The feasibility of implementing an electronic prescribing decision support system: a case study of an Australian public hospital

David Bomba and Tim Land

Abstract

Medication errors are common in public hospitals, with the majority at the prescribing stage of the medication pathway. Electronic prescribing decision support (EPDS) is a rules-based computer system that can be used by clinicians to warn against such errors to improve patient safety and support staff workflows. Despite its apparent advantages, this technology has not been widely adopted in Australian public hospitals for inpatient prescribing. A case study using Sauer's (1993) Triangle of Dependencies Model was conducted in 2003 into the feasibility of implementing an EPDS system at an Australian public hospital in New South Wales. It was found not feasible to implement an EPDS at the hospital studied due to the legacy patient administration system, low availability of information technology on the wards, differing stakeholder views, legislation, and the Independent Pricing and Regulatory Tribunal of NSW report recommendations. A statewide standard was preferred, with an agreed specification framework identifying basic core data items and functions that an EPDS must meet which can then be used by area health services to: (i) choose a solution which best meets their contextual needs; and (ii) engage vendors to tender for building an open source (non-proprietary) system based on the specification framework.

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David Bomba, PhD, Senior Research Fellow
Tim Land, BInfoTech(Hons), Research Assistant
Centre for Health Service Development, University of Wollongong, Wollongong, NSW.

Correspondence: Dr David Bomba, Centre for Health Service Development, University of Wollongong, Northfields Ave, Wollongong, NSW 2522. **bomba@uow.edu.au**

What is known about the topic?

Medication errors account for 20% of all hospital adverse events. While not widely accepted in Australia, in other systems electronic prescribing decision support (EPDS) has been found to reduce adverse drug events.

What does this paper add?

This paper presents the results of a qualitative study of health professionals designed to determine the feasibility of implementing EPDS in one Australian public hospital. The study found that it was not feasible to implement an EPDS due to the legacy patient administration system, low availability of IT on the wards, differing stakeholder views, legislation, and statewide report recommendations.

What are the implications for practitioners?

The authors suggest that the study framework can be used by other organisations considering the implementation of EPDS. The findings can also be used by others to explore the feasibility of EPDS and information systems in their context. ◆

A GREAT DEAL of research is conducted both nationally and internationally on errors in health care, known as adverse events (AEs). The Australian Council for Safety and Quality in Health Care found AEs associated with medications, or adverse drug events (ADEs), accounted for up to 20% of all hospital errors.[1] In the United States, Bates et al conducted a study in 1995 to assess the incidence and preventability of ADEs and potential ADEs. The main finding from the study was that "adverse drug events were common and often preventable", with errors much more likely to be intercepted if they occurred early in the process, at the prescribing stage (49% of all errors).[2] In addition to determining the frequency of errors at each stage of the pathway, the study also reported the five most common types of error at the prescribing stage: wrong dose (38%), wrong choice (19%), known allergy (12%), wrong frequency (6%), and drug–drug interactions (5%).[2]

Medication errors are costly. The Taskforce on Quality in Australian Health Care reported an estimated cost to the Australian health care system for the additional bed-days as a result of AEs to be in excess of $800 million per year.[3] Figures on the inappropriate use of medicines in the Australian public hospital system estimate the cost of medication errors to be $380 million each year.[1]

The system used in public hospitals for administering drugs is known as the medication pathway, comprising three major stages: prescribing, dispensing, and administering. Those involved in the pathway include doctors, nurses, clerks, pharmacists, and technicians. The medication pathway uses paper charts for prescribing and recording the administration of drugs to patients. These charts have a number of inherent problems, which can lead to medication errors, such as handwriting illegibility, incompleteness, transcription errors, or the loss of the chart itself.[3]

One proposed solution to providing safer prescribing is electronic prescribing decision support (EPDS) systems, which include patient specific information, such as allergies, and generate alerts to medical staff about potential problems and drug interactions.[4] They are rules-based computer systems (referred to as Computer Physician Order Entry [CPOE] in the US) which aim to prevent physicians from writing incorrect or inappropriate prescriptions.[5] In one study at the Brigham and Women's Hospital in the US, the use of EPDS reduced serious medication errors by 55%; and in another study conducted over 4.5 years at the same hospital all errors (excluding missed doses) were reduced by 81%.[6]

