

Medicines Reconciliation Using a Shared Electronic Health Care Record

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Objective: This study aimed to evaluate the use of a shared electronic primary health care record (EHR) to assist with medicines reconciliation in the hospital from admission to discharge.

Methods: This is a prospective cross-sectional, comparison evaluation for 2 phases, in a short-term elderly admissions ward in the United Kingdom. In phase 1, full reconciliation of the medication history was attempted, using conventional methods, before accessing the EHR, and then the EHR was used to verify the reconciliation. In phase 2, the EHR was the initial method of retrieving the medication history—validated by conventional methods.

Results: Where reconciliation was led by conventional methods, and before any access to the EHR was attempted, 28 (28%) of hospital prescriptions were found to contain errors. Of 99 prescriptions subsequently checked using the EHR, only 50 (50%) matched the EHR. Of the remainder, 25% of prescriptions contained errors when verified by the EHR. However, 26% of patients had an incorrect list of current medications on the EHR.

Using the EHR as the primary method of reconciliation, 33 (32%) of 102 prescriptions matched the EHR. Of those that did not match, 39 (38%) of prescriptions were found to contain errors. Furthermore, 37 (36%) of patients had an incorrect list of current medications on the EHR.

The most common error type on the discharge prescription was drug omission; and on the EHR, wrong drug. Common potentially serious errors were related to unidentified allergies and adverse drug reactions.

Conclusions: The EHR can reduce medication errors. However, the EHR should be seen as one of a range of information sources for reconciliation; the primary source being the patient or their carer. Both primary care and hospital clinicians should have read-and-write access to the EHR to reduce errors at care transitions. We recommend further evaluation studies.

Key Words: electronic health record, medicines reconciliation, pharmacist reconciliation, prescribing errors

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Key Messages

- Access to a shared electronic health care record assists with ascertaining an accurate medication history and can reduce medication errors
- However, the electronic primary health care record may contain out-of-date or incomplete information
- The primary source of information is the patient or their carer. Electronic records may be used to complement information provided by the patient or carer but should not currently be used as the sole source of information
- A 2-way information flow would be beneficial to inform primary care physicians of discrepancies in the medication history and also to provide information about changes to medicines on discharge from hospital
- Further work is required to incorporate the EHR into routine clinical practice

Medication errors are a major cause of patient harm,¹ and prescribing errors are the most common type of medication error.² More than 50% of all hospital patients are victims of at least 1 prescribing error,³ and their vulnerability to error is especially marked at the point of admission.^{4–7} A study of 60 randomly selected patients established that 60% of patients at admission and discharge had at least 1 unintended error and that 18% of these were clinically important.⁸ Such evidence has prompted the U.S. Joint Commission on Accreditation of Health Care⁹ and the National Patient Safety Agency (NPSA) for England and Wales to make medication reconciliation a patient safety priority.¹⁰

The NPSA has advised that all health care providers should have a formal reconciliation policy, and pharmacists should be involved in the reconciliation process as close to admission as possible. This is supported by a systematic review¹¹ that identified 11 medication reconciliation studies based on pharmacist interventions which have improved medication safety.

Reconciliation is part of a 3-stage process¹²: verification of the patient's drug history before admission, clarification that the history is accurate, and, finally, reconciliation of the previous primary care prescription and the initial prescription. The process can, however, be time-consuming and often ineffective, especially when access to primary health care records is not available instantaneously. Furthermore, the primary health care record may not, in itself, be the criterion standard for accurate information.

