analyzed the inpatient and outpatient revenue data of all general hospitals (212) in South Korea obtained from the Korean National Health Insurance Corporation (KNHIC) during the period from 1996 to 1999 using the mixed model for repeated measure data. RESULTS: Analysis of the 4-years' panel data showed that both outpatient and inpatient revenues increased significantly after POE introduction. The hospital characteristics significantly influencing inpatient revenue were the number of beds, number of physicians and the tertiary status of a hospital; whereas those for outpatient revenue were the number of beds, number of physicians, the private status of a hospital, the tertiary status of a hospital and the urban status of a hospital. CONCLUSION: The revenues from both outpatients and inpatients were found to be increased after the introduction of the POE, while controlling for population size, competition, income, hospital location, hospital size, tertiary status and public status.

266) Patterson, E. S., Cook, R. I. and Render, M. L. “Improving patient safety by identifying side effects from introducing bar coding in medication administration” Journal of the American Medical Informatics Association. **9**(5): 540-53. (2002)

Abstract: OBJECTIVE: In addition to providing new capabilities, the introduction of technology in complex, sociotechnical systems, such as health care and aviation, can have unanticipated side effects on technical, social, and organizational dimensions. To identify potential accidents in the making, the authors looked for side effects from a

natural experiment, the implementation of bar code medication administration (BCMA), a technology designed to reduce adverse drug events (ADEs). DESIGN: Cross-sectional observational study of medication passes before (21 hours of observation of 7 nurses at 1 hospital) and after (60 hours of observation of 26 nurses at 3 hospitals) BCMA implementation. MEASUREMENTS: Detailed, handwritten field notes of targeted ethnographic observations of in situ nurse-BCMA interactions were iteratively analyzed using process tracing and five conceptual frameworks. RESULTS: Ethnographic observations distilled into 67 nurse-BCMA interactions were classified into 12 categories. We identified five negative side effects after BCMA implementation: (1) nurses confused by automated removal of medications by BCMA, (2) degraded coordination between nurses and physicians, (3) nurses dropping activities to reduce workload during busy periods, (4) increased prioritization of monitored activities during goal conflicts, and (5) decreased ability to deviate from routine sequences. CONCLUSION: These side effects might create new paths to ADEs. We recommend design revisions, modification of organizational policies, and "best practices" training that could potentially minimize or eliminate these side effects before they contribute to adverse outcomes.

267) Patterson, R. “Physician satisfaction with order entry systems” Journal of the American Medical Informatics Association **9**(3): 308-9; discussion 309. (2002)

Abstract:

268) Patterson, R. and Harasym, P. “Educational instruction on a hospital information system for medical students during their surgical rotations” Journal of the American Medical Informatics Association **8**(2): 111-6. (2001)

Abstract: OBJECTIVE: To evaluate the benefit, for medical students on their surgical rotations, of real-time educational instruction during order entry on a hospital information system. DESIGN: Prospective controlled trial. INTERVENTION: Access to educational information during computerized order entry. SUBJECTS: Medical students in their final year at the University of Calgary. Main outcomes: Attainment of the surgery rotation educational objectives, as measured by performance on a multiple-choice examination. METHODS: Before they began their surgical rotations, students at two hospitals took a multiple-choice examination to measure their knowledge of surgery. One hospital had an information system with computerized order entry; students at this hospital had access, while composing orders, to educational material on the system. The other hospital did not have an information system; students there wrote orders on a paper chart. At the end of the rotation, all students took another multiple-choice examination. RESULTS: Of 50 eligible students, 45 agreed to participate in the project, 21 in the treatment group and 24 in the control group. Pre-rotation scores were similar for the two groups (43 percent in the treatment group and 40 percent in the control group; SD, 10 percent). Post-rotation scores were identical for the two groups (65 percent in the treatment group and 65 percent in the control group; SD, 12 percent). A t-test analysis

revealed no significant difference in performance on the examinations between the two groups. CONCLUSION: This study did not demonstrate a learning advantage for medical students who have access to educational material on a hospital information system.

269) Payne, T. H. “The transition to automated practitioner order entry in a teaching hospital: the VA Puget Sound experience” Proceedings / AMIA Annual Symposium: 589-93. (1999)

Abstract: We recently installed an automated practitioner order entry system on our busiest inpatient wards and critical care units. The installation followed 20 months preparation in which we created the workstation, network, and host infrastructure, developed requisite policies, recruited personnel to support the system, and installed the software in areas where the pace of order entry was less intense. Since implementing automated order entry, we have experienced problems such as an increase in time required for practitioners to enter orders, workflow changes on inpatient units, difficulties with patient transfers, and others. Our user support system has been heavily used during the transition period. Software tailoring and enhancements designed to address these problems are planned, as is installation of the order entry system in remaining clinical units in our medical centers.

270) Payne, T. H. “Computer decision support systems” Chest **118**(2 Suppl): 47S-52S. (2000)

Abstract: Computer decision support systems are computer applications designed to aid clinicians in making diagnostic and therapeutic decisions in patient care. They can simplify access to data needed to make decisions, provide reminders and prompts at the time of a patient encounter, assist in establishing a diagnosis and in entering appropriate orders, and alert clinicians when new patterns in patient data are recognized. Decision support systems that present patient-specific recommendations in a form that can save clinicians time have been shown to be highly effective, sustainable tools for changing clinician behavior. Designing and implementing such systems is challenging because of the computing infrastructure required, the need for patient data in a machine-processible form, and the changes to existing workflow that may result. Despite these difficulties, there is substantial evidence from trials in a wide range of clinical settings that computer decision support systems help clinicians do a better job caring for patients. As computer-based records and order-entry systems become more common, automated decision support systems will be used more broadly. [References: 32]

271) Payne, T. H., Hoey, P. J., Nichol, P. and Lovis, C. “Preparation and use of

preconstructed orders, order sets, and order menus in a computerized provider order entry system" Journal of the American Medical Informatics Association. **10**(4): 322-9. (2003)

Abstract: OBJECTIVE: To describe the configuration and use of the computerized provider order entry (CPOE) system used for inpatient and outpatient care at the authors' facility. DESIGN: Description of order configuration entities, use patterns, and configuration changes in a production CPOE system. MEASUREMENTS: The authors extracted and analyzed the content of order configuration entities (order dialogs, preconfigured [quick] orders, order sets, and order menus) and determined the number of orders entered in their production order entry system over the previous three years. The authors measured use of these order configuration entities over a six-month period. They repeated the extract two years later to measure changes in these entities. RESULTS: CPOE system configuration, conducted before and after first production use, consisted of preparing 667 order dialogs, 5,982 preconfigured (quick) orders, and 513 order sets organized in 703 order menus for particular contexts, such as admission for a particular diagnosis. Fifty percent of the order dialogs, 57% of the quick orders, and 13% of the order sets were used within a six-month period. Over the subsequent two years, the volume of order configuration entities increased by 26%. CONCLUSIONS: These order configuration steps were time-consuming, but the authors believe they were important to increase the ordering speed and acceptability of the order entry software. Lessons learned in the process of configuring the CPOE ordering system are given. Better understanding of ordering patterns may make order configuration more efficient because many of the order configuration entities that were created were not used by clinicians.

272) Payne, T. H., Nichol, W. P., Hoey, P. and Savarino, J. "Characteristics and override rates of order checks in a practitioner order entry system" Proceedings / AMIA. Annual Symposium.: 602-6. (2002)

Abstract: Order checks are important error prevention tools when used in conjunction with practitioner order entry systems. We studied characteristics of order checks generated in a sample of consecutively entered orders during a 4 week period in an electronic medical record at VA Puget Sound. We found that in the 42,641 orders where an order check could potentially be generated, 11% generated at least one order check and many generated more than one order check. The rates at which the ordering practitioner overrode 'Critical drug interaction' and 'Allergy-drug interaction' alerts in this sample were 88% and 69% respectively. This was in part due to the presence of alerts for interactions between systemic and topical medications and for alerts generated during medication renewals. Refinement in order check logic could lead to lower override rates and increase practitioner acceptance and effectiveness of order checks.

273) Payne, T. H., Savarino, J., Marshall, R. and Hoey, C. T. "Use of a clinical event

monitor to prevent and detect medication errors" Proceedings / AMIA Annual Symposium: 640-4. (2000)

Abstract: Errors in health care facilities are common and often unrecognized. We have used our clinical event monitor to prevent and detect medication errors by scrutinizing electronic messages sent to it when any medication order is written in our facility. A growing collection of medication safety rules covering dose limit errors, laboratory monitoring, and other topics may be applied to each medication order message to provide an additional layer of protection beyond existing order checks, reminders, and alerts available within our computer-based record system. During a typical day the event monitor receives 4802 messages, of which 4719 pertain to medication orders. We have found the clinical event monitor to be a valuable tool for clinicians and quality management groups charged with improving medication safety.

274) Pedersen, C. A., Schneider, P. J. and Santell, J. P. "ASHP national survey of pharmacy practice in hospital settings: prescribing and transcribing--2001" American Journal of Health-System Pharmacy. **58**(23): 2251-66. (2001)

Abstract: Results of the 2001 ASHP national survey of pharmacy practice in hospital settings that pertain to prescribing and transcribing are presented. A stratified random sample of pharmacy directors at 1091 general and children's medical-surgical hospitals in the United States was surveyed by mail. SMG Marketing Group, Inc., supplied data on hospital characteristics; the survey sample was drawn from SMG's hospital database. The response rate was 49.0%. During 2001, nearly all hospitals are estimated to have pharmacy and therapeutics (P&T) committees that meet an average of seven times per year. It is estimated that more than 90% of P&T committees are responsible for formulary development and management, drug policy development, adverse-drug-reaction review, and medication-use evaluation. More than 90% of hospitals use clinical and therapeutic, cost, and pharmacoeconomic information in the formulary management process, while nearly two thirds consider quality-of-life issues. Nearly 70% use clinical practice guidelines in the formulary management process, and 78% have a medication-use evaluation program designed to improve prescribing. Pharmacists in more than 75% of hospitals provide consultations on drug information, dosage adjustments for patients with renal impairment, antimicrobials, and pharmacokinetics. Further, a majority of hospitals ensure accurate transcription of medication orders by clarifying illegible orders before transcription or entry into medication administration records (MARs), using standardized prescriber order forms, requiring prescribers to countersign all oral orders, and reconciling MARs and pharmacy patient profiles at least daily. In 2001, large hospitals are most likely to use prescriber order-entry systems to improve patient safety and are least likely to require the reentry of medication orders into the pharmacy computer system. The 2001 ASHP survey results suggest that pharmacists in hospital settings have positioned themselves well to improve the prescribing and transcribing components of the medication-use process.

275) Pedersen, C. A., Schneider, P. J. and Scheckelhoff, D. J. “ASHP national survey of pharmacy practice in hospital settings: prescribing and transcribing--2004” American Journal of Health-System Pharmacy **62**(4): 378-90. (2005)

Abstract: PURPOSE: Results of the 2004 ASHP national survey of pharmacy practice in hospital settings that pertain to prescribing and transcribing are presented. METHODS: A stratified random sample of pharmacy directors at 1183 general and children's medical-surgical hospitals in the United States was surveyed by mail. SMG Marketing Group, Inc., supplied data on hospital characteristics; the survey sample was drawn from SMG's hospital database. RESULTS: The response rate was 41.7%. Compared with the results of the 2001 survey, the number of times pharmacy and therapeutics committees met increased, suggesting an increase in efforts to monitor and manage medication use in hospitals. There was an increase in the use of quality-of-life information to make formulary decisions, indicating a shift away from cost-based formularies. There was a decrease in the rates of formulary compliance, but an increase in the use of evidence-based clinical practice guidelines, suggesting the emergence of more comprehensive approaches to improving prescribing. The use of medication-use evaluations increased in smaller hospitals, suggesting greater use of best practices is occurring in these institutions. The use of drug information services continues to decline, as the use of more efficient and easily accessible online sources of drug information increases. Reading back oral orders to improve accuracy dramatically increased since 2001. The adoption of computerized prescriber-order-entry systems continues to be slow, with fewer than 5% of hospitals reporting their use. CONCLUSION: The 2004 ASHP survey results indicate that pharmacists are continuing to improve medication use at the prescribing and transcribing steps of the medication-use system.

276) Peterson, J. F., Kuperman, G. J., Shek, C., Patel, M., Avorn, J. and Bates, D. W. “Guided prescription of psychotropic medications for geriatric inpatients” Archives of Internal Medicine **165**(7): 802-7. (2005)

Abstract: BACKGROUND: Inappropriate use or excessive dosing of psychotropic medications in the elderly is common and can lead to a variety of adverse drug events including falls, oversedation, and cognitive impairment. METHODS: We developed a database of psychotropic medication dosing and selection guidelines for elderly inpatients. We displayed these recommendations to physicians through a computerized order entry system at a tertiary care academic hospital. The system was activated for 2 of 4 six-week study periods in an off-on-off-on pattern. Main outcome measures were agreement with the recommended daily dose for the initial drug order, incidence of dosing at least 10-fold greater than the recommended daily dose, prescription of nonrecommended drugs, inpatient falls, altered mental status as measured by a brief nursing assessment, and hospital length of stay. RESULTS: A total of 7456 initial orders for psychotropic medications were prescribed for 3718 hospitalized elderly patients with a mean +/- SD age of 74.7 +/- 6.7 years. The intervention increased the prescription of the recommended daily dose (29% vs 19%; P<.001), reduced the incidence of 10-fold

dosing (2.8% vs 5.0%; P<.001), and reduced the prescription of nonrecommended drugs (10.8% vs 7.6% of total orders; P<.001). Patients in the intervention cohort had a lower in-hospital fall rate (0.28 vs 0.64 falls per 100 patient-days; P =.001). No effect on hospital length of stay or days of altered mental status was found. CONCLUSION: A geriatric decision support system for psychotropic medications increased the prescription of recommended doses, reduced the prescription of nonrecommended drugs, and was associated with fewer inpatient falls.

