Effect of Provider Continuity on Test Repetition

CARL VAN WALRAVEN,* GETA CERNAT, and PETER C. AUSTIN

Background: Provider continuity (PC) occurs when a patient is treated by the same physician over time. A perceived benefit of PC is decreased test repetition. Repeat tests make up a significant proportion of overall laboratory utilization. This study determined whether test repetition increases when PC decreases.

Methods: Cohort study of adults in eastern Ontario, Canada between Sept. 1999 and Sept. 2000 using population-based clinical databases. The primary study outcome was the probability that 7 common laboratory tests (hemoglobin, sodium, creatinine, thyrotropin, total cholesterol, ferritin, and hemoglobin A1C) were repeated at physician visits subsequent to the index test. We determined whether the probability of test repetition changed if the follow-up physician ordered the index test. We adjusted for multiple factors regarding the patient (age, sex, days in hospital, and number of physician visits in previous year), index test (normality and location), follow-up visit (location and time from index test), and follow-up physician (age and specialty).

Results: The study included 881 353 patients, 1 419 438 index laboratory tests, and 7 622 938 follow-up physician visits. After adjusting for other important factors, we found that tests were significantly more likely to be repeated if the follow-up physician ordered the index test (adjusted odds ratio range 2.5–5.9). This association was consistent in most subgroups.

Conclusions: For these common laboratory investigations, PC was associated with increased, not decreased, test repetition. This suggests that increased PC alone will likely not decrease test utilization.

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Laboratory test utilization has increased throughout the world (1–6). Repeat tests account for a considerable portion of overall laboratory testing (7–12). Tests repeated within 30 days of the index test account for 30% of total laboratory utilization (13). Repeat tests are frequently necessary for best patient care (14, 15), but many believe that repeat testing could be a modifiable component of laboratory utilization (16–18). As a result, several studies have evaluated interventions aimed at repeat laboratory testing (19–23).

Continuity of care, which occurs when a patient experiences coherent and linked care over time, primarily entails provider continuity (PC)2 (wherein a patient is treated by the same physician over time) and information continuity (wherein data regarding prior events are available at subsequent encounters) (24). Poor continuity of care could increase repeat testing (25); thus reducing “duplicative” testing by increasing health information sharing between providers has been investigated (26).

Several studies suggest that poor continuity of care increases testing. A cross-sectional survey of general practitioners showed that laboratory testing was 10 times more likely when physicians had “scant” knowledge of a patient (27). Laboratory tests performed at previous visits were identified as necessary and missing at subsequent visits (28, 29) and were frequently repeated (28). The adjusted odds of redundant repeat tests at a single teaching hospital were 3.3 times higher when the requesting physician did not order the index test (30).

Physician continuity is also associated with increased test repetition, however. Physicians may repeat tests when they are abnormal or if the result is incompatible with the clinical context (14, 15), and physicians frequently use laboratory tests to monitor patient conditions. Such monitoring is usually done by one physician. Thus the influence of continuity of care on repeat testing requires clarification. If low physician continuity of care increases test repetition, improved communication of previous test results between physicians could decrease

2 Nonstandard abbreviations: PC, provider continuity; DoLTEOn, Database of Laboratory Tests in Eastern Ontario; DAD, Discharge Abstract Database; PSD, Physicians Services Database; OR, odds ratio.
test utilization (22). We used population-based databases to determine if provider discontinuity increased the repetition of simple tests.

**Materials and Methods**

**STUDY AREA**

This study included all adults living in eastern Ontario, defined here as the area east of a line connecting the towns of Arnprior in the north with Trenton in the south. In 2000, this area contained 1.09 million adults. Costs for all hospitalizations, physician visits, and laboratory tests are covered by the publicly administered healthcare system. In Ontario, medical laboratory testing is provided by both private and hospital-based laboratories, with the former primarily servicing community-based patients (6). Hospital-based laboratories primarily serve hospitalized patients but also community patients who attend hospital-based clinics or live in areas where private laboratories are unavailable.

Clinicians themselves do not perform laboratory tests and therefore are not remunerated for them. During the study period, 14,959 physicians in the study area ordered at least 1 laboratory test with most, but not all, of the physicians working in the study area. The mean (SD) age of these physicians was 48 (10.9) years, 26% were female, and 47% were specialists.