EPDS systems are in use in many countries. While most general practitioners in Australia use prescription writing software such as Medical Director (Health Communication Network Ltd, Sydney, NSW) to produce prescriptions for their patients, the adoption of EPDS technology for inpatient prescribing in public hospitals has not yet occurred on a wide scale in Australia. At the time of the study, there was only one known non-pilot system in use for inpatient prescribing in a public hospital at Frankston Hospital in Victoria.[7]

Despite the apparent relative advantages, there are significant barriers to implementing such systems in a hospital environment, such as cost; the complexity of integration with existing legacy computer systems; and the socio-technical constraints of designing and implementing computer technology, attitudes and data standards. Also, legislation presents a barrier in New South Wales; the Poisons and Therapeutic Goods Regulation (2002) specifies that all the particulars of a prescription may be produced by a "system" except the signature, which must be handwritten.[8]

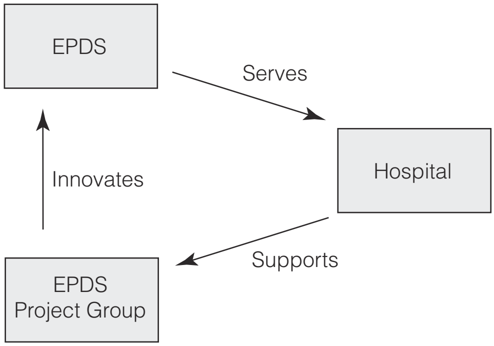
However, recognition and support for EPDS is steadily growing among health care professionals and peak industry bodies, such as the Australian Council for Quality and Safety in Health Care.[1] EPDS is also seen as a key component of NSW Health's $240 million clinical information systems program.[9]

The aim of this research was to investigate the feasibility of EPDS system implementation at a public hospital and to contribute knowledge on EPDS and the issues affecting its adoption in Australian public hospitals.

Research framework

Sauer's Triangle of Dependencies model was selected as a useful information systems framework. Sauer's model suggests that the success or failure of an information system is dependent on the organisational context in which it is placed.[10] The model postulates three key parties involved in the "information system process": the project organisation; the system; and the supporters. The "project organisation" is a group of people who are involved in "... initiating, developing, implementing, operating or maintaining" a system.[10] The "system" is the information system. The "supporters" are those who support the project organisation by providing money, materials, or information, and in return expect some benefit from the system. This Triangle of Dependencies demonstrates the relationships between the three groups — "the information system depends on the project organi-

1 Application of the triangle of dependencies model to the research



Adapted from Sauer.[10] EPDS = electronic prescribing decision support.

sation, the project organisation depends on its supporters, and the supporters depend on the information system".[10]

The Triangle of Dependencies is not a closed feedback loop; there are six "exogenous" factors which affect the relationship of dependencies and level of support provided. Labelled as the "information systems context", they are: cognitive limits, technical process, environment, politics, structure, and history.

Cognitive limits apply to the problem-solving and decision-making capacity of human beings and include limits on memory, attention, logical skills, and conceptual understanding.[10] The technical process factor includes the constraints derived from the characteristics of computer-based systems. Both the internal and external environments of the organisation have the potential to influence the feasibility of implementing an information system. Politics can affect the feasibility of an information system in a number of ways. In the evaluation process, for example, politics is often involved if there are several projects competing for the support of the evaluator. Organisational structure has an impact on the flow of information within an organisation. Accordingly the structure of an organisation has an impact on the dissemination of information about an information system to users and decision makers. Management of communication about the proposed system with these groups may help to control user reactions to the innovation. Sauer includes history as a factor so that past events are taken into consideration. To put it succinctly, "the past constrains the present and the future"[10] and includes commitments made by stakeholders which impact the decision-making process, and past experiences of decision makers that may influence the evaluation process, for example, legacy systems, vendor-specific software, and failed IT projects.

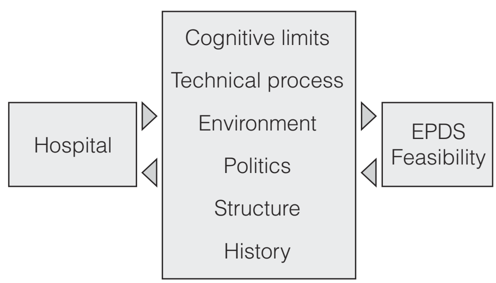
Methods

The research method was a case study evaluation using face-to-face interviews and focus group sessions with staff at the hospital. Standard university ethics approval was granted and also endorsed by the Chief Medical Superintendent of the hospital for the conduct of this research project. In order to maintain anonymity the hospital is not referred to by name. The target population consisted of clinicians (medical staff, pharmacists and nurses) and clinical IT experts (the "expert group"). The application of Sauer's triangle of dependencies model can be seen in Box 1.

To account for the influence of the six contextual factors, a schema was formed which proposed a relationship between the hospital, the contextual factors, and the feasibility of implementing EPDS (Box 2).

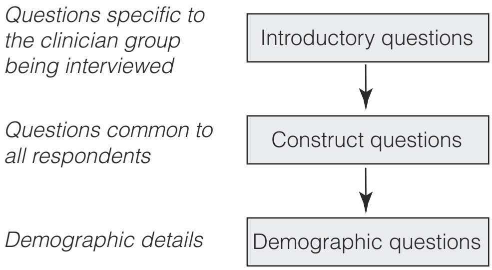
Developing the data collection instrument proved difficult. Because clinicians had little available time it was recommended by the Hospital

2 Framework schema of the research



EPDS = electronic prescribing decision support.

3 Clinician interview instrument structure



Superintendent that a combination of interviews and focus groups be used and individual interview times be kept to 15 minutes and focus group sessions to 45 minutes. This had a bearing on the number of questions. The question formulation was driven by the framework schema (Box 2).

The instrument structure is illustrated in Box 3.

After a review process, the instrument was piloted with six interviews. Piloting on the Hospital Superintendent and Directors offered dual benefits of obtaining their valuable feedback and allowing them the opportunity to approve the instrument. The pilot interviews were too long and, as a result, several questions were removed, after which the average interview time was close to 15 minutes (Box 4). The data analysis NUD*IST (Nonnumerical Unstructured Data Indexing Searching and Theorizing) software package N6 (QSR International Pty Ltd, Melbourne, Vic) was used for qualitative data analysis.

Results

Junior Medical Officer's (JMOs) comprising two Interns and two Residents participated. Access to the Registrar population at the hospital was limited by workloads and lack of "buy-in" to the research, and as a result their response rate was low. Six Visiting Medical Officers (VMOs) representing a range of specialties were interviewed: two oncologists, one anaesthetist, one neurologist, one emergency department (ED) physician and one consultant physician (general medicine). Though limited, this range captured responses from different areas. After a poor response to an invitation for a focus group session, the Nurse Unit Managers (NUMs) were asked for one-on-one interviews, to which there were five acceptances, and eight pharmacists also participated in a focus group session. Box 5 provides a summary of the clinician participation.

4 The ten construct questions

Cognitive limits

- What are the limitations of the present paper-based prescribing system?

Technical process

- Is a handheld wireless tablet or notebook computer on a trolley suitable for writing, (checking or marking off) prescriptions? Why/why not?
- What are the minimum features an electronic prescribing system must have to gain clinician adoption?

Environment

- Adoption of an electronic prescribing system would mean significant work practice changes for all staff involved in the medication pathway. How could this impact best be managed?
- Given that proper authentication measures would be included in the electronic prescribing system, how confident would you [medical staff] be in working with electronically signed prescriptions?

Politics

- While being a decision support tool, electronic prescribing also has the capacity to flag errors in prescribing, how do you think medical staff will respond to this?
- Do you favour a national/statewide approach to IT implementation in public hospitals, or should Area Health Services be able to make their own IT system decisions?

Structure

- Is there a ward that is especially suited to electronic prescribing?

History

- The benefits of electronic prescribing are well documented and demonstrated internationally, yet it remains that no public hospital in NSW has fully implemented electronic prescribing. Why do you think this is so?
- Experience has shown that it is vital to consult medical staff during the design and implementation of information systems. How could this best be done with electronic prescribing? ◆

5 Overall clinician response rate

Type	No. of respondents	Total staff	Response rate
Medical staff	13	146	9%
Nurse Unit Managers	5	25	20%
Pharmacists	8	15	53%
Total	26	186	14%

The total number of Nurse Unit Managers includes inpatient and outpatient wards. ◆

Demographics

Gender and age were the key demographic details collected from clinical respondents. Of the respondents, 38% were men (10 medical staff), and 62% were women (3 medical staff, 5 NUMs and 8 pharmacists). An interval scale was used to obtain the age of respondents Most respondents (56%) lay in the age brackets 36–45 and 46–55 (Box 6).

Cognitive limits factor

Ninety six percent of clinicians replied that they would be willing to adopt electronic prescribing. Only one responded negatively, concerned with the potential for additional time required to order electronically. Both clinicians and the expert group commented that if EPDS required more time to prescribe it would create a serious issue. The expert group, however, stressed that when referring to time, one must consider the total time spent in dealing with a prescription, including looking up interactions and/or checking laboratory results, writing the order, and fielding phone calls from pharmacists or nurses who need clarification. When viewed in that light it is possible to see that prescribing electronically may be faster. Also, the need to transcribe medication charts is eliminated with EPDS, as is the time wasted looking for missing paper charts.

Despite pharmacists citing illegibility as the primary problem with paper charts, remarkably, the pharmacist focus group commented that it is often harder to interpret clearly typed script than an illegible handwritten prescription. This is because there is an extra level of embedded tacit knowledge that comes from years of experience in recognising certain illegible handwritten scripts — that is, the style of (illegible) handwriting actually helps to identify the prescriber. A Resident commented that he can distinguish between orders by the handwriting, important when making many changes to several medication charts over a period of time. Two experts explained that systems can display the prescriber's name next to each order, which is beneficial when nurses need to contact the prescriber. Another Resident stated that while he was not afraid to use an EPDS system, a hard copy to sign off on would also act as a check for orders.

Participants were asked about computer use at home, and 24 of 26 respondents indicated they

6 Age of respondents

	Age group (years)					
Type	18–25	26–35	36–45	46–55	56–65	65+
Medical staff	2	4	4	2	1	0
Nurse Unit Managers	0	0	2	2	1	0
Pharmacists	2	1	1	3	0	0
Total	4	5	7	7	2	0
% of total respodents	16%	20%	28%	28%	8%	0

One pharmacist did not respond to the age question. ◆

used a computer at home. Respondents were also asked to rate their confidence in using computers on a five-point Likert scale, with 1 = "not confident" through to 5 = "very confident". The majority (50%) chose the neutral middle value (3); medical staff appeared to have more confidence in using computers than nurses and pharmacists, with three medical officers rating themselves "very confident". No one was "not confident". Some respondents demonstrated a considerable lack of confidence in electronic signatures, while the majority indicated they needed assurance that only clinicians authorised to prescribe could do so electronically.

Training and support was highlighted as a concern by both clinicians and experts, outlining the difficulty in providing training in a 24-hour, 7-days per week operating environment, particularly for permanent nightshift staff. The agreed solution was to look at innovative methods of training including video, online courses and good documentation. An ED physician commented that, while comfortable with the medicines with which he is familiar, his capacity to keep up with new drugs is limited and the decision support aspect of EPDS at the point of care offers a potential solution.

Technical process factor

To explore all avenues of EPDS implementation, two experts were asked if the hospital Information Services Department (ISD) would consider developing a system "in-house". Both replied they would not, primarily because of the technical complexity involved, but also the necessity of keeping abreast of the changing regulatory environment, the high maintenance required and lack of sufficient human resources in-house for such a complex application.

There tended to be four PCs per ward with a common configuration of two at the nurses' station and one each in the NUMs' and A/NUMs' offices. All of the NUMs indicated that congestion on the two PCs at the nurses' station was common and a cause of annoyance for staff. The problem for ED staff was cited as, "At the moment we're running pathology, we're running radiology, we're running EDIS [Emergency Department Information System] . . . and that is done on a limited number of PCs." Clinicians provided mixed responses when asked how they would feel using wireless PDAs (personal digital assistants), laptops, and/or tablets. For example, a VMO preferred PDA, while a Resident preferred a lightweight laptop. The most logical strategy for the NUMs would be a laptop on the medication trolley. Pharmacists indicated that PCs on benchtops would be the most suitable solution in the pharmacy, however they would also require mobile hardware for ward rounds.

In order for people to change from paper to computer it must be just as easy to write a script electronically as it is on paper. Ease of use was found to be related to minimal keystrokes and ensuring simple navigation.

