Information technology–based approaches to reducing repeat drug exposure in patients with known drug allergies

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There is increasing interest internationally in ways of reducing the high disease burden resulting from errors in medicine management. Repeat exposure to drugs to which patients have a known allergy has been a repeatedly identified error, often with disastrous consequences. Drug allergies are immunologically mediated reactions that are characterized by specificity and recurrence on reexposure. These repeat reactions should therefore be preventable. We argue that there is insufficient attention being paid to studying and implementing system-based approaches to reducing the risk of such accidental reexposure. Drawing on recent and ongoing research, we discuss a number of information technology–based interventions that can be used to reduce the risk of recurrent exposure. Proven to be effective in this respect are interventions that provide real-time clinical decision support; also promising are interventions aiming to enhance patient recognition, such as bar coding, radiofrequency identification, and biometric technologies. (J Allergy Clin Immunol 2008;121:1112-7.)

Key words: *Drug allergies, information technology, patient safety, systems approach*

Abbreviations used

ADR:	Adverse drug reaction
CPOE:	Computerized physician order entry
IT:	Information technology
RFID:	Radiofrequency identification
UK:	United Kingdom

An adverse drug reaction (ADR) is an undesired outcome attributable to a drug. There are 2 main classes of ADRs recognized: type A ADRs are predictable and therefore potentially preventable, whereas type B ADRs are unpredictable and therefore far more difficult to prevent.[1]

Allergic reactions to drugs are a class of type B ADRs that are immunologically mediated, with this reaction being directed either at the drug in question or its breakdown product.[2] The widely used Gell and Coombs classification system can be used to categorize allergic reactions on the basis of the underlying mechanisms involved.[3,4]

These immunologic mechanisms share the characteristic of specificity, transferability, and, crucially, a high risk of recurrence on reexposure. Repeat reactions in individuals with a previous reaction should therefore be preventable. There are, however, often a number of important practical challenges to clearly establishing a diagnosis of drug allergy, including the need to obtain a detailed clinical history, the relatively few validated tests, and the issue of possible cross-sensitivity, all of which often result in considerable uncertainty in relation to securing a diagnosis of drug allergy. Notwithstanding these difficulties, it is often possible for clinicians to arrive at a working diagnosis of drug allergy, and it is these individuals (ie, those in whom a working diagnosis of drug allergy has been made and documented in the clinical records) that represent the focus of our deliberations and who are henceforth described as having a known drug allergy.

EPIDEMIOLOGY

Obtaining epidemiologic data on the frequency of reexposure to drugs in those with known drug allergies is difficult for a number of reasons. First, there is a problem with underreporting in schemes that collect information on ADRs, such as the Yellow Card system run by the United Kingdom (UK) Medicines and Healthcare products Regulatory Agency,[5] the US Food and Drug Administration's MedWatch Program (http://www.fda.gov/medwatch/index.html), or the recently established National Reporting and Learning System, the first national database of patient safety incidents.[6]

Second, retrospective reviews might not provide sufficient information to clearly establish the background and context of the event, raising the possibility of significant misclassification errors.

Third, there is still uncertainty among many patients and health care professionals as to which reactions are truly allergic and which are, for example, caused by intolerances and other nonallergic mechanisms.

Despite these difficulties, data from US studies conducted in secondary care suggest that between 6% and 12% of medication errors are due to patients receiving a medication to which they were already known to be allergic.[7-9] This translates into between 90,000 and 180,000 episodes per year in the United States (based on the assumption that medication errors harm about 1.5 million persons per year). Research from US ambulatory care suggests similarly high figures.[10] Crucially, most instances of these repeat exposures have been judged across studies as being preventable.[9,10]

More recent epidemiologic data comes from an analysis of around 60,000 patient safety incidents reported to the UK

