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REPORTS OF ORIGINAL INVESTIGATIONS

Non-essential blood tests in the intensive care unit: a prospective observational study

Tests sanguins non essentiels à l'unité de soins intensifs: une étude observationnelle prospective

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Abstract

Purpose *Non-essential blood testing in the acute care setting can be a prominent source of morbidity, patient discomfort, increased workload for the healthcare provider, and wasteful spending. The magnitude of such non-essential blood testing has not been well described. We aimed to measure the extent of unnecessary blood testing in a 33-bed intensive care unit (ICU) at a tertiary-care teaching hospital in Ontario, Canada.*

Methods *Over a period of four weeks, all ICU attending physicians were asked to select, from a comprehensive list, blood tests that they deemed essential to the appropriate care for each of their patients on the following day. The actual tests processed on the following day were recorded. Descriptive statistics were used to determine what proportion of all processed tests were deemed essential blood tests. The association between patient characteristics and the total cost of unnecessary tests was assessed using the Wilcoxon rank-sum test and the Spearman correlation coefficient, as appropriate.*

Results *Nine attending physicians provided input for a total of 81 patient days. In 65 (80%) of these days, at least one test was considered non-essential. Physicians deemed only 338 (48.7%) of 694 processed blood tests as essential, which amounted to $2,243.41 (46.0%) out of an overall cost of $4,882.11. Patients' age, sex, mechanical ventilation status, and treatment with vasoactive drugs on the study day were not associated with the number of non-essential tests.*

Conclusions *Attending physicians deemed a substantial proportion of the blood tests processed in a tertiary care ICU setting as unnecessary. Furthermore, the non-essential tests incurred substantial additional cost. Further work is required to gain a better understanding of the underlying factors contributing to these wasteful practices.*

Résumé

Objectif *Dans un contexte de soins aigus, les tests sanguins non essentiels peuvent constituer une importante source de morbidité, un inconfort pour le patient, une charge de travail supplémentaire pour le fournisseur de soins de santé, et une dépense inutile. L'ampleur de tels tests sanguins non essentiels n'a pas été bien décrite. Notre objectif était de mesurer l'envergure des tests sanguins inutiles dans une unité de soins intensifs (USI) de 33 lits dans un hôpital universitaire de soins tertiaires en Ontario, au Canada.*

Méthode *Au cours d'une période de quatre semaines, on a demandé à tous les médecins travaillant à l'USI de choisir, dans une liste exhaustive, les tests sanguins qu'ils estimaient essentiels pour prodiguer des soins adaptés à chacun de leurs patients le jour suivant. Les tests véritablement réalisés le jour suivant ont été enregistrés. Des statistiques descriptives ont été utilisées afin de déterminer quelle proportion de tous les tests réalisés étaient jugés comme étant des tests sanguins essentiels. L'association entre les caractéristiques du patient et le*

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coût total des tests inutiles a été évaluée à l'aide du test de Wilcoxon et du coefficient de corrélation de Spearman, selon le cas.

Résultats *Neuf médecins ont fourni des données concernant un total de 81 jours patient. Durant 65 (80%) de ces jours, au moins un test était considéré non essentiel. Les médecins ont jugé que seuls 338 (48,7%) des 694 tests sanguins réalisés étaient essentiels, ce qui s'est chiffré à un total de 2243,41 $ (46,0%) sur un coût global de 4882,11 $. L'âge, le sexe, le statut de ventilation mécanique et le traitement à l'aide d'agents vasoactifs des patients le jour de l'étude n'ont pas été associés au nombre de tests non essentiels.*

Conclusion *Les médecins en charge ont jugé qu'une proportion importante des tests sanguins réalisés dans le cadre d'une USI de soins tertiaires était inutile. En outre, les tests non essentiels ont engagé des coûts supplémentaires importants. Des travaux supplémentaires sont nécessaires afin de mieux comprendre les facteurs sous-jacents contribuant à ces pratiques dilapidatrices.*