Medical staff highlighted concerns about the potential for excessive drug interaction alerts; all drugs interact one way or another, and if an EPDS system flagged every possible drug–drug interaction it would become annoying. For example, it is not uncommon for a renal patient to be on 20 different drugs, which could generate hundreds of interaction alerts, making it highly likely that the physician would ignore all the alerts including the life-threatening ones. It was suggested that it would be helpful if interactions could be graded according to severity.

Issues were raised pertaining to internal and external security. Many clinicians expressed concern about authentication; medical staff were concerned someone may log in as them and start prescribing, while pharmacists wanted similar reassurance — that a prescription saying doctor "X"really was ordered by doctor "X". The existing practice of log-in sharing is unacceptable when prescribing medications using EPDS. Firstly, not logging out represents a major security and patient safety breach, and secondly, it is vital to have the correct identity of the prescriber for clarification and tracking purposes. Measures against outside attack included the internal security features of the application, hacker ignorance and using a two-tiered architecture to hide the database from outside access.

An EPDS system must be operational 24 hours a day, 7 days a week and therefore, "the system has to

7 Advantages and disadvantages of a statewide solution

Advantages	Disadvantages
Benchmarking	Delayed vendor selection process
Clinician familiarity	Delayed benefits realisation
Improved data flow and research	Increased consultation costs
Economies of scale	Integration with many legacy systems
Uniformity	Not addressing each area health service's needs ◆

be super reliable". Also, with 24-hour operation, backups must be carried out while the system is live.

One benefit of the decision-support component of an EPDS system is the capacity to alert medical staff to potential drug-allergy interactions. Interfacing clinical IT systems, while technically possible, it is not always easy. The current patient administration system (PAS) at the hospital would not be useful in decision support as it does not contain patient data such as allergies, weight, and height, which are three important factors when prescribing (however the Cerner PAS proposed as a replacement system has these capabilities). More sophisticated capabilities of EPDS systems include decision support for appropriate medications based on a patient's pathological status: for example, if a clinician considers prescribing Lasix they could first check the patient's potassium level via the pathology system. Similarly, drug–food interactions could be checked and drug inventory management streamlined.

Environment factor

One participant in the expert group commented that health care professionals were saying, "It's time to start looking at EPDS systems, the market has matured, the clinicians are ready and the infrastructure is ready". It was suggested that NSW Health viewed EPDS as a later stage in implementing a suite of clinical systems. The IT project prioritisation is to replace the PAS, while concurrently reconciling medical record numbers among hospitals to create unique patient identifiers for area health services. Once this baseline is in place across the state, systems that can provide an integrated view of a patient's status will be implemented, followed by EPDS systems.

The NSW *Poisons and Therapeutic Goods Act 1966* and *Poisons and Therapeutic Goods Regulation 2002* legislate the requirements for prescribing medications and currently require handwritten signatures. The Director-General of NSW Health may have the authority to deem electronic signatures lawful. While this has not occurred, it may solve this legislative barrier to implementing EPDS systems.

EPDS systems must also take into account the strict regulations surrounding Schedule 4 restricted substance drugs and Schedule 8 drugs of addiction, which require two nurses to jointly administer the drugs and both to sign the medication chart. EPDS applications would need to allow for two electronic signatures.

An advantage of EPDS systems is the ability to easily capture data on medications prescribed per clinician. This may make clinicians more accountable, but may also cause them to feel that "big brother" is watching. The system would also need to be able to easily track what a patient has received, which would be useful if a legal claim is made against the hospital.

Politics factor

The overwhelming response from clinicians was that alerts are positive and they would not find them offensive. Many clinicians also pointed out that in today's medical liability culture, alerts or warnings become even more desirable in managing risks and making the system more transparent.

The study explored whether local or statewide solutions would be preferred, with advantages and disadvantages to each approach. The majority of respondents said that they would prefer a statewide solution, as clinicians (in particular JMOs) change hospitals many times throughout their career and they would need to learn only that one system. A statewide solution would also make it easier to communicate between area health services, facilitating the transfer of patient informa-

8 Advantages and disadvantages of an area-wide solution

Advantages	Disadvantages
Close fit with area needs	New clinician unfamiliarity
Faster decision making process	Difficult data flow between areas
Greater potential for benefits realisation	Disparity across the state

tion and enabling benchmarking. By using one system, over time, data sets can be collated and measured for research purposes. Box 7 outlines the advantages and disadvantages of implementing a statewide solution. The Independent Pricing and Regulatory Tribunal of NSW (IPART) report released in August 2003[11] recommended that future information systems be mandated on a statewide basis.

