Developing an Online Widget to Demonstrate Potential Financial, Human, and Environmental Savings in Canadian Diagnostic Testing.

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Introduction

In 2018, the Canadian Society for Medical Laboratory Science (CSMLS) and the University of Alberta (UA) partnered on a project to consolidate the medical laboratory professionals' (MLP) position in reducing unnecessary testing and resource waste in health care. In addition to developing a profession-specific list for Choosing Wisely Canada (CWC), they created LabWisely.ca, a website that contains a searchable database of all laboratory-relevant CWC recommendations along with an assortment of tools, resources, and products that encourage MLP participation in improving laboratory utilization. In 2023, CWC announced a grant for projects that promote the uptake and implementation of CWC recommendations. Once again, the UA and the CSMLS partnership was successful – they proposed and secured funding to develop an innovative interactive web-based widget. By inputting specific parameters into the widget, MLPs, or really any healthcare professional, could estimate how much could be 'saved' by reducing unnecessary laboratory testing.

When discussing resource waste in healthcare, the focus tends to be on financial cost. However, waste can also be quantified in other ways, such as labour and materials. It is well-accepted that the healthcare system is a substantial contributor to waste (1,2,3). As a simple example, a routine phlebotomy episode collecting two evacuated containers (tubes) plus a single-use needle collection set produces between 10-20 grams of plastic and rubber waste. The primary goal of the widget is to provide a multifaceted estimation of the costs of performing unnecessary tests and procedures. This report summarizes the project's first phase—a scoping review that extracts available information about various types of 'costs' (financial, labour, environmental) of laboratory testing from multiple sources, such as peer-reviewed literature, government reports, etc.

Approach

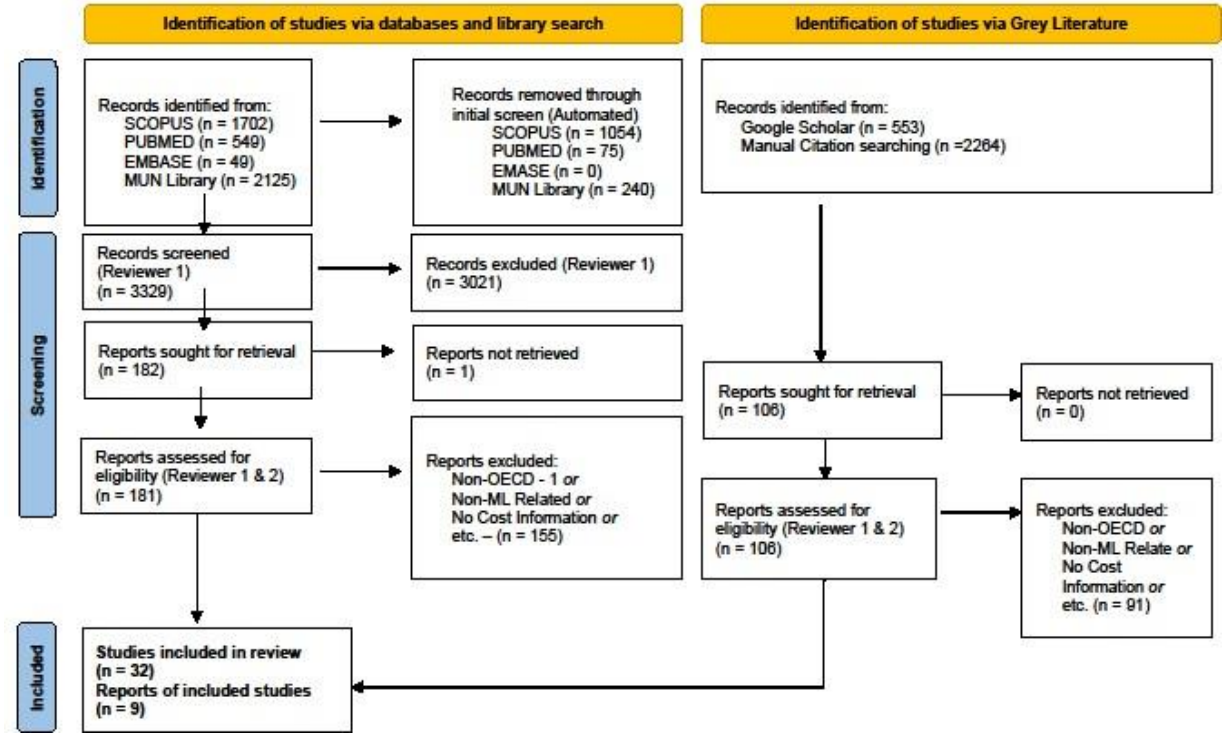
According to Arksey & O'Malley (4), a scoping review involves a rigorous process of defining search terms, searching multiple databases, vetting documents, extracting information, and summarizing findings. A formal framework guides this process. The search terms included words synonymous with (1) cost-effectiveness, (2) resources, (3) diagnostic tests, and (4) medical laboratory, with secondary keyword searches including (1) stewardship, (2) healthcare expenditures, (3) test utilization, (4) demand management and (5) environmental waste. These terms were searched in SCOPUS, PUBMED, MEDLINE, EMBASE, Google, Google Scholar, and Memorial University of Newfoundland library for English documents published between 2003-2023