Over the past several decades, healthcare expenditures have risen dramatically.[1,2] Technological advancements have contributed considerably to the increasing costs; however, some of the increase, estimated to be 25-30%, is attributed to wasteful practices.[3] In recent years, initiatives such as the Choosing Wisely® campaign have been launched to increase patients' and providers' awareness and to develop strategies to prevent wasteful utilization of healthcare resources.[4]

Blood tests are commonly performed in hospitals. The measurement of various blood components is essential to identify and monitor physiological functions, track pathologic conditions, and inform about different aspects of clinical care. Nevertheless, it has been shown that blood tests are commonly overprescribed without adding value to patient care, and such practice may even be harmful. For example, unnecessary phlebotomy can lead to hospital-induced anemia, need for transfusion, discomfort, work overload, and added cost.[5–10]

Different strategies to ensure appropriate utilization of lab tests have been studied.[11] Nevertheless, objectively evaluating the necessity for tests is challenging, and the increasing reliance on electronic databases for this purpose has resulted in suboptimal quality of utilization reviews.[12] Therefore, particularly for purposes of quality improvement (QI), it is important to identify efficient, reliable, and sustainable methods for determining the need for tests.

The primary objective of this study was to quantify the extent of non-essential blood testing in an intensive care unit (ICU) setting and to use the findings as a baseline for future quality assurance initiatives. We were also interested in estimating the additional costs incurred by performing non-essential blood tests. We endeavoured to create a simple and reliable prospective measurement strategy that would facilitate assessment of performance over time. Our ultimate goal is to decrease unnecessary phlebotomy and the associated harm to patients and organizations.

Methods

This study was conducted in accordance with the amended Declaration of Helsinki. The protocol was approved by Queen's University Health Sciences & Affiliated Teaching Hospitals Research Ethics Board, approval number: 6012884. This cross-sectional observational study was carried out in June and July 2014 at the 33-bed ICU of Kingston General Hospital, a tertiary care teaching centre in southeastern Ontario, Canada.

In this closed-model ICU, about eight to 12 patients are assigned at a given time to one of three attending physicians who are responsible for patient care. At the same time, the attendings must also manage interprofessional teams, including residents with various levels of training and backgrounds, nurses, respiratory therapists, pharmacists, dieticians, and other healthcare professionals. Decisions regarding lab tests can be made at any time, particularly during the daily interprofessional bedside rounds led by the attending physician and also in response to a changing clinical situation. Input from the attending physicians regarding such decisions may vary according to their level of involvement in any given clinical situation. Other ICU providers may order tests according to their clinical judgement. Nevertheless, at the time of this study, there was no explicit common acceptable process in our unit for discussing and ordering lab tests for the following morning—neither during the daily rounds nor at any other time. In devising a strategy for assessing the adequacy of lab testing, we concluded that the attending physicians would be best suited to provide this assessment simply due to their designation as the healthcare provider directly responsible for the patient's well-being.

Over a period of four weeks, all ICU attending physicians were interviewed once, each during a single weekday after routine morning rounds. They were asked the following question concerning each of their patients: "What blood tests do you consider to be essential for

tomorrow morning to maintain appropriate care for this patient?" Along with this question, we provided a comprehensive list of common blood tests from which to choose, including complete blood count, electrolytes, calcium, magnesium, phosphate, creatinine, urea, arterial blood gases, venous blood gases, bilirubin (total and direct), alkaline phosphatase, aspartate aminotransferase, alanine aminotransferase, gamma-glutamyl transferase, total protein, albumin, prothrombin time (PT), partial thromboplastin time (PTT), blood glucose, and lactate. We recorded the tests that each attending physician indicated as necessary and classified these as the *essential* blood tests for study purposes. On the following day, we recorded the actual blood tests that were performed and processed for each patient and labelled these as *processed* tests.

The primary outcome of interest was the proportion of non-essential blood tests, defined as the processed blood tests that the attending physician had not previously indicated as essential on the prior day. In the absence of formal consensus-driven guidelines regarding the utilization of blood tests for critically ill patients, we based the decision regarding a test's necessity on the opinion of the attending physician. Secondary outcomes included the possible relationships between patient factors, such as age, sex, mechanical ventilation, and vasoactive drug use, and the likelihood of ordering non-essential blood tests. Additionally, we calculated the cost of the non-essential testing in Canadian dollars and based our calculation on the hospital's lab cost for analyzing the samples.