The main concerns from respondents opposed to a statewide solution were that while preferable it is not practical, that bureaucracy adds years to a selection decision, and the possibility of ending up with a system that does not meet their needs. A workable solution was offered of a framework that identifies the specifications which the application must have and the information that is required from it, allowing areas to choose the solution which best meets their business needs. Box 8 outlines the advantages and disadvantages of area solutions.

Structure factor

Respondents were asked about the impact of an EPDS system on information flow among hospital staff at the hospital. Most clinicians had difficulty answering this, however the expert group indicated that the flow of information would definitely be improved, suggesting that legibility can improve information flow.

The characteristics of the ward and the staff were seen as important in choosing a pilot site. Most clinicians agreed that a ward with a limited casemix would reduce initial complexity. In a low turnover ward, medication management per patient could be evaluated over a longer period of time. Obviously, a smaller ward requires less hardware and has fewer patients, again reducing complexity. Lastly, existing technology may also contribute to how receptive clinicians will be to the trial. Clinicians in units such as Intensive Care or Coronary Care currently work with many electronic devices, so adding an EPDS system into their workflow may be better received than on a ward with less technology. However, project champions may be more important than the characteristics of the ward, because a pilot has a better chance of success if the clinicians are predisposed to innovation.

History factor

As expected, lack of funding was a commonly cited reason for lack of adoption. This ties with another common response, lack of computer hardware on wards and the current state of disparate clinical IT systems. The clinical IT systems at the hospital were seen as department-centric, not patient-centric, which means logging onto different systems for different results. Clinicians need an integrated patient-centric system.

Ideas for staff consultation included running seminar programs, small group information sessions, conducting in-service training and sending emails and newsletters. Engaging clinicians in systems design will always be a contentious issue, as one VMO stated, “It was difficult to achieve clinician involvement because people were busy and not interested, and consulting clinicians about the system would be a waste of time”. In terms of system useability and reliability, an anaesthetist commented, “If you go ahead and implement the system most people would give it a try, if it works well they will keep using it”. Another issue raised was the need to ensure that JMOs are included in the consultative process as they do the bulk of inpatient prescribing, which might be difficult as JMOs rotate wards every 9 weeks and usually move on to other hospitals as they finish their contract.

Discussion

While the study has provided valuable insight into the issues surrounding EPDS implementation, the single case study approach can limit generalisation. Time constraints of the respondents also had an impact on the amount of data that could be collected.

The results uncovered several contradictions from respondents. For example, while indicating a personal willingness to adopt, few respondents felt the clinician population as a whole would be so accepting. When most respondents were discussing their peers, reference to "resistance to change" was often cited. Many pharmacists commented they are now so conditioned to working with hardcopy charts and interpreting handwriting that some believed they would need a major change in mindset to work with an EPDS system, yet it was pharmacists who cited illegibility as the primary problem with paper charts.

"Technical complexity" ruled out in-house development of an EPDS system, leaving vendor solutions as the alternative. However vendors may not have a product suited to Australia's complex medication environment, such as the administration of Schedule 4 and Schedule 8 drugs. The availability of hardware was an issue raised by the majority of respondents, and solving this problem requires careful assessment and consultation. While mobility of hardware is viewed as preferable, a key requirement is uniformity, however, a "one size fits all" device for all users is not necessarily realistic.

Log-in sharing among medical staff was identified as an important problem. The probable factors contributing to log-in sharing are time pressures, oversight, and a lack of PCs, creating congestion, however this needs further study. Finally, the study identified the potential for poor decision support due to the limited scope of the existing PAS at the hospital.

Conclusion

The research framework and approach can be used by other researchers to build further evidence on the feasibility of EPDS systems implementation. Sauer's framework has utility for studying the feasibility of introducing information systems and information technology into organisations, however, a more finely tuned model may need to be developed, as the results of this study indicate. Based on the contextual factor analysis, EPDS implementation at the hospital studied was not supported. The current legacy patient administration system, the level of IT available on the wards, differing stakeholder views and timeframes and the IPART report recommendations were important issues impacting EPDS feasibility.

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Competing interests

The authors declare that they have no competing interests.

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