What is the effect of electronic pathology ordering on test re-ordering patterns for paediatric patients?

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Abstract. Electronic ordering systems have the potential to enhance the efficient utilisation of pathology services. The aim of this study was to assess the effect of electronic pathology ordering on repeat test ordering for paediatric patients (ages 0 to 18 years) who were in intensive care units (ICUs) and non-ICU wards. The dataset described 85,728 pathology tests ordered for 5,073 children before and after the implementation of electronic ordering. This study showed that, for children in ICUs, the repeat test order rate was significantly lower for electronic orders than for paper-based orders. Similarly, the rate of repeat tests ordered within short intervals (up to 23-hours), for children older than one-year in non-ICU wards, was lower for electronic ordering than for paper ordering. The proportion of repeat tests occurring within one-hour of the previous test was consistently lower for tests ordered using electronic ordering than it was for tests ordered using the paper based system for patients older than one-year in all wards and for patients under one-year in ICUs. These results suggest that features of the electronic system, including alerts about previously ordered tests and the availability of information about previous orders, can help clinicians to identify and reduce unnecessary repeat tests.

Keywords. Laboratory test utilisation, test appropriateness, repeat test, computerised provider order entry, child health, paediatric pathology

Introduction

Laboratory test utilisation has steadily increased in many healthcare jurisdictions around the world [1, 2] and repeat tests account for a considerable proportion of overall pathology testing [3-5]. A test order is classified as a repeat test when the test being ordered is identical to a previously ordered test, for the same patient. Repeat tests are frequently necessary for appropriate patient care in order to monitor a condition or treatment, but there is also evidence indicating that quality of pathology services can
benefit from monitoring and reducing the prevalence of unnecessary or redundant test orders [6, 7]. Unnecessary repeat tests can increase laboratory workload and costs, along with associated patient discomfort and safety risks associated with blood draws [8] that can be particularly acute for paediatric patients. In addition to being physically and emotionally vulnerable to such discomfort and risk, children also have unique medical needs relative to adults [9]. Yet, despite the importance of this topic, there has been little prior research in this area.

Tests may be repeated when the previous result is unavailable or the ordering clinicians are unaware that the test had already been conducted [6, 10]. Electronic ordering systems (referred to as Computerised Provider Order Entry [CPOE] systems a core element of electronic medical record systems [EMR]) allow clinicians to electronically enter orders for pathology tests. Electronic ordering has the potential to improve the efficient utilisation of pathology services [11]. The aim of this study was to assess the impact of the implementation of electronic ordering of pathology tests on rates of repeat tests among paediatric patients.

1. Method

1.1. Study Setting

This study was part of a larger project assessing the impact of electronic ordering on hospital pathology services [12]. The project was undertaken across two hospitals and a single pathology laboratory service employing over 828 staff and providing comprehensive biomedical laboratory testing including: Anatomical Pathology, Blood Bank, Clinical Chemistry, Microbiology, Endocrinology, Haematology, Molecular Genetics and Immunology. The hospitals in the study involved two metropolitan specialist hospitals – one for women and neonates (187 beds) and another for children aged under 18 (159 beds). In the women’s hospital, the study dataset included only the latter category of patients, i.e. those younger than one-year. There was one intensive care unit (ICU) at the children’s hospital and three neonatal ICUs at the women’s hospital.

A data extract from the pathology service laboratory information system (LIS) generated a dataset containing information relating to all tests conducted on specimens received by the pathology service for the August-September period of each year from 2008 to 2011. Data extracts for equivalent time periods were performed on the Patient Administration System (PAS) of the study hospitals and, in the case of the children’s hospital, the Emergency Department computer system.

Ethics approval was provided by the relevant Local Health District Human Research Ethics Committee (HREC: Project No. 11/146) and ratified by the University of New South Wales HREC (Project No. 11380). This project was been funded by an Australian Government Department of Health: Quality Use of Pathology Program grant.

1.2. Electronic Ordering System

An EMR, which allowed clinicians to create electronic orders, was introduced on 26 October 2009 across the two hospitals using a Cerner PowerChart system Version 2007.16, which was subsequently upgraded in May 2011 to Version 2010.02.16. The Laboratory Information System (LIS) was the Integrated Software Solutions (ISS)
Omnilab v9.4.2 SR10 system. The electronic ordering system presented clinicians with information about previous test orders and results, and alerted clinicians when a repeat test was ordered within a certain time interval, in most cases 24-hours (Figure 1), of the previous test. Clinicians could elect to cancel the order or, if clinically appropriate, to override the alert and proceed with the order.

1.3. Statistical Analysis

Since the pathology test ordering profile for patients younger than one-year of age was noticeably different to that of older children, we stratified the study population by age, i.e. age under one-year (age<1 year) and older children (age≥1 year). Children in ICU are expected to require more frequent testing than other children; therefore we conducted separate analyses for children in ICU and other wards. The final analysis contained four groups stratified by age (<1 year or ≥1 year) and ward (ICU and non-ICU). Repeat tests were identified and time intervals between the repeat tests and previous tests of the same type were calculated for all tests. The percentage of repeat tests was defined as the number of repeat tests out of all tests ordered, and calculated for each of the four study groups for both paper and electronic test orders. The cumulative percentage was computed for each whole hour. Two sample tests for proportions were applied to compare the percentages of repeat tests between paper and electronic orders within one-hour and 24-hours of the previous test. The level of significance was set at $p$-value <0.05.

2. Results

During the study period, there were 85,728 pathology tests ordered for 5,073 children in the study; 52,331 tests for 2,747 children using the paper-based ordering and 33,397 tests for 2,469 children using electronic ordering. There were 143 children who had admissions in both study periods.

