

How Siemens' Computerized Physician Order Entry Helps Prevent the Human Error

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Keywords

- CPOE • medication error • ADE
 - clinical information systems
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Background

In 1999, the American IOM published, *"To Err Is Human – Building a Safer Health System"* [1]. A review of major studies of adverse medical events and medication errors led to estimations that in the USA between 44,000 to 98,000 people die in hospitals each year as a result of medical errors. The lower number would make medical errors the number 8th leading death cause – above motor vehicle accidents, breast cancer and AIDS in the USA. The study estimated that more than 7,000 people die in hospitals each year due to medication errors alone. The IOM report indicated that the overall average proportion of patients who experience adverse events that could be prevented is 1,8% of all admissions [1].

In a recently published study for the European countries, the WHO attributed the following hospital admission rates to adverse medication reactions [2]: Norway 11,5%, UK 16%, and France 13%. A report from the NHS in the UK, published in 2000, estimates that adverse events occur in approximately 10% of UK patient admissions [3]. In Australia 16,6% of hospital admissions were attributed to an adverse drug event, 51% were considered highly preventable [4].

Process breakdown, including traditional patient safety issues, workflow interruptions and inefficiencies have been shown to account for as much as 78% of adverse drug events [5, 6] contributing significantly to an increase in associated cost.

In a meta-analysis of adverse drug events reports performed by Kelly, et. al. [7], 78% of the cases were from North America and 17% from Europe. About half the patients with permanent disabilities received a higher than usual drug dosage. The event types were classified as 55% medication errors and 43% drug reactions. Together, 84% were classified as preventable. The average judgement and settlement costs for litigation in these cases averaged \$ 4,3 million.

The medication administration environment in Europe is similar to the one in the USA, with a more prominent role of pharmacists in the medication process in the USA. While there have not yet been comprehensive studies published substantiating differences and impacts, we believe that Europe experiences the same overall frequency of adverse medication events as the USA, and therefore can experience similar reductions in drug errors, morbidity and mortality by implementing the technologies reviewed here.

In Sweden, healthcare organizations and pharmacy operations are run and controlled by different organizations. The national pharmacy organization, Apoteket AB and Helsingborgs Lasarett AB, a healthcare provider in Sweden, documented in a study performed in early 2001, that a drug related problem occurred for 28% of all admissions. In 6% of all admissions a drug related problem was the principal cause for admission. The annual cost of these admissions was estimated to be four million USA dollars. Both organizations engaged in a project to improve quality of care by optimising medication management [8].

In March 2001, the IOM released a second report, *"Crossing the Quality Chasm [9]: A New Health System for the 21st Century"*. This report builds on the IOM's first report and provides recommendations to redesign the American healthcare system, including specific direction for policy makers, healthcare leaders, clinicians, regulators, purchasers and others. This comprehensive report includes a set of performance expectations for the 21st century healthcare system, a set of 10 new rules to guide patient-clinician relationships, an organizational framework to better align payment and accountability with quality improvements, and key steps to promote evidence-based practice and to strengthen clinical information systems.

Workflow Supporting Software Solutions for Healthcare and Their Potential Impact

Siemens Medical Solutions has invested in the development of clinical information systems over the past 15 years in various countries. The solutions commercially

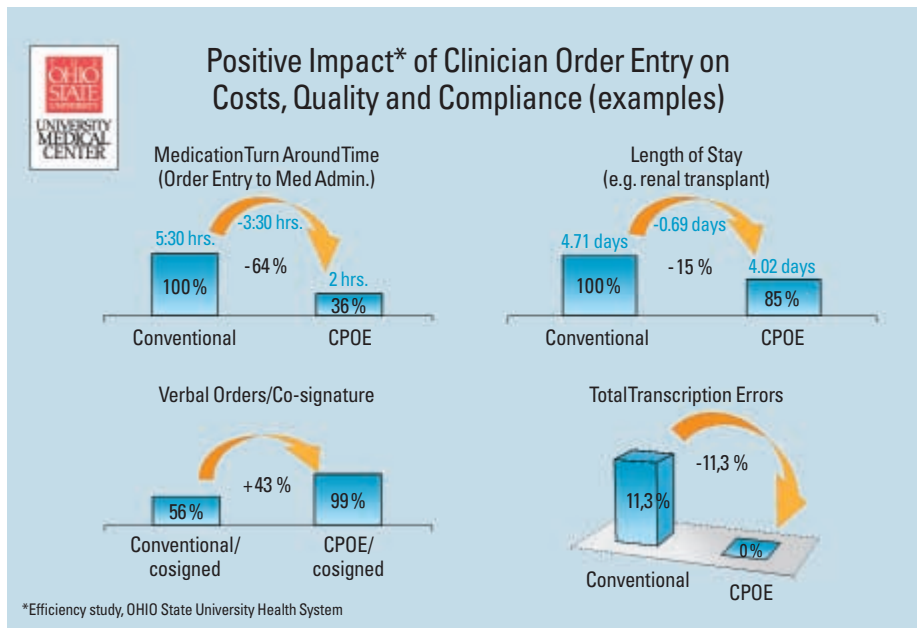


Fig. 1
Positive outcomes of CPOE at
the Ohio State University:
Quality of care, cycle time,
regulatory compliance and error
reduction.

