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REPORTS OF ORIGINAL INVESTIGATIONS

A Canadian survey of perceptions and practices related to ordering of blood tests in the intensive care unit

Enquête canadienne sur les perceptions et pratiques liées à la prescription de tests sanguins aux soins intensifs

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Abstract

Purpose *The ordering of routine blood test panels in advance is common in intensive care units (ICUs), with limited consideration of the pretest probability of finding abnormalities. This practice contributes to anemia, false positive results, and health care costs. We sought to understand practices and attitudes of Canadian adult intensivists regarding ordering of blood tests in critically ill patients.*

Methods *We conducted a nationwide Canadian cross-sectional survey consisting of 15 questions assessing three domains (global perceptions, test ordering, daily practice), plus 11 demographic questions. The target sample was one intensivist per adult ICU in Canada. We summarized responses using descriptive statistics and present data as mean with standard deviation (SD) or count with percentage as appropriate.*

Results *Over seven months, 80/131 (61%) physicians responded from 77 ICUs, 50% of which were from Ontario. Respondents had a mean (SD) clinical experience of 12 (9) years, and 61% worked in academic centres. When asked about their perceptions of how frequently unnecessary blood tests are ordered, 61% responded "sometimes" and 23% responded "almost always." Fifty-seven percent favoured ordering complete blood counts one day in advance. Only 24% of respondents believed that advanced blood test ordering frequently led to changes in management. The most common factors perceived to influence blood test ordering in the ICU were physician preferences, institutional patterns, and order sets.*

Conclusion *Most respondents to this survey perceived that unnecessary blood testing occurs in the ICU. The survey identified possible strategies to decrease the number of blood tests.*

Résumé

Objectif *La prescription à l'avance de tests sanguins de routine est courante dans les unités de soins intensifs (USI), avec une prise en compte limitée de la probabilité de découverte d'anomalies avant le test. Cette pratique contribue à l'anémie, aux résultats faussement positifs et aux coûts des soins de santé. Nous avons cherché à comprendre les pratiques et les attitudes des intensivistes pour adultes au Canada en ce qui concerne la prescription d'analyses sanguines chez la patientèle gravement malade.*

Méthode *Nous avons mené un sondage transversal à l'échelle nationale au Canada en posant 15 questions évaluant trois domaines (perceptions globales, commande de tests, pratique quotidienne), ainsi que 11 questions démographiques. L'échantillon cible était composé d'un·e intensiviste par unité de soins intensifs pour adultes au Canada. Nous avons résumé les réponses à l'aide de statistiques descriptives et présenté les données sous forme*

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de moyennes avec écarts type (ET) ou de dénombrements avec pourcentages, selon le cas.

Résultats *Sur une période de sept mois, 80 médecins sur 131 (61%) ont répondu dans 77 unités de soins intensifs, dont 50% en Ontario. Les répondant·es avaient une expérience clinique moyenne (ET) de 12 (9) ans, et 61% travaillaient dans des centres universitaires. Lorsqu'on leur a demandé ce qu'ils ou elles pensaient de la fréquence à laquelle des tests sanguins inutiles étaient prescrits, 61% ont répondu « parfois » et 23% ont répondu « presque toujours ». Cinquante-sept pour cent étaient en faveur de la réalisation d'une formule sanguine complète un jour à l'avance. Seulement 24% des personnes interrogées estimaient que la prescription de tests sanguins à l'avance entraînait fréquemment des changements dans la prise en charge. Les facteurs les plus souvent perçus comme influençant la prescription d'analyses sanguines à l'unité de soins intensifs étaient les préférences des médecins, les habitudes institutionnelles et les ensembles d'ordonnances.*

Conclusion *La plupart des répondant·es à ce sondage ont l'impression que des tests sanguins inutiles sont prescrits aux soins intensifs. L'enquête a permis d'identifier des stratégies possibles pour réduire le nombre de tests sanguins.*

Keywords blood test ordering · critical care · cross-sectional survey · intensive care unit · physician perspective