**LABORATORY TESTS**

This study examined the utilization of 7 very common (including hemoglobin, creatinine, sodium) and less common (thyrotropin, total cholesterol, ferritin, hemoglobin A1C) laboratory tests. All private laboratories operating in Eastern Ontario participated in the study (Appendix A). All hospital laboratories in the area participated as well (Appendix A) except for those in the towns of Hawkesbury and Cornwall, because of technical limitations of the laboratory information systems. Based on our data, we estimate that our sample missed 1.5% of all tests in Eastern Ontario. The study was approved by the ethics review board of the Ottawa Hospital as well as the ethics review board or administrative representatives of all participating institutions.

Between September 1, 1999, and September 1, 2000, laboratories extracted the patient identifier, test date, test result, and ordering physician of all study tests. Patients were identified by their Ontario Health Insurance Plan (OHIP) number and physicians were identified by their OHIP billing number. Data were encrypted and transferred electronically to the Institute for Clinical Evaluative Sciences. The file was then decrypted by someone allowed to view unencrypted patient and physician identifiers. The OHIP numbers and physician identifiers were then individually encrypted and the file was stored on a stand-alone and secured computer. This created the Database of Laboratory Tests in Eastern Ontario (DoLTEOn).

**DATABASE LINKAGE**

Patient and physician identifiers were encrypted with the same algorithm that was used for all other administrative databases at the Institute for Clinical Evaluative Sciences, a procedure that allowed the laboratory files to be linked to the Institute’s databases so that information about the person, test, follow-up visits, and follow-up physicians was accessible (Fig. 1). The index test physician and date were determined from the DoLTEOn. The Registered Patient Database, which records basic demographic information for each Ontarian, was used to identify each person’s age and sex. We measured overall patient illness using the number of days hospitalized and the number of physician visits in the year before the study. The former was measured by using the patient identifier to link to the Discharge Abstract Database (DAD), which records the admission and discharge date of all hospitalizations (including same-day surgeries) in Ontario. The latter was measured by linking to the Physicians Services Database (PSD) with the patient identifier. At the time of the study, the PSD recorded claims for physician services of ~95% of Ontario’s family physicians and almost all specialists. Each claim records the patient, the assessing physician, and the date of the service.

For each laboratory test, we used the patient’s age and sex from the Registered Patient Database to determine test normality using the reference range of the laboratory where it was conducted. To determine if the test was conducted while the patient was in the hospital, we linked to the DAD. If the test was conducted at the hospital laboratory and its date occurred between the admission and discharge dates of the patient’s hospitalization, the test location was classified as “in-hospital”. Test location was classified as “emergency department” if the test was performed by a hospital laboratory and was ordered by a physician who claimed an emergency room assessment for the patient on the test date. Physician assessments conducted in emergency departments are identified in the PSD by special claim codes. All other tests were classified as “community” tests.

We used the PSD to identify the physician and date of each follow-up visit. By linking to the DAD, we classified a physician visit as occurring in the hospital if the visit date occurred between the admission and discharge date of a hospitalization for the patient. Using the aforementioned emergency department codes in the PSD, we classified a physician visit as occurring in the emergency room if it was associated with an emergency claim code. The difference in days between the index test and the physician visit was the time to follow-up visit. All visits were considered in the analysis. Visits after an index test did not require a follow-up test to be considered. Index tests that were never repeated were also included in the study.

We linked to the Physician Database to determine the age and specialty of all follow-up physicians. The Physician Database records information about each physician
who practices in Ontario. Finally, we determined whether or not the follow-up physician ordered the index test by comparing the physician identifiers of the index and follow-up visit. If they were the same, physician continuity existed and the order was coded as 1. Otherwise, physician continuity did not exist and the order was coded as 0.

ANALYSIS
Because each laboratory’s testing methodology and reference ranges for each test were similar (13), we standardized test results. As in our previous study (13), tests were excluded for missing or invalid patient identifier, result, patient sex or age, ordering, or follow-up physician identifier.

The unit of analysis for the study was the index test-follow-up visit pair (Fig. 1). The index test was paired with each subsequent follow-up visit to form a series of index test-follow-up visit pairs. This process continued until the test was repeated at a follow-up visit. When this occurred, this test became the index test for the next series of test-visit pairings. See text for more details. MD, Physician
could determine if the test was repeated at each physician visit. Because patients may not get their laboratory work done on the same day as their physician visit, tests were classified as repeated if they were conducted within a week of the physician visit.