2.1. Children Aged One and Above

There were 3,124 children aged one to 18 years in this study. 46,939 tests (84%) were ordered from non-ICU wards and 8,839 (16%) from ICU (Table 1). The top two graphs in Figure 2 show that the cumulative percentages of repeat tests using the paper (dashed line) or electronic ordering (solid line) for children in non-ICU wards (top-left graph) and ICU (top-right graph) ward. Figure 2 shows that, in both ICU and non-ICU contexts, the proportions of repeat tests within 23-hours from the previous test, were smaller for electronic ordering than for paper-based ordering. After 24 hours, this
pattern continued for orders from ICU (top-right graph). However, the opposite pattern, with electronic ordering having a greater proportion of repeat tests than paper-based ordering, emerged after 24-hours for non-ICU wards (top-left graph). All four curves showed sharp increases in repeat test orders at around 24-hours from the previous order, which reflect widespread practice of repeating a range of tests on a daily basis.

Table 1 shows that the proportion of repeat tests ordered within one-hour of the previous test, for all tests ordered in non-ICU wards, was significantly lower for electronic orders than it was for paper-based orders (0.25% vs. 1.67%, \( p < 0.0001 \)). A similar difference was observed in ICU wards (0.93% vs. 2.17%, \( p < 0.0001 \)). In the ICU, the proportion of repeat tests occurring within 24-hours of the previous test was significantly smaller for electronic ordering (47.16%) than it was for paper-based ordering (55.22%, \( p < 0.0001 \)). However, in the non-ICU wards, the opposite pattern emerged, the proportion of repeat tests occurring within 24 hours of the previous test was significantly larger for electronic ordering (23.16%) than it was for paper-based ordering (20.67%), also a significant difference (\( p < 0.0001 \)).

![Graphs showing repeat testing proportions](image1)

**Figure 2.** Cumulative percentages of repeat testing, as a proportion of all tests ordered, within one-hour to 35-hours of the previous test, for tests orders using the paper-based (dashed line) and electronic ordering system (solid line). Time intervals longer than 35 hours are not shown.

<table>
<thead>
<tr>
<th>Age</th>
<th>ICU</th>
<th>Time interval</th>
<th>Paper % (95%CI; n*)</th>
<th>Electronic ordering % (95%CI; n*)</th>
<th>( p )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥1 year</td>
<td>No</td>
<td>≤ one-hour</td>
<td>1.67(1.51-1.82; 434)</td>
<td>0.25(0.19-0.32; 53)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≤ 24-hours</td>
<td>20.67(20.18-21.16; 5,383)</td>
<td>23.16(22.59-23.73; 4,840)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Total tests (N)</td>
<td>26,040</td>
<td>20,899</td>
<td>46,939</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>≤ one-hour</td>
<td>2.17(1.79-2.54; 124)</td>
<td>0.93(0.59-1.27; 29)</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>
2.2. Children Under One

There were 29,950 test orders for 2,004 children under one-year of age. Most tests for children younger than one-year were ordered in ICUs (58.50%, n=17,522). The bottom two graphs in Figure 2 show the cumulative percentage of repeat test orders for patients younger than one-year in ICUs (bottom-right) and non-ICU wards (bottom-left). Similar to the pattern of results described above for children older than one-year of age, for these very young patients there is a large difference between the curves in the ICU and non-ICU wards. The proportion of repeat tests was consistently lower for electronic orders than it was for paper orders in ICUs, while the opposite pattern was observed in non-ICU wards. As was the case for children older than one-year of age, all four curves shown in the bottom two graphs of Figure 2 indicate a sharp increase of repeat test orders occurring at approximately 24 hours after the previous test.

Table 1 shows that the proportions of repeat tests ordered within one-hour and within 24-hours of the previous test were significantly smaller for electronic orders in ICU than for paper orders (one hour: 2.97% vs. 0.39%; 24-hours: 54.16% vs. 35.27%; p<0.0001); while there were no significant differences in non-ICU wards.

3. Discussion

This study showed that, for children in ICUs, the repeat test order rate was significantly lower for electronic orders than for paper-based orders. The repeat test order rate within short time intervals (up to 23-hours), for children older than one-year in non-ICU wards, was lower for electronic ordering than for paper ordering. The proportion of repeat tests occurring within one-hour of the previous test was consistently lower for tests ordered using electronic ordering than it was for tests ordered using the paper based system for patients older than one-year of age in all wards and also for patients younger than one year in ICUs.

This study demonstrated that the electronic ordering system was associated with a significant reduction in repeat tests, especially within the shortest time intervals from the previous test (< one-hour). Two potential mechanisms for this effect are (a) the visual duplicate order alerts in the electronic ordering system, that reminded clinicians that an identical test had already been ordered within 24 hours for the same patient; and (b) that the electronic ordering system allowed clinicians to much more easily see...
existing test orders and test results and thereby allow them to better regulate their ordering decisions.

Previous studies have reported grossly varied estimates of the proportion of laboratory testing which is redundant (4.5%-95%) [6]. Assessing the appropriateness of test ordering is a complex process, not least because test ordering decisions are made according to the nuances of each patient’s condition [14]. When a repeat test is ordered within a very brief interval of the previous test (e.g. one-hour), however, there is a high likelihood that it will be redundant and will provide no additional information. Any intervention that reduces the rate of repeat test orders within such a brief interval of the previous test, as has been demonstrated in this study for electronic ordering, is contributing to improvements in the quality utilisation of pathology services.

This study makes a valuable contribution to the knowledgebase on laboratory test utilisation for paediatric patients, which has thus far been a neglected area of research. The electronic ordering reduced repeat tests ordered for children in hospital and the effect was particularly pronounced for children in the ICUs, arguably the most vulnerable of all patients in the hospital system.

References