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National Reporting and Learning System between 2005 and 2006.[11] This found that the administration of medication despite a known drug allergy was the cause of 3.2% of medication-related patient safety incidents in hospitals and of 2.6% of incidents in family practice settings. Almost one third of these resulted in harmful consequences to patients, including death in some cases. Drugs most frequently involved in these incidents were found to be antibiotics (penicillins in particular), opioids, and nonsteroidal anti-inflammatory drugs. Moreover, the UK Department of Health report of medical insurance claims found that 11 (5.7%) of 193 Medical Protection Society claims (for family practice) and 25 (10.7%) of 234 Medical Defence Union claims (for hospital care) related to allergic reactions to medication.[12] Many of these concerned antibiotics that had been prescribed to patients with known allergies.[11] Other drugs and agents that are commonly responsible for triggering allergic reactions include antihypertensive agents, vaccines, anesthetic agents, and seizure and antiarrhythmia medications.

However, the conclusions drawn from these studies do have to be treated with some caution because data derived from retrospective studies of adverse drug events might not be directly comparable with those derived from studies of global medication errors or studies of medication administration. Nevertheless, a growing body of international evidence suggests that accidental reexposure in patients with known drug allergies is one of the most common preventable medication errors, often with disastrous consequences for the patient (Fig 1). This appears to be true for both hospital and community care.

Of concern is that despite the frequency of accidental reexposure and the likely consequences, systems-based approaches to reducing the risk of repeat exposure in individuals with known drug allergies are not being given the attention they warrant, as evidenced, for example, by their failures to be considered in key relevant international allergy guidelines.[13-15]

"GP [general practitioner] on call administered amoxicillin to the patient. A short time later the patient collapsed in cardiac arrest. An ambulance was called and a CPR [cardiopulmonary resuscitation] protocol followed. Whilst CPR was being completed, it was ascertained that the patient had been prescribed an antibiotic ... which a relative stated the patient had told the GP that they were allergic to. (Reported as resulting in death)"

"A patient was prescribed and given a dose of amoxicillin. The patient developed itching and felt unwell, and later collapsed requiring anti-histamine and adrenaline injection to treat the reaction. The patient was known to be penicillin allergic but this had not been transcribed onto the new medicine chart."

"A patient with a penicillin allergy documented on their medicine chart and who was wearing a red allergy alert wristband, was prescribed and given a dose of piperacillin."

From the National Reporting and Learning System.[11]

FIG 1. Clinical examples.

INFORMATION TECHNOLOGY–BASED APPROACHES TO REDUCING MEDICATION ERRORS

Information technology (IT)–based solutions are particularly promising in reducing the risk of reexposure because they can help in overcoming some of the underlying systemic failings, particularly in relation to managing, processing, retaining, and making accessible large amounts of disparate data to multiple end users.

Below we consider theoretic and, where available, empiric evidence of a number of key IT-based approaches currently under investigation, with the aim of reducing the risk of reexposure in individuals with known drug allergies. In so doing, where possible, we focus on findings from studies with rigorous designs, but because this is very much an area still under development, for some of the newest technologies, where such experimental studies have yet to be conducted, we also draw on evidence from relevant formative work, research, or both in other disease areas that might be generalizable to the context of managing patients with known drug allergies. Tables E1 through E4 in the Online Repository (available at www.jacionline.org) provide a detailed summary of key studies evaluating these interventions.

Computer systems with hazard messages

There is strong evidence for the effectiveness of using computer systems incorporating hazard messages that alert health care professionals to patients' allergies (see Table E1 in the Online Repository and Fig 2). For example, Bates et al[16] evaluated the effectiveness of computerized physician order entry (CPOE) alone and in combination with a team intervention in preventing medication errors in a tertiary care hospital over a 6-month period. CPOE in this study involved physicians electronically entering medication orders chosen from a drop-down menu. The system also had a component that checked for the most common drug allergies. It was found that CPOE reduced known drug allergy errors by 56%. In a similar study in an intensive care unit, Evans et al[17] found that a computerized decision support system program linked to patient records and that issued recommendations, as well as warnings, significantly reduced (from 146 to 35, $P < .01$) the number of instances in which drugs were ordered to which the patient had a recorded allergy. Studies of CPOE and computerized decision support systems from family practice have pointed in a similar direction.[10]

Despite these very encouraging results, there are several issues with computerized prescribing support tools that often prevent them from realizing their potential.