available range from electronic patient records, order processing, clinical documentation and reporting for nursing and physicians, to computerized physician order entry in combination with rules-based decision support and electronic medication dispensing and administration solutions. Siemens is currently investing approx. one half a billion dollars on the development of its third generation clinical information system, which includes industry standard workflow management tools. The system provides highly flexible coordination and automation of the multitudinous manual and error prone process steps existing within the highly specialized and fragmented healthcare environment. Its goal is to reduce the human error factor in this safety-sensitive environment [10]. To achieve substantial improvements, Siemens Medical Solutions is working closely with key customers in the requirement engineering, validation and implementation processes for its workflow-support software applications. The solutions described and validated in this paper are the outcomes of this close cooperation.

CPOE

CPOE provides complete and accurate information, automatic dose calculations and clinical decision support at the point of care. This includes drug-drug interaction and allergy checking as well as ordering supported by evidence-based best practices. These features help minimize human error, improve medication management, facilitate reporting and decision-making and improve resource utilization. These allow timely and ubiquitous access to information and support compliance. There are a number of studies in the USA that have proven their positive impact to quality of care, satisfaction and cost [1, 11-13].

Merely 2% of US-based healthcare providers have implemented CPOE. In a CPOE system, the physician is required to enter orders for patient care directly into a computer system. In a 2002 study to evaluate the benefits of CPOE and electronic medication administration on the delivery of healthcare at the Ohio State University Health System (Fig. 1), USA, Mekhjian et al. [14] validated major benefits and outcomes of its implementation of Siemens' INVISION™ solution, which had been adapted by the health system, using vendor provided tools:

- A statistically significant 64% reduction in medication turn-around times (from ordering to actual administration).
- A statistically relevant 25% improvement in result reporting times.
- Physician Order Entry combined with electronic medication administration eliminated all physician and nursing transcription errors.
- Although total cost per admission decreased significantly within selected services, it did not decrease significantly across the institution.
- The significant cultural and workflow changes that accompanied the implementation of CPOE did not adversely affect the acuity-adjusted length of stay or total cost.

Mekhjian et al. [14] conclude that the reduction in transcription errors, medication turnaround times, and timely reporting of results, support the view that CPOE and electronic medication management provide a good return on investment.

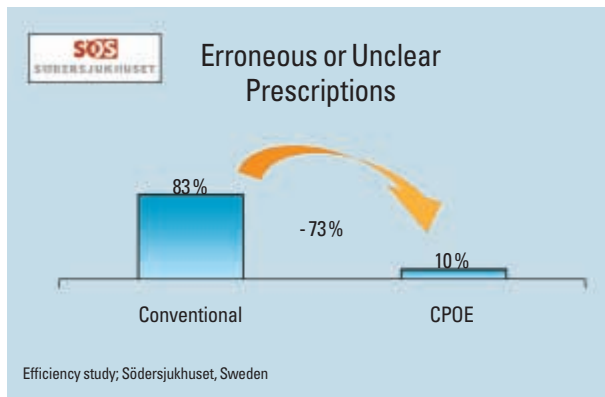


Fig. 2 Study at Soedersjukhuset in Stockholm demonstrated a positive impact after CPOE implementation for medication orders: Erroneous or incomplete medication orders were reduced by 73%.

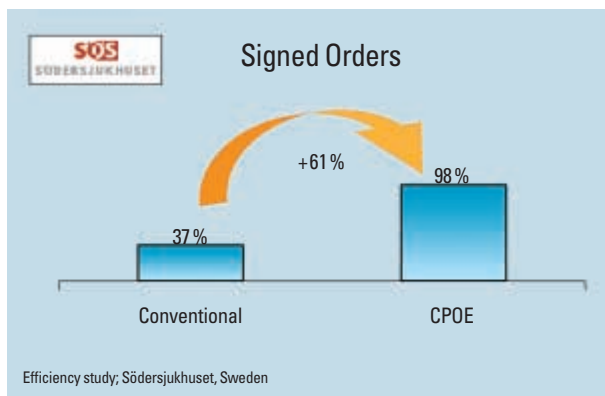


Fig. 3 Study at Soedersjukhuset in Stockholm showed a 61% increase in signed orders.

