The Role of Medical Laboratory Professionals in Laboratory Stewardship

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Public Health

School of Public Health
University of Alberta

Abstract

With thousands of available laboratory tests and countless patient variables, clinical decision-making is highly complex. It occurs against a backdrop of time pressures, disjointed communication structures, and a culture that emphasizes certainty. Both over- and under-utilization of laboratory tests occur at unacceptably high rates. Despite considerable research into characterizing misutilization and understanding contributing factors, it remains an issue. There is a progressive trend of involving laboratory medicine professionals in ensuring appropriate ordering and management of laboratory tests. As this perspective becomes more sophisticated, it is increasingly aligned with the concept of stewardship. Stewardship calls for a wholistic, multidisciplinary approach to responsible resource use with an emphasis on securing value for efforts, and has led to new roles, and new challenges, for many healthcare professionals. Stewardship is a relatively recent concept within healthcare, and it is still being defined and integrated.

Behind the scenes in healthcare, there are many professionals that generate and validate the information that is used to make clinical decisions. Medical Laboratory Professionals (MLPs), a term primarily inclusive of Medical Laboratory Technologists (MLTs) and Assistants (MLAs), are a skilled population that collects, processes, and tests biological specimens. MLTs also ensure result quality and communication to the ordering provider. The research presented in this thesis focuses on MLPs. Currently, little is known about how MLPs contribute to existing utilization issues in laboratory testing, or how they impact patient and resource waste in their routine practices. It is also difficult to articulate tangible and practical ways that MLPs can contribute to stewardship interventions and activities, as this deviates from how their work has been historically viewed through the lens of preventing errors and maximizing efficiency. This

understanding is vital in highlighting their importance as stakeholders in laboratory stewardship. However, even if new roles and their explicit inclusion in stewardship activities can be justified, the barriers they face may be substantial as they have little visibility and authority outside of the laboratory.

We used a modified Delphi process with a panel of MLPs to identify common practices that contribute to harm and waste. A scoping review expanded on this work to discover what has been published about the impact of MLP practices on inappropriate laboratory utilization, and the roles they can play in stewardship interventions. We administered a Canada-wide cross-sectional survey to assess knowledge, attitudes, and barriers experienced by MLPs as they considered active participation in laboratory stewardship. We used the Theoretical Domains Framework and the Behaviour Change Wheel to characterize survey findings and suggest tailored interventions, respectively. We also asked MLPs about their observations about inappropriate laboratory test ordering to highlight this unexplored perspective.

This research shows that MLPs impact laboratory utilization in both direct and indirect ways during their routine activities, but many practices are absent from published research. Globally, there are staff shortages and burnout, and correspondingly, available research tends to focus on recruitment and retention. This reveals the historical view of the laboratory as a factory of inputs and outputs, with replaceable workers. However, our research shows that these skilled professionals are dedicated to patient care and wise resource use, can offer unique and valuable insights, and want to contribute in meaningful ways to stewardship. Unfortunately, they face environmental, cultural, and social barriers. A shift to laboratory stewardship may bring new roles and new opportunities to MLPs but it must be proactively and intentionally inclusive of all professionals who work in the laboratory.

Preface

Most of the research for this thesis was generated during a research collaboration between personnel in the Canadian Society for Medical Laboratory Science (CSMLS) and the Medical Laboratory Science program at the University of Alberta. This collaboration was initiated by the CSMLS, and I then led the project conceptualization, methodology, investigation, and analysis. I composed all manuscripts, though all co-authors provided feedback and approved final copies.

An earlier version of Chapter 2 has been published as original research in the American Journal of Clinical Pathology. I was responsible for study design, method development, analysis, and writing. Co-authors Villatoro and Zychla contributed primarily as co-leaders of the expert panel and helped facilitate initial item generation and make key decisions during the Delphi process. These two authors, along with Wang, aided in the scoping review portion of the process. Co-authors Turley, Yuan, and Ohinmaa form my PhD supervisory team, and provided feedback and insight at all stages.

Chapter 3 has not been submitted for publication. I was responsible for all steps of the scoping view. Co-author Wang contributed to search term development as well as abstract and full-text screening in the initial database searches starting in January 2020. Co-authors Turley, Yuan, and Ohinmaa form my PhD supervisory team, and provided feedback and insight at all stages.

An earlier version of Chapter 4 has been published as original research in the Journal of Applied Laboratory Medicine. I was responsible for study design, survey development, analysis, and writing. Co-author Zychla facilitated the technical aspects of survey development and deployment, including translation to French. She also participated as part of the coding team for the open-ended responses and theme generation. Co-author Villatoro primarily contributed to analysis and discussion of themes. Co-authors Turley, Yuan, and Ohinmaa form my PhD supervisory team, and provided feedback and insight at all stages.

Chapter 5 has not been submitted for publication. I was responsible for study design, survey development, analysis, and writing. Co-author Zychla facilitated the technical aspects of survey development and deployment, including translation to French. She also participated as part of the coding team for the open-ended responses and theme generation. Co-authors Turley, Yuan, and Ohinmaa form my PhD supervisory team, and provided feedback and insight at all stages.

Chapter 6 is currently submitted (March 2022) for publication as original research. I was responsible for study design, survey development, analysis, and writing. Co-author Zychla facilitated the technical aspects of survey development and deployment, including translation to French. She also participated in coding the open-ended responses and theme generation. Co-author Villatoro primarily contributed to analysis and discussion of themes. Co-authors Turley, Yuan, and Ohinmaa form my PhD supervisory team, and provided feedback and insight at all stages.

Dedication

For Punchy, Missy, Hot Pink, Bananas, Chuckie, Noodsie, & Jimbo

You remind me of what is important

Acknowledgments

This work would not have been possible without input and support. First, I must acknowledge the Canadian Society of Medical Laboratory Science (CSMLS), a remarkable organization staffed by individuals who are passionate about the potential of medical laboratory professionals (MLPs) to contribute positively to laboratory stewardship. They touched many areas of this research, such as survey translation and dissemination and recruitment of the Expert Panel, but have also been key in raising awareness of this research, and the issue of inappropriate laboratory utilization, through social media, webinars, and articles in their print journal. I commend their work building Lab Wisely and their interest in incorporating findings from this research into building tools and resources. I would like to specifically mention Laura Zychla, CSMLS Researcher, and Christine Nielson, CSMLS Chief Executive Officer. They are both forces of nature with can-do attitudes, and working with them allowed ideas to enlarge, and possibilities to open. It is also important to acknowledge the Expert Panel of CSMLS volunteers, who dove deep to reframe MLP practices in the context of laboratory stewardship to help generate ideas for the Choosing Wisely Canada list.

I am fortunate to have MLP colleagues who I can count on for guidance and insight. Rhonda (Diva) Pouliot has been a valued sounding-board for many years, and her thoughtful questions at key stages helped me think more deeply about this work. Valentin (Tino) Villatoro was vital to both the breadth and the depth of this project. He has endless faith in the potential of MLPs, and his enthusiasm and willingness to explore any angle of this potential enriched every discussion. This project also provided opportunity for me to work with younger MLPs, such as Yutian Wang, who helped with the scoping reviews initially as part of her undergraduate research experience, but later from the fresh perspective of a new graduate who wants to see her field grow and evolve.

Finally, I must acknowledge the contributions of my doctoral supervisory committee members. They were responsive, supportive, and focused on my growth. Elona Turley provided valuable clinical insight, and pushed me to explore and emphasize practical value. As a hematopathologist, she let me know how this research changed the way she thinks about MLPs, which is generous and motivating. Arto Ohinmaa consistently encouraged me to focus on the scholarly contribution and value of this work and to think critically about how it is situated within the broader field. And finally, there is Yan Yuan. She asks great questions that helped me become a better communicator, but also challenged me to consider the intricacies of my work more fully. I was her first PhD student, and I hope I made her proud.

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Chapter 1: Introduction

Issues With Medical Laboratory Utilization

There are many types of medical laboratory professionals who work together in a dynamic environment to deliver high quality services. Medical laboratory testing is the highest volume activity in the healthcare system, with approximately 1.2 million tests performed daily in Canada.[1] In the laboratory, biological specimens are tested according to requests received by various healthcare professionals. Test results can inform decisions about diagnoses, prognoses, treatments, risk stratification, and disease progression.[2] The primary ordering provider is the physician, but other healthcare professionals have ordering privileges in certain settings, such as pharmacists, nurses, and nurse practitioners. However, a significant, longstanding problem is inappropriate laboratory testing. The estimated extent of inappropriate testing varies widely depending on the setting and the analyte, ranging from 5-95%.[3] In Canada, the overall rate of inappropriate testing is estimated to be between 20-30%.[4] There are many contributing factors, such as habituated ordering patterns, communication issues, and disjointed ordering mechanisms.[5] Historically, there has been little ability to limit or modify these orders by professionals within the medical laboratory. In addition, the guidelines supporting appropriate testing approaches in a variety of clinical scenarios is inconsistently applied or unavailable.[4] Gaps remain in understanding best ordering practices for many available tests. Where these gaps have been closed or narrowed, uptake of changed practices has been slow.[6] Because the overall issue of inappropriate testing is so complex, it is challenging to address.

Inappropriate testing is when the test result does not contribute to informing accurate diagnostic, prognostic, or treatment decisions. Inappropriate testing can also occur when an appropriate test is not ordered at the correct time; in other words, when tests are under-utilized.[7] Inappropriate testing is part of a broader issue of inappropriate laboratory utilization, which considers all unnecessary actions and the waste of resources. Taking an even broader lens situates this issue within inappropriate utilization of healthcare resources, where much research has been performed to understand the phenomenon of ‘too much medicine’, or the widespread practice of unnecessary tests, processes, and procedures, such as prescriptions, diagnostic imaging, and surgeries.[8] Considerable research is underway to understand and quantify consequences, such as patient harm and resource waste.

The harms from inappropriate laboratory testing are difficult to elucidate, because any one test is usually part of a larger clinical pathway, multiple tests are often ordered simultaneously and repeatedly, and many relevant outcomes do not occur in the short term. It is also difficult to measure outcomes of when appropriate tests are not ordered.[7] However, false results are more frequent when the ordered tests are not clinically indicated. The sensitivity and specificity of any given laboratory test is rarely 100%, thus the possibility of a false result is almost always present, and is impacted by pre-test probabilities that determine predictive values.[2] Direct patient harm can result from the psychological impact of false results.[9] Harm can also result if these misleading test results lead to costly or invasive follow-up investigations.[10] Harm on the healthcare system occurs when clinician effort, money, and resources are wasted pursuing false or meaningless results.[4]

When considering harms, it is important to note that obtaining biological samples is not a risk-free event, and physical harm can come to both the professional obtaining blood and the patient themselves. Needlestick injuries during the venipuncture process can expose healthcare workers to infectious diseases.[11] Anemia in hospitalized patients is a common development, and it is associated with worsened outcomes.[12] A large retrospective cohort study found that the number of phlebotomy events was closely correlated to a drop in hemoglobin level.[13] Maqueda-Palau and Perez-Juan [14] demonstrated that 40% of blood taken is wasted, and there is a drop in hemoglobin within 24 hours of being admitted to intensive care units (ICU). Bodley *et al* [15] found that blood loss from daily phlebotomy was an independent predictor of the need for blood transfusion due to anemia in the ICU. However, the relationship between diagnostic blood loss, anemia, and worsened outcomes is confounded by the relationship between disease severity and the number and frequency of tests ordered, which are often higher when a patient is more ill.[16] While research into this phenomenon is ongoing, it is clear that harm can come from both acquiring a biological sample as well as the way the result is perceived and handled.

Increasing Involvement of Professionals Who Work in the Medical Laboratory

In response to the recognition of waste and harm resulting from overuse of tests and procedures in healthcare, formal organizations and initiatives have been developed. An important example is Choosing Wisely, which started in 2012 in the United States and has sister organizations in multiple countries, including in Canada since 2014.[17] Choosing Wisely

Canada publishes lists of low value tests and procedures, and creates tools and resources to reduce unnecessary activities, such as organizing campaigns and developing toolkits.[18] While Choosing Wisely began as a physician-centric organization with recommendations generated only by physician societies, they are increasingly publishing recommendations from other healthcare professional societies, such as nursing, physiotherapy, and radiation technology. This mirrors an overall trend in healthcare of increased collaborative team-based healthcare and use of advanced practice clinicians, such as nurse practitioners and physician assistants.[19]

In addition to clinically-oriented organizations, interventional research addressing inappropriate laboratory utilization has been conducted for several years. Systematic reviews are starting to characterize what makes approaches effective. Interventions tend to target the ordering clinician. However, person-oriented interventions are generally less effective than administrative design-oriented interventions.[4,20] Educational approaches, or displaying cost or peer performance information shows some effectiveness in short-term testing reductions, but long term impact is rarely demonstrated.[21,22] Colla *et al* [23] found that while clinicians want to deliver cost-conscious, safe care, approximately one-third felt too busy to think about costs, and less than half understand the impact of testing on resource use. A recent study showed that less than half of the time, internal medicine physicians feel able to take cost or patient comfort into consideration when ordering tests.[15] Another study demonstrated that family physicians view laboratory tests as relatively trivial in the context of existing heavy workloads and cognitive demands.[24] Lack of time, workflow challenges, and a massive number of test choices places limits on individual well-intentioned clinicians to make correct ordering decisions.[25] In an era of heightened focus on overutilization and resource waste, this suggest that past efforts to target the ordering clinician in interventions are too narrowly focused.

Overall, there is a trend of increasing laboratory oversight in test utilization management.[26] Progress is slow in part because of decades of financial and system incentive to focus on cost and operational efficiencies rather than patient and system outcomes.[27] Many laboratories still do not measure patient outcomes as part of their routine quality assurance management activities.[28] Progress is also hampered because of lack of communication structures and mechanisms for integrating laboratory expertise.[29] Other healthcare professionals have a poor understanding of laboratory processes and contributions.[30] Laboratory medicine professionals have been trying to take larger roles in educating and

consulting with ordering practitioners[31], advocating for membership on diagnostic management teams[32], and promoting active participation in collaboratively preparing evidence-based clinical practice guidelines.[33,34]

Ultimately, laboratory testing is complex, and typical formularies are vast. The number of unique tests to order is well over 4,000, and continues to grow.[35] This is a staggering amount of potential information for an individual ordering provider to manage and integrate into clinical decision-making. In addition, obsolete tests may also remain on the testing menu due to poor institutional delisting processes.[36] With every test, performance characteristics and biological variation can impact result interpretation, but these metrics are often poorly understood by end-users.[37] Laboratory professionals have recognized that these complexities can contribute to inappropriate testing. The increasing use of tools like clinical commenting and decision aids tied to laboratory test results has helped to highlight the expertise held within the medical laboratory, and improved receptiveness to laboratory professionals playing key roles in improving test utilization.

A Closer Look at Professionals within the Medical Laboratory

There are many types of professionals working in the medical laboratory. The most responsible professional is the laboratory-based physician, or pathologist. Pathologists have specialised in the laboratory investigation into manifestations and diagnosis of disease.[38] They hold expertise in the selection and interpretation of laboratory tests, and can apply this to treatment and diagnostic decisions. There are several sub-specialties, including but not limited to anatomical pathology, biochemistry, hematology, and transfusion medicine. Pathologists serve as medical directors, and occasionally administrative directors, of clinical laboratories. There are also laboratory professionals who are PhD-level scientists with specialized post-doctoral training. Their title tends to reflect their specialization; for example, a Clinical Biochemist has post-doctoral training and certification in clinical biochemistry, which is one of the disciplines within the clinical laboratory.[39] These scientists also contribute to interpretation and selection of laboratory tests, and play leadership roles in quality management systems over the entire testing pathway. They have oversight for various testing programs and evaluating new testing methods. Pathologists and PhD laboratory scientists generally have the most authority within the

clinical laboratory. However, in smaller settings, such as in rural hospitals, they might not have any significant on-site presence.

The 'total testing process' describes all steps of the testing cycle starting at the decision about which test to order, and ending with the clinical action taken with the laboratory test result.[40] This is represented in **Figure 1.1**.

Figure 1.1: The Total Testing Process

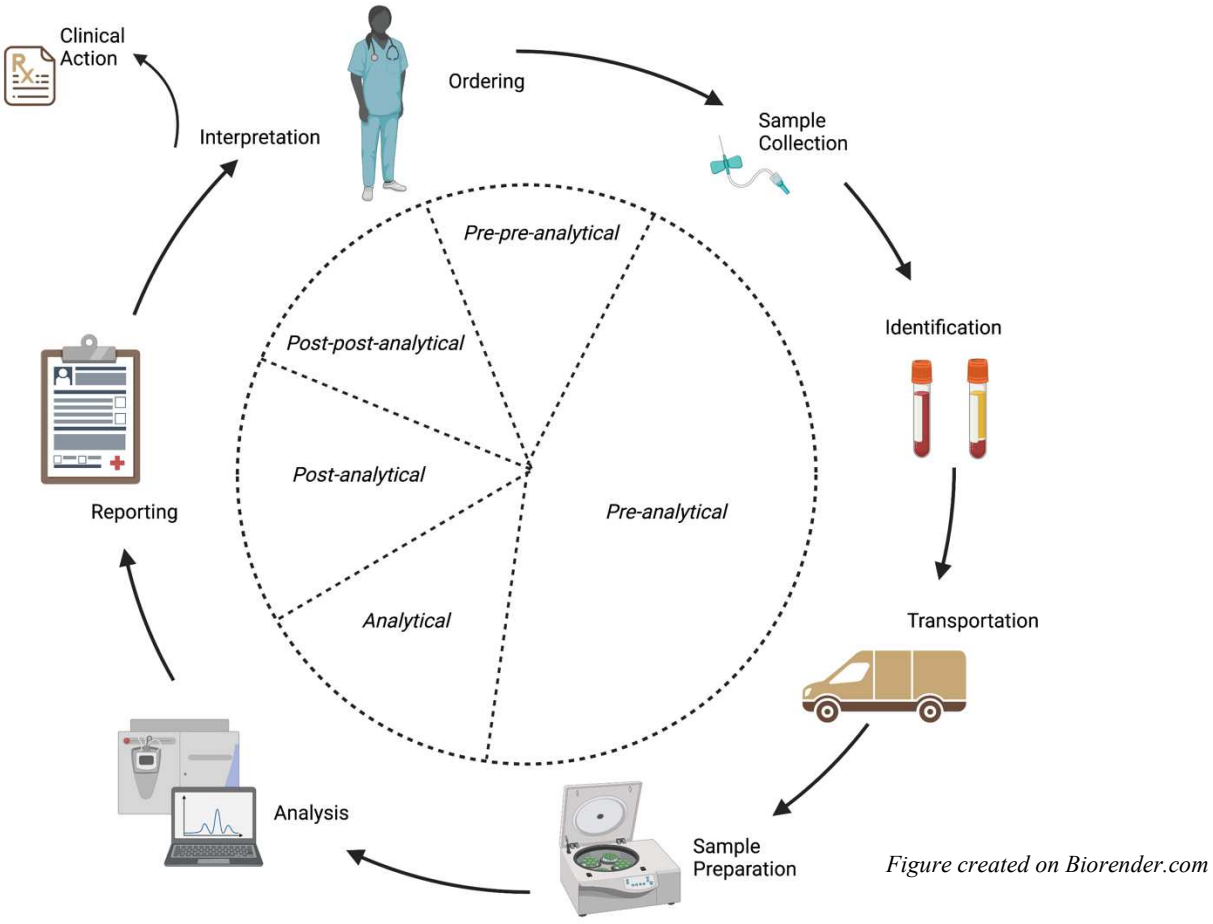

Figure created on Biorender.com

The professionals responsible for specimen procurement, preparation, and testing are called scientists, technologists, technicians, or assistants. In Canada, these are primarily Medical Laboratory Technologists (MLTs) and Medical Laboratory Assistants (MLAs). There is some overlap in scope of practice, but also some key differences. The MLT scope of practice is the collection and testing of biological specimens, while employing and interpreting appropriate quality assurance measures.[41] MLTs are also responsible for the communication of test results. Routine MLT activities are described as pre-analytical, analytical, and post-analytical.

Conversely, MLAs are primarily involved with pre-analytical activities, such as phlebotomy, specimen receipt, and specimen preparation for testing. MLTs may hold leadership positions within the clinical laboratory, such as supervisors, managers, or directors. They often have oversight for MLA activities. Reflecting the differences in responsibilities and complexity of duties, educational and training requirements differ. MLTs require either a diploma or degree from an accredited educational institution, and must pass a certification exam with the Canadian Society for Medical Laboratory Science (CSMLS).[42] The shortest MLT program in Canada is 25 months. MLA training varies considerably, measured in a few months or weeks. While the CSMLS offers a certification exam for MLAs, it is currently not required for practice in any jurisdiction in Canada. Another important difference is that MLTs are regulated professionals and require a license to practice, whereas MLAs are currently unregulated across Canada.[43] For the purposes of this thesis, MLTs and MLAs will collectively be referred to as Medical Laboratory Professionals (MLPs). Pathologists and PhD-trained clinical scientists will be excluded from this definition.

All the professionals in the medical laboratory work together to deliver high quality services, but they suffer from low recognition from both the public and other healthcare workers.[30,44] This is particularly true of MLPs as they have less visibility, authority, and interaction with broader clinical teams compared to pathologists and PhD-trained clinical scientists. Laboratory work is complex and dynamic, demanding a great deal of intuition and skill to manage the integrity of testing data but also to anticipate and control problems.[45,46] The nature of this work is affected tremendously by technological developments that change not only how work is performed, but how it is shared and communicated. MLPs tend to downplay their roles[47], referring to themselves as “button-pushers”.[48] Highly quantifiable activities have left the laboratory prone to sweeping structural changes made in response to budget restrictions. The impact of these factors on MLPs is under-researched, but available work reveals feelings of burnout, dissatisfaction, disempowerment, and lowered career commitment.[49-51] The devastating impact of mid-1990s major restructuring in Alberta on the laboratory workforce was chronologically detailed by Pat Lentedre, former MLT educator, on her website.[52] In many jurisdictions both in Canada and across the globe, there are already significant human workforce shortages.[28,53] For example, in 2021, 97% of Ontario laboratories were short-staffed.[54] In other research, MLPs feel as though their activities are underappreciated by other

healthcare professionals, and their available career paths are limited.[55] However, MLPs experience higher career satisfaction when they are included on interprofessional teams and have the opportunity for challenging work.[56] The rise of laboratory stewardship may provide opportunities for MLPs to become more empowered, integrated, and visible within healthcare, and enhance the value this dedicated professional group offers. Their explicit inclusion into stewardship activities may improve the quality of these activities as well. There are gaps in our understanding of what their roles and contributions could be.

From Utilization Management to Laboratory Stewardship

Stewardship is becoming a common term in healthcare settings since it was first described in the 2000 World Health Report as one of the four pillars of a healthcare system.[57] Around the same time, harms related to the errors in medicine and the diagnostic process were coming to light.[58] Part of this harm is caused by inappropriate use of tests, procedures, and treatments. Since then, stewardship has increasingly been used to label approaches that aim to use finite resources sustainably and appropriately while maximizing value in all outcomes. The most well-known are antimicrobial stewardship programs, which seek to reduce antimicrobial resistance. Likewise, opioid stewardship programs and antithrombotic stewardship programs aim to reduce inappropriate use by improving prescribing, testing, monitoring, and discontinuing these drugs. Antimicrobial stewardship programs have been shown to improve patient outcomes and reduce costs.[59] Published literature about antimicrobial stewardship has increased exponentially since approximately 2012.[60] The concept of clinical laboratory stewardship is more recent. Laboratory stewardship aims to ensure that the correct test is performed at the correct time, while avoiding unnecessary tests[61], and is predicted to reduce both under- and over- diagnosis and overspending.[62,63]

Efforts to address the problem of inappropriate laboratory utilization initially fell under the umbrella of demand or utilization management. However, this is shifting, as this frame was too limiting and overly focused on internal laboratory activities. The preferred term is now ‘laboratory stewardship’. Meier and Badrick [64] contend that being more active in laboratory stewardship is important for demonstrating the true value of the clinical laboratory. There are increasing calls for the laboratory to establish its value and importance in an integrated quality patient-care delivery system, rather than to be seen as a relatively isolated factory-like service

centre and an early target for reductions when healthcare system budgets are tightened.[65] Laboratory stewardship activities extend beyond traditional internal activities into how the laboratory can impact test ordering as well as result interpretation [65] – the pre-pre- and post-post- analytical realms illustrated in **Figure 1.1**. Actions are more supportive, rather than punitive, to enable responsible resource use. For example, enabling institutional and regional teams and networks to support benchmarking, communication, data analysis, and the development of quality indicators.[60] Laboratory quality has historically been equated with analytical quality. However, with the fewest errors in laboratory medicine occurring in the analytical phase, and the most occurring before and after, the biggest gains to improving patient care and safety will come with a stewardship approach.[65]

With the rise in application of stewardship to healthcare, it is important to consider how it is integrated into existing structures. One area of concern is whether there is a shared understanding of how stewardship is defined. Without this, it may be difficult for those tasked with stewardship to understand their roles or how to effectively contribute.[60] With respect to the recency of the concept of clinical laboratory stewardship, the laboratory's role in antimicrobial stewardship programs could offer instructive starting points. Several factors related to the issue of antimicrobial resistance and the emergence of 'superbugs' can be directly linked to the clinical laboratory. For example, poorly collected specimens or confusing, mistimed reporting can contribute to suboptimal antimicrobial usage. Laboratory professionals can play an active role into providing guidance about specimen collection requirements, or improving report format to highlight clinically relevant details.[66] Morency-Potvin *et al* [66] argue that professionals within the microbiology laboratory should be part of antimicrobial stewardship leadership, and by doing so would amplify the relevance of the laboratory in the eyes of other healthcare professionals.