The proportions of the non-essential tests and the respective incurred costs were analyzed using descriptive statistics. The association between patient characteristics and the number and total costs of the non-essential tests was determined using the Wilcoxon rank-sum test for binary characteristics and the Spearman correlation coefficient for continuous patient characteristics. These non-parametric rank-based tests were used because of the strong positive skewing of the number of unnecessary tests and the corresponding costs per patient. All analyses were performed using Statistical Analysis System version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Demographic and clinical characteristics of the ICU patients and attending physicians are shown in Table 1. In total, 694 blood tests were processed on 81 patient days treated by nine physicians. In each of 65 (80%) of these patient days, at least one test was considered non-essential. The attending physicians deemed 338 (48.7%) of the 694 processed tests as essential. Conversely, 53 (15.6%) of the 338 tests that were deemed essential were not processed.

Table 1 Patient and physician characteristics

Patient Characteristics (n = 81)	
Age, yr, mean (SD)	63 (16)
Sex, male, n (%)	50 (62%)
Admission diagnoses, n (%)	
Respiratory Insufficiency	22 (27%)
Sepsis	19 (23%)
Cardiac complications	11 (14%)
Trauma	8 (10%)
Hemorrhage	7 (9%)
Postoperative care	5 (6%)
Neurologic	4 (5%)
Other	5 (6%)
Mechanical Ventilation*, n (%)	28 (35%)
Vasoactive Medications*, n (%)	16 (20%)
Physician Characteristics (n = 9)	
Sex, male, n (%)	7 (78%)
Primary Specialty, n	
Emergency Medicine	3 (33%)
Internal Medicine/Respirology	3 (33%)
Anesthesia	2 (22%)
Neurology	1 (11%)
Years of practice, years (SD)	7 (4)

*On day of data collection. SD = standard deviation.

The Figure depicts the number of processed tests that were deemed necessary by the treating physician the prior day as well as the number of non-essential tests. The most common unnecessary tests were blood glucose (n = 58), PTT (n = 45), PT (n = 43), and urea (n = 40).

The processing costs for all blood tests are shown in Table 2. The most expensive tests were lactate ($16.75) and blood gases ($12.41). The total cost for all ordered tests for the 81 patients was $4,882.11, $2,243.41 (46.0%) of which was attributed to unnecessary tests. The average cost of unnecessary tests was $27.70 per patient day. Forty-three percent of the cost of unnecessary tests was attributed to PTT, PT, and calcium/phosphate/magnesium (17%, 14%, and 12%, respectively).

Patients' age, sex, and mechanical ventilation status were not significantly associated with the number of non-essential tests (all $P > 0.3$). Although not statistically significant, the 16 patients being treated with vasoactive drugs on the study day had only 2.7 non-essential tests on average compared with 4.7 non-essential tests in the 65 patients not treated with vasoactive drugs (P = 0.10). Similarly, unnecessary cost was not associated with patients' age (P = 0.14), sex (P = 0.69), and mechanical ventilation status (P = 0.63). Nevertheless, the average cost of unnecessary tests tended to be lower for patients receiving infusions of vasoactive drugs ($16.37 *vs* $30.06; P = 0.06).

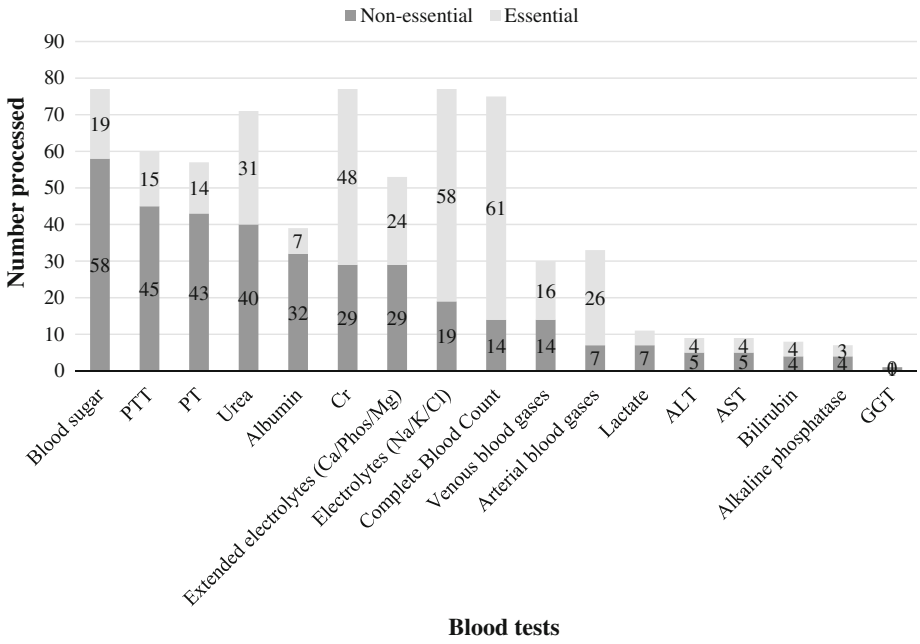

Figure Number of essential and non-essential tests processed. ABG, arterial blood gas; ALP, alkaline phosphatase; ALT, alanine aminotransferase; AST, aspartate aminotransferase; Ca/Phos/Mg, calcium/phosphate/magnesium; CBC, complete blood count; Cr, creatinine; GGT, gamma-glutamyl transferase; PT, prothrombin time; PTT, partial thromboplastin time; VBG, venous blood gases

Table 2 Cost of blood tests

Blood test	Unit cost CAN$	All processed tests			Unnecessary tests		
		# processed	Total cost CAN$	% of total cost	# processed	Total cost CAN$	% of all unnecessary cost
PTT	$8.69	60	$521.40	11%	45	$391.05	17%
PT	$7.44	57	$424.08	9%	43	$319.92	14%
Ca^{2+}, Mg^{2+}, PO_4^{3-}*	$9.30	53	$492.90	10%	29	$269.70	12%
Blood glucose †	$3.10	77	$238.70	5%	58	$179.80	8%
Na^{+}, K^{+}, Cl^{-}*	$9.30	77	$716.10	15%	19	$176.70	8%
VBG	$12.41	30	$372.30	8%	14	$173.74	8%
CBC	$11.17	75	$837.75	17%	14	$156.38	7%
Urea	$3.10	71	$220.10	5%	40	$124.00	6%
Lactate	$16.75	11	$184.25	4%	7	$117.25	5%
Albumin	$3.10	39	$120.90	2%	32	$99.20	4%
Creatinine	$3.10	77	$238.70	5%	29	$89.90	4%
ABG	$12.41	33	$409.53	8%	7	$86.87	4%
ALT	$3.10	9	$27.90	1%	5	$15.50	1%
AST	$3.10	9	$27.90	1%	5	$15.50	1%
Bilirubin‡	$3.10	8	$24.80	1%	4	$12.40	1%
ALP	$3.10	7	$21.70	0%	4	$12.40	1%
GGT	$3.10	1	$3.10	0%	1	$3.10	0%
Total Protein	$3.10	0	$0.00	0%	0	$0.00	0%
Total		694	$4,882.11	100%	356	$2,243.41	100%

* The processing of each electrolyte (Na^{+}, K^{+}, Cl^{-}, Ca^{2+}, Mg^{2+}, PO_4^{3-}) costs CAN$3.10. In this cohort, they were all ordered as a bundle, hence the overall cost is $9.30 per each. † Cost for random or fasting blood glucose; ‡ Cost for total or direct bilirubin

ABG = arterial blood gases; ALP = alkaline phosphatase; ALT = alanine aminotransferase; AST = aspartate aminotransferase; CAN$ = Canadian dollar; CBC = complete blood count; GGT gamma-glutamyl transferase; PT = prothrombin time; PTT = partial thromboplastin time; VBG = venous blood gases

Discussion

We have shown that the ICU attending physicians at this tertiary care teaching hospital considered more than half of the processed blood tests for critically ill patients to be non-essential. A small proportion of essential tests, about 16%, were not processed at all. The estimated additional unnecessary cost was at least $27.70 per patient day, and the tests that contributed most to the avoidable expenses were PTT, PT, calcium/phosphate/magnesium, and urea. Unnecessary tests were not significantly associated with severity of illness indicators or other measured variables.

