

The Rate of Missed Test Results in an Emergency Department

An Evaluation Using an Electronic Test Order and Results Viewing System

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Keywords

Information systems, CPOE, diagnostic tests, health care quality improvement, patient safety

Summary

Objectives: 1) To measure the incidence and impact of missed radiology and microbiology test results in an emergency department with an electronic test order and results viewing system, and 2) to assess the average times from test order to test availability.

Methods: The study was conducted in the emergency department (ED) of a 370-bed metropolitan teaching hospital in Sydney, Australia. A computerised provider order entry (CPOE) system was used to order all diagnostic tests and view all test results. For microbiology and radiology tests electronic results were then printed for ED patients not admitted to the hospital to allow ED physicians to document follow-up. All radiology (n = 197) and microbiology (n = 66) tests ordered and results received for discharged ED patients were collected for a seven-day period. We measured the: 1) proportion of radiology and microbiology test results without follow-up for discharged patients; 2) impact of non follow-up on patient outcomes;

3) average time from radiological examination and microbiology specimen collection to reporting of results; and 4) average time from reporting of results to follow-up.

Results: Two radiology (1.0%) and two microbiology reports (3.0%), all of which had negative findings, were never followed-up. Review of these patients' medical records indicated there was no impact on patient outcomes or management. The average time from radiological examination to reporting of a result was 1.5 days, and from microbiology specimen collection to reporting was 2.5 days. Eighty-nine percent of radiology and 68% of microbiology results were followed-up on the same day that they were available to physicians.

Conclusions: Our rates of missed test results are lower than those reported from studies where paper ordering and reporting systems were used. This suggests that the availability of CPOE systems may reduce the risk of these events. Electronic result delivery, with electronic endorsement to allow documentation of follow-up of test results, may provide additional efficiency benefits and further reduce the risk of test results which are not followed up.

1. Introduction

Failure to follow-up results of radiology and laboratory tests has the potential to compromise patient care [1–4]. Lack of follow-up of abnormal test results can lead to missed or delayed diagnoses [4–9] and impact adversely on patient outcomes with potential medico-legal implications [10–13]. Doctors [3, 11] and patients [14] are concerned about this issue. Doctors acknowledge that the way they manage results for their patients may not be systematic [8, 15]. A survey [11] of 207 physicians found that, depending on the test ordered, 17% for blood studies and 32% for x-rays, they reported that they had no reliable method of ensuring that results of all tests were received, whilst another study [3] found that only 15% of physicians were satisfied with their system of notifying patients of abnormal results. Research in this area has focused on the primary care setting with follow-up of PAP smears and mammograms [16–19]. The few studies which have examined missed test results in hospital settings have found 41% and 45% of results were either pending at discharge [4, 20] or never accessed once patients had left the hospital [21]. Given the complexity of medical practice in hospitals, the volume of interventions and tests, team-based care and the rapid turnaround of patients, particularly in emergency departments (EDs), errors relating to failure to follow-up abnormal results seem likely [22, 23].

Existing manual test management systems are often inadequate [6, 8, 11]. Health systems internationally have made substantial investments in clinical information systems designed to improve the safety and quality of health services [24–27]. These technologies include computerised pro-

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Methods Inf Med 2010; 49: 37–43

doi: 10.3414/ME09-01-0011

received: February 11, 2009

accepted: July 28, 2009

prepublished: November 5, 2009

vider order entry (CPOE) systems which allow the ordering of tests and reviewing of results online [28–30]. They also allow physicians to explicitly acknowledge viewing of results and electronically document follow-up actions [24] and thus provide opportunities for more systematic review and follow-up of test results [3, 7, 24, 31] resulting in reduced risk of results being missed.

The few studies which have measured the extent of missed results with the use of electronic test management systems have shown mixed results [7, 21]. One study, which replaced telephoning results to the ED with results delivered via computer terminals, found 45% of results were never accessed via computer [21]. However, Kuperman et al. [7] reported positive outcomes in a randomized controlled trial which evalu-

ated the effects of an automatic alerting system of critical laboratory results via pager for medical and surgical inpatients. The study compared the time to treatment once test results were available via a non-alerting versus an alerting system and found the median time to treatment decreased by 38% (1 hour versus 1.6 hours) compared to the control group [7].

