

ORIGINAL ARTICLE

Medical stewardship: Pathology evidence based ordering to reduce inappropriate test ordering in a teaching hospital

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ABSTRACT

Objective: This study was designed as an educational program aimed at promoting evidence-based pathology ordering with the aim of reducing inappropriate test ordering.

Methods: Researchers benchmarked the hospital's pathology tests ordered in 2013-2014 before conducting a multifaceted education program in 2014-2015. The intervention consisted of main priorities including pathology test auditing, in-services and lectures, development and implementation of investigation pathways, and policy and procedure compliance. The main outcome measures was a reduction in commonly inappropriate ordered pathology testing leading to a reduction in the average test per hospital admission, and a reduction in specimen collection errors.

Results: Through this educational method the researchers achieved a reduction in the average test per admission in 2014-2015 ($M = 12.98$) from 2013-2014 ($M = 13.83$). A two sample t -test indicated that this difference was significant, $t(3.3006) = 0.0071$, $p = .01$. The intervention included a focus on specimen collection errors and achieved a reduction in specimen error rates ($M = 2,695$) from the previous year ($M = 3,000$). A one sample t -test indicated that this difference was significant, $t(3.0804) = 0.0105$, $p = .05$. This intervention decreased commonly inappropriate pathology requests of Full Blood Count (FBC, -4.21%), Liver Function Tests (LFTs, -8.36%), Vitamin B₁₂ (B₁₂, -6.45%) and Coagulation profile (-21.22%). Commonly inappropriate pathology tests decreased ($M = 7,120.33$) from ($M = 7,609.67$). A two sample t -test indicated that this difference was significant, $t(3.7730) = 0.0031$, $p = .005$.

Conclusions: Results confirmed that a multi-faceted education program can reduce inappropriate pathology test ordering, commonly over-ordered pathology test ordering, and pathology specimen error rates while maintaining positive patient outcomes.

Key Words: Medical education, Inappropriate pathology test ordering, Evidence based pathology test ordering, Specimen error reduction, Over-ordered medical tests

1. INTRODUCTION

Pathology has a critical role in the diagnosis, monitoring, and screening for disease. In Australia the number of pathology tests has increased by 35% from 2000-2001 to 2007-2008, equalling a volume increase from 62.1 million to 95.7 million

tests.^[1] While some of this increase is appropriate, a growing body of evidence suggests that over-testing is a growing problem in Australia.^[2,3]

Australian data suggests that pathological testing does not necessarily meet recommended guidelines, including

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25%-75% of tests ordered not being supported by evidence or expert opinion.^[4] The National Coalition of Public Pathology^[4] (p5) defined inappropriate pathology as requests “performed at the wrong time or too frequently to be of value in diagnosis, prognosis, or ongoing clinical management”. Appropriateness has included concerns associated with common tests such as Full Blood Count (FBC),^[5] Liver Function Tests (LFTs),^[6] Vitamin B₁₂/folate (B₁₂),^[7] Thyroid Function Tests (TFTs),^[8] Vitamin D (Vit D), Prostate-Specific Antigen (PSA), and Troponin.^[9]

This issue is compounded in teaching hospitals, because the least experienced medical officers; interns and residents order the majority of tests.^[10,11] As such, inappropriate tests are most common in teaching hospitals.^[12] Junior doctors account for a significant proportion of inappropriate pathology test ordering.^[12] This is reinforced at Australian hospitals by a culture where the risk of over-ordering tests is perceived to have less serious consequences than not having ordered a required test.^[9] It has been identified that within the hospital that in some situations junior nurses are pre-empting the treating doctor’s pathology testing, leading to a significant proportion of unnecessary ordering.^[12] Furthermore it was identified that pathology test requests are being submitted in advance for the perceived duration of the patient’s admission and particularly the weekend period resulting in some inappropriate testing and duplicate test request forms being submitted. These outcomes provide an opportunity to reinforce the shared accountability for appropriate clinical decision making and better use of resources.

