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Relevance or performance: potential savings associated with verification of prior results before performing microbiology analysis☆

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ABSTRACT

Objective: In an era of rising healthcare expenditures, it is critical to find ways to decrease cost. The objective of this study is to evaluate the number of repeated tests and the associated cost savings in a university-affiliated hospital.
Methods: The following 7 microbiology analysis were assessed for nonrepeat testing: HCV antibody, HBV core antibody, CMV IgG, rubella IgG, *Treponema pallidum* antibodies, *Clostridioides difficile* toxin detection, and vancomycin-resistant enterococci PCR. Presence of a prior positive result leads to the cancellation of subsequent orders.
Results: Percentages of not repeated test ranged from 0.1% to 21.4%. Rubella IgG had the highest proportion of unnecessary repeat testing. Total cost savings were estimated at $33,627 for 2016.
Conclusion: Unnecessary repeated microbiologic test can account for a non-negligible part of total volume test. Use of an automated software to detect unnecessary repeated microbiologic test through laboratory information system can generate important savings.

1. Introduction

Laboratory testing is an indispensable component of today's healthcare system. Whether it is for a screening purpose, diagnosis, management, or disease control, it is used in almost all fields of medicine. It is estimated that 174 million tests are ordered each year in the province of Quebec, Canada (Ministère de la Santé et des Services sociaux (MSSS), 2013). Healthcare expenditure continues to rise at an increased rate every year and was expected to reach $234 billion by 2020 in Canada (Canadian Institute for Health Information, 2017). Accordingly, cost of laboratory testing is also increasing yearly, and laboratory budgets are often restrained to limit this increase (Naugler, 2014).

Inappropriate testing often occurs and can take several different forms, including unnecessary repeated testing, ordering tests that are not indicated, or not ordering evidence-based tests. Studies have revealed that 20–50% of laboratory testing is inappropriate (Carter, 2014; Naugler, 2014; van Walraven and Raymond, 2003; Zhi et al., 2013). A Canadian study showed that 30% of 8 evaluated tests were considered to be wasteful, with attributable cost ranging from $13.9 to $35.9 million annually (van Walraven and Raymond, 2003). In addition to cost, inappropriate testing can be associated with unnecessary blood drawn and harmful sample-collection procedure. Disruption of sleep pattern can occur in patients with repeated testing as well as hospital-acquired anemia in severe cases (Huck and Lewandrowski, 2014). Furthermore, repeated tests can increase the likelihood of false-positive or false-negative results, leading to additional interventions and costs. This can result in adverse outcomes for patients (Rang, 1972).

Changing physician's behavior towards laboratory testing has proven to be difficult (Axt-Adam et al., 1993). Multiple reasons may explain inappropriate test ordering, such as the lack of knowledge on how to appropriately order it, routine behavior, failure to check previous results, and fear of misdiagnosis (Kwok and Jones, 2005; Wong, 1995; Zaat and van Eijk, 1992). Different test alternatives were proposed through the laboratory information system (LIS) in order to prevent overtesting. Alerts, whether passive or interruptive, have proven to be successful in reducing repeat testing (Baron and Dighe, 2014). Finally, restrictive approach with test ordering frequency filters showed a decrease in total test volume and laboratory costs (Baron and Dighe, 2014; Janssens Pim and Wasser, 2013).

To define a test which would be inappropriate to repeat, one must define a time frequency in which a repeat test will not yield any changes. Data on optimal frequency to repeat testing are limited in the literature and are based on international or local consensus opinions.

Abbreviations: CPOE, computerized physician order entry; CMV, cytomegalovirus; HBV, Hepatitis B virus; HCV, hepatitis C virus; MSSS, Ministère de la santé et des services sociaux; LIS, laboratory information system; VRE, vancomycin-resistant enterococci.

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Only a few tests have such widely accepted intervals (Orth et al., 2014). Nevertheless, some tests do not need to be repeated no matter the time interval because they are not likely to change. For instance, serologic tests assessing immunity in patients with prior documentation of immunity are generally not required. Overall, data remain scarce on the impact of intervention created by repeat testing.

We conducted a single-center study to evaluate the proportion of tests that were canceled because of prior positive results in our center and the savings generated by a restrictive test ordering filter.

2. Methods

2.1. Percentage of not repeated tests

SoftMic and SoftLab (SCC Soft Computer, Florida, USA) are the 2 software used in the microbiology laboratory of Hôpital Maisonneuve-Rosemont, a university-affiliated hospital in Montréal, Canada. Our LIS is configured to automatically detect the presence of previously performed tests. If an ordered test is judged to be unnecessary, a pop-up alert is triggered, displaying the date, the time, and the previous result of the analysis. A laboratory technician can then cancel the repeated test and issue a report with the previous result of the test to the ordering health worker.

