

BMJ Open Quality **Implementing effective test utilization via team-based evaluation and revision of a family medicine laboratory test requisition**

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INTRODUCTION

Revision of laboratory test requisitions is a simple utilisation strategy that can reduce unnecessary testing.^{1 2} The goal of this study was to improve test utilisation via a collaborative team-based evaluation and revision of a standardised lab requisition used by six large family medicine units.

METHODS

Revising the family requisition form

A historical laboratory requisition used by the Family Medicine Department at Unity Health, St. Michael's Hospital site, Unity Health Toronto, Toronto, Canada, was reviewed and modified by a steering committee comprised of family medicine clinicians (physicians and a nurse practitioner), lab medicine specialists and a quality improvement specialist. Decisions were made by consensus, and input was sought from the entire Department of Family Medicine via departmental rounds before changes were finalised. Laboratory tests were removed from the requisition if there was evidence in the literature of overuse (eg, Aspartate Aminotransferase (AST), folate, urea, Erythrocyte Sedimentation Rate (ESR)),^{3 4} if they were outdated (eg, amylase, Creatine Kinase (CK)),³ or if there was consensus that they were infrequently needed in a family practice (eg, rheumatoid factor, direct bilirubin). The requisition was also revised to improve readability, and education was imbedded regarding some special tests such as urine toxicology screening and coagulation testing (changes in online supplemental table 1). Tests that were removed from the requisition remained orderable with longhand.

Data analyses

The primary outcome was the monthly volume of targeted tests ordered by the

family medicine clinic 6 months pre- and 6 months post-requisition changes (September 2018 to September 2019). The proportion of abnormal test results and the ratio of Alanine Aminotransferase (ALT) (not targeted) to AST (targeted) were used as balance measures. Outpatient monthly laboratory test volumes for 20 tests were extracted from the laboratory information system. Process Control charts were generated using GraphPad Prism V.8.2.0. The proportion of abnormal results was calculated using R studio program V.1.2.5033. A two-tailed t-test was used to explore whether testing volumes were significantly different pre-requisition changes compared to post-requisition changes. Non-targeted tests (eg, ALT, total bilirubin, creatinine, haemoglobin) were used as negative controls. Cost analysis was performed using the Ontario Health Insurance Plan laboratory service fees as an estimate of true cost. The project was formally reviewed by institutional authorities at Unity Health Toronto and deemed to neither require research ethics board approval nor written informed consent from participants. Patients and/or the public were not included in the design, conduct, reporting, or dissemination of our research.

RESULTS

Ninety-nine thousand four hundred and thirteen laboratory tests were included in this analysis. Modifying the family medicine lab requisition resulted in a significant reduction in volume of targeted tests on AST (-50.8%), direct bilirubin (-68.2%), CK (-31.9%), amylase (-61.2%), urea (-79.9%), ESR (-31.3%), serum folate (-87.2%) and Red Blood Cell (RBC) folate (-76.8%) as depicted in [figure 1](#) and online supplemental table 2. Although