Today, nine hospitals with approximately 2,000 physicians and nurses in Sweden use Siemens' Melior system for electronic Medication Ordering (CPOE) and Medication Administration. The number of hospitals and users will continue to increase during 2003.

A study performed in 2001 at Soedersjukhuset, Stockholm, Sweden before and after the implementation of CPOE and electronic medication management at the women clinic (Fig. 2), demonstrated a reduction of erroneous or incomplete medication orders of 73%, and an increase of signed orders from 37% to 98%, as the most prominent benefits (Fig. 3). Surveys of nurses showed very favorable results to the change in process induced by the adoption of the new technology.

The Medication Use Process (Fig. 4)

The "Five Rights" of Medication Administration

To ensure a safe medication administration process, healthcare systems have established the so-called "Five Rights": Right-Patient, Right-Medication, Right-Time, Right-Dose and Right-Route.

For a six-month period, and with 58,000 documented medications from November 2001 to April 2002, Carilion Health System in Roanoke, VA., USA, utilizing the Siemens Medication Administration Check Solution, reported causes of errors that were consistent with the nationally published data (Fig. 5).

Medication Dispensing

Medication Dispensation is the process of packaging and/or mixing pharmaceuticals, and transporting them to patient care locations, for patient administration. Due to the multiple pharmaceuticals that a patient may be taking, and due to the various possible routes of administration (i. e. oral, rectal, epidermal, intradermal, subcutaneous, intramuscular, intrathecal, intravenous), the dispensing process is highly complex. This is especially true given the increasing proportion of high-morbidity cases. Pharmacy-based robots, which pack/dispense unit doses for ready consumption, as well as unit-based automated drug dispensing devices linked to clinical information systems (CPOE and/or Pharmacy Information Systems), facilitate this process and are a means to reduce the 11% to 14% of medication errors attributable to the medication dispensing process [15].

Outcomes

Danville Regional Medical Center, USA was the beta customer for Siemens' Medication Administration Check solution. This solution uses a combination of Siemens-developed applications and wireless point-of-care technology, to re-engineer the medication administration workflow process. It is designed to reduce the potential errors in the medication administration process by

Where Do Medication Errors Occur?

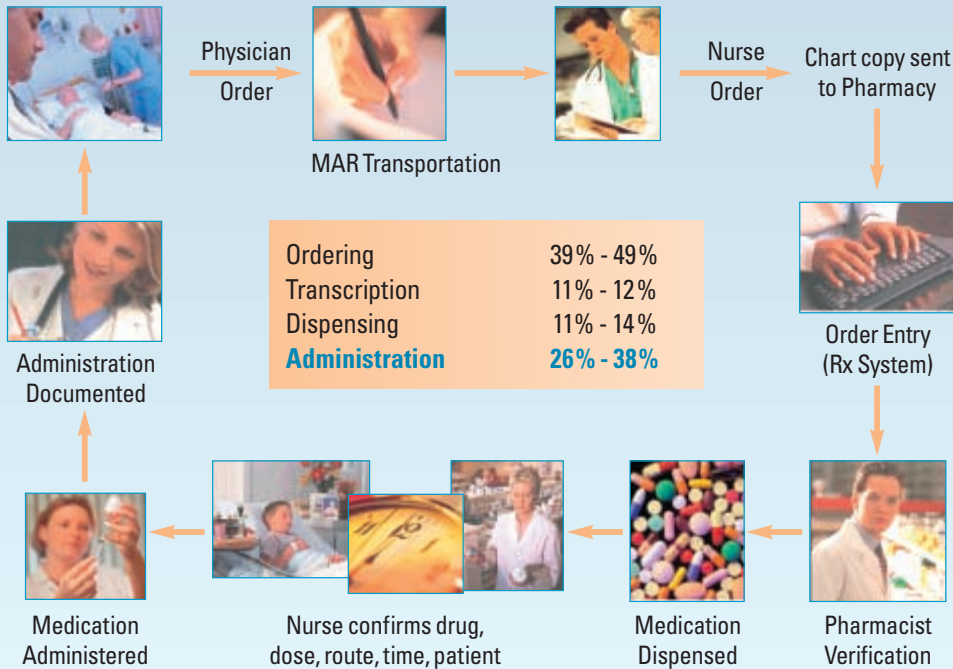


Fig. 4 Traditional medication process with manual prescription, redundant documentation, manual transcription, manual medication dispensing (either by the pharmacy or by the nurse from a decentralized storage on the ward) and an error-prone process of medication administration to the patient.

Distribution of errors according to the AHRQ, Rockville, MD, USA [15].

MAC Results Comparison of Med Error Type

Proportion of errors by type 11/01-4/02

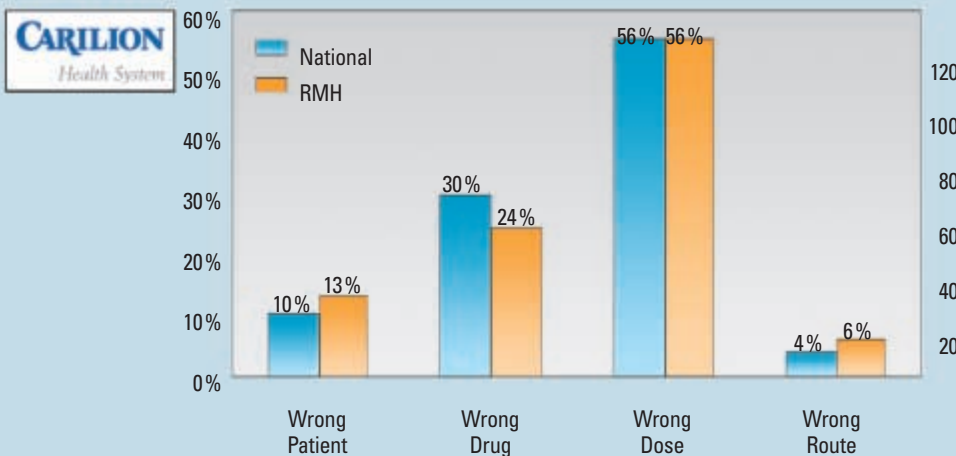


Fig. 5 Distribution of serious errors against the “Five Rights” in the medication administration process reported by Carilion Health System compared to the nation wide published data. “Right time” violations (too late, too early) account for approx. 30% of the warnings during medication charting using Siemens Medication Administration Check at Carilion Health System and were excluded for the purpose of the chart.

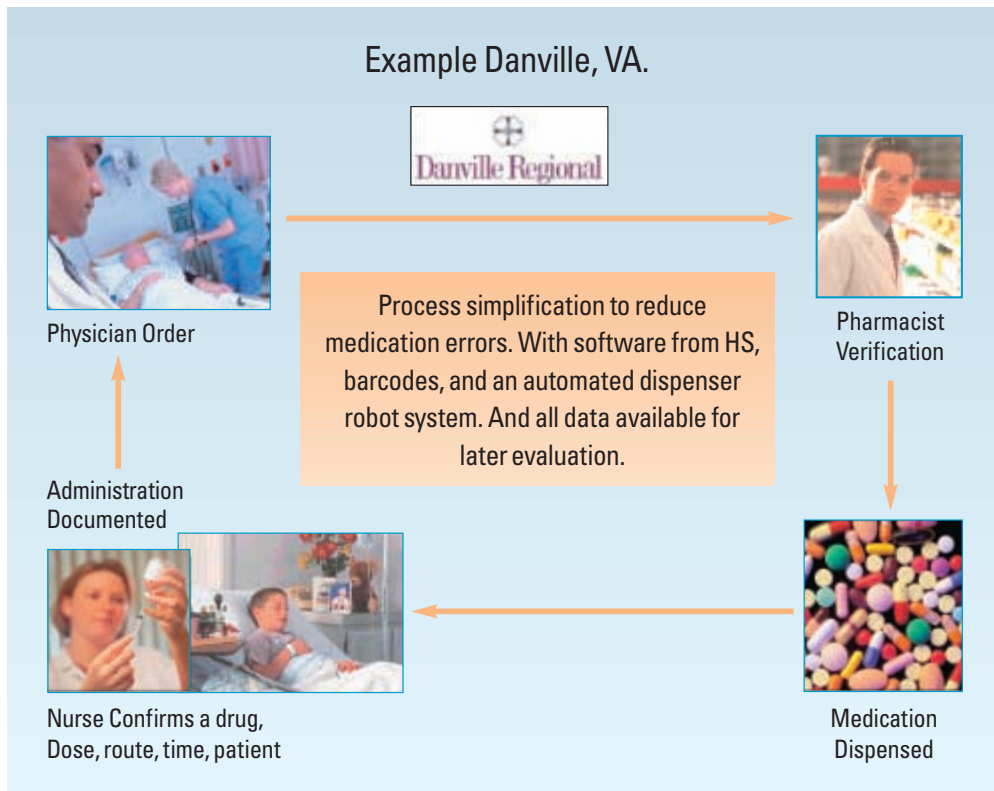


Fig. 6
Process simplification by automation and elimination of error prone process steps compared with Fig. 5.

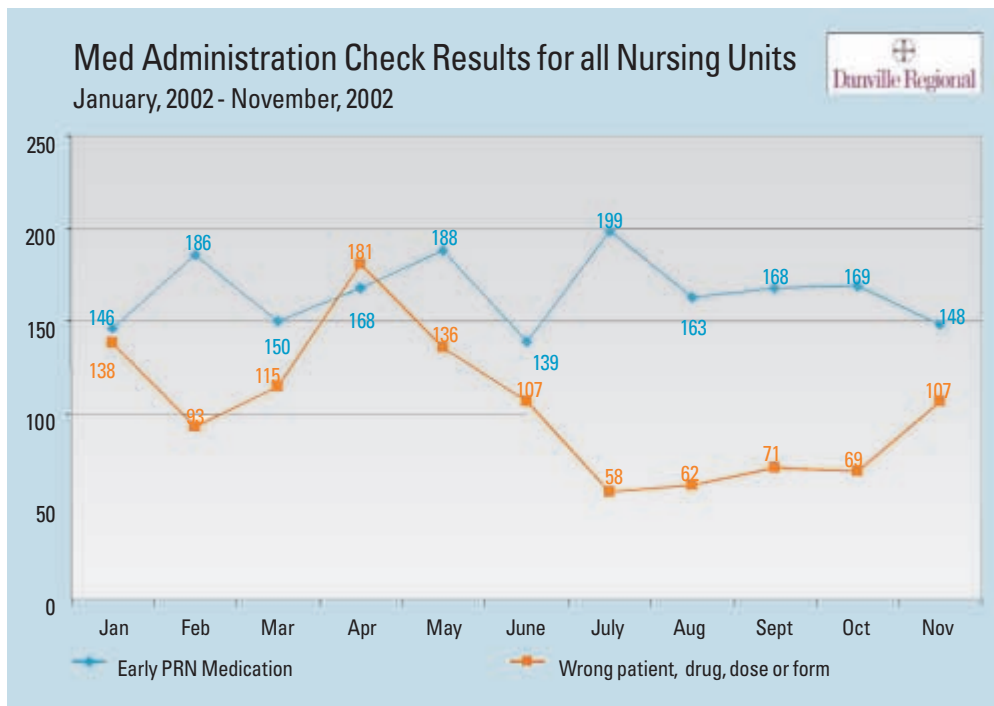


Fig. 7
Potential medication administration errors prevented monthly using Siemens Medication Administration Checking at Danville Regional Medical Center, VA., USA. PRN = pharmaceuticals prescribed on an as needed basis.

checking and verifying the “Five Rights” of medication administration (Fig. 6).

The solution at Danville is deployed on 70 wireless mobile computers with bar code scanners and is used by the nursing staff. Medication Administration Check has been fully deployed since March 2001 at Danville Regional, which today is one of five Siemens customers fully utilizing the benefits of this modern technology. According to Patsy Sublet, Radiological Nurse at Danville Regional Medical Center [16]: “At least 10 to 12 potential errors per day are averted because of this functionality. Danville Regional Medical Center is leveraging the best available technology to make life easier for our clinical staff, but more importantly, to make sure we provide the safest possible care for our patients (Fig. 7). Our results are powerful proof that clinical expertise, combined with information technology, can save lives.” For 2003, there are 13 more US-based Siemens customers that are scheduled to go live on this solution.

The cost incurred by each ADE has been reported in several studies (\$ 2,262 [17] and \$ 4,700 [18]), for an average cost of \$ 3,474. ADEs contribute to an average increased length of stay of 1.91 days.

Overall, for a twelve-month period in 2002, Danville Regional Medical Center has reported estimated savings of USA \$ 840,809 (Fig. 8). The number of avoided medication errors has been adjusted for the estimated clinically relevant ones. This cost savings estimate is conservative, including only the financial benefit of reductions in length of stay and avoided medical treatment for the prevented errors. Errors of omission, early/late administration errors, and litigation settlements are not included. Also, not all nurse stations were live on Med Administration Check at the beginning of 2002.

Carilion Health System, also using Siemens Medication Administration Check, extrapolated their data from their completed pilot units, estimating a potential savings of \$ 380,000 – to \$ 760,000 based on an expected avoidance of 152 clinically relevant errors (based on the cost of an ADE between \$ 2,500 and \$ 5,000).

Helsingborg Lasarett, Sweden conducted a study [19] from March to April 2001 in order to evaluate the impact of electronic medication ordering, dispensing and administration on one pilot ward and the hospital’s pharmacy. The study assessed how process changes and automation with the electronic solution impacted quality of care, time to dispense and administer a drug, and cost. Methods used were time-motion studies for time impacts, a detailed log for medications, and a questionnaire for nurses to assess the quality of care, perceived stress, time and other work impacts.

The study found, that 66% (57,484 drugs/year) of the drugs administered on the pilot ward were unit dose packed through the hospital pharmacies robot instead of

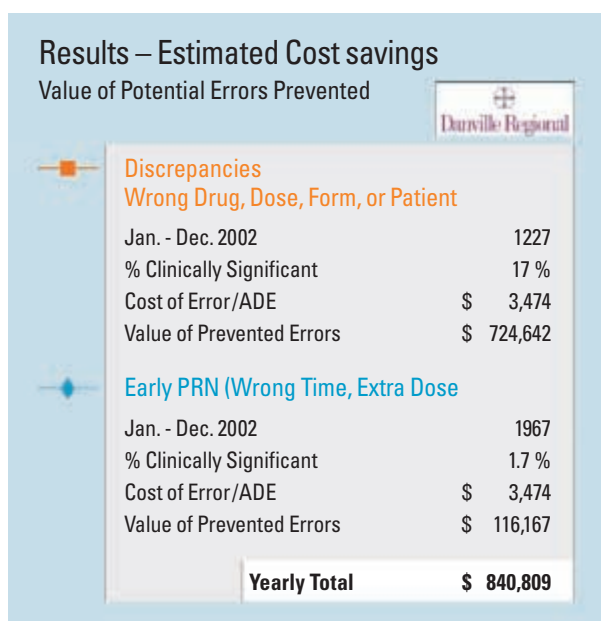


Fig. 8
Estimated cost savings from medication error reduction at Danville Regional Medical Center, VA., USA.

the traditional dispensing from the decentralized ward storage. The implementation of the system and the study did not impact or measure the manual infusion preparation and administration process.

The study also found that 89% of the medication process was performed in the wards and 11% at the hospital pharmacy. While the time savings in the ward were 30 hrs per week, the time consumption at the pharmacy increased by 7,5 hrs per week. This means that the saving potential was approximately 22,5 hrs per week, which corresponds to 0,5 FTE’s. Since Helsingborgs Lasarett consists of 19 wards, the extrapolated saving potential for the hospital could be 9,5 FTE’s. This time could be spent on direct patient care, improving quality (Fig. 9).

A reduction in time spent for handling medications (dispensing and administration) from on average 4,2 min to 3,0 min per patient demonstrates that electronic solutions can help free up time for direct patient contact and care (Fig. 10).

Further, the study suggests that the inability to plan and coordinate drug dispensation, due to a lack of workflow support tools, are major contributing factors to the waste of expensive medications. The biggest reason in more than 46% is the discharge or death of the patient without notification of the pharmacy (Fig. 11). With the IT-interface to Melior, the pharmacy is now getting this information automatically, and it is anticipated that the waste of drugs will decrease from today 4,8% to below 2%.

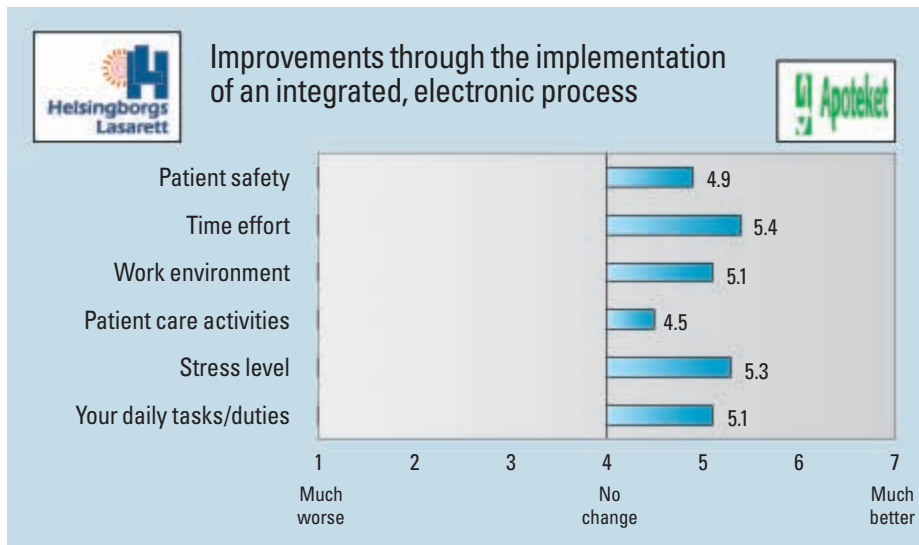


Fig. 9 Study at Helsingborg Hospital, Sweden: Shows measurable positive impact on the nursing staffs perception about patient safety, patient care and their own work environment.

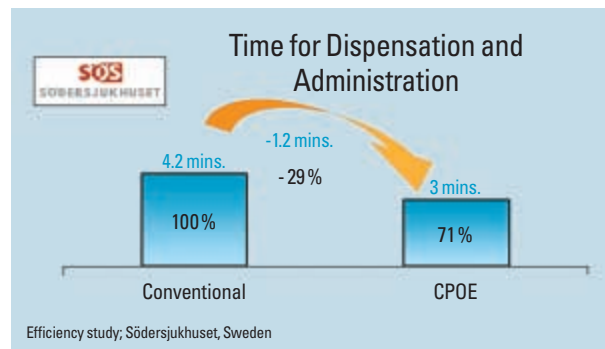


Fig. 10 Study at Soedersjukhuset in Stockholm showed a 29% decrease in the time spent on dispensing and administration.

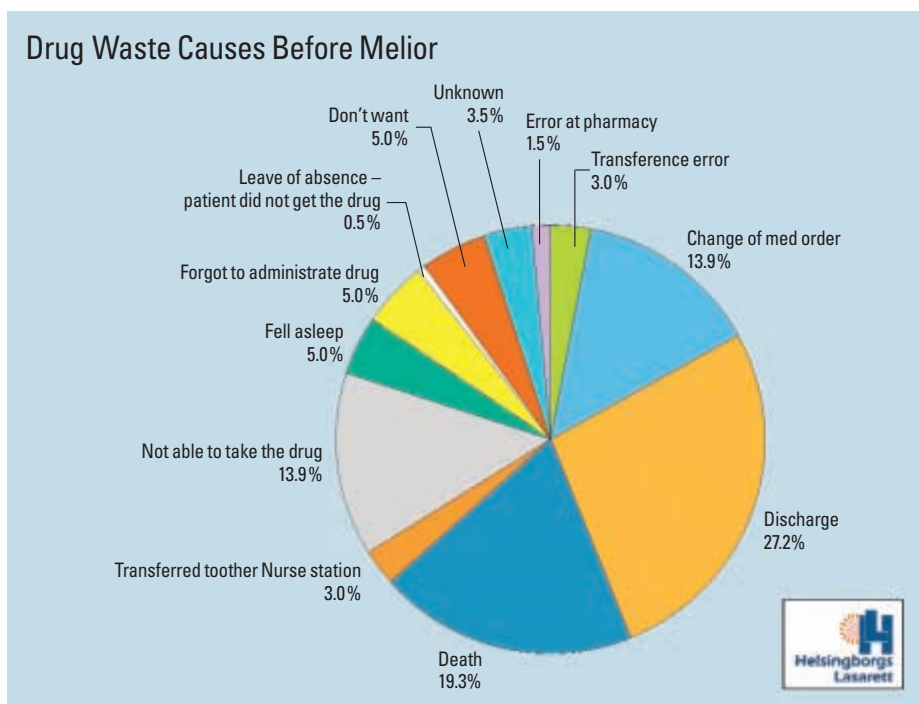


Fig. 11 Helsingborg Hospital, Sweden. Reasons for drug waste before implementation of electronic medication dispensing. Helsingborg hospital is the first healthcare provider in Sweden using a dispensing robot in an inpatient setting. A report on Swedish national TV was broadcasted in July 2002, informing the public of this innovative project and its positive outcomes with the Siemens Melior system.