Over-testing and inappropriate testing can lead to potential patient harm. The pre-test probability of disease in the general public is relatively low. This means that false positive tests are common, even in tests with reasonable specificity.^[9] False positives can result in a cascade of further tests, leading to a greater risk of complications and patient harm.^[13] As discussed by Hammett *et al.* if a healthy person is subjected to 10 unnecessary tests, there is a 40% chance of a least one test being a false-positive result. Over-testing may also lead to over-diagnosis, which leads to unnecessary treatment, and adds to the risk of patient harm.^[14] A number of influences have been described^[15-17] for the test ordering behaviours of clinicians including doctor related factors such as experience, perceived medico-legal risk, patient related factors such as anxiety, hospital related factors such as procedures, and systems related factors such as the development of new tests. Over-testing, diagnosis, and treatment are now the subject of much debate, and research has demonstrated that up to one third of all tests ordered are inappropriate and do not contribute to the diagnosis and treatment of patients.^[9]

This paper is aimed at filling the clinical gap associated with implementing an educational intervention strategy to reduce inappropriate pathology test ordering as it relates to reducing commonly over-ordered pathology test and specimen request errors. It is hoped that this intervention can provide hospital educators with strategies that could benefit their interventions into appropriateness of pathology ordering. Of note, The Royal College of Pathology Australia (RCPA) has recently recommended hospital pathology stewardship programs with multidisciplinary input, educational strategies, and collection and analysis of data.^[18] This paper directly responds to this recommendation and provides a clinical hospital example.

Hypothesis 1: Multi-faceted education interventions aimed at reducing inappropriate pathology tests ordered reduces the hospital’s average pathology per admission.

Hypothesis 2: Multi-faceted education interventions aimed at reducing inappropriate pathology tests ordered reduces the hospital’s specimen and labelling errors rates.

Hypothesis 3: Multi-faceted education interventions reduce commonly over-ordered pathology tests including FBC, LFTs, Vit D, B₁₂, Coagulation profiles (Coags), and Beta-Human Chorionic Gonadotropin (BHCG).

2. METHOD

2.1 Case hospital

The case hospital is an accredited 250 bed public hospital located in Canberra Australia. The hospital has many services including an Emergency Department (ED), an Intensive and Coronary Care Unit, medical and surgical wards, a Maternity Unit, a voluntary psychiatric ward, and ambulatory care and outreach facilities and services. The hospital is a teaching hospital with associations with local universities.^[19] The fully accredited clinical laboratory provides specialist pathology services to the general public and while patients are in hospital.^[20]

2.2 Participants

The participants were all Admitted Patients (N = 24,376) and ED Presentations (N = 54,987) attending hospital, and all pathology tests ordered (N = 337,030) between 1 May 2013 and 31 April 2014. This was compared to the intervention year’s Admitted Patients (N = 26,111) and ED Presentations (N = 55,905), and the pathology tests ordered (N = 338,182) between 1 May 2014 and 31 April 2015.

2.3 Design

The benchmark data included the pre-intervention year (2013-2014) average test per admission, specimen and labelling collection issues, commonly over-ordered pathology

tests, Relative Stay Index (RSI) mean, and the Casemix mean. The RSI summarizes the length of stay for admitted patients, with adjustments for Casemix; the types of patients treated and the types of treatments provided. An RSI greater than 1.0 indicates that an average patient's length of stay is higher than expected, given the Casemix for the separations being considered. An RSI of less than 1.0 indicates that the length of stay was less than expected. The RSI is an indicator of the efficiency of the hospital as it relates to patient outcomes.^[21]

To compare the intervention year to the non-intervention year the researchers accessed and formulated specific data:

- Hospital data including monthly admissions, presentations, and Occupied Bed Days (OBD).
- ACT Pathology raw data including monthly pathology testing and specimen errors.

The researchers audited pathology request forms, specimen data, and patient notes. This data was used to compare means, and to highlight pathology ordering trends during the intervention.

2.4 Statistical analysis

A two sample *t*-test was used to compare the non-intervention year to the intervention year by comparing the means of each set of data. In the case when only one year of data was available, such as the specimen sample error rates, a one sample *t*-test was used. In both instances a level of significance of .05 was used.

2.5 The intervention

The education intervention consisted of conducting medical stewardship orientation lectures (N = 10) for the rotating medical officers (N = 129), and conducting medical stewardship lectures (N = 2) during the nursing orientation (N = 36). The researchers conducted regular in-services and departmental briefs (N = 20) in the ED, Medical Admission Planning Unit (MAPU), Maternity, and on the Wards (attendance N = 264). To present the case at the senior level the researchers conducted a Grand Rounds presentation and a Continual Medical Education (CME) lecture. Grand Rounds consisted of Hospital employees from nursing, medical, physiotherapy, pharmacy, pathology, and administration (attendance N = 30). CME consisted of senior medical employees from the differing specialities (attendance N = 40). Total education attendance equalled 429 from April 2014 to May 2015.