First, they require relevant and accurate drug allergy information to be entered into the record to be effective.

Second, the production of hazard alerts of known drug allergies depends on the level of system sophistication.[16]

Third, studies have shown that there is often a lack of training among health care professionals as to how best to use these systems, sometimes resulting in a false sense of security if data on allergies are, for example, entered into an inappropriate section of the records or as a free-text entry rather than as a code that will be recognized by the system.[18]

Fourth, they often lack specificity, which can result in spurious hazard messages being generated. This in turn might lead to frustration among users with the consequent danger that hazard messages might be accidentally overridden.[19] Conversely, an overreliance on warnings might contribute to errors with clinicians "blindly" trusting system alerts.[18]

Finally, there are still sometimes problems with the underlying design of the prescribing software, as demonstrated in a study by Fernando et al[20] in which they tested the safety features of 4 widely used family practice computer systems in the UK and found that only 3 of 4 systems produced alerts when penicillin was prescribed to a dummy patient with a penicillin allergy

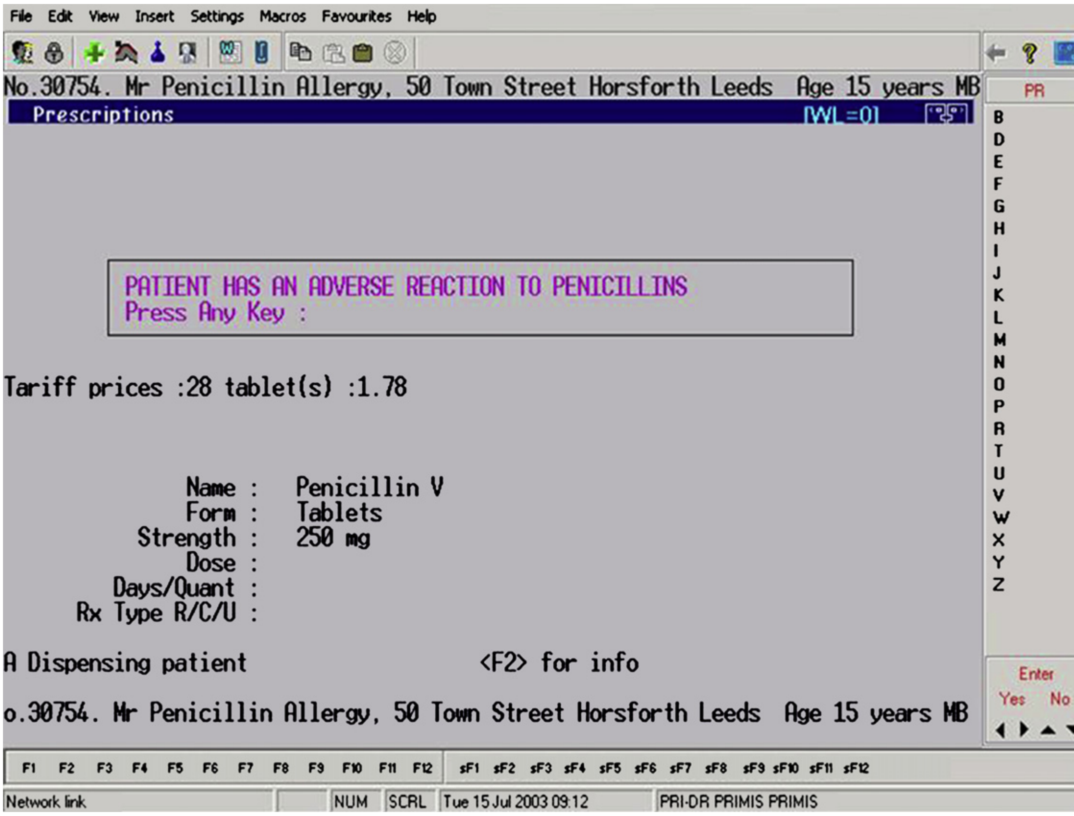

FIG 2. Example of a drug allergy alert.

previously recorded in the system. Thus efforts still need to concentrate on improving the safety features of such prescribing support systems to further enhance their effectiveness.