277) Peth, H. A., Jr. “Medication errors in the emergency department: a systems approach to minimizing risk” Emergency Medicine Clinics of North America **21**(1): 141-58. (2003)

Abstract: Adverse drug events caused by medication errors represent a common cause of patient injury in the practice of medicine. Many medication errors are preventable and hence particularly tragic when they occur, often with serious consequences. The enormous increase in the number of available drugs on the market makes it all but impossible for physicians, nurses, and pharmacists to possess the knowledge base necessary for fail-safe medication practice. Indeed, the greatest single systemic factor associated with medication errors is a deficiency in the knowledge requisite to the safe use of drugs. It is vital that physicians, nurses, and pharmacists have at their immediate disposal up-to-date drug references. Patients presenting for care in EDs are usually unfamiliar to their EPs and nurses, and the unique patient factors affecting medication response and toxicity are obscured. An appropriate history, physical examination, and diagnostic workup will assist EPs, nurses, and pharmacists in selecting the safest and most optimum therapeutic regimen for each patient. EDs deliver care "24/7" and are open when valuable information resources, such as hospital pharmacists and previously treating physicians, may not be available for consultation. A systems approach to the complex problem of medication errors will help emergency clinicians eliminate preventable adverse drug events and achieve a goal of a zero-defects system, in which medication errors are a thing of the past. New developments in information technology and the advent of electronic medical records with computerized physician order entry, ward-based clinical pharmacists, and standardized bar codes promise substantial reductions in the incidence of medication errors and adverse drug events. ED patients expect and deserve nothing less than the safest possible emergency medicine service. [References: 35]

278) Pizzi, L. T., Suh, D. C., Barone, J. and Nash, D. B. “Factors related to physicians' adoption of electronic prescribing: results from a national survey” American Journal of Medical Quality **20**(1): 22-32. (2005)

Abstract: Electronic prescribing (E-RX) is a component of the Medicare Prescription Drug, Improvement, and Modernization Act of 2003 (MMA). The objective of this study was to identify factors related to physicians' adoption of E-RX for outpatients. This study

employed an electronic survey of US physicians who subscribe to the Physicians Online Internet service. Electronic prescribers were compared to traditional prescribers in terms of demographics, practice type and location, technology use, and beliefs about E-RX. A total of 1104 physicians responded, 19% of whom prescribed electronically. Electronic prescribers were more likely to be generalists practicing in academic or publicly funded centers, have fewer years in practice, and work in technology-equipped offices. They also held different beliefs versus traditional prescribers in terms of E-RX limitations and its potential to improve medication safety and prescribing efficiency. In addition to financial incentives established by MMA, adoption can be stimulated by improvements in the technology and on organizational commitment.

279) Poissant, L., Pereira, J., Tamblyn, R. and Kawasumi, Y. “The impact of electronic health records on time efficiency of physicians and nurses: a systematic review” Journal of the American Medical Informatics Association **12**(5): 505-16. (2005)

Abstract: A systematic review of the literature was performed to examine the impact of electronic health records (EHRs) on documentation time of physicians and nurses and to identify factors that may explain efficiency differences across studies. In total, 23 papers met our inclusion criteria; five were randomized controlled trials, six were posttest control studies, and 12 were one-group pretest-posttest designs. Most studies (58%) collected data using a time and motion methodology in comparison to work sampling (33%) and self-report/survey methods (8%). A weighted average approach was used to combine results from the studies. The use of bedside terminals and central station desktops saved nurses, respectively, 24.5% and 23.5% of their overall time spent documenting during a shift. Using bedside or point-of-care systems increased documentation time of physicians by 17.5%. In comparison, the use of central station desktops for computerized provider order entry (CPOE) was found to be inefficient, increasing the work time from 98.1% to 328.6% of physician's time per working shift (weighted average of CPOE-oriented studies, 238.4%). Studies that conducted their evaluation process relatively soon after implementation of the EHR tended to demonstrate a reduction in documentation time in comparison to the increases observed with those that had a longer time period between implementation and the evaluation process. This review highlighted that a goal of decreased documentation time in an EHR project is not likely to be realized. It also identified how the selection of bedside or central station desktop EHRs may influence documentation time for the two main user groups, physicians and nurses. [References: 68]

280) Poon, E. G., Blumenthal, D., Jaggi, T., Honour, M. M., Bates, D. W. and Kaushal, R. “Overcoming barriers to adopting and implementing computerized physician order entry systems in U.S. hospitals” Health Affairs **23**(4): 184-90. (2004)

Abstract: Few U.S. hospitals have implemented computerized physician order entry (CPOE) in spite of its effectiveness at preventing serious medication errors. We

interviewed senior management at twenty-six hospitals to identify ways to overcome barriers to adopting and implementing CPOE. Within the hospital, strong leadership and high-quality technology were critical. Hospitals that placed a high priority on patient safety could more easily justify the cost of CPOE. Outside the hospital, financial incentives and public pressures encouraged CPOE adoption. Dissemination of data standards would accelerate the maturation of vendors and lower CPOE costs. These findings highlight several policy levers to speed the adoption of this important patient safety technology.

281) Potts, A. L., Barr, F. E., Gregory, D. F., Wright, L. and Patel, N. R. “Computerized physician order entry and medication errors in a pediatric critical care unit” Pediatrics **113**(1 Pt 1): 59-63. (2004)

Abstract: OBJECTIVE: Medication errors are a major concern of health care professionals and medical institutions, especially errors involving children. Studies in adults have shown that computerized physician order entry (CPOE) systems reduce medication errors and adverse drug events (ADEs). The effect of CPOE implementation in a pediatric population has not been reported. The objective of this study was to evaluate the impact of CPOE on the frequency of errors in the medication ordering process in a pediatric critical care unit (PCCU). METHODS: A prospective trial was conducted of 514 pediatric patients who were admitted to a 20-bed PCCU in a tertiary-care children's hospital before and after implementation of CPOE. Medication errors were identified after review of all orders during the study period and then further classified as potential ADEs, medication prescribing errors (MPE), and rule violations (RV). RESULTS: A total of 13 828 medication orders were reviewed. Before implementation, potential ADEs occurred at a rate of 2.2 per 100 orders, MPEs at a rate of 30.1 per 100 orders, and RVs at a rate of 6.8 per 100 orders. After implementation, the rate of potential ADEs was reduced to 1.3 per 100 orders, MPEs to 0.2 per 100 orders, and RVs to 0.1 per 100 orders. The overall error reduction was 95.9%. Potential ADEs were reduced by 40.9%, and MPEs and RVs were reduced by 99.4% and 97.9%, respectively. CONCLUSIONS: The implementation of CPOE resulted in almost a complete elimination of MPEs and RVs and a significant but less dramatic effect on potential ADEs.

282) Privighitorita, R., Sobottka, H. G. and Lordieck, W. “Experiences with DHE: an order entry and result reporting case study” Studies in Health Technology & Informatics **45**: 74-9. (1997)

Abstract: Organization of hospital information systems that are currently in use is characterized by a multitude of simple, unfortunately less integrated components. For the integration of the already available as well as new components into a hospital information system, the "Committee European de Normalisation" (CEN) proposed a basic "Conceptual Architectural Framework". Based on the CEN proposal, in this paper

we present first results of a case study in order to investigate the usability of the Distributed Healthcare Environment (DHE), as a standard architecture for hospital information systems. Another aim of this case study was to design an Order Entry and Result Reporting System and implement it by using DHE.

283) Quinn, M. M. and Mannion, J. “Improving patient safety using interactive, evidence-based decision support tools” Joint Commission Journal on Quality & Patient Safety **31**(12): 678-83. (2005)

Abstract: BACKGROUND: Meridian Health developed interactive protocols using computerized physician order entry (CPOE), providing clinicians with a concurrent clinical decision-support tool that helps increase compliance with evidence-based guidelines. INTERACTIVE DECISION SUPPORT: Guidelines for acute myocardial infarction (AMI) were developed into interactive protocols that prompt the physician to administer aspirin and a beta-blocker at the time of admission to patients who present with suspected AMI but offer the opportunity to document contraindications instead. By March 2005 all three Meridian hospitals had implemented the AMI interactive protocol. Seventeen interactive clinical decision-support protocols are now in use across six categories of care. RESULTS: Compliance rates for the AMI guidelines increased by 10% within two months of implementation and have been at 100% in all months when the interactive protocols have been used. Meridian is also seeing a steady climb in the number of total orders physicians are placing online, increasing as much as 46% at one hospital. DISCUSSION: Meridian physicians now recognize that CPOE is a valuable tool in improving patient safety through its interactive protocols. It has also enabled Meridian to analyze usage patterns as part of its continuous process improvement methodology. CONCLUSION: The use of interactive protocols using CPOE represents an innovative approach to improving patient safety.

284) Qureshi, F. “Minimising computer script errors” Australian Family Physician **30**(4): 350. (2001)

Abstract: With increasing awareness of informatics and the advantages it can bring, more and more general practitioners are computerising their practices. Many of them are using computer packages for script writing. Invariably with the expanding repertoire, come errors in writing computer scripts and the following article sets some of the main areas in which errors occur and how to correct them. As Medical Director is the most commonly used software for writing medical scripts, it has been used as the example in showing how to write correct scripts.

285) Rabert, A. S. and Sebastian, M. M. “The future is now: implementation of a tele-intensivist program” Journal of Nursing Administration **36**(1): 49-54. (2006)

Abstract: Based on overwhelming scientific evidence, The Leapfrog Group focused on 3 practices that have tremendous potential to save lives by reducing preventable mistakes in hospitals. The authors describe these practices and how they served as a driving force to create a "virtual ICU" within a Magnet hospital network. The effort combined services of a board-certified intensivist and technological advancements in telemedicine to ensure the delivery of high-quality care to all critically ill patients throughout the network. A computerized physician-order entry system, an electronic medication administration record, an electronic documentation system, and a remote ICU were the 4 programmatic phases necessary to realize the concept. The purpose of this article is to describe the process of planning and implementing the tele-intensivist program.

286) Raschke, R. A., Gollihare, B., Wunderlich, T. A., Guidry, J. R., Leibowitz, A. I., Peirce, J. C., Lemelson, L., Heisler, M. A. and Susong, C. “A computer alert system to prevent injury from adverse drug events: development and evaluation in a community teaching hospital” JAMA **280**(15): 1317-20. (1998)

Abstract: CONTEXT: Adverse drug events (ADEs) are the most common type of iatrogenic injury occurring in hospitalized patients. Errors leading to ADEs are often due to restricted availability of information at the time of physician order writing. OBJECTIVES: To develop, implement, and evaluate a computer alert system designed to correct errors that might lead to ADEs and to detect ADEs before maximum injury occurs. DESIGN: Prospective case series. SETTING: A 650-bed community teaching hospital in Phoenix, Ariz. PATIENTS: Consecutive sample of 9306 nonobstetrical adult patients admitted during the last 6 months of 1997. INTERVENTIONS: Thirty-seven drug-specific ADEs were targeted. Our hospital information system was programmed to generate alerts in clinical situations with increased risk for ADE-related injury. A clinical system was developed to ensure physician notification of alerts. MAIN OUTCOME MEASURES: A true-positive alert was defined as one in which the physician wrote orders consistent with the alert recommendation after alert notification. RESULTS: During the 6-month study period, the alert system fired 1116 times and 596 were true-positive alerts (positive predictive value of 53%). The alerts identified opportunities to prevent patient injury secondary to ADEs at a rate of 64 per 1000 admissions. A total of 265 (44%) of the 596 true-positive alerts were unrecognized by the physician prior to alert notification. CONCLUSIONS: Clinicians can use hospital information systems to detect opportunities to prevent patient injury secondary to a broad range of ADEs.

287) Ravnan, S. L. and Ravnan, M. C. “Utilization of physician order entry to improve community-acquired pneumonia management” Pharmacotherapy **20**(3): 368. (2000)

Abstract:

288) Rich, D., Menke, J. and Fisher, D. “Dose range checking in a computer order entry system” AMIA. Annual Symposium Proceedings/AMIA Symposium **985**. (2003)

Abstract: We recently implemented a computer order entry (COE) system which uses decision support for dose range checking. In addition to providing decision support at the point of order entry via "alerts", the system tracks data regarding the occurrence of alerts related to dosing errors. We reviewed the dosing alerts for a "high risk" medications in a COE system. Telephone alerts were more likely to trigger alerts. There were more low dose than high dose alerts. Some alerts could be avoided by adjusting the threshold.

289) Richards, J. “Pandora's box: physician order entry and nursing work redesign” Canadian Journal of Nursing Leadership **13**(2): 15-9. (2000)

Abstract: The Canadian health care industry is undergoing unprecedented restructuring in response to the quest for quality management and cost reduction. Physician order entry and on-line results viewing within a fully integrated hospital clinical information system is often thought to be essential to maximum quality management, cost control, and clinical decision support. Using Hackman and Oldham's Job Characteristics model (1989) as a grounding for discussion, this author examines the impact of computerized physician order entry and on-line results viewing on the intrinsic meaning of nursing work and its subsequent redesign. This paper explores the historical meaning of nursing work related to the manual transcription of physician's orders, and contemplates the implications for future nursing work and research. Until now there has been little discussion in the current informatics literature on this topic.

290) Rind, D. M., Davis, R. and Safran, C. “Designing studies of computer-based alerts and reminders” MD Computing **12**(2): 122-126. (1995)

Abstract:

291) Ringold, D. J., Santell, J. P. and Schneider, P. J. “ASHP national survey of pharmacy practice in acute care settings: dispensing and administration--1999” American Journal of Health-System Pharmacy **57**(19): 1759-75. (2000)

Abstract: Results of the 1999 ASHP national survey of pharmacy practice in acute care settings that pertain to drug dispensing and administration practices are presented. Pharmacy directors at 1050 general and children's medical-surgical hospitals in the United States were surveyed by mail. The response rate was 51%. About three-fourths

of respondents described their inpatient pharmacy's distribution system as centralized. Of those with centralized distribution, 77.4% indicated that their system was not automated. Decentralized pharmacists were used in 29.4% of the hospitals surveyed; an average of 58.9% of their time was spent on clinical, as opposed to distributive, activities. About 67% of directors reported pharmacy computer access to hospital laboratory data, 38% reported access to automated medication-dispensing-unit data, and 19% reported computer access to hospital outpatient affiliates. Only 13% of hospitals had an electronic medication order-entry system; another 27% reported they were in the process of developing such a system. Decentralized medication storage and distribution devices were used in 49.2% of hospitals, while 7.3% used bedside information systems for medication management. Machine-readable coding was used for inpatient pharmacy dispensing by 8.2% of hospitals. Ninety percent reported a formal, systemwide committee responsible for data collection, review, and evaluation of medication errors. Virtually all respondents (98.7%) reported that their staff initiated manual reports. Only two thirds tracked these reports and reported trends to the staff. Fewer than 15% reported that staff were penalized for making or contributing to an error. Pharmacists are making a significant contribution to the safety of medication distribution and administration. The increased use of technology to improve efficiency and reduce costs will require that pharmacists continue to focus on the impact of changes on the safety of the medication-use system.

292) Rivkin, S. “Opportunities and challenges of electronic physician prescribing technology” Medical Interface **10**(8): 77-8, 83. (1997)

Abstract: The results of a six-month pilot with electronic prescribing used by 17 Health Alliance Plan (HAP) physicians are reported. All 17 practice in an IPA setting in southeastern Michigan. This critical evaluation reveals the many opportunities and various challenges that this new technology brings to the managed health care environment.

293) Rochon, P. A., Field, T. S., Bates, D. W., Lee, M., Gavendo, L., Erramuspe-Mainard, J., Judge, J. and Gurwitz, J. H. “Computerized physician order entry with clinical decision support in the long-term care setting: insights from the Baycrest Centre for Geriatric Care” Journal of the American Geriatrics Society **53**(10): 1780-9. (2005)

Abstract: Although computerized physician order entry (CPOE) has been successfully implemented in many acute care hospitals, few descriptions of its use in the long-term care (LTC) setting are available. This report describes the experiences of one LTC facility in developing and implementing a CPOE system with clinical decision support (CDS). Even when a facility has the necessary resources and "institutional will," many challenges are associated with the implementation of this application. The system was designed to meet the needs of healthcare providers in the LTC setting, in particular

by informing prescribing decisions, reducing the frequency of prescribing and monitoring errors, and reducing adverse drug event rates. Based on experience adopting this technology early, 10 insights are offered that it is hoped will assist others who are considering the implementation of CPOE systems with CDS in the LTC setting.