These presentations consisted of highlighting the following key outcomes:

- Outlining the extent in Australia to which medical investigations by clinicians are unnecessary or inappropriate and highlighting intervention strategies to

achieve sustainable change in behaviour. Essentially, providing contemporary Australian data on the problem of inappropriate pathology test ordering to inspire a change in behaviour.

- Highlighting specimen labelling problems.
- Highlighting relevant data and associated issues with regularly over-ordered pathology tests within the hospital.
- Highlighting evidence-based ordering protocols and guidelines.

To assist learning the researchers highlighted online clinical applications. This included providing ward and area computer links to the RCPA manual, the Irefer Ipad/phone application, and the iNvestigate clinical site.^[22-24] These resources helped junior clinicians in troubleshooting recommended test ordering and provided education and justification on appropriate test ordering.

As recommended by Morgan *et al.*^[9] the researchers implemented a "Framework for analysis of test ordering":

- Why did you order the test?
- How will the ordered test alter your management?
- What are the potential risks of ordering or not ordering the test?
- Is there a potential of over diagnosis?
- What is the likelihood of a positive result?
- What is the prevalence of the provisional diagnosis?
- Were you influenced by anything else?
- Are there guidelines related to this presentation?

This framework was given to clinicians during scheduled in-services and orientation lectures, and voluntarily requested answers to the above questions based on a pathology test requested in the past 12-24 hours. The framework was beneficial in conceptualising rational pathology test ordering.^[9]

The pathology auditing activities triggered the implementation of a Pathology Traffic Light system (May 2014) and the use of the Royal College of Pathologists of Australasia's and Australasian College for Emergency Medicine's Pathology Ordering Matrix (December 2014).^[25] The Pathology Traffic Light system identified which tests may be ordered by which category of clinical staff, using colour coded levels. The Pathology Ordering Matrix was designed as a rapid reference guide for junior medical and nursing staff for the treatment of adult patients attending the hospital. The Pathology Traffic Light posters and the Pathology Ordering Matrix were located in applicable areas around the hospital. Interested senior clinicians from MAPU, Maternity, and the ED provided education and support to junior doctors and

other staff in the Pathology Traffic Light processes use and specifically assisted with appropriate test selection.

In accompaniment with regular education, the researchers implemented college guidelines and formulated Hospital wide imaging and pathology guidelines. Initially this consisted of using the established (implemented November 2014) Australasian College for Emergency Medicine’s and the Royal Australian and New Zealand College of Radiologists Imaging Decision Guidelines.^[26,27] Due to limitations associ-

ated with pathology test guidelines/pathways, the researchers developed (February 2015) “Hospital Wide Investigation Guidelines” consisting of medical testing recommendations associated with cancer staging, cardiovascular, ear nose and throat, endocrine, gastrointestinal, musculoskeletal, neurological, obstetrics and gynaecological, respiratory, trauma, and urological. These guidelines included teaching points, pathology and laboratory testing, image galleries, and diagrams (see Figure 1 and Table 1).

