Pathology processes and emergency department length of stay: the impact of change

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ABSTRACT

Objectives: To determine whether redesign of pathology processes, including indicators of sample priority, could reduce patient length of stay (LOS) in an emergency department (ED), and assess the long-term impact of two indicators of sample priority on pathology clinical performance indicators for ED samples.

Design, setting and participants: Two observational studies of de-identified data from standard databases were conducted — a single-site pilot trial of patients attending the ED of one hospital compared with historical controls, and a multisite study of 132 521 full blood count (FBC) requests for patients attending seven EDs that utilised either of two pathology process changes (coloured specimen transport bags alone, or coloured specimen bags plus blood tubes with a priority indicator).

Main outcome measures: LOS in the ED was measured for the pilot trial, and collected-to-validated times for FBCs that fulfilled computer algorithm validation rules were measured for the multisite study.

Results: In the pilot trial, the redesigned pathology process resulted in a 29-minute reduction (15.6%) in the median ED LOS for all patients ($P < 0.001$) compared with historical controls. In the multisite study, use of coloured specimen bags plus blood tubes with a priority indicator resulted in an 8-minute reduction (20.1%) in mean collected-to-validated times for FBC requests compared with FBC requests that used coloured specimen bags alone ($P < 0.001$).

Conclusions: Our pilot trial revealed a direct relationship between pathology process design and LOS in the ED, suggesting that redesigned pathology processes can significantly reduce LOS in the ED. Our multisite study showed that collecting samples directly into blood tubes with an incorporated priority indicator reduces pathology test turnaround times. These data suggest that LOS in the ED can be significantly reduced by simple changes to pathology processes, such as collecting samples directly into specimen containers with an incorporated priority indicator.

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Several publications have directly linked adverse patient outcomes, including increased morbidity, mortality and inpatient length of stay (LOS), with overcrowding or LOS in the emergency department (ED).[1-3] Recent studies have highlighted that reducing the percentage of turnaround time outliers for pathology tests can reduce LOS in the ED,[4] even though standard laboratory processes have been mature for a long time.[5] Alternative approaches that use point-of-care (POC) testing in the ED can reduce pathology test turnaround times and LOS in the ED,[6,7] but this is not always the case.[8,9]

Our study addressed these issues via two components. A single-site pilot trial was used to assess whether readily achievable modifications to the pathology request–test–report cycle, using existing resources, could have a significant impact on LOS in the ED. Implementation of this redesigned process at multiple sites was endorsed and funded by the Innovation Branch of Queensland Health. Staff at each site chose elements of the redesigned process that they felt were appropriate for their site. Optional uptake of various components of the modified processes, combined with issues encountered in implementing large-scale multisite change management, enabled analysis of post-implementation turnaround times for full blood count (FBC) results that fulfilled computer algorithm validation rules. This analysis was used to compare the impact of two indicators of sample priority on FBC turnaround times.

METHODS

Single-site pilot trial

The pilot trial was a prospective observational analysis of de-identified trial data compared with historical control data. Historical data represented patients attending one hospital ED before implementation of a redesigned pathology process, and trial data represented patients attending the same ED after implementation of the redesigned pathology process (Box 1). Historical and trial data spanned October 2004 to March 2005, thus minimising potential seasonal effects on LOS in the ED, and included the triage category for each patient. The outcome measure was total ED time.[10]