The primary exposure variable in each analysis was physician continuity. This analysis was adjusted for patient characteristics (age, sex, and healthcare utilization), test characteristics (location and result), follow-up visit characteristics (location, days from index test), and follow-up physician characteristics (age and specialty). The consistency of the association between PC and test repetition was explored with an analysis that was stratified by other important variables.

Separate regression models were created for each test type. Logistic regression models were estimated with generalized estimating equation methods (31), allowing us to account for the potential lack of independence of test repetition within patients. Thus, tests and follow-up visits were treated as dependent within a patient, but independent across patients, a method that helped avoid differences in standard error estimates attributable to the potential lack of independence among multiple observations for the same patient.

Because generalized estimating equation estimations with a large number of observations per individual are computationally intensive, we used a random number function to randomly choose 1.3 million physician visits for each laboratory test. To model nonlinear relationships between time to follow-up visit and probability of test repetition, we used natural spline regression techniques (32). For all analyses, 2-tailed P values <0.05 were considered statistically significant. SAS 9.1 (Cary, N.C.) was used for all database linkages and analyses.

**Results**

Between September 1, 1999, and September 1, 2000, the participating laboratories conducted a total of 4 277 558 index tests; 565 170 tests (13.2%) were excluded because the patient was <18 years old (n = 210 076), the test was a duplicate (n = 77 486), the patient had an invalid identifier (n = 4472), the result was missing (n = 3717), the patient’s age or sex was missing (n = 2384), the test was initiated by the laboratory as a check (n = 662), or the ordering physician identifier was missing (n = 266 373).

After the remaining 3 712 338 index tests were linked to follow-up visits, we ended up with a total of 14 553 563 observations; 270 068 were excluded because the follow-up physician identifier was missing and 6 660 557 were not randomly selected for the final model. Appendix B gives exclusion details for each test.

The 881 353 patients, 1 419 438 index tests, and 7 622 938 physician visits included in the study are described in Table 1. Patient characteristics varied between the tests. Physician characteristics of the follow-up visits were occasionally distinct from the physician population.

<table>
<thead>
<tr>
<th>Table 1. Description of patients, index tests, and follow-up visits.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test Type</strong></td>
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<tr>
<td><strong>Patients</strong></td>
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<tr>
<td>n</td>
</tr>
<tr>
<td>Mean age</td>
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<tr>
<td>Female, %</td>
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<tr>
<td>Mean index tests / patient, n (SD)</td>
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<tr>
<td>Hospitalized during previous year, %</td>
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<tr>
<td>Annual physician visits, n (SD)</td>
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<tr>
<td><strong>Index tests</strong></td>
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<tr>
<td>n</td>
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<tr>
<td>Index test in ER, %</td>
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<tr>
<td>Index test in hospital, %</td>
</tr>
<tr>
<td>Index test abnormal, %</td>
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<tr>
<td>Visits per index test, n (SD)</td>
</tr>
<tr>
<td><strong>Follow-up Visits</strong></td>
</tr>
<tr>
<td>n</td>
</tr>
<tr>
<td>Months, index test-FU visit, n (SD)</td>
</tr>
<tr>
<td>Visit in ER, %</td>
</tr>
<tr>
<td>Visit in hospital, %</td>
</tr>
<tr>
<td>MD specialist, %</td>
</tr>
<tr>
<td>MD age, years (SD)</td>
</tr>
<tr>
<td>Visit with MD who ordered index test, %</td>
</tr>
</tbody>
</table>

Patients, index tests, and follow-up visits are described for the study tests. TSH, thyroid stimulating hormone; HgA1C, glycated hemoglobin A1; MD, physician; ER, emergency room; FU, follow-up.
Table 2. Adjusted ORs for test repetition estimates for baseline models of each test.