The test result follow-up process is complex [5, 6, 19] with physicians required to review results, discuss these with the patient and colleagues, decide on an appropriate plan, institute and follow-up treatment and document their actions. When electronic systems are applied to a multi-part clinical process, such as the management of test results, it is often the case that parts of the process are computerised and some elements are still reliant on docu-

mentation in existing manual information systems, such as paper-based patient records. This mixed-media environment can be present for some time as organizations convert from paper-based to electronic information systems [15]. The management of test results in the ED of the study site illustrates this point. The CPOE system was used in the ED to order all diagnostic tests and view all test results for every patient, however, a duplicate manual follow-up system for radiology and microbiology results was used as a safety check for discharged ED patients.

2. Objectives

No studies have examined the extent of missed test results for discharged ED pa-

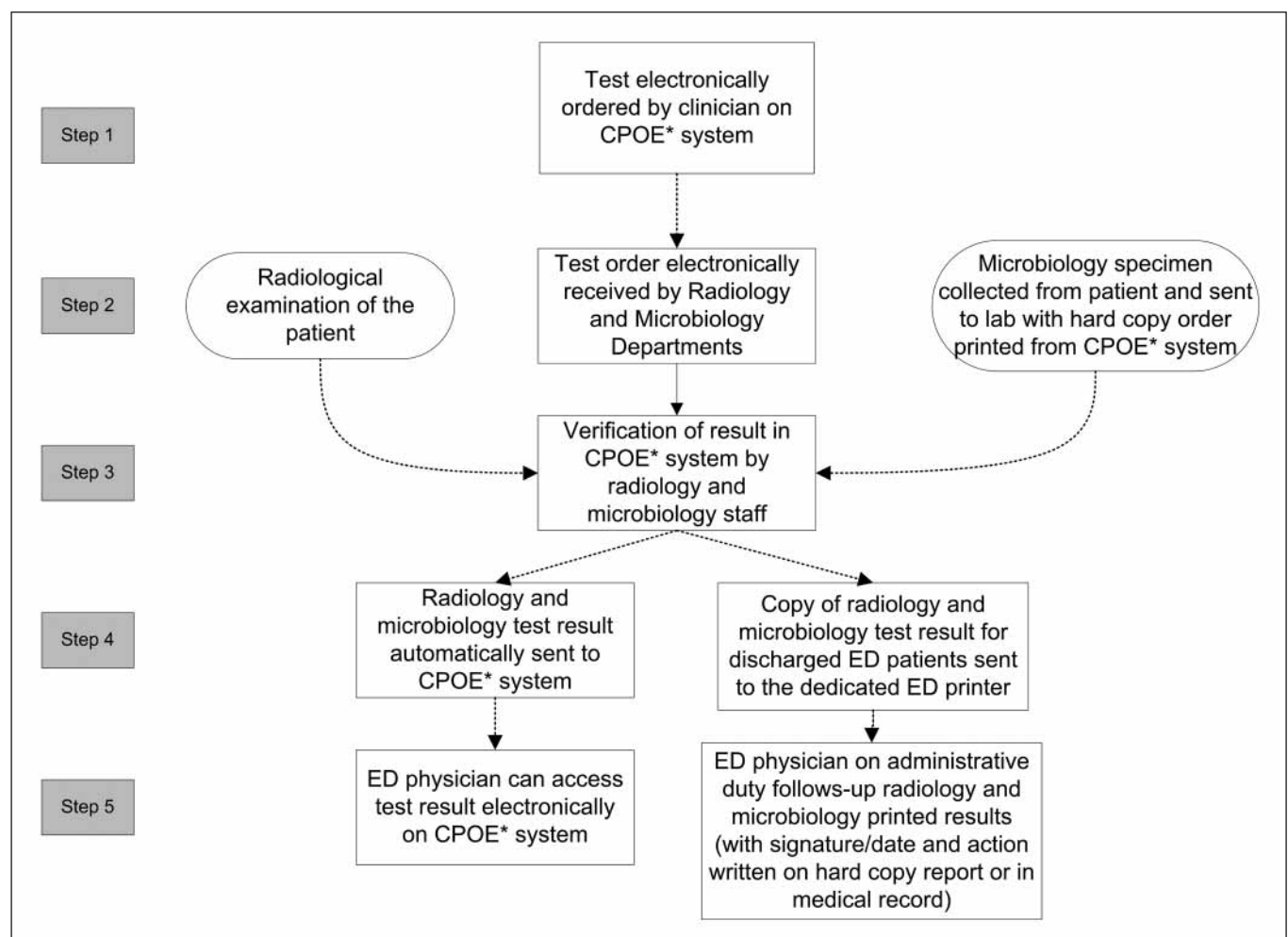


Fig. 1 Test management process for radiology and microbiology orders and results for discharged emergency department (ED) patients. * Computerised provider order entry

tients where CPOE is used for ordering tests and viewing results. The aim of this study was to fill that gap by exploring how clinicians manage test results in an electronic test management environment. The objectives are: 1) to measure the incidence and impact of missed radiology and microbiology test results in an emergency department with an electronic test order and results viewing system, and 2) to assess the average times from test order to test availability.