294) Rochon, P. A., Field, T. S., Bates, D. W., Lee, M., Gavendo, L., Erramuspe-Mainard, J., Judge, J. and Gurwitz, J. H. "Clinical application of a computerized system for physician order entry with clinical decision support to prevent adverse drug events in long-term care" CMAJ Canadian Medical Association Journal **174**(1): 52-4. (2006)

Abstract: Commentary

295) Roggow, D. J., Solie, C. J., Tracy, M. F. and Gjere, N. "Clinical nurse specialist leadership in computerized provider order entry design" Clinical Nurse Specialist **19**(4): 209-14. (2005)

Abstract: PURPOSE: The purpose of this clinical project was to design and implement a computerized provider order entry system. BACKGROUND: Well-designed clinical computer systems can advance best practice and quality decision making, leading to improvements in patient and organizational outcomes. DESCRIPTION OF THE PROJECT: An Orders Design Group composed of clinical nurse specialists (CNSs), staff nurses, and information management personnel was formed. CNSs used competencies in the system sphere to lead the integration of the needs of patients, nurses, and organizations into new technologies. OUTCOME: CNSs facilitated implementation of a collaboratively designed interdisciplinary computerized order entry process. CONCLUSION: Evaluation of the design and implementation process demonstrated greater success with the order entry system under the leadership of CNSs than past initiatives where CNSs were not in leadership roles. IMPLICATIONS FOR NURSING PRACTICE: CNS competencies in designing and implementing innovative system-level solutions are key to clinical information systems design.

296) Rosenbloom, S. T., Geissbuhler, A. J., Dupont, W. D., Giuse, D. A., Talbert, D. A., Tierney, W. M., Plummer, W. D., Stead, W. W. and Miller, R. A. "Effect of CPOE user interface design on user-initiated access to educational and patient information during clinical care" Journal of the American Medical Informatics Association **12**(4): 458-73. (2005)

Abstract: OBJECTIVE: Authors evaluated whether displaying context sensitive links to infrequently accessed educational materials and patient information via the user interface of an inpatient computerized care provider order entry (CPOE) system would

affect access rates to the materials. DESIGN: The CPOE of Vanderbilt University Hospital (VUH) included "baseline" clinical decision support advice for safety and quality. Authors augmented this with seven new primarily educational decision support features. A prospective, randomized, controlled trial compared clinicians' utilization rates for the new materials via two interfaces. Control subjects could access study-related decision support from a menu in the standard CPOE interface. Intervention subjects received active notification when study-related decision support was available through context sensitive, visibly highlighted, selectable hyperlinks. MEASUREMENTS: Rates of opportunities to access and utilization of study-related decision support materials from April 1999 through March 2000 on seven VUH Internal Medicine wards. RESULTS: During 4,466 intervention subject-days, there were 240,504 (53.9/subject-day) opportunities for study-related decision support, while during 3,397 control subject-days, there were 178,235 (52.5/subject-day) opportunities for such decision support, respectively ($p = 0.11$). Individual intervention subjects accessed the decision support features at least once on 3.8% of subject-days logged on (278 responses); controls accessed it at least once on 0.6% of subject-days (18 responses), with a response rate ratio adjusted for decision support frequency of 9.17 (95% confidence interval 4.6-18, $p < 0.0005$). On average, intervention subjects accessed study-related decision support materials once every 16 days individually and once every 1.26 days in aggregate. CONCLUSION: Highlighting availability of context-sensitive educational materials and patient information through visible hyperlinks significantly increased utilization rates for study-related decision support when compared to "standard" VUH CPOE methods, although absolute response rates were low.

297) Rosenbloom, S. T., Grande, J., Geissbuhler, A. and Miller, R. A. “Experience in implementing inpatient clinical note capture via a provider order entry system” Journal of the American Medical Informatics Association **11**(4): 310-5. (2004)

Abstract: Care providers' adoption of computer-based health-related documentation ("note capture") tools has been limited, even though such tools have the potential to facilitate information gathering and to promote efficiency of clinical charting. The authors have developed and deployed a computerized note-capture tool that has been made available to end users through a care provider order entry (CPOE) system already in wide use at Vanderbilt. Overall note-capture tool usage between January 1, 1999, and December 31, 2001, increased substantially, both in the number of users and in their frequency of use. This case report is provided as an example of how an existing care provider order entry environment can facilitate clinical end-user adoption of a computer-assisted documentation tool-a concept that may seem counterintuitive to some.

298) Rosenbloom, S. T., Talbert, D. and Aronsky, D. “Clinicians' perceptions of clinical decision support integrated into computerized provider order entry” International Journal of Medical Informatics **73**(5): 433-41. (2004)

Abstract: Computerized provider order entry systems can improve patient care by integrating clinical decision support. Decision support is most effective when its content and delivery are acceptable. The authors report the results of a multifaceted survey of the attitudes of housestaff and medical student users of a provider order entry system with integrated decision support at an academic medical center. The survey contained 16 items covering four themes: efficiency, quality of care, results reporting and embedded guidelines. Responses were captured using a five point Likert scale, and were compared using ANOVA and Bartlett's testing. Out of 491 housestaff and 128 medical students, response rates were 47 and 29%, respectively. Among respondents, 72% agreed or strongly agreed that the provider order entry system improves the quality of care that they provide, 54% that the decision support usually help them to provide quality patient care, and 62% that it improves the efficiency of order entry. Respondents were least likely to agree that the display of prior laboratory results influenced their decision to order a subsequent test. There were no significant differences between subspecialties and by advancing years of training among housestaff. Respondents agreed that the integrated clinical decision support enhanced their medical training.

299) Rothschild, A. S. and Lehmann, H. P. “Information retrieval performance of probabilistically generated, problem-specific computerized provider order entry pick-lists: a pilot study” Journal of the American Medical Informatics Association **12**(3): 322-30. (2005)

Abstract: OBJECTIVE: The aim of this study was to preliminarily determine the feasibility of probabilistically generating problem-specific computerized provider order entry (CPOE) pick-lists from a database of explicitly linked orders and problems from actual clinical cases. DESIGN: In a pilot retrospective validation, physicians reviewed internal medicine cases consisting of the admission history and physical examination and orders placed using CPOE during the first 24 hours after admission. They created coded problem lists and linked orders from individual cases to the problem for which they were most indicated. Problem-specific order pick-lists were generated by including a given order in a pick-list if the probability of linkage of order and problem (PLOP) equaled or exceeded a specified threshold. PLOP for a given linked order-problem pair was computed as its prevalence among the other cases in the experiment with the given problem. The orders that the reviewer linked to a given problem instance served as the reference standard to evaluate its system-generated pick-list. MEASUREMENTS: Recall, precision, and length of the pick-lists. RESULTS: Average recall reached a maximum of.67 with a precision of.17 and pick-list length of 31.22 at a PLOP threshold of 0. Average precision reached a maximum of.73 with a recall of.09 and pick-list length of.42 at a PLOP threshold of.9. Recall varied inversely with precision in classic information retrieval behavior. CONCLUSION: We preliminarily conclude that it is feasible to generate problem-specific CPOE pick-lists probabilistically from a database of explicitly linked orders and problems. Further research is necessary to determine the usefulness of this approach in real-world settings.

300) Rothschild, J. “Computerized physician order entry in the critical care and general inpatient setting: a narrative review” Journal of Critical Care **19**(4): 271-8. (2004)

Abstract: 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. [References: 45]

301) Rotman, B. L., Sullivan, A. N., McDonald, T., DeSmedt, P., Goodnature, D., Higgins, M., Suermondt, H. J., Young, C. Y. and Owens, D. K. “A randomized evaluation of a computer-based physician's workstation: design considerations and baseline results” Proceedings / AMIA Annual Symposium: 693-7. (1995)

Abstract: We are performing a randomized, controlled trial of a Physician's Workstation (PWS), an ambulatory care information system, developed for use in the General Medical Clinic (GMC) of the Palo Alto VA. Goals for the project include selecting appropriate outcome variables and developing a statistically powerful experimental design with a limited number of subjects. As PWS provides real-time drug-ordering advice, we retrospectively examined drug costs and drug-drug interactions in order to select outcome variables sensitive to our short-term intervention as well as to estimate the statistical efficiency of alternative design possibilities. Drug cost data revealed the mean daily cost per physician per patient was 99.3 cents +/- 13.4 cents, with a range from 0.77 cent to 1.37 cents. The rate of major interactions per prescription for each physician was 2.9% +/- 1%, with a range from 1.5% to 4.8%. Based on these baseline analyses, we selected a two-period parallel design for the evaluation, which maximized statistical power while minimizing sources of bias.

302) Saathoff, A. “Human factors considerations relevant to CPOE implementations” Journal of Healthcare Information Management **19**(3): 71-8. (2005)

Abstract: Although many studies have discussed the benefits of computerized provider order entry (CPOE), the actual number of hospitals using this technology remains low because of the many challenges that accompany the implementation of CPOE in healthcare facilities. It is common for user resistance to challenge

implementation efforts. As more hospitals undertake CPOE implementations, a solid understanding of how to foster acceptance of CPOE is necessary to reap the benefits of medical error reduction, improved quality of care, and decreased healthcare costs. The principles and practices of human factors can be used to bolster physician satisfaction and increase usability, thereby increasing the chances of success for CPOE implementation. This article reviews the recent literature regarding CPOE and human factors, discussing how the human factors principles of task analysis, interface design, and computer supported cooperative work can be utilized to promote user acceptance and enhance CPOE implementation efforts. [References: 27]

303) Sabo, D. “Clinical information system: a "gateway" to the 21st century” Nursing Administration Quarterly **21**(3): 68-75. (1997)

Abstract: This article describes the selection, design, and implementation of a clinical information system that includes order entry, results reporting, physical assessments, and critical care. The benefits of implementing this data management system such as cost savings, chart-as-you-go documentation, use of wireless technology, online quality improvement audits, and rapid data retrieval will be explained.

304) Safran, C. and Detmer, D. E. “Computerized physician order entry systems and medication errors.[comment]” Jama **294**(2): 180-1. (2005)

Abstract:

305) Sanders, D. L. and Miller, R. A. “The effects on clinician ordering patterns of a computerized decision support system for neuroradiology imaging studies” Proceedings / AMIA Annual Symposium: 583-7. (2001)

Abstract: OBJECTIVE: To evaluate the impact of computerized ordering guidelines on clinician ordering patterns for neuroradiology imaging studies of the head. DESIGN: A retrospective analysis was performed using a pre-post design. A 9-week control period was followed by an 8-week intervention period. SUBJECTS: All clinicians who placed an order for either an MRI of the brain or a CT of the head on inpatients using a computerized order entry system. METHODS: We designed, implemented, and evaluated a decision support system for the implementation of test ordering guidelines. Changes in ordering patterns were evaluated with a Chi-square analysis. RESULTS: 742 tests were ordered in the pre-intervention period, while 704 studies were ordered after the intervention. A significant change in the distribution of tests ordered resulted from the intervention (p=0.048). Changes trended toward the guideline recommendations for all tests considered. 60% of users receiving a recommendation ordered the suggested study. DISCUSSION: Our intervention successfully influenced clinician ordering patterns. Examination of detailed usage patterns may aid in further

quality improvement of both the guidelines and the decision support tool used to implement them.

306) Sands, D. Z. and Safran, C. “Closing the loop of patient care--a clinical trial of a computerized discharge medication program” Proceedings / AMIA Annual Symposium: 841-5. (1994)

Abstract: A frustrating time for hospitalized patients and their primary care providers is after discharge from the hospital, because of changes in patients' medications. We developed a computer program to improve the discharge process, by providing guidance to the physician writing the prescriptions, offering educational material to the patients, and providing electronic notification of medication changes to the primary care providers. During a one-year clinical evaluation of this system, in which use of the program was voluntary, 1000 patients were discharged through the program. House officers tended to use the program more often for patients who were older and in the hospital longer. Both house officers and primary care physicians found the program extremely useful, and the process took no longer than the manual method of creating discharge medication lists. Patients who were discharged using this program may have had better adherence to medication regimens. We conclude that computer-assisted compilation of a discharge medication list is a useful method for improving the discharge process.

307) Scalise, D. “CPOE. Secrets of success” Hospitals & Health Networks. **77**(8): 18, 20. (2003)

Abstract:

308) Scanlon, M. “Computer physician order entry and the real world: we're only humans” Joint Commission Journal on Quality & Safety **30**(6): 342-6. (2004)

Abstract: BACKGROUND: Computer physician order entry (CPOE) may have significant benefit to reducing medical errors in the hospital setting. The belief in the promise of CPOE has led organizations such as the Leap Frog Group to advocate for the implementation of CPOE in hospitals to improve patient safety. Human factors, or ergonomics, is the study of the interaction between humans and the systems and tools they use. It is unclear whether human factors principles have been applied to commercially available CPOE systems. CONCLUSIONS: CPOE's true utility for preventing medical errors and harm is largely undetermined. The evidence that exists for error reduction with CPOE is in the setting of "homegrown" systems and not commercially available products. The cases portrayed in the two scenarios described in this article were drawn from actual events to illustrate how failure to attend to human factors and human-centered design can create or facilitate errors and harm.

RECOMMENDATIONS FOR ORGANIZATIONS IN IMPLEMENTING, CPOE: Organizations implementing CPOE or considering doing so could evaluate potential systems on the basis of evidence for human-centered design. An organization interested in addressing human factors issues as they relate to CPOE might, for example, familiarize itself with the basics of human factors, usability, and with existing evaluation methods for CPOE; involve the people who do the daily work in the evaluation and selection process; and ask potential vendors how they have addressed human factors in their CPOE systems.

309) Scavuzzo, J. and Gamba, N. “Bridging the gap: the virtual chemotherapy unit” Journal of Pediatric Oncology Nursing **21**(1): 27-32. (2004)

Abstract: Due to the complexity of pediatric chemotherapy administration, systems promoting safety must be utilized. Computerized order entry has been proven to reduce errors in the ordering of chemotherapeutic agents. A task force (the Breakthrough Committee) at The Children's Hospital of Philadelphia (CHOP) evaluated systems and identified the need to streamline the chemotherapy admission process from the outpatient clinic to the inpatient unit. In the outpatient setting chemotherapy orders were handwritten, whereas inpatient orders were computerized. Patients due for chemotherapy admissions were unable to start chemotherapy until they were physically admitted to an inpatient bed. In many cases, patients would not start receiving chemotherapy until late in the evening or even overnight. The Breakthrough Committee created the Virtual Chemotherapy Unit (Virtual Unit), which standardizes the ordering and documentation for all chemotherapy admissions. As per its name, the Virtual Unit is not an actual hospital unit but merely a location in the computer system where the patient is admitted prior to having a bed on the inpatient unit. Patients are now able to start chemotherapy infusions in the outpatient setting early in the day, rather than waiting until arrival to the inpatient unit. The nurses in the outpatient clinic are able to document chemotherapy administration online, giving the inpatient staff the ability to view the medications that were given. The Virtual Unit bridges the gap in chemotherapy ordering and documentation by utilizing 1 online episode per patient admission. Oncology nurses at CHOP played a fundamental role in the creation of the Virtual Unit. Nurses identified situations with potential for error in the ordering and administration of chemotherapy. These scenarios were analyzed and used in creating a safer system.