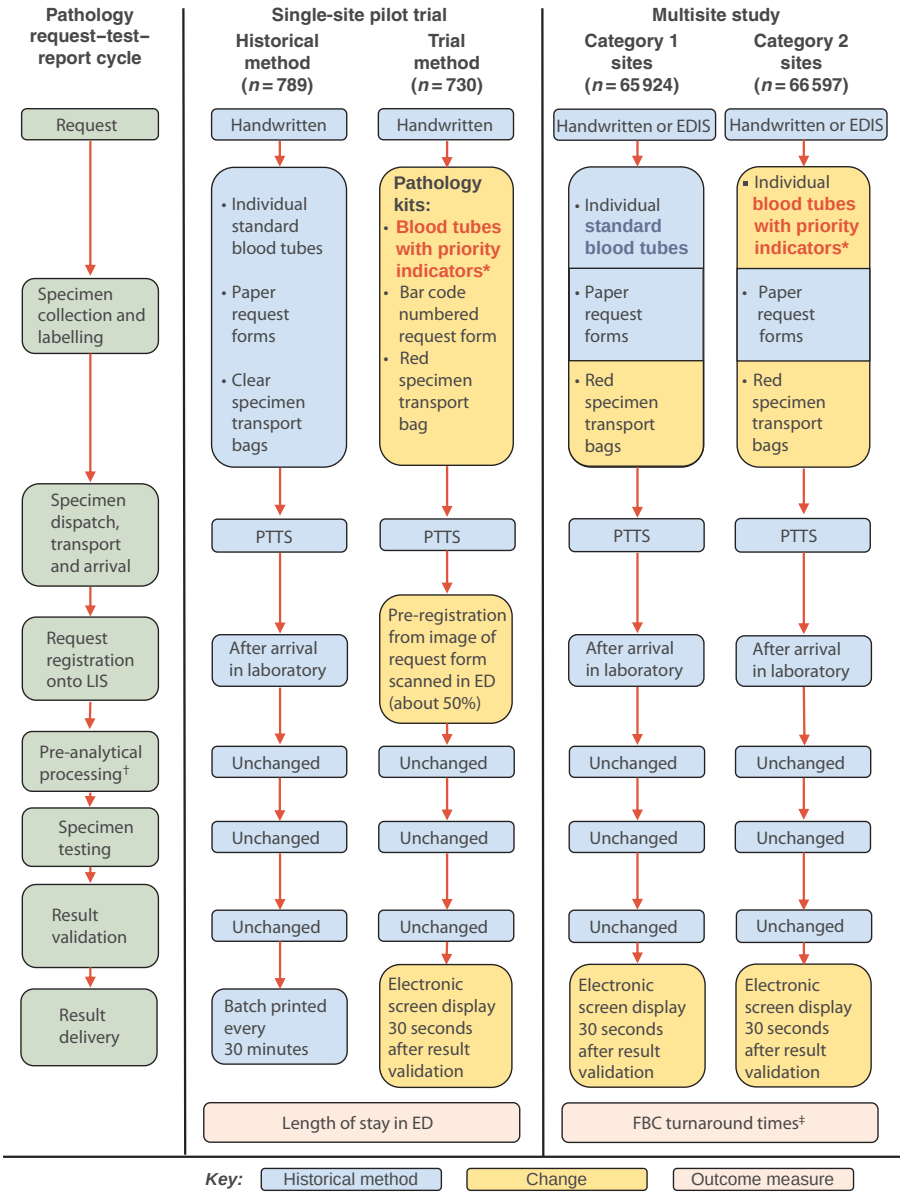
Data from days when major problems or malfunctions occurred (with specimen transport systems, laboratory instrumentation or the laboratory information system) were excluded from trial and historical control datasets. During the study period, no changes were made to numbers of laboratory staff, laboratory instrumentation, specimen transport systems, laboratory information systems, numbers of senior medical and nursing staff in the ED, or numbers of beds in the ED or hospital. This meant that the effects of the redesigned pathology processes, rather than infrastructure and resources, were assessed.

During the pilot trial, the pathology laboratory that processed samples from the ED was responsible for servicing a 500-bed acute-care public hospital, a collocated 162-bed private hospital, surrounding medical centres, and two on-site acute-care EDs. At the time, Queensland Health used a Hospital Based Corporate Information System (HBCIS [iSOFT Australia, Sydney, NSW) database to record times of arrival and discharge from the public hospital ED. Data from HBCIS were exported into Microsoft Excel (Microsoft, Redmond, Wash, USA) for calculation of LOS.

Multisite post-implementation study

The multisite study was a long-term retrospective analysis of de-identified data (with no exclusions) representing 132 521 FBC requests for patients attending seven EDs that implemented pathology process changes (coloured specimen transport bags alone, or coloured specimen bags plus blood tubes with a priority indicator) (Box 1). The outcome measures were the total pathology turnaround time (collected-to-validated time) and within-laboratory turnaround

1 Pathology request–test–report cycle, historical processes and changes



ED = emergency department. EDIS = Emergency Department Information Systems. FBC = full blood count. LIS = Laboratory Information System (Auslab, PJA Solutions Pty Ltd, Melbourne, Vic). PTTS = pneumatic tube transport system. * Blood tubes with priority indicators were produced for Queensland Health under licence using intellectual property from Priority Laboratory Services Australia (Adelaide, SA) and blood tubes from Greiner Bio-One (Kremsmünster, Austria), and are covered by an Australian Innovation Patent (further patents pending). † Includes centrifuging, aliquoting, etc. ‡ FBC fulfilling computer algorithm validation rules. ◆

time (received-to-validated time) for FBC requests that did not require examination of a blood film and that were validated automatically via a computer algorithm.

In contrast to the pilot trial, information technology (hardware and software) issues precluded successful use of pre-scanned pathology request forms and pre-laboratory data entry. Implementation of Emergency Department Information System (EDIS [iSOFT Australia]) precluded the use of pre-packaged specimen collection kits incorporating pre-numbered bar-coded pathology test request forms. Therefore, the multisite study comprised two categories of sites.