3. Methods

3.1 Research Questions

1. What are the proportions of radiology and microbiology test results without follow-up for discharged ED patients?
2. What is the impact of non follow-up on patient outcomes?
3. What is the average time from radiological examination and microbiology specimen collection to reporting of results?
4. What is the average time from reporting of test results to follow-up?

3.2 Sample

Data relating to all radiology and microbiology tests ordered and results received for patients subsequently discharged from ED were collected for seven days (August 10–17, 2007). These tests have previously been identified as being at greater risk of poor follow-up [4].

3.3 Study Design

A prospective audit to determine the proportion of radiology and microbiology test results which had evidence of follow-up was performed. Follow-up of test results was assessed based on physicians' documentation on the printed paper copy of the test result or in the medical record. This follow-up usually took the form of the doctors' initials or signature, date, and any action taken following viewing of the result. An electronic result endorsement function which is available through the CPOE sys-

tem was not operational at the study site. The study was approved by the Human Research Ethics Committee of the study site.

3.4 Setting

The study was conducted in the ED of a 370-bed Sydney metropolitan teaching hospital which has used a CPOE system to order tests and view results for all inpatients since 1999. There are 30,000 attendances per annum to the ED of which 20,000 are discharged (67%).

3.5 The Management of Test Results in the ED

The management of radiology and microbiology test results for ED patients is shown in ►Figure 1. Physicians use the CPOE system to order all diagnostic tests (►Fig. 1, Step 1) and view all test results (►Fig. 1, Step 5). This delivery is instantaneous and reduces the risk of losing paper results or results being sent to the wrong clinical area. Additionally, for radiology and microbiology test results the CPOE system also checks whether the patient was discharged from the ED or admitted to a ward. The CPOE system then sends only discharged ED patients' radiology and microbiology reports to a dedicated ED printer (►Fig. 1, Steps 3 and 4). By doing this the CPOE system is saving ED clinicians time as previously they had to sort through all manual microbiology and

radiology results. The time saved is considerable as approximately one third of patients who attend the ED are admitted and therefore the radiology and microbiology results of ED patients who are admitted are accessed electronically by physicians on the ward. Radiology results are not delivered in real-time in Australia. Microbiology results take approximately 48 hours to become positive and hence there are multiple reports for each specimen with the final report being verified a number of days following the initial specimen analysis. This means for ED patients who are discharged home there needs to be a safe system to follow-up test results which have not been verified by the laboratory or the radiology department before the patient is discharged. The two key advantages of the CPOE system are: 1) the timeliness of electronic delivery of results in the CPOE system with a resultant decreased risk of losing paper results or paper results being delivered to the wrong clinical area, and 2) clinicians saved time in sorting through all microbiology and radiology results as the electronic CPOE system does this work for them by only sending microbiology and radiology reports to the printer for ED patients who are discharged. Those ED patients who are admitted will have electronic results accessed via CPOE from the ward.

In Australia emergency physicians have shift-work rosters. On clinical shifts there is generally little or no time for work other than direct patient care. Administrative or 'non-clinical' shifts are used to perform tasks that support departmental activities

Table 1 Number of test results for discharged ED* patients without evidence of follow-up for the one-week study period

Test type	No. of tests ordered	No. of corresponding result reports manually collected in ED*	No. of additional reports identified through medical record review	No. of test results without follow-up	
				n	% of orders without follow-up
Radiology	197	151	44	2	1.0%
Microbiology	66	91**	7	2	3.0%
Total	263	242	51	4	1.5%

* Emergency Department

** includes 57 corresponding result reports plus 34 multiples reports as one microbiology test order can have multiple reports for each specimen

such as quality assurance, teaching and policy development. The national standard of one administrative shift per week for each full-time emergency physician and the practice of post-discharge result checking in relation to microbiology and radiology have been in place for many years. The ED physician rostered to administrative duty reviews all printed radiology and microbiology results several times daily. Abnormal and potentially significant results are checked against information in the electronic discharge summary and, if required, the written medical record to determine whether appropriate treatment was initiated. Medical records for discharged patients are kept in the ED clerical office for five days to facilitate this review.