Antimicrobial stewardship development and progress can also be instructive from another perspective: the efforts to involve all stakeholders, particularly the diversity of health professionals. Historically, healthcare was, and still to a lesser extent is, hierarchically structured and siloed. This has been a significant barrier to interprofessional collaboration.[67] Participation in antimicrobial stewardship has empowered healthcare professionals with new or expanded roles and responsibilities. For example, pharmacists [68], nurses [69], and laboratory professionals [66] can have enhanced or new key roles. These new roles may improve

confidence and can lead to improved patient outcomes.[70] However, there are challenges. A clear, practical understanding of what being a steward means is needed but is often lacking.[70] A recent qualitative study about nursing roles in antimicrobial stewardship identified barriers related to interprofessional collaboration and integrating nursing expertise into stewardship programs.[71] They identified that lack of stewardship education has a negative impact, as does lack of clarity of roles, and social dynamics that defer to physician expertise and the desire to avoid appearing like their decisions are being questioned. They also observed nurses pushing back on stewardship activities because they were seen as extra work (burden) rather than part of the workload. Consensus activities to define competencies in stewardship in educational programs demonstrate that accountability and understanding roles of self and others is important.[72] Recent research in antimicrobial stewardship focuses on attitudes toward their roles as stewards.[73] Given the recency of laboratory stewardship, little research has been conducted into stewardship roles of the various healthcare professionals involved, particularly MLPs.

Research Overview and Significance

The relationship of MLPs to inappropriate laboratory utilization is unknown. We do not know about MLP awareness levels, their beliefs and attitudes, their desire to be involved, or how they currently contribute to the issue. This research focuses on MLPs and their roles within laboratory stewardship, seeking to identify and define what these roles are and could be, as well as the opportunities and challenges to their integration in stewardship programs and activities. We worked closely with the CSMLS as one of their goals is to enhance the participation of MLPs in activities that improve the appropriateness of laboratory utilization. A multi-faceted understanding of MLPs in this context is vital to developing an effective campaign to increase and support the roles of MLPs in laboratory stewardship, and provide future directions for research.

Research Questions

1. **How do MLPs contribute to resource waste and patient harm in the context of overutilization?**
2. **What roles can MLPs play to augment laboratory stewardship initiatives?**

3. **What barriers do MLPs face when accessing opportunities to contribute to laboratory stewardship activities?**

Thesis Chapter and Research Methods Overview

The first research question focuses on ways that MLPs currently contribute to resource waste and patient harm. To explore this, we convened an Expert Panel to generate ideas followed by the Delphi technique of iterative consensus-building. This approach allowed us to develop a list of profession-specific items for Choosing Wisely Canada, which is a prominent organization seeking to reduce overuse in medicine. This list consists of current top practices within the MLP scope of practice that contribute to overutilization of resources and/or patient harm. This process and findings are described in the second chapter. The third chapter is a scoping review of published evidence about MLP roles and practices in the context of inappropriate laboratory utilization. This scoping review provides insight into both the first and second research questions.

The third research question focuses on barriers that MLPs face when participating in stewardship activities. We administered a cross-sectional survey about these perceived barriers as well as knowledge and attitudes about inappropriate laboratory utilization. The fourth chapter reports on the survey responses from MLTs. The findings are mapped to the Theoretical Domains Framework (TDF), which is increasingly used in implementation science to understand behaviours across multiple contexts. Use of the TDF allows utilization of the Behaviour Change Wheel (BCW), which is a framework that can help build more effective behaviour change interventions. We present a case example how we used the BCW in an initiative called Lab Wisely in the fifth chapter.

The sixth chapter draws from the lived experience of MLPs as they describe their understanding of the primary causes of inappropriate testing. These perceptions were gleaned from qualitative analysis of an open-ended survey question. This analysis primarily informs the second and third research question, as it highlights how the observations of MLPs can strengthen and focus stewardship activities, but can also impede their efforts to become involved. The final chapter consolidates the major understandings illuminated in the previous chapters, and outlines a roadmap for future work.

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Chapter 2:A new list for Choosing Wisely Canada from the 'hidden profession' of Medical Laboratory Science

An earlier version of this manuscript is published in the American Journal of Clinical Pathology 2022;157(1):40-6

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Abstract:

Objective. Choosing Wisely Canada (CWC) publishes lists of practices that may contribute to medical overuse and patient harm. Many practices concern laboratory testing, but the recommendations are written for the test-ordering professionals. Our objective was to develop a list for CWC reflecting the non-pathologist medical laboratory professional (MLP) scope of practice.

Methods. We used a national survey, a convention session, and a panel of MLPs from across Canada to generate content for the CWC list. We used a modified Delphi process to identify the most important items and scoping reviews to gather evidence supporting each item.

Results. We identified 95 potential CWC list items. After two Delphi rounds, there was little movement in the top items. Scoping reviews revealed varying degrees of evidentiary support, which influenced the composition of the final list of seven CWC items submitted. Three of the final recommendations address ways MLPs preserve the status quo with respect to overutilization of laboratory tests by other healthcare professionals. The remaining recommendations prompt MLPs to exert clinical judgment in specific scenarios, particularly where they can impact blood collection volumes.

Conclusions. This work brings a more nuanced and comprehensive understanding of the relationships among MLPs, patient safety, and resource waste.

Introduction

The clinical laboratory is an essential healthcare service industry that delivers on physician requests for biochemical testing on blood, other body fluids, tissues, and organs. Ordering laboratory tests is a common outcome of many patient encounters with the healthcare system. Per capita, Canadians have 14-20 laboratory tests performed annually.[1] Despite this, the clinical laboratory suffers from low public recognition, particularly the technical professionals who often have limited direct patient contact.[2] Though these workers consider themselves to be key members of the healthcare team, they often feel overlooked and hidden from both the public and even other healthcare professionals.[3,4] Being characterized by highly quantifiable activities has left the clinical laboratory susceptible to budgetary cuts and restructuring efforts.[2] This has exacerbated feelings of disempowerment.[4]

Long characterized by a siloed and hierarchical environment, healthcare is moving slowly but steadily towards a more team-based approach. In response to several key issues, there is a call for greater participation of allied health professionals, such as enhancing the role of pharmacists in the opioid epidemic[5] or of nurses in antimicrobial resistance.[6] Similarly, a recent shift in the Choosing Wisely (CW) initiative is the participation of non-physician health professions societies. CW began in the United States in 2012 as a new approach to address the problem of the overuse of tests and procedures in healthcare.[7] This campaign arose as a reaction to what was viewed as heavy-handed and blame-focused measures that reduced physician autonomy and authority, appealing instead to stewardship and professionalism. CW calls on professional practise societies to each develop a list of procedures or tests that should be questioned because they contribute to resource waste and patient harm.[8] CW country-specific initiatives have been started in more than 20 countries, including Canada where it is named 'Choosing Wisely Canada' (CWC). In Canada, there are over 50 professional societies and almost 400 recommendations.[9]

An estimated 20-50% of all laboratory testing is inappropriately ordered, meaning that it is either an incorrect test, a redundant test, or a correct test ordered at the wrong time.[1] Thus, it is not surprising that over one-third of current CWC recommendations are related to clinical laboratory test ordering.[10] While other non-physician societies have generated CWC lists, such as nurses, occupational therapists, and pharmacists, there were none specifically for medical laboratory professionals (MLPs, a term encompassing medical laboratory scientists,

technologists, and assistants). There are recommendations developed for the clinical laboratory in many country-specific CW lists, but these are largely from the perspective of pathologists, who are laboratory physicians, who have more authority and a different scope of practice than MLPs. In 2018, the Canadian Society for Medical Laboratory Science (CSMLS) signed an agreement to become a campaign partner with CWC, signalling the intent of this non-physician technical profession to become a visible partner in improving the utilization of healthcare resources.

With respect to list generation by healthcare societies, CWC provides broad guidance.[11] Key requirements are that each item must be within the scope of practice of the respective society and that there must be high-quality published evidence supporting the link between the practice and patient harm and/or resource waste. The scope of practice of MLPs in Canada includes the collection and performance of ordered tests, validation and communication of test results, and management of quality assurance processes.[12] MLPs are not permitted to order laboratory tests. The historic focus on MLP activities concerning patient safety is about avoiding error.[13] Discussion about common practices that may contribute to medical overuse and patient harm has been limited. The aim of our study was to identify MLP-specific CWC list items that meet existing criteria.

Methods

A working group (herein referred to as the 'Expert Panel') of experienced MLPs from across Canada was assembled to help develop the list of CWC items. Expert Panel members were recruited via a request for volunteers to the general membership of the CSMLS. They were chosen to have a maximal representation of geography, years and variety of work experience, and professional designation. Nineteen MLPs were selected for a core Expert Panel group. All traditional disciplines of medical laboratory science (chemistry, hematology, transfusion, microbiology, and histology) were represented by at least two Expert Panel members. One new graduate was invited to join to gain committee experience. A group of five MLPs with extensive experience highly specialized areas were asked to be consultants. The full composition is in **Table 2.1**. The Panel met virtually five times between February 2019 and September 2020, and engaged in asynchronous discussion throughout this period via an online platform and group email. The process used to identify CWC items is illustrated in **Figure 2.1**.

Potential CWC list items were generated by three mechanisms. Firstly, Expert Panel members were instructed to create a list based on their experience and observations. They were also encouraged to network locally and develop ideas with their colleagues. This lasted eight weeks beginning February 2019. Secondly, we solicited ideas using an online CSMLS membership survey in March 2019. Lastly, we held a concurrent session at the June 2019 CSMLS annual convention and facilitated conversations with attendees. Each of these items was discussed extensively with the entire Expert Panel to determine adherence to CWC list parameters [11] and ensure understanding before moving to a consensus process.

We used the modified Delphi technique[14] to identify the most important practises with respect to their potential to impact patient safety and resource waste. Two rounds were needed to reach an acceptable level of consensus, which was signalled by little movement in the rankings of the highest-ranked items. An example of the Delphi form is found in **Appendix A.** The highest ranked items were subjected to scoping reviews. Key words and terms were searched in PubMed, Embase, Cochrane Database of Systematic Reviews, and Google. Two researchers (AV and YW) screened the records generated from this process, and performed a basic quality assessment of eligible full-text articles using the 2011 Levels of Evidence tool developed by the Oxford Centre for Evidence-Based Medicine.[15] Three researchers (AV, VV, LZ) analyzed the results of the scoping reviews to identify the strongest evidence but also to inform editing of the final list items.

Results

In the first Expert Panel meeting, we needed to overcome challenges to item idea generation. An early sentiment was that the only way of harming a patient within the MLP scope of practice was to commit an error that led to a false laboratory test result. Another cognitive hurdle was discussing how MLP practices might impact patients, because MLPs are not able to order tests. This leads to the assumption that issues with medical overuse originate with the health professional who submitted the order. However, to adhere to CWC guidelines[11], we needed to focus on commonly performed practices within the MLP traditional scope, or well-accepted ‘ways of doing things’ that contribute to harm and waste. The Expert Panel members initially submitted a total of 107 unique items. The range of ideas submitted by each Panel member was 2 items to 11 items. The membership survey generated 48 unique items, 41 of

which duplicated items submitted by the Expert Panel. The annual convention, held last, provided 16 ideas but all were previously identified. Through discussion with the Expert Panel, 19 items were rejected as they were unanimously declared to be out of the scope of MLP practice or unrelated to the potential for patient harm or resource waste. Ultimately, a list of 95 was approved for the first round of the Delphi process. The items involved in each round of the Delphi process are found in **Appendix B**.

In the first Delphi round, 95 potential ideas were individually ranked by Expert Panel members. When making their rankings, they were asked to consider the frequency of the practice and the relationship of the practise to waste and harm. The lowest ranked items were dropped, and 51 items were carried to a second Delphi round. For this next round, the group ranking distribution of each item was presented to each Expert Panel member along with their previous response. With this information, they ranked each potential list item again using the same scale as the first round. Subsequent analysis was performed to see if there were major changes compared to the first round. There was little movement in the highest-ranked 20 items, signalling an acceptable level of consensus on a short list.

Initial evidence searching for specific items often yielded little to no evidence. This necessitated combining concepts into a more generally worded recommendation. For example, the concept of not obtaining more blood than necessary was a unifying concept in several items, but in any one scenario described by a specific item, there was limited evidence. After the scoping reviews, we revisited the original items to edit and combine them where evidence overlapped or was insufficient. Proposed modifications were discussed extensively with the Expert Panel until a final list was agreed upon. This list was then submitted to the CSMLS Board of Directors for approval. After approval, these were submitted to CWC to undergo their review and validation process. Minor changes were requested before final approval and publication in late 2020.

We included 16 of the highest ranked items into 7 distinct recommendations that were approved for publication by CWC. The final approved list is displayed in **Table 2.2** along with items that were highly ranked but lack the robust evidence needed to publish the list with CWC.

Discussion

We successfully identified several laboratory-related practices that MLPs should be questioning because of their potential for patient harm and waste. After the idea generation period and vetting discussions, 95 initial ideas were developed, which exceeded our expectations considerably. These ideas considered both practices exclusive to MLPs and practices where MLPs can intersect with other healthcare professionals. At the conclusion of our process, we identified seven recommendations on behalf of MLPs for CWC. Our work brings a more nuanced and comprehensive understanding of the relationships among the technical workers within the clinical laboratory, patient safety, and resource waste.

The seven approved CWC recommendations can be united by three broad themes. The first three recommendations oppose practises that MLPs commonly engage in that preserve the status quo with respect to the overutilization of laboratory tests by other healthcare professionals. The next two recommendations aim to limit the development of iatrogenic anemia by reducing the amount of blood that is collected. The last two of the recommendations identify internal MLP practises that require the use of careful judgement before proceeding.

Limiting overutilization by other healthcare professionals

- ***Recommendation 1:*** *Don't support repeat test ordering (re-testing) at a frequency that is not backed by evidence.*
- ***Recommendation 2:*** *Don't support ordering system mechanisms that contribute to over-testing. Encourage the development of an evidence-based utilization management program that may include interventions such as unbundling order sets, reflex testing algorithms, and decision-support technology*
- ***Recommendation 3:*** *Don't allow standing orders for repeat testing without a stop or review date*

These three recommendations directly encourage the MLP to be more active in positively affecting the ordering patterns of other health professionals. This echoes recent suggestions that MLPs should play a larger role in improving laboratory utilization.[16] Multi-faceted interventions that employ administrative strategies such as modifications to computer-based ordering systems are shown to be more effective than those that use only a single approach.[17] MLPs may be able to influence the design and utility of these ordering systems, and provide feedback or information about changes to guidelines and testing algorithms. However, this

demands that MLPs are more formally knowledgeable about specific utilization issues, such as which tests are prone to re-testing at inappropriate intervals. This also requires awareness of local utilization issues and active local interventions. While some MLPs may already be suitably equipped in this regard, they may lack the organizational support, or be deterred by existing organizational culture to affect change. Historically, MLPs were discouraged from contributing to decisions related to laboratory testing [18-20], and this sentiment endures as an unwillingness to question orders.[2] In addition, research suggests that professional identity of MLPs is weakly defined, which is thought to hamper efforts to embrace larger role in the healthcare team.[4]

Addressing these three recommendations also requires building capacity in MLPs to communicate and network effectively within the healthcare team. In studies on physicians about seeking laboratory testing information, they did not frequently contact the laboratory, preferring instead to use other resources such as peers.[21] Other research has demonstrated that MLPs are not utilized effectively as a resource for test-related queries because this is seen as too time-consuming or confusing to navigate.[22] MLPs can serve as knowledge agents about the testing process [14,23], including how reliable the methods are [24] but need to raise their profile. This may be a significant challenge as many MLPs have limited direct contact with other healthcare professionals even when they work in a hospital. Many clinical laboratories in urban centres are free-standing testing facilities, limiting opportunities for direct interaction even further. Efforts are needed to create and sustain an effective laboratory-ordering professional interface.

Limiting the amount of blood collected

- ***Recommendation 4:*** *Don't collect more than what is needed. Use short draw tubes, consider add-on testing, and reduce or combine duplicate orders.*
- ***Recommendation 5:*** *Don't collect extra blood tubes in anticipation of test orders.*

Collecting more blood than necessary connects these recommendations. Patient outcome research is generally lacking in laboratory medicine[25], and our scoping reviews demonstrate no exception. The development of iatrogenic anemia is an adverse outcome of laboratory testing, postulated to be worsened by inappropriate laboratory utilization.[26] Both of these practices may have arisen from a sentiment that saving time leads to more clinical value than the potential harm from obtaining a sample that is ultimately unused. There is a heavy focus on turn-around-times in the clinical laboratory. The common mantra, held by both patients and

healthcare professionals, that 'faster is better' is rarely challenged. It may be worthwhile to be more judicious about the weight placed on this metric as research into evidence-based laboratory medicine grows. Unnecessarily fast turn-around-times may even exacerbate overutilization.[27] Others have warned that the laboratory must be more proactive in demonstrating its value beyond simple efficiency, otherwise it may be reduced to a factory-model list of quantifiable inputs and outputs.[25]

Increasing use of professional judgement

- ***Recommendation 6:*** *Don't routinely repeat critical results for most common analytes before reporting*

This recommendation is linked to internal quality processes within the laboratory, and likely does not require additional capacity development or extraordinary effort on behalf of MLPs. Repeating critical results may be a holdover from when the analytical ability of instrumentation was less reliable, or when more procedures were performed manually. Evidence suggests that repeating critical results is usually unnecessary and can cause delays in communicating results.[28] This practice should use professional judgement rather than being an operational rule, given the analytical accuracy achievable with modern instrumentation and availability of delta checks facilitated with increasingly sophisticated laboratory information systems.

- ***Recommendation 7:*** *Don't proceed with testing or reporting when sample quality or identification is suspect.*

This recommendation also calls for increased use of professional judgement, but in many circumstances also involves interacting with other healthcare professionals. While MLPs know that the quality of the result has a direct relationship to the quality of the original specimen, the potential of conflict or communication difficulties may derail the necessary steps to improve specimen quality. Testing poor quality specimens contributes to unnecessary repeat examinations. A complicating factor is that specimens may be collected by other healthcare professionals, or at a different location. However, the responsibility for quality management often remains with the testing laboratory. Concerted effort to ensure high sample quality through establishing and enforcing standards is important.[29] However, the soft skills and organizational will needed to enforce these standards and work to provide education, training,

and feedback on proper technique to other involved healthcare providers should not be discounted.

We were unable to find sufficient high-quality evidence against the remaining practices that were highly ranked by the Expert Panel. Evidence identified was either insufficient in amount, low quality, and/or lacking outcomes that addressed patient harm and/or resource waste. These practises can serve as topics for future research and awareness campaigns, and are bookmarked for potential inclusion into an expanded future CWC list. The highest ranked item by the Expert Panel that failed to make the final list was *"Don't absolve yourself from the responsibility of blood sample quality even when collection is performed by other professionals. Seek to provide adequate training and feedback, such as in point-of-care or the emergency department."* Point-of-care-testing (POCT) occurs outside of a centralized laboratory, often by non-laboratorians. However, the laboratory is usually responsible for testing program coordination and quality oversight. While there is increasing amounts of research elucidating various issues related to POCT[30], there is a gap in understanding the impact of the MLP role with respect to patient and resource-related outcomes. As the use of POCT continues to grow, research to fill this gap is urgently needed. This echoes calls to better understand the impact of laboratory roles that focus on adding clinical value throughout all stages of testing.[31]

The requirement by CWC that the published recommendations represent commonly performed practices may have imposed limitations that caused us to overlook discipline-specific practices as worthy considerations. For example, recommendations related to histology were unlikely because there are fewer histology laboratories in Canada. Creating discipline-specific CWC recommendations may be needed in the future.

Wording the recommendations more generally was a trade-off taken to be able to encompass higher quality evidence, as research related specifically to activities within the MLP scope of practices is scant. Regional differences, or differing duties between small rural laboratories and large consolidated urban diagnostic facilities may have also contributed to decreased specificity in the final recommendations. This can make them more difficult to apply in practice. Communication campaigns should include specific examples of how the recommendations may be employed to help alleviate this barrier. In general, there is a dearth of research into MLP-specific practises, and more is needed to support and enhance the legitimacy of MLP participation in initiatives to reduce medical overuse.

Conclusion

By identifying MLP-specific CWC recommendations, we can highlight that MLPs can be more than passive service providers in the healthcare system. Given the potential for MLP-specific practices to contribute to the issues of patient harm and resource waste, there should be more research into these areas, particularly where practices impact patient outcomes. There are specific ways that MLPs reinforce existing social and physical structures that lead to the overutilization of laboratory tests and resultant patient harm. There are also internal practices that contribute to harm and waste that should be questioned when they arise. When considering the MLP who can judiciously implement the CWC recommendations we identified, we paint a picture of an engaged, knowledgeable, and organizationally supported professional. The journey to move the needle to this image from its current place has challenges. Addressing these practises demands that MLPs increase their interactions with the entire healthcare team.

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Table 2.1: Expert Panel and Consultant Composition

Role	Designation	Areas of Expertise	Years of Experience	Locations Worked
Member	MLT	Hematology, Specimen Collection, Pre-analytics	10-19	Prince Edward Island
Member	MLT	Quality Management, Transfusion, Core	10-19	British Columbia, Alberta, Northwest Territories
Member	MLT	Transfusion, Quality Management	30-39	Nova Scotia
Member	MLT	Transfusion, Management	40+	Ontario
Member	MLA	Specimen Collection, Pre-analytics	5-9	Alberta
Member	MLT	Specimen Collection, Core	20-29	Saskatchewan
Member	MLT	Core - Rural	30-39	Alberta
Member	MLT	Hematology, Coagulation	30-39	Ontario
Member	MLT	Transfusion, Chemistry, Hematology	20-29	Nunavut, Ontario
Member	MLT	Chemistry, Specimen Collection	30-39	Nova Scotia
Member	MLT	Safety, Transfusion	30-39	Saskatchewan
Member	MLA	Histology Pre-analytics, Specimen Collection	5-9	Alberta
Member	MLT	Chemistry, Histology	10-19	Alberta, New Brunswick
Member	MLT	Hematology, Flow Cytometry	10-19	Ontario
Member	MLT/MLA	Core, Microbiology, Point-of-Care	10-19	Ontario
Member	MLT	Histology	10-19	Ontario
Member	MLT	Specimen Collection, Core, Microbiology	5-9	Nunavut
Member	MLT	Core - Rural	5-9	Manitoba
Member	MLT	Microbiology, Core	20-29	Manitoba
Consultant	PhD Clinical Chemist	Clinical Biochemistry, Toxicology	10-19	New Brunswick
Consultant	CYTO	Cytology	5-9	British Columbia
Consultant	MLT	Education, Leadership, Accreditation	20-29	Ontario
Consultant	MLT/MLA	Education, Phlebotomy, Histology	20-29	Quebec
Consultant	MLT	Leadership, Health System Performance	30-39	Nova Scotia, British Columbia
New Graduate	MLT	Core	0-4	Ontario

Legend: MLT = Medical Laboratory Technologist
MLA = Medical Laboratory Assistant
CYTO = Cytotechnologist
Core = Largely non-specialized Chemistry, Hematology, and Transfusion