Kuperman et al[21] have recommended several approaches to ensure more effective checking in relation to drug allergies. Included in these is the suggestion that computer systems should store allergy information centrally to ensure it is up-to-date and readily available in different settings (eg, family practices and hospitals). The authors also suggest assigning levels of importance to allergy warnings so that the likelihood of truly important alerts being overridden will be minimized. Creating a common language for groups of allergies and strategies to prompt health care professionals to enter all allergic reactions into the system are additional helpful suggestions. Investigations into the effectiveness and potential improvement of existing computer systems incorporating hazard messages that alert health care professionals to patients' allergies are ongoing.

Bar codes in wristbands

Another stream of efforts has focused on investigating the use of bar-coded wristbands in hospital settings (see Table E2 in the Online Repository at www.jacionline.org). Although color-coded wristbands can help to identify a particular risk in a patient (eg, a drug allergy), bar-coded wristbands can provide more comprehensive patient-specific information on the class of drug to which the patient is allergic. Here the system includes a bar-code reader that is connected to a host computer that retrieves the desired patient information when the wristband is scanned. The scanned information can then be checked against the medication packaging, which might also have a bar code. Although there is a broader literature surrounding bar codes on medication packaging, we focus here on bar codes in wristbands because this is most relevant for preventing repeat exposure in patients with drug allergies.

A number of different wristband bar-coding systems have now been developed and are at various stages of implementation in hospitals across the world. For example, Franklin et al[22] have recently investigated the effectiveness of what is described as a "closed-loop electronic prescribing and administration system" in a surgical ward of a UK teaching hospital. This involves giving patients bar-coded wristbands, which are connected to a reader on a drug trolley. After the wristband is scanned, the trolley releases medication through a drawer; details of items dispensed in this way are stored on computer. This has been shown to significantly reduce prescribing and medication administration errors; it also resulted in increased identity checking of the patient by hospital staff.

The majority of studies investigating the effectiveness of bar-coded wristbands come from the area of transfusion medicine. For example, an investigation by the Department of Hematology at the Oxford Radcliffe Hospital in the UK found that the introduction of patients wearing a bar-coded identification wristband that could be scanned into a handheld computer for compatibility resulted in a significant improvement in patient identification.[23] When the same model was tested in 2 other hospitals, one in Italy and the other in the United States,[24] similar results were obtained, demonstrating the generalizability of these findings.

Although promising, there is as yet a paucity of high-quality evidence from randomized controlled trials for the effectiveness of bar-coded wristbands. Systems have also thus far not been tested specifically with regard to reducing known drug allergies. In addition, some have questioned the practicality of such devices.

The National Patient Safety Agency in the UK, for example, refers to health care staff's lack of compliance with using bar-coded wristbands (Fig 1) and a lack of standardization across institutions.[25] There is furthermore a danger of patients inadvertently being given a wristband belonging to another patient and the associated risk that might ensue from this misidentification.[26] Other issues include the problem of access because wristbands need to be scanned with a handheld device from relatively close proximity. This might under some circumstance prove problematic, such as if the position of the patient does not permit scanning (eg, the patient is sleeping or unconscious) or if the handheld scanner is impractical to use (eg, in the operating room).[27]

Bar-code technology can also be used for MedicAlert bracelets. These are simple bracelets or necklaces with the medical condition of the patient (eg, allergy information) recorded, an identification number, and a telephone number for someone who can be contacted in an emergency. Although MedicAlert bracelets are commonly recommended to allergic patients and highly valued by physicians (especially in patients with anaphylaxis), we are not aware of any studies evaluating their effectiveness. A likely benefit of these bracelets is that they can be carried around by patients and therefore used outside hospital settings. Nevertheless, it has to be kept in mind that in addition to the problems mentioned above, there might be issues with compliance with wearing MedicAlert bracelets.[28]