From January 1, 2016, to December 31, 2016, we extracted from our LIS the number of samples that were not tested due to previous positive or negative results for the following 7 assays: anti-HCV, anti-HBc, CMV IgG, rubella IgG, *Treponema pallidum* (syphilis) antibodies, *Clostridioides difficile* toxin, and vancomycin-resistant enterococci (VRE) PCR. For serological analysis (anti-HCV, anti-HBc, CMV IgG, rubella IgG, and syphilis), any previous positive result was sufficient to prevent repeating testing. For VRE PCR, a sample repeated within 3 days following a prior positive sample was enough to be canceled. For *C. difficile* toxin detection, any sample repeated within 7 days of a prior sample was canceled despite its results. Canceled tests are defined as samples that were not tested by the laboratory after receiving the order and the specimen.

2.2. Cost analysis

In Quebec, each analysis performed has been assigned a relative value by the Ministère de la Santé et des Services sociaux du Québec (MSSS). The calculation of this weighted value (WV) takes into account the time required to receive and prepare the specimen, perform testing, and transmit the result to the clinician and the cost of materials and reagents. Costs for quality control and development/validation of the assay are also included in this calculation. The WV is reevaluated yearly and is published by the MSSS (Ministère de la Santé et des Services sociaux (MSSS), 2016). The WV used in the cost-saving analysis was in place at the time the analysis was performed. Results are expressed in Canadian dollars.

3. Results

For the 7 assays included, a total of 85,725 tests were recorded for the study period. As shown in Table 1, 3013 (3.5%) tests were not performed and referred to previous results. The percentage of unrepeated analysis varied greatly between the different assays, ranging from 0.6% for anti-HCV to 21.4% for rubella serology.

The estimated total cost savings of not repeating theses analysis were $36,795. More than 80% of cost savings were attributed to 3 assays: VRE PCR, rubella IgG, and *C. difficile* toxin PCR. For VRE PCR and *C. difficile* toxin PCR, although their percentage of unrepeated analysis was relatively low, they had the highest WV at $35 and $19, respectively. This explains why the savings associated with these assays were the greatest. For rubella IgG, although the WV is lower than VRE PCR and *C. difficile* toxin PCR, the high number of canceled repeated tests (1231) explains the savings associated with this assay.

4. Discussion

Among the 7 assays evaluated, unnecessary testing can represent up to 20% of the total assays ordered. Data on prevalence of repeated testing are variable, and some studies showed higher prevalence (Carter, 2014; Naugler, 2014; van Walraven and Raymond, 2003; Zhi et al., 2013). One possible explanation is the fact that chemistry and hematology tests were mainly assessed rather than microbiologic tests. For instance, hemoglobin is more conducive to be ordered on a more frequent manner because of its clinical use than serology for rubella. Computerized physician order entry (CPOE) is an electronic process where medical practitioners can enter orders in regard to patient care. Repeated testing has been shown to be potentially promoted by CPOE, especially order sets. The absence of CPOE in our hospital could contribute to our lower prevalence on repeated testing (Koppel et al., 2005; Magid et al., 2012).

The assay with the highest proportion of canceled tests was the serology for rubella. However, because of its relatively low WV, it did not generate the most important savings. Nonetheless, there are other costs associated with unnecessary repeat of rubella serology. A recent study evaluating the performance of commercial immunoassays for rubella showed that the false-negative proportion varied from 24 to 64% depending on the assay used (Bouthry et al., 2016). The presence of a false-negative result could lead to unnecessary revaccination after pregnancy, but there are also published cases where women were incorrectly diagnosed with acute rubella during pregnancy because of this (Hutton et al., 2014).

The VRE PCR assay produced the most savings because of its higher WV. This suggests that in a perspective of cost-effectiveness, one should not only investigate the most frequent unnecessary repeated tests but also consider less frequent but more expensive tests.

Out of the 7 assays being investigated, only 2 (*C. difficile* toxin detection and VRE PCR) were attributed a specified time frame in their definition of repeated testing. For many other microbiology tests, data

Table 1
Total weighted value of canceled repeated tests among 7 microbiology analysis.