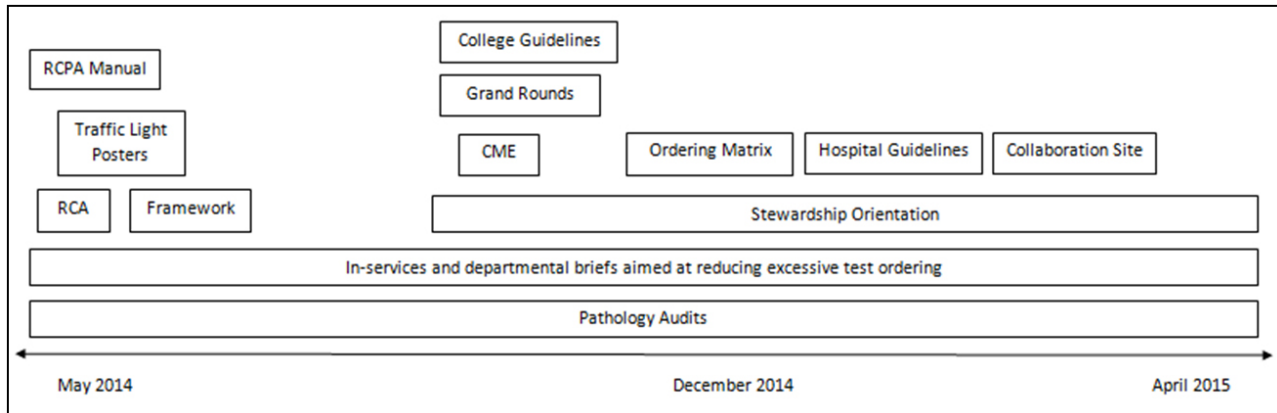


Figure 1. Intervention timeline

Table 1. Summary of intervention

Approach and Strategies	Description	Date(s) Completed
General		
Hospital pathology test trend auditing	12 audits conducted	Monthly (April 2014-May 2015)
Pathology test specimen error reduction	12 audits conducted	Monthly (April 2014-May 2015)
Medical stewardship orientation lectures	129 participants	November (N = 2) 2014, January (N = 2) 2015, February (N = 2) 2015, April (N = 2) 2015, May (N = 2) 2015
Nursing stewardship orientation lectures	36 participants	March (N = 1) 2015 and April (N = 1) 2015
In-services and departmental briefs	264 participants	Monthly (May 2014-April 2015)
Grand Rounds lecture	30 participants	October 2014
Continual Medical Education (CME) open forum	40 participants	November 2014
Medical Stewardship Collaboration Site	53 unique users	Established February 2015
Specific		
Random case analysis	12 clinical notes accessed	April 2014
Pathology test FBC repeat audits	10 pathology audits conducted	Monthly (July 2014-April 2015)
Framework for analysis of test ordering	105 voluntary participants	Established May 2014
Traffic Light Posters and Pathology Ordering Matrix	Compliance measured via audit accessing 382 pathology request forms. Non-compliance communicated to area heads.	May 2014 and December 2015
College guidelines		November 2014
Hospital Wide Investigation Guidelines		February 2015
Resources		
Royal College of Pathology Australia Manual	Uploaded on Calvary Computers	Established May 2014
Irefer	Highlighted during education	Monthly (May 2014-April 2015)
iNvestigate	Highlighted during education	Monthly (May 2014-April 2015)

3. RESULTS

This project was implemented in May 2014. The overall impact of this program became apparent after tabulation and analysis of the monthly pathology test reports from May 2014 to April 2015. These results were compared to the monthly data from May 2013 to April 2014.

The national yearly average in pathology ordering increased annually by 4.4% from the years 2000 to 2008^[28] whereas our results demonstrated an increase of 0.34% in 2014-2015. The national average for OBD per admission was 4.8 (21) in 2013-2014 whereas our results indicated 3.79 in 2013-2014 and 3.52 in 2014-2015. Between 2010-2011 and 2013-2014 the hospital's pathology services increased by an average of

6.25% a year per OBD, whereas our results indicated a 0.81% increase between 2013-2014 and 2014-2015. Between 2005-2006 and 2009-2010 Australian public hospital pathology services increased by an average of 3.8% a year per OBD,^[29] whereas our results indicated a 0.81% increase between 2013-2014 and 2014-2015. A two sample *t*-test indicated that this difference was significant, $t(6.5996) = 0.0222$, $p = .05$. This result could indicate that better stewardship in testing leads to less over diagnosis and treatment. From the below table it can be seen that the average test per admission decreased ($M = 12.98$) from the previous year ($M = 13.83$). A two sample *t*-test indicated that this difference was significant, $t(3.3006) = 0.0071$, $p = .01$ (see Table 2).

Table 2. Results summary

	1 st May to the 31 st April		Difference %	p-value
	2013-2014	2014-2015		
All admissions	24,376.00	26,111.00	1,735.00 (7.12%)	-
OBD (including day only)	92,350.00	91,935.00	-415.00 (-0.45%)	-
OBD/Admissions	3.79	3.52	-0.27 (-7.12%)	-
Total pathology test (including ED)	337,030.00	338,182.00	1,152.00 (0.34%)	-
Average: test/admission	13.83	12.98	-0.85 (-6.15%)	.0071
Average: test/OBD	3.65	3.68	0.03 (0.81%)	-
Total pathology test performed for ED	174,513.00	175,069.00	556 (0.32%)	-
Total ED presentations	54,987.00	55,905.00	918 (1.64%)	-
Average: ED test/presentation	3.12	3.13	0.01 (0.32%)	-
Specimen collection issues	3,000	2695	-305 (-10.17%)	.0105
Pathology testing cost per* admission (@\$30.70 per test)	\$424.58	\$398.48	-26.1 (-6.15%)	-

*This cost does not represent the amount paid. Payment information is based on contractual arrangements.