Radiofrequency identification

An even more recent development is radiofrequency identification (RFID). These are chipped tags that are connected to a transceiver through radio waves, which allow the storage of information (eg, drug allergies) remotely. RFID chips allow more information to be stored than bar codes, are more user friendly (because they can be scanned through fabric), and are commonly regarded as more failsafe (because they can work independently of any user input). They are also relatively cheap at a cost of between 5 and 10 cents each. Pilot studies in hospitals support the effectiveness of such systems, but as with bar codes, more rigorous evidence of effectiveness is still needed (see Table E3 in the Online Repository at www.jacionline.org). Most activity in the developing and implementing RFID chips can currently be found in the United States. For example, the Jacobi Medical Center in New York has already implemented a system using RFID tags in wristbands to improve patient identification and reduce medication errors in 2 acute care departments.[29] Patients are issued with a so-called "Smart Band" on admission, which can be scanned by a handheld reader that brings up all necessary patient information on a screen at the bedside (see Fig E1 in the Online Repository at www.jacionline.org). This information can then be updated and modified as necessary. The Jacobi Medical Center has reported a reduction of medication errors, as well as staff time, associated with data entry as a result of introducing the system.

Again, there are several pilot studies using RFID chips to try to reduce errors in blood transfusion. The San Raffaele Hospital in Milan (Italy) is currently piloting a system in which RFID tags are incorporated into wristbands given to donors.[30] These are matched with a tag on the blood, which is then scanned at the time of transfusion (see Fig E2 in the Online Repository at www.jacionlie.org). Similar systems are also currently being piloted in hospitals in the German Saarbrucken Clinic Winterberg, in Washington and Boston in the United States, and in Taiwan.[31-33]

In the UK the Birmingham Heartlands Hospital is implementing RFID wristbands in surgical wards after successful piloting. Here the whole operating team has wireless personal digital assistants that can be used to scan a patient's wristband, giving instant access to operating schedules and patient records.[34]

Taking the use of RFID chips one step further, the Hackensack University Medical Centre in the United States is currently piloting a patient identification system using implantable RFID chips for patients with chronic conditions, which provide detailed and instantly accessible patient information in emergencies.[35] A similar pilot has been started in the Alzheimer's Community Care headquarters in the United States in August 2007.[36] The advantages of these implants include the comfort of wearing them and their potential application in the community. Here the family physician will merely have to scan the patient, gaining instant and up-to-date access to medical records. However, these implants do raise important ethical concerns, and their effectiveness remains to be evaluated in high-quality clinical trials.

Biometric technologies

Another possible way to facilitate patient identification (and therefore potential drug allergies) is the use of biometric technologies, such as fingerprint, face, or iris scanning. These systems are not as invasive as implanted RFID chips and have the distinct advantage of being easily and instantly accessible. Obviating the need for patients to carry or wear an external object, there are also no issues with compliance. Such systems have already been piloted around the world, again mainly in the United States (see Table E4 in the Online Repository at www.jacionline.org). The majority of applications have been implemented in outpatient clinics helping to identify patients coming in to collect medication. For example, the government of The Netherlands is using fingerprint scanners to identify heroin addicts who come to methadone distribution services.[37] Also, an increasing number of health care providers in the United States are using fingerprint scanning to prevent recipient and provider fraud.[38] Moreover, South Africa has launched a project allowing for patient identification using fingerprints,[39] and the "Methadose" system in Australia is scanning the irises of patients who collect their methadone at St Vincent's Hospital in Sydney.[40]

In the UK the Patient Access to Electronic Records System gives patients electronic access to their medical records in family physician practices through fingerprint scanning. The system is now implemented in 13 practices across England.[41]

However, robust scientific evidence of the effectiveness of such systems is lacking. These remain as yet untested with regard to reducing repeat exposure in patients with known drug allergies, an area in which their application might have significant potential.