regarding laboratory testing in middle-to-high-income countries.

Results

After applying initial limits (English language, OCED country, published after 2003), we identified 3329 documents. After the title and abstract review, 238 documents remained. These were each screened by two independent researchers, who ultimately identified 41 documents for review. Figure 1 highlights this inclusion/exclusion process.

Figure 1: PRISMA Flow Diagram



Analysis

We found several fee schedules published by provincial health authorities, which we used in our calculations of cost estimates. However, we had limited, if any, information about how the costs were determined. As an example, the US (5) produces reports for the 25 most commonly encountered tests as billed through Medicare, which were compared to the Canadian billing process in British Columbia, Ontario, and Saskatchewan (6,7,8). The cost across jurisdictions was quite similar for some tests but differed substantially for others, such as Vitamin D. Using details extracted from all of the documents, we were ultimately able to

generate a cost of approximately 27 CAD (20 USD) per test, with a wide range depending on the precise test and whether it is ordered individually or within a bundle.

The majority of the documents were peer-reviewed research studies. We categorized the goal of each study into three key groups, including (1) studies which involved an intervention to reduce unnecessary testing, (2) retrospective studies that established a framework or estimation of test cost, and (3) studies which included an estimation of environmental impact associated with diagnostic testing. Key details about these studies are found in Tables 1, 2, and 3, respectively, and each group is summarized below.

Intervention Studies

The reviewed studies described a range of successful outcomes, and some level of savings were evident in all but one of the thirteen studies in this category. Of note, interventions varied from education-focused with minimal monetary investment to those with an information technology aspect (i.e., pop-up alerts within LIS systems), which would require substantially more planning and coordination. Most of these studies calculated their savings simply as a sum of the total costs of testing multiplied by the number of reduced or unnecessary tests. For example, Aesif et al. (9) evaluated an intervention involving a review of microbiology send-out testing, and quantified savings at approximately 50 thousand dollars. Similarly, a multi-tiered intervention by Ambasta et al. (10) resulted more than 60 thousand dollars of savings. From these types of studies, we can extract an estimate of cost per test, though the details included in their calculations were often limited.

Cost Determination Studies

Determining exact testing costs presents a substantial challenge. Nevertheless, the fourteen retrospective studies in this category established detailed costing information across many of the most common diagnostic tests. However, the studies differed in whether and how they accounted for labour and material costs. For example, some studies included analyzer costs, whereas others only considered reagent costs. Unsurprisingly, cost estimations could differ significantly based on test or laboratory discipline. Moreover, there was broad geographic representation, with studies from numerous OECD member countries, including Italy, Chile, and Canada. Ultimately, these studies allowed us to estimate the average contributions of labour (~57%), consumable (~14%), and capital (~28%) costs to total testing costs, albeit crudely.