310) Schenkel, S. “Promoting patient safety and preventing medical error in emergency departments” Academic Emergency Medicine **7**(11): 1204-22. (2000)

Abstract: An estimated 108,000 people die each year from potentially preventable iatrogenic injury. One in 50 hospitalized patients experiences a preventable adverse event. Up to 3% of these injuries and events take place in emergency departments. With long and detailed training, morbidity and mortality conferences, and an emphasis

on practitioner responsibility, medicine has traditionally faced the challenges of medical error and patient safety through an approach focused almost exclusively on individual practitioners. Yet no matter how well trained and how careful health care providers are, individuals will make mistakes because they are human. In general medicine, the study of adverse drug events has led the way to new methods of error detection and error prevention. A combination of chart reviews, incident logs, observation, and peer solicitation has provided a quantitative tool to demonstrate the effectiveness of interventions such as computer order entry and pharmacist order review. In emergency medicine (EM), error detection has focused on subjects of high liability: missed myocardial infarctions, missed appendicitis, and misreading of radiographs. Some system-level efforts in error prevention have focused on teamwork, on strengthening communication between pharmacists and emergency physicians, on automating drug dosing and distribution, and on rationalizing shifts. This article reviews the definitions, detection, and presentation of error in medicine and EM. Based on review of the current literature, recommendations are offered to enhance the likelihood of reduction of error in EM practice. [References: 127]

311) Schiff, G. D. “Computerized prescriber order entry: models and hurdles” American Journal of Health-System Pharmacy. **59**(15): 1456-60. (2002)

Abstract:

312) Schiff, G. D. and Rucker, T. D. “Computerized prescribing: building the electronic infrastructure for better medication usage” JAMA **279**(13): 1024-9. (1998)

Abstract: Computerized prescribing in the practice of medicine is a change that is overdue. Virtually all prescriptions in the United States are still handwritten. Instead, medications should be ordered on a computer interacting with 3 databases: patient drug history, scientific drug information and guideline reference, and patient-specific (weight, laboratory) data. Current problems with prescribing on which computerized prescribing could have a positive impact include (1) drug selection; (2) patient role in pharmacotherapy risk-benefit decision making; (3) screening for interactions (drug-drug, drug-laboratory, drug-disease); (4) linkages between laboratory and pharmacy; (5) dosing calculations and scheduling; (6) coordination between team members, particularly concerning patient education; (7) monitoring and documenting adverse effects; and (8) postmarketing surveillance of therapy outcomes. Computerized prescribing is an important component of clinician order entry. Development of this tool has been impeded by a number of conceptual, implementation, and policy barriers. Overcoming these constraints will require clinically and professionally guided vision and leadership.

313) Schmidek, J. M. and Weeks, W. B. “What do we know about financial returns on

investments in patient safety? A literature review" Joint Commission Journal on Quality & Patient Safety **31**(12): 690-9. (2005)

Abstract: BACKGROUND: A framework was proposed for making a business case for patient safety interventions and to evaluate whether and how thoroughly financial aspects of investments and returns have been reported. METHODS: MEDLINE was searched from inception through January 21, 2005. Articles were selected if they reported on a patient safety intervention or a patient safety related outcome within the United States and indicated that a financial or economic analysis of the intervention was an objective. RESULTS: For 165 articles, a financial or economic analysis was indicated as an objective; 36.4% used original data, 28.5% used referenced data, and 35.2% provided no analysis. Only 13 articles (7.9%) included original data on start-up costs, 45 articles (27.3%) included original data on operating expenses and benefits, and 9 articles (5.5%) provided original financial data on outcomes. Of the 165 articles, 56.4% evaluated technological methods of improving patient safety, such as adoption of computer physician order entry, 20.6% evaluated changes in processes of care, such as staffing changes, and 23% involved other types of interventions or outcomes. DISCUSSION: Few articles provided complete information on the required investment and anticipated return on patient safety interventions. Use of standard financial techniques may strengthen the business case for patient safety interventions. [References: 30]

314) Schneider, R. and LaBatt, E. P. "Computerized system for physician order entry" American Journal of Health-System Pharmacy **52**(20): 2184-6. (1995)

Abstract:

315) Schriger, D. L., Baraff, L. J., Rogers, W. H. and Cretin, S. "Implementation of clinical guidelines using a computer charting system. Effect on the initial care of health care workers exposed to body fluids" JAMA **278**(19): 1585-90. (1997)

Abstract: CONTEXT: While clinical guidelines are considered an important mechanism to improve the quality of medical care, problems with implementation may limit their effectiveness. Few empirical data exist about the effect of computer-based systems for application of clinical guidelines on quality of care. OBJECTIVE: To determine whether real-time presentation of clinical guidelines using an electronic medical record can increase compliance with guidelines. DESIGN: Prospective off-on-off, interrupted time series with intent-to-treat analysis. SETTING: University hospital emergency department. SUBJECTS: Patients were 280 health care workers (50 in the baseline control phase, 156 in the intervention phase, and 74 in the postintervention control phase) who presented for initial treatment of occupational body fluid exposures, including 89% (248/280) who sustained punctures and 81% (208/257) who were exposed to blood. Physicians included resident physicians and attending physicians working in the emergency department during the study. INTERVENTIONS:

Implementation of a computer charting system that provides real-time information regarding history and recommendations for laboratory testing, treatment, and disposition based on rules derived from clinical guidelines. MAIN OUTCOME MEASURES: Quality of care as determined by essential items documented in the medical record and in aftercare instructions, compliance with testing and treatment guidelines, and total charges and percentage of charges attributable to guideline-endorsed activities. RESULTS: Mean percent documentation of 7 essential items regarding patient history in the medical record increased from 57% during the baseline period to 98% in the intervention phase (42% increase; 95% confidence interval [CI], 34%-49%) and 11 items in aftercare instruction increased from 31 % at baseline to 93% during the intervention phase (62% increase; 95% CI, 51%-74%), but both decreased to baseline when the computer system was removed. Percent compliance with 4 laboratory testing guidelines increased from 63% at baseline to 83% during the intervention phase (20% increase; 95% CI, 9%-31 %) but decreased to 52% when the computer system was removed. Compliance with 5 treatment guidelines increased from 83% at baseline to 96% during the intervention phase (13% increase; 95% CI, 9%-17%) and decreased to 84% following the intervention. Percentage of charges incurred for indicated laboratory tests and treatment increased from 44% at baseline to 81% during the intervention phase (37% increase; 95% CI, 22%-52%) and decreased to 36% following the intervention. Average total per-patient charges were $460, $384, and $373 in each phase, respectively. CONCLUSIONS: Use of a computer-based system for clinical guidelines for management of patients with occupational exposure to body fluids improved documentation, compliance with guidelines, and percentage of charges spent on indicated activities, while decreasing overall charges. The parameters returned to baseline when the computer system was removed.

316) Schumock, G. T., Marwaha, T. R., McBride, J. M. and Clark, T. “Automated order-entry mechanisms to influence prescribing” Topics in Hospital Pharmacy Management **14**(3): 21-9. (1994)

Abstract: On-line prescribing is available in many hospitals in the United States and has distinct advantages. On-line drug prescribing can be influenced by the use of automated prompts that guide and direct the prescriber to the preferred agent, dosage, or regimen. The authors have adapted screen prompts to facilitate appropriate prescribing as defined by pharmacy and therapeutic (P&T) committee decisions, restricted drug or target drug initiatives, drug-usage evaluation (DUE) actions, departmental guidelines and order-sets, and other institutional directives. Objective evidence for the effectiveness of on-line prompts is provided for H2-antagonists and antibiotics. As computer technology advances even further and is increasingly utilized in the health care setting, on-line interventions to facilitate appropriate prescribing may become increasingly useful.

317) Schuster, D. M., Hall, S. E., Couse, C. B., Swayngim, D. S. and Kohatsu, K. Y.

"Involving users in the implementation of an imaging order entry system" Journal of the American Medical Informatics Association. **10**(4): 315-21. (2003)

Abstract: Physician order entry is a powerful function of a computerized hospital information system. Although designed to be clinician-driven, the imaging section of the order entry system may not be designed optimally to engage the clinician with imaging procedures logically organized for the clinician's typical work patterns. There also may be resistance among overburdened clinicians in having to take the time to learn a new computer system and to assume "clerk's duties" of entering imaging orders. A potential means to address clinician opposition is to cooperatively engage each clinical service in the design of an imaging order entry system with customized menus for each service. This article reports a step-by-step process for the implementation of an imaging order entry system with specialized menus for an orthopedic service. This implementation process includes (1) identification of key personnel, (2) familiarization with the system, (3) discussion and dialogue between key personnel, (4) addressing specific problems, (5) education and orientation of the target group, (6) initial implementation, (7) feedback and improvement, (8) demonstration project (time study) to foster acceptance, and (9) ongoing enhancement.

318) Seger, D. L. "Computerized POE: changing roles for the clinical pharmacist" Journal of the American Pharmaceutical Association **39**(5): 710. (1999)

Abstract:

319) Sengstack, P. P. and Gugerty, B. "CPOE systems: success factors and implementation issues" Journal of Healthcare Information Management **18**(1): 36-45. (2004)

Abstract: The medication error dilemma has come to the forefront of most hospitals' improvement agendas. The most often cited solution to the problem has been computerized provider order entry (CPOE) systems. These systems have significant potential to improve errors associated with illegibility as well as inappropriate drug use and dosing. On the other hand, CPOE system implementation is fraught with barriers that impede acceptance and use of these systems. Knowing what strategies have proven successful and what upfront analysis is required can help increase the chances of success and ultimately improve the quality of patient care.

320) Senholzi, C. and Gottlieb, J. "Pharmacist interventions after implementation of computerized prescriber order entry" American Journal of Health System Pharmacy **60**(18): 1880-2. (2003)

Abstract:

321) Shah, N. R., Seger, A. C., Seger, D. L., Fiskio, J. M., Kuperman, G. J., Blumenfeld, B., Recklet, E. G., Bates, D. W. and Gandhi, T. K. "Improving acceptance of computerized prescribing alerts in ambulatory care" Journal of the American Medical Informatics Association **13**(1): 5-11. (2006)

Abstract: Computerized drug prescribing alerts can improve patient safety, but are often overridden because of poor specificity and alert overload. Our objective was to improve clinician acceptance of drug alerts by designing a selective set of drug alerts for the ambulatory care setting and minimizing workflow disruptions by designating only critical to high-severity alerts to be interruptive to clinician workflow. The alerts were presented to clinicians using computerized prescribing within an electronic medical record in 31 Boston-area practices. There were 18,115 drug alerts generated during our six-month study period. Of these, 12,933 (71%) were noninterruptive and 5,182 (29%) interruptive. Of the 5,182 interruptive alerts, 67% were accepted. Reasons for overrides varied for each drug alert category and provided potentially useful information for future alert improvement. These data suggest that it is possible to design computerized prescribing decision support with high rates of alert recommendation acceptance by clinicians.

322) Shane, R. "Computerized physician order entry: challenges and opportunities" American Journal of Health-System Pharmacy. **59**(3): 286-8. (2002)

Abstract:

323) Shane, R. "CPOE: the science and the art" American Journal of Health System Pharmacy **15**(60(12)): 1273-6. (2003)

Abstract:

324) Shojania, K. G., Duncan, B. W., McDonald, K. M. and Wachter, R. M., Eds. (2001). Making health care safer: a critical analysis of patient safety practices. Evidence Report/Technology Assessment No. 43 (Prepared by the University of California at San Francisco-Stanford Evidence-based Practice Center under Contract No. 290-97-0013), AHRQ Publication No. 01-E058, Rockville, MD: Agency for Healthcare Research and Quality. July 2001.

Abstract: OBJECTIVES: Patient safety has received increased attention in recent years, but mostly with a focus on the epidemiology of errors and adverse events, rather than on practices that reduce such events. This project aimed to collect and critically review the existing evidence on practices relevant to improving patient safety. SEARCH STRATEGY AND SELECTION CRITERIA: Patient safety practices were defined as

those that reduce the risk of adverse events related to exposure to medical care across a range of diagnoses or conditions. Potential patient safety practices were identified based on preliminary surveys of the literature and expert consultation. This process resulted in the identification of 79 practices for review. The practices focused primarily on hospitalized patients, but some involved nursing home or ambulatory patients. Protocols specified the inclusion criteria for studies and the structure for evaluation of the evidence regarding each practice. Pertinent studies were identified using various bibliographic databases (e.g., MEDLINE, PsycINFO, ABI/INFORM, INSPEC), targeted searches of the Internet, and communication with relevant experts. DATA COLLECTION AND ANALYSIS: Included literature consisted of controlled observational studies, clinical trials and systematic reviews found in the peer-reviewed medical literature, relevant non-health care literature and "gray literature." For most practices, the project team required that the primary outcome consist of a clinical endpoint (i.e., some measure of morbidity or mortality) or a surrogate outcome with a clear connection to patient morbidity or mortality. This criterion was relaxed for some practices drawn from the non-health care literature. The evidence supporting each practice was summarized using a prospectively determined format. The project team then used a predefined consensus technique to rank the practices according to the strength of evidence presented in practice summaries. A separate ranking was developed for research priorities. MAIN RESULTS: Practices with the strongest supporting evidence are generally clinical interventions that decrease the risks associated with hospitalization, critical care, or surgery. Many patient safety practices drawn primarily from nonmedical fields (e.g., use of simulators, bar coding, computerized physician order entry, crew resource management) deserve additional research to elucidate their value in the health care environment. The following 11 practices were rated most highly in terms of strength of the evidence supporting more widespread implementation. Appropriate use of prophylaxis to prevent venous thromboembolism in patients at risk; Use of perioperative beta-blockers in appropriate patients to prevent perioperative morbidity and mortality; Use of maximum sterile barriers while placing central intravenous catheters to prevent infections; Appropriate use of antibiotic prophylaxis in surgical patients to prevent postoperative infections; Asking that patients recall and restate what they have been told during the informed consent process; Continuous aspiration of subglottic secretions (CASS) to prevent ventilator-associated pneumonia; Use of pressure relieving bedding materials to prevent pressure ulcers; Use of real-time ultrasound guidance during central line insertion to prevent complications; Patient self-management for warfarin (Coumadin) to achieve appropriate outpatient anticoagulation and prevent complications; Appropriate provision of nutrition, with a particular emphasis on early enteral nutrition in critically ill and surgical patients; and Use of antibiotic-impregnated central venous catheters to prevent catheter-related infections. CONCLUSIONS: An evidence-based approach can help identify practices that are likely to improve patient safety. Such practices target a diverse array of safety problems. Further research is needed to fill the substantial gaps in the evidentiary base, particularly with regard to the generalizability of patient safety practices heretofore tested only in limited settings and to p

325) Shojania, K. G., Yokoe, D., Platt, R., Fiskio, J., Ma'luf, N. and Bates, D. W. "Reducing vancomycin use utilizing a computer guideline: results of a randomized controlled trial" Journal of the American Medical Informatics Association **5**(6): 554-62. (1998)

Abstract: BACKGROUND: Vancomycin-resistant enterococci represent an increasingly important cause of nosocomial infections. Minimizing vancomycin use represents a key strategy in preventing the spread of these infections. OBJECTIVE: To determine whether a structured ordering intervention using computerized physician order entry that requires use of a guideline could reduce intravenous vancomycin use. DESIGN: Randomized controlled trial assessing frequency and duration of vancomycin therapy by physicians. PARTICIPANTS AND SETTING: Three hundred ninety-six physicians and 1,798 patients in a tertiary-care teaching hospital. INTERVENTION: Computer screen displaying, at the time of physician order entry, an adaptation of the Centers for Disease Control and Prevention guidelines for appropriate vancomycin use. MAIN OUTCOME MEASURES: The frequency of initiation and renewal of vancomycin therapy as well the duration of therapy prescribed on a per prescriber basis. RESULTS: Compared with the control group, intervention physicians wrote 32 percent fewer orders (11.3 versus 16.7 orders per physician; P = 0.04) and had 28 percent fewer patients for whom they either initiated or renewed an order for vancomycin (7.4 versus 10.3 orders per physician; P = 0.02). In addition, the duration of vancomycin therapy attributable to physicians in the intervention group was 36 percent lower than the duration of therapy prescribed by control physicians (26.5 versus 41.2 days; P = 0.05). Analysis of pharmacy data confirmed a decrease in the overall hospital use of intravenous vancomycin during the study period. CONCLUSION: Implementation of a computerized guideline using physician order entry decreased vancomycin use. Computerized guidelines represent a promising tool for changing prescribing practices.