Patient-managed electronic health records

The approaches outlined above all involve some type of IT application. They also rely, to a lesser or greater extent, on patient involvement, and it is important in this respect that parallel attempts are made to improve provider-patient communication and more actively involve patients (and caregivers) in their care with a view to reducing such reactions.[42] Patients, after all, have the most to lose through accidental reexposure and the most to gain through getting involved with care delivery in general. Patient-generated and patient-managed electronic health records will thus be particularly important in this respect, with the onus on patients taking responsibility for ensuring that their records are accurate and up-to-date and that they are not given treatments that place them at unnecessary risk.[43] Examples of the successful implementation of personal health records include HealthConnectOnline in the United States, where patients can access and update their medical records and manage treatments online (http://www.healthconnectonline.com/). A similar service has been introduced in some parts of Europe (including Germany, Switzerland, Austria, and Bulgaria) under the name LifeSensor (https://www.lifesensor.com/us/us/), which is a Web-based personal health record accessible for both health professionals and patients. Patients in England can use a secure Web service named HealthSpace, which does as yet not include detailed medical information. An evaluation of this service is shortly about to start in UK hospital care, and actively modifiable medical records are planned to be implemented by the end of 2008 (https://www.healthspace.nhs.uk/).

Although some concerns have been voiced regarding the accuracy of personal health records, their potential to help improve delivery of care is increasingly being recognized by both patients and professionals. In the context of patients with known drug allergies, they provide a valuable additional safety net for use in combination with other established and emerging technologies discussed above.

Which of the approaches or combinations of approaches discussed will ultimately prove most effective in reducing instances of repeat exposure in patients with known drug allergies remains to be determined. Given the strong empiric evidence supporting their use, it is important that CPOE systems with hazard alerts are increasingly implemented and refined in both community and hospital settings to help reduce repeat exposure. Similarly, it is expected that patient-managed electronic health records will in due course occupy a more central position in helping to deliver care. Among the other emerging technologies discussed, RFID chips and biometrics hold great potential for the integration of allergy information across care settings. But the lack of formal evaluations of the effectiveness of such devices with regard to patients with known drug allergies, their high capital costs, and a potential fear of technology among many health care staff and patients might slow developments in this area. Also, ethical issues, including the accessibility of confidential information that patients carry with them at all times, might prove problematic.

CONCLUSIONS

There is an increasing body of epidemiologic work indicating that ADRs caused by known drug allergies are relatively common and potentially preventable. Alongside the need for increased research into investigating the underlying mechanisms and processes involved in allergic reactions to drugs and the accompanying need to develop improved screening and diagnostic tests,[4] there is, we believe, the pressing need to investigate and, where found to be effective, implement systems-based approaches to reducing these events in routine care. We have discussed existing and emerging IT-based interventions, which are proven and have the potential to prove successful in minimizing the risk of reexposure. Computer systems with hazard alerts are likely to continue to play an important role, but much is also to be expected from newer technologic developments in this area as bar codes in wristbands and MedicAlert bracelets, RFID chips, biometrics, and patient-managed electronic health records become a reality in routine day-to-day care. There is, however, an urgent need to evaluate the effectiveness of these newer technologies in the context of managing patients with a history of drug allergy. Although these developments are important, they do not detract from the onus of responsibility on the prescribing and administering clinician and the patient who agrees to take the drug.

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FIG E1. Handheld scanner attached to a screen and RFID-tagged wristband used at the Jacobi Medical Center in New York. Reproduced with permission from Siemens IT Services and Solutions. Available at: http://www.ti.com/rfid/docs/news/eNews/enewsvol40.htm. Accessed February 6, 2008.