3.6 Data Collection

Details regarding the number of radiology and microbiology tests ordered by ED physicians during the study period were extracted from the CPOE system. This information was compared with the test results printed in the ED to ensure all test results generated for discharged patients were printed and reviewed.

The patients' medical records were reviewed by two authors (RP and MP) in cases where: a test was ordered and appeared on the CPOE system, but for which

a printed report was not present in the ED; and where there was no evidence of physician review on the printed copy of the report. If documentary evidence of test result follow-up was not present, an assessment of the impact of the missed result on patient outcomes was made by an independent emergency physician after review of the patient's medical record.

3.7 Data Analysis

Descriptive statistics were calculated using SPSS. Time, automatically recorded on the CPOE system, was used to calculate the average duration from radiological examination and microbiology specimen collection to availability of results. The proportion of results followed-up was ascertained from evidence recorded on the test result report printed in the ED or in the patients' medical record.

4. Results

4.1 Demographics

A total of 263 tests were ordered for 194 ED patients discharged during the study period (197 radiology and 66 microbiology tests). The majority of radiology orders were for x-rays ($n = 151$). Urine ($n = 36$)

and blood cultures ($n = 17$) were the most frequent microbiology orders.

4.2 Test Result Follow-up

Verification of whether a radiology or microbiology result has been followed-up by the physician can only be ascertained by assessing the physicians' documentation on the printed paper copy of the result or in the medical record. For the 197 radiology tests, ordered and reported electronically in the CPOE system, 195 paper result reports contained evidence of follow-up (doctors' initials or signature, date and action). For two radiology investigations no paper report could be located (1.0%) and review of these patients' medical record revealed no evidence of follow-up of these test results (► Table 1).

For every microbiology test ordered electronically using the CPOE system there are multiple result reports as microbiology results take approximately 48 hours to become positive and hence there are several reports for each specimen. Microbiology reports are accessible electronically via the CPOE system and for discharged ED patients they can be viewed manually as well through the hardcopy report sent to the ED printer. For the 66 microbiology orders there were a total of 100 microbiology results. Two microbiology result reports (3.0%), belonging to one patient, could not be located and review of the patients' medical record revealed no evidence of follow-up (► Table 1).

4.3 Impact of Non-followed-up Test Results

The two radiology result reports, one chest x-ray and one brain computerised-tomography scan, and two microbiology results reports, a blood and urine culture, without follow-up were reviewed on the CPOE system by an independent emergency physician using the CPOE system followed by a review of each of these patients' written medical record. All four tests had non-significant findings and had no adverse impacts on patient management or outcomes.

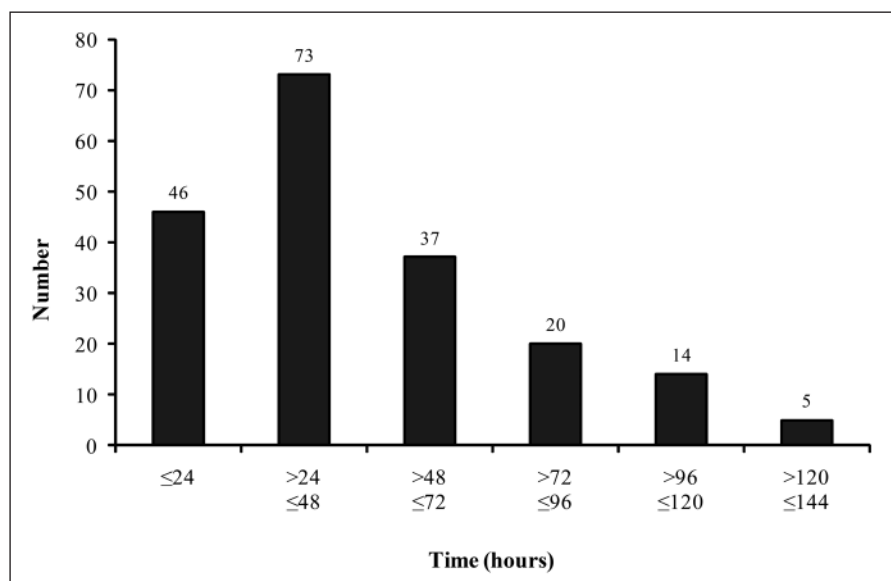


Fig. 2 Time from radiological examination to availability of results to the physician

4.4 Time from Radiological Examination to Availability of Results

The average time from radiological examination to a result posted in the CPOE system and a report printed in ED was 1.5 days. Most results were available within three days of examination (79%; $n = 156$), with 37% ($n = 73$) available 24 to 48 hours after examination (► Fig. 2).