Figure 2.1: Medical Laboratory Science List Development Process

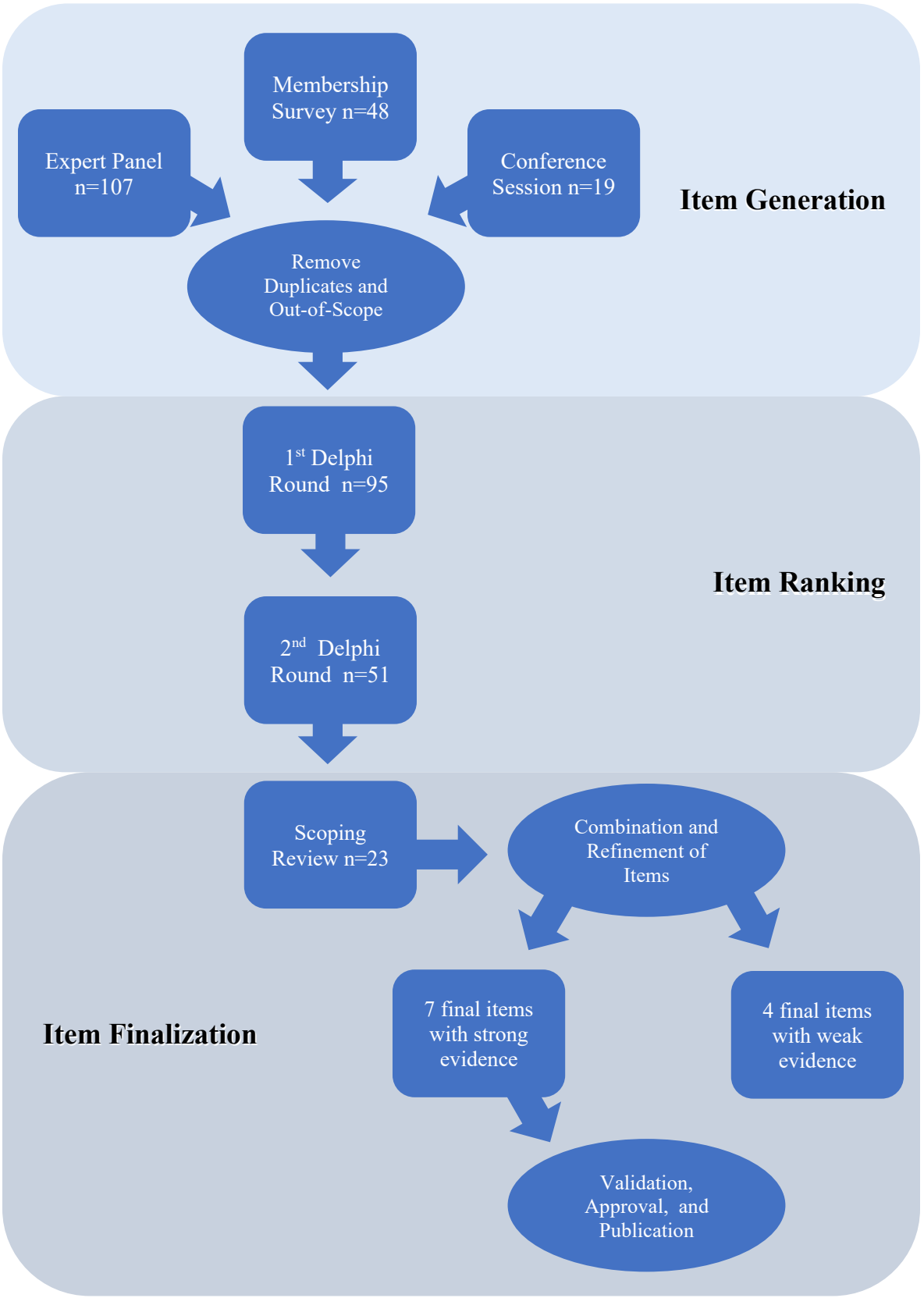

Table 2.2: Choosing Wisely List Items for Medical Laboratory Professionals

Final Recommendation	Source – Original Specific Items	Validation Outcome
1. Don't support repeat test ordering (re-testing) at a frequency that is not backed by evidence.	Don't process repeated tests within specified time windows, particularly for inpatients where hospital acquired anemia is a concern	**Approved**
	Don't process routine bloodwork on an inpatient more than once per day unless required for repeating abnormal results.	
2. Don't support ordering system mechanisms that contribute to over-testing. Encourage the development of an evidence-based utilization management program that may include interventions such as unbundling order sets, reflex testing algorithms, and decision-support technology	Don't allow orders for specialized testing without confirming collection and/or processing instructions. Where possible, create electronic pop-up reminders.	**Approved**
	Don't include low-value tests in order sets.	
	Don't process requisitions from multiple providers that duplicate testing. Utilize electronic ordering mechanisms to detect duplicate orders.	
3. Don't allow standing orders for repeat testing without a stop or review date.	Don't continue to collect patient samples that have extended standing orders or daily routine testing without requesting a physician review the order.	**Approved**
4. Don't collect more than what is needed. Use short draw tubes, consider add-on testing, and reduce or combine duplicate orders.	Don't draw more blood than necessary. Use short draw tubes.	**Approved**
	Don't re-collect from the same patient without first checking to see if the ordered tests can be performed on the original sample.	
	Don't collect additional tubes for duplicate test orders when receiving requisitions simultaneously from multiple providers.	
	Don't wait until a specimen is collected to cancel orders that do not meet institutional guidelines	
5. Don't collect extra blood tubes in anticipation of test orders.	Don't draw extra tubes in anticipation of ordering professionals ordering tests after the venipuncture.	**Approved**
	Don't collect samples from patients in the emergency department before their symptoms have been evaluated.	
6. Don't routinely repeat critical results for most common analytes before reporting	Don't repeat abnormal and critical results, particularly if the patient has a history of similar results.	**Approved**
7. Don't proceed with testing or reporting when sample quality or identification is suspect.	Don't culture a sputum sample that is of poor quality.	**Approved**
	Don't accession a requisition that has incomplete or erroneous information.	
	Don't run a laboratory assay if the minimum volume of whole blood is not received.	
Don't fail to ensure quality of laboratory processes performed by other healthcare professionals	Don't absolve yourself from the responsibility of blood sample quality even when collection is performed by other professionals. Seek to provide adequate training and feedback, such as in point of care or the emergency department.	Not Approved – Lack of Evidence
Don't proceed when recent valid results are on file	Don't collect repeat blood cultures when there is a clinically significant organism already identified	

	Don’t perform a manual differential on a CBC within 24 hours if the autodiff remains unchanged	Not Approved – Lack of Evidence
	Don’t ask for an additional sample to confirm blood typing if there is a blood group on file.	
Don’t automatically proceed with sample collection re-attempts without consultation in non-urgent scenarios	Don’t attempt to obtain blood from an adult patient more than twice, or a pediatric patient more than once, particularly in stable inpatients or when non-urgent bloodwork is required.	Not Approved – Lack of Evidence
	Don’t automatically redraw a sample that is insufficient or inadequate due to challenges during venipuncture without consulting to see if the testing is still required.	
Don't release results in a way that increases the chance of misinterpretation	Don’t provide a name or susceptibility results for organisms deemed normal flora in non-sterile specimens	Not Approved – Lack of Evidence

Chapter 3:Are medical laboratory professional practices represented in literature about inappropriate laboratory utilization? A scoping review.

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Introduction

The clinical laboratory contributes a large amount of data to inform clinical decision-making. Unfortunately, inappropriate testing occurs, for a wide variety of individual and system-level reasons.[1] While the extent varies widely according to setting and context, the general estimate in Canada is that 20-30% of tests are unnecessarily ordered.[2] The alarm bells of inappropriate laboratory utilization have been ringing for decades.[3] This coincides with increased automation in the laboratory, which allowed much higher test volumes alongside greatly decreased turnaround times.[4] Many studies have been devoted to understanding and addressing this issue. Recent systematic reviews have synthesized existing evidence about a wide range of interventions that have been used to improve laboratory utilization[5], such as the impact of clinical decision support [6] or the effectiveness of audit and feedback.[7] Some systematic reviews are geared towards specific ordering providers, such as primary care physicians.[8] Despite a considerable amount of research, inappropriate laboratory utilization remains a persistent problem that contributes to harm and waste in the healthcare system.

Technological advances and increased digitization of health will impose new challenges and opportunities on the laboratory. For example, research is examining how machine learning can help select appropriate laboratory tests.[9] However, even with increasing levels of sophistication, clinical decisions and activities remain enormously complex and involve human actors operating within established systems.[10-12] Multi-faceted solutions will be needed. A multidisciplinary approach has long been recognized as important.[13,14] Dickerson et al [15] contend that laboratory staff at all levels should be part of efforts, but the medical laboratory professionals (MLPs) who procure and test samples are rarely directly mentioned in contemporary laboratory utilization management literature. The scope of practice of these professionals includes collecting, processing, and testing biological samples while performing and managing various rigorous activities that assure validity and quality.[16] They are also

responsible for communicating results to the ordering clinician. Most research linking laboratory practices to adverse outcomes considers the impact of errors or inefficiencies within pre-analytical, analytical, and post-analytical processes.[17] However, this lens is not suitable for understanding laboratory impacts on inappropriate utilization, as it is an issue perpetuated by system deficiencies rather than individual mistakes.

The Canadian Society for Medical Laboratory Science (CSMLS) and University of Alberta recently engaged in a systematic process to identify MLP practices that can contribute to the inappropriate utilization of laboratory resources.[18] The goal was to publish these practices in a list for Choosing Wisely Canada (CWC). CWC is a prominent organization whose aim is to reduce medical overuse, and they publish lists of practices that have questionable value in healthcare. As part of the CWC requirements, potential items must be supported by high quality evidence before they can be part of the published list.[19] Eventually, seven items for MLPs were approved by CWC and their community of partners, and subsequently published. There were several items that were not incorporated into the final list because they lacked published evidence of sufficient quality and quantity.[18] Other items were generalized and combined for the same reason. An observation arising from this work is that many MLP practices are under-researched in the context of how they might contribute to inappropriate laboratory utilization and the resulting outcomes of resource waste and patient harm.

MLPs also frequently describe themselves as part of a 'hidden profession.' While they are concerned about inappropriate laboratory utilization, and want to be part of solutions, they express difficulty describing the roles they can play in such efforts.[20] There is a lack of practical guidance around tangible roles that MLPs can play in interventions to reduce inappropriate testing. We undertook a scoping review to understand the scope and nature of published evidence about inappropriate laboratory utilization that includes MLP practices and roles. Scoping reviews are suitable when little is known about a topic and guidance for future research is needed. They are useful for making recommendations for future research or practice changes.[21] Given the dearth of research on this topic, a broad approach is prudent.

Methods

This scoping review was guided both by the framework proposed by Arksey and O'Malley[22], and the practice and reporting structure developed by the Preferred Reporting

Items for Systematic reviews and Meta-Analyses (PRISMA).[23] We used the systematic review software Covidence [24] to help ensure that all the citations were accounted for and to facilitate data extraction.

Research Question

The scoping review sought to answer the question *'What is the scope and nature of published evidence that considers medical laboratory professional practices in the context of inappropriate laboratory utilization?'* The primary objective was to understand which MLP practices have, and have not, been studied for their contributions to resource waste and patient harm. A secondary objective was to identify roles that MLPs have played during interventions addressing inappropriate laboratory utilization.

Information Sources and Search Strategy

We searched the following databases for publications: MEDLINE/PubMed, Embase, Web of Science, Google Scholar, Cumulative Index to Nursing and Allied Health, and Scopus. We used Google to search for grey literature and other publication types. The reference lists of relevant articles were manually searched. The initial searches began in January 2020 and were repeated in July 2021. The search query was developed to include the four main eligibility criteria of context (inappropriate laboratory utilization), population (MLPs), practice (pre-analytical factors, analytical factors, post-analytical factors, or quality management), and outcomes (patient harm or resource waste). **Table 3.1** contains the search strategy used in electronic databases. Synonyms were truncated where appropriate, and combined with the Boolean operator OR within each parameter, and parameters were combined with the Boolean operator AND.

Selection of Sources of Evidence

We used a two-stage screening process by two independent reviewers (AV and YW). Any disagreement was resolved through discussion. At the first stage, only the title and abstract of citations were reviewed. All citations that appeared relevant according to inclusion and exclusion criteria after this stage moved on to have the full text article reviewed. These criteria are found in **Table 3.2**. For articles that could not be obtained via institutional permissions, an

email was sent to the corresponding author. If a citation was considered relevant after full-text review, it proceeded to data extraction.

Data Items and Synthesis

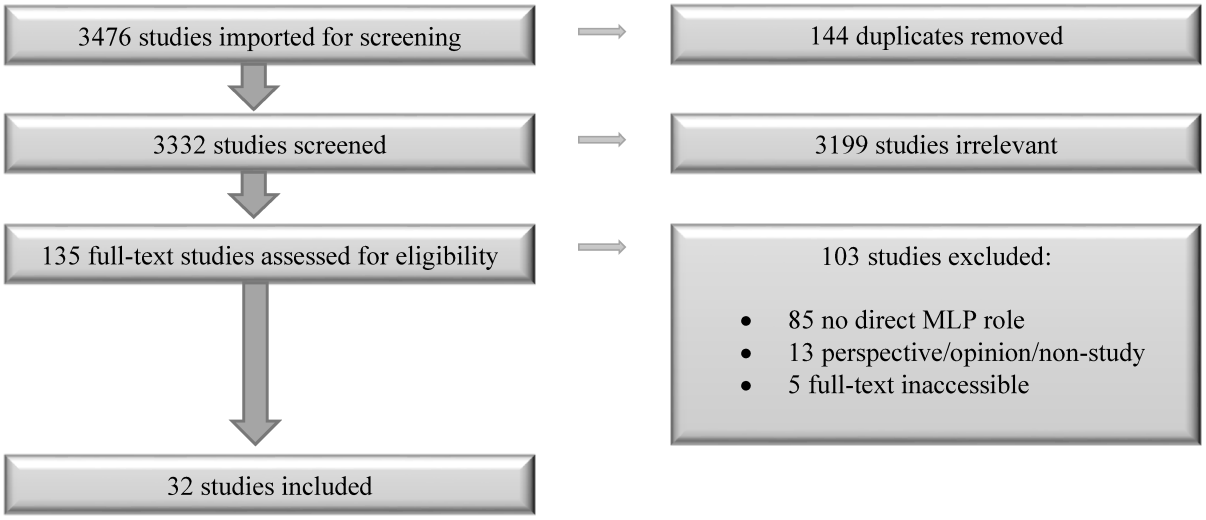
A data charting form was created with the data extraction template tool in Covidence. The data collected was title, year of publication, country in which the study was conducted, study aim, design, setting, and sample, description of intervention, MLP role, start and end date, primary findings, and outcomes related to patient harm or resource waste. A formal critical appraisal of individual sources of evidence was not performed, which aligns with the standard approach to conducting scoping reviews.[23]

Results

Selection of sources of evidence

The search conducted yielded 3476 studies imported for screening. After removing 144 duplicates, 3332 titles and abstracts were screened. Of these, 135 full-text articles were assessed for eligibility, and 32 were included in the data charting. Of the 103 articles that were excluded after full-text review, 79 were because there was no clear MLP practice or role described. There were 31 that were otherwise irrelevant, and three where the full-text could not be accessed. **Figure 3.1** provides the PRISMA flow diagram of the overall process.

Figure 3.1: PRISMA diagram



Overall characteristics of sources of evidence

The 32 studies included in this scoping review were conducted in 10 countries[25-56], with most coming from the United States (15), followed by Canada (4). There are 14 observational studies exploring an MLP practice[25-28,34-43], 16 experimental studies about interventions aimed to improve laboratory resource utilization[29-33,44-54], and two reviews with case studies about laboratory stewardship.[55,56] All but two studies occurred in a single institution.[25-41,43-48,50-56] With the observational studies, the duration ranged from two weeks to 15 months. In the experimental studies, the length of intervention follow-up time ranged between two weeks and 12 years. In 21 studies, there was measurement of an outcome related to resource waste or patient harm, such as direct or indirect costs, reduction in error or turnaround time, or improved treatment.[26,27,29-32,38,42-56]

There were two specific medical laboratory practices studied in the context of resource utilization: collecting blood, with nine citations[25-33], and repeating test results, with 12 citations.[34-45] These two practices were examined in both observational and experimental research. Nine of the remaining studies were all experimental where there was a specific role for MLPs as part of the intervention.[46-54] Two reviews included brief case studies of intervention projects also described a role for MLPs.[55,56]

Studies about the practice of collecting blood

There are four observational studies that evaluated ways that the laboratory draws more blood than necessary.[25-28] The details of these studies are found in **Table 3.3**. Three of these studies looked at the phenomenon of collecting extra tubes at the time of order[25-27], particularly to complete the 'rainbow draw', which is a colloquial way of describing the selection of vacutainer tubes where each brightly coloured cap indicates which additive a tube holds. Obtaining a full 'rainbow draw' means that all possible specimen types were obtained from an individual patient, regardless of need. The remaining study [28] examined collection practices in a neonatal intensive care unit where it was noted that phlebotomists would often collect blood to a level that was higher than needed. The study duration ranged from two weeks to six years. Two of the studies estimated the cost of unnecessary blood collection [26,27], but the other two did

not.[25,28] All of the studies concluded that an unacceptable amount of collected blood is unused.

There are five studies describing interventions seeking to reduce the amount of blood drawn.[29-33] The details of these studies are found in **Table 3.4**. In four of these studies, the intervention was to replace standard-volume blood collection tubes with small volume blood collection tubes, which gather 1/2 to 1/3 less blood.[29-32] In the remaining interventional study, they studied the impact of a policy to stop collecting extra tubes ('rainbow draw') in the emergency department.[33] The intervention follow-up time studied was between two weeks and one year.

All four of the small volume collection tube intervention studies measured outcomes related to resource waste and/or harm.[29-32] For measuring impact on resource waste, researchers measured the number of recollections or sample preparation time.[29] For measuring impact on patient harm, researchers assessed episodes of severe anemia[31], number of blood transfusions[32], or instances of analytical error.[30] For each of these studies, there was either no impact or a positive impact, indicating that the switch to small volume tubes did not waste additional resources and did not harm patients. The remaining intervention about drawing extra collection tubes provided a cost estimate of the status quo, but did not provide figures after a policy change to stop this practice.[33]

Studies about the practice of repeating test results

There are 10 observational studies that determined the necessity of a fairly common practice where tests results are repeated before being reported to the ordering provider.[34-43] One of these studies collected data from 86 different institutions.[42] The details of these studies are found in **Table 3.5.** This practice might occur when the initial result falls into a range that should prompt immediate clinical intervention. These are often called 'critical' or 'panic' values, and should be communicated directly. In many institutions, it is routine practice to repeat these tests before calling the clinician. The study duration ranged from six weeks to 15 months. Seven of these studies did not measure variables related to resource waste and harm.[34-37,39-41] Two studies quantified the time that results were delayed because of repeating the test.[38,42] Two studies also estimated the costs associated with repeating tests unnecessarily, but neither included labour in the cost.[38,43] In nine studies, the authors concluded that virtually all repeat

testing is unnecessary.[34-39,41-43] The remaining study flagged a concern with limiting repeating with two specific analytes, but acknowledged that this might be related to their instrumentation.[40]

Two studies evaluated the impact of discontinuing routine or automatic repeating of tests.[44,45] The details of these studies are found in **Table 3.6.** The intervention follow-up time was one month and two months. Both studies measured the impact on reporting time and costs. Both studies found that discontinuing this practice decreased the delay in reporting the patient result while saving laboratory resources, including labour costs.

Studies including an MLP role in a resource utilization intervention

Nine studies explored the impact of various interventions to improve laboratory utilization[46-54], and two reviews included stewardship intervention case studies.[55,56] The details of these citations are found in **Table 3.7.** In these studies, a role for MLPs in interventions was explicitly described. Six of the interventions were conducted in the microbiology discipline[49-54], two in transfusion medicine [47-48], two spanned an entire multi-discipline site[46,55], and one dealt with thyroid testing in chemistry.[56] The intervention follow-up time was between six months and 12 years.

The MLP role in the interventions varied considerably. In two interventions, one from microbiology and the other in broader laboratory, the role was mostly clerical where the MLP would interact with a physical requisition or order form that was altered as part of the intervention.[46,49] With the two interventions situated in the transfusion medicine laboratory, MLPs were involved with screening transfusion orders and communicating with healthcare providers about the next steps, which depended on the initial appropriateness of the request and biochemical parameters of the patient.[47-48] Similarly, in one intervention that spanned multiple disciplines, researchers described a communication role where MLPs handled direct clinician requests to bypass imposed testing restrictions or fielded questions about testing changes.[55] In three of the interventions in the microbiology laboratory, MLPs also had a role in communicating with the clinicians on the patient care team about changes to testing based on new policy or the MLP assessment of sample quality or appropriateness.[50,53-54] In the remaining two interventions in the microbiology laboratory, MLPs were involved in a reflex pathway where the initial sample was assessed by the MLP, and further testing was then ordered

or cancelled based on this assessment.[51-52] Finally, in a brief case study, an MLP had a leadership role in initiating a utilization project, and was involved with data gathering, data analysis, and forming the project team.[56]

All but one of the interventions in this category included measurement of outcomes related to resource waste and/or patient harm.[46-55] A study about add-on testing in the general laboratory found that their intervention created more work and additional staff was hired, but the existing collected blood samples were used more effectively to reduce re-collection events.[46] Both of the transfusion medicine studies found that there was no increase in patient deaths when blood transfusion products were limited as part of the intervention.[47-48] Four of the microbiology studies reported on the outcome of avoiding unnecessary antibiotic treatment, and in all cases, the findings were positive.[50-51,53-54] One study also measured post-operative infections, and found there was no increase after the intervention.[50] Four microbiology interventions looked at laboratory resource outcomes and found that workload and reagent use decreased after the interventions.[49,52-54] Finally, one citation describing multiple clinical decision projects found significant cost savings, and they estimated the number of tests the intervention avoided.[55]

Discussion

This scoping review indicates that in the context of contributing to wasted laboratory resources, there are only two MLP practices substantively represented in existing literature: collecting blood and repeating laboratory tests. All the citations except for one conclude that there are unnecessary actions in these domains. Studies linking laboratory practices to patient harm are usually related to errors, though even these are limited in number.[17] This scoping review demonstrates that there is a dearth of study that links other practices to patient harm and resource waste outside of this context. With respect to the citations about MLP roles in utilization improvement interventions, there were five types of roles identified. The first type is clerical, the second type involves communication, the third is to evaluate the appropriateness of requests or samples and recommending follow-up, and the fourth is performing testing and then follow-up actions. Lastly, a review study described a case example where an MLP, a laboratory manager, had significant involvement in the utilization project lifecycle, including initiation, data analysis, and liaising with subject matter experts.

Using extrapolated figures, Levi [57] calculated that approximately 25 million litres of blood is wasted annually in Western countries. With technological advances in analytical instrumentation, sample volumes required for testing have decreased substantially, but the amount drawn from a patient has not followed suit. Tests that historically required millilitres of blood now require a few microlitres, but a recent estimate of blood loss for diagnostic testing ranged from 8.5 mL/day to 27.2 mL/day in inpatients depending on what ward they are on.[58] A standard vacutainer tube of blood can be used for dozens or even hundreds of tests. However, reducing the amount of blood drawn is not as simple as underfilling the vacutainer tube. There are minimum requirements necessary for proper sampling with the various analyzers, and to account for analytical procedures such as measuring the hemolysis index. Samples that are too small can have issues with incorrect anticoagulant/blood ratios, which can alter results and cellular morphology. Aiming to draw smaller volumes increases the rate of sample rejection under the 'quantity not sufficient' guidelines.[59] The citations identified in this scoping review studied exclusive or increased use of low-volume vacutainer tubes, which are often reserved for pediatric patients, and concluded that there are no adverse effects. Exploring ways to reduce the amount of blood collected was one of the items on the CWC list for Medical Laboratory Science.[18,19] There is evidence that moving towards routine use of low volume collection containers can be encouraged, though more study is needed, particularly to understand impact on add-on orders.

Within the practice of drawing blood, collecting extra blood tubes in anticipation of add-on orders was identified as a wasteful practice. This is also one of the 'don't do' items on the CWC list for Medical Laboratory Science.[18,19] Add-on ordering occurs when the clinician is aware of a recent collection and would like tests performed on the previously collected blood specimens. This cannot always be accommodated as certain analytes decline or degrade with storage, and certain analytes have specific collection requirements. For example, most coagulation testing must occur with sodium citrate-anticoagulated blood, whereas most hematology testing occurs with EDTA-anticoagulated blood, and these are not interchangeable. The citations included in this scoping review agreed that collecting extra tubes without specific clinician orders is a wasteful common practice, though well-intentioned. Others have shown that add-on testing only comprises roughly 1% of all test orders [60], supporting the conclusion that if the practice of collecting extra tubes was widespread, there would be a large amount of waste

and possible impact on patient anemia. Policies should be enacted to limit indiscriminate drawing of extra blood tubes.

Unlike other practices that may be related to inappropriate laboratory utilization, the practice of repeating test results is entirely internal to the laboratory. Different institutions may have different policies about appropriate junctures where laboratory tests might be repeated on the same sample, though this is not necessarily the case.[61] Repeating a test can occur according to the judgement of the individual MLP. For example, noticing unusual sights and sounds with the testing instrumentation might cast doubt on the results of a specific testing run. More commonly, tests may be repeated for unusual results, results that differ significantly from historical results, or results that fall outside of, or are on the margins of validated analytical limits. However, it was clear from the studies included in this scoping review that analytical performance on modern instrumentation is generally high enough to negate the need for repeating tests, particularly for 'critical' results on common analytes. An item on the CWC Medical Laboratory Science relates specifically to limiting the practice of repeating critical results[18,19], but some of the studies in this scoping review suggest that there may be other situations in which repeating tests unnecessarily delays results. Further research is needed to determine if this recommendation can be expanded to include other situations where repeating tests is common or habituated.

We found that it was uncommon to describe roles for MLPs in interventions. The activities assigned to MLPs in the included citations shows that there are several types of possible roles for MLPs, particularly involving communication with other healthcare providers. These provide important illustrative examples for a population that has a hard time imagining how they can contribute to improving inappropriate utilization.[20] Our exclusion criteria meant that many intervention studies were rejected when they did not clearly describe a role for MLPs during the intervention. However, in any study manuscript, many specific details are omitted. It is possible interventions that involved changes to workflow or processes needed consultation with MLPs, but these details might be seen as irrelevant to the study results and discussion. There are also other elements that are not described in manuscripts. For example, it is uncommon that roles of stakeholders or committee members, or the composition of committees themselves are provided, even as guidance for laboratory stewardship program development is starting to emerge in recent publications. In a recent review, White & Wong [56] borrow from

the fundamentals of change management to recommend components of effective implementation of stewardship initiatives. Governance is a key component of a sustainable initiative. Dickerson et al [15] list multidisciplinary committees, discrete-topic subcommittees, and laboratory expertise as essential parts of stewardship program governance. They suggest that MLPs can perform guidance and consultation functions around workflow and testing algorithms. The development of new skills, such as presentation and project management skills, can enhance stewardship programs [55,56], and possibly open the door for new roles for MLPs. The relationship between organizational structures or stewardship program development and the success of stewardship interventions is infrequent in the literature, and should be the subject of future study. Likewise, little is known about barriers and facilitators to implementation. Given the relative newness of laboratory stewardship programs, research into many components is in infancy. Further definition of the role of MLPs to augment interventions is a research priority.

It is worth noting that while many of the studies included measurement of outcomes relevant to stewardship, this measurement was more substantive with respect to resource waste, and less so with respect to patient harm. Measures of patient harm were often indirect, and noted absence rather than presence. This aligns with other observations that the linkage of laboratory activities with patient outcomes is lacking.[62] Our work here supports the idea that more research exploring the relationships between inappropriate testing and patient outcomes is needed.

We chose to perform a scoping review because they are appropriate for identifying knowledge gaps over a broad landscape.[21] We can confirm that there are many MLP practices that are absent from the literature, such as result communication, or other ways that MLPs exert judgement about how orders are processed, samples are rejected, tests are performed, or results are validated. Scoping reviews do not have mandatory critical analysis or bias assessment, as the goal is breadth and providing a comprehensive overview.[22] However, almost half of the citations were observational studies and almost all were conducted at a single site, suggesting that future research of higher rigour and generalizability is needed

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Table 3.1: Terms Searched in Scoping Review

Parameter	Main Term	Synonyms
Population	Medical laboratory professionals	Medical Laboratory Technologist, Medical Laboratory Assistant, Medical Laboratory Scientist, Laboratory Scientist, Medical Laboratory Technician, Biomedical Laboratory Scientist, Clinical Laboratory Technologist, Clinical Laboratory Technician, Clinical Laboratory Scientist, clinical laboratory, medical laboratory, diagnostic laboratory, pathology
Context	Inappropriate laboratory utilization	utilization management, demand management, stewardship, unnecessary testing, too much testing, over-testing, inappropriate testing, resource management
Practice	Pre-analytical factors	hemolysis, lipemia, icterus, refusal, missed requests, phlebotomy, venipuncture, venepuncture, rainbow draw, just-in-case, extra tube, test cancellation, sample quality, order modification, sample retrieval, duplicate requisition, multiple requisition, sample rejection, add-on testing, capillary collection, centrifugation, aliquoting, plating
	Analytical factors	repeat testing, reflex testing, algorithm, stat testing, automation, point-of-care testing, analytical measurement range
	Post-analytical factors	result communication, critical result, panic value, early notification, delta check, abnormal result, retrieval, archival, validation, result release, result follow-up, extra-analytical phase, communication
	Quality management	quality control, quality indicator, total quality management, quality assurance, error
Outcomes	Patient harm	hospital-acquired anemia, anemia, iatrogenic anemia, injury, length of stay, hospital stay, delayed diagnosis, diagnostic error, patient safety, discharge, diagnostic blood loss, delay, mortality, morbidity
	Resource waste	workload, cost, environmental impact, time, labour, reagent, economic assessment
	Injury – patient or worker	needle-stick, repetitive injury, infection, blood-borne infection, nosocomial, hospital-acquired, workplace injury

Table 3.2: Inclusion and Exclusion Criteria

Inclusion	Exclusion
• English Language • Empirical citations – reviews, original research, letters • Grey literature – guidelines • Eligibility criteria (context, population, practice, outcomes) • Full-text available	• Failing to describe a role for MLPs • Policies • Opinion, perspective, editorials • Commentaries • Book reviews

Table 3.3: Observational Studies about Drawing Too Much Blood

Citation, author, year, title	Aim of study	Sample	Country and setting	Study design and duration	Primary findings	Measures related to stewardship
[25]Humble *et al* 2017 *The "rainbow" of extra blood tubes – useful or wasteful practice?*	Determine how frequently extra blood tubes collected without orders are used for additional testing	370,601 extra tubes	United States Emergency department, inpatient, and outpatient units at one hospital	Retrospective study [Letter] 6 years	Only 7% of extra tubes were used for add-on testing. One outlier patient had 165 extra blood tubes, and 572 had more than 50 extra tubes each	Not specifically measured, but noted the extra tubes that were not used were collected and disposed of by medical laboratory professionals
[26]Snozek *et al* 2019 *"Rainbow draws" in the emergency department: clinical utility and staff perceptions*	Determine how many extra blood tubes were collected at their institution and collect subjective perceptions of the practice with emergency department staff	All laboratory test orders	United States One emergency department	Retrospective data study with survey 2 weeks	Rainbow draws occurred on 66.2% of patient visits. 8.5% of these tubes were used for add-on tests. Staff perceived that these collections were valuable and >25% were used for add on testing	10.6 mL of blood was wasted for each rainbow draw, or greater than 240 L unused blood. Estimated material and labour costs was >45000 tubes and $64,000 USD
[27]Loh *et al* 2010 *Extra blood tubes - an affordable excess?*	Determine how frequently extra tubes were collected and the cost of this practice	All extra blood tubes received	Singapore One hospital emergency department and inpatient units	Retrospective study [Letter] 1 year	There were 4670 extra blood tubes received from 4022 patients during the study period	In the study period, unused blood volume was estimated to be 13.6 L, costing $10988 in local currency ($8050 USD)
[28]Lin *et al* 2000 *Phlebotomy overdraw in the neonatal intensive care nursery*	Determine the extent of excess blood drawn from preterm infants, and factors contributing to this phenomenon	578 blood samples	United States Two neonatal special care units in one hospital over multiple shifts	Prospective study 4 months	The amount drawn exceeded requested amount by 19% on average, with significant variation depending on phlebotomist, shift worked, and type of collection tube	None specifically measured

Table 3.4: Interventional Studies about Reducing Amount of Blood Collected

Citation, author, year, title	Aim of study	Country and setting	Sample	Study design and length of follow-up	Description of intervention	Primary findings	Outcomes related to stewardship
[29]Sanchez-Giron *et al* 2008 *Reduction of blood loss from laboratory testing in hospitalized adult patients using small-volume (pediatric) tubes*	To assess the impact of using small volume collection tubes on the analytical phase of testing	Mexico One academic general hospital	1360 non-emergency test requisitions from 473 adult patients	Before-after (pre-post) study 2 weeks	Two weeks to obtain baseline data from collecting/testing blood from hospitalized patients in the existing way. Then, two weeks of transitioning to small volume collection tubes. Then, they collected data for two weeks with use of small volume collection tubes.	The amount of blood collected after intervention decreased by a median of 73%. There was no impact on the analytical phase	There was no need to recollect any sample because of insufficient volume, and no added workload from having to transfer samples to a new testing container

[30]Myles *et al* 2018 *A cohort study assessing the impact of small volume blood tubes on diagnostic test quality and iatrogenic blood loss in a cohort of adult haematology patients*	Determine the reduction in blood loss associated with the use of small volume collection tubes. They also want to quantify any negative impact on laboratory analytical error.	Australia Hematology unit of a single tertiary hospital	Consecutively enrolled adult patients with historical control group	Cohort study 1 year	Implement use of small volume collection tubes instead of traditional collection tubes	The amount of blood collected per day was reduced by 42% (8.5 mL)	Significant increase in fibrin error in EDTA small collection tubes, but no increase in total laboratory errors
[31]Briggs *et al* 2019 *Small volume vacuum phlebotomy tubes: a controlled before-and-after study of a patient blood management initiative in an Australian adult intensive care unit*	To test the hypothesis that using small volume collection tubes rather than traditional collection tubes would have a significant impact on hemoglobin levels in intensive care unit patients	Australia Intensive care unit in one hospital	318 patients, admitted for at least 48 hours	Before-after (pre-post) study 1 year	For patients in the study group, they replaced four different types of traditional vacuum collection tubes with ones that collected smaller volumes. They collected data one year before and one year after the intervention	The difference between study group and control group was 6.7 g/L of hemoglobin concentration. Those in the study group had fewer episodes of severe anemia	There were no significant increases in analytical error with the use of small volume collection tubes. Those in the study group had fewer episodes of severe anemia
[32]Yu *et al* 2021 *Reducing blood loss by changing to small volume tubes for laboratory testing*	Evaluate the impact of changing to small volume blood collection tubes on volume of blood collected and redraws, hemoglobin levels, and number of transfusions	United States One tertiary care academic hospital	All inpatients admitted to 10 units	Before-after (pre-post) study 6 months	Blood collection tubes were changed to small volume collection tubes	Post-intervention, hemoglobin levels increased significantly in transplantation and critical care inpatient units, and volume of blood collected decreased significantly across all units	The number of blood transfusions decreased significantly in all units, and the number of redraws did not meaningfully change
[33]Gray 2012 *Drawing extra blood tubes in the ED*	Determine how many extra tubes were collected and how many were eventually used, and then create a policy stopping low value practice	United States One large hospital system	Not specified	Quality improvement study [Report] Unknown length of follow-up	They stopped collecting extra tubes in the emergency department without a physician order	Before the intervention, they were handling 400 extra tubes per day at 1.75 minutes per tube or 12 hours per week. Only 4% of tubes were used for add-on testing	Not specifically measured, but before intervention, the cost to their laboratories was over $200,000 $USD per year

Table 3.5: Observational Studies about Repeating Tests

Citation, author, year, title	Aim of study	Sample	Country and setting	Study design and duration	Primary findings	Measures related to stewardship
[34]Chima *et al* 2009 *Is it necessary to repeat critical values in the laboratory?*	To identify reasons for repeating tests, and whether the repeat improved the accuracy of the result	580 repeated laboratory samples that were classified as critical or early notification	United States One tertiary hospital	Prospective study 6 weeks	566/580 (97.6%) repeated results agreed with the initial result within accepted limits. Some differences were statistically significant, but none were clinically significant	Not measured but noted that repeats that did not agree would have required redraw because of spurious findings
[35]Toll *et al* 2015 *Does routine repeat testing of critical laboratory values improve their accuracy?*	They looked at 13 different chemistry, hematology, and coagulation tests to determine the effect of repeating tests when the initial result was a critical value	2233 repeated laboratory samples	Iran One tertiary hospital	Prospective study 1 year	99.1% of repeated tests were within accepted limits of allowable error, with no critical values becoming noncritical because of repeat testing. They concluded that the tests did not become more accurate with repeat testing	None specifically measured
[36]Niu *et al* 2013 *Utility and necessity of repeat testing of critical values in the clinical chemistry laboratory*	To analyze the accuracy of repeated routine chemistry critical values	601 repeated chemistry samples	China One tertiary hospital	Prospective study 3 months	Most repeated results (96%, or 572/601) were within the analytical measurement range of the chemistry instrument. The largest difference noted was 5.4% in one sodium repeated measurement	None specifically measured
[37]Baradaran *et al* 2011 *Does routine repeat testing of critical values offer any advantage over single testing?*	Determine whether repeat testing of critical values for five common hematology and coagulation tests improves accuracy of results	Consecutive critical results for 5 different common hematology tests	United States One hematology laboratory	Prospective study Duration not specified	2601/2627 (99%) of repeated tests were within acceptable ranges, with 4/2627 becoming non critical	None specifically measured
[38]Sana *et al* 2020 *Clinical significance of repeat testing of critical results in a hematology laboratory*	Determine the clinical and cost impact of unnecessarily repeating critical complete blood count tests	944 critical values	Pakistan One academic hospital	Cross-sectional study [Letter] 6 months	98.2% of hemoglobin, 97.5% of white blood cell, and 64.9% of platelet repeat results were within accepted limits. No results became non-critical on repeat.	Average delay was 6 minutes with some over an hour with an annual cost, not including labour, of almost $6700 USD
[39]Deetz *et al* 2012 *An examination of the usefulness of repeat testing practices in a large hospital clinical chemistry laboratory*	Determine the validity of existing repeat testing rules regarding exceeding range limits, delta checks, and critical results	25,553 repeated clinical chemistry laboratory samples	United States One tertiary hospital	Prospective study 15 months	35 errors were detected by performing repeat testing, with 3 of 605 repeated critical values indicating an error. Analytical performance was strongest with general analytical chemistry	None specifically measured.

[40]Saffar *et al* 2020 *Necessity of routine repeat testing of critical values in various working shifts*	To determine the utility of repeat testing of critical values in four common tests across different working shifts representing a 24-hour cycle	All laboratory results for 4 analytes	Iran One referral tertiary hospital	Prospective Study 2 months	There were potassium and prothrombin time tests that were outside of acceptable limits. There were 3/178 potassium repeats and 12/107 prothrombin repeats that became non-critical. These results were largely outside of the analytical measurement range of the analyzer. The night shift had the worst performance.	While not specifically measured, it was noted that differences noted were likely not clinically significant
[41]Ustundag *et al* 2019 *Determining the need for repeat testing of blood ethanol concentration: evaluation of the Synchron blood ethyl alcohol assay kit*	To determine if the common practice of repeating blood ethanol concentration improves result accuracy	1133 repeated blood ethanol laboratory samples	Turkey One tertiary academic hospital	Retrospective study 1 year	70% of results are repeated as a decision made by the laboratory professional. There was no significant difference between mean initial test and mean repeat test. At the high level where results have forensic importance, there was 99% agreement between initial and repeat results	None specifically measured
[42]Lehman *et al* 2014 *Utility of repeat testing of critical values: a Q-probes analysis of 86 clinical laboratories*	To determine common practices and policies in different laboratories with respect to handling critical values. They also gathered data related to accuracy compared to original result, turnaround times, and patient outcomes	86 laboratories	86 clinical laboratories with 81 from the United States, and the remainder from Canada, Saudi Arabia, and Australia	Cross-sectional study Duration not specified	Most laboratories do not have a policy that defines acceptable limits for change in repeat results. More than 99% of all four laboratory tests were still critical after repeat and did not differ significantly from the original value.	The median repeat times were at least 10 to 21 minutes. 20% of laboratories reported at least 1 incident within the past year where a reporting delay had a negative impact on a patient
[43]Rodrigues *et al* 2017 *Repetition of biochemistry tests in a laboratory of public hospital in southwest of Bahia, Brazil and associated cost*	Determine if there are meaningful differences between original and repeat laboratory test results, then quantify the costs associated with unnecessarily repeating laboratory tests	1350 repeated samples for biochemistry tests	Brazil One general hospital	Cross-sectional study 3 months	81.31% of repeated tests were classified as unnecessary. Many of the necessary repeats were from the ion-selective electrode module	Annual cost not including labour for unnecessary testing is R$ 4,792 ($853 USD)

Table 3.6: Interventional Studies about Repeating Tests

Citation, author, year, title	Aim of study	Country and setting	Sample	Study design and length of follow-up	Description of intervention	Primary findings	Outcomes related to stewardship
[44]Soleimani *et al* 2021 *Termination of repeat testing in chemical laboratories based on practice guidelines: examining the effect of rule-based repeat testing in a transplantation center*	Characterize repeat testing from all causes (critical and noncritical repeats) in the clinical chemistry laboratory, and determine impact on turnaround time and cost	Iran A liver transplantation centre in one tertiary hospital	Laboratory test results from 26 chemistry analytes from inpatients and outpatients	Prospective study 2 months	They designed and implemented a series of repeat testing rules, where this testing could only occur under specific conditions	The number of repeated tests decreased by 38% post-intervention	Costs related to repeat testing decreased by 32%, and the time delay decreased by 36%
[45]Sun *et al* 2018 *Repeating critical hematology and coagulation values wastes resources, lengthens turnaround time, and delays clinical action*	Evaluate the necessity of performing repeat critical hematology and coagulation results, the impact on laboratory resources, and the impact on patient care	United States One laboratory	5 cohorts: 1 to assess necessity of repeating critical values. 2 to assess the impact of repeating critical values on turnaround time. 2 to evaluated clinical impact	Mix of retrospective and prospective cohort 1 month	One cohort used to evaluate if repeating the result changed the outcome. Other cohorts used to calculate impact of turnaround time and resource waste	896 critical values were repeated in one month. In no instance was the result changed by repeating the test. Once the practice of repeating criticals was discontinued, all turnaround times decreased significantly.	The average time for a technologist to repeat the test was 28 minutes, and multitasking during this time was not always possible This labour cost averaged >$112,000 per year

Table 3.7: Citations that Describe Medical Laboratory Professional Roles in Utilization Interventions

Citation, author, year, title	Aim of study	Country, setting, and sample	Study design and length of follow-up	Description of intervention	Medical Laboratory Professional role	Primary findings	Outcomes related to stewardship
[46]Shahnazarian *et al* 2016 *Improve the laboratory add-on process and increasing housestaff satisfaction with an EMR intervention*	To improve the process of add-on testing and reduce the number of phlebotomies performed as the result of STAT lab orders	United States One community hospital All inpatient laboratory tests	Quality improvement report 19 months	Created a new electronic process for ordering add-on testing from an older labour-intensive paper-based system	Receive printed add-on orders in the laboratory, input the orders, and perform the testing	There was a significant increase in number of add-on tests with high user satisfaction. The number of STAT tests was not measured	A higher volume of add-on testing resulted in workload disruption and the need to hire additional laboratory staff
[47]Tavares *et al* 2014 *Reduction in red blood cell transfusion associated with engagement of the ordering physician*	To evaluate impact of a quality improvement project that aimed to decrease overutilization of blood transfusions	United States One tertiary care hospital All transfusion and hospital records	Retrospective study 12 years	Several educational interventions followed by intentional physician engagement combined with transfusion orders	Screening transfusion orders based on hemoglobin level, and communicating with the physician who made the order	There was a significant decrease in the trend of number of red blood cell units transfused with no increase in inpatient mortality	The appropriate utilization of blood transfusion increased without causing patient harm
[48]Lin *et al* 2016 *Improving transfusion practice with guidelines and prospective auditing by medical laboratory technologists*	To improve utilization of red blood cell transfusion at a community hospital	Canada Single community hospital with four sites	Quality improvement before-after project 1 year	There were several educational rounds, adoption of new transfusion guidelines, and prospective screening of transfusion orders	Prospective screening of all orders for red blood cell transfusions except from bleeding or operative patients. MLPs made recommendations to the nurse or lab physician depending on type of inappropriate order.	The mean monthly units of red blood cell transfusions decreased without an increase in mean monthly deaths. This decrease was sustained for 12 months	Appropriate use of blood transfusion products increased without an increase in mortality
[49]Passi *et al* 2021 *A low-cost initiative to reduce duplicate hepatitis B virus serological testing*	To determine the effectiveness of a requisition-stamping protocol to reduce duplicate testing when transferring specimens for testing at more than one laboratory	Canada Two microbiology laboratory sites 803,637 screening results	Before-after (pre-post) study 15 months	A stamp was applied to requisition forms at one laboratory that indicated whether certain testing was already performed. This requisition was sent to another laboratory, who would perform the rest of the testing other than those indicated on the stamp	Apply the stamp to the requisition and complete clerical steps to ensure duplicate testing was not performed	The amount of duplicate testing decreased from 20.8% to 3.7% after the stamp system was implemented	Reduction in laboratory testing resources and possible duplicate testing discrepancies
[50]Lamb *et al* 2016	To evaluate the impact of a policy to no longer	Canada	Before-after (pre-post) study	Urine culture was removed from the pre-operative order-set. Any samples received	Implement new policy to hold and discard samples according to protocol,	There was a 99% relative reduction in urine culture screen orders. Only 1	Urine cultures and antibiotic prescriptions decreased without any

Elimination of screening urine cultures prior to elective joint arthroscopy	process urine specimens from orthopedic preoperative clinics	Orthopedic surgery centre at one hospital 5414 elective joint surgeries	13 months	were held for 24 hours and discarded if no phone call from the preoperative clinic was received to obtain exemption according to new guidelines	and receive any phone call from preoperative clinic	telephone request to process a held sample was received.	increase in periprosthetic joint infection
[51]Yen *et al* 2018 *Reducing Clostridium difficile colitis rates via cost-saving diagnostic stewardship*	To evaluate the impact of an educational program and laboratory rejection protocol on hospital-acquired Clostridium difficile rates	United States One hospital All C. difficile nucleic acid amplification tests	Before-after (pre-post) study 12 months	Educational campaigns and two laboratory protocol changes. The first was test cancellation by the laboratory information system if more than 24 hours elapsed between sample receipt and order placement. The second involved the laboratory performing an assessment of stool consistency	Performing the assessment of stool consistency and cancelling the order when stool consistency was inconsistent with potential Clostridium difficile infection	They noticed a 60% reduction in false positive testing with no increase in delayed diagnosis	Fewer patients received inappropriate antibiotic treatment
[52]Epstein *et al* 2016 *Evaluation of a novel intervention to reduce unnecessary urine cultures in intensive care units at a tertiary hospital in Maryland, 2011-2014*	To evaluate the impact of a reflex urine culture protocol in intensive care units	United States 5 different intensive care units at one hospital All rates of urine culture set-up	Before-after (pre-post) study 15 months	In January 2013, a reflex urine culture protocol was implemented. This involved the laboratory performing a urinalysis, with culture only being performed if pyuria is present	Perform initial urinalysis and manually order urine culture if pyuria was detected	Urine culture rates were significantly decreased immediately, with a downward trend continuing during the post-intervention period	Unnecessary urine cultures were decreased
[53]Mozafarihashjin *et al* 2021 *Safety, effectiveness, and sustainability of a laboratory intervention to de-adopt culture of midstream urine samples among hospitalized patients*	To evaluate the impact of a reporting protocol change where culture results are released only when clinicians called the laboratory	Canada Medical and surgical units of a single tertiary hospital	Prospective study 6 years	Following information sessions, they implemented a system where the computerized order-entry system notified the laboratory to store rather than process midstream urine culture samples from participating hospital units	Change process so samples are properly stored when indicated, and receive phone calls according to clinician initiative	There were no patient deaths, prolonged hospitalization, or rehospitalization that could be attributable to not processing the midstream urine sample. Approximately half of the positive cultures represented asymptomatic bacteriuria. About 6% of patients avoided unnecessary antibiotic treatment, and about 0.5% avoided an antibiotic-associated adverse event	This intervention led to decreases in unnecessary antibiotic treatments and decreased laboratory resource use from avoiding processing of many specimens
[54]Marchand-Senecal *et al* 2020	To determine if rejection of low-quality wound	Canada	Before-after (pre-post) study	Standard operating procedure was changed to include rejection criteria based on	Evaluate the Gram stain of each wound swab specimen to determine	58% of wound swab specimens were low quality, and 68% of these were not	Laboratory workload and reagent use decreased. Antibiotic

Impact of rejection of low-quality wound swabs on antimicrobial prescribing: a controlled before-after study	swab specimens would reduce reflexive antibiotic initiation without negative patient consequences	Single tertiary hospital and long-term care home All wound swabs from adult patients	1 year	Gram staining. Specimens categorized as low-quality were resulted with a message that further processing was halted unless formally requested. These swabs were stored for 48 hours, and then discarded if not processed. This change was not broadly communicated outside of the laboratory	quality. The MLP would activate communication according to quality, and arrange for sample storage or further actions.	processed. Antibiotic prescriptions declined significantly for patients with low-quality swabs	prescribing because of positive culture results on low-quality specimens decreased.
[55]Procop *et al* 2019 *Operational aspects of a clinical decision support program*	Describe factors important to successful implementation of a clinical decision support program, and provide case examples	United States Since tertiary hospital	Review & Case study Various lengths approximately 2 years	There were 8 projects outlined, each representing different types of clinical decision support tools, such as hard stops, soft stops, restricted testing, expensive test notification, and three-day alerts	Communication as part of a Laboratory Client Services team that would field special requests or questions about the clinical decision support tools	All described projects resulted had specific lessons learned that could be applied to future interventions or interventions at other sites	Except for best practice alerts, which were ignored, all other clinical decision support projects resulted in cost savings (>$3 million USD) and avoided tests (~24,000) between 2017-2019
[56]White *et al* 2021 *Strategies for laboratory professionals to drive stewardship*	Propose a framework for implementing a laboratory stewardship program, and provide a case study	United States One 3-hospital system	Review & Quality improvement case study 6 months	A laboratory manager initiated a multi-pronged project to address inappropriate thyroid testing. The intervention included education, targeting high test users, and changing the order set	Initiate early discussions and project committee development, gather and present initial data, analyze data	Few physicians were responsible for most of the inappropriate ordering. A historical order set was being used instead of an algorithm. Changes improved appropriate of testing.	Not specifically measured

Chapter 4: Engaging laboratory staff in stewardship: Barriers experienced by medical laboratory technologists in Canada

An earlier version of this chapter was published in the Journal of Applied Laboratory Medicine 2022, 7(2):480-94

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Abstract:

BACKGROUND. Laboratory stewardship programs aim to improve the use of laboratory resources, including reducing inappropriate testing. These programs should engage all healthcare stakeholder groups, including all levels of laboratory staff. Medical laboratory technologists (MLTs) are highly skilled professionals and are well positioned to play a supportive role in stewardship, but may be overlooked. The aim of this study is to identify the barriers to MLT participation in stewardship activities.

METHODS. We developed and disseminated a self-administered survey to MLTs in Canada to assess their knowledge and attitudes towards inappropriate laboratory utilization, and explore perceived barriers to taking on an active role in stewardship initiatives. Themes were identified in open-ended responses and mapped to the Theoretical Domains Framework (TDF).

RESULTS. MLTs feel accountable for appropriate resource use, and recognize that it is an important issue to address. However, they experience significant barriers and have low intention to act. The self-reported barrier most frequently described was lack of time arising from excessive workloads, but other constraints exist. Themes mapped to the TDF most strongly in the domain of 'environmental context and resources', supporting evidence that workplace structure and culture play key roles in impacting this group.

CONCLUSIONS. To meaningfully engage MLTs in stewardship activities, these barriers should be addressed. Highlighting MLT expertise and creating communication structures for their unique contributions may be fruitful.