Ordering of blood tests in advance, at regular recurring intervals (e.g., daily or twice daily), particularly if ordered routinely and unrelated to specific clinical indications, is common in intensive care units (ICUs). This practice promotes iatrogenic ICU-acquired anemia,[1,2] need for blood transfusion,[3] and false positive findings[4] that can lead to further unnecessary (sometimes invasive) investigations, and wastes both laboratory resources and physician and nursing time.[5,6] Observational studies have shown that 35–40 mL of blood is drawn per patient per day in adult ICUs[1,2] and that approximately 40% of ICU patients, in the absence of documented blood loss, require at least one transfusion of red blood cells during their ICU stay.[3] A retrospective cohort study of hospitalized general internal medicine patients found that every 100 mL of blood drawn was associated with a decrease in hemoglobin concentration of approximately 7 $g{\cdot}L^{-1}$.[7]

Evidence suggests that advance ordering of laboratory tests without specific clinical reasoning is of little benefit to patients.[8] Reducing this type of testing in ICUs has the potential to optimize resources and decrease the need for blood transfusion, without adverse consequences.[3,9,10] Choosing Wisely Canada is a national, clinician-led campaign wherein different specialty societies develop evidence-based lists of tests, treatments, and procedures that add no clinical value and can cause harm. Both Choosing Wisely Canada (in collaboration with the Canadian Critical Care Society) and Choosing Wisely in the United States recommend not ordering routine investigations, including chest radiographs or blood tests in critically ill patients, except if to answer a specific clinical question.[11]

In a prospective study examining a single Canadian centre, most ICU physicians believed that over half of the blood tests ordered for critically ill patients were nonessential.[12] To better understand the nature of this problem and to assist in the design of improvement strategies, we sought to undertake a nationwide survey of Canadian intensivists pertaining to blood testing in critically ill patients. We aimed to assess current practices in Canadian ICUs, as well as attitudes and perceptions of Canadian adult intensivists regarding the ordering of blood tests in critically ill patients.

Methods

With approval from the Hamilton Integrated Research Ethics Board (Hamilton, ON, Canada), we conducted a nationwide cross-sectional electronic survey that was sent to adult ICU physicians who practiced in centres across Canada. Participant consent was implied by survey completion.

Survey development

We initiated survey development via a series of focus groups among our research team (M. O. R., A. K., K. G., B. R.). We identified three domains of interest through discussion, literature review, and expert input: global perception, test ordering, and practice. Two content experts (B. R., M. O. R.) generated items for inclusion based on these domains, and then reduced the number of items to decrease respondent burden while ensuring that crucial questions remained.

We formatted questions with ordinal responses and a five-point Likert scale. They probed the extent to which physicians believed that blood tests were ordered unnecessarily in their ICUs, and whether results of these tests informed patient management. Questions also assessed test ordering practices at respondents' sites, including who orders blood tests, how often blood test ordering is reassessed, and the impact of point-of-care testing on laboratory testing. We did not provide a standard

definition for point-of-care testing, and left it open to the respondents' interpretation. Finally, we requested respondents' demographic information including professional position, years of clinical practice, and descriptors of their predominant practice setting (i.e., community *vs* academic centre, number of ICU beds, and type of patients).

Survey testing

First, two team members pretested the survey instrument to evaluate the appropriateness of each question and to ensure that respondents interpreted the questions as they were intended. Second, our research team piloted the survey to assess for thoroughness. Then, two adult intensivists not involved in the study assessed clinical sensibility. We modified the survey at each stage of development based on the results of pretesting, pilot testing, and clinical sensibility testing. One investigator (E. C.) translated the survey into French for distribution to respondents in Quebec. The French version also underwent piloting to ensure that comprehensiveness was maintained during translation. The final survey consisted of 26 questions (15 questions addressing the three domains and 11 demographic questions).

Survey administration and statistics

The target sample was at least one intensivist from each level 3 ICU in Canada, defined as units that provide invasive mechanical ventilation and multiorgan system support. We determined a total of 131 ICUs to be eligible for the study. We did not place any limitations on unit size, university affiliation, or ICU structure (i.e., open or closed unit with dedicated intensivist as most responsible physician for each patient).

We identified potential target respondents within each eligible ICU and obtained their e-mail addresses through personal networks among the investigators and by contacting critical care leaders in each provincial regional health authority. We administered the survey via e-mail between October 2017 and July 2019.[13] We sent e-mail reminders to potential respondents every one to two months. One of our survey questions asked for the name of the centre worked at, which allowed us to keep track of responses from each site. We did not provide incentives for completing the survey. Participation was voluntary and all responses were securely stored.

We summarized the survey responses using descriptive statistics and present continuous data as mean (standard deviation [SD]) and categorical data as count (percentage).

Results

We distributed the survey to 131 eligible ICUs and obtained responses from 80 ICU physicians (61% response rate) representing 77 ICUs. Fifty percent were from Ontario, 13% from Quebec, 13% from Nova Scotia, and 10% from Alberta (Table). Eighty-four percent of respondents practiced in an urban centre, and 61% practiced at a teaching facility. Most respondents (95%) practiced in a closed ICU (Table). Respondents practiced critical care medicine for a mean (SD) duration of 12 (9) yr.

When asking about respondents' perceptions of how often blood tests are ordered unnecessarily in the ICU, 61% of respondents answered "sometimes" and 23% answered "almost always" (Fig. 1). When asked about the optimal frequency of preordering specific blood tests in critically ill patients, 57%, 66%, and 64% of respondents believed that complete blood count (CBC), a basic serum electrolyte panel (sodium, potassium, and chloride), and serum urea and creatinine should be ordered at least daily, respectively (Fig. 2). Regarding beliefs about how often results of blood tests that were ordered in advance lead to a change in patient management, 57% of respondents answered "sometimes," while only 24% answered "frequently." The factors most often believed to influence advance ordering of blood tests were, in descending frequency: physician preferences (62 respondents, 76%), institutional practice patterns (43 respondents, 54%), preprinted order sets (43 respondents, 54%), nursing preferences (27 respondents, 34%), and residents/trainees ordering (18 respondents, 23%).

Respondents stated that most blood test ordering was done by attending physicians (77 respondents, 96%) and residents (62 respondents, 76%), and less often by consulting physicians (41 respondents, 51%) and nurses (31 respondents, 39%). Forty-three percent of respondents reported that their core laboratory could decline to process blood tests if they were perceived to have been ordered too frequently, so the appropriateness of the ordering could be assessed by the clinical team. Among these sites, 82% of respondents believe that blood tests are "rarely" declined, and only 13% stated that they are "sometimes" declined.

Fifty-one percent of respondents reported having daily goal-oriented checklists for their patients that are addressed during ICU rounds, 71% of which included re-evaluation of routine blood test ordering and frequency. When asked about blood conservation strategies such as pediatric test tubes or blood conservation devices to minimize discarded blood, 30% of respondents answered that they were used in only select populations (such as Jehovah's Witnesses); 19% were unaware about their use (Fig. 3). Almost half of the respondents (45%) used point-of-care testing in their

Table Respondent demographics

Characteristic	Responses
Number of respondents, *N*	80
Years experience, mean (SD)	12 (9)
Urban, *n*/total *N* (%)	65/80 (84%)
Teaching hospital, *n*/total *N* (%)	47/80 (61%)
Number of beds in ICU, mean (SD)	14 (6)
Closed ICU, *n*/total *N* (%)	73/80 (95%)
Respondents from British Columbia, *n*/total *N* (%)	4/80 (5%)
Respondents from Alberta, *n*/total *N* (%)	8/80 (10%)
Respondents from Saskatchewan, *n*/total *N* (%)	1/80 (1%)
Respondents from Manitoba, *n*/total *N* (%)	3 /80 (4%)
Respondents from Ontario, *n*/total *N* (%)	40/80 (50%)
Respondents from Quebec, *n*/total *N* (%)	10/80 (13%)
Respondents from Newfoundland and Labrador, *n*/total *N* (%)	4/80 (5%)
Respondents from Nova Scotia, *n*/total *N* (%)	10/80 (13%)

*Zero responses were received from New Brunswick, Prince Edward Island, Yukon Territory, and Northwest Territories

ICU = intensive care unit; SD = standard deviation

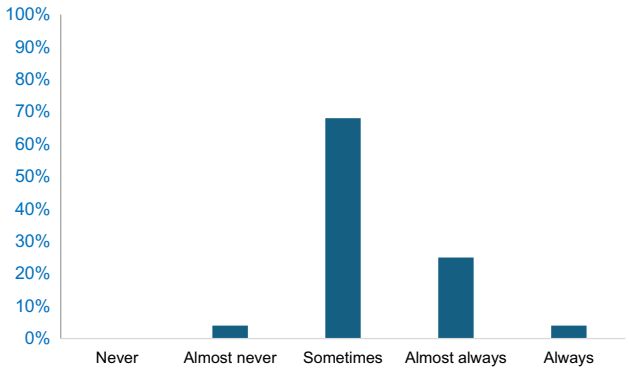

Fig. 1 Opinions on frequency of ordering unnecessary blood tests in the intensive care unit

ICU; of these respondents, 38% believed that point-of-care testing "slightly decreases" the frequency of blood testing and 50% answered that it has no impact on testing (Fig. 4).