Environmental Cost Studies

Laboratories are substantial waste producers across various hazardous classifications, particularly biological or chemical ones, amplified through the increased use of single-use plastics and glass. However, research into the amounts of waste generated is somewhat limited, with our review only identifying six studies incorporating aspects of environmental costs, and the oldest was published in 2020. Most focused on total CO2 emissions. We can combine this information with what we can readily measure (such as the weight of plastic waste from collection tubes) to provide a well-rounded picture of the extent of environmental waste associated with testing.

Discussion & Conclusion

Our scoping review allows us to elucidate a compelling picture of the environmental and economic costs connected with the overuse of diagnostic testing and advocate for prudence in test ordering systems. However, enumerating the costs for laboratory testing is a complex problem as many factors are associated with offering a complete picture. This is particularly evident within the Canadian health system, as each province has unilateral and constitutional control over health care spending. When combined with a mixed economic system, including for-profit partnerships and publicly funded institutions, transparency of health spending becomes muddied. Human resources, consumables, capital, and physical plant capacity all represent competing costs. Nevertheless, we extracted costing information for many of the most common laboratory tests and will use these cost averages in the widget prototype. However, because the costs vary, sometimes significantly, we recommend that utilizing the widget requires a clear caveat that the estimations are just that: estimations. This also points to the need to offer flexibility within the widget. We suggest that the widget should have both a basic version that requires minimal user input and an advanced feature that allows users who know exact numbers to generate tighter estimations.

Though diagnostic testing represents a fraction of the overall cost of delivery of health care (11), the total costs do represent a substantial burden and one that is worthy of continued discussion, particularly because the results of laboratory testing impacts many downstream actions, few of which are taken into account when quantifying costs of testing. In addition, the amount of inappropriate testing varies widely across specific tests and settings. However, at an average cost of approximately 27 CAD, with even the most conservative estimates

of interventions showing a marked reduction in unnecessary testing of 4.5% (12), and according to the CMLTO ((13) nearly 500K tests performed each day, Ontario alone could realize potential daily savings of nearly $600k. Nationally, the potential cost savings are remarkable when coupled with more assertive estimates of over-testing. Currently, there is limited generalizable literature and few tools that laboratory administrators can use to determine potential savings associated with a responsible reduction in diagnostic tests. Our work takes a step towards addressing this gap.

Given that determining costs associated with laboratory testing is challenging, the establishment of estimates, even with limited generalizability, may allow organizations to inform intervention practices, such as deciding which tests may offer the most significant value regarding targeted intervention. In other words, organizations should be able to assess their 'biggest bang for their buck' by using our widget. Ideally, the widget will provide medical professionals with evidence to support the adoption of recommendations and better equip them to impact change within their workplaces.

Finally, though more research is urgently needed, this review establishes an approximate starting point for developing a formula to calculate associated environmental wastes connected with laboratory testing. Developing such a formula may encourage future conversations about reducing carbon-containing substances such as plastic and rubber and contribute to their accumulation within Canada's landfills.

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Table 1: Measures (Pre/Post Interventions)