326) Shortliffe, E. H. "CPOE and the facilitation of medication errors" Journal of Biomedical Informatics **38**(4): 257-258. (2005)

Abstract:

327) Shu, K., Boyle, D., Spurr, C., Horsky, J., Heiman, H., O'Connor, P., Lepore, J. and Bates, D. W. "Comparison of time spent writing orders on paper with computerized physician order entry" Medinfo **10**(Pt 2): 1207-11. (2001)

Abstract: Computerized physician order entry (CPOE) has been shown to improve quality, and to reduce resource utilization, but most available data suggest that it takes longer to enter orders using CPOE. We had previously implemented a CPOE system, and elected to evaluate its impact on physician time in the new setting. To do this, we performed a prospective study using random reminder methodology. Key findings were that interns spent 9.0% of their time ordering with CPOE, compared to 2.1% before, although CPOE saved them an additional 2% of time, so that the net difference was 5%

of their total time. However, this is counterbalanced by decreased time for other personnel such as nursing and pharmacy, and by the quality and efficiency changes. We conclude that while CPOE has many benefits, it represents a major process change, and organizations must factor this in when they implement it.

328) Sittig, D. and Stead, W. “Snap-shot of CHIME: physician order entry” Healthcare Informatics **11**(10): 38. (1994)

Abstract:

329) Sittig, D. F., Krall, M., Kaalaas-Sittig, J. and Ash, J. S. “Emotional aspects of computer-based provider order entry: a qualitative study” Journal of the American Medical Informatics Association **12**(5): 561-7. (2005)

Abstract: OBJECTIVES: Computer-based provider order entry (CPOE) systems are implemented to increase both efficiency and accuracy in health care, but these systems often cause a myriad of emotions to arise. This qualitative research investigates the emotions surrounding CPOE implementation and use. METHODS: We performed a secondary analysis of several previously collected qualitative data sets from interviews and observations of over 50 individuals. Three researchers worked in parallel to identify themes that expressed emotional responses to CPOE. We then reviewed and classified these quotes using a validated hierarchical taxonomy of semantically homogeneous terms associated with specific emotions. RESULTS: The implementation and use of CPOE systems provoked examples of positive, negative, and neutral emotions. Negative emotional responses were the most prevalent, by far, in all the observations. CONCLUSION: Designing and implementing CPOE systems is difficult. These systems and the implementation process itself often inspire intense emotions. If designers and implementers fail to recognize that various CPOE features and implementation strategies can increase clinicians' negative emotions, then the systems may fail to become a routine part of the clinical care delivery process. We might alleviate some of these problems by designing positive feedback mechanisms for both the systems and the organizations.

330) Sittig, D. F., Kuperman, G. J. and Fiskio, J. “Evaluating Physician Satisfaction Regarding User Interactions with an Electronic Medical Record System” Proceedings / AMIA Annual Symposium: 400-404. (1999)

Abstract: A limiting factor in realizing the full potential of electronic medical records (EMR) is physician reluctance to use these applications. There have been very few formal usability studies of experienced physician users of EMRs in routine clinical use. We distributed the Questionnaire for User Interaction Satisfaction (QUIS) to 75 primary care physicians who routinely use the Brigham and Women's Integrated Computing

System (BICS). BICS scored highest in the area of screen design and lowest in the area of system capability. Overall user satisfaction was most highly correlated with screen design and layout, and surprisingly not with system response time. Human-computer interaction studies can help focus our design efforts as we strive to increase clinician usage of information technology.

331) Siwicki, B. “Electronic prescriptions: just what the doctor ordered” Health Data Management **3**(10): 62-8. (1995)

Abstract: Electronic prescription systems address many of the ills in the current paper-based system of getting drug orders from physicians to pharmacies. This new automation application shows tremendous potential for saving time and money and reducing the chance for medication errors. But many hurdles must be overcome before electronic prescribing is widely used.

332) Solomon, D. H., Shmerling, R. H., Schur, P. H., Lew, R., Fiskio, J. and Bates, D. W. “A computer based intervention to reduce unnecessary serologic testing” Journal of Rheumatology **26**(12): 2578-84. (1999)

Abstract: OBJECTIVE: Laboratory testing is important in the evaluation of patients with possible systemic rheumatic disease, but uncritical use of any test may result in misleading information and unnecessary costs. We attempted to reduce the number of unnecessary antinuclear antibody, rheumatoid factor, and complement level tests ordered by house officers at a large teaching hospital, where inpatient orders are written through a computer based order entry system. METHODS: We conducted a prospective cohort study of an interactive test ordering program. The intervention consisted of displaying post-test probability estimates during the usual physician order entry session. These estimates were based on pretest probabilities entered by the ordering physician and sensitivities and specificities derived from a literature review. Another group of test orders did not prompt the intervention and were considered controls. The outcome of interest was the percentage of tests canceled in the intervention group versus the control group. RESULTS: Eleven percent (11/99) of intervention orders were canceled, versus only one order among 236 controls ($p = 0.001$). However, there was no association between the physicians' pretest probability estimates and whether test orders were canceled ($p = 0.59$). Additionally, 43 of the 335 orders (13%) yielded positive tests, but only 4 patients (1%) were given new diagnoses of rheumatic disease. CONCLUSION: The computer based intervention significantly reduced orders for antinuclear antibody and rheumatoid factor levels by 10%. Further reductions without clinical harm are probably possible, since the yield of testing for new rheumatic diseases was low.

333) Soulliard, D., Hong, M. and Saubermann, L. “Development of a pharmacy-managed medication dictionary in a newly implemented computerized prescriber order-entry system” American Journal of Health System Pharmacy **61**(6): 617-22. (2004)

Abstract:

334) Spencer, D. C., Leininger, A., Daniels, R., Granko, R. P. and Coeytaux, R. R. “Effect of a computerized prescriber-order-entry system on reported medication errors” American Journal of Health System Pharmacy **62**(4): 416-9. (2005)

Abstract:

335) Stablein, D., Welebob, E., Johnson, E., Metzger, J., Burgess, R. and Classen, D. C. “Understanding hospital readiness for computerized physician order entry” Joint Commission Journal on Quality & Safety. **29**(7): 336-44. (2003)

Abstract: BACKGROUND: Many hospitals in the United States are in early stages of decision making and planning to implement computerized physician order entry (CPOE) to improve patient safety and quality of care. The targeted processes and the software for CPOE are complex, and implementation is a large-scale change effort for most hospitals. Hospitals can increase the likelihood of success by understanding and addressing gaps in CPOE readiness. ASSESSING CPOE READINESS: A CPOE readiness assessment tool was developed that includes several different components: external environment; organizational leadership, structure, and culture; care standardization, order management; access to information; information technology composition; and infrastructure. The presence or absence of these indicators in a particular hospital was determined by on-site interviews, walkarounds with direct observations, and document review. RESULTS: Assessment results for the first 17 hospitals (bed size, 75-906 beds) indicated that the lowest average component score was in care standardization, while the highest average component score was in organizational structure and function. Organizational culture and the order management process also had low average scores. CONCLUSIONS: This CPOE readiness assessment revealed significant gaps in all the hospitals examined. Identifying these gaps and addressing them before CPOE implementation can reduce risks. Organizations need to develop expertise at accomplishing and sustaining change; understanding and building CPOE readiness is an important first step.

336) Stair, T. O. and Howell, J. M. “Effect on medical education of computerized physician order entry” Academic Medicine **70**(6): 543. (1995)

Abstract:

337) Stavri, P. Z. and Ash, J. S. “Does failure breed success: narrative analysis of stories about computerized provider order entry” International Journal of Medical Informatics **72**(1-3): 9-15. (2003)

Abstract: OBJECTIVE: To assess the definitions of success and failure as defined by the participants of the Menucha Consensus Conference on Computerized Provider Order Entry (CPOE). DESIGN: Thirteen experts from various fields participated in Menucha Consensus Conference. Though they belonged to different fields, all of them had some kind of experience in CPOE implementation. MEASUREMENTS: The stories of these experts were analyzed using a constant comparison method and partially ordered display. RESULTS: Each participant told a success and a failure story. Definitions of success and failure, as well as variables contributing to the success and failure of CPOE implementations, were extracted from the transcripts. CONCLUSION: Analysis reveals that what is considered a failure is context dependent and that it often is an antecedent to success.

338) Strohecker, S. “Medication management. Polished automation tools allow patient safety to shine” Nursing Management **2003 Dec; 34**(12): 34. (2003)

Abstract: Follow the impact of computerized provider order entry on an acute care team.

339) Sugden, B. and Wilson, R. “Integrated care and electronic transmission of prescriptions: experience of the evaluation of ETP pilots” Health Informatics Journal **10**(4): 277-90. (2004)

Abstract: The NHS Care Records Service will connect more than 30,000 GPs and 270 acute, community and mental health NHS trusts in a single, secure national system. This will support electronic transmission of prescriptions (ETP) to pharmacies linked to the NHS Care Records Service spine and also to the national Prescription Pricing Authority (PPA). This article reflects on the experience of evaluating three pilot implementations of ETP in England in 2002, and concludes that some evaluation findings may be relevant not only to ETP messaging but also to electronic health record (EHR) systems and hence to the broader implications of implementing the NHS Care Records Service. (C) 2004 SAGE Publications Ltd.

340) Tamblyn, R., Huang, A., Kawasumi, Y., Bartlett, G., Grad, R., Jacques, A., Dawes, M., Abrahamowicz, M., Perreault, R., Taylor, L., Winslade, N., Poissant, L. and Pinsonneault, A. “The development and evaluation of an integrated electronic prescribing and drug management system for primary care” Journal of the American Medical Informatics Association **13**(2): 148-59. (2006)

Abstract: OBJECTIVE: To develop and evaluate the acceptability and use of an integrated electronic prescribing and drug management system (MOXXI) for primary care physicians. DESIGN: A 20-month follow-up study of MOXXI (Medical Office of the XXIst Century) implementation in 28 primary care physicians and 13,515 consenting patients. MEASUREMENT: MOXXI was developed to enhance patient safety by integrating patient demographics, retrieving active drugs from pharmacy systems, generating an automated problem list, and providing electronic prescription, stop order, automated prescribing problem alerts, and compliance monitoring functions. Evaluation of technical performance, acceptability, and use was conducted using audit trails, questionnaires, standardized tasks, and information from comprehensive health insurance databases. RESULTS: Perceived improvements in continuity of care and professional autonomy were associated with physicians' expected use of MOXXI. Physician speed in using MOXXI improved substantially in the first three months; however, only the represcribing function was faster using MOXXI than by handwritten prescription. Physicians wrote electronic prescriptions in 36.9 per 100 visits and reviewed the patient's drug profile in 12.6 per 100 visits. Physicians rated printed prescriptions, the current drug list, and the represcribing function as the most beneficial aspects of the system. Physicians were more likely to use the drug profile for patients who used more medication, made more emergency department visits, had more prescribing physicians, and lower continuity of care. CONCLUSION: Primary care physicians believed an integrated electronic prescribing and drug management system would improve continuity of care, and they were more likely to use the system for patients with more complex, fragmented care.

341) Tang, P. C., LaRosa, M. P., Newcomb, C. and Gorden, S. M. “Measuring the Effects of Reminders for Outpatient Influenza Immunizations at the Point of Clinical Opportunity” J Am Med Inform Assoc **6**(2): 115-121. (1999)

Abstract: Objective: To evaluate the influence of computer-based reminders about influenza vaccination on the behavior of individual clinicians at each clinical opportunity. Design: The authors conducted a prospective study of clinicians' influenza vaccination behavior over four years. Approximately one half of the clinicians in an internal medicine clinic used a computer-based patient record system (CPR users) that generated computer-based reminders. The other clinicians used traditional paper records (PR users). Measurements: Each nonacute visit by a patient eligible for an influenza vaccination was considered an opportunity for intervention. Patients who had contraindications for vaccination were excluded. Compliance with the guideline was defined as documentation that a clinician ordered the vaccine, counseled the patient about the vaccine, offered the vaccine to a patient who declined it, or verified that the patient had received the vaccine elsewhere. The authors calculated the proportion of opportunities on which each clinician documented action in the CPR and PR user groups. Results: The CPR and PR user groups had different baseline compliance rates (40.1 and 27.9 per cent, respectively; $P < 0.05$). Both rates remained stable during a two-year baseline period ($P = 0.34$ and $P = 0.47$, respectively). The compliance rates in

the CPR user group increased 78 per cent from baseline (P < 0.001), whereas the rates for the PR user group did not change significantly (P = 0.18). Conclusions: Clinicians who used a CPR with reminders had higher rates of documentation of compliance with influenza-vaccination guidelines than did those who used a paper record. Measurements of individual clinician behavior at the point of each clinical opportunity can provide precise evaluation of interventions that are designed to improve compliance with guidelines.