Discussion

In this nationwide cross-sectional survey of Canadian adult intensivists to examine blood test ordering practices in adult critical care, we found that that over 80% of respondents believed that blood tests are at least "sometimes" or "almost always" ordered unnecessarily in the ICU. At the same time, over half of the respondents believed that certain tests (i.e., CBC, electrolytes, and serum renal studies) should be ordered in advance daily, while this would not be necessary for other tests, including liver function tests, lactate, and blood gases. Our survey respondents perceived that ICU blood test ordering practices are primarily driven by physician preferences, institutional practice patterns, and preprinted order sets.

These findings are consistent with a Canadian single-centre observational study in which adult intensivists described that 49% of blood tests drawn in the ICU were considered nonessential.[12] Participants in this study also believed that over the course of 81 patient-days, at least one nonessential blood test was ordered on 80% of these days.[12] A single-centre study of patients admitted under a general internal medicine service in the USA found that only 0.6% of the results of routine complete blood counts led to changes in patient management.[14]

Reducing blood test ordering in ICUs can likely be done safely without important compromises to patient care. A 2013 health technology assessment by the Canadian Agency for Drugs and Technologies in Health examined both the clinical and cost effectiveness of daily blood testing in ICUs. Investigators analyzed five nonrandomized studies and one economic evaluation from the UK, concluding that implementing interventions to reduce blood tests in ICUs could reduce costs without compromising patient safety.[15] The economic evaluation showed that the introduction of a blood investigation order set, for completion by the attending physician to specify blood tests for the next day, reduced blood tests orders by 33%, saving GBP 18,000 per year.[16] Kumwilaisak *et al.*'s prospective study examined blood test ordering practices after the implementation of guidelines that mandated written orders for daily labs, and found a 37% reduction in the number of tests ordered with no change in the rate of complications.[9]

Similar results are reported by quality improvement studies. Delgado-Corcoran *et al.*'s study in pediatric cardiac surgery patients showed that the introduction of a practice change limiting standing blood test orders, requiring individualized ordering, led to a significant reduction in the number of blood tests per patient, decreased hospital length of stay, and 32% cost reduction.[17] Martínez-Balzano *et al.* reported that the use of an arterial blood gas ordering guideline reduced testing by 41.5% and saved more than USD 39,000 over one year.[18]

Excess blood drawing, a direct consequence of over-testing, is also associated with patient harm. Bodley *et al.*'s retrospective study of 428 adult ICU admissions at a single tertiary care centre reported that an average phlebotomy volume per patient day of 48 mL, 15 mL of which was discarded.[19] Multivariate regression showed statistically