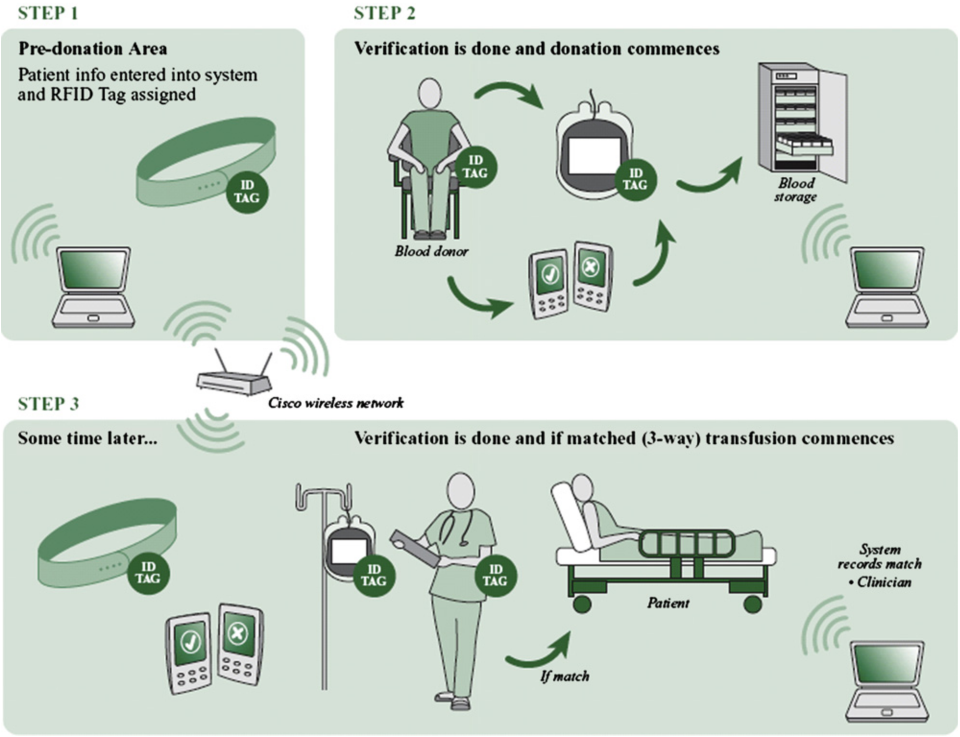

FIG E2. Blood-handling process using RFID technology at the San Raffaele Hospital in Italy. Adapted with permission from Intel Corporation from: http://www.cisco.com/web/IT/local_offices/case_history/rfid_in_blood_transfusions_final.pdf. Accessed February 6, 2008.

TABLE E1. Summary of studies investigating the effectiveness of the CPOE/CDSS in reducing instances of repeat exposure in patients with known drug allergies

Reference	Year	Country	Setting	Design	Main findings
Bates et al[E1]	1998	United States	Tertiary care hospital	Randomized comparison of numbers of medication errors before and after implementing CPOE alone and in combination with a team intervention over a 6-mo period	CPOE significantly reduced known allergy errors.
Evans et al[E2]	1998	United States	Intensive care unit (12 beds)	Prospective cohort study of CDSS program implemented for 1 y compared with data of patients admitted 2 y before the intervention period	The number of instances in which drugs were ordered to which the patient had a recorded allergy were reduced significantly.
Gandhi et al[E3]	2003	United States	Four adult family practices (2 hospital-based and 2 community-based practices)	Prospective cohort study including chart reviews of prescriptions and comparison of adverse drug events between practices where prescriptions were computerized and those where they were handwritten	Authors concluded that serious preventable events could have been prevented with computerized checks for drug allergies and interactions.

CDSS, Computerized decision support system.