342) Taylor, L. K. and Tamblyn, R. "Reasons for physician non-adherence to electronic drug alerts" Medinfo **11**(Pt 2): 1101-5. (2004)

Abstract: CONTEXT: Many adverse drug errors may be prevented through electronic order entry systems that provide decision support to physicians by screening prescriptions for dosing errors, drug-disease, drug-allergy and drug-drug interactions. The adherence to such decision aids is varied and the reasons for this variance not well understood. OBJECTIVE: To assess the feasibility and performance auto-mated drug alerts within an electronic decision support system for physician prescribing. METHODS: Drug alert data were collected from a pilot project with 30 participating general practitioners who were provided with interactive electronic prescription capabilities through a personal digital assistant (PDA). RESULTS: 66,642 electronic prescriptions resulted in a total of 1,869 drug alerts. The most common alert types were analysed, along with reasons for non-adherence to automated drug alerts. CONCLUSIONS: Non-adherence to alert information appears to be associated with additional knowledge of the clinical situation, beyond that inherent in the decision support tool, for the specific patient context. Further work is required to understand how best to provide this type of support to physicians.

343) Taylor, R., Manzo, J. and Sinnett, M. "Quantifying value for physician order-entry systems: a balance of cost and quality" Healthcare Financial Management. **56**(7): 44-8. (2002)

Abstract: Healthcare CFOs commonly demand hard data to prove that an investment in computerized physician order entry (CPOE) will be worthwhile. However, a balanced analysis of cost and quality of the CPOE system has advantages over traditional return-on-investment appraisals. Montefiore Medical Center (MMC), Bronx, New York, assessed the value of its CPOE system by quantifying cost and quality measures rather than relying solely on dollar returns. MMC collected process times for medication ordering before and after the CPOE system was introduced and demonstrated that the use of CPOE increased medication ordering efficiency by 92 percent. MMC calculated additional process times for ward clerks, nurses, and pharmacists before and after CPOE implementation and determined the time saved per employee. From that number, the dollars potentially saved per employee and total potential dollar value of time savings per year were calculated.

344) Teich, J. M., Glaser, J. P., Beckley, R. F., Aranow, M., Bates, D. W., Kuperman, G. J., Ward, M. E. and Spurr, C. D. “The Brigham integrated computing system (BICS): advanced clinical systems in an academic hospital environment” International Journal of Medical Informatics **54**(3): 197-208. (1999)

Abstract: The Brigham integrated computing system (BICS) provides nearly all clinical, administrative, and financial computing services to Brigham and Women's Hospital, an academic tertiary-care hospital in Boston. The BICS clinical information system includes a very wide range of data and applications, including results review, longitudinal medical records, provider order entry, critical pathway management, operating-room dynamic scheduling, critical-event detection and altering, dynamic coverage lists, automated inpatient summaries, and an online reference library. BICS design emphasizes direct physician interaction and extensive clinical decision support. Impact studies have demonstrated significant value of the system in preventing adverse events and in saving costs, particularly for medications.

345) Teich, J. M., Merchia, P. R., Schmiz, J. L., Kuperman, G. J., Spurr, C. D. and Bates, D. W. “Effects of computerized physician order entry on prescribing practices” Archives of Internal Medicine **160**(18): 2741-7. (2000)

Abstract: BACKGROUND: Computerized order entry systems have the potential to prevent errors, to improve quality of care, and to reduce costs by providing feedback and suggestions to the physician as each order is entered. This study assesses the impact of an inpatient computerized physician order entry system on prescribing practices. METHODS: A time series analysis was performed at an urban academic medical center at which all adult inpatient orders are entered through a computerized system. When physicians enter drug orders, the computer displays drug use guidelines, offers relevant alternatives, and suggests appropriate doses and frequencies. RESULT: For medication selection, use of a computerized guideline resulted in a change in use of the recommended drug (nizatidine) from 15.6% of all histamine(2)-blocker orders to 81.3% (P<.001). Implementation of dose selection menus resulted in a decrease in the SD of drug doses by 11% (P<.001). The proportion of doses that exceeded the recommended maximum decreased from 2.1% before order entry to 0.6% afterward (P<.001). Display of a recommended frequency for ondansetron hydrochloride administration resulted in an increase in the use of the approved frequency from 6% of all ondansetron orders to 75% (P<.001). The use of subcutaneous heparin sodium to prevent thrombosis in patients at bed rest increased from 24% to 47% when the computer suggested this option (P<.001). All these changes persisted at 1- and 2-year follow-up analyses. CONCLUSION: Computerized physician order entry is a powerful and effective tool for improving physician prescribing practices.

346) Teich, J. M., Osheroff, J. A., Pifer, E. A., Sittig, D. F., Jenders, R. A. and The, C. D. S. E. R. P. “Clinical decision support in electronic prescribing: recommendations and an action plan: report of the joint clinical decision support workgroup.[see comment]” Journal of the American Medical Informatics Association **12**(4): 365-76. (2005)

Abstract: Clinical decision support (CDS) in electronic prescribing (eRx) systems can improve the safety, quality, efficiency, and cost-effectiveness of care. However, at present, these potential benefits have not been fully realized. In this consensus white paper, we set forth recommendations and action plans in three critical domains: (1) advances in system capabilities, including basic and advanced sets of CDS interventions and knowledge, supporting database elements, operational features to improve usability and measure performance, and management and governance structures; (2) uniform standards, vocabularies, and centralized knowledge structures and services that could reduce rework by vendors and care providers, improve dissemination of well-constructed CDS interventions, promote generally applicable research in CDS methods, and accelerate the movement of new medical knowledge from research to practice; and (3) appropriate financial and legal incentives to promote adoption.

347) Teich, J. M., Schmiz, J. L., O'Connell, E. M., Fanikos, J., Marks, P. W. and Shulman, L. N. “An information system to improve the safety and efficiency of chemotherapy ordering” Proceedings / AMIA Annual Symposium: 498-502. (1996)

Abstract: We developed a computer application to support the ordering of chemotherapy. Key goals were to guard against errors in chemotherapy ordering and dosing, to, coordinate the outpatient and inpatient chemotherapy services, and to support the overall process flow of a chemotherapy cycle. In a six-month period, 512 daily-dose and 386 weekly-dose warnings were generated; 167 (19%) resulted in a cancellation or re-evaluation of the dose. The system has been well accepted, and has helped to coordinate the efforts of the many members of the oncology care team.

348) Teich, J. M., Spurr, C. D., Flammini, S. J., Schmiz, J., Beckley, R. F., Hurley, J. F., Aranow, M. and Glaser, J. P. “Response to a trial of physician-based inpatient order entry” Proceedings / AMIA Annual Symposium: 316-20. (1993)

Abstract: Our group has developed a physician-operated inpatient order-entry system (BICS-OE). Mindful of the problems inherent in bringing a radical cultural change such as this to the hospital, we conducted two pilots of the system prior to its full implementation. Physicians and nurses both identified a number of benefits from the use of OE. Physicians reported a number of areas where OE use was difficult or could be improved; nurses reported fewer problems. Based on the pilot trials, we modified the

interface and some data constructs. These changes have enhanced the usefulness of OE in patient care in our hospital, and can serve as a model to others developing order entry.

349) Teich, J. M., Spurr, C. D., Schmiz, J. L., O'Connell, E. M. and Thomas, D. "Enhancement of clinician workflow with computer order entry" Proceedings / AMIA Annual Symposium: 459-63. (1995)

Abstract: Physician-operated order entry systems can bring great benefits to an institution. Such systems can improve the consistency, accuracy, safety, and cost-effectiveness of orders. When building or selecting order entry for an institution, consideration must be given to the many different scenarios in which orders are written and communicated. Transfer, post-op, pre-admission and discharge orders have different communication requirements from standard inpatient orders. In certain services, orders from a very limited set (such as warfarin orders) must be written frequently for a large number of patients. Intensive-care patients, chemotherapy patients, and others have particular requirements for ordering. A computerized order entry system should respond to these requirements in order to promote correct and efficient ordering. We present a number of these issues, their specific requirements, and the approach we have taken to ensure that the system both supports and enhances workflow.

350) Teich, J. M. and Wrinn, M. M. "Clinical decision support systems come of age" MD Computing. **17**(1): 43-6. (2000)

Abstract:

351) Thompson, W., Dodek, P. M., Norena, M. and Dodek, J. "Computerized physician order entry of diagnostic tests in an intensive care unit is associated with improved timeliness of service" Critical Care Medicine **32**(6): 1306-9. (2004)

Abstract: 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.

352) Thornton, P. D., Simon, S. and Mathew, T. H. “Towards safer drug prescribing, dispensing and administration in hospitals” Journal of Quality in Clinical Practice **19**(1): 41-5. (1999)

Abstract: A multidisciplinary workshop was held in order to identify strategies likely to produce a reduction in adverse drug events, by targeting hospital systems involved in drug prescribing, dispensing and administration. Strategies identified at the workshop included: (i) improving the education and practice development of medical and nursing staff, concerning drug therapy and safe prescribing principles; (ii) introducing and using information technology and electronic prescribing processes; (iii) implementing the Australian Pharmaceutical Advisory Council (APAC) national guidelines to achieve the continuum of quality use of medicines between hospitals and the community; (iv) enhancing the importance of medication history taking as a routine part of the admission process; (v) instituting individual patient supply as the standard method of drug distribution in hospitals; and (vi) stimulating the hospital-based clinical pharmacy workforce.

353) Thull, B., Janssens, U., Rau, G. and Hanrath, P. “Approach to computer-based medication planning and coordination support in intensive care units” Technology & Health Care **5**(3): 219-33. (1997)

Abstract: Due to more and more complex diagnosis and therapy measures, the critical care of patients requires an extensive work organisation which comprises patient, doctors, nurses and external services (e.g., central laboratory). In this organisation, the documentation plays a major role for the planning and coordination of work procedures and information flow within the medical staff. Various studies in intensive care units (ICU) reveal that the complex work organisation and the related information flow are faulty. Breakdowns are often caused by a lack of coordination between doctors and nurses and by poor transparency of work procedures. A typical example is the incorrect application of a doctor's medication orders by a nurse because she might have overseen a plan modification. This intransparency increases the strain on the medical staff and might result in critical effects on the patient. One approach to design a computer support for medication planning as well as the coordination when executing medication plans is given by work flow models. This paper shows that work flow models could be used to improve deficiencies in medication planning and coordination. Furthermore, it is demonstrated how such a support can be mediated to the user through an appropriately designed user interface.

354) Tierney, W. M., Overhage, J. M., McDonald, C. J. and Wolinsky, F. D. “Medical students' and housestaff's opinions of computerized order-writing” Academic Medicine **69**(5): 386-9. (1994)

Abstract: BACKGROUND. Greater use of computers has been touted as one way in which health care quality can be enhanced while reducing costs. The authors assessed factors associated with acceptance of computerized order-writing. METHOD. From April 1990 through October 1991 a survey was administered to 275 medical students and housestaff who used computer workstations to write all their orders on the general medicine wards at Wishard Memorial Hospital. The survey assessed computer literacy, ease of workstation use, effects on practice and time management, and usefulness of information provided. RESULTS. A total of 212 (77%) of the computer-workstation users responded. Opinions were generally positive. Those of junior students were the most positive, with opinions declining progressively for senior students, interns, and residents. The housestaff were most critical of time spent using the workstations, although they required less time to write orders than the students did. CONCLUSION. The favorableness of the respondents' opinions declined as the level of training increased, a trend that was independent of computer literacy. Hence, increasing computer use by physicians will probably require modification of the educational and socialization process rather than mere reliance on increasing computer literacy.

355) Travers, D. “Order entry and results reporting” Topics in Emergency Medicine **17**(4): 64-73. (1995)

Abstract: Computerized order entry (OE) and clinical results reporting (RR) have the potential to improve the efficiency of clinical order processing, access to clinical results, and the timeliness of charge capture. Enhancements to basic OE and RR systems can enhance data accessibility from multiple clinical information systems, and even aid in clinical decision making. A comprehensive plan for OE includes planning, analysis, design, testing, and training. The amount of time and resources necessary to computerize OE and RR processes varies among hospitals and may take considerably longer in large, complex organizations such as teaching hospitals.

356) Travers, D. A. and Downs, S. M. “Comparing the User Acceptance of a Computer System in Two Pediatric Offices: A Qualitative Study.” Proceedings / AMIA Annual Symposium: 853-857. (2000)

Abstract:

357) Upperman, J. S., Staley, P., Friend, K., Benes, J., Dailey, J., Neches, W. and Wiener, E. S. “The introduction of computerized physician order entry and change management in a tertiary pediatric hospital” Pediatrics **116**(5): e634-42.

(2005)

Abstract: OBJECTIVES: The objectives of this review were to document the introduction of computerized physician order entry (CPOE)-centered changes in an academic tertiary care center and to review the CPOE-focused literature. DESIGN: We performed a systematic literature review of CPOE-related articles indexed on Medline, with particular emphasis on pediatric applications. We focused our commentary around the concepts involved in the implementation process at a tertiary pediatric hospital. RESULTS: In 2001, the Children's Hospital of Pittsburgh (CHP) embarked on the process of CPOE design and implementation. We determined that CPOE is a tool for improving pediatric care. The CPOE implementation process is more than a technologic change; it involves an organizational cultural transformation. Although the complete transition to CPOE was little more than 1 year ago, CHP has overcome the typical obstacles of CPOE implementation to begin to realize its many benefits. The early success of CHP was achieved by creating a realistic, positive, work environment, which fostered hospital-wide participation and integration. CONCLUSION: CPOE is an invaluable resource for supporting patient safety in health care settings. The successful implementation of CPOE requires a paradigm shift in hospital policies and processes.

358) Valenstein, P. and Meier, F. “Outpatient order accuracy. A College of American Pathologists Q-Probes study of requisition order entry accuracy in 660 institutions” Archives of Pathology & Laboratory Medicine **123**(12): 1145-50. (1999)

Abstract: CONTEXT: Laboratory test order entry errors potentially delay diagnosis, consume resources, and cause patient inconvenience. OBJECTIVE: To evaluate the frequency and causes of computer order entry errors in outpatients. DESIGN: Cross-sectional survey and prospective sample of errors. Participants answered questions about their test order entry policies and practices. They then examined a sample of outpatient requisitions and compared information on the requisition with information entered into the laboratory computer system. Order entry errors were divided into 4 types: tests ordered on the requisition, but not in the computer; tests performed but not ordered on the requisition; physician name discrepancies; and test priority errors. PARTICIPANTS: Six hundred sixty laboratories enrolled in the College of American Pathologists Q-Probes program. MAIN OUTCOME MEASURE: Overall order entry error rate. RESULTS: A total of 5514 (4.8%) of 114 934 outpatient requisitions were associated with at least 1 order entry error. The median participant reported 1 or more order errors on 6.0% of requisitions; 10% of institutions reported errors with at least 18% of requisitions. Of the 4 specific error types, physician name discrepancies had the highest error rate, and test priority errors the lowest error rate. Four institutional factors were significantly associated with higher overall error rates: orders verbally communicated to the laboratory; no policy requiring laboratory staff to compare a printout or display of ordered tests with the laboratory requisitions to confirm that orders had been entered correctly; failure to monitor the accuracy of outpatient order entry on a regular basis; and a higher percentage of occupied beds (ie, a busier hospital).

CONCLUSIONS: Computer order entry errors are common, involving 5% of outpatient requisitions. Laboratories may be able to decrease error rates by regularly monitoring the accuracy of order entry, substituting written and facsimile orders for verbal orders, and instituting a policy in which orders entered into computer systems are routinely rechecked against orders on requisitions.