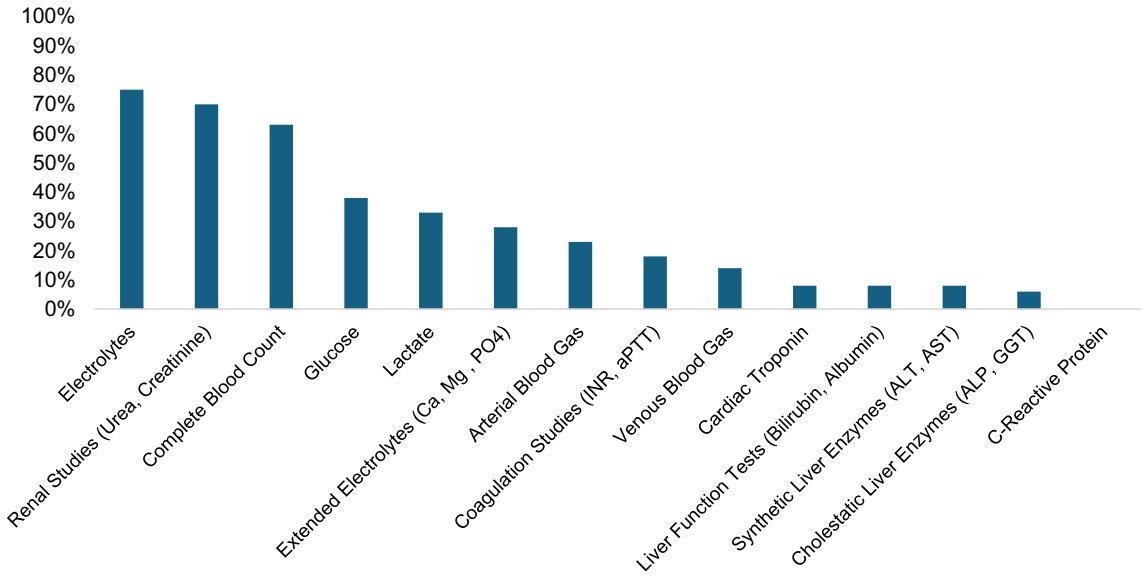

Fig. 2 Opinions on blood tests that should be ordered daily

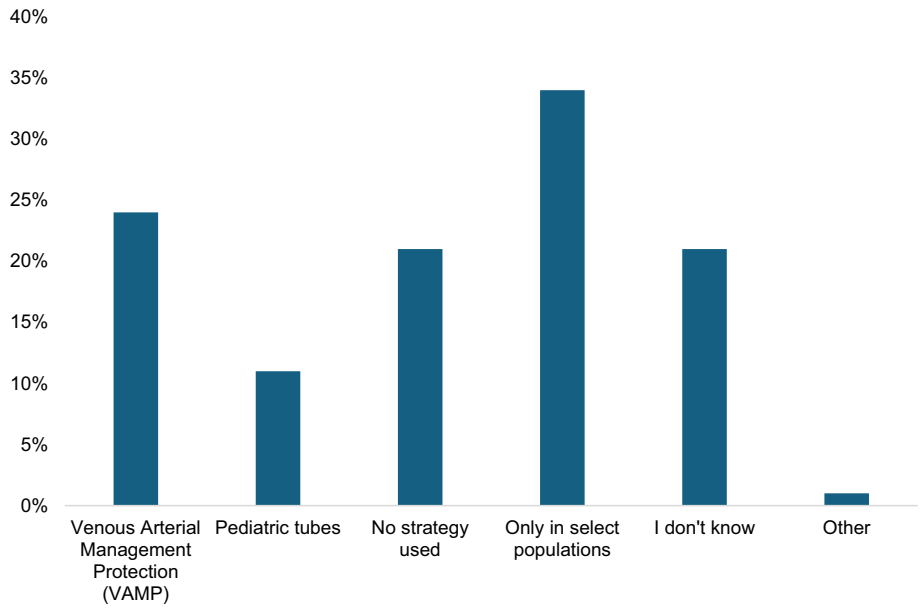

Fig. 3 The reported use of blood conservation strategies among intensive care units represented

significant associations between total daily phlebotomy volume and hemoglobin under 80 $g{\cdot}L^{-1}$ (odds ratio [OR], 1.03; 95% confidence interval [CI], 1.10 to 1.06), red blood cell (RBC) transfusion (OR, 1.03; 95% CI, 1.01 to 1.05), and inpatient mortality (OR, 1.02; 95% CI, 1.01 to 1.04).[19] These findings are consistent with a prospective study in pediatric ICUs, which showed a mean blood volume sample of 3.9 $mL{\cdot}kg^{-1}$ per stay, 26% of which was discarded.[20] Volume of blood sampled was significantly associated with anemia at discharge.[20] Bateman *et al.*'s prospective study following patients six months after adult ICU discharge found that anemia (defined as hemoglobin under 100 $g{\cdot}L^{-1}$) was associated with inappropriately low erythropoietin, elevated inflammatory biomarkers, and suppressed reticulocytosis.[21]

In 2022, a scoping review showed that the implementation of smaller volume blood tubes, blood conservation devices, point-of-care testing, and protocolized ordering bundles with staff education was associated with a significant reduction in blood loss and transfusions in hospitalized adult patients.[22] Siegal *et al.*'s stepped-wedge cluster randomized controlled trial found