Introduction

On average, Canadians have 14-20 laboratory tests performed per capita annually. However, 20-50% of testing is inappropriately ordered.[1] This results in large amounts of wasted public healthcare spending, misdirected clinical effort, and the potential for patient harm.[2] The causes are multifactorial, and many centres have implemented some form of laboratory utilization management, such as establishing utilization committees. In the literature, interventional studies tend to target those who order the tests, such as physicians. Research investigating the role of laboratory professionals usually focuses on pathologists or doctoral-trained clinical staff. There is little exploration of potential roles for the other professionals who work in the laboratory, such as medical laboratory technologists (MLTs). These workers often describe themselves as being part of a 'hidden profession' which alludes to perceptions of low recognition and low external influence.[3-5] In Canada, the MLT scope of practice involves procuring and testing patient samples while employing and interpreting appropriate quality control measures.[6] MLTs are also responsible for communicating or transmitting results to the ordering practitioner.

There is a push to move from utilization management to laboratory stewardship. Stewardship is broader in scope, and involves careful responsible and ethical resource management from a wholistic, value-based perspective.[7] In healthcare, an early focus was on antimicrobial stewardship programs, which have successfully reduced antimicrobial resistance by improving the appropriateness of antimicrobial use.[8] Stewardship programs have evolved to incorporate culture and team.[9] Laboratory stewardship programs aim to ensure the correct test is performed at the correct time and avoiding unnecessary tests.[10] They are predicted to reduce both under- and over- testing and overspending.[11.12] Laboratory stewardship programs also attend to issues downstream of ordering, such as result retrieval and interpretation.[12] Focusing on clinical laboratory stewardship could be an antidote to historical focus on improving laboratory efficiency through consolidation and outsourcing.[10]

Despite the increasing application of stewardship principles to clinical laboratory resource issues, there are no published studies examining MLT willingness or ability to engage in stewardship. The National Committee for Laboratory Stewardship recently outlined core components of laboratory stewardship programs.[12] The recommendations include that

"laboratory staff at all levels" become involved. With respect to resource use interventions, MLTs are uniquely placed to communicate laboratory utilization recommendations, observe the impact of changes, and support modernized test ordering habits of other health professionals. Our primary research partner is the Canadian Society for Medical Laboratory Science (CSMLS), which is the national professional society and certification body for MLTs. The CSMLS intends to enact a campaign to engage their membership to participate in appropriate laboratory utilization initiatives.

The effectiveness of interventions increases when there is a multi-faceted understanding of local contexts.[13] The Theoretical Domains Framework (TDF) can be used to study behaviours and motivations in order to consider specific needs and behavioural influences of the target population.[14] The TDF is a validated distillation of multiple health behaviour theories into 14 distinct domains, and it is becoming increasingly popular when assessing and designing interventions or promoting professional behaviours.[14,15] The TDF provides an evidence-based approach to study barriers to behaviours across several domains that span multiple contexts, including individual, social, and environmental.[15] The TDF is now the most common framework used in initiatives seeking to de-implement tests and procedures that are inappropriate or low value.[16]

Little is known about the knowledge and attitude of MLTs towards current laboratory stewardship initiatives or whether they feel capable of influencing or participating in interventions. We aim to identify barriers to the participation of MLTs in initiatives that improve the utilization of laboratory services, and align these findings to the TDF. We also aim to learn more about perceptions of their professional role and accountability in such initiatives.

Methods

We developed a self-administered online survey of MLTs in Canada. Ethical approval was granted by both the University of Alberta Research Ethics Board and the CSMLS Ethics Board. There were multiple question formats, including agreement on a 5-point Likert scale and open-ended text response. The survey can be found in **Appendix C.** The electronic survey invitation was emailed to the CSMLS membership list in March 2019. The survey was available in French and English. Reminders were sent via social media and electronic newsletters. In addition to collecting demographic information, there were closed-response questions in four

areas: 1) knowledge and awareness; 2) attitudes and beliefs; 3) perceptions of responsibility and accountability; and 4) intentions towards participating in actions to improve laboratory utilization. An open-ended question asked: "If you wanted to become more involved in discussions or initiatives to address inappropriately ordered laboratory tests, what might prevent you from doing so?" Two authors (AV and VV) are MLTs, which provided subject matter expertise to ensure question applicability. The survey was pre-tested with a small (n=20) representative sample of the target population to assess understandability and question validity. At the time of survey distribution, there were 9,440 active CSMLS members who held an MLT designation. According to the Canadian Institute for Health Information, there were 20,048 working MLTs in Canada in 2019.[17]

Descriptive analysis of the quantitative Likert scale questions was performed using open-source statistical software jamovi.[18] We took an inductive approach to mapping the open-ended responses to the TDF, seeking first to identify themes in the responses. We used the Framework Method as described by Gale *et al* [19] to identify themes. This begins with the research team reading all responses, then assigning a brief conceptual label (code) to excerpts of text. This was completed for several responses to develop the working analytical framework that was then applied to the remainder of the responses. Two researchers independently identified codes. Regular discussions occurred to clarify code descriptions and resolve discrepancies. The codes arising were then categorized into broad themes with sub-themes. Operational definitions for each domain of the TDF were developed to reflect the study context. The relevance of each subtheme was considered against these definitions and then aligned with one or more of the theoretical domains, as described by Atkins *et al*.[14]

Results

We received 1504 surveys completed by MLTs. Surveys from respondents who solely answered demographic questions were excluded (n=204). 1300 complete and partially complete responses were included in the analysis. 908 surveys had responses to the open-ended question about barriers. Responses were gathered from every province and territory in Canada, and were highest from Ontario, the most populous region. The complete demographic profile is displayed in **Table 4.1**.

Results of Closed-Response Questions

Table 4.2 contains findings from closed-response survey questions. With respect to knowledge and awareness, only 31.2% of respondents correctly answered a question about the rate of inappropriate test ordering. The highest proportion underestimated this rate (42.4%). Only 10.5% have been directly involved with a formal committee or task force that addressed inappropriate utilization, and only 21.6% were aware of any local initiative or study. However, 71.1% reported discussing inappropriate utilization with a laboratory colleague within the past year. Discussions outside of this were less frequent, with 29.4% and 33.4% reporting discussions with pathologists and other healthcare professionals, respectively.

More than half believe that involvement is a valuable use of their time (55%), and they have an important role to play (70.6%). They also believe that initiatives are important (90.4%), and that resources should be devoted to them (77.6%). Over half (60.8%) of MLTs believe they can have a positive impact on laboratory ordering practices, but only 24.8% feel they have enough power to influence them. Many MLTs feel their colleagues and leadership team would support their involvement in initiatives to improve laboratory utilization, with 60.8% and 48.2% agreeing with these statements, respectively.

Over half (58.1%) of MLTs agreed with the statement "I feel a sense of accountability for helping to improve the appropriateness of laboratory test ordering." However, fewer (47.8%) feel it is part of their professional responsibilities. When asked about their intentions towards engaging in actions to improve laboratory utilization, only 14.9% of MLTs responded positively. The majority (58.3%) responded they 'didn't know'. While 57.1% of respondents agree that they are comfortable initiating conversations with other healthcare professionals about proper laboratory resource use, only 40.1% intend to have these conversations.

Analysis of Open-Ended Responses

We identified six themes and 16 sub-themes arising from the analysis of the open-ended question: "If you wanted to become more involved in discussions or initiatives to address inappropriately ordered laboratory tests, what might prevent you from doing so?" The themes were 1)Lack of Time; 2)Workplace Culture; 3)Power and Politics; 4)Hopelessness; 5)Lack of Opportunity; and 6)Deficit in Capacities. Theme definitions and sub-themes are found in **Table 4.3.**

Theme #1: Lack of Time

By far, the most frequently expressed sentiments relate to this theme. Over half of respondents (59.1%) reported constraints on their time. Many comments assert that adding more activity to the average workday would be impossible. One participant stated that *"I cannot express enough the pressure and workload I work under – it's excessive. I do my best to cope."* With some respondents, this was complicated by short-staffing issues and competing priorities. One respondent stated that "*we are very, very short staffed and don't have enough hours in the day to do the things we already strive to do."* Other sentiments in this theme related to concerns about maintaining work-life balance. For example, one respondent commented that *"I'm a bench tech and we don't have enough staff – we all work overtime weekly. I have no time or energy for anything extra. My family is suffering because of my workplace."*

Theme #2: Workplace Culture

In this theme, respondents described barriers related to lack of support from their co-workers. One respondent stated bluntly that the *"laboratory I work in would never consider addressing the subject."* Some also reported their leadership would not consider involving front-line staff in laboratory utilization issues. One participant stated that *"when you are a front-line bench worker, this is not a place that anyone seeks input into decisions. This process is left to those higher up so even if you wanted to be involved you would never be chosen to participate."* This theme also captures sentiments about peer expectations, where some MLTs felt as though engaging in utilization initiatives may be viewed as leaving more work for others. As one respondent put it, *"spending time or thoughts on anything outside of daily necessities is frowned upon. It's seen as if you are therefore leaving more work for someone else to try and cover and not pulling your weight."*

Theme #3: Power and Politics

In this theme, respondents described barriers related to the hierarchical nature of their workplaces. MLTs expressed concern about potential conflict with other care providers. One participant described *"the feeling that ordering tests is the domain of doctors, and lab professionals are just to do as ordered."* Another participant described *"fear of backlash from physicians, being that I work in a smaller rural hospital. Our physicians have the run of the*

place." Perceptions of little influence or importance in the healthcare hierarchy were mentioned from both the individual and institutional perspective. For example, one participant expressed that *"unfortunately in the lab environment, we generally are not heard by nurses and physicians."* Another participant worried that *"we won't be taken seriously by other non-lab professionals."* One respondent stated simply that they *"feel inferior to other medical professionals."*

Theme #4: Hopelessness

In this theme, respondents expressed disbelief that positive outcomes were likely. At times, this was in response to previous failures, as described by a participant who stated that there is *"nothing actually being done when the initiative or discussion takes place."* MLTs may not want to exert effort when there is a *"feeling like it wouldn't accomplish anything."* One participant mused that *"I think a certain amount of apathy exists, that nothing will ever change because we are only the lab – nameless, faceless, unimportant people in healthcare."* Related to this pessimism was the concern that reducing unnecessary testing would translate to job loss. One respondent worried that *"it is hard enough to find jobs with provincial budget cuts. Less testing will result in decreased workload and less staffing."*

Theme #5: Lack of Opportunity

In this theme, respondents described barriers related to the nature of their job that limit access to opportunities. Some respondents mentioned unpredictable work schedules impeding necessary collaboration, such as one who reported that "*shift work makes me unavailable when meetings may be held."* Others worked at rural or specialized testing sites, where *"smaller labs with specific testing are often left out of discussions."* Within this theme, the constraints related to the MLT scope of practise were perceived to be a barrier. One respondent described that *"regulatory structures in Canada silence the role of the medical laboratory technologist in any form of constructive decision making."* Another respondent stated that *"this would be considered 'out of the scope of the job' to initiate on my own."*

Theme #6: Deficit in Capacities

In this theme, respondents described barriers brought on by gaps in knowledge or skills they felt were necessary. Respondents were willing to be involved, but may lack information, such as an MLT who stated: *"I lack the knowledge and access to data in my role."* Another respondent stated they are *"not sure where to start or how to become involved."* Some worried they lacked specific skills or knowledge. For example, one MLT indicated they did *"not have a broad enough understanding of the ordering of testing by physicians and how to improve the process."*

Mapping to the Theoretical Domains Framework

The sub-themes mapped most strongly to the 'environmental context and resources' domain of the TDF (**Table 4.4**). This domain considers external factors related to the working culture and climate that impact behaviours. Eight of the sub-themes mapped to this domain, including those related to the most frequently related theme of 'Lack of Time'. Four sub-themes were each mapped to two domains: 'social/professional role & identity' and 'social influences. The 'social/professional role & identity' domain considers the extent to which individuals align a certain behaviour within the perceived boundaries of their role. The 'social influences' domain considers the impact of interpersonal factors on the behaviour. The sub-themes also mapped, but less strongly, to the domains of: 1)knowledge; 2)skills; 3)beliefs about capabilities; 4)beliefs about consequences; and 5)emotion.

Discussion

MLTs were surveyed about their knowledge and perceptions about the issue of inappropriate laboratory utilization, and about their attitudes and intentions towards participating in actions addressing this issue. The results were illuminating and overall describe a population that agrees that it is an important issue, feels a sense of accountability towards ensuring wise resource use, but experiences knowledge deficits and significant barriers when considering involvement in improving the situation. MLTs reported recent discussions about the issue were occurring, though mostly with colleagues rather than pathologists or other healthcare professionals. Thus, MLTs may view themselves as stewards of laboratory resources, but feel they are unable to take on an active stewardship role. This is particularly concerning in a profession that is in some level of tumult as suggested with high burnout [4] and low career

commitment.[5,20] There is a connection between being able to act as a steward and ensuring that a profession remains vibrant, able to respond to change, and relevant.[21] Efforts to enhance a sense of stewardship in this professional group are warranted.

We found the most significant barrier to be lack of time. Overwhelmingly, MLTs reported feeling too busy and overworked to participate in improving laboratory utilization. In many areas of Canada, there is a shortage of qualified MLTs, and it is predicted that this situation will worsen, suggesting that this will remain a significant barrier for the foreseeable future.[22] Robust laboratory stewardship programs have strong potential to reduce waste and patient harm. As such, this should provide financial incentive to ensure adequate compensation for clinician participation in stewardship initiatives, least of which is ensuring proper staffing levels so there is time for this activity.[23] Further research is needed on existing stewardship programs to quantify benefits.

We found that many MLTs felt intimidated by the possibility of opposition from their managers and other healthcare providers, particularly physicians. Hierarchies within healthcare are well established. Our findings support the notion that many MLTs view themselves as service agents who can only respond rather than being proactive or involved in decision-making. Pessimism was noted in many survey responses. However, laboratory testing menus have increased considerably, and new tests and testing algorithms are being developed at a rapid pace.[24] There is a call for pathologists and doctoral-level laboratory clinicians to increase their external consultation activities.[12,25-26] While MLTs in Canada are not qualified to inform diagnostic decision-making, they can offer unique knowledge on the testing process and algorithms, the impact of testing changes, alternatives to antiquated tests, the effect of interferences and sample instability, and frontline acceptance of interventions.[27] MLTs may not even be aware of their specific expertise because of infrequent opportunity to demonstrate it, which may be partially due to an indistinct professional identity.[28] When seeking information relating to testing, asking a laboratory professional is uncommon.[29] In a recent study, after collaborative working opportunities, healthcare practitioners had a greater appreciation and respect for laboratory expertise and improved receptiveness for laboratory professional involvement in appropriate test utilization.[30]. However, other research has demonstrated that MLTs are not an effectively utilized resource because the laboratory is seen as too confusing or

time-consuming to navigate.[31] There is a need for more formalized communication structures that highlight the type of information that MLTs can offer, alongside an increased focus on ways that MLTs can contribute in non-outward facing roles.[32] This may be a significant challenge as many MLTs have limited direct contact with other healthcare professionals even when they work in a hospital. Some clinical laboratories in urban centres are free-standing testing facilities, limiting opportunities for direct interaction even further.

We used an inductive approach with identifying relevant domains in the TDF. McGowan *et al* [33] cautions against rigid adherence to the TDF in explorative stages to avoid limiting the identification of non-TDF ideas. As stated previously, little is known about MLT behaviour and attitudes with respect to laboratory utilization issues. However, the use of the TDF in our study as a scaffold for emerging themes supports an emphasis on environmental context, interpersonal influences, and role constraints that arose through other survey findings. The TDF mapping can be used by organizations to provide starting points for interventions to increase MLT engagement and participation in resource use initiatives.

We were limited by the inability to probe open-ended responses. It is likely that only the most frequent or top of mind barriers were identified. In addition, the results cannot be described as representative, and proper cautions must be applied to the interpretation. When compared with available Canadian workforce demographic data from 2019 [17], the high proportion of female sex aligns with our survey respondent population. However, there are no current available statistics about racial or ethnic composition of MLTs in Canada. When exploring perceptions of power, under-sampling of visible minorities may skew the results. Important barriers may remain hidden, and targeted research is needed. While we were likely able to identify significant barriers for this population, more research is needed to understand the extent to which MLTs experience these barriers. In addition, the structure of clinical laboratory service delivery is different across Canada. Considering the large geographical coverage spanning multiple governmental policies, the barriers may be quite different in different jurisdictions. The current survey results provide a starting point for organizations seeking to understand if specific barriers are at play in their local environment.

Conclusion

Most MLTs feel a sense of accountability for ensuring the appropriate use of laboratory resources, and are optimistic about their potential for positive impact. However, many feel as

though they lack power, time, and organizational support to affect change. Very few MLTs have been involved with formal initiatives to address inappropriate laboratory utilization, and some have had negative experiences when attempting to directly address issues with the ordering practitioner. Taken together, this suggests that efforts to create purposeful campaigns or structures that promote the unique expertise that MLTs can provide to healthcare teams may be fruitful. Laboratory leadership can help identify and create opportunities for MLTs to engage in stewardship in collaborative – rather than confrontational – roles. Ultimately, this must occur against a backdrop of systems working to address human resource shortages and staff burnout.

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Table 4.1: Demographic Profile of Survey Respondents

Location	Number	Percent
Alberta	196	15.1%
British Columbia	176	13.6%
Manitoba	146	11.3%
New Brunswick	95	7.3%
Newfoundland	44	3.4%
Northwest Territories	4	0.3%
Nova Scotia	147	11.4%
Nunavut	1	0.1%
Ontario	344	26.6%
Prince Edward Island	14	1.1%
Quebec	36	2.8%
Saskatchewan	74	5.7%
Yukon	3	0.2%
Ethnicity		
Asian	112	8.6%
Black	18	1.4%
Caucasian	1041	80.2%
Hispanic	8	0.6%
Indigenous	24	1.8%
Middle Eastern	16	1.2%
Pacific Islander	2	0.2%
Prefer not to say	77	5.9%
Years of Experience		
0-10 years	440	33.9%
11-20 years	230	17.7%
21 or more years	627	48.3%
Sex		
Female	1084	84.4%
Male	171	13.3%
Prefer not to disclose	29	2.3%

Table 4.2: Responses to Closed Survey Questions

Survey Question	Results
Knowledge and Awareness	
Approximately what percentage of laboratory testing do you believe is over-ordered?	42.2% believe that less than 20% of tests are over-ordered 31.2% believe that 21- 30% of tests are over-ordered 26.7% believe that more than 30% are over-ordered
Have you heard of Choosing Wisely Canada?	39.7% of respondents answered 'YES'
Have you ever served on a committee or task force that addressed inappropriate laboratory utilization?	10.5% of respondents answered YES
Has your laboratory been part of any study or initiative that addressed inappropriate laboratory utilization?	21.6% of respondents answered YES 46.5% of respondents answered DON'T KNOW
Within the past year, have you discussed inappropriate laboratory utilization with another medical laboratory professional?	71.1% of respondents answered 'YES'
Within the past year, have you discussed inappropriate laboratory utilization with a pathologist?	29.4% of respondents answered 'YES'
Within the past year, have you discussed inappropriate laboratory utilization with another healthcare professional?	33.4% of respondents answered 'YES'
Attitudes and Beliefs	
Becoming involved in initiatives aimed at curbing inappropriate laboratory test ordering would be a valuable use of my time	55.0% of respondents AGREE or STRONGLY AGREE 33.7% of respondents were NEUTRAL
Do you believe that initiatives to limit inappropriate testing are important?	90.4% of respondents answered YES 7.1% of respondents answered UNSURE
Non-physician medical laboratory professionals have an important role to play in curbing inappropriate laboratory test ordering	70.6% of respondents AGREE or STRONGLY AGREE 18.3% of respondents were NEUTRAL
I can have a positive impact on laboratory ordering practises by participating in initiatives to curb inappropriate laboratory utilization	60.3% of respondents AGREE or STRONGLY AGREE 29.3% of respondents were NEUTRAL
Do you believe that inappropriate laboratory utilization may contribute to patient harm?	58.7% of respondents answered 'YES' 22.9% of respondents answered 'UNSURE'
Do you believe that resources (time and money) should be devoted to researching inappropriate laboratory utilization?	77.6% of respondents answered 'YES' 13.2% of respondents answered 'UNSURE'
Non-physician medical laboratory professionals have enough power to influence laboratory test ordering practises	24.8% of respondents AGREE or STRONGLY AGREE 23.5% of respondents were NEUTRAL

My colleagues would support me if I wanted to become involved in initiatives aimed at curbing inappropriate laboratory test ordering	60.8% of respondents AGREE or STRONGLY AGREE 30.1% of respondents were NEUTRAL
My laboratory leadership team would support me if I wanted to become involved in initiatives aimed at curbing inappropriate laboratory test ordering	48.2% of respondents AGREE or STRONGLY AGREE 34.4% of respondents were NEUTRAL
Perceptions of Responsibility and Accountability	
Who do you believe should be responsible for ensuring that laboratory tests are appropriately utilized?	Respondents assigned the category of 'significant responsibility' to: the pathologist (77.8%), the ordering physician(69.9%), PhD-trained laboratory clinicians(64.5%), laboratory directors (48.4%). Respondents assigned the category of 'some responsibility' to: MLTs (59.8%), laboratory supervisors (51.4%), federal government (45.7%), provincial government (44.8%).
Becoming involved in initiatives aimed at curbing inappropriate laboratory test ordering is part of my professional responsibilities	47.8% of respondents AGREE or STRONGLY AGREE 35.2% of respondents were NEUTRAL
I feel a sense of accountability for helping to improve the appropriateness of laboratory test ordering	58.1% of respondents AGREE or STRONGLY AGREE 30.2% of respondents were NEUTRAL
Intentions	
Do you intend to be involved in initiatives or actions that address inappropriate laboratory utilization?	14.9 % of respondents answered 'YES' 58.3% of respondents answered 'DON'T KNOW'
I intend to have conversations about inappropriately ordered laboratory tests in my workplace with other healthcare professionals	40.1% of respondents AGREE or STRONGLY AGREE 39.1% of respondents were NEUTRAL
I am comfortable initiating conversations about inappropriately ordered laboratory tests in my workplace with other healthcare professionals	57.1% of respondents AGREE or STRONGLY AGREE 23.9% of respondents were NEUTRAL

Table 4.3: Themes arising from open-ended question: If you wanted to become more involved in discussions or initiatives to address inappropriately ordered laboratory tests, what might prevent you from doing so?

Theme	Sub-theme	Description
Lack of Time – *mentioned by 59% of respondents*	Too Busy	Respondents perceived that they were overly busy at their work and could not take on any extra projects or duties. This lack of time was attributed to a variety of factors, such as understaffing or too much work.
	Work-Life Balance	Respondents perceived that engaging in extra activities would take away from their free time and disrupt the balance the desired between personal time and work time.
	Unwilling to volunteer	Respondents felt that becoming involved in initiatives would result in unpaid labour.
Workplace Culture – *mentioned by 14.6% of respondents*	Lack of engagement from management	Responses here refer to the perception that management or supervisors would not be receptive or supportive towards this work.
	Lack of support from peers	Responses here refer to the perception that peers might react negatively towards the respondent's engagement in the work.
Power and Politics – *mentioned by 15.7% of respondents*	Obstacles Related to Physicians	Responses here refer to the perception that attempts to engage in this behaviour would result in backlash or roadblocks set up by physicians. There may be a belief that physicians view this work as confrontational or would outright dismiss any attempt to engage with them on matters relating to inappropriate test ordering.
	Organizational Priorities	Responses here refer to the idea that the greater organization has priorities that are not aligned with improving the appropriateness of laboratory testing.
	Lack of Influence	Responses here refer to the perception that the MLP has a lack of power to influence processes or outcomes.
Hopelessness – *mentioned by 8.1% of respondents*	Feeling like Change Won't Happen	Responses here refer to the perception that any effort to reduce inappropriate ordering will ultimately be fruitless because system-wide change is impossible.
	Apathy and Disillusionment	Responses here convey a sense of giving up because of negative previous experiences.
	Fear of Job Loss	Responses here refer to the perception that engagement in initiatives to reduce the inappropriateness of laboratory test ordering will result in the need to also reduce staffing.
Lack of Opportunity – *mentioned by 10.9% or respondents*	Location or Size Constraints	Responses here refer to the constraints imposed by the respondent working at a site that was too remote or too small to be involved in any initiative.
	Professional Role Constraints	Responses here refer to the respondent perceiving that they might not be involved because it was either outside of their professional scope of practise, or that this type of involvement only occurs at a management or supervisory level.
	Nature of Scheduling Constraints	Responses here refer to the respondent feeling that because they do not work traditional hours that it would be too difficult to be involved with initiatives.

Deficit in Capacities ***– mentioned by 12.1% of respondents***	Deficit in knowledge	Responses here indicate a willingness to be involved, but there may be an inability to access the right type of information that is required to understand the problem or make meaningful contributions in content.
	Deficit in skill	Responses here indicate a willingness to be involved, but the skill set in how to approach or study the problem is lacking.

Table 4.4: Open-Ended Response Themes Mapped to Theoretical Domains

Domain & Operational Description	Themes Mapped
Knowledge *Awareness and understanding of the issue of inappropriate laboratory utilization*	1. Deficit in knowledge
Skills *Ability or proficiency in relevant skills to participate in improving laboratory utilization, including interpersonal skills*	1. Deficit in skill 2. Obstacles related to physicians
Social/Professional Role & Identity *Coherent set of behaviours and qualities ascribed to a professional role or professional/group identity that permits participation in improving laboratory utilization*	1. Professional role constraints 2. Obstacles related to physicians 3. Lack of influence 4. Lack of support from peers
Beliefs about capabilities *Professional confidence, or facility or ability that can be put to constructive use to contribute meaningfully*	1. Obstacles related to physicians 2. Deficit in knowledge 3. Deficit in skill
Optimism *Confidence that things will happen for the best and that goals can be attained*	• None
Beliefs about consequences *Acceptance of the truth, reality, or validity about outcomes because of participation in improving laboratory utilization*	1. Feeling like change won't happen 2. Fear of job loss
Reinforcement *Increasing likelihoods of participating in improving utilization because of continuing positive experiences*	• None
Intentions *Conscious decisions to engage in improved laboratory utilization*	• None
Goals *Holding clear mental representations of outcomes that an individual wants to achieve because of participating in improving laboratory utilization*	• None
Memory, attention, and decision processes *The ability to retain information and choose between alternatives in how to approach improving laboratory utilization*	• None
Environmental context & resources *Any circumstance, culture, or climate of the environment that encourages or discourages participating in improving laboratory utilization*	1. Too Busy 2. Lack of engagement from management 3. Organizational priorities 4. Nature of scheduling constraints 5. Obstacles related to physicians 6. Work-life balance 7. Location or size constraints 8. Lack of influence
Social influences *Interpersonal processes, pressures, norms, and support that impact perceptions of whether to engage in improving laboratory utilization*	1. Lack of support from peers 2. Lack of engagement from management 3. Lack of influence 4. Obstacles related to physicians
Emotion *Reaction pattern when considering involvement with trying to become more involved with improving laboratory utilization*	1. Apathy and Disillusionment 2. Obstacles Related to Physicians 3. Feeling like Change Won't Happen
Behavioural Regulation *How an individual manages their behaviours with respect to improving laboratory utilization*	• None

Chapter 5: Using the Behaviour Change Wheel to Inform the Development of LabWisely.ca

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Additional Author: Laura Zychla

Manuscript type: Letter to the editor or short report

Introduction and Methods

Laboratory stewardship programs have been proposed to shift the conversation from ordering-practitioner focused interventions to a more wholistic approach that examines the entire cycle of test ordering to sustainably preserve clinical laboratory resources and maximize value for patients. Evolution of stewardship programs, such as those that address antimicrobial resistance, demonstrate enhanced effectiveness when all healthcare stakeholder groups are engaged and empowered to act to their full capacity.[1] Medical laboratory technologists (MLTs) are highly skilled professionals and are well positioned to play a supportive role in stewardship activities, but face several psychological, social, and physical barriers when considering action.

In a recently published study[2], we reported on our efforts to identify and characterize these barriers. In addition to several closed-response questions, we asked an open-ended question *'If you wanted to become more involved in discussions or initiatives to address inappropriately ordered laboratory tests, what might prevent you from doing so?'* From 908 respondents across Canada, the most frequent self-reported barrier was lack of time, but workplace culture, existing hierarchies, feelings of hopelessness, lack of opportunity, and perceived lack of capability were also reported. These findings were mapped to the Theoretical Domains Framework (TDF).[3] The top three domains of the TDF were 'environmental context and resources', 'social/professional role and identity', and 'social influences', indicating that it is important to consider how the working environment, professional identity, and social structures might constrain or support efforts of this population to engage effectively in addressing inappropriate testing.

In our recently published work[2], we used the TDF to help organize and categorize the themes we uncovered. However, understanding the factors that influence behaviours alone does not result in behaviour change. This understanding needs to be shaped into effective and targeted interventions.[4] A distinct benefit of using the TDF is that it can be further linked to tools that help identify interventions that are the most effective in the population of interest because they are tailored to need. One tool is the Behaviour Change Wheel (BCW), which is a framework synthesized from several theories and methods.[5] The BCW is centred on the capability, opportunity, and motivation model of behaviour (COM-B). These three components interact to support behaviours. The TDF domains each feed into one of the COM-B components. Each COM-B component in turn links to intervention functions. The process of mapping findings to the TDF and using the BCW to guide researchers to contextually important interventions has been validated in several settings[6], including antimicrobial stewardship programs.[7]

We used the "The Behaviour Change Wheel: A Guide to Designing Interventions" handbook by Michie *et al* [4] to guide our process of mapping relevant TDF domains to the BCW. Briefly, operational definitions of each TDF domain were created to fit the specific context. Then, the themes arising from our qualitative analysis were evaluated to see where they fit according to the operational definitions. Frequency of theme from the population and the number of themes linked to each domain indicates the importance of the domain itself. TDF domains identified as important are read on the BCW (**Figure 5.1**), followed by the intervention function matrix (**Figure 5.2**). The intervention functions are associated with many possible behaviour change techniques that can be used to impact behaviours.

Results

Table 5.1 displays the TDF domains along with the associated behavioural components and suggested intervention functions. While all three behavioural components are represented, most themes identified in our study eventually link to the 'opportunity-physical', 'opportunity-social' and 'motivation-reflection' components of the COM-B model. Opportunity relates to having the time, material, and financial resources to act, but also ways that individuals and institutions can support action. Motivation refers to having the will to do something differently, and the reflective aspect involves a level of planning and evaluation. **Table 5.2** elaborates on these intervention functions to suggest intervention options in the context of increasing MLT participation in stewardship activities.

Discussion

MLT participation in stewardship activities is an under-researched topic that is only beginning to be explored. The barriers to MLT participation in laboratory stewardship activities have multiple influences. It follows that a multi-faceted intervention approach should be used to increase MLT participation. The target behaviour is increasing MLT participation in laboratory stewardship activities, which is broad and difficult to measure. Implementation may be more straightforward if it focuses on discrete and measurable behaviours,[3] such as stopping the practice of drawing extra tubes of blood or educating other healthcare providers about test performance limitations.

Case Study

Use of the BCW provides focus for organizations that want to encourage this stakeholder group to be a more active stewards of laboratory resources. We bring a case example of our efforts to address some of these identified barriers. The initiative is called Lab Wisely, and is a collaboration between the Canadian Society for Medical Laboratory Science (CSMLS) and the University of Alberta. To date, we have created tools and resources that are linked to training, education, enablement, persuasion, and modelling. For example, for 'modelling', we published a series of articles highlighting laboratory utilization projects in Canada that explicitly involved laboratory professionals.[8-10] For 'education', we created infographics about various aspects of inappropriate laboratory utilization. For 'training', we developed a mini-course about interprofessional communication. For 'enablement', we created a presentation slide deck that professionals can use to increase awareness of inappropriate laboratory utilization and Lab Wisely at their local sites. The CSMLS created a website (www.LabWisely.ca)[11] as a central repository where these tools and resources can be accessed, and infographics and posters can be downloaded. This website and CSMLS social media pushes also touch on the intervention function 'persuasion' by disseminating broad messaging. We aim to evaluate engagement over time. We recommend that institutions use our exploration as a starting point for their own behavioural diagnosis and intervention activities in this population.

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Figure 5.1: Behaviour Change Wheel with Theoretical Domains

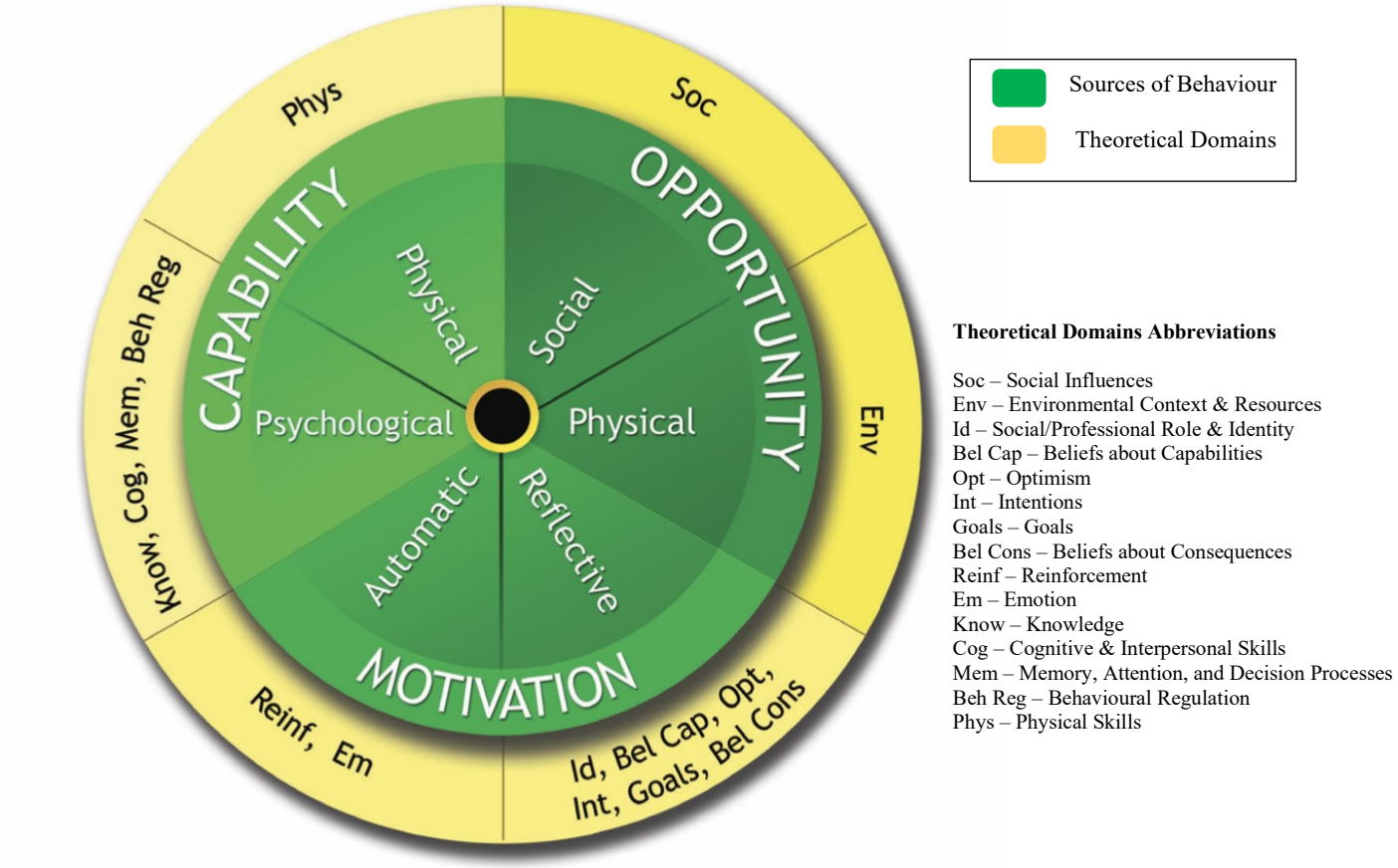

Figure used with permission from *Michie S, Atkins L, West R. (2014) The Behaviour Change Wheel: A Guide to Designing Interventions. London: Silverback Publishing. www.behaviourchangewheel.com.*

Figure 5.2: Capability, Motivation, and Opportunity Matrix with Intervention Functions

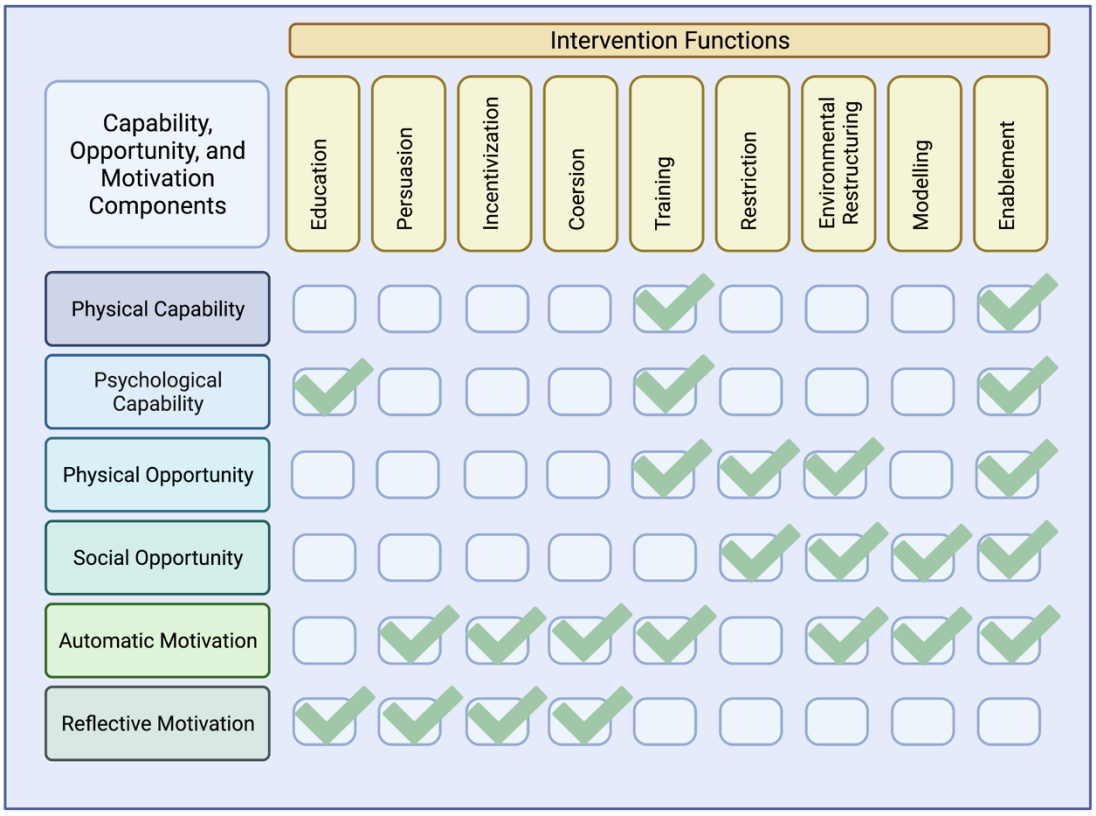

Figure created with Biorender.com, adapted from *Michie S, Atkins L, West R. (2014) The Behaviour Change Wheel: A Guide to Designing Interventions. London: Silverback Publishing. www.behaviourchangewheel.com*

Table 5.1: Mapping Research Themes and TDF* Domains to Intervention Functions via the Behaviour Change Wheel

Theoretical Domain with Operational Description	Source of Behaviour	Feasible Intervention Functions	Themes Mapped
Strong Mapping			
Environmental context & resources Any circumstance, culture, or climate of the environment that encourages or discourages participating in improving laboratory utilization	Opportunity - Physical	• Training • Restrictions • Environmental Restructuring • Enablement	1. Too Busy 2. Lack of engagement from management 3. Organizational priorities 4. Nature of scheduling constraints 5. Obstacles related to physicians 6. Work-life balance 7. Location or size constraints 8. Lack of influence .
Moderate Strength Mapping			
Social/Professional Role & Identity Coherent set of behaviours and qualities ascribed to a professional role or professional/group identity that permits participation in improving laboratory utilization	Motivation - Reflective	• Education • Persuasion • Incentivization	1. Professional role constraints 2. Obstacles related to physicians 3. Lack of influence **4.** Lack of support from peers
Social influences Interpersonal processes, pressures, norms, and support that impact perceptions of whether to engage in improving laboratory utilization	Opportunity - Social	• Restrictions • Environmental Restructuring • Modelling • Enablement	1. Lack of support from peers 2. Lack of engagement from management 3. Lack of influence 4. Obstacles related to physicians
Low Strength Mapping			
Knowledge Awareness and understanding of the issue of inappropriate laboratory utilization	Capability - Psychological	• Education • Training • Enablement	1. Deficit in knowledge
Physical Skills	Capability - Physical	• Training • Enablement	1. Deficit in skill 2. Obstacles related to physicians

Ability or proficiency in relevant skills to participate in improving laboratory utilization, including interpersonal skills			
Beliefs about capabilities Professional confidence, or facility or ability that can be put to constructive use to contribute meaningfully	Motivation - Reflective	• Education • Persuasion • Incentivization	1. Obstacles related to physicians 2. Deficit in knowledge 3. Deficit in skill
Beliefs about consequences Acceptance of the truth, reality, or validity about outcomes because of participation in improving laboratory utilization	Motivation - Reflective	• Education • Persuasion • Incentivization	1. Feeling like change won't happen 2. Fear of job loss
Emotion Reaction pattern when considering involvement with trying to become more involved with improving laboratory utilization	Motivation - Automatic	1. Persuasion 2. Incentivization 3. Training 4. Environmental Restructuring 5. Modelling 6. Enablement	1. Apathy and Disillusionment 2. Obstacles Related to Physicians 3. Feeling like Change Won't Happen

*TDF=Theoretical Domains Framework

Table 5.2: Examples of Behaviour Change Techniques for Medical Laboratory Professionals

Feasible Intervention Function	Potential Behaviour Change Technique
Training	Imparting skills. Provide opportunities to build and practice skills that can be used in laboratory stewardship activities, such as public speaking, speaking persuasively, conducting research or audits.
Enablement	Providing support to improve likelihood of action. Establish an advocacy program that provides tools for individual MLPs to advocate in their local environments, such as a presentation slide deck and promotional materials.
Environmental Restructuring	Changing the context by shaping the physical and social environment. Create different types of committees that can be struck to tackle inappropriate utilization of laboratory services. Normalize participation as part of regular workload.
Education	Increasing understanding. Provide professional learning modules on gaining a deeper understanding of the contributors to inappropriate laboratory utilization and the potential roles of MLPs in initiatives.
Persuasion	Using influential communication. Disseminate broad messages to increase awareness and spread key messages using a variety of modes, such as posters, social media, website, etc.
Incentivization	Create rewards and change the attractiveness of being involved in stewardship activities. Develop a utilization champion program that publicizes the work of individuals and organizations
Modeling	Providing examples for people to aspire to. Publish a series of articles in the Canadian Journal for Medical Laboratory Science that highlight MLPs participating successfully in initiatives to improve the utilization of laboratory resources

Chapter 6: Causes of inappropriate laboratory test ordering from the perspective of medical laboratory technical professionals: implications for research and education.

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Abstract

Inappropriate laboratory test ordering is a significant and persistent problem. Many causes have been identified and studied. Medical Laboratory Professionals (MLPs) are technical staff within clinical laboratories who are uniquely positioned to comment on why inappropriate ordering occurs. This may reveal new or underemphasized interventional targets. We developed and disseminated a self-administered survey to MLPs in Canada, including open-ended responses to questions about the causes of inappropriate laboratory test ordering. Four primary themes arose: ordering-provider factors, communication factors, existing test-ordering processes, and patient factors. While the causes identified by MLPs can be found in previous literature, MLPs emphasized factors that are not typically featured in commonly promoted utilization management tools. Their insights into non-physician triage ordering and poor result communication provide targets for further investigation, as these are under-studied. A heavy focus on individual clinician factors suggests that current understandings and interprofessional skills in the MLP population can be improved.

MeSH index terms: Clinical Laboratory Services, Medical Laboratory Personnel, Medical Laboratory Science, Allied Health Occupations, Interprofessional Skills

Introduction

Laboratory testing is the most common diagnostic procedure in Canada. However, an estimated 20-50% of testing is inappropriately ordered.[1] Inappropriate testing results in large amounts of wasted resources, misdirected clinical effort, and the potential for patient harm.[2] The causes are numerous, overlapping, and intersecting. Research into contributing factors demonstrates that there is a mix of healthcare professional, patient, and system factors.[3] Healthcare systems globally are responding with a wide variety of interventional approaches, with some having greater success than others. Evidence arising from current reviews encourages approaches that include administrative or computerized strategies that limit access to inappropriate tests.[4-7] For example, ordering forms or processes could be adjusted to prevent ordering a test more inconsistent with guidelines. Interventions could be supported by complementary means, such as providing peer practice variation metrics, educational sessions, or audit and feedback.[4] Despite some gains, inappropriate testing remains a persistent and widespread issue, and the sustainability of interventions is largely unknown.[5,6]

Medical laboratory professionals (MLPs), often called scientists, technologists, technicians, or technical assistants, are underrepresented in literature related to inappropriate laboratory utilization. Unsurprisingly, the predominant intervention target is the test-ordering practitioner, as they steer the trajectory of testing being conducted. Recommended contributions from those in the laboratory are usually focused on high-authority actors, such as pathologists, managers, or PhD-trained clinical scientists. The scope of practice of MLPs in Canada includes the collection and performance of ordered tests, validation and communication of test results, and management of quality assurance processes.[8] For this article, we use the term MLP to encompass multiple designations, primarily Medical Laboratory Technologist (MLT) and Medical Laboratory Assistant (MLA). In general, an MLT has received a baccalaureate degree or diploma from an accredited training program and is required to be certified to practice in Canada. An MLA is typically trained at a vocational or private institution, and certification is not universally required across Canada.[9] There is some overlap in scope of practice, but MLAs tend to focus on pre-analytical activity while MLTs have significantly more oversight and involvement in analytical processes and quality management.[10] MLPs work directly with ordering practitioners and systems, as well as with healthcare professionals tangentially involved with test orders. Recent studies have explored the perceptions of other healthcare professionals,

such as physicians, nurses, and advanced practice providers, about why they believe inappropriate laboratory testing occurs.[11,12] However, the observations arising from MLP experience in relation to the contributing factors of inappropriate laboratory test-ordering has not been investigated. The purpose of this study is to characterize existing MLP perceptions in this domain, which may reveal new or understudied targets for improvement activities.

Materials and Methods

We developed a self-administered online survey of MLPs in Canada, which was to evaluate behaviours, knowledge, and attitudes of MLPs with respect to their participation in laboratory stewardship.[13] The survey also examined MLP perspectives of external factors that contribute to inappropriate laboratory testing, which is analyzed and discussed here. Ethical approval was granted by both the ethics boards of University of Alberta and the Canadian Society for Medical Laboratory Science (CSMLS), which is the national certifying body and professional society for MLPs in Canada.[14] The survey was sent to the active members of CSMLS in March 2019 and was available in French and English. Reminders were sent via social media, electronic newsletters, and direct emails. An open-ended question asked: "What do you believe are the primary reasons for over-ordering of laboratory tests?" The survey was pre-tested with a small (n=20) sample of the target population to assess understandability and question validity. At the time of survey distribution, there were 9,440 active CSMLS members with an MLT designation, and 1,833 who held an MLA designation.[15] According to the Canadian Institute for Health Information, there were 20,048 working MLTs in Canada in 2019.[16] There is no database that tracks practicing MLAs, as in most jurisdictions they are not required to be registered.

Descriptive analysis of the quantitative demographic questions was performed using open-source statistical software jamovi.[17] We used the Framework Method as described by Gale *et al* [18] to identify themes in the open-ended question. This begins with the research team reading all responses, then assigning a brief conceptual label (theme) to excerpts of text. This was completed for 50 responses to develop the working analytical framework that was then applied to the remainder of the responses. Two researchers independently identified codes. Regular discussions occurred with any discrepancies solved by clarifying theme descriptions. The codes arising were then categorized into broad themes with sub-themes.

Results

We received 1161 surveys from MLPs with responses to the open-ended question about reasons for inappropriate ordering. 151 respondents provided more than one reason. Most respondents hold the professional designation of Medical Laboratory Technologist. Responses were gathered from every province and territory in Canada, and were highest from Ontario, the most populous region. The complete demographic profile is displayed in **Table 6.1**.

There were four major themes identified in the open-ended responses. Ordered by frequencies, they were: ordering provider factors (72%), coordination factors (22%), ordering process factors (15%), and patient factors (4%). These themes along with associated subthemes and definitions are found in **Table 6.2.**

Theme 1: Ordering Provider Factors

Most respondents mentioned a cause directly attributed to the ordering provider (physician, nurse practitioner, pharmacist, etc.), including characteristic, confidence, or capability. Many respondents felt as though clinician training or professional development in laboratory medicine is inadequate, particularly in the context of advancements in testing and/or testing parameters. For example, respondents remarked that clinicians may lack *"education about the benefits of newer and more accurate testing methods,"* or may not be aware of the "*validity of certain tests when diagnosing their patients."*

This knowledge gap was also thought to be related to clinical competency, particularly with less experienced ordering providers. One respondent stated that they see "*new [clinicians] order everything to try to catch something abnormal that might explain the clinical picture."* This type of sentiment is echoed in the sense that some ordering providers may lack confidence and are using "*tests to make a diagnosis rather than to support a diagnosis."* This is closely related to the label of *"shotgun medicine*" that many participants indicated in their response. At times, this approach to testing was given in the context of a fear of litigation, or a lack of time. As one respondent described: "*Doctors don't have enough time to spend with patients to determine the true cause of the complaint, so they blanket order tests to cover all bases."* In some responses, participants linked this defensive ordering approach to cost. If testing is viewed as cheap and plentiful, there is no need to consider restrictions. Frustration was noted frequently,

as illustrated by a respondent lamenting that ordering providers *"undervalue how much a lab test costs in labour hours and transportation costs."*

Some respondents perceived that inappropriate testing is performed because of ingrained ordering practices. As one respondent put it, *"it's habit. Clinicians order the same tests that were ordered last time, or the same set of tests for all their patients."* This was not necessarily attributed to individual ordering providers, but occasionally departments. The emergency department was frequently singled out. For instance, a respondent described that *"the emergency department orders the same things on everybody. I think it's a convenience for them."*

Theme 2: Coordination Factors

While not mentioned as frequently as clinician-related factors, many respondents feel that factors related to the way care is communicated and coordinated contribute to inappropriate ordering of laboratory tests. When patients see more than one care provider, there can be duplication of efforts. One respondent believed that excess tests are ordered because of a *"lack of communication between general physicians and specialists. I see a lot of times a general physician will order tests and then a specialist will order the same tests."* This lack of coordination was also noted across locations or departments. One respondent commented that *"different locations order the same tests when patient is transferred, not waiting for first result to come back before ordering again."* Several survey participants commented that there were challenges when trying to access prior patient test results. One respondent summed this up as *"poor information sharing, poor communication between areas, and a lack of a centralized patient care computer system."* Respondents also noted that in some clinical areas, tests were ordered by a nurse or clerk before a physician saw the patient in hopes of making triage more effective. A participant remarked that this practice occurs *"to have results before the doctor even sees the patient in emergency department."*

Theme 3: Ordering Process Factors

Several survey participants brought up ideas related to the ordering system and process itself. One major issue identified is standing orders, particularly ones that do not require a stop date. The presence of order sets and testing panels was also identified as potentially problematic, because they are easy to utilize yet may contain uninformative tests. One respondent described

that *"unnecessary tests are on an order set so get ordered without a second thought of appropriateness."* Some respondents qualified that these order sets are often outdated or lack the proper review needed to updating ordering to current best practices.

The relative ease of ordering was frequently listed as a factor contributing to over-testing. A respondent described that it is *"very easy for physicians to check off the boxes on requisitions."* Some felt that this ease was exacerbated by lack of accountability. This is illustrated by the following quote that ordering providers *"are not held responsible for the monetary, and systematic cost incurred by inappropriately ordered lab tests."*

Theme 4: Patient Factors

Responses related to patients themselves were infrequent, but present. A representative quotation from a respondent is that unnecessary testing occurs because of *"pressure exerted by patients and their families on physicians to investigate illness regardless of the opinion of the healthcare professionals."*

Discussion

MLPs identified a wide range of factors that contribute to inappropriate ordering of laboratory tests. They mentioned factors related to ordering providers most frequently, which mirrors the emphasis on the ordering provider found in the utilization management literature. Multi-pronged interventions are the most successful [4], but they largely focus on the ordering process and those ordering the tests. This focus may miss opportunities to improve the appropriateness of ordering, as illustrated by the variety of factors identified by MLPs. Further research into factors related to health system structure, such as ways care is coordinated, is needed.

MLPs identified several factors related to the coordination or communication of results. They witnessed a lack of access to valid previous results, and believe this contributes to over-ordering. Other research supports that missing results contributes to inappropriate repeat test ordering [19], as does transferring patients from one hospital to another.[20] Being seen by multiple providers also contributes to over-ordering [21], but this type of systems-lens research is scant. As clinical information systems continue to evolve and connection between and within sites improves, attention should be paid to how effectively clinicians are able to access test

results, particularly when historical results remain valid. As it is within the scope of practice of MLPs to communicate results, they can be part of initiatives to improve result receipt. Research has linked issues of result communication with diagnostic errors.[22] More research is needed to understand relationships between result communication, result receipt, and inappropriate testing, particularly in an era where test results are increasingly being communicated directly to patients.[23]

The emergency department was mentioned specifically as a source of inappropriate test ordering, which aligns with a recent study that also explored MLP perspectives.[24] In our study, MLPs doubted the effectiveness of obtaining laboratory test results before the patient is seen by a physician, or 'triage ordering'. The emergency department is a place where unnecessary testing is not uncommon.[25] In general, increased number of tests and order episodes tends to increase patient length of stay.[26] However, in specific cases, such as patients presenting with chest pain, ordering triage laboratory tests may quicken important clinical decisions.[27] A recent qualitative study revealed that staff believe that this type of advance ordering is important for efficiency and continuity of care.[28] The impact of ordering triage laboratory tests is an emerging, context-dependent area where research is needed. A recent review found that non-physician-ordered triage laboratory testing did not result in clinically meaningful changes to length of stay in the emergency department, nor did it always line up with what would be ordered once complete clinical information is obtained.[29] This may result in unnecessary phlebotomy events, which are not without risks such as nerve injury [30] or hospital-acquired anemia.[31] This is complicated by settings where specific tests are required for referral or consultation, even though the relevance of these tests is suspect. For example, mandatory screening tests for people with psychiatric complaints in the emergency department rarely impacted patient care.[32] Optimizing emergency department ordering sets and test availability can decrease unnecessary laboratory tests [33] but this approach usually focuses on physician ordering once the patient has been seen.

The factors identified by MLPs with respect to individual ordering providers are present to varying degrees in the literature. Ordering providers agree that habit is an important driver of inappropriate testing.[12,34] Limited laboratory medicine training in many medical schools means that physicians may lack understanding of the basic concepts of laboratory testing.[11,35] Studies indicate a wide variation in test-ordering practices between individual physicians even

within the same diagnoses.[36]. For every test, performance characteristics and biological variation can impact result interpretation, but these metrics are often poorly understood by ordering providers.[37] MLPs hold expertise on testing requirements and workflow, and can have a role in helping provide education on testing parameters, changes in testing, and updates in technology. However, it is not within their scope of practice to advise on clinical decision-making, such as helping understand the diagnostic meaning of a particular result.

The most frequently mentioned cause of inappropriate testing related directly to individual ordering providers, and at times the phrasing seemed to betray frustration. MLPs do not have an opportunity to interact with ordering providers directly or frequently in a way that allows them to have a full understanding of their role. Other research describes interactions between laboratory staff and physicians about utilization issues as frequently negative.[24] Historically, healthcare has been hierarchical and siloed. This hierarchy can impede stewardship efforts of those who perceive themselves in positions of less power. For example, a recent qualitative study about nursing roles in antimicrobial stewardship identified lack of clarity of roles has a negative impact on collaboration and integration of nursing expertise, as well as the social dynamics that defer to physician expertise and the desire to avoid appearing like physician decisions are being questioned.[38] Enhancing teamwork in healthcare has been promoted as a strategy for many contemporary problems.[39] The perceptions that one holds about others can facilitate or impede effective teamwork.[40,41] MLPs may be reluctant to be part of interdisciplinary teams working to solve problems if they perceive that individual ordering providers are primarily responsible for the issue, and are intimidated by perceived relative positions of power. Building trust for effective collaboration between healthcare professionals requires understanding and respecting each other's roles and expertise, and efforts to overcome biases.[42] With a goal of enhancing teamwork and collaboration, there is room to improve MLP overall understanding to include more nuanced and system-based factors.

Limitations

We were unable probe responses to have a full description of existing perceptions. Thus, only the most obvious, or top-of-mind responses were likely given. Our sample was based on non-probability voluntary response of CSMLS members, and was overrepresented by MLTs (91%). Thus, we do not claim that the results are representative of the entire MLP population.

In addition, the structure of clinical laboratory service delivery is different across Canada, which likely impacts MLP lived experience. We echo other researchers that when addressing inappropriate utilization, a careful study of local contexts is vital.[2,7,43]

Conclusion

Given the nuance added through exploring the observations of MLPs, we encourage their inclusion as stakeholders in utilization management and laboratory stewardship activities.

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Table 6.1: Demographic information of survey respondents

Category	N (%)
Professional Designation	
Medical Laboratory Technologist	1052 (91%)
Medical Laboratory Assistant	71 (6.1%)
Other	34 (2.9%)
Years of Clinical Experience	
0-10 years	410 (35.3%)
11-20 years	215 (18.6%)
21 or more years	534 (46.1%)
Location	
Alberta	198 (17.3%)
British Columbia	154 (13.4%)
Manitoba	125 (10.9%)
New Brunswick	77 (6.7%)
Newfoundland & Labrador	37 (3.2%)
Northwest Territories, Nunavut, Yukon	10 (0.9%)
Nova Scotia	135 (11.8%)
Ontario	298 (26.0%)
Prince Edward Island	12 (1.0%)
Quebec	30 (2.6%)
Saskatchewan	69 (6.0%)
Sex	
Male	142 (12.4%)
Female	986 (85.8%)
Other/Prefer not to disclose	21 (1.8%)

Table 6.2: Analysis of Reasons for Over-ordering

Theme	Sub-theme	Description
Ordering Provider Factors – mentioned by 72% of respondents	Inadequate training in laboratory medicine	Responses here refer to the perception that ordering provider training in laboratory medicine (in university, residency, or continued professional development) may be inadequate.
	Habit	Responses here refer to the perception that there are some ordering providers who order the same tests for their patients most or all the time.
	Shotgun approach	Responses here describe the perception that ordering providers are ordering excessive tests in hopes that one may generate a result that could help with diagnostic decision-making
	Inexpensive tests	Responses here refer to the perception that ordering providers view testing as inexpensive and plentiful, and thus not subject to limits.
	Fear of litigation	Responses here refer to the perception that ordering providers may order too much because they are concerned about litigation arising from not exhaustively investigating each patient case.
	Lack of time	Responses here describe situations where ordering providers order excessive testing because they do not have enough time to obtain complete clinical histories or take a measured, stepwise approach
Coordination factors – mentioned by 22% of respondents	Duplication of efforts	Responses here indicate that problems with disjointed or fragmented care is one of the drivers of inappropriate ordering. Over-testing arises when multiple ordering providers or care settings order duplicate tests.
	Barriers to accessing history	Responses here describe perceptions that inappropriate ordering occurs because there is poor access to previous results. This access may be because of system deficiencies, or the lack of mechanisms to support this action by physicians or other healthcare professionals.
	Ordering before patient is seen by physician	Responses here describe the practises performed by other healthcare professionals that contribute to overordering, particularly the practise of pre-filled or nursing/clerk-filled requisitions that are submitted before the patient sees the physician or advanced care practitioner. This leads to testing that may not match symptoms.
Ordering process factors – mentioned by 15% of respondents	Order sets and panels	Responses here describe the belief that many existing testing bundles often contain tests that are not relevant for a given patient.
	Daily or standing orders	Responses here describe how ordering systems may also contribute to extended inappropriate testing through standing orders existing in perpetuity without requiring review.
	No oversight	Responses here indicate that a lack of oversight for ordering allows inappropriate practices to perpetuate
Patient Factors - mentioned by 4% of respondents	None	Responses here refer to the perception that the patient is the primary driver of inappropriate testing.

Chapter 7: Discussion & Recommendations

Addressing inappropriate laboratory utilization in a more wholistic, integrated, and multi-disciplinary way has paved the way to the concept and adoption of laboratory stewardship.[1] This transformation reflects the maturity of our understanding as well as the desire for a shift away from a factory-like input/output model to a to value-based model of clinical laboratory services. In this model, all professionals are engaged, and their efforts are sustainable and lead to clinically meaningful results. Part of demonstrating value is being able to influence test-ordering and perform essential functions in resource stewardship.[2] A shift to stewardship empowers both individuals and institutions to consider all activities through the lens of wise resource use to maximize benefit for clinical decision-making and improve patient outcomes.[3] The recency of this shift is reflected in a lack of published research, particularly with respect to medical laboratory professionals (MLPs), which were already an under-researched group. A broad conclusion from this thesis research is that medical laboratory professional engagement in laboratory stewardship is underused and faces challenges, but it is worth pursuing. While I can provide answers to the thesis research questions, there is room to expand scope and depth, and tease out how observations differ in various contexts, such as in different models of laboratory service delivery. As a reminder, this research aimed to answer the following questions:

1. *How do MLPs contribute to resource waste and patient harm in the context of overutilization?*
2. *What roles can MLPs play to augment laboratory stewardship initiatives?*
3. *What barriers do MLPs face when accessing opportunities to contribute to laboratory stewardship activities?*

Major findings and critical points from each research chapter

In Chapter Two, we found that some MLP practices that contribute to resource waste and patient harm when used automatically or routinely. These may be internal activities (such as inappropriately repeating results) or external activities (such as drawing too much blood). MLPs have enabled the status quo by failing to be proactive or communicate observations about patterns of inappropriate testing. There were also many other practices that an Expert Panel of MLPs thought had the potential to contribute to harm and waste, but they lacked the evidence needed to properly support recommendations against those practices. Our approach resulted in

broad recommendations, but there are other specialized disciplines, such as point-of-care testing or anatomical pathology, that were not well served. In particular, the anatomical pathology laboratory is unique in that testing is more determined by sample characteristics than requests from external healthcare providers. Our Expert Panel only had two MLPs who worked in this area, and a fulsome exploration was lacking. More attention should be devoted to discovering potentially wasteful and/or harmful practices in specialized laboratory areas. In addition, because of a general lack of research into MLP practices, some of the recommendations we put forth to Choosing Wisely Canada used softer verbiage in order not to overstep the MLP scope of practice. For example, instead of "don't do" or "don't perform", we start two of our recommendations with "don't support". At best, the very publication of these recommendations can empower MLPs and allow them to cite them when acting or trying to affect change. At worst, the wording may exacerbate a sense that MLPs do not have a clear role in addressing inappropriate laboratory utilization. At the very least, this underlines the need for further research into the role of MLPs in stewardship activities.

The scoping review in Chapter Three sought to discover what has been published with respect to MLP practices and roles in the context of inappropriate laboratory utilization. We found that existing literature focused on only two specific practices (collecting blood and repeating critical results), both of which align with specific recommendations that we published in the Choosing Wisely Canada Medical Laboratory Science list. With one exception, the findings of these studies support that these unnecessary actions within these practice realms contribute to wasted resources and hold potential for patient harm. Several studies described a role for MLPs when addressing inappropriate laboratory utilization, such as screening test order validity [4] or handling questions related to clinical decision support tools.[5] These provide illustrative examples of concrete activities, and contribute to the general discourse around the value of involving multiple types of professionals. A scoping review might not be the best tool to understand practical roles of MLPs in interventions, as reporting on this type of information is not traditionally required. While more labour-intensive, this knowledge could be gleaned from interview or survey research, which we would recommend. We can also conclude that elements that focus on practical implementation of interventions and/or contribution of steering or guiding committees are under-reported. We did not perform a quality assessment with our scoping

review, but noted that most studies were either observational, short-term, or conducted at a single site.

In Chapter Four, we reported results of a self-administered survey given to both MLTs and MLAs, but because of underrepresentation of MLAs, we focused only on MLTs. The survey touched on several aspects of the issue of inappropriate laboratory utilization, and explored MLT identity with respect to stewardship. This was the first study in Canada that has studied this topic with this population. We learned that MLTs feel they have a level of responsibility for safeguarding laboratory resources for the best possible use in patient care, but they face significant social and psychological barriers. MLTs feel burdened by too much work, and perceive their workplaces as having unsupportive cultures. MLTs are also reluctant to engage in stewardship work because of anticipated conflict with other healthcare professionals, and they lack confidence that their existing skill and knowledge can make a difference. The overall impression is that MLTs are dedicated to ensuring safe, sustainable, and appropriate patient care, but they lack opportunity, support, and tangible starting places. As our reach was broad and exploratory, the survey was non-representative and self-administered. This limits further generalizability of our findings. However, it can serve as a springboard to a regional approach particularly fitting of a country like Canada with healthcare systems that differ across provinces and territories.

Chapter Five is a follow-up to the survey work in the previous chapter. We developed intervention tools and published them on LabWisely.ca. The barriers that were identified in the survey were organized using tools from implementation science, namely the Theoretical Domains Framework (TDF) and the Behaviour Change Wheel (BCW). These two validated frameworks allow researchers to both understand behaviours across several contexts, and then use that understanding to identify relevant intervention approaches.[6,7] Increasingly, the TDF is being used as the framework to understand barriers and enablers to reduce unnecessary medical tests and procedures, and is one of the frameworks that informed the development of the Choosing Wisely De-Implementation Framework.[8] The behaviour we seek to impact is participating in initiatives to improve laboratory utilization. Using the findings from the survey, we demonstrated that the MLT population may benefit from multi-pronged interventions that primarily use training, enablement, and environmental restructuring, but also education, persuasion, modelling, and incentivization. We illustrated how these findings could be used by

providing the case of Lab Wisely. However, while there are practical guidelines for using these frameworks, there can be several intervention options in the end, and the best choice is not always clear.[9] The Lab Wisely initiative would benefit from a robust evaluation plan to contribute to this evidence base.

Finally, Chapter Six emphasizes how the observations from MLPs can augment existing understandings of the causes of inappropriate testing. We probed their lived experience by exploring their perceptions in an open-ended question. We heard about individual ordering practitioner factors most frequently, but MLPs also brought insight into how care coordination and communication systems can contribute to inappropriate testing. These types of factors are generally understudied.[10] MLPs also drew attention to test ordering practices that occur before the patient is assessed by an ordering provider, particularly in the emergency department, and how those tests may be inappropriate. While these observations can help shape intervention development and directions for further research, the nature of some of the responses indicates that more work is needed to improve knowledge and interdisciplinary teamwork skills. This work is part of our earlier survey analysis, which suffers from the same limitations listed previously. In this analysis, we included responses from all MLPs, whereas in Chapter Four we only analyzed the responses from MLTs. This leaves a sample that is over-represented by one group, and specific outreach to MLAs is needed to explore their observations more deeply.

Future directions

While a considerable amount of work remains, I believe that MLPs are valued partners in laboratory stewardship and more should be done to create, define, and promote roles for them. Gaps in knowledge still need to be filled, and effort should also be devoted to understanding how we best support MLPs and leverage their experience in stewardship activities. While suggestions for future research and recommendations for actions were supplied above and in individual chapters, I propose that the following are broad priorities:

1. **Advance the research about the impact of MLP practices on patient harm and resource waste**

   The work of technical professionals is often overlooked and poorly understood.[11-13] This is reflected in the lack of research in MLP practices. There were 95 potential list

items identified during the idea generation phase of the quest to develop a Choosing Wisely Canada list of MLP-specific recommendations. Seven items were accepted for inclusion. During this idea generation phase, the Expert Panel was also focused on items that could touch on several areas of the laboratory. This leaves an opportunity to continue this work to expand the current list or create new lists to address specialized laboratory areas. However, while research evaluating the relationship between patient outcomes and laboratory activity is limited in general[14], this is particularly true of the impact of MLP practices. It is vital to interrogate usual 'ways of doing things' through the lens of inappropriate activity or medical overuse, not just avoiding error. The list published to Choosing Wisely Canada is a valuable starting point, but there were also many items that did not make the final list because of the lack of evidence. In particular, the following four potential list items were near the top of our ranked list but failed to be included in the published list:

i. Don't fail to ensure quality of laboratory processes performed by other healthcare professionals
ii. Don't proceed when recent valid results are on file
iii. Don't automatically proceed with sample collection re-attempts without consultation in non-urgent scenarios
iv. Don't release results in a way that increases the chance of misinterpretation

The Expert Panel reported that these items are commonly practiced in laboratories across Canada. These practices have potential to cause harm and waste resources, but I could not find sufficient research that explores the outcomes of these practices, or the impact of changing these practices. I believe that research on these items should be a priority to fill this knowledge gap and highlight the extent of the impact MLP practices have in a stewardship context.

2. Perform additional qualitative research on both general and discrete behaviours, particularly with MLAs

While I surveyed both MLTs and MLAs, much of the discussion centred on MLTs as they represented most of our respondents. The MLA population is difficult to access on a national scale, as they are not required to be CSMLS members or write the CSMLS

exam. Because they are an unregulated profession, they are also not present on province-level registration lists. Reaching out on an institution-by-institution basis was beyond our available resources. However, engagement with MLAs is urgently needed, as they are increasingly the MLP that interacts directly (face-to-face) with patients and other healthcare providers outside of the laboratory because of their responsibility for specimen collection, particularly through phlebotomy. They are a key population for on-the-ground observations of laboratory test ordering behaviours and the impact of unnecessary testing on patients and other healthcare providers.

An acknowledged weakness of the behavioural diagnosis was the focus on a nebulous behaviour that is difficult to parse out. At this exploratory stage, it was an appropriate choice, but it doesn't provide discrete starting points that organizations may need to build the case for additional resources or time to create interventions. There is a dearth of research on MLP behaviour in general, and more should be performed. Future qualitative studies on specific behaviours could provide needed insight.

3. Develop practical guidance about how to integrate MLPs in laboratory stewardship, leveraging existing expertise where possible

My research has provided some clarity about how MLPs currently contribute to laboratory stewardship, both in their normal practices and during interventions. Further dissemination about tangible roles is recommended to help the current practitioner that feels helpless and cannot envision a role for themselves in laboratory stewardship. A focus on stewardship may also offer new or expanded roles, and changes in the field may also do the same.[15] For example, increased use of AI may require that laboratorians, including subject matter experts about operational knowledge (such as workflow constraints and considerations) and clinical knowledge (such as requirements of specimens and test methods and impacts on variation of quality).[16] MLPs and MLP leadership needs to be encouraged to anticipate these new opportunities so they can capitalize on them when they arise.

Laboratory stewardship is a recent concept and lags behind antimicrobial stewardship. There are parallels in the research priorities of antimicrobial stewardship and laboratory stewardship. For example, antimicrobial stewardship research priorities include developing best practices for implementation in a variety of settings, determining suitable evaluation frameworks, using implementation and behavioural science to improve behaviours of all stakeholders to improve antimicrobial use.[17] There is also poor understanding of the optimal configuration of stewardship leadership teams, what capacities these healthcare professionals need to have, and what stewardship programs in settings other than the hospital looks like (community care, long-term care, etc.).[18] Both the successes and failures of antimicrobial stewardship programs can be instructive, but laboratory stewardship programs may need to be more complex, as laboratory activities touch a broader array of medical decisions. A significant amount of research is needed on practical aspects of stewardship programs, including how to integrate all stakeholders.

MLTs must demonstrate quality management knowledge and often gain additional quality improvement (QI) competency through continuous professional development, particularly if they aspire to hold managerial roles. Beriault *et al* [19] suggest that misutilization problems can be addressed with a QI approach, and that laboratory stewardship teams should have technical and day-to-day process leaders. QI monitoring activities are important for assessing the effectiveness of interventions that address inappropriate testing. Several groups have demonstrated success with a QI approach to laboratory utilization problems.[20-22] The clinical laboratory has a long history of applying QI lens to laboratory processes[23], an expertise that can be leveraged in laboratory stewardship efforts. Others have specifically promoted MLTs as valuable additions to QI teams.[23] Currently, the College of Medical Laboratory Technologists of Ontario state that MLTs should "apply and share quality management principles and a process-oriented approach to the healthcare system."[24] I am encouraged by this focus and believe it can be extended to laboratory stewardship, and should be widely adopted.

4. **Continue work with Lab Wisely and support related initiatives and educational efforts to equip MLPs with skills and knowledge required to become effective stewards**

   To overcome some of the barriers we identified, I believe that involvement of MLPs in laboratory stewardship needs to be normalized as part of regular activities and internalized as part of the MLP professional identity. In antimicrobial stewardship research, nurses saw themselves as patient advocates, needing to push back against decisions that did not align with antimicrobial stewardship.[25] MLPs dedication to patient care may align with taking on a role of patient advocate, building on the "LabVocate" (Lab + Advocate) initiative by the CSMLS.[26] Kirby & Broom [25] also identified that specific education related to antimicrobial stewardship was needed in order to properly equip nurses with required knowledge. Monsees [27] outlines key elements of efforts to integrate nurses into antimicrobial stewardship efforts: enhancing education about content, strengthening communication in interdisciplinary settings, using an improvement model, evaluating opportunities to integrate stewardship activities into the existing workflow, and identifying and addressing social and cultural barriers. This can provide a starting point for an MLP curriculum, but research is needed to evaluate whether needs differ.

   Training in stewardship has been identified as an important need in medical schools[28] and for multidisciplinary stewardship teams.[29] All professionals who are involved in stewardship should have access to knowledge that enhances their roles in stewardship.[30] I believe this need is elevated in MLP education, not just for students but for currently practicing MLPs. Multiple ways of engaging audiences in active learning are more effective than passive learning approaches.[30] Education should be promoted across the continuum from early post-secondary education to continuous professional development.[29]

Final remarks

Some of ways that MLPs commonly practice may be contributing to the undesirable outcomes that stewardship programs aim to ameliorate, such as patient harm and resource waste.

Stewardship involves responsible and ethical resource management. Stewardship programs have evolved from an early focus on administrative aspects to incorporating culture and team.[31] This thesis shows that MLPs identify as stewards, and thus opportunities will be missed if they are not engaged as participants and partners in stewardship activities. These opportunities are missed in part because there is a lack of clarity as to what these roles are, but significant professional and personal barriers are also present. The work presented here provides some direction, but concerted effort is needed by laboratory leaders and professional organizations to raise visibility of the profession, remove barriers, and mobilize resources. Further research is needed to define essential elements of laboratory stewardship teams and initiatives, and build the evidence base linking practices with outcomes.