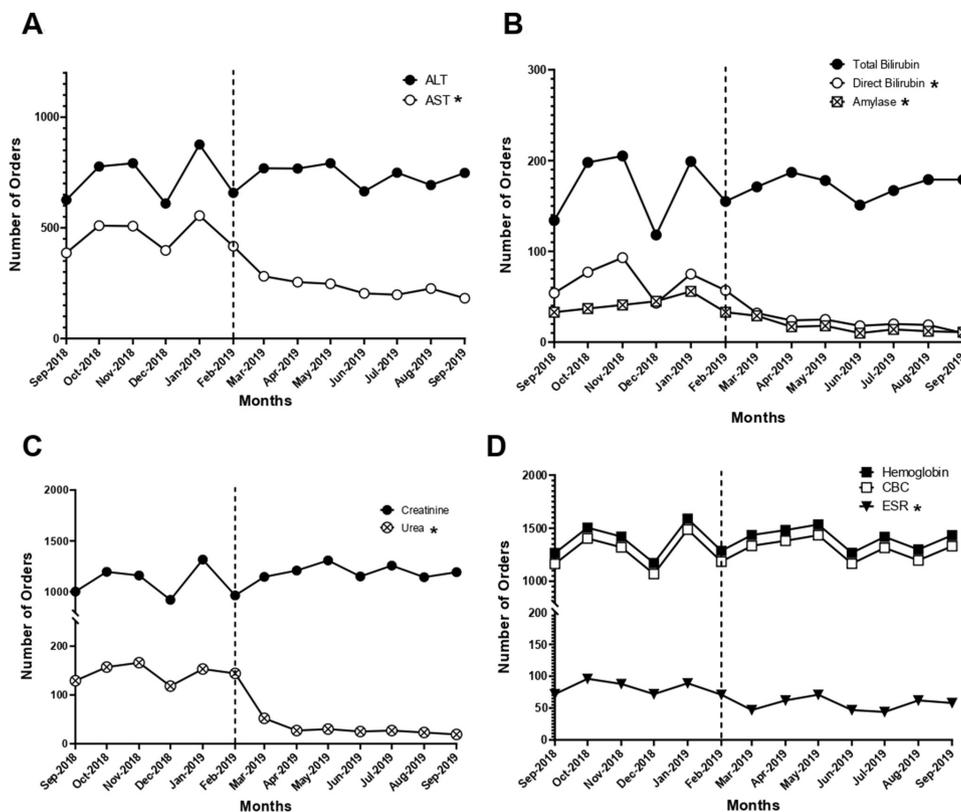


Figure 1 Decline in ordering of tests removed from the family medicine laboratory test requisition form over time. (A) AST and ALT, (B) amylase, total and direct bilirubin, (C) urea and creatinine and (D) ESR and negative controls, Haemoglobin and CBC (platelets and white blood cells). Dotted lines show the point of QI intervention. Asterisk denotes tests removed from the requisition. AST, Aspartate Aminotransferase; ALT, Alanine Aminotransferase; ESR, Erythrocyte Sedimentation Rate; CBC, Complete Blood Count.

there was a trend towards an increase in ordering ALT, total bilirubin, creatinine, haemoglobin over time, this change was not significant, except in the case of sodium (online supplemental table 2), and could reflect seasonal variation in overall clinic volume. The decrease in ordering resulted in cost savings each month. Online supplemental table 3 shows that the monthly cost of AST dropped by 50.8%, direct bilirubin by 68.7%, CK by 31.9%, amylase by 61.0%, urea by 80.0%, ESR by 30.9%, serum folate by 87.1% and RBC folate by 76.9%. On average, the cost of unnecessary testing used to be CAD 4687.41 per month prior to our quality improvement initiative and was reduced to CAD 2738.41 per month, amounting to an average of CAD 1949.00 in savings per month.

We performed a focused analysis on AST to evaluate whether the removal of AST from the family medicine lab requisition impacted the AST to ALT ordering ratio. A lower ratio of AST to ALT suggests more appropriate or targeted testing.^{5–7} The AST:ALT ratio prior to our intervention was 0.6 whereas the average AST:ALT ordering ratio post intervention was 0.3 ($p < 0.05$) (figure 2). The proportion of abnormal results in AST and ALT tests was then calculated as the proportion of results that were outside the reference intervals (ALT: 10–45 U/L, AST: 7–40 U/L) used for the tests. AST showed a significant increase of 40% (p value < 0.05) in the percentage of abnormal results

after it was removed from the requisition potentially indicating more targeted usage of this test. ALT, our negative control in this analysis, did not show any significant change in the percentage of abnormal results. This finding suggests that modifying the family

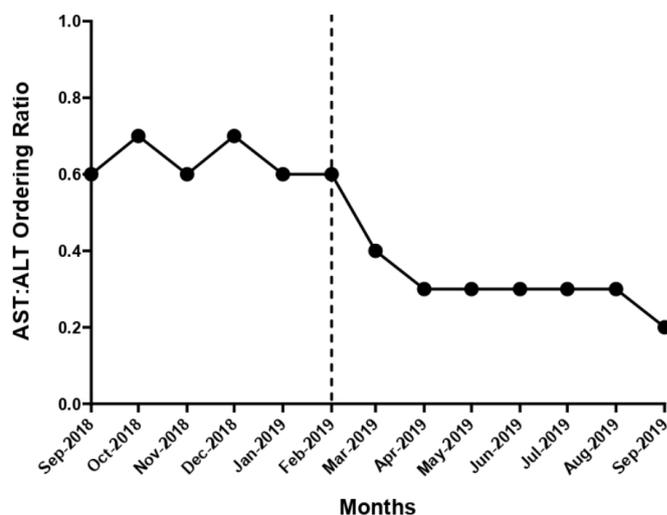


Figure 2 AST to ALT ordering ratio before and after removal of tests from family medicine laboratory tests requisition. A significant drop in AST:ALT ordering ratio was observed (p value < 0.05) after removing AST from the family medicine test requisition. Dotted lines show the point of QI intervention. AST, Aspartate Aminotransferase; ALT, Alanine Aminotransferase; QI, Quality Improvement.

medicine requisition only impacted the utilisation of the targeted tests removed.

CONCLUSIONS

Revision of a family medicine lab requisition was a simple, but effective strategy to decrease unnecessary laboratory testing and improve appropriate testing at our hospital. We recommend reviewing and revising historical requisitions and/or order sets as a way to encourage appropriate lab testing practices.