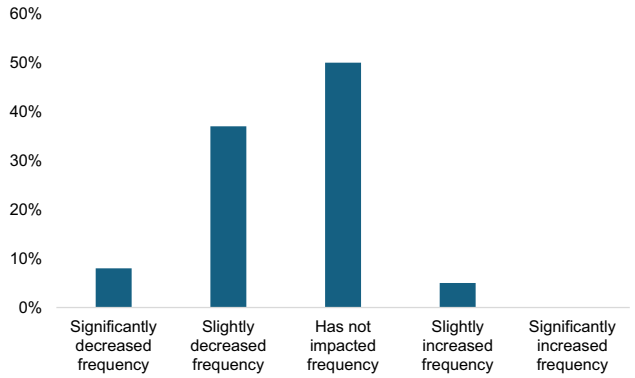

Fig. 4 The perceived impact of point-of-care testing on the frequency of blood test ordering in the intensive care unit

that transition from standard-volume to small-volume collection tubes was associated with decreased RBC transfusions, with an absolute reduction of 9.84 RBC units per 100 patients per ICU stay.[23] This trial shows the potential benefit of reducing phlebotomy volume while maintaining clinically necessary testing.

Our findings suggest that, despite the extensive body of literature and Choosing Wisely recommendations, adult ICU blood test ordering practices in Canada are primarily driven by the practice pattern of the ordering physician and institutional culture. To effectively reshape clinical practice, and ultimately reduce blood test ordering in adult ICUs, it is important to implement strategies to reduce testing at an institutional level. These strategies could include: more judicious options on preprinted order sets, targeted nursing and physician education around the futility of most scheduled blood testing, the use of daily goal-oriented checklists that include reassessment of blood test frequency, and the use of blood conservation such as pediatric test tubes or devices to minimize discarded blood.

Our study has some limitations. Although the response rate was higher than those in most electronic surveys, it was lower than expected, which prevented us from adequately assessing subgroup responses. We relied on personal networks and local health network leads to generate our samples, as there is no centralized mailing list for Canadian intensivists. As a result, some provinces are underrepresented in our results, and we cannot rule out sampling bias. Furthermore, testing institutional culture may have influenced respondents, as the perception of over-testing would likely differ based on the level of emphasis placed on this by the centre the respondent practices at. Regarding our sampling strategy, we aimed to obtain responses from at least one intensivist per centre to ensure a representative sample of Canadian ICUs. Nevertheless, by using this approach, we missed the opportunity of obtaining input from a larger number of intensivists. In addition, as the objective of the survey was to assess physicians' blood test ordering practices, we did not collect data on the important perspectives of nurses, advance care practitioners, and trainees. We plan to focus on these respondents in a future study.

The strengths of our study include a comprehensive approach to domain and item generation with the input of content experts as part of our research team from across Canada. We tested our survey extensively and modified it based on the feedback received. We had a systematic plan for sampling and our approach of eliciting one response from each level 3 ICU across Canada helped to ensure a representative sample with a clear denominator. The findings of this survey and the results of a local audit of current practice will be used to inform the development of a multi-faceted intervention aimed at reducing unnecessary blood testing in Canadian adult ICUs.

Conclusion

Canadian intensivists report that unnecessary blood testing occurs commonly in ICUs. Our survey identified a number of targets for behaviour change and potential strategies to address this problem. Advanced daily test ordering could be a first target, as it would help to eliminate ordering of tests whose results are less likely to influence patient care.

Author contributions *Omair Rahman* and *Bram Rochwerg* contributed to all aspects of this manuscript including survey conception and design; data acquisition, analysis, and interpretation; and drafting the manuscript. *Emannuel Charbonney* contributed to the conception and design of the survey, the translation of the survey into French, and in manuscript development. Ryan Vaisler contributed to data acquisition and the nationwide outreach to recruit potential respondents to complete our survey. *Abubaker Khalifa* contributed to the survey conception and design, as well as manuscript development. *Kiera Gossack-Keenan* contributed to the survey conception and design. *Waleed Alhazzani*, *Allan Garland*, *Timothy Karachi*, *Erick Duan*, *Sean M. Bagshaw*, *Maureen Meade*, *Chris Hillis*, *Peter Kavsak*, *Karen Born*, *Lawrence Mbuagbaw*, *Deborah Siegal*, *Tina Millen*, *Damon Scales*, *Andre Amaral*, *Shane English*, *Victoria A. McCredie*, *Peter Dodek*, and *Deborah J. Cook* all provided constructive feedback to the initial survey, and contributed to manuscript development

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