Author	Selection/Measurement of Outcomes or Type of Intervention	Country	Parameters of Analysis	Key Widget Development Considerations
(5)	Multi-tiered program	Israel	36 common tests	• Significant decrease in the number of tests per hospital admission for all the major laboratory tests ordered with intervention.
(6)	Multi-tiered intervention of microbiologic send-out tests	United States	Microbiology testing only.	• 65% of cancellations included such reasons as a confirmation test ordered in the absence of a screening test order or a confirmation test ordered with a negative screening test. • 35% of cancelled tests included mistaken orders, duplicate orders, incorrect test orders, and insufficient specimen.
(7)	Multicomponent intervention	Canada	10 common tests	• 11% reduction was noted at the intervention site from the pre-intervention to post-intervention period
(8)	A multifaceted intervention	Canada	6 most routinely used tests.	• A significant reduction of 14% in the incidence of routine laboratory tests. • A 15% reduction in the incidence of top 80 tests by volume.
(9)	Single intervention analysis	Canada	Vitamin B12	• Provincial monthly test volumes before this intervention ranged from 54,182 to 73,522 tests per month, and after this intervention, they ranged from 59,116 to 74,006.
(10)	Single intervention analysis	United States	ESR	• Co-ordering rates dropped to 16.4%, representing an unadjusted 42% relative rate reduction.
(11)	Single intervention analysis	Italy	15 common tests.	• There was a 22% reduction in the total number of tests performed and a 12.8% financial saving.
(12)	Single intervention analysis	Canada	Select referred-out tests.	• Of 910 requested tests, 428 (47.0%) were approved, and 482 (52.9%) were cancelled.
(13)	Single intervention analysis	Canada	HbA1C only.	• A reduction of 41,549 HbA1c tests (or 3.3%) and a predicted reagent cost savings of approximately $145,422.
(14)	Single intervention analysis with two stop methodology	United States	All laboratory testing	• The Hard Stop CDST was 92.3% effective in averting duplicate orders. The calculated cost savings for this intervention was $94,225.
(15)	Single intervention analysis	United States	All laboratory testing	• 11,790 unnecessary duplicate orders were blocked by the hard stop CDST in 2 years of activity (2011 and 2012).
(16)	Single intervention analysis	United States	18 most ordered laboratory	• The mean number of laboratory tests ordered PP/PD by resident service decreased during the intervention period.

			tests	

Table 2: Establishment of Cost per test (Financial)

Author	Selection/Measurement of Outcomes or Type of Intervention	Country	Parameters of Analysis	Key Widget Development Considerations
(17)	Retrospective analysis	Chile	92 tests	• Overall laboratory costs can be calculated via the formula: CMT = CMDL+ CMIL+ CMII
(18)	Retrospective analysis	Belgium	156 tests	• Staff costs (57.4%), costs of support services (22.7%), reagents (13.7%), and costs of the analyzers (4.6%).
(19)	Retrospective analysis	Türkiye.	All laboratory testing within the health unit.	• The total cost for hospital-related PA test errors was calculated as TRY 390,238.06 • The total cost for central laboratory-related PA test errors was TRY 48,046.45.
(20)	A cost analysis	Sweden	All aspects of costs, including staffing, support services, and reagents.	• Laboratory costs represent approximately 5% of the total budget. • The annual cost of PAE was estimated to be 74,267 euros per 54,040 blood drawings, corresponding to 13,756 euros per 10,000 blood drawings or 1.5 euros per draw. • The cost of PAEs per 10,000 blood drawings was estimated to be 13,756 euros.
(21)	Direct Cost analysis of two common laboratory test panels.	Canada	CBC and Electrolyte panel	• The total annual cost for an inappropriately repeated (or previously normal result) CBC and EP in inpatient and ER settings within 24 hours was over $2.4 million.
(22)	Retrospective analysis regarding the proportion of preanalytical errors	United States	INR only.	• Total cost of USD 25.09 per error • Average unit cost of 1 INR test was USD 3.32
(23)	Retrospective Analysis of an eight-step costing model	Canada	Costs associated with transfusion of 1 unit of RBCs.	• The total cost associated with the delivery, receipt, storage, testing and transfusion of 1 unit of PRBC was $243.10. • Hospital personnel, consumables and capital costs contributed 77.54%, 19.86% and 2.60% to this cost, respectively.
(24)	Retrospective analysis	Canada	51 laboratory tests	• In the 2015 calendar year, the three most ordered laboratory tests by total test volume in Calgary and the surrounding area were: (CBC, Creatine, and Electrolyte Panel)
(25)	Retrospective analysis of budgetary considerations in laboratory operations.	United States	Methodology only.	• Calculation of cost savings should use standard accounting methods and include all relevant costs, including pre-analytic and analytic, variable, semi-variable and fixed costs.