359) van den Bemt, P. M., Egberts, T. C., de Jong-van den Berg, L. T. and Brouwers, J. R. “Drug-related problems in hospitalised patients” Drug Safety **22**(4): 321-33. (2000)

Abstract: Drug-related problems include medication errors (involving an error in the process of prescribing, dispensing, or administering a drug, whether there are adverse consequences or not) and adverse drug reactions (any response to a drug which is noxious and unintended, and which occurs at doses normally used in humans for prophylaxis, diagnosis or therapy of disease, or for the modification of physiological function). Furthermore, adverse drug events can be defined as an injury--whether or not causally-related to the use of a drug. Drug-related problems are relatively common in hospitalised patients and can result in patient morbidity and mortality, and increased costs. In order to get an overview of studies on drug-related problems in hospitalised patients, with specific attention to the incidence of drug-related problems and their costs, to the possibilities of prevention and to the effect of these interventions, we performed a literature search. Incidences of medication errors reported in studies vary widely. The range of reported incidences of adverse drug reactions is even wider. These wide ranges can be largely explained by the different study methods and definitions used. Problems related to drug therapy may be averted by preventive interventions. Several possibilities for prevention exist, especially for the prevention of medication errors. Prescribing, transcription and interpretation errors can be reduced by using computerised physician order entry. Together with the use of automated dispensing systems and bar-code technology, this will aid in the reduction of both dispensing and administration errors. Education of nursing staff involved in the process of drug distribution is another important measure for preventing medication errors. Finally, the introduction of systems for the early detection of adverse drug reactions may help to reduce problems related to drug therapy. Identifying risk factors that contribute to the development of adverse drug reactions, may aid in the prevention of these reactions. [References: 89]

360) van der Kam, W. J., Meyboom de Jong, B., Tromp, T. F., Moorman, P. W. and van der Lei, J. “Effects of electronic communication between the GP and the pharmacist. The quality of medication data on admission and after discharge” Family Practice **18**(6): 605-9. (2001)

Abstract: BACKGROUND: When a patient is admitted to a hospital, the need for information about the medications prescribed is an important issue. OBJECTIVES: Our

aim was to assess whether electronic communication between the GP and the pharmacist provides better information regarding current medication when a patient is admitted to the hospital than paper-based communication. METHODS: A prospective study was carried out whereby on the day of admission and 10 days after discharge, three different data collectors independently asked the patient, the GP and the pharmacist details of the patient's current medication. Five GPs and a local pharmacy relying on electronic communication, and five GPs and a local pharmacy relying on paper-based communication were studied. RESULTS: A total of 139 patients were included on the first day of their admission, and 116 on the tenth day after discharge. Of the 275 drugs that the patient, the GP and/or the pharmacist reported on admission in the electronic group, 134 (49%) were reported by the patient, the GP and the pharmacist, and 79 (29%) were not reported by the patient. For the paper group, these figures were 340 drugs on admission, of which 107 (31%) were reported by the patient, the GP and the pharmacist, while 130 (38%) were not reported by the patient. CONCLUSIONS: We conclude that electronic communication between the GP and the community pharmacist results in a better agreement between them with respect to the current medication of the patient than paper-based communication. However, electronic communication does not suffice as a solution to obtain reliable information.

361) van der Sijs, H., Aarts, J., Vulto, A. and Berg, M. “Overriding of drug safety alerts in computerized physician order entry” Journal of the American Medical Informatics Association **13**(2): 138-47. (2006)

Abstract: Many computerized physician order entry (CPOE) systems have integrated drug safety alerts. The authors reviewed the literature on physician response to drug safety alerts and interpreted the results using Reason's framework of accident causation. In total, 17 papers met the inclusion criteria. Drug safety alerts are overridden by clinicians in 49% to 96% of cases. Alert overriding may often be justified and adverse drug events due to overridden alerts are not always preventable. A distinction between appropriate and useful alerts should be made. The alerting system may contain error-producing conditions like low specificity, low sensitivity, unclear information content, unnecessary workflow disruptions, and unsafe and inefficient handling. These may result in active failures of the physician, like ignoring alerts, misinterpretation, and incorrect handling. Efforts to improve patient safety by increasing correct handling of drug safety alerts should focus on the error-producing conditions in software and organization. Studies on cognitive processes playing a role in overriding drug safety alerts are lacking.

362) Villella, R. “Lab connections. Allina Laboratories, Minneapolis” Healthcare Informatics **17**(10): 119-20. (2000)

Abstract: PROBLEM: Need for a flexible system to handle lab order entry and results reporting that could roll out quickly to numerous clinics and hospitals. SOLUTION:

Implementation of a Web-based lab ordering and results management information system. RESULTS: Increased efficiency, decreased test duplication, reduced misinformation and errors, improved user satisfaction. KEYS TO SUCCESS: Inclusion of clinic clients and lab staff in the program's development and ongoing communication with them to see that their needs continue to be met.

363) Walton, R. T., Gierl, C., Yudkin, P., Mistry, H., Vessey, M. P. and Fox, J. “Evaluation of computer support for prescribing (CAPSULE) using simulated cases” BMJ **315**(7111): 791-795. (1997)

Abstract: Objective: To evaluate the potential effect of computer support on general practitioners' prescribing, and to compare the effectiveness of three different support levels. Design: Crossover experiment with balanced block design. Subjects: Random sample of 50 general practitioners (42 agreed to participate) from 165 in a geographically defined area of Oxfordshire. Interventions: Doctors prescribed for 36 simulated cases constructed from real consultations. Levels of computer support were control (alphabetical list of drugs), limited support (list of preferred drugs), and full support (the same list with explanations available for suggestions). Main outcome measures: Percentage of cases where doctors ignored a cheaper, equally effective drug; prescribing score (a measure of how closely prescriptions matched expert recommendations); interview to elicit doctors' views of support system. Results: Computer support significantly improved the quality of prescribing. Doctors ignored a cheaper, equally effective drug in a median 50% (range 25%-75%) of control cases, compared with 36% (8%-67%) with limited support and 35% (0-67%) with full support (P

364) Wang, J. K., Shabot, M. M., Duncan, R. G., Polaschek, J. X. and Jones, D. T. “A clinical rules taxonomy for the implementation of a computerized physician order entry (CPOE) system” Proceedings / AMIA. Annual Symposium.: 860-3. (2002)

Abstract: Many of the benefits of computerized physician order entry (CPOE) stem from its ability to support medical decision-making and error-reduction during patient care. This automated "intelligence" is typically represented by a network of rules. We describe a taxonomic representation of clinical decision-support rules in the context of developing and implementing a de novo CPOE and decision-support system. In our experience, this clinical rules taxonomy facilitated our implementation goals in the areas of physician acceptance and approval, rules construction and maintenance, and technical development and testing. This rules taxonomy may eventually be used to establish standards by which CPOE-based decision-support is measured.

365) Wang, S. J., Blumenfeld, B. H., Roche, S. E., Greim, J. A., Burk, K. E., Gandhi, T. K., Bates, D. W. and Kuperman, G. J. “End of visit: design considerations for

an ambulatory order entry module" Proceedings / AMIA. Annual Symposium.: 864-8. (2002)

Abstract: Current paper-based processes for performing billing documentation and test ordering at the end of a clinic visit are fraught with problems, resulting in numerous workflow inefficiencies and significant revenue losses for a healthcare organization. Paper forms are often filled out inaccurately or incompletely, or can be misrouted or lost. Computerizing these processes can alleviate many of these problems. We are building a new module for our ambulatory electronic medical record system to automate these "end of visit" (EOV) activities, which includes completing encounter forms, ordering lab and diagnostic tests, and printing patient visit summaries. An EOV module must be carefully designed to incorporate the needs of clinicians, front office staff, ancillary labs, medical records, and finance departments. An optimally designed EOV system should be customizable to fit into the clinician's workflow, and should help reduce financial losses, improve clinical documentation, and reduce workflow inefficiencies.

366) Watanabe, M., Sugiura, M., Seino, T., Mitsunaga, Y., Nakamura, H., Yamada, Y., Tsuchiya, F., Ohe, K. and Iga, T. "The construction and evaluation of the preventing method for the input mischoice in a prescription order entry system--usefulness of a three-character input and a warning screen display system" Yakugaku Zasshi - Journal of the Pharmaceutical Society of Japan. **122**(10): 841-7. (2002)

Abstract: In the computerized prescription order entry system, it has been pointed out that a physician's input mischoice for medicine is one of the causes of medication errors. We therefore investigated the input mischoices by physicians at the time of writing prescriptions. Subsequently, the number of input characters in a prescription order was changed to three characters from two characters. Furthermore, 105 items of high-alert medications, which are likely to result in injury if errors occur, were established. A warning screen display system that requests reconfirmation of the effect, name, usage, and dosage of those medicines was also built. It was found that 70% of input mistakes were caused by choosing the medicine displayed immediately above or below the desired drug. By changing the number of input characters of a prescription order to three characters from two characters, the rate of specification of a trademark improved sharply from 36% to 85%. Consequently, the rate of choice of a drug with another trademark decreased significantly from 0.028% to 0.0047%. In 5% of cases when the warning screen was displayed for a high-alert medicine, the prescription was stopped, and 25% were changed to other medicines. The above results show that the system that requires the input of three or more characters for the physician order entry and displays a warning screen for high-alert medicines is useful in preventing mischoices at the time of prescription input.

367) Weiner, M., Gress, T., Thiemann, D. R., Jenckes, M., Reel, S. L., Mandell, S. F.

and Bass, E. B. “Contrasting views of physicians and nurses about an inpatient computer-based provider order-entry system” Journal of the American Medical Informatics Association **6**(3): 234-44. (1999)

Abstract: OBJECTIVE: Many hospitals are investing in computer-based provider order-entry (POE) systems, and providers' evaluations have proved important for the success of the systems. The authors assessed how physicians and nurses viewed the effects of one modified commercial POE system on time spent patients, resource utilization, errors with orders, and overall quality of care. DESIGN: Survey. MEASUREMENTS: Opinions of 271 POE users on medicine wards of an urban teaching hospital: 96 medical house officers, 49 attending physicians, 19 clinical fellows with heavy inpatient loads, and 107 nurses. RESULTS: Responses were received from 85 percent of the sample. Most physicians and nurses agreed that orders were executed faster under POE. About 30 percent of house officers and attendings or fellows, compared with 56 percent of nurses, reported improvement in overall quality of care with POE. Forty-four percent of house officers and 34 percent of attendings/fellows reported that their time with patients decreased, whereas 56 percent of nurses indicated that their time with patients increased ($P < 0.001$). Sixty percent of house officers and 41 percent of attendings/fellows indicated that order errors increased, whereas 69 percent of nurses indicated a decrease or no change in errors. Although most nurses reported no change in the frequency of ordering tests and medications with POE, 61 percent of house officers reported an increased frequency. CONCLUSION: Physicians and nurses had markedly different views about effects of a POE system on patient care, highlighting the need to consider both perspectives when assessing the impact of POE. With this POE system, most nurses saw beneficial effects, whereas many physicians saw negative effects.

368) Weiner, M., Gress, T., Thiemann, D. R., Reel, S. L., Mandell, S. F. and Bass, E. B. “Concerns about the use of computerized physician order entry in cardiac care” Journal of Investigative Medicine **45**(3): 293A. (1997)

Abstract:

369) Weingart, S. N., Toth, M., Sands, D. Z., Aronson, M. D., Davis, R. B. and Phillips, R. S. “Physicians' decisions to override computerized drug alerts in primary care” Archives of Internal Medicine **163**(21): 2625-31. (2003)

Abstract: BACKGROUND: Although computerized physician order entry reduces medication errors among inpatients, little is known about the use of this system in primary care. METHODS: We calculated the override rate among 3481 consecutive alerts generated at 5 adult primary care practices that use a common computerized physician order entry system for prescription writing. For detailed review, we selected a random sample of 67 alerts in which physicians did not prescribe an alerted medication and 122 alerts that resulted in a written prescription. We identified factors associated

with the physicians' decisions to override a medication alert, and determined whether an adverse drug event (ADE) occurred. RESULTS: Physicians overrode 91.2% of drug allergy and 89.4% of high-severity drug interaction alerts. In the multivariable analysis using the medical chart review sample (n = 189), physicians were less likely to prescribe an alerted medication if the prescriber was a house officer (odds ratio [OR], 0.26; 95% confidence interval [CI], 0.08-0.84) and if the patient had many drug allergies (OR, 0.70; 95% CI, 0.53-0.93). They were more likely to override alerts for renewals compared with new prescriptions (OR, 17.74; 95% CI, 5.60-56.18). We found no ADEs in cases where physicians observed the alert and 3 ADEs among patients with alert overrides, a nonsignificant difference (P =.55). Physician reviewers judged that 36.5% of the alerts were inappropriate. CONCLUSIONS: Few physicians changed their prescription in response to a drug allergy or interaction alert, and there were few ADEs, suggesting that the threshold for alerting was set too low. Computerized physician order entry systems should suppress alerts for renewals of medication combinations that patients currently tolerate.

370) Weir, C., Hoffman, J., Nebeker, J. R. and Hurdle, J. F. “Nurse's role in tracking adverse drug events: the impact of provider order entry” Nursing Administration Quarterly **29**(1): 39-44. (2005)

Abstract: Adverse drug events (ADE), or injuries caused by drug therapy, are a frequent and serious problem in hospitalized patients. Monitoring, preventing, and treating ADEs is an important patient safety function. Nurses play a significant role in this function, because their data is a unique and important indicator of ADEs and because they are the final point of medication administration. New provider order entry systems with electronic medical records have been viewed as an effective innovation and solution to high rates of ADEs. These systems increase legibility of drug orders, provide decision support, and increase access to the medical record. However, they may not interface with nursing processes effectively. This study reports the experience of a team conducting an ADE surveillance study in a Veterans Health Administration setting where extensive computerized innovations are in place. Lessons learned regarding the integration of nursing work processes with the computerized setting are described. Three areas of concern are highlighted: decreased access to nursing narratives, lack of decision support for medication administration, and failure to code nursing data. Each of these is discussed in terms of relevance to patient safety and the design of information systems.

371) Weir, C., Johnsen, V., Roscoe, D. and Cribbs, A. “The impact of physician order entry on nursing roles” Proceedings / AMIA Annual Symposium: 714-717. (1996)

Abstract: This study examines the impact of physician order entry (POE) on nurses perceptions of work, quality of care, and nurse/physician communication. Four hospitals that have implemented a computerized order-entry system with POE were compared

with four similar hospitals using the same computerized system with clerk order entry only. Three factors were extracted from the 29 item survey using principal component extraction with varimax rotation that accounted for 16.5%, 12.4% and 8.7% of the variance respectively. Three scales were constructed from these factors measuring perceptions of impact of the information system on the quality of care, job, control, and nurse/physician communication. Nurses working in the POE environment rated their computer system as having greater impact on the quality of care and lower ratings of perceived control than those working in non-POE environments. No differences were found between nurses working in POE environments and those working in POE in terms of their ratings of frequency of contact and ease of access to physicians

372) Weir, C., Lincoln, M., Roscoe, D. and Moreshead, G. “Successful implementation of an integrated physician order entry application: a systems perspective” Proceedings / AMIA Annual Symposium: 790-4. (1995)

Abstract: Direct physician order entry is required for effective implementation of an integrated electronic medical record. This effort involves multi-level changes in the whole system of care, from physicians attitudes to interdepartmental relations. This study reports the findings of a follow-up study that quantified dimensions associated with successful implementation identified in a previous study. Results identified several implementation strategies associated with success. These include an interdisciplinary implementation group, involvement of large numbers of regular staff, early and intensive training and support, and 24 hour available assistance as important to success. In addition, attitudes of physicians and their level of involvement were found to be associated with success.