4.5 Time from Microbiology Specimen Collection to Availability of Results

The average time from microbiology specimen collection to reporting of a result was two days. The majority were available within three days of specimen collection (90%; $n = 90$), with 48% ($n = 48$) available 24 to 48 hours after specimen collection.

Microbiology results are reported in stages of preliminary and final, and occasionally amended. The average time for availability of a preliminary result ($n = 54$) was approximately 1.5 days, while availability of final results ($n = 41$) averaged 2.5 days. Almost all preliminary results were available within two days of specimen collection (83%; $n = 45$), while most final results were available between 24 and 48 hours after specimen collection (► Fig. 3).

4.6 Time from Result Availability to Physician Follow-up

Almost all radiology results (89%; $n = 176$) were followed-up by an emergency physician on the day of availability. For microbiology 68% ($n = 68$) of results were followed-up on the day of availability (► Fig. 4).

5. Discussion

The results showed that the vast majority of radiology and microbiology test results generated for discharged ED patients were followed-up by physicians on the same day the result was available. The proportions of results not followed up, 1.0% of radiology and 3.0% of microbiology, are less than

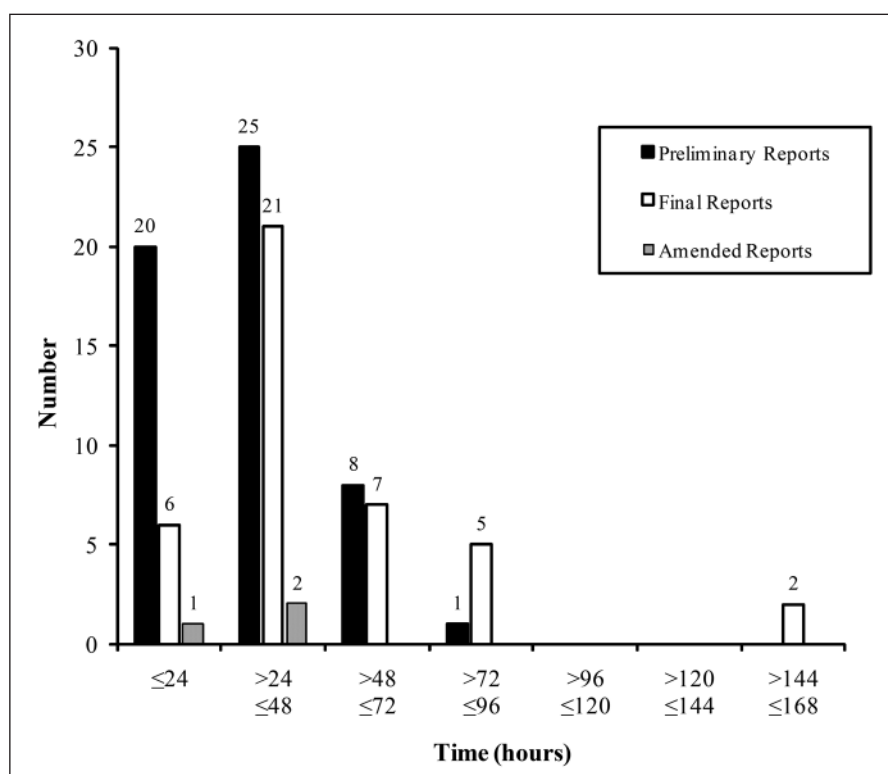


Fig. 3 Time from microbiology specimen collection to availability of results to the physician