Test	Weighted value (CAD) (Ministère de la Santé et des Services sociaux (MSSS), 2016)	Total number of test	Canceled test (% of total test)	Total weighted value (% of cost savings)
Clostridioides difficile toxin detection	19.8	4420	6[a] (0.1) 160[b] (3.6)	119[a] (0.3) 3 168[b] (8.6)
VRE PCR	35.0	29,962	542 (1.8)	18,970 (51.6)
Anti-HBc	4.7	5877	477 (8.1)	2242 (6.1)
Anti-HCV	9.4	17,962	102 (0.6)	959 (2.6)
CMV IgG	7.7	2940	307 (10.4)	2364 (6.4)
Rubella IgG	6.8	5756	1231 (21.4)	8371 (22.8)
Syphilis EIA	3.2	18,808	188 (1.0)	602 (1.6)
Total		85,725	3013 (3.5)	36,795 (100.0)

[a] Canceled test for prior positive result.
[b] Canceled test for prior negative result.

regarding the optimal frequency interval of repeat testing remain scarce and require further study (Orth et al., 2014). We used a 7-day interval to define a repeated test for *C. difficile* toxin PCR based on the literature (Aichinger et al., 2008; Luo et al., 2013; Luo and Banaei, 2010; Otto et al., 2015). Repeating a negative PCR test within 7 days does not yield a different test result in 97% to 99% of cases (Aichinger et al., 2008; Luo and Banaei, 2010). Increasing the interval between repeated tests to greater than 7 days would result in greater cost savings because more tests would be canceled. However, the risk of obtaining a positive result on the repeated test would be higher, and therefore, a missed diagnosis would be more likely to happen. Luo et al. evaluated the effect of PCR testing within 14 days and concluded that repeating PCR testing within 7 to 14 days can be useful when a high clinical suspicion of infection is present (Luo and Banaei, 2010). Although studies were mostly aimed at repeated *C. difficile* toxin PCR with a prior negative result, some studies collected data with prior positive results. Prevalence of repeated *C. difficile* toxin PCR in a prior positive result is variable but can go up to 30% (Aichinger et al., 2008; Luo et al., 2013; Otto et al., 2015). To our knowledge, clinical outcomes of not repeating a positive *C. difficile* toxin PCR within 7 days have not been assessed. As patients treated for *C. difficile* diarrhea receive a minimum of 10 days of antibiotic therapy, we can think that there might be little use of retesting positive *C. difficile* toxin PCR while the patient is on treatment.

In regard to PCR testing for VRE, we did not find any studies comparing different frequency intervals for unnecessary repeat testing. Thus, a 3-day interval was arbitrarily assigned to minimize the risk of performing more than 1 screening test on the day of admission. This was meant to simplify management of weekly screening of all patients on a ward during outbreak with previous testing done on a few patients within the specified time frame.

In a context where laboratory budgets are being restrained, we have shown that computerized interventions can lead to important absolute savings by preventing unnecessary testing. Nonetheless, there are limitations to our study and its reproducibility. At our institution, during the study period, all tests were centrally recorded in the LIS directly at the laboratory. This means that a few individuals are responsible for generating these “no-repeat” reports immediately when the LIS flags these orders. These reports are not significantly longer to issue than recording the actual assay, so costs of this procedure are deemed to be negligible. One drawback of this system is that it does not have the potential to prevent the specimen from being drawn from the patient. A delocalized ordering system could save even more resources in phlebotomist time and material if the feedback was provided before samples were collected. Ultimately, ordering systems that provide feedback to prescribers in real time could help to educate physicians about unnecessary repeat testing and actually lower the number of inappropriate prescriptions. Because no such feedback in real time was provided in our study, it is unlikely that changes in ordering practice occurred because of our intervention. Even if it occurred, this would mean that we have actually underestimated the proportion of unnecessary testing that can occur in laboratories without a similar system in place. It is also important to note that some exception exists regarding reordering a test with prior documented immunity, especially in the context of transplantation or newborns. It is then essential to have a way for physicians to still order these tests when really necessary.

Another limitation is the use of the WV as the measure of cost savings. Although these values are calculated every year, they do not represent the actual cost of performing a single analysis but represent the average cost per test for performing that analysis (Ministère de la Santé et des Services sociaux (MSSS), 2016). Although these costs might not be exactly the same in other jurisdiction, the proportion of tests that are unnecessarily performed should be similar throughout the country.

The total amount of money saved does not appear to be important, but province wide, if we assume that our proportion of unnecessary tests are the same, that would result in savings of $342,337 for CMV IgG, rubella IgG, and VRE PCR (fiscal year 2015–2016, personal communication). Also, in a fee-for-service funding structure, interventions directed towards unnecessary testing could be detrimental. While profits are generated by test volume, reduced total number of analysis could have an impact on the financial support of a healthcare center. Nonetheless, if unnecessary testing is redirected towards other indicated testing without decreasing the test volume, the impact on financial support can be minimal.

5. Conclusion

Unnecessary and repeated microbiologic testing can represent a substantial amount of total test volume, and its prevalence depends on the type of assay. Automatic detection of repeated tests by LIS can be safe and easily implanted without generating more cost.

Reducing repeated tests by cancellation can generate significant savings, and its application with the right tools in the right context can be beneficial to a nationally funded healthcare system.

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