The intervention included a focus on specimen and labelling collection issues. A one sample *t*-test was used to compare the intervention observed data 2014-2015 to the 2013-2014 reported mean. The hypothetical mean for 2013-2014 was 250 errors per month. The researchers used this hypothetical mean because individual monthly specimen error data was not collected in 2013-2014. A one sample *t*-test indicated that this difference was significant, $t(3.0804) = 0.0105$, $p = .05$. To further validate this data, the researchers divided the intervention year from May to October 2014 ($M = 247.67$) and November to April 2015 ($M = 201.50$). The researchers saw a decrease in error rates between the two six month's intervention periods with high significance, $t(4.2946) = 0.0078$, $p = .01$. This process resulted in the development of a hospital policy "Patient identification and pathology specimen labelling" based on current literature.^[30,31]

This multi-faceted education intervention focused on commonly inappropriate pathology tests such as FBC, LFT, Vit D, B₁₂, Coags, and BHCG.^[9] This intervention decreased the total pathology requests of FBC (-4.21%), LFT (-8.36%),

B₁₂ (-6.45%) and Coags (-21.22%). In contrast to these results Vit D and BHCG pathology testing increased. A contributor to this could be the growing literature around the importance of Vit D testing.^[32] The total commonly over ordered tests from 2014-2015 decreased ($M = 7,120.33$) from 2013-2014 ($M = 7,609.67$). A two sample *t*-test indicated that this difference was significant, $t(3.7730) = 0.0031$, $p = .005$. The study included audit data on repeated pathology testing of FBCs, as highlighted in Table 3, Table 4, Table 5.

Table 3. Commonly over ordered pathology tests results

Test	2013-2014	2014-2015	Difference (%)	p-value
FBC	49,315	47,239	-2,076.00 (-4.21%)	.0192
LFT	29,502	27,036	-2,466.00 (-8.36%)	.0012
Vit D	1,054	1,255	201.00 (19.01%)	-
B ₁₂	1,333	1,247	-86.00 (-6.45%)	.4174
Coags	7,051	5,555	-1,496.00 (-21.22%)	.0003
BHCG	3,061	3,112	51.00 (1.67%)	-
TOTAL	91,316	85,444	-5,872.00 (-6.43%)	.0031

Table 4. Data results: repeated FBC pathology test

Date	ED	MAPU	ICU	CCU	DELS	3S	BC	4E	4W	5W	Total FBC Repeats	Hospital Total Pathology	Total FBC Requests Audited	% of Total Pathology	% of FBC Audited	Cost (@\$16.95)
Jul-14	70	42	57	7	11	12	0	48	50	60	357	30,367	4215	1.18	8.47	6,051.15
Aug-14	52	41	62	12	1	4	0	38	38	50	298	30,073	4120	0.99	7.23	5,051.1
Sep-14	61	41	60	26	4	8	0	33	42	45	320	30,338	4287	1.05	7.46	5,424
Oct-14	52	41	65	10	4	11	0	34	38	48	303	29,051	4020	1.04	7.54	5,135.85
Nov-14	37	47	54	11	7	7	0	45	34	35	277	27,112	3843	1.02	7.21	4,695.15
Dec-14	44	23	61	2	6	10	0	58	49	17	270	27,398	3848	0.98	7.02	4,576.5
Jan-15	60	24	57	6	5	2	0	40	42	12	248	26,824	3715	0.92	6.68	4,203.6
Feb-15	49	55	50	7	4	11	0	31	37	28	272	25,474	3579	1.08	7.60	4,610.4
Mar-15	48	38	60	6	4	10	0	56	55	30	307	27,114	3716	1.13	8.26	5,203.65
Apr-15	39	45	63	5	3	8	0	34	35	24	256	26,907	3683	0.95	6.95	4,339.2
Total	512	397	589	92	49	83	0	417	420	349	2,908	280,658.00	39,026.00	1.04	7.45	\$49,290.60

Table 5. Data results: repeated FBC pathology test by hospital area

	Total FBC Requests Audited	Total FBC Repeats	Percentage of Total FBC Requests	FBC Cost (@16.95)	POC Est Cost (@7.85)
ED	18,959	512	2.70	8,678.4	4,019.2
MAPU	3,058	397	12.98	6,729.15	3,116.45
ICU	1,925	589	30.60	9,983.55	4,623.65
CCU	658	92	13.98	1,559.4	722.2
DELS	1,135	49	4.32	830.55	384.65
3S	1,077	83	7.71	1,406.85	651.55
BC	80	0	0	0	0
4E	2,300	417	18.13	7,068.15	3,273.45
4W	2,367	420	17.74	7,119	3,297
5W	2,015	349	17.32	5,915.55	2,739.65
TOTAL	39,026.00	2,908	7.45	\$49,290.6	\$22,827.80