373) Weir, C., Lincoln, M., Roscoe, D., Turner, C. and Moreshead, G. “Dimensions associated with successful implementation of a hospital based integrated order entry system” Proceedings / AMIA Annual Symposium: 653-7. (1994)

Abstract: Implementation of an integrated electronic medical record requires direct physician order entry. This application involves multi-level changes in the whole system of care, from physicians attitudes to interdepartmental relations. This study reports the results of the first round of a modified Delphi, where a diverse group of individuals were asked to identify the most important facilitating and impeding factors associated with implementation of an order entry application. From a Q-sort of their responses, we identified 20 systemic, behavioral, and attitudinal dimensions perceived to be causal factors in successful implementation. We also explored how these dimensions may influence success by comparing successful with unsuccessful hospitals in terms of the frequency with which these dimensions were differently mentioned by respondents. We found that although available functionality was the most commonly mentioned factor by all participants, hardware availability, physician involvement, administration support, and medical administration involvement were more often mentioned by successful hospitals

than by less successful hospitals. These results suggest that these factors were not present in the less successful hospitals. We also found that the frequency of responses within each category varied depending on the institutional role of the individuals responding. Those involved in support tended to see organizational variables as more important than those in clinical positions, whereas clinicians viewed administrative support and involvement of the chief as more important. These findings support the notion that the changes involved in instituting a physician order entry system are system wide and involve individual as well as organizational factors.

374) Weir, C., McCarthy, C., Gohlinghorst, S. and Crockett, R. “Assessing the implementation process” Proceedings / AMIA Annual Symposium: 908-12. (2000)

Abstract: A Computerized Patient Record System (CPRS) has many benefits and could improve health care outcomes. Reaping these benefits, however, is dependent on successful implementation of a provider order entry system. The literature supports substantial evidence that even systems that are usable, effective and reliable have not been adopted by the intended users. A successful implementation may be substantially a function of the degree to which the processes of care have changed to adapt to the new system. To ensure successful implementation we suggest monitoring the implementation process itself. The purpose of this paper is to report the methodology we developed for assessing how successfully a provider order entry system is being implemented. We adopt a model of diffusion of information technology developed by Fichman (1994) and expanded by Ash (1997). In this model, diffusion is characterized be three categories, "breadth" (infusion) and "depth" (diffusion) and "quality" (appropriateness of use). In this paper we discuss the typology of diffusion and describe specific measures designed to measure infusion and diffusion of a hospital information system.

375) Weir, C. R., Crockett, R., Gohlinghorst, S. and McCarthy, C. “Does user satisfaction relate to adoption behavior? an exploratory analysis using CPRS implementation” Proceedings / AMIA Annual Symposium: 913-7. (2000)

Abstract: User satisfaction is commonly assessed in evaluations of information systems as a proxy for user adoption. However few studies actually report directly assessing the relationship between the two constructs. In this study the relationship between four user satisfaction measures and five adoption behaviors were explored in the context of the implementation of the Veteran's Health Administration Computerized Patient Record System 1.0. Findings suggest that the relationship is modest and depends on the measurement system used. Specifically, direct reports of affect and judgements of specific task efficacy related to behavior more often than usability and a general user satisfaction instrument.

376) West, D. W., Levine, S., Magram, G., MacCorkle, A. H., Thomas, P. and Upp, K. "Pediatric medication order error rates related to the mode of order transmission" Archives of Pediatrics & Adolescent Medicine. **148**(12): 1322-6. (1994)

Abstract: OBJECTIVE: This study was undertaken to measure the medication error rates associated with verbal orders compared with handwritten and computer-entered orders in an acute-care children's hospital. METHODS: All medication and intravenous fluid orders for a 3-month interval were entered into a computer database. For the same interval, all errors pertaining to the transmission of a medication or intravenous fluid order were also entered into the database. Errors were detected by the hospital pharmacy, which continuously reviews all inpatient medication and intravenous fluid orders for potential errors before dispensing. Errors were also detected by nurses on the floors, who submit incident reports when medication or intravenous fluid errors occur. RESULTS: Verbal orders were associated with significantly lower error rates than either handwritten orders or computer-entered orders (2.6, 8.5, and 6.3 per 1000, respectively), with transcription errors and dosage errors in particular being reduced. Total error rates did not differ between residents and attending physicians. Error rates did not differ between verbal, written, and computer orders for medications with a low frequency of verbal orders and therefore presumed greater complexity. However, the verbal order error rates seemed more sensitive to order complexity than order error rates in general. CONCLUSIONS: The hypothesis that verbal orders are more prone to transmission error than written or computer orders is not supported by the findings in this study. Identifying medications with high levels of order complexity for restriction of verbal order use seems justified. Suggested guidelines for verbal order transmission are presented.

377) Williams, R. B. "Successful computerized physician order entry system implementation. Tools to support physician-driven design and adoption" Healthcare Leadership & Management Report. **10**(10): 1-13. (2002)

Abstract:

378) Wilson, J. P., Bulatao, P. T. and Rascati, K. L. "Satisfaction with a computerized practitioner order-entry system at two military health care facilities" American Journal of Health-System Pharmacy **57**(23): 2188-95. (2000)

Abstract: User satisfaction with a computerized practitioner order-entry (POE) system at two military health care facilities was studied. A survey was mailed in May 1998 to providers authorized to enter drug orders into the Composite Health Care System (CHCS) (including two clinical pharmacists) and pharmacy staff members at two department of defense (DOD) medical treatment facilities. Of 189 questionnaires with the potential to be returned completed, 112 were usable, for a net response rate of

59.3%. The internal consistency of the survey items measuring user satisfaction (Cronbach's alpha) was 0.86. The typical respondent was male, was employed by the DOD, had fair to excellent computer and typing skills, had received eight hours or less of training on the CHCS POE system, had been using the system for two years or less, and had been a health care practitioner for 10 years or less. Overall, users were satisfied with the POE system (mean +/- S.D. rating of 3.78 +/- 0.87 on a 5-point scale where 5 represented the highest satisfaction level). Satisfaction was correlated most strongly with ratings of the POE system's efficiency. Nonphysicians were more satisfied, on average, than physicians. No significant relationship was found between other individual characteristics and satisfaction. Qualitative analysis reinforced the finding that users were interested in efficiency issues. Overall, users at two military health care facilities were satisfied with a computerized POE system. Satisfaction was most strongly correlated with the perceived efficiency of the system.

379) Windle, J., Van-Milligan, G., Duffy, S., McClay, J. and Campbell, J. “Web-based physician order entry: an open source solution with broad physician involvement” AMIA. Annual Symposium Proceedings/AMIA Symposium. (2003)

Abstract: Computerized physician order entry (CPOE) is a disruptive technology but holds great promise for reducing medical errors, improving workflow and in the long run, producing cost-savings. However, many studies have reported significant physician resistance to implementing CPOE. In this manuscript we present a two-prong strategy for quick implementation of CPOE: 1) a web-based deployment tool using an open source, secure environment that allows rapid development and deployment of content, and 2) the development of a large set of disease specific order sets and knowledge bases based on established vocabulary standards such as LOINC and SNOMED CT by teams of multidisciplinary content experts at the departmental level. The order sets can be viewed, edited and signed through a standard browser interface. This paper presents the conceptual framework and implementation requirements for such an endeavor.

380) Wolf, E. J. “Critical success factors for implementing CPOE” Healthcare Executive. **18**(5): 14-9. (2003)

Abstract:

381) Wu, R. C., Abrams, H., Baker, M. and Rossos, P. G. “Implementation of a computerized physician order entry system of medications at the University Health Network--physicians' perspectives on the critical issues” Healthcare Quarterly **9**(1): 106-9. (2006)

Abstract: There are many reasons why most hospitals have not adopted physician order entry systems for medications. It is a costly endeavour (Kuperman and Gibson

2003) that can cause major disruptions to workflow for physicians, pharmacists and nurses. Yet, the technology can reduce medication errors, especially with sophisticated decision support. We have presented many of the lessons learned from our successful implementation experience. To date, over 90% of medication orders are entered by physicians. The technology must be ready for the implementation. System issues such as errors, slowness and freezing give ready opportunity for critics who will claim the system is just not ready for real-time. Through rigorous testing, we were able to avoid issues previously seen in our pilot study. Usability testing with end-users was also critical in both guiding decision-making as well as validating that the system was ready for implementation. Proper training and support were also necessary. To ensure ready adoption, decision support was optimized to reduce the volume of less important alerts. Most importantly, we found that active physician involvement at multiple levels was key. This ensured that physicians understood from a high-level perspective that this change was necessary. Planning for specific implementation details had the benefit of input from physicians working in the area. Day-to-day issues of our residents and staff were also addressed promptly.

382) Wyatt, J. and Walton, R. “Computer based prescribing.[comment]” Bmj. **311**(7014): 1181-2. (1995)

Abstract:

383) Yamauchi, K., Ikeda, M., Suzuki, Y., Asai, M., Toyama, K. and Hayashi, E. “Evaluation of the order entry system by end users--a step to the new hospital information system” Nagoya Journal of Medical Science **57**(1-4): 19-24. (1994)

Abstract: Nagoya University Hospital has developed a new, comprehensive computerized hospital administration system since April 1992. In the present study, a user's evaluation questionnaire survey on the order entry system revealed that the improvements at the human interface level were appreciated by some respondents, but not all users felt the human interface provided, adequately meets their needs. Another presumed advantage of the micro-mainframe-link architecture is fast response, but in our study respondents considered the response time too long. Most users felt that transmission of orders was fast, accurate and clear, and that fast retrieval of the results of laboratory tests was good. Our system with this kind of architecture has thus proved satisfactory except for the slow response time. This study will be useful to reengineer our hospital information system in the next phase. [References: 13]

384) Yan, Q. and Hunt, C. A. “Preventing adverse drug events (ADEs): The role of computer information systems” Drug Information Journal **34**(4): 1247-1260. (2000)

Abstract: The occurrence of adverse drug events (ADEs) is recognized as an important health care issue. This paper provides a review of the computer information systems that have been developed and used for the prevention of ADEs. Following an introductory section that defines concepts and terms, the clinical manifestations, influences, and costs of ADEs are reviewed, along with the medication classes, types, and causes of ADEs. Information systems that target different stages of the drug ordering and delivery process are discussed. Different studies show that computerized physician order entry systems are essential in the prevention of ADEs. Computer-assisted decision support programs that are integrated with systems that cover each stage of the drug ordering and delivery process provide the most powerful prevention tools. Through comparison with other methods, computer-based information systems are shown to be the most cost-effective and promising strategy for preventing ADEs. Further challenges and possible improvements are also discussed.

385) Ying, A. “Mobile physician order entry” Journal of Healthcare Information Management. **17**(1): 58-63. (2003)

Abstract: Because both computerized physician order entry (CPOE) systems and mobile technologies such as handheld devices have the potential to greatly impact the industry's future, IT vendors, hospitals, and clinicians are simply merging them into a logical convergence--"CPOE on a handheld"--with an expectation of full functionality on all platforms: computer workstations, rolling laptops, tablet PCs, and handheld devices. For these trends to succeed together, however, this expectation must be revised to establish a distinct category--mobile physician order entry (MPOE)--that is different from CPOE in form, function, and implementation.

386) Yoshihara, H. “Status quo and future prospects of the total hospital information system of a Japanese medical college” Journal of Medical Systems **18**(5): 229-40. (1994)

Abstract: Six years have passed since the total hospital information system of Miyazaki Medical College, nicknamed PHOENIX, began its functions for the first time. It started with order entry systems, and has accomplished various systems, leaving one entry system unfinished; the injection order entry system which will be completed in the near future. It was revealed that the waiting period was most reduced at the hospital pharmacy. The waiting period for the visitors was also reduced. Usefulness of the PHOENIX system was greatly advanced by the function of a unique system of personal computer LAN, nicknamed PALM. This personal computer environments consisted of 200 or more Apple Macintosh computers. In this PALM environment, file servers, CD-ROM MEDLINE, clinical information databases, electronic mails (available in LAN and Internet) and sharing of printers are on service 24 hr a day.

387) Yoshihara, H. “Development of the electronic health record in Japan” International Journal of Medical Informatics **49**(1): 53-8. (1998)

Abstract: In Japan, the order entry system has been employed in almost all university hospitals and popularisation of this system has also started in medium-sized hospitals. However, there has been a tendency in general hospitals in Japan to consider the electronic chart system where there has been no order entry system. Moreover, in small-scale clinics, there is no benefit in using the order entry system. Young doctors in Japan are beginning to employ the electronic chart system directly for the first time, without experience with the order entry system. In this paper, the development of the hospital information system in Japan and that of the electronic health record system are described.

388) Zhan, C., Hicks, R. W., Blanchette, C. M., Keyes, M. A. and Cousins, D. D. “Potential benefits and problems with computerized prescriber order entry: analysis of a voluntary medication error-reporting database” American Journal of Health-System Pharmacy **63**(4): 353-8. (2006)

Abstract: PURPOSE: The potential benefits and problems associated with computerized prescriber-order-entry (CPOE) systems were studied. METHODS: A national voluntary medication error-reporting database, Medmarx, was used to compare facilities that had CPOE with those that did not have CPOE. The characteristics of medication errors reportedly caused by CPOE were explored, and the text descriptions of these errors were qualitatively analyzed. RESULTS: Facilities with CPOE reported fewer inpatient medication errors and more outpatient medication errors than facilities without CPOE, but the statistical significance of these differences could not be determined. Facilities with CPOE less frequently reported medication errors that reached patients ($p < 0.01$) or harmed patients ($p < 0.01$). More than 7000 CPOE-related medication errors were reported over seven months in 2003, and about 0.1% of them resulted in harm or adverse events. The most common CPOE errors were dosing errors (i.e., wrong dose, wrong dosage form, or extra dose). Both quantitative and qualitative analyses indicate that CPOE could lead to medication errors not only because of faulty computer interface, mis-communication with other systems, and lack of adequate decision support but also because of common human errors such as knowledge deficit, distractions, inexperience, and typing errors. CONCLUSION: A national, voluntary medication error-reporting database cannot be used to determine the effectiveness of a CPOE system in reducing medication errors because of the variability in the number of reports from different institutions. However, it may provide valuable information on the specific types of errors related to CPOE systems.

389) Zimmerman, M. “Provider order entry: it can work!” Journal of Emergency Nursing **23**(5): 463-6. (1997)

Abstract: