Information technology and automation in hospitals: strategies and experience in a tertiary hospital in Spain

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Abstract

Introduction: Providers and patients demand a high-quality, efficient, and cost-effective service. Different publications highlight the role of health information technology (HIT) and automation in reducing the number of medication errors and increasing efficiency, with the greatest emphasis on computerised prescriber order entry (CPOE) combined with computerised clinical decision support. Technologies such as automated preparation and dispensing systems, electronic medication administration records, and smart infusion pumps are also important. However, HIT and implementation of automation in hospitals often meet with resistance.

Study objectives: To describe the implementation of an automated medication use process for prescription and dispensing in an acute care tertiary hospital in Spain, the strategies developed to ensure its success and the results in terms of quality, efficiency, and cost.

Results: The process is described in three phases: (1) reorganisation of the pharmacy department and HIT processes, (2) design and implementation of CPOE, and (3) implementation of decentralised profiled automated dispensing cabinets. Strategies include prioritisation of projects and the steps to be developed to implement new technology. The new model reduced the medication error rate from 13.6% to 8.7% compared with that based on handwritten prescriptions and ward stock distribution. It also increased pharmacy interventions by 40% and reduced pharmacy department activity cost, measured in relative value units, by 28%.

Conclusion: Implementation of an automated medication use process requires a careful balance between technical, clinical, and organisational factors. If implementation is managed properly, the process can increase quality and efficiency and reduce costs in the pharmacy department.

Keywords

Automation, health care, hospital, medication errors, pharmacy service, quality assurance, technology

Introduction

Nowadays, both providers and patients demand a high-quality, efficient, and cost-effective service. Therefore, the primary drivers of current trends are improved safety, quality, operating efficiency, integration and management of data, cost reduction, increased revenue, and outstanding customer service [1].

The importance of technology in improving the healthcare delivery process—from computerised systems to electronic medical records—is widely accepted by healthcare experts, policy makers, payers, and consumers alike.

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One of the main problems facing the medication use process is the error rate. Strategies for preventing errors and adverse events are based on improved communication systems, more readily accessible knowledge, key information, rapid calculations, real-time monitoring, and decision support [2]. In addition, the complexity of the medication use process is such that errors can appear at one, some, or even all the stages between prescription and administration. The frequency of medication errors has been estimated to be 39% in the prescription process, 12% in the transcription process, 11% in the dispensing process, and 38% in the administration process [3, 4]. Therefore, changes to the system aimed at improving the ordering and administration phases are likely to have a marked impact on reducing medication errors and preventing adverse drug events.

Different publications highlight the role of health information technology (HIT) and automation in the medication use process, not only in reducing the number of medication errors, but also in increasing efficiency, with the greatest emphasis being on computerised prescriber order entry (CPOE) combined with computerised clinical decision support (CDS) [5-13]. This system has revolutionised the workflow of healthcare practitioners and the way information and treatments are used. CPOE has allowed nursing and pharmacy staff to eliminate the transcription process and has proven to be a decisive step in the creation of the electronic medical record. Furthermore, it can be used in combination with the electronic medical record and with drug information systems or CDS processes, thus improving safety.

The application of automated dispensing systems to the practice of pharmacy began in the early 1960s. However, changes in the healthcare system and the shift towards pharmaceutical care have dramatically increased the need for automation during the past 15 years. Automated preparation and dispensing in the pharmacy department and on the ward have been shown to minimise errors, increase efficiency, and improve information management. Along the same lines, data suggest more benefits in increasing the availability of pharmacists for clinical activities and an improvement in billing efficiency, although the effect on reduction in the number of medication errors has not been uniformly appreciated to date [14-16].

The incorporation of new technology in the last stage of the medication use process, through the electronic medication administration record with an integrated bar code scanner, has proven effective in reducing administration errors by enabling nursing staff to verify a patient's identity and validate medications against active orders, even though the data available are still more limited than with CPOE [17-24]. For example, the Veterans Affairs Medical Centers, USA, [18] reported a global reduction of 86% in administration errors, a 75% reduction in the administration of wrong medication, a 62% reduction in the wrong dose, a 93% reduction in drugs being prescribed to the wrong patient, an 87% reduction in errors caused by administering drugs at the wrong time, and a 70% reduction in the number of omitted doses. The University of Wisconsin Medical Center, USA [19] showed a reduction in these administration errors from 9.1% to 1.2%; the Northern Michigan Regional Health System study [20] reported a reduction of 1,300 medication errors, and Paoletti et al. [21] showed a reduction of 54% in administration errors.