Further work is needed to ascertain which reconciliation systems would be the most reliable and responsive to workflow.¹³ Although the benefits of harnessing electronic health records (EHRs) to facilitate the reconciliation process have been subject to some examination,^{14,15} there is still insufficient evidence to show that information technology systems can improve

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TABLE 1. Available Sources of Initial Drug History

	Notes
Patients' own medicines brought in	■ Some or all medicines may be missing ■ Patient may have brought in medicines that they are no longer taking ■ Instructions on the containers may be missing or not up-to-date
Nursing home/residential home, e.g., medicine chart	■ Usually the criterion standard for nursing home residents
Patients' own medicines in a monitored dosage system	■ Only provides a list of tablets and capsules. Does not include inhalers, eye drops, liquids, "as-required" medications, etc. Some tablets are not included in compliance aids because they deteriorate when removed from the original blister pack
Family physician (primary care general practitioner) repeat prescription slip received via fax from family/community practice	■ Only contains ongoing repeat prescriptions ■ May not be up-to-date ■ May not include recent changes, particularly for recent readmissions ■ Does not include family physician immediate prescriptions ■ May list items the patient is not currently taking, e.g., recent items stopped or medicines for seasonal disorders ■ Medicines prescribed by other physicians may be missing, e.g., specialist medications such as oral chemotherapy, anticoagulants, immunosuppressants, unlicensed medicines
Recent hospital discharge letter	■ Only accurate if the previous medication history was correct
Patient verbal information only	■ Often unavailable or incomplete in short-term admissions
Ambulance sheet	■ May be rushed and incomplete
Family physician referral letter	■ Details of drugs/doses sometimes missing
Family/community practice provided information verbally	■ Errors with verbal messages

patient safety in this regard. The accuracy of an EHR medication list was compared with actual drug use through a telephone survey of 85 patients and found 233 discrepancies (mean, 2.7 per record), 80% being classified as system-generated and 20% patient-generated.¹⁶

An EHR should improve communication, information transfer, and, consequently, safety.¹⁷ Access to a single, shared, contemporaneous patient record should lead to improved safety and quality of care and may be especially helpful for certain groups, such as the elderly, who have more long-term conditions. A position article on information technology systems to improve the quality of prescribing has called for any such system to be based on reducing human error,¹⁸ providing a further rationale for

exploring the utility of EHRs in combating prescribing errors. This study is based on an evaluation of a pharmacist-led reconciliation process using an EHR across primary and secondary care, based in an elderly medical admission ward.

SETTING AND EXISTING RECONCILIATION PROCESSES

The study was conducted on an elderly care medical admissions ward in an acute teaching hospital with approximately 1100 beds, located in the north of England. The ward is a short-stay 39-bed assessment unit with between 6000 and 6500 admissions per year. All patients admitted to the ward are reviewed by a consultant on the following morning's post-take ward round. Patients being discharged have a preliminary discharge letter handwritten by a physician, with a discharge medication list that includes any pre-existing medications that are to continue, as well as any new or altered medications. The discharging physician either documents any deliberate changes to the patient's previous medications or confirms that there have been no intentional changes. The discharge form serves as a prescription for the hospital pharmacy to supply any medicines required, particularly new or altered medications. Each prescription is checked by a pharmacist to confirm that it is safe to dispense. This includes a verification of the initial drug history and confirmation that the discharge prescription is reconciled with the initial history, taking into account explanation of any changes. A variety of information sources can be used to verify the initial drug history depending on the circumstances surrounding admission and the ability of the patient in providing information (Table 1).

More than half of the local primary care physicians have access to an EHR system (SystmOne, TPP, Leeds, UK). This system stores EHRs on a central database that can also be accessed by named users in the hospital via smart cards and personal identification numbers. Before this study, the EHR had not been formally evaluated as either a primary or a secondary source of reconciliation. The aim of this study was to formally evaluate the role of a shared EHR in reconciling medications. First, by carrying out a conventional reconciliation process and then comparing the results with the patient's prescription in the EHR. Second, by using the EHR to assist with reconciliation at the very beginning of the reconciliation process.