Category 1 sites used coloured specimen transport bags alone and applied a marker of specimen priority to the sample *after* the specimen arrived in the laboratory. Three hospitals were in this category, and they used haematology analysers:

- COULTER Gen·S System 2 (Beckman Coulter, Fla, USA) and back-up COULTER MAXM;
- COULTER Gen·S System 2; and
- Two Sysmex XE-2100 (Sysmex, Kobe, Japan).

Category 2 sites used coloured specimen transport bags and collected specimens directly into blood tubes with an incorporated priority indicator. Blood tubes with priority indicators were produced for Queensland Health under licence using intellectual property from Priority Laboratory Services Australia (Adelaide, SA) and blood tubes from Greiner Bio-One (Kremsmünster, Austria), and are covered by an Australian Innovation Patent (further patents pending). Four hospitals were in this category, and they used haematology analysers:

- COULTER Gen·S and back-up COULTER HmX with autoloader;
- COULTER Gen·S System 2 and back-up COULTER HmX with autoloader;
- Sysmex XT-2000i; and
- Sysmex SE-9000 and back-up Sysmex XT-2000i.

All seven hospitals operated 24 hours/day, 7 days/week, had a minimum of 30 000 ED presentations per year, had a pneumatic tube transport system (PTTS), and were concurrently connected to a single statewide laboratory information system (AUSLAB [PJA Solutions, Melbourne, Vic]) that applies identical autovalidation rules for each brand and model of haematology analyser used. Data were analysed for an 11-month period (December 2007 to October 2008), commencing 18–33 months after implementation of the pathology process changes.

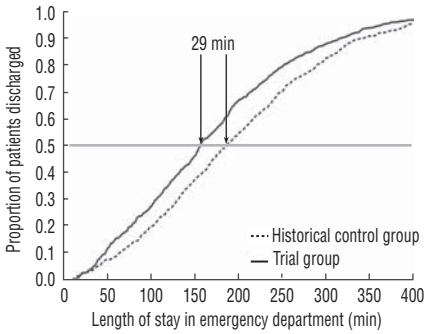
Queensland Health uses a Holos (Seagate Technology, Scotts Valley, Calif, USA) front-end program with an Oracle database (Oracle Corporation, Redwood City, Calif, USA) decision support system (DSS) to record pathology turnaround times for patients attending EDs across the state. Recorded times include time of specimen collection (if recorded by clinical staff), time of specimen receipt in the laboratory, and time of final test result validation. Additionally, the DSS database specifically includes collected-to-validated and received-to-validated times for specific tests for all patients attending Queensland Health EDs. Data from the DSS were exported into Microsoft Excel for checking and de-identification. The DSS database has some limitations because it records the time of the last test result validation, therefore data are skewed by samples that are revalidated (eg, those for which

2 Triage categories of patients attending an emergency department during a pilot trial of pathology process redesign

	Historical control group	Trial group
No. of patients	789	730
No. of days*	24	22
Triage category†		
1	0.3%	0.7%
2	26.6%	23.8%
3	43.0%	39.7%
4	21.9%	24.4%
5	8.2%	11.4%

* Number of days for which data were collected and analysed. † According to the Australasian Triage Scale.[11]

3 Proportion of patients discharged from the emergency department, by length of stay, during a pilot trial of pathology process redesign*



* The horizontal grey line indicates the median length of stay for all patients in the emergency department.

delayed results are added). Hence, data analysis was confined to the data range from zero to the 97.5th percentile.

Statistical analysis

Statistical analysis was performed using SPSS version 14 (SPSS Australasia, Sydney, NSW). As the data were not normally distributed, non-parametric statistical testing was used. Summary values are expressed as means, or medians with interquartile ranges. In the pilot trial, the Mann–Whitney *U* test was used to compare LOS between historical control and trial groups and Pearson χ^2 analysis was used to compare the percentages of patients in each triage group for trial versus control groups. Differences between Kaplan–Meier plots were measured by log-rank (Mantel–Cox) analysis.

Ethics approval

Ethics approval for the pilot trial and multisite study was granted by the Human Research Ethics Committee of The Prince Charles Hospital.

RESULTS

For the pilot trial, analysed data meeting the inclusion criteria represented 789 patients from the historical control group and 730 patients from the trial group. For Category 1 sites of the multisite study, 65 924 FBC requests met the inclusion criterion for data analysis, of which 46 093 (69.9%) met autovalidation rules and 39 097 (59.3%) met autovalidation rules and had a valid time of specimen collection. For Category 2 sites of the multisite study, 66 597 FBC requests met the inclusion criterion for data analysis, of which 47 036 (70.6%) met autovalidation rules and 37 413 (56.2%) met autovalidation rules and had a valid time of specimen collection.