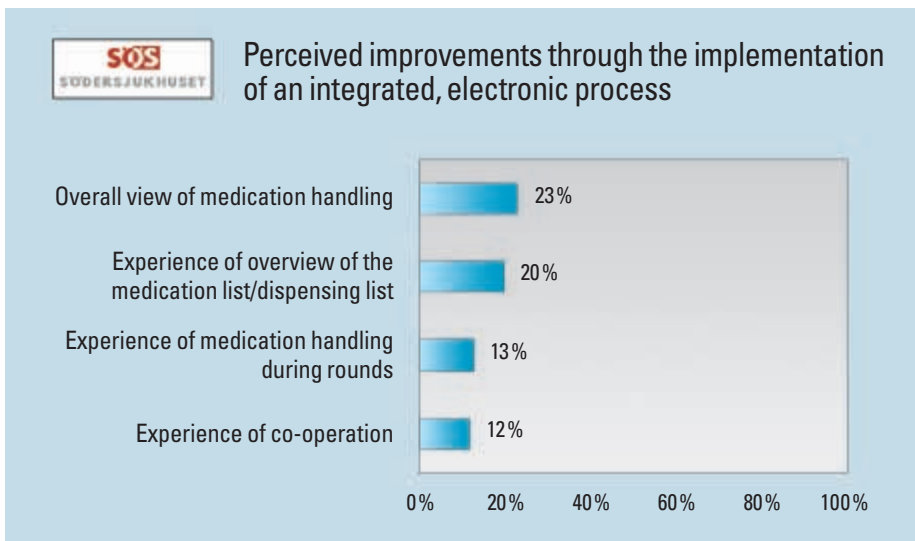


Fig. 12
Soedersjukhuset, Sweden:
Subjective impact on nursing
staff.

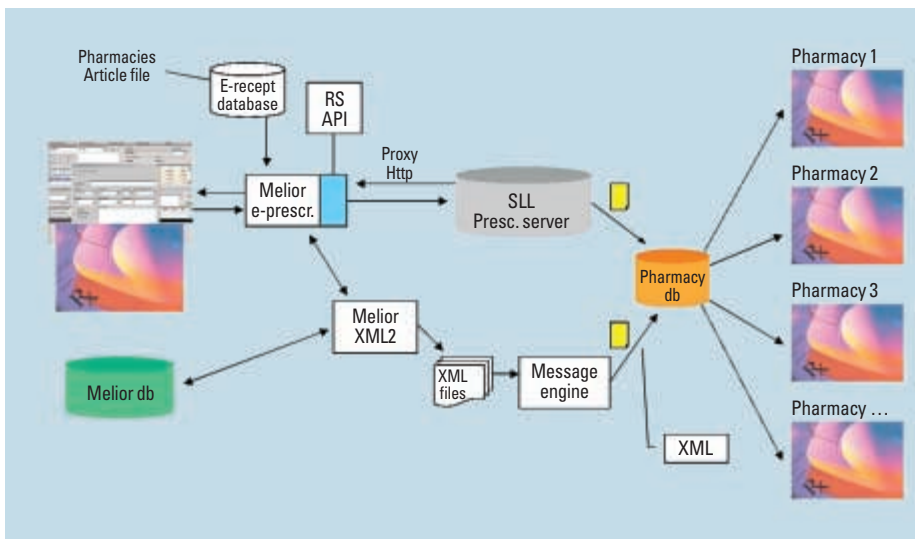


Fig. 13
Technical design of the Melior
e-prescription electronic transfer
to Sweden's pharmacies.

The study at Soedersjukhuset in Sweden demonstrated a perceived improvement from the nursing staff in various areas after the implementation of the Melior medication administration module (Fig. 12).

Electronic Transfer of Electronic Prescriptions to Outside Pharmacies

Within a given healthcare system, electronic prescriptions are either printed and sent, or electronically communicated to the healthcare system's pharmacy department (Fig. 13).

Using Siemens Melior Systems, Swedish healthcare organizations currently lead the USA in their ability to electronically transfer prescribed pharmaceuticals realizing all the previously described benefits of: Decision support, drug-drug and drug-allergy checking. Currently,

the information is electronically routed to a specific pharmacy in Sweden. During the first quarter of 2003, the direct routing will be replaced and all pharmacies in Sweden will be able to access the electronic prescriptions for all patient prescriptions. This eliminates any risk of transcription errors and loss of paper prescriptions. It provides a substantial benefit not only for patient safety, but also for patient convenience. The solution has been in use since November 2002 at the Women Clinic, Soedersjukhuset in Stockholm. Other Swedish healthcare providers are scheduled to implement the solution in 2003 as well.

Conclusion

Healthcare systems in most countries are struggling with the increasing demand for healthcare services,

increasing cost, limited financial resources and an increasing public demand for substantial quality improvements. Efficiency gains can help overcome these challenges. Increased automation in healthcare, utilizing electronic solutions designed for process improvements and active workflow management, along with electronic decision support, results in the reduction of error-prone manual process steps and handoffs. This frees financial resources, which can be invested to support further cost containment. Human resources can focus more on patient care, and quality improvements are reducing medical and medication errors.

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Abbreviations

ADE	= Adverse Drug Event
AHRQ	= Agency for Healthcare Research and Quality
CPOE	= Computerized Physician Order Entry
FTE	= Full Time Employees
IOM	= Institute of Medicine
NHS	= National Health Service
WHO	= World Health Organisation

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