METHOD

The correct version of the medication history was assumed to be what the patient or carers confirmed to be correct, or the most recently dated source of information. Patients consecutively admitted to the elderly care admissions ward were included in the study, unless inclusion would have led to an unacceptable delay in discharge. The 2-phase study took place

TABLE 2. Sample Characteristics

	Phase 1	Phase 2
Total no. reconciled prescriptions	210	167
Total no. patients with medication details recorded on EHR	99	102
Age, yr		
Range	70–100	71–100
Median	84	85
Mean no. medications listed on admission	6.6	6.6
Mean no. medications listed on EHR	6.9	8

TABLE 3. Error and Potential Adverse Drug Event Severity

Score	Harm Level	Description	Example
0	None	No harm would be expected	Incorrect timing of vitamin or mineral supplements
1	Minor	Minor harm possible	Omission of laxatives Omission of mild analgesics
2	Significant	Significant immediate or long-term harm possible	Omission of cardiovascular medicine, e.g., β -blocker
3	Serious	Serious immediate or life-threatening harm	Unintended variation of dosage Unintended variation of dosage to a degree that would cause immediate harm Prescription of medication to which there is a recorded allergy

from December 2007 to January 2008 and from October to December 2008 on days when a second clinical pharmacist was available to allow time for the investigating pharmacist to conduct the study. Sample characteristics are shown in Table 2.

Phase 1: EHR Used as a Secondary Information Source

Discharge prescriptions were written and reconciled by a physician and then consecutively checked and verified by a clinical pharmacist as was usual practice. Because most patients were admitted the previous day, the final medication history check was usually done at the time of discharge. Once the pharmacist felt satisfied that the prescription had been fully verified and reconciled, it was sent to the pharmacy for dispensing. A record of both the initial medication history, taken by the admitting physician, and the medication history after verification by the clinical pharmacist was kept. Any interventions needed to amend either the initial drug histories or the discharge prescriptions were also recorded.

The EHR was then accessed in the pharmacy department to view the list of current medications on the primary care records. Any differences between the verified drug history and the list of current medications on the EHR were recorded. Additional questions were asked (with the patient, carer, family physician, or other source) to determine whether the difference was either due to a reconciliation error or to an error in the EHR. Differences in regular medications listed on the EHR, which identified further drug history errors, were immediately reported back to the prescribing physician, and the discharge prescription was amended. Error types were identified together with an assessment of the potential severity of medication history errors and discharge prescribing errors. Three pharmacists independently rated error and potential adverse drug event severity using a modified version of a grading scale previously developed and tested in the research setting.^{19,20} This also allowed grading of minor errors.

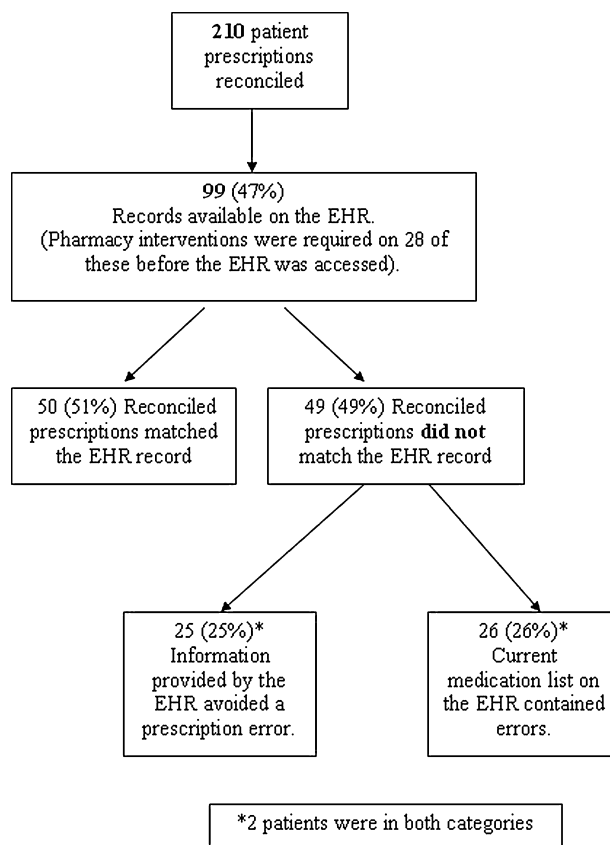
Phase 2: EHR Used as an Initial (Primary) Information Source