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Supplemental Table 1: Tests removed from the Family Medicine Laboratory Test requisition

Tests removed from the requisition		
CO2	CK-MB Fraction	ESR
Anion Gap	PSA	Malaria
Chloride	Rheumatoid Factor	Sickle Cell
Urea	Creatinine Clearance	G6PD
AST	PKU	Haptoglobin
LD		Serum Folate
Direct Bilirubin	ANA	RBC Folate
Total Protein	Anti DNA-Crithidia	Eosinophil Count
Globulin	C3 / C4	Bone Marrow
Amylase	Immunoglobins (IgG, IgA, IgM)	
CK	DNA FARR (aka ds-DNA)	
GGT		
Osmolality	Acetaminophen	
	Digoxin	
BHCG Screen	Acetone	
Growth Hormone	Ethanol	
Free testosterone	Ethylene Glycol	
T3 Uptake	Isopropanol	
	Methanol	
	Phenobarbital	
	Primidone	
	Procainamide	
	Quinidine	
	Salicylates	
	Theophylline	
	Barbiturates (blood)	
	Benzodiazepines screen (blood)	
	Tricyclic screen (blood)	
	Blood Drug Screen	

Supplemental Figure 1: New requisition after revisions.

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Patient ID

Laboratory Medicine Requisition #1
Biochemistry and Haematology

Health Centre at 410, 410 Sherbourne Street, Toronto, Ontario M4X 1K2

Specimen Taken	Telephone	<input type="checkbox"/> Stat
D M Y Time		<input type="checkbox"/> Routine
Signature of Specimen Collector		Signature of Ordering Physician

CODE	BIOCHEMISTRY	CODE	Special CHEMISTRY	CODE	TOXICOLOGY	CODE	HAEMATOLOGY
NA	Sodium	FER	Ferritin		URINE	CBC	CBC
K	Potassium	HBA	Hb A ₁ C	UAMP	Amphetamines Som.	ESR	ESR
CL	Chloride	HDLC	HDL-Cholesterol	UBAR	Barbiturates Som.	RET	Reticulocyte
CO2	CO2	CKMBB	CK-MB Fraction	UBNZ	Benzodiazepines Som.	HBEL	Hb Electrophoresis Order CBC also
	Anion Gap	CAI	CA (Ionized)	UTHC	Cannabinoids Som.		
GLF	Glucose, Fasting	PSA	PSA	UCOB	Cocaine/Benzoylec. Sc.	MALR	Malaria
GLR	Glucose, Random	RFA	Rheumatoid Factor	UMTD	Methadone Som.	SIC	Sickle Cell
GLPC	Glucose, 2h PC	OTHER:		UOPT	Opiates Som.	G6PD	G6PD
GTF	Glucose, Fasting Tol.			UPCP	Phencyclidine Som.	HAP	Haptoglobin
GT2	Glucose, 2h Tol			OTHER:		B12F	B12 / Folate
GLGST	Glucose, Screen, Gest					B12RF	RBC Folate
GGTO	Glucose, Fasting, Gest	CODE	BIOCHEMISTRY			EOSSM	Eosinophil Count Specimen type:
GGT1	Glucose, 1h Gest						
GGT2	Glucose, 2h Gest	UMAC	Routine Microscopic			OTHER:	
CREA	Creatinine	UCLAB	Creat. Clearance				
URE	Urea		24 hr. Urine	CODE	IMMUNOLOGY		
ALP	Alk. Phos.		Test.				
AST	AST	OTHER:	Microalb/creat ratio	ANAP	ANA (ANF)		
ALT	ALT			CRIT	Anti DNA-Crithidia		
LD	LD			C34	C3 / C4		
TBIL	Bilirubin, Total	CODE	TOXICOLOGY	IG	ICC, IGA, IGM	CODE	HAEMATOLOGY Booked tests Phone ext. 2138
DBIL	Bilirubin, Direct			FARR	DNA FARR		
CA	Calcium		BLOOD	OTHER:		BM	Bone Marrow
PHOS	Phosphorous	ACO	Acetone			CSM	CD4 / CD8 profile
TP	Protein, Total	ACE	Acetaminophen			SPECIMEN ACCEPTED Monday - Thursday 0800 - 1500 hrs. Friday until Noon	
ALB	Albumin	CARB	Carbamazepine				
GLOB	Globulin	DIG	Digoxin				
EP	Electrophoresis	ETOH	Ethanol				
URIC	Uric Acid	ETG	Ethylene Glycol	CODE	ENDOCRINOLOGY	OTHER:	
AMYL	Amylase	ISOP	Isopropanol				
CK	CK	LIT	Lithium	HCGS	BHCC Screen		
GGT	GGT	MEON	Methanol	HCGQ	BHCG Quant		
FE	Iron, Total	PNB	Phenobarbital	E2	Estradiol	CODE	COAGULATION
TIBC	TIBC	PTN	Phenytoin	FSH	FSH		
SAT	Saturation	PRI	Primidone	GH	Growth Hormone	INR	
CHOF	Cholesterol, Fasting	PCN	Procainamide	LH	LH	Patient on Coumadin	
CHOR	Cholesterol, Random	QND	Quinidine	PTH	PTH	OTHER:	
TRIF	Triglyceride, Fasting	ASA	Salicylates	PROG	Progesterone		
TRI	Triglyceride, Random	THE	Theophylline	PROL	Prolactin		
MG	Magnesium	VPA	Valproic Acid	TT	Testosterone		
OSM	Osmolality	BAR	Barbiturates Frac.	FT	Free Testosterone		
OTHER:		SBNZ	Benzodiazepines Som.	TSH	TSH	INR & PTT are not indicated for monitoring of DOACs. More information here. If concerned about a bleeding disorder, use the Bleeding Assessment Tool (BAT) which is more sensitive than any lab test.	
		STCA	Tricyclic Screen	TT3	Total T3		
CODE	PAEDIATRIC CHEMISTRY	DRSC	Drug Screen	T4	T4		
NBIL	Bilirubin, Neonatal	OTHER:		T3U	T3 Uptake		
	PKU			OTHER:	Free T4		
OTHER:						TRANSFUSION SERVICES	
						SEPARATE REQUISITION MUST BE COMPLETED AND SIGNED	
				COPY to:			