Single-site pilot trial

In the pilot trial, the proportion of patients in the trial group for each triage category was not statistically different to that of the control group ($P = 0.08$; Box 2). The redesigned pathology process was associated with a 29-minute (15.6%) reduction in median LOS in the ED ($P < 0.001$; Box 3). Considerable reductions in LOS were also revealed in triage categories 2, 3 and 4 (Box 4).

Although data from days when major problems or malfunctions occurred were excluded from the pilot trial analysis, a separate analysis of data from the pilot trial period showed a 35-minute prolongation in median ED LOS on trial days when major problems or malfunctions occurred (eg, prolonged malfunction of the PTTS, laboratory information system or main laboratory instruments) compared with trial days when the PTTS, laboratory information system and main laboratory instruments were functioning normally ($P < 0.001$).

Multisite post-implementation study

The use of coloured specimen transport bags plus blood tubes with an incorporated priority indicator showed a sustained and highly significant reduction in pathology test result turnaround time for FBC requests for patients attending EDs when compared with FBC requests that used coloured specimen bags alone (with standard blood tubes). A reduction in total pathology turnaround time was revealed for the entire patient population ($P < 0.001$; Box 5). The percentage improvements for the total laboratory turnaround time and within-laboratory turnaround time were similar (20.1% and 17.8% reductions, respectively; Box 6). Also, these proportional improvements are similar to the 15.6% proportional improvement in ED LOS in the pilot study.

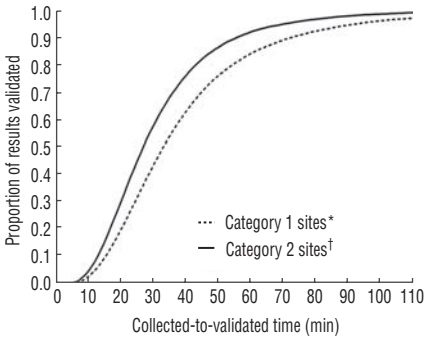
In addition, there was a highly significant reduction in turnaround time outliers when the data were analysed according to timeframes specified in the Australian Council

4 Patient length of stay (LOS) in the emergency department during a pilot trial of pathology process redesign

		Triage category			
	All categories	2	3	4	5
Median (interquartile range) LOS, min					
Historical control group	186 (118–268)	206 (143–278)	217 (152–290)	131 (73–217)	73 (35–143)
Trial group	157 (92–234)	186 (124–258)	191 (138–266)	100 (58–182)	72 (39–139)
Reduction in LOS for trial group, min	29 (15.6%)	20 (9.7%)	26 (12.0%)	31 (23.7%)	1 (1.4%)
P for reduction in LOS	< 0.001	0.04	0.02	0.01	ns

ns = not significant.

5 Proportion of full blood count results validated, by collected-to-validated time, in a multisite study of pathology process redesign



* Coloured specimen bags alone. † Coloured specimen bags plus blood tubes with a priority indicator. ◆

6 Mean laboratory turnaround times for full blood count requests from emergency departments in a multisite study of pathology process redesign

	Within-laboratory turnaround time* (min)	Total laboratory turnaround time† (min)
Category 1 sites: coloured specimen bags alone	20.8	39.9
Category 2 sites: coloured specimen bags plus blood tubes with a priority indicator	17.1	31.9
Reduction in mean turnaround time‡	3.7 (17.8%)	8.0 (20.1%)
P for reduction in mean turnaround time‡	< 0.001	< 0.001

* Received-to-validated time. † Collected-to-validated time. ‡ Data represent Category 2 sites compared with Category 1 sites. ◆

on Healthcare Standards (ACHS) Pathology Indicators (Box 7).[12] Again, the percentage improvements for reduction in outliers for total laboratory turnaround times (49.7%) and within-laboratory turnaround times (44.2%) were similar.