The second phase of this study, 9 months later, looked at the feasibility of using the EHR as a primary information source. The pharmacist first accessed patients' EHRs directly from a computer on the ward, before carrying out verification of the initial medication history that had been first recorded by the admitting physician. Specifically, the EHR was used as the pharmacist's first-line source when verifying the initial medication history. Final verification of the drug history came after taking all other available sources into account. Error types and their potential severity were again recorded as in phase 1. In both

phases of the study, the time spent by the pharmacists on the reconciliation process was recorded.

Analysis

We also calculated the frequency of error type, and 3 pharmacists (non-unique) rated and agreed with level of potential adverse drug event severity according to a locally developed scale (Table 3). Levels of interrater agreement concerning severity were recorded, and interrater reliability was subjected to an unweighted κ statistic. Differences in opinion on severity were then discussed and resolved, or in the few cases where resolution was not possible, the median score was selected.

**FIGURE 1.** Phase 1.

Ethics committee approval was obtained for the study. The patient's EHR automatically logs the identity of any user opening a patient's file and records whether access was made with or without consent being specifically requested. The general practitioner may then contact the user to verify reasons for accessing the record. The user opening the record is also automatically listed in an electronic journal and is expected to provide their reason for accessing the record.

RESULTS

In phase 1, 99 (47%) of 210 patients had a list of current medications recorded on the primary care EHR. Verification of the drug history by a pharmacist resulted in 28 (28%) discharge prescriptions having errors detected by the pharmacist and amendments made before the EHR was accessed. The electronic record matched this pharmacist-verified discharge prescription in 50 cases (51%). However, in the other 49% of the cases, it did not match; of which in 25 cases (25%), the details led to further amendments to the prescription. In 26 (26%) of the cases, current medication details on the EHR were inaccurate (Fig. 1). The type and frequency of verification sources used by the pharmacist are shown in Table 4; the most common was review of the patient's own medicine, including a discussion with the patient or carer where possible.

In phase 2, where the EHR was used as the initial source of verification through using a laptop computer by the bedside, there were 102 (61%) of 167 patients for whom a list of medications was recorded on the primary care EHR. A total of 11% of prescriptions required amendments before the electronic record was accessed; these were obvious errors or omissions that stood out as needing amendment before a proper drug-history check using the EHR was performed. The electronic record matched the prescription in 33 cases (32%). In 69 cases (68%), it did not match; of these, in 39 cases (38%), the EHR details led to further errors being detected. In 37 cases (36%), the current medication details on the EHR were believed to be currently incorrect (Fig. 2). Data from phases 1 and 2 of the study are summarized together in Figures 1 and 2. Figures 3 to 6 detail the potential severity of errors and error types. An overall (unweighted) κ statistic on interrater agreement across 3 raters was 0.39 (fair). The idiosyncratic conditions under which reconciliation was carried out did not allow accurate comparative measurement of the time taken to reconcile across the 2 study phases.

The most common error type detected on the discharge prescriptions was drug omissions. The error type most commonly judged to be potentially serious (level 2 or 3) was unidentified drug allergy or adverse drug reactions subsequently highlighted by the EHR. The most common error type detected in the EHR was the inclusion of a wrong drug on the current medication list. The error type most commonly judged to be potentially serious

TABLE 4. Initial Sources Used by Pharmacist in Phase 1 to Verify the Drug History

Patients' own medicines	38
Patients' own medicines in compliance aids	17
Repeat prescription slips provided by the patient	13
Nursing or care home charts	12
Family physician's repeat prescription received via fax	9
Previous discharge letter	3
Other	9
Total	101

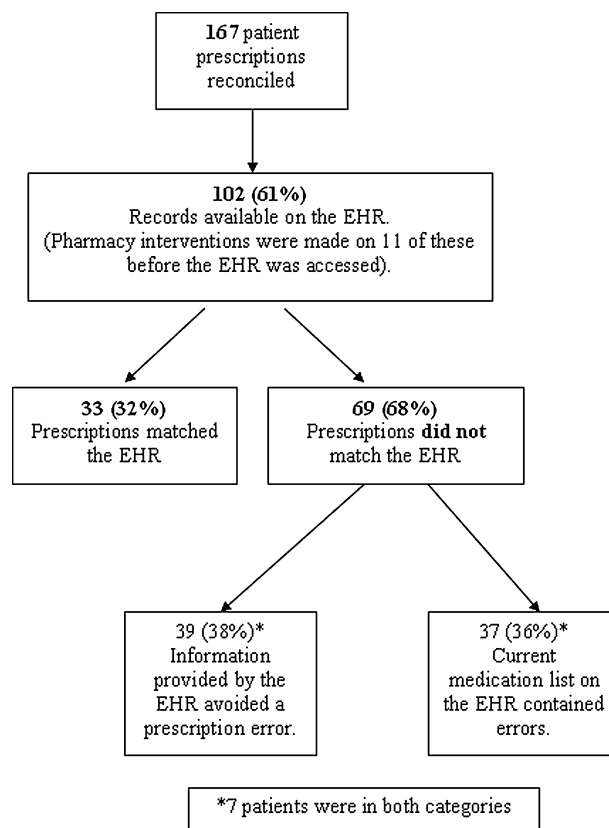


FIGURE 2. Phase 2.

in the EHR was unrecorded drug allergy. Illustrative cases are shown in Table 5.

DISCUSSION

We have looked at using a shared electronic record for reconciliation at 2 different points in time for a patient population who commonly receive multiple medications. In phase 1, full reconciliation of the medication history was attempted before accessing the EHR, using conventional methods such as the patient's own medicines or associated paper documentation. The EHR was simply used to verify the reconciliation. In phase 2, the EHR was the primary method of verifying the medication

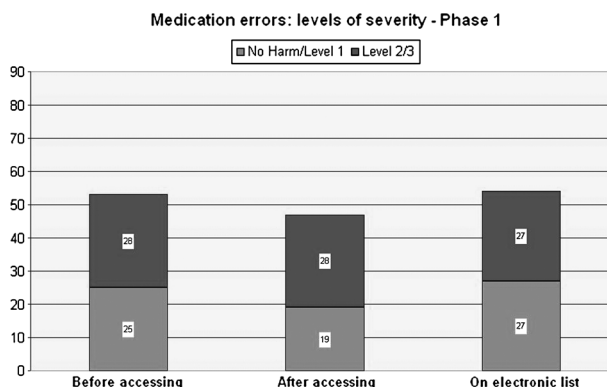


FIGURE 3. Medication errors: levels of severity—phase 1.

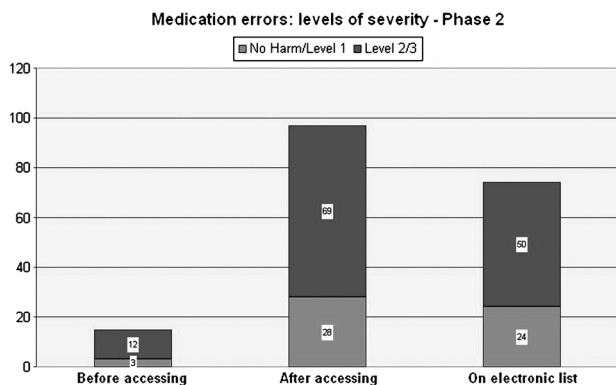


FIGURE 4. Medication errors: levels of severity—phase 2.

history, and conventional sources were solely used to validate the reconciliation.

A shared EHR can help identify errors in the hospital and reduce the risk of harm, but we found significant problems. The patient (or carer), in combination with an appropriate clinician physically reviewing their medicines, seem to remain the primary source of reconciliation, substantiating the recommendations of National Institute for Clinical Excellence and the NPSA that a shared EHR cannot replace trained experts.¹⁰ The findings show, however, that access to a shared EHR can assist with ascertaining a medication history as well as providing vital safety information that would otherwise have been missed. It may be especially helpful when a patient lacks capacity and other forms of information are unavailable. Yet, an EHR may, like other forms of clinical data, contain out-of-date or incomplete information, such as the listing of wrong drugs. Orrico¹⁶ recommends foreseeable medication end dates and patient involvement at the time of electronic prescribing, reflecting some of the established maxims of effective design for safety.²⁰ Safety could be further enhanced by standardizing the layout of the medicines component of the EHR across the United Kingdom in line with recent calls for a national prescription chart (General Medical Council, 2009: <http://www.gmc-uk.org/news/5156.asp>). It is not unusual for medications to be discontinued by physicians other than the patient's general practitioner—particularly hospital physicians—yet the patient's primary care list might not be updated. Relevant communications may not have been received, acted on, or even sent; a problem exacerbated by short time scales and increasingly rapid admission and discharge turnarounds. We found cases where medicines had been discontinued many months previously, in common with a recent survey of U.K. primary care

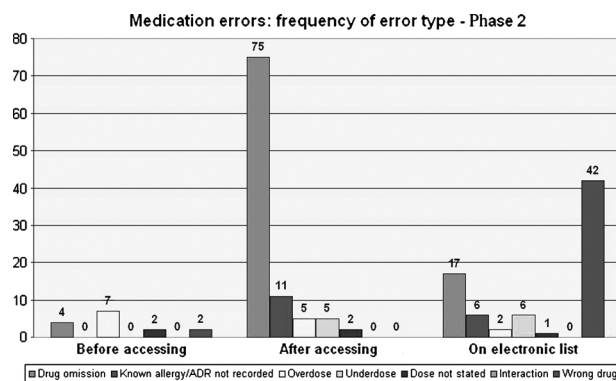


FIGURE 6. Medication errors: frequency of error type—phase 2.

practices by the Care Quality Commission, which found that information shared between primary and hospital care can be “patchy, incomplete, and not shared quickly enough.”²¹

Drug omission errors were common, strengthening the argument for a 2-way communication process; it would surely be beneficial to inform the primary care physician of discrepancies in the medication history and to provide information about medicines on discharge, via the EHR. This, however, has data protection implications. During this study, researchers were contacted by a primary care physician expressing concern about access being given to hospital clinicians for the express purpose of reconciliation. There is a wider debate about consent for sharing data, but demonstration of the benefits such as improved safety could help make the case.

Further study is required to evaluate the role of EHRs in medicines reconciliation. Organizations might periodically record the number of patient prescriptions reconciled on discharge and admission, alongside potential adverse events. The reconciliation process should be examined as part of existing pathways of care. The feasibility and willingness of patients as active collaborators in reconciliation in acute care settings should be further explored, as well as the potential role of junior clinicians in using a shared EHR to reduce medication errors, especially at admission. A combination of methods should be used to accurately establish error rates across the various sources of reconciliation because different methods uncover different medication errors with surprisingly little overlap.²²

Limitations

It was helpful for the research team to retest a modified version of a severity grading scale developed in the research setting,¹⁹ although as with all such scales, it is still vulnerable to subjective interpretation. Nevertheless, for the purpose of charting severity, the scale chosen allowed a collapsing of the 4 original categories into the 2 categories of no harm/minor harm and significant/serious harm. One issue that was not resolved was that the severity may be different for the same error depending on whether that error occurs on a short-term basis (e.g., for the duration of the hospital stay) or whether that error was prolonged in the community. An example of this is missed medicines to prevent osteoporosis. There would be no short-term harm but long-term harm could result in fractures, with the associated complications. Any further studies of reconciliation that compare traditional methods to those incorporating the EHR should also include an economic appraisal to evaluate pharmacist's time and other costs, especially because recent guidance in the United Kingdom demands that reconciliation is implemented within