Smart infusion pumps are also playing a critical role in reducing the number of administration errors related to IV drugs, with the incorporation of a drug library that sets standard concentrations, dose limits, and infusion rates [25-27].

In this paper, we present our strategies and experience in the implementation of new technology in the medication use process.

Introduction of HIT and automation: strategies and experience in a tertiary hospital

The Pharmacy Department of Hospital Gregorio Marañón, Madrid, Spain, began to implement HIT in the hospital in 1998, when the main problem affecting the medication use process was the complexity of the hospital's structure: 1,800 beds in seven different buildings. The pharmacy department is located in a separate building, and its services cater for the whole hospital by delivering all the drugs in vans.

A new 350-bed facility for women and children was built in 2002, with the ambitious objective of becoming one of the country's most technologically advanced hospitals. The hospital was initially intended to have a satellite pharmacy with traditional unit-dose cassettes; however, this idea had to be ruled out due to the distance between the new facility and the central pharmacy, as well as the increased activity in ambulatory care and the short length of stay of its patients, 2–3 days, where necessary.

The pharmacy department had to design a dispensing system that would provide the same safety features of unit-dose distribution, but with greater efficiency for its users. These goals could be accomplished by implementing an automated medication use process from the prescription to the administration phase.

The leadership of the Pharmacy Director was critical in the process of facilitating deployment of this technology (justification of resources and co-ordination of processes). The Pharmacy Director built a cohesive team comprising clinical pharmacists and pharmacists with advanced knowledge of HIT, thus creating an environment that allowed the clinical and support activities of pharmacists to be developed. It was very important to create a balance between these two activities, as, for example, clinical pharmacists would be required to play an educational and supportive role in the implementation of CPOE.

The person in charge of information technology and implementation of the automated process had a detailed knowledge of the pharmacy service's computer system, the medication use process, safety issues, clinical management, and drug distribution and administration, as well as considerable expertise in the technology used to support these activities.

How did we choose and prioritise projects?

Once it was decided to implement an automated model, the first phase was to clearly describe the problem that the new technology was to solve, and the desired objectives, so that progress could be measured. We described each step of the current medication use process and the desired solution for each step. Manual prescription was to be substituted by creating a CPOE program with online pharmacy validation, and the traditional unit-dose cassettes were to be replaced by profile-driven automated decentralised dispensing cabinets. In the future, a robotic compounding system for IV drugs will replace the manual system and, in the administration phase, an electronic medication administration record and smart infusion pumps will be installed. Figure 1 shows the process of change from our traditional model to our automated model.

A detailed analysis of requirements was made before each stage. We defined the technical, functional, and business requirements that the technology would need to fulfil, and all potential users, including nurses and IT staff, participated in the definition of these requirements. Physicians from the Critical Care and Internal Medicine Departments also played a key role at this stage. The time spent answering 'who, what, when, where, and how' was essential for the success of the system.

Once all the requirements had been met, priorities in the implementation of these technologies were established. These were assessed using a two-axis matrix placing outcomes against cost, see Figure 2. The outcomes axis represented value for users and functionality, while the cost axis represented costs in terms of money, effort, and resources involved, such as support and infrastructure, as well as complexity. If a project was in the quadrant of high results and low cost, it was to be carried out immediately, whereas if it was in the quadrant of high cost and low results, it was ruled out. However, as most projects fell into the other two quadrants, they were broken down into small, manageable steps so that they could be accomplished gradually. Below, we set out the steps followed in the implementation of our current automated model—prescription and dispensation phases.

Reorganisation of the pharmacy and current HIT processes

Before initiating the implementation of the new system, the hospital pharmacy had to ensure that all processes were designed, implemented, and maintained in a safe and efficient fashion. Such an approach involved reorganisation of the pharmacy and current HIT processes.

The first stage in the automation process was to improve the pharmacy information system—physician prescription order entry, drug use monitoring, cytotoxic drugs, nutrition, bar code control. As the pharmacy department has more than one supplier, the interface with the rest of the system was a determining aspect in the choice of a new approach. A new modular but well-integrated information system was installed in 2001. This was linked to hospital admissions and the billing information system and connected to the electronic medical record.

The second concern was to centralise automation in order to store and monitor all the medication except for that of the outpatient pharmacy, cytotoxic drugs, and IV and parenteral nutrition solutions. Not only did this technology meet the needs of nursing units by enabling automatic transfer from the cabinets to the carousel, but it also provided the pharmaceutical companies with a purchase order list according to the par level and the standard purchase for each reference. Therefore, in 2001, three carousels were installed; two for room-temperature drugs and one for refrigerated drugs, thus minimising errors during medication selection and increasing the efficiency of the process. Furthermore, the reorganisation also made it possible to create a new pharmacogenomics laboratory in the area previously used for medication storage, thus increasing the list of clinical services provided by the pharmacy department.

During the last seven years, the activity of our pharmacy department has focused on the incorporation of HIT and automation in other areas, with the implementation of

Figure 1: Evolution from our traditional model to our automated model

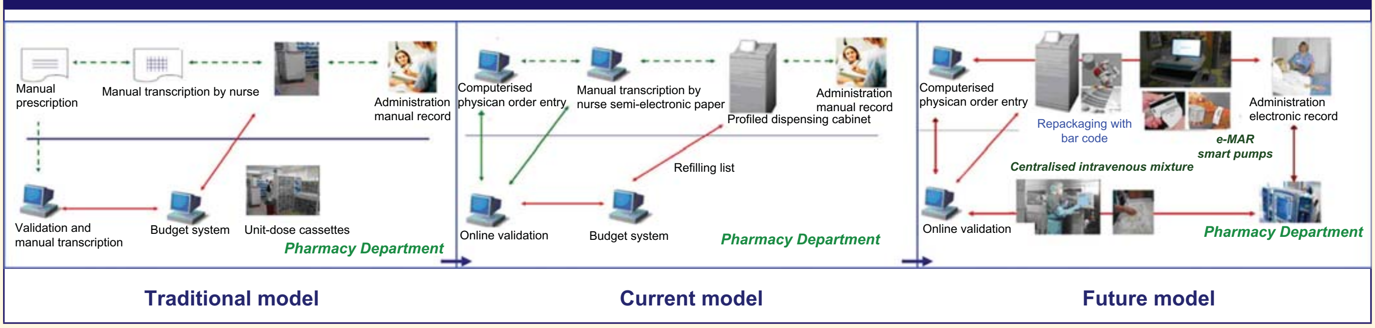
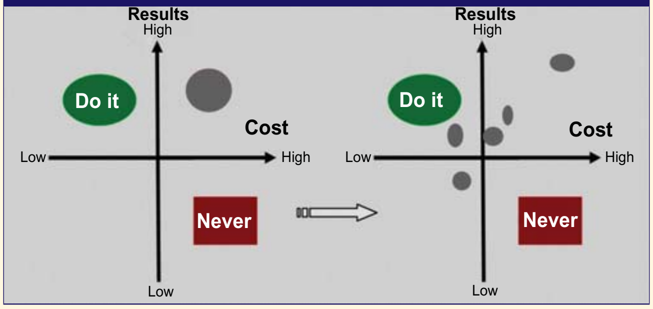


Figure 2: Methods for prioritising projects



CPOE and CDS tools for prescribing and the introduction of decentralised automated profiled dispensing cabinets for dispensing.

Design and implantation of the CPOE

The project was led by two pharmacists, two physicians, and two HIT technicians. It consisted of a Java product on the hospital intranet providing an online pharmacy validation feature that made it possible to eliminate the transcription process followed by pharmacy and nursing staff. Although currently at a very basic stage, the CPOE has facilitated the prescription process: it is based on protocols, the doses of most drugs are standardised, and the presence of a CDS tool generates alerts for allergy, duplications, and interactions. Additional reasons for its success are its user-friendliness and low technical support requirements: the training of new users is conducted by an advanced-level user and takes no longer than 30 minutes. The design also included a procedure manual, a contingency plan in case of failure, and a list of telephone contacts.

Implementation of decentralised automated profiled dispensing cabinets

Once the CPOE was functioning, the decentralised automated dispensing cabinet was installed in the unit after a two-week training period. The pharmacy department and the nursing supervisor participated in the definition of stocks and the procedure for refilling.

A project involving such important changes in HIT processes has to be designed in such a way that delays in performance are avoided. From the outset, each step included schedules, goals, budgets, activities, and monitoring. Furthermore, our suppliers formed an integral part of the team creating the plan, as the demands expected of the technology had to be discussed to avoid increased financial and workload costs. The different steps followed in the implementation of this new technology in the medication use process are shown in Figure 3.

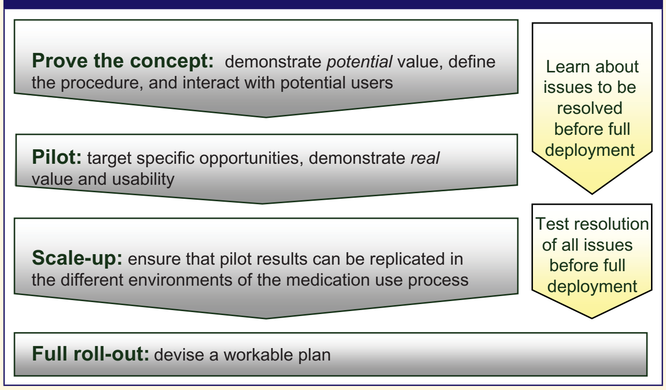
Finally, considering that the implementation of new technology requires improvements and changes that can alter daily activities, it is important to take into account the types of people the process would affect. We identified five basic types: the 'pioneers', whose abundant enthusiasm and drive were key to the success of the process; 'early adopters', who had a significant impact on their peers and were to be the persons responsible for introducing the technology once it was running, despite having a low tolerance for challenges; the 'pragmatists', who joined the system once it was shown to be stable; the 'conservatives', who were not willing to undertake the new process if it involved a lot of work; and finally, the 'laggards', who avoided getting involved for as long as they could. We began to implement the new processes—prescription and dispensation—in those units that we knew were willing to implement the systems. Thus, it was easier to convince the more conservative professionals, as they were able to see the systems functioning in other units.

Monitoring the process: quality, efficiency, and economic impact

We were aware that new technology rarely prevents medication errors by itself, and that, if not managed properly, the implementation of HIT and automation could lead to more error-prone systems. Implementing automation is often a very complicated process that markedly modifies the practice of pharmacy, nursing, and medicine. The only way to guarantee patient safety is by effectively integrating the existing medication use system with appropriate management of the transition.

Thus, regardless of whether state regulations exist to guarantee safe use of these systems, our pharmacy department is developing, enforcing, and continuously improving policies and procedures. Specific areas addressed include reporting, documentation, training of personnel, routine quality assurance and safety checks, scheduled

Figure 3: Steps in the implementation of new technology



(and unscheduled) hardware and software maintenance and support, and contingency plans for maintaining safe systems and service in the event of unscheduled downtime.

Our pharmacy department has also started to systematically monitor some of these new processes for quality, efficiency and cost.

In terms of *quality*, one study developed with the Preventive Medicine Services of the institution, showed a global reduction in the medication error rate with the current model compared with the traditional model, which was based on handwritten prescriptions and ward stock distribution (13.6% vs 8.7%) [28].

In terms of *efficiency* of the prescription process, physicians usually complain about the time they need to enter the order into the system. In this case, having a CDS tool proved very helpful. Doctors have the information they need at a given time and place in the hospital, and no longer rely on other people to bring them the medical charts.

Regarding the efficiency of pharmacists' activities, HIT has increased the amount of work that the existing workforce can accomplish, by making it possible to carry out new activities without increasing staff numbers, which is extremely valuable when facing a shortage of hospital pharmacists and an unfavourable economic environment. This technology has enabled us to work more closely with physicians and other healthcare providers in order to facilitate appropriate therapeutic decisions. We can now direct more attention to issues related to high-risk drugs/patients and high-cost diseases, instead of distributive tasks or drug order transcription. For example, the implementation of our current model has generated a 43% increase in the activity of pharmacists and a 40% increase in clinical interventions in automated areas.

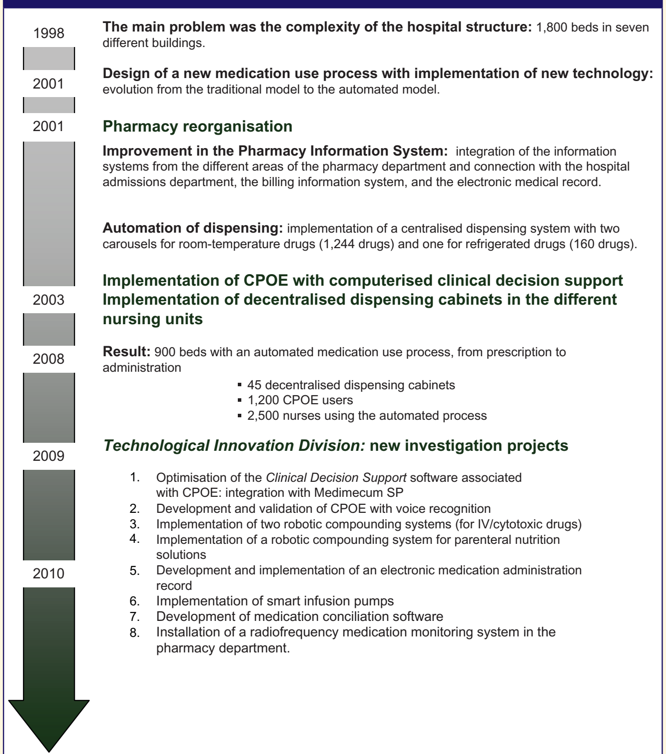
Finally, as distribution activities are decentralised, the nurses themselves prepare the drugs they need, instead of using the cassettes from the central pharmacy. This change has led to a reduction in overall pharmacy workload. Many nurses complained when the system was first implemented; however, these very same nurses are now the most active users of the system.

In terms of *cost*, the results must be judged on how well the new process is managed, the efficiency of the manual system being replaced, and the extent to which different disciplines cooperate to maximise the system's capabilities. Our pharmacy department has achieved a 28% reduction in its activity cost measured in relative value units (for example, one line of automated dispensing costs Euros 0.63 with the new medication use process, compared with Euros 0.87 with the previous technology).

The last ten years of technological innovation have enabled our pharmacy department to create a technological innovation division, iPharma®, to design and coordinate new projects aimed at enhancing the safety and efficiency of medical care. The goal of the division is to facilitate technology and innovation throughout the pharmacy service. The division also keeps track of the other departmental activities in order to improve and implement best practices in innovation. Figure 4 summarises the HIT and automation implementation process in the Gregorio Marañón Hospital since 1998.

Projects under development include optimisation of the CDS tool in collaboration with other hospitals and the Medimecum SP programme, which will provide a higher level of support and enable access to information on best practices and guidelines. It will also be possible to implement a system for monitoring and assessing information. The implementation of an electronic medication administration

Figure 4: Implementation of new technology in Hospital Gregorio Marañón



CPOE: Computerised prescriber order entry record, smart IV infusion pumps, robotic IV compounding, and software for radiofrequency identification of high-cost drugs are also worthy of mention.

Conclusion

Our experience suggests that the way we manage the implementation of new technologies is fundamental. If pharmacists are involved in the process, they can dramatically improve the success rate of implementation, because their extensive knowledge of the process can ensure that new technologies lead to safer and more effective medication use. Developing multidisciplinary plans for ongoing communication, training, user support, downtime contingencies, security, and confidentiality is also key to this success.

Pharmacists and pharmacy managers must understand both the positive effects and limitations of automated systems before implementing new technology. It is also crucial to have clear goals and realistic expectations of the benefits and limitations of the technology. Lastly, yet equally important, we should bear in mind the need to assess results before, during, and at the end of each stage of the implementation process to ensure rigorous monitoring of progress.

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