TABLE E2. Summary of studies investigating the effectiveness of bar codes in wristbands in improving patient identification

Reference	Year	Country	Setting	Design	Main findings
Marconi et al[E4]	2000	Italy/United States	Two hospitals (1 in Italy and 1 in the United States)	Implementation of bar-coded wristbands and handheld computers to facilitate patient and component identification in blood transfusion	The system was found to result in 100% accuracy.
Turner et al[E5]	2003	UK	Department of Hematology at the Oxford Radcliffe Hospital	Audit of practice before and after the introduction of bar-coded wristbands and handheld computers to facilitate patient and component identification in blood transfusion	A significant improvement in patient identification was found.
Franklin et al[E6]	2007	UK	Surgical ward of a teaching hospital	Comparison of numbers of prescribing and administration errors before and after implementing a "closed-loop electronic prescribing and administration system" with bar codes in patient wristbands	Intervention significantly reduced prescribing errors and medication administration errors and resulted in increased identity checking of the patient by hospital staff.

TABLE E3. Summary of pilot studies investigating the effectiveness of RFID technology in improving patient identification

Reference	Year	Country	Setting	Design	Main findings
Wessel[E7]	2004	United States	Jacobi Medical Center (first implemented in acute care and then in the medical surgery unit)	RFID tags in wristbands to reduce patient identification and medication errors; tags can be scanned with tablet PC/reader	The hospital reported a reduction of patient identification and medication errors, as well as staff time, as a result of introducing the system.
Dalton et al[E8]	2004	Italy	San Raffaele Hospital	RFID tags incorporated into wristbands given to blood donors matched with a tag on the blood, which is then scanned at the time of transfusion	The hospital reported that during the initial 6-mo pilot period, there were no errors in the transfusion process, but evaluation is ongoing.
Dzik[E9]	2005	United States	Georgetown University Hospital, Washington, DC (oncology unit)	Aims at evaluating the effectiveness of bar-coded and RFID-tagged wristbands during blood transfusions	Ongoing
Dzik[E9]	2005	United States	Massachusetts General Hospital, Boston	Aims at evaluating the effectiveness of bar-coded and RFID-tagged wristbands during blood transfusions	Ongoing
Precision Dynamics Corp[E10]	2005	Taiwan	Chang-Gung Memorial Hospital	RFID tags in wristbands used in the operating room	The hospital reported that since the introduction of wristbands, they had 100% accuracy in patient identification.
Wessel[E11]	2006	Germany	Saarbrucken Clinic Winterberg (internal medicine division)	RFID chips on wristbands and blood bags scanned with handheld computers	The hospital reported that the system is reducing mistransfusion and reducing staff time spent on managing blood bags.
Medical News Today[E12]	2006	United States	Hackensack University Medical Centre, New York	Patient identification system using implantable RFID chips for patients with chronic conditions	Ongoing
Bacheldor[E13]	2007	UK	Birmingham Heartlands Hospital	RFID tags in wristbands used in the operating room	The hospital reported that there have been no patient identification errors since the introduction of the system, and the system has prevented 2 "near misses."
More RFID[E14]	2007	United States	Alzheimer's Community Care headquarters	RFID Patient Identification System using implants in patients with Alzheimer's disease	Ongoing

TABLE E4. Summary of applications of biometric technologies in health care

Reference	Year	Country	Setting	Design	Main findings and rollout
Head[E15]	2002	Australia	Methadone clinic at St Vincent's Hospital in Sydney	System scanning the irises of patients who collect their methadone	Piloted and subsequently rolled out in 60 methadone clinics across Australia, the designers of the system report that it reduces staff time and patient identification errors.
E Health Insider[E16]	2003	UK	One family physician practice in southeast London	Patient Access to Electronic Records System gives patients electronic access to their medical records in family physician practices through fingerprint scanning.	After a successful pilot period, the system is now implemented in 13 practices across England.
Kohl[E17]	2004	United States	Medicaid system	Use of fingerprint scanning to prevent recipient and provider fraud	Medicaid reported a reduction in program expenditures and an improvement in program integrity.
Czernowalow[E18]	2005	South Africa	Piloted by health workers in 3 South African provinces	Patient identification using fingerprints	Ongoing
NEC Security Solutions[E19]	2005	The Netherlands	Methadone distribution services	Fingerprint scanners to identify individuals who come to collect methadone	Piloted and subsequently rolled out across the country.

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