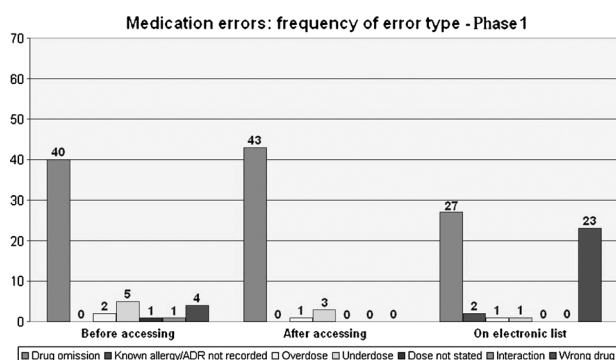


FIGURE 5. Medication errors: frequency of error type—phase 1.

TABLE 5. Illustrative Cases

EHR Provided Useful Information That Avoided a Prescribing Error on Admission to Hospital:	EHR Contained Wrong Information That May Have Led to the Wrong Drugs Being Prescribed on Admission:
Nine items were missed off the initial drug history but confirmed by the EHR: Missed items included digoxin, diltiazem, aspirin, furosemide, calcium/vitamin D supplements, nutritional supplements, fluticasone with salmeterol inhaler, and tiotropium inhaler.	The EHR listed 26 medicines on the current list, but the patient currently only took 12 of these and did not use: domperidone, glycerol trinitrate patch, ipratropium inhaler, salbutamol, terbutaline inhaler, pholcodine, ibuprofen gel, aspirin, verapamil, dihydrocodeine, co-codamol omeprazole, digoxin, hexetidine mouthwash.
Eleven medicines were missed off the initial drug history on admission. The omission was detected by looking at the EHR. The missed medicines were aspirin, quinine sulfate, tiotropium inhaler, tramadol, spironolactone, beclomethasone inhaler, salbutamol inhaler, alendronic acid, felodipine, furosemide, and lactulose.	The EHR stated that the patient was taking aspirin and clopidogrel. However, these had been stopped previously as the patient was now taking warfarin. (There were 3 other cases in which warfarin was not recorded on the EHR, but the patients obtained it from the anticoagulant clinic).
The EHR highlighted that the patient also used salbutamol and beclomethasone inhalers and calcium/vitamin D supplements, which had been missed off the initial drug history.	The EHR had not been updated. The nursing home record was more accurate. The EHR listed that the patient was taking tamoxifen; however, she was now taking aromasin instead.
The EHR highlighted previous adverse drug reactions to metoprolol and NSAIDs. This was not known from the admission notes. (There were 2 other patients in whom the EHR identified previous adverse drug reactions to β -blockers).	Allergy to ciprofloxacin was listed on EHR in error. A laboratory report of a <i>Pseudomonas</i> culture, which was sensitive to ciprofloxacin, had been listed as an allergy.
Eye drops for glaucoma (latanoprost) were missed.	A neurology specialist family physician had increased the dose of co-beneldopa 6 mo ago and recorded this in correspondence, but the current EHR medication list had not been updated.
The EHR showed that the patient previous took NSAIDs and clopidogrel. This was not known from the admission notes; however, the patient was anemic on admission, and these could have been a contributory factor.	The EHR did not have ramipril on the current medication list, but it had been recently issued. As such, it did not appear on the patient's repeat medication list.
NSAID indicates nonsteroidal anti-inflammatory drug.	

24 hours of admission.¹⁰ This study was carried out in 1 health care district, which limits the generalizability of the findings. However, this health service is likely to be representative of other districts.

CONCLUSIONS

A shared EHR can reduce medication errors and is complementary to the medicines reconciliation process as part of a range of information sources. However, the primary source of reconciliation is the patient or their carer. To further improve the reliability of information in the EHR, both primary care and hospital clinicians, who are specifically caring for the patient, should have read-and-write access to the record. Further evaluation of this safety intervention is recommended to establish how it might be best incorporated into practice.

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