(26)	Retrospective study establishment of costing incorporating across six Canadian laboratories.	Canada	6 tests	• Nearly 400,000 test instances were included in the study, performed on just over 100,000 patients.
(27)	Retrospective analysis	United States	Total cost per slide	• Labour costs constitute the most significant component of laboratory expenses (70% when equipment and other expenses are excluded). • For H&E staining, a cost of $18 per slide was established, with high costs of labour and overhead, contributing approximately 80% of the total cost for a single H&E stain.
(28)	Retrospective analysis across 10 Canadian Laboratories	Canada	All laboratory testing	• Primary care physicians as a group accounted for 58% of total test costs but, on an individual basis, ranked well below several other specialties.
(29)	Retrospective cohort study of patients transferred to a tertiary hospital.	United States	11 common tests	• For each laboratory test studied, the rate of repeat normal testing was between 46% (for CBC) and 100% (for UA). Calcium, magnesium, lipase, pt-INR, and UA were normal at both institutions greater than 90% of the time. • Total yearly estimated charges of all repeat normal tests was $580,526.
(30)	Retrospective analysis involving screening panels.	United States	13 testing panels	• A total of 3,982 tests generated charges of $417,839. • A total of 1,292 abnormal tests (32%) cost $114,753. Of these, 253 (6%) were clinically significant tests, costing $36,703.

Table 3: Studies Incorporating Environmental Costs

Author	**Selection/Measurement of Outcomes or Type of Intervention**	**Country**	**Parameters of Analysis**	**Key Widget Development Consideration**
(1)	Retrospective assessment	Australia	Vitamin D only	• 2020 total cost to Medicare of vitamin D tests providing no net health benefit was $87,229, and the total cost of all Vitamin D testing was $114,025,739. • 2020 carbon footprint of unnecessary vitamin D tests was 28 576 kg (base case) and 42 012 kg (sensitivity) CO2 e
(2)	Retrospective Life Cycle Assessment	United States	Specific to an 11-step biopsy process	• 20 million biopsies are performed in the US annually; emissions from biopsy processing are equivalent to yearly GHG emissions from 1,200 passenger cars.
(31)	Retrospective assessment	Australia	Assessed the carbon footprint of five pathology tests	• For all tests except CRP, the primary sources of CO2e emissions were sample collection consumables. • Proportions of emissions attributable to sample collection were 63% (74 of 116 g) for full blood examination (i.e., CBC); 90% (89 of 99 g) for U&E; 94% (46 of 49 g) for ABG; and 95% (78 of 82 g) for coagulation.
(3)	An administrative intervention	Australia	Assessed the carbon footprint and	• 24,585 pathology collections in 5695 patients. • The intervention was estimated to have saved 132 kg CO2e (95% CI, 59–205 kg) and $53 573 (95% CI, 22 076–85 096).

			costs of six pathology tests	• GHG emissions were 4038 kg CO2e.
(32)	Prospective study	Canada	POD1 laboratory testing consisted of a CBC, CR, and electrolytes.	• The study extrapolated financial and environmental costs from institutional costs and practices. • POD1, which costs $25.79 per patient in lab processing fees alone.
(33)	A retrospective cohort study of patients admitted to the acute care surgery service at Vancouver General Hospital	Canada	Assessment of six common tests	• 76% of evaluated patients underwent unnecessary bloodwork, resulting in a mean of 1.84 phlebotomies, 4.4 blood vials, 16.5 tests and 18mL of blood loss per patient. • The hospital and environmental cost of these unnecessary activities was $C5,235, and 61 kg. • The carbon footprint of a common set of tests (was 332 g CO2)