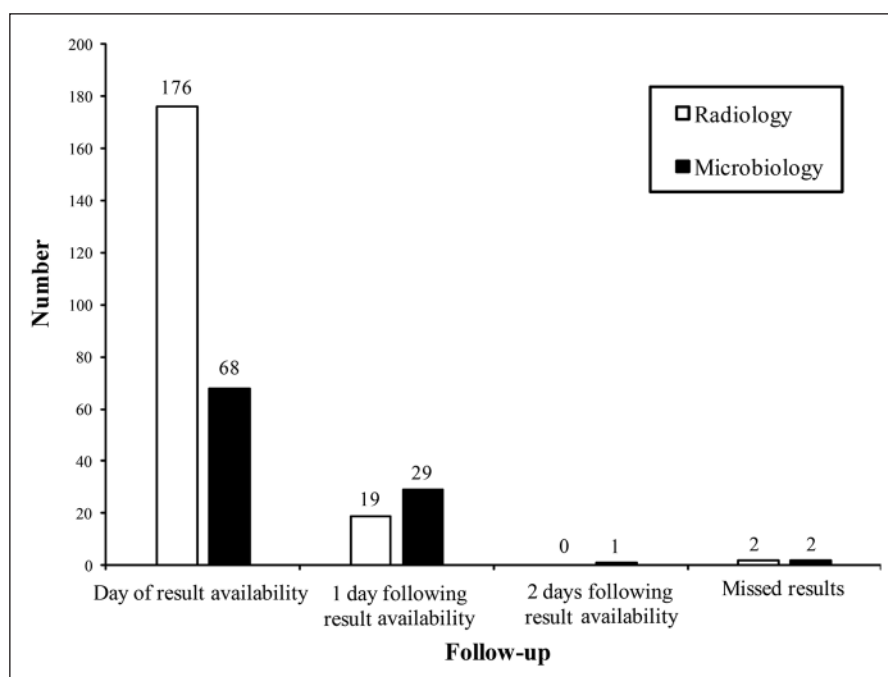


Fig. 4 Time from results availability to physician follow-up

those reported by other studies in EDs which used paper-based ordering and results reviewing systems. Stiehl et al. [23] reported information gaps or missing infor-

mation in 23.3% of laboratory test results for ED patients and 4.7% of imaging results. The small number of missed test results in our study suggests that the CPOE

system assists in reducing the risk of missed test results. Upon patient discharge physicians are required to manually keep track of outstanding results, although the electronic nature of the order and the result allows for rapid and accurate delivery of these results.

The procedure in our study site of simultaneously printing radiology and microbiology reports in the ED, as well as posting the results electronically in the CPOE system, provided an added safety check to assist physicians in the result review process, particularly for discharged patients. The strategy of transmission of results by more than one method has been suggested as a way of reducing missed results [32]. Information technology alone will not ensure improvements in communication of information: new work practices need to be developed to reduce errors in follow-up of test results. Direct patient notification of test results could also reduce the burden of test follow-up on providers, empower patients and create a backup system for ensuring that patients are notified of their test results [5, 14, 32, 33].

The time delay in receiving results of radiology and microbiology tests is a potential contributor to missed results for discharged ED patients. Other studies support this finding with EDs identified as being particularly susceptible [33, 34]. Systems that ensure that test results are safely communicated to patients and/or their general practitioners after discharge are needed. Time is important in accessing critical results [35, 36] to ensure there are no delays in commencement of treatment and an electronic alerting system for critical results has been shown to reduce time until treatment [7]. This electronic result notification facility for critical results would seem to be an essential requirement in an ED which sees high volumes of patients with rapid turnaround.

5.1 Limitations

It should be noted that the study was undertaken in one ED, focusing on radiology and microbiology results only, and this may limit the generalisability of these findings to other settings or test categories. The

study method did not include a control group and this would be valuable in future studies in order to compare on-line and manual test result validation processes.

6. Conclusions

We found a lower rate of test results not followed-up in an ED with an electronic ordering and results reporting system compared with that reported in previous studies of EDs which use paper-based ordering and viewing systems. Electronic endorsement of test results, which was not a feature available in our study site, may further improve the efficiency and safety of this process. Most CPOE systems allow physicians to endorse test results electronically, however, given the acknowledged complexity of the test management process [5, 6, 37], this function is not widely used and there is an absence of evidence of its effectiveness to reduce missed test results. Further studies are required to evaluate the electronic test endorsement function and to explore how it can be utilized effectively to improve the efficiency and reliability of test management practices [4, 24, 31, 35]. Although in our study there were no clinical implications of the failure to follow-up on test results, such findings demonstrate the potential to miss a significant result. Electronic result delivery, with electronic endorsement to indicate follow-up of test results, should be investigated as a way of improving patient outcomes and closing patient safety gaps.

Acknowledgement

This study is part of an Australian Research Council Linkage Grant (LP0989144) funded project to investigate the use of information and communication technologies to support effective work practice innovation in the health sector.

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