Form No. 90227 Rev. Feb. 12/2019

Supplemental Table 2: Percentage change in laboratory test ordering after quality improvement implementation in the Family Medicine requisition.

	Test	Change post QI (%)	Is change post-QI significant? (P-values)
Tests removed	AST	-50.8%	<0.001
	Conjugated (Direct) Bilirubin	-68.2%	<0.001
	Creatinine Kinase	-31.9%	0.03
	Amylase	-61.2%	<0.001
	Urea	-79.9%	<0.001
	Total PSA	-6.4%	0.49
	Rheumatoid Factor	-12.5%	0.13
	ESR	-31.3%	0.03
	Serum Folate	-87.2%	<0.001
	RBC Folate	-76.8%	<0.001
Control Tests	ALT	+2.4%	0.70
	Total Bilirubin	+3.0%	0.74
	Sodium	+18.8%	0.01
	Creatinine	+9.9%	0.12
	Hemoglobin	+2.9%	0.62
	Platelets CBC	+2.9%	0.62
	WBC CBC	+2.9%	0.62

Supplemental Table 3: Percentage change in cost after quality improvement implementation in the Family Medicine requisition.

A.

Test	OHIP Cost (CAD)	Average orders/month Pre QI	Average orders/month Post QI	Cost/month Pre QI (CAD)	Cost/ month Post QI (CAD)	Change in cost/month post-QI (%)
ALT	1.28	723	741	925.44	948.48	2.5
Amylase	2.25	41	16	92.25	36.00	-61.0
AST	1.28	463	228	592.64	291.84	-50.8
Bilirubin, Direct	1.28	67	21	85.76	26.88	-68.7
Bilirubin, Total	1.28	168	173	215.04	221.44	3.0
Creatinine Kinase	1.28	72	49	92.16	62.72	-31.9
ESR CBC	1.79	81	56	144.99	100.24	-30.9
Folate Serum	3.11	287	37	892.57	115.07	-87.1
RBC Folate	11	52	12	572.00	132.00	-76.9
Rheumatoid Factor	3.1	24	21	74.40	65.10	-12.5
Total PSA	30	58	55	1740.0	1650.0	-5.2
Urea	1.28	145	29	185.60	37.12	-80.0

B.

Test	OHIP Cost (CAD)	Absolute # of orders Pre-QI	Absolute # of orders Post-QI	Cost before (CAD)	Cost After (CAD)	Absolute change in cost (CAD)	Percentage change in Cost (%)
ALT	1.28	4339	5184	5553.92	6635.52	1081.6	19.5
Amylase	2.25	245	111	551.25	249.75	-301.5	-54.7
AST	1.28	2775	1593	3552	2039.04	-1512.96	-42.6
Bilirubin, Direct	1.28	399	148	510.72	189.44	-321.28	-62.9
Bilirubin, Total	1.28	1009	1212	1291.52	1551.36	259.84	20.1
Creatinine Kinase	1.28	429	341	549.12	436.48	-112.64	-20.5
ESR CBC	1.79	488	391	873.52	699.89	-173.63	-19.9
Folate Serum	3.11	1723	258	5358.53	802.38	-4556.15	-85
RBC Folate	11	314	85	3454	935	-2519	-72.9
Rheumatoid Factor	3.1	144	147	446.4	455.7	9.3	2.1
Total PSA	30	350	382	10500	11460	960	9.1
Urea	1.28	867	203	1109.76	259.84	-849.92	-76.6