DISCUSSION

The request–test–report cycle for pathology tests is a multistep process, involving up to 20 people for each sample. Accumulation of low rates of human error during the cycle can contribute to significant failure rates. Failure rates for urgent tests commonly requested by EDs can exceed 20%.[13]

Laboratories provide up to 80% of the information used by clinicians to make important medical decisions.[14] However, in many instances, the percentage of laboratory turnaround time outliers has not changed significantly for up to 10 years.[15-17] It has been suggested that timeliness of result reporting has not been a major focus in clinical laboratories[16] and that, for at least some critical tests, the actual turnaround times fail to meet the expectations of the test provider and test user.[16-19]

Faster access to pathology results can reduce LOS in EDs and thereby improve clinical care and reduce total cost of care for individual patients.[4,7,14,17,20,21]

Several approaches have been used to try to improve laboratory services for EDs. Point-of-care testing, phlebotomists dedicated to ED collections, a dedicated satellite laboratory in the ED, and large-scale laboratory automation systems are costly and unlikely to meet the needs of most hospitals and laboratories as cost-effective solutions to poor turnaround times for analysis of samples from the ED.[22,23]

Pre- and post-analytical aspects of the pathology request–test–report cycle comprise a larger component of the testing process than the analysis. Improvements in laboratory turnaround time parameters have been achieved by the implementation of lean processing initiatives in the pre-analytical aspect of testing.[5] These changes may be easier to achieve and more cost-effective than changes to specific analytical aspects of specimen analysis.[5,17,18]

Our study demonstrates the practical and achievable long-term outcome of widespread multisite implementation of a process improvement initiative that demonstrated clear benefits in a single-site pilot trial. Although widespread multisite implementation of all elements of the pilot trial protocol was not achieved, long-term follow-up data analysis of 132 521 FBC requests from seven EDs indicated that key clinical performance indicators — pathology turnaround times — can be significantly and sustainably improved (up to 20.1% reduction) by collecting samples from ED patients directly into specimen containers with an incorporated priority indicator. In addition, the changes made to the pathology process in the pilot trial were implemented easily and with minimal cost, and demonstrated a clear and direct relationship between LOS in the ED and the pathology request–test–report cycle that had not previously been fully appreciated or quantified at this site. This suggests that LOS in the ED can be significantly reduced by simple changes to pathology processes.

This work has the limitations of all observational studies, and long-term multisite follow-up of ED LOS is fraught with the potential impact of many uncontrolled variables. However, we believe that the comparison groups are sufficiently well matched, the candidate test (a robust and well defined pathology clinical indicator) used in the multisite study is the most informative and most appropriate test, and the results are sufficiently statistically significant to provide information that can be used to guide and improve clinical practice. Importantly, improvements in the multisite study

7 Turnaround time outliers for full blood count (FBC) requests* from emergency departments in a multisite study of pathology process redesign

	FBCs with within-laboratory turnaround time† ⩾ 40 min	FBCs with total laboratory turnaround time ‡ ⩾ 60 min
Category 1 sites: coloured specimen bags alone	8.6% (3958/46093)	16.3% (6364/39097)
Category 2 sites: coloured specimen bags plus blood tubes with a priority indicator	4.8% (2268/47036)	8.2% (3061/37413)
Reduction in percentage of outliers	44.2%	49.7%
P for reduction in outliers	< 0.001	< 0.001

* FBC requests not processed within standard timeframes according to the Australian Council on Healthcare Standards Pathology Indicators, version 3.[12] † Received-to-validated time. ‡ Collected-to-validated time. ◆

occurred without changes to the specimen transport system, laboratory location, laboratory instrumentation or laboratory information system.

By extrapolating our data to public EDs in Queensland, about 247 000 ED patients per year have an FBC that is autovalidated. Thus, the use of coloured specimen bags plus blood tubes with a priority indicator, compared with coloured specimen bags alone, would result in a time saving of more than 32 000 hours per year (which would benefit all ED patients), and more than 20 000 additional samples would meet the ACHS Pathology Indicator FBC collected-to-validated time of less than 60 minutes.[12]

There is an imperative to improve many aspects of the health care system,[24] including patient flow in EDs, throughout the world. Rapid access to diagnostic tests is a prerequisite for good clinical outcomes.[25] The initiatives described here are simple and cost-effective, and can be readily implemented at any hospital with an on-site laboratory.

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COMPETING INTERESTS

Andrew Francis is a Director and indirect beneficial owner of companies that own the intellectual property rights associated with the specimen containers with an incorporated priority indicator that were used in this study. He may benefit from use or commercialisation of this intellectual property. He has received funding from Change Champions and the Australasian College for Emergency Medicine to attend conferences.

Funding for original trial work at The Prince Charles Hospital (January 2005 to March 2005) was jointly provided by Queensland Health and Priority Laboratory Services Australia. Funding for the multisite implementation was provided by the Innovation Branch of Queensland Health. These funding sources had no role in designing the study, collecting, analysing and interpreting the data, or preparing this article for publication.

Some of this work has been published in PathWay and *The Australian* newspaper and presented at conferences since 2005. Some is available at <http://www.changechampions.com.au/>.

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