Respondents (N = 105) from the “Framework for analysis of test ordering”,^[9] indicated that 28.57% (N = 30) did not know why they ordered the test, 63.80% (N = 67) acknowledged the test ordered would not alter their management, 71.43% (N = 75) highlighted potential risks of ordering or not ordering the test, 35.24% (N = 37) acknowledged there was a risk of over diagnosis, 60.95% (N = 64) acknowledged that a positive result was likely, 86.66% (N = 91) highlighted the prevalence of the provisional diagnosis, 59.05% (N = 62) admitted they were influenced by something else, and 84.76% (N = 89) recalled guidelines related to this presentation. A number of factors contributed to these responses including perceived experience and knowledge of the junior medical officer, junior medical officers ordering what they think their senior medical officer will require, patient anxiety and requesting, procedural difficulties, and perceived medico-legal risks.

To determine whether the decrease in pathology had an effect on patient outcomes, the researchers calculated the interven-

tion RSI. The RSI decreased from 1.20 in 2013-2014 to 1.08 in 2014-2015. This figure indicates improvements in the Hospital length of stays compared to patient Casemix. A two sample *t*-test indicated that this difference was significant, $t(4.4458) = 0.0009, p = .001$. These results demonstrate a correlation between focused pathology ordering and benefits in patient outcomes.

4. DISCUSSION AND CONCLUSION

The primary aim of this project was to see whether a multifaceted educational program aimed at inappropriate pathology ordering could reduce the average pathology per hospital admission. As hypothesised, the results indicate that ongoing multifaceted education aimed at appropriate pathology ordering reduces pathology per admission. These results were achieved with increases in hospital admissions (7.12%) and ED presentations (1.64%).

The secondary aim of this project was to see whether a multifaceted educational program aimed at inappropriate pathol-

ogy ordering could reduce the hospitals specimen error rates. As hypothesised, ongoing education reduces pathology error rates.

The third aim of this study was to see whether targeting commonly over ordered pathology tests including FBC, LFT, Vit D, B₁₂, Coags, and BHCGs in a multi-faceted education program could reduce this trend. As hypothesised, the results indicate that ongoing education aimed at appropriate pathology ordering reduces commonly over ordered pathology tests, although some tests including Vit D and BHCG increased slightly.

The results of this study are consistent with research recommendations by Morgan *et al.* indicating that teaching rational ordering can reduce inappropriate pathology.^[9] These results are consistent with other research: Random case analysis is a powerful tool in clinical education;^[33] auditing of test and pathology data, figures, and results assists clinical education;^[34] making clinicians aware of the issues associated with inappropriate test ordering benefits appropriate pathology ordering.^[35,36]

In conjunction with face-to-face education the researchers set up a “Medical Stewardship” online collaboration site in February 2015. This site was established as research indicates that the incorporation of social media into “emergency medicine resident” education provides opportunities for individualized learning and greater dissemination of information.^[37,38] This site was communicated via Hospital Grand Rounds for two weeks in February 2015 and included information on blood and blood products, Choosing Wisely, and pathology testing guidelines, policies, and procedures. The objective of this site was to encourage night shift employees with online access to medical stewardship resources,

including pathology test ordering strategies and trends. The site had the following statistics:

- Feb-2015: 74 hits and 19 unique users.
- March-2015: 119 hits and 30 unique users.
- April- 2015: 12 hits and 4 unique users.

Of note, the Choosing Wisely Australian campaign was launched in April 2015.^[39] The Choosing Wisely campaign has a similar theme to this research product and it is hoped that the growing momentum around appropriate ordering could further benefit the Australian community.

Limitations of this study include:

- Identifying which intervention had the most impact.
- Pathology specimen error data limited to one year.

Multi-faceted education programs that include traditional and modern education methods, investigation pathways and guidelines, pathology error reduction audits, and compliance strategies can lead to a reduction in inappropriate pathology ordering while maintaining positive patient outcomes. In clinical settings it has been well demonstrated that educational results can be limited, unless continuously reinforced with effects decreasing after cessation.^[12]

Future interventions should focus on decreasing the labour-intensity of continually conducting auditing and education. One recommendation would be to conduct research into the effectiveness of creating an information system that assists auditing and appropriate test ordering.

CONFLICTS OF INTEREST DISCLOSURE

The author would like to acknowledge he is an employee of Calvary Health Care.

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