Our study was not designed to examine the underlying factors contributing to the wasteful ordering of blood tests. Nevertheless, from a systems-level perspective, we hypothesize that the major reasons have to do with process and team factors.[13] There are currently no explicit guidelines or strategies in our ICU for considering and ordering necessary tests; consequently, a consistent underlying decision-making process and reliable follow-through remain elusive. Routine procurement of blood samples for a range of common tests is the norm, perhaps due to well-established habits and inertia. Initial orders for blood tests are routinely given upon a patient's admission to the ICU. These are often in the form of pre-printed orders and typically given when patients are unwell and require close monitoring. The absence of a regular deliberate decision-making process, followed respectively by clear and effective orders, may result in tests being carried forward for the remainder of a patient's stay. The busy ICU environment and the multiple and competing demands on clinicians' attention undermine recovery from such errors.[14] A QI initiative is currently underway to identify and address the relevant factors.

It is worrisome that some essential tests were not ordered. The underlying reasons for this are likely similar to those mentioned above. When an explicit decision-making process does not exist, the attending physician's intentions may not readily translate into actual orders. Such errors may result in patient harm through failure to diagnose and respond to vital physiological derangements.

Defining essential blood tests for any given patient is challenging. Almost all studies that attempted to define the appropriateness of laboratory tests analyzed the ordering practices of small numbers of physicians in training.[5] Furthermore, there was substantial heterogeneity across those studies, and the common reliance on electronic databases has resulted in suboptimal quality of utilization reviews.[12] The spectrum of opinions among providers regarding the necessity of any given test potentially challenges the validity of the approach used in the present study. Nevertheless, in the absence of established guidelines, we propose that blood tests deemed to be "essential" by the attending physician provide a real-life expert-based benchmark. Furthermore, for the purpose of QI, this strategy is simple to execute, repeatable, and sustainable.

This study has several important strengths. First, the internal validity of our findings is supported by the prospective data collection process and by reliance on the opinions of full-time attending physicians. Second, we propose a straightforward generalizable assessment scheme that can be easily implemented in any ICU (and other clinical areas) and support future QI initiatives. Third, we hope that the described magnitude of deviation from ideal practice will encourage other centres to examine their processes and procedures and respond as needed.

We acknowledge the following limitations. First, a potential for bias was introduced by the experimental design, i.e., interviewing the attending physicians might have altered their decision to order certain blood tests. Another threat to the study's internal validity is the possibility that either the attending physicians or other ICU providers ordered some necessary tests later in the evening after the physicians had been interviewed. Third, the reported cost analysis includes only the lab processing charges. Due to the study design, we cannot comment on other sources of expense such as intravenous access equipment, test tubes, and other technological and human resources. Therefore, it is important to recognize that our report likely underestimates the true unnecessary costs. Finally, we did not examine outcomes such as patient discomfort, anemia, and extra workload for staff. Nevertheless, while this was not the objective of this study, it has been previously shown that increased phlebotomy can lead to adverse patient outcomes and has a negative impact on healthcare systems.[5–10]

Conclusions

In conclusion, attending physicians deemed a considerable proportion of the blood tests processed in the ICU as unnecessary. Furthermore, the non-essential testing incurred substantial additional cost. Further work is required to comprehend and address the underlying factors contributing to this wasteful practice. We suspect that a major contributor was the lack of a routine daily process for delineating and ordering blood tests. The results of this project will be used to guide QI measures.

Conflicts of interest None declared.

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Author contributions Michael Mikhaeil, Andrew G. Day, and Roy Ilan made substantial contributions to the study design, data analysis and interpretation, and writing the manuscript.

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