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Appendices

Appendix A: Example of the Delphi Form

Appendix B: All items in each round of the Delphi process

Appendix C: Laboratory Resources and Behaviour Survey

Appendix A: Example of Delphi Form

Item	Ranking Criteria	NUMBER of EXPERT PANEL Members Assigning Each Rank					YOUR PREVIOUS RESPONSE	YOUR NEW RESPONSE	COMMENTS
Don't process orders for aspartate aminotransferase (AST) from the emergency department for liver injury assessment.		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree			
	Ranked as likely to have sufficient EVIDENCE that this practise should be QUESTIONED or DISCONTINUED	0	1	1	11	6			
	Ranked according to likelihood that this questionable practise is associated with INCREASED RISK OF PATIENT HARM	0	8	5	5	1			
	Ranked that this questionable practise is being FREQUENTLY or COMMONLY performed (opposed to rarely performed)	0	2	2	11	3			
Don't process questionable transfusion orders without having a conversation with the clinician.		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree			
	Ranked as likely to have sufficient EVIDENCE that this practise should be QUESTIONED or DISCONTINUED	0	1	2	7	9			
	Ranked according to likelihood that this questionable practise is associated with INCREASED RISK OF PATIENT HARM	0	0	2	9	8			
	Ranked that this questionable practise is being FREQUENTLY or COMMONLY performed (opposed to rarely performed)	0	1	3	10	5			
Don't issue non-urgent blood components without ensuring that patient testing history is within published guidelines.		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree			
	Ranked as likely to have sufficient EVIDENCE that this practise should be QUESTIONED or DISCONTINUED	0	0	1	10	9			
	Ranked according to likelihood that this questionable practise is associated with INCREASED RISK OF PATIENT HARM	0	1	2	10	7			
	Ranked that this questionable practise is being FREQUENTLY or COMMONLY performed (opposed to rarely performed)	1	1	5	8	5			
Don't proceed with oral glucose tolerance testing for Type 2 Diabetes in healthy individuals without first ensuring the patient has been screened with fasting plasma glucose and/or hemoglobin A1C.		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree			
	Ranked as likely to have sufficient EVIDENCE that this practise should be QUESTIONED or DISCONTINUED	0	1	0	9	9			
	Ranked according to likelihood that this questionable practise is associated with INCREASED RISK OF PATIENT HARM	0	3	2	10	4			
	Ranked that this questionable practise is being FREQUENTLY or COMMONLY performed (opposed to rarely performed)	1	3	5	5	4			
Don't process fecal occult blood test (FOBT) until confirming that the patient has met the corresponding diet restrictions.		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree			
	Ranked as likely to have sufficient EVIDENCE that this practise should be QUESTIONED or DISCONTINUED	0	0	0	9	9			
	Ranked according to likelihood that this questionable practise is associated with INCREASED RISK OF PATIENT HARM	1	3	3	9	2			
	Ranked that this questionable practise is being FREQUENTLY or COMMONLY performed (opposed to rarely performed)	2	4	2	7	3			
Don't collect samples for type and screens without checking testing history to see if a valid result is on file. [		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree			
	Ranked as likely to have sufficient EVIDENCE that this practise should be QUESTIONED or DISCONTINUED	1	1	1	6	11			
	Ranked according to likelihood that this questionable practise is associated with INCREASED RISK OF PATIENT HARM	3	3	5	3	6			
	Ranked that this questionable practise is being FREQUENTLY or COMMONLY performed (opposed to rarely performed)	1	3	2	6	8			
Don't process low-value tests when there is a high-value alternative (i.e. C-reactive protein instead of erythrocyte sedimentation rate; troponin instead of creatinine kinase; ferritin instead of iron).		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree			
	Ranked as likely to have sufficient EVIDENCE that this practise should be QUESTIONED or DISCONTINUED	0	0	0	7	12			
	Ranked according to likelihood that this questionable practise is associated with INCREASED RISK OF PATIENT HARM	1	3	3	10	2			
	Ranked that this questionable practise is being FREQUENTLY or COMMONLY performed (opposed to rarely performed)	2	2	0	9	6			

Appendix B: All Items in the Delphi Process

	Round 1 Ranking
1	Don’t re-collect from the same patient without first checking to see if the ordered tests can be performed on the original sample.
2	Don’t draw more blood than necessary. Use short draw tubes.
3	Don't process repeated tests within specified time windows, particularly for inpatients where hospital acquired anemia is a concern (i.e., daily troponins after a peak has been reached).
4	Don’t accession a requisition that has incomplete or erroneous information.
5	Don’t process requisitions from multiple providers that duplicate testing. Utilize electronic ordering mechanisms to detect duplicate orders.
6	Don’t continue to collect patient samples that have extended standing orders or daily routine testing without requesting a physician review the order.
7	Don’t draw extra tubes in anticipation of ordering professionals ordering tests after the venipuncture.
8	Don’t allow orders for specialized testing without confirming collection and/or processing instructions. Where possible, create electronic pop-up reminders.
9	Don’t process questionable transfusion orders without having a conversation with the clinician.
10	Don’t process routine bloodwork on an inpatient more than once per day unless required for repeating abnormal results.
11	Don't collect additional tubes for duplicate test orders when receiving requisitions simultaneously from multiple providers.
12	Don’t issue non-urgent blood components without ensuring that patient testing history is within published guidelines.
13	Don’t attempt to obtain blood from an adult patient more than twice, or a pediatric patient more than once, particularly in stable inpatients or when non-urgent bloodwork is ordered.
14	Don’t allow automatic test ordering for inpatients for longer than three days.
15	Don’t wait until a specimen is collected to cancel inappropriate orders that do not meet institutional guidelines for ordering.
16	Don't absolve yourself from the responsibility of blood sample quality even when collection is performed by other professionals. Seek to provide adequate training and feedback, such as in point of care or the emergency department.
17	Don’t include low-value tests in order sets. For example, don’t provide partial thromboplastin time (PTT) and prothrombin time (PT) as a bundle.

18	Don’t perform venipuncture where there is an active IV line. Wait a minimum of two minutes after the line has been turned off before obtaining the sample.
19	Don’t provide a name or susceptibility results for organisms deemed normal flora in non-sterile specimens.
20	Don’t proceed with a blood collection until at least two forms of identification have occurred (or three forms in transfusion science).
21	Don't process low-value tests when there is a high-value alternative (i.e., C-reactive protein instead of erythrocyte sedimentation rate; troponin instead of creatinine kinase; ferritin instead of iron).
22	Do not repeat abnormal and critical results if the patient has a history of similar results.
23	Don’t automatically redraw a sample that is insufficient or inadequate due to challenges during venipuncture without consulting to see if the testing is still required.
24	Don’t proceed with oral glucose tolerance testing for Type 2 Diabetes in healthy individuals without first ensuring the patient has been screened with fasting plasma glucose and/or hemoglobin A1C.
25	Don’t ask for an additional sample to confirm blood typing if there is a blood group on file.
26	Don't process fecal occult blood test (FOBT) until confirming that the patient has met the corresponding diet restrictions.
27	Don’t thaw excessive amounts of plasma in anticipation of a massive transfusion protocol or major surgery, such as liver transplant.
28	Don’t create procedures that reflexively order tests unless rigorous evidence for those follow-up tests is in place.
29	Don't collect repeat blood cultures when there is a clinically significant organism already identified.
30	Don’t collect samples from patients in the emergency department before their symptoms have been evaluated.
31	Don’t collect more than one order for blood cultures within a certain time frame.
32	Don’t perform a manual differential on a CBC within 24 hours if the autodiff remains unchanged.
33	Don’t try to convince a patient to have their blood drawn when they refuse because of lack of understanding of what the tests are for.
34	Don’t process orders for hemoglobinopathy investigations without checking patient history for a previous diagnosis.

35	Don’t collect samples for type and screens without checking testing history to see if a valid result is on file.
36	Don’t insert the needle for venipuncture until the alcohol is dry.
37	Don't dispose garbage in a biohazard bucket unless grossly contaminated.
38	Don’t run a laboratory assay if the minimum volume of whole blood is not received.
39	Don’t support a high crossmatch:transfuse ratio in fridges in clinical wards outside of the laboratory.
40	Don’t tag RBC units for a specific patient at the time of order if eligible for electronic crossmatch. Wait until they are ready to transfuse.
41	Don’t process samples for H. pylori antibody testing without alerting clinicians to the possibility of false positives.
42	Don’t process H. pylori serology if the patient already has a positive H. pylori serology result. Refer to Urea Breath Test result or cancel.
43	Don't process Urea (BUN) if creatinine has already been ordered. Consult to see if both tests are necessary.
44	Don’t culture a sputum sample that is of poor quality.
45	Don’t leave the tourniquet on for longer than one minute.
46	Don’t process orders for aspartate aminotransferase (AST) from the emergency department for liver injury assessment.
47	Don’t routinely interpret weak reactions by direct agglutinations with anti-D as Rh positive in females with child-bearing potential.
48	Don't choose a d-dimer assay with low specificity, as this increases the risk of unnecessary imaging and invasive procedures.
49	Don’t process standing orders on analytes known to be stable.
50	Don’t report elevated potassium levels without investigating EDTA contamination (through direct EDTA testing, or assessing other analytes that are impacted by EDTA, such as calcium, magnesium, or alkaline phosphatase).
51	Don’t automatically draw a blood culture on an outpatient without consultation.
	Don't use a butterfly needle unless absolutely necessary
	Don’t perform routine, non-emergent tests in the emergency department, for example hemoglobin A1C and thyroid stimulating hormone (TSH), for concern of lack of follow-up.
	Don’t perform urine cultures on patients with <10 WBC/HPF and no bacteria, except on pediatric patients.

	Don’t proceed with malaria testing without checking if the patient has relevant travel history.
	Don’t perform a bleeding time in the investigation of a bleeding disorder.
	Don’t routinely titrate anti-K alloantibodies in pregnant women; all levels of anti-K are clinically significant and reporting a low titre may give a false impression of safety.
	Don’t use cord samples for crossmatching.
	Don’t have a policy that permits on-call services for testing that is available by point-of-care testing (POCT) in labs that have limited staff available off hours.
	Don’t use inappropriate delta checks that result in the need for blood film review for patients with known, stable laboratory abnormalities (i.e., chronic lymphocytic anemia or hemoglobinopathies).
	Don't perform unnecessary sample manipulation procedures before testing, such as aliquoting.
	Don’t require a default set of histology stains based on type of tissue.
	Don’t routinely perform direct antiglobulin testing on cord blood samples unless the infant shows signs of hemolysis or requires a weak D test because the mother is an Rh immune globulin candidate. [
	Don’t perform passive anti-A and/or anti-B testing on cord samples.
	Don’t process a culture and sensitivity on solid stools without a patient history.
	Don’t repeat immunofixation if serum protein electrophoresis pattern has not changed from previous results.
	Don’t automatically set up a urine culture with a positive nitrite on routine urinalysis.
	Don’t process orders for flow cytometry without asking for sufficient clinical information, such as previous morphological screening.
	Don't add fixative to a sample of fresh tissue without asking a pathologist if any special testing is required.
	Don’t process requisitions in the lab for more than two days ahead.
	Don’t waste reagents by switching to a new container at the beginning of your shift.
	Don't perform rare special stains that have common alternatives without consulting the ordering professional.
	Don’t report antimicrobial results about antibiotics that are known to be resistant by the organism.

	Don't perform unnecessary coagulation reagent validation. Request that reagent and QC lot numbers to be sequestered by manufacturing company.
	Don’t perform weekly decontamination on equipment that has not been used within that time frame.
	Don’t perform daily quality control for analytes that are ordered infrequently.
	Don’t cut excessive deepers on tissues without consultation.
	Don’t perform troponin testing on outpatients where appropriate follow-up is unknown.
	Don’t discard pediatric samples with abnormal coagulation screening results up to a specified age (i.e., five years). Rather, process the sample appropriately and then freeze.
	Don't process all tests within a Thrombophilia Panel unless it is a referred case to a specialist.
	Don’t perform kit testing for Infectious Mononucleosis unless reactive lymphocytes comprise more than 50% total lymphocytes in the WBC differential.
	Don’t routinely perform post-mortem cultures after a post-mortem interval of greater than two days.
	Don’t use parafilm to seal samples for transport, even if it is for a short distance.
	Don’t proceed with rubella testing without checking if the patient has known immunity.
	Don’t perform a manual differential when the delta check fails because the parameter is normalizing.
	Don't have multiple stain procedures for a single stain unless necessary.
	Don't automatically order special stains on cases known to have split specimens.
	Don’t inoculate additional selective agar plates for positive blood cultures where the direct gram smear or other procedures indicate an organism that grows on routine agar plates.
	Don’t automatically perform antibody screening on pre-operative patients without consulting the ordering professional.
	Don’t routinely stain for H. pylori using immunohistochemistry methods.
	Don’t perform antibody screening on Rh positive patients suspected of a possible miscarriage.
	Don’t make a cell block on urine cytology specimens.

	Don’t submit the entire specimen for transurethral resection of the prostate (TURPs) or uterine myomectomies if you confirm there is no suspicion of malignancy.
	Don’t process samples for Tuberculosis polymerase chain reaction (PCR) testing without consulting about appropriate symptomatology.
	Don’t proceed with chemiluminescent microparticle immunoassay (CMIA) testing for syphilis without checking patient history.

Final after Round 2	**Rank**
Don't process repeated tests within specified time windows, particularly for inpatients where hospital acquired anemia is a concern (i.e., daily troponins after a peak has been reached).	1
Don’t accession a requisition that has incomplete or erroneous information.	2
Don’t draw extra tubes in anticipation of ordering professionals ordering tests after the venipuncture.	3
Don’t process requisitions from multiple providers that duplicate testing. Utilize electronic ordering mechanisms to detect duplicate orders.	4
Don’t draw more blood than necessary. Use short draw tubes.	5
Don't collect additional tubes for duplicate test orders when receiving requisitions simultaneously from multiple providers.	6
Don't absolve yourself from the responsibility of blood sample quality even when collection is performed by other professionals. Seek to provide adequate training and feedback, such as in point of care or the emergency department.	7
Don’t process routine bloodwork on an inpatient more than once per day unless required for repeating abnormal results.	8
Don’t attempt to obtain blood from an adult patient more than twice, or a pediatric patient more than once, particularly in stable inpatients or when non-urgent bloodwork is ordered.	9
Don’t allow orders for specialized testing without confirming collection and/or processing instructions. Where possible, create electronic pop-up reminders.	10
Don’t re-collect from the same patient without first checking to see if the ordered tests can be performed on the original sample.	11
Don’t automatically redraw a sample that is insufficient or inadequate due to challenges during venipuncture without consulting to see if the testing is still required.	12
Don’t wait until a specimen is collected to cancel inappropriate orders that do not meet institutional guidelines for ordering.	13

Don’t collect samples from patients in the emergency department before their symptoms have been evaluated.	14
Don’t culture a sputum sample that is of poor quality.	15
Don't collect repeat blood cultures when there is a clinically significant organism already identified.	16
Don’t include low-value tests in order sets. For example, don’t provide partial thromboplastin time (PTT) and prothrombin time (PT) as a bundle. [	17
Don’t run a laboratory assay if the minimum volume of whole blood is not received.	18
Don’t perform a manual differential on a CBC within 24 hours if the autodiff remains unchanged.	19
Don’t continue to collect patient samples that have extended standing orders or daily routine testing without requesting a physician review the order.	20
Don’t provide a name or susceptibility results for organisms deemed normal flora in non-sterile specimens.	21
Do not repeat abnormal and critical results if the patient has a history of similar results.	22
Don’t ask for an additional sample to confirm blood typing if there is a blood group on file.	23
Don’t allow automatic test ordering for inpatients for longer than three days.	24
Don't dispose garbage in a biohazard bucket unless grossly contaminated.	25
Don’t collect more than one order for blood cultures within a certain time frame.	26
Don’t tag RBC units for a specific patient at the time of order if eligible for electronic crossmatch. Wait until they are ready to transfuse.	27
Don’t try to convince a patient to have their blood drawn when they refuse because of lack of understanding of what the tests are for.	28
Don’t process samples for H. pylori antibody testing without alerting clinicians to the possibility of false positives	29
Don’t proceed with a blood collection until at least two forms of identification have occurred (or three forms in transfusion science).	30
Don’t perform venipuncture where there is an active IV line. Wait a minimum of two minutes after the line has been turned off before obtaining the sample.	31
Don’t insert the needle for venipuncture until the alcohol is dry.	32
Don’t process H. pylori serology if the patient already has a positive H. pylori serology result. Refer to Urea Breath Test result or cancel.	33
Don’t support a high crossmatch:transfuse ratio in fridges in clinical wards outside of the laboratory.	34

Don’t process questionable transfusion orders without having a conversation with the clinician.	35
Don’t leave the tourniquet on for longer than one minute.	36
Don’t process orders for aspartate aminotransferase (AST) from the emergency department for liver injury assessment.	37
Don't process Urea (BUN) if creatinine has already been ordered. Consult to see if both tests are necessary.	38
Don’t issue non-urgent blood components without ensuring that patient testing history is within published guidelines.	39
Don’t thaw excessive amounts of plasma in anticipation of a massive transfusion protocol or major surgery, such as liver transplant.	40
Don’t create procedures that reflexively order tests unless rigorous evidence for those follow-up tests is in place.	41
Don’t report elevated potassium levels without investigating EDTA contamination (through direct EDTA testing, or assessing other analytes that are impacted by EDTA, such as calcium, magnesium, or alkaline phosphatase).	42
Don’t collect samples for type and screens without checking testing history to see if a valid result is on file.	43
Don't choose a d-dimer assay with low specificity, as this increases the risk of unnecessary imaging and invasive procedures.	44
Don't process low-value tests when there is a high-value alternative (i.e., C-reactive protein instead of erythrocyte sedimentation rate; troponin instead of creatinine kinase; ferritin instead of iron).	45
Don’t process orders for hemoglobinopathy investigations without checking patient history for a previous diagnosis.	46
Don’t routinely interpret weak reactions by direct agglutinations with anti-D as Rh positive in females with child-bearing potential.	47
Don’t process standing orders on analytes known to be stable.	48
Don't process fecal occult blood test (FOBT) until confirming that the patient has met the corresponding diet restrictions.	49
Don’t automatically draw a blood culture on an outpatient without consultation.	50
Don’t proceed with oral glucose tolerance testing for Type 2 Diabetes in healthy individuals without first ensuring the patient has been screened with fasting plasma glucose and/or hemoglobin A1C.	51

Appendix C: Laboratory Resources and Behaviour Survey

Laboratory Resources & Behaviour Survey

Demographics

Q1: Are you currently a CSMLS member?
[Yes, No]

Q2: Which professional designation do you hold?
[Medical Laboratory Technologist (MLT) - General, Medical Laboratory Assistant/Technician (MLA/T), MLT - Clinical Genetics, MLT - Diagnostic Cytology, Combined Laboratory and X-Ray Technologist (CLXT), Other]
[If Other, please list]

Q3: How many years have you been working in the medical laboratory profession in Canada?
[0-5 years, 6-10 years, 11-15 years, 16-20 years, 21 or more years]

Q4: What type of laboratory have you worked at predominately during your career?
[General Hospital, Centralized Diagnostic Laboratory Facility, Free-Standing Diagnostic Laboratory, Other]
[If other, please list]

Q5: What discipline have you worked at for the majority of your career (i.e., Histology, Microbiology, etc.)?
[Open]

Q6: Your current province or territory of residence is _____
[British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Newfoundland & Labrador, Nova Scotia, Prince Edward Island, Yukon, Northwest Territories, Nunavut, International]

Q7: You identify your ethnicity as (select all that apply) _____
[Asian, Black/African, Caucasian, Hispanic/Latinx, Indigenous, Middle Eastern or North African, Pacific Islander, Other, Prefer not to disclose]

Q8: You identify your gender as _____
[Male, Female, Other, Prefer not to disclose]

1) Awareness

a) Knowledge about overuse

Preamble: Inappropriately ordering laboratory tests means that the test is ordered without evidence-based reasons. For example, inappropriately ordering laboratory tests might mean that the test is ordered too frequently, or when a valid result is currently available. This is becoming a problem in healthcare. The study of this phenomenon is often referred to as the study of laboratory utilization.

Q9: Approximately what percentage of laboratory testing do you believe is over-ordered?
[0-10%, 11-20%, 21-30%, 31-40%, 41-50%, 51-60%, over 60%]

Q10: What do you believe the three most over-ordered tests are?
[PTT, Vitamin D, Electrolyte Panel, CBC, Folate, ESR, Ferritin, TSH, Magnesium, Calcium, ANA, HbA1c, Glucose]
[Other - fill]
[No, I do not believe there is over-ordering of these tests]
Q11: What do you believe is the primary reason for inappropriate laboratory test ordering?
[Open]

b) Knowledge about initiatives to curb overuse

Q12: Have you heard of Choosing Wisely Canada?
[Yes, No, Don't know]

[if Yes, How would you describe your understanding of Choosing Wisely Canada?]
[Vague/Low, Basic/Average, In-Depth/High]

Q13: Have you used any Choosing Wisely recommendations directly in your work?
[Yes, No, Don't know]
[if yes - please describe]

c) Attitudes towards initiatives to curb overuse

Q14: Do you believe that initiatives to limit inappropriate laboratory utilization are important?
[Yes, No, Unsure]

Q15: Do you believe that inappropriate laboratory utilization may contribute to patient harm?
[Yes, No, Unsure]

Q16: Do you believe that resources (time and money) should be devoted to researching inappropriate laboratory utilization?
[Yes, No, Unsure]

2) Engagement

a) Involvement with initiatives to curb overuse

Q17: Have you ever served on a committee or task force that addressed inappropriate laboratory utilization?
[Yes, No]

Q18: Has your laboratory been part of any study or initiative that addressed inappropriate laboratory utilization?
[Yes, No, Don't Know]
[if yes - please describe]

Q19: Do you intend to be involved in initiatives or actions that address inappropriate laboratory utilization?
[Yes, No, Don't Know]
[if yes - please describe]

b) Barriers to involvement

Q20: If you wanted to become more involved in discussions or initiatives to address inappropriately ordered laboratory tests, what might prevent you from doing so?
[OPEN]

c) Attitudes towards influencing change

Q21: Please indicate your level of agreement with the following statements:
[Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree]

I can have a positive impact on laboratory ordering practises by participating in initiatives to curb inappropriate laboratory utilization

My colleagues would support me if I wanted to become involved in initiatives aimed at curbing inappropriate laboratory test ordering

My laboratory leadership team would support me if I wanted to become involved in initiatives aimed at curbing inappropriate laboratory test ordering

Non-physician medical laboratory professionals have an important role to play in curbing inappropriate laboratory test ordering

Non-physician medical laboratory professionals have enough power to influence laboratory test ordering practises

Becoming involved in initiatives aimed at curbing inappropriate laboratory test ordering would be a valuable use of my time
Becoming involved in initiatives aimed at curbing inappropriate laboratory test ordering is part of my professional responsibilities

I feel a sense of accountability for helping to improve the appropriateness of laboratory test ordering

3) Capacity

a) Perceptions of accountability for appropriate utilization

Q22: **Who** do you believe should be responsible for ensuring that laboratory **tests** are **appropriately utilized**?
[Very Little to No Responsibility, Some Responsibility, Significant Responsibility]

Provincial Government
Federal Government
Non-laboratory Physicians (i.e. Family Physicians & Specialists)
Laboratory Physicians (Pathologists)
PhD-trained Laboratory Clinicians (i.e. Clinical Chemists)
Non-physician Medical Laboratory Directors/Executives
Medical Laboratory Supervisors
Medical Laboratory Technologists
Medical Laboratory Assistant/Technicians
[Other - Fill]

b) **Capacity to have conversations about appropriate utilization**

Q23: If a patient refuses to have their blood drawn, what is your general response to them?
[Open]

Q24: If a patient asks questions about their testing, what is your general response to them?
[Open]

Q25: Within the past year, have you discussed the issue of inappropriately ordered laboratory tests with another **medical laboratory professional**?
[Yes, No, Can't Remember]
[If yes - please describe]

Q26: Within the past year, have you discussed issue of inappropriately ordered laboratory tests with a **patient**?
[Yes, No, Can't Remember]
[If yes - please describe]

Q27: Within the past year, have you discussed issue of inappropriately ordered laboratory tests with a **pathologist**?
[Yes, No, Can't Remember]
[If yes - please describe]

Q28: Within the past year, have you discussed issue of inappropriately ordered laboratory tests with a **physician (non-pathologist)**?
[Yes, No, Can't Remember]
[If yes - please describe]

Q29: Within the past year, have you discussed issue of inappropriately ordered laboratory tests with **other healthcare providers**?
[Yes, No, Can't Remember]
[If yes - please describe]

c) **Intention to have conversations about appropriate utilization**

Q30: Please indicate your level of agreement with the following statements:
[Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree]

I am comfortable initiating conversations about inappropriately ordered laboratory tests in my workplace with other healthcare professionals

I am comfortable initiating conversations about inappropriately ordered laboratory tests with my patients

I intend to have conversations about inappropriately ordered laboratory tests in my workplace with other healthcare professionals

I intend to have conversations about inappropriately ordered laboratory tests with my patients

I intend to have conversations about inappropriately ordered laboratory tests with my friends and family.

4. Ideas for MLP-specific Choosing Wisely Recommendations

Preamble: Choosing Wisely Canada is an organization dedicated to identifying tests, tasks, and procedures that are potentially wasteful. In other words, by performing such tests, tasks, and procedures, we might not gain any value. Money and time might be wasted.

Many professions have created their own Choosing Wisely lists in order to raise awareness and halt the practise of unnecessary actions. A key feature of a profession-specific Choosing Wisely recommendation is that it is **under the control of the profession**. An example for Family Physicians is to reduce their ordering of the ESR test. An example for Nurses is to not add extra layers of bedding beneath a patient on a therapeutic surface. An example for Physiotherapists is to not use passive motion machines for patients that have total knee replacement.

Q31: Can you think of a recommendation that is specific to **non-physician Medical Laboratory Professionals,** such as Medical Laboratory Technologists or Medical Laboratory Assistant/Technicians?
[Open]