<table>
<thead>
<tr>
<th>Test Type</th>
<th>TSH</th>
<th>Ferritin</th>
<th>HbA1C</th>
<th>Cholesterol</th>
<th>Hemoglobin</th>
<th>Sodium</th>
<th>Creatinine</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>2.22 (2.14,2.3)</td>
<td>4.03 (3.75,4.34)</td>
<td>6.07 (5.67,6.5)</td>
<td>3.19 (3.07,3.32)</td>
<td>4.04 (3.77,4.34)</td>
<td>5.25 (4.91,5.6)</td>
<td>4.2 (3.91,4.51)</td>
</tr>
<tr>
<td>Patient factors</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Age increased by 10 years</td>
<td>0.92 (0.91,0.93)</td>
<td>0.99 (0.97,1.00)</td>
<td>0.95 (0.93,0.97)</td>
<td>0.94 (0.92,0.95)</td>
<td>0.96 (0.97,0.98)</td>
<td>1.10 (1.09,1.12)</td>
<td>1.04 (1.02,1.06)</td>
</tr>
<tr>
<td>Female (vs male)</td>
<td>1.06 (1.01,1.11)</td>
<td>0.89 (0.82,0.97)</td>
<td>0.94 (0.89,0.99)</td>
<td>0.85 (0.82,0.88)</td>
<td>1.04 (0.96,1.13)</td>
<td>0.88 (0.83,0.93)</td>
<td>0.92 (0.86,0.98)</td>
</tr>
<tr>
<td>Days in hospital/year</td>
<td>1.01 (1.00,1.01)</td>
<td>1.01 (1.00,1.01)</td>
<td>1.00 (0.98,1.03)</td>
<td>1.01 (1.00,1.01)</td>
<td>1.00 (1.00,1.01)</td>
<td>1.00 (1.00,1.00)</td>
<td>1.00 (0.99,1.00)</td>
</tr>
<tr>
<td>Visits to MD/year</td>
<td>0.99 (0.99,0.99)</td>
<td>0.99 (0.99,0.99)</td>
<td>0.99 (0.98,0.99)</td>
<td>0.99 (0.98,0.99)</td>
<td>0.99 (0.98,0.99)</td>
<td>1.00 (1.00,1.00)</td>
<td>1.00 (0.99,1.00)</td>
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<tr>
<td>Index test factors</td>
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<tr>
<td>Abnormal (vs normal)</td>
<td>1.94 (1.86,2.02)</td>
<td>1.37 (1.28,1.46)</td>
<td>1.46 (1.38,1.54)</td>
<td>1.15 (1.11,1.19)</td>
<td>1.36 (1.25,1.47)</td>
<td>1.34 (1.25,1.43)</td>
<td>1.45 (1.31,1.60)</td>
</tr>
<tr>
<td>ER (vs community)</td>
<td>3.52 (2.65,4.67)</td>
<td>4.92 (2.91,8.32)</td>
<td>1.37 (0.48,3.91)</td>
<td>7.62 (3.99,14.54)</td>
<td>2.32 (2.05,2.63)</td>
<td>2.42 (2.24,2.62)</td>
<td>2.48 (2.23,2.75)</td>
</tr>
<tr>
<td>Hospital (vs community)</td>
<td>1.13 (1.06,1.20)</td>
<td>1.41 (1.26,1.75)</td>
<td>0.78 (0.67,0.89)</td>
<td>1.20 (1.13,1.28)</td>
<td>1.38 (1.06,1.20)</td>
<td>1.72 (1.63,1.83)</td>
<td>1.69 (1.58,1.82)</td>
</tr>
<tr>
<td>Follow-up visit factors</td>
<td></td>
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</tr>
<tr>
<td>ER (vs community)</td>
<td>0.27 (0.24,0.31)</td>
<td>0.24 (0.19,0.31)</td>
<td>0.09 (0.05,0.14)</td>
<td>0.27 (0.23,0.31)</td>
<td>1.48 (1.38,1.59)</td>
<td>2.19 (2.07,2.31)</td>
<td>1.77 (1.66,1.90)</td>
</tr>
<tr>
<td>Hospital (vs community)</td>
<td>0.86 (0.77,0.95)</td>
<td>0.99 (0.85,1.31)</td>
<td>0.18 (0.11,0.28)</td>
<td>0.95 (0.83,1.09)</td>
<td>2.08 (1.89,2.29)</td>
<td>2.81 (2.64,2.98)</td>
<td>2.12 (1.95,2.30)</td>
</tr>
<tr>
<td>Follow-up physician factors</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age increased by 10 years</td>
<td>1.14 (1.11,1.16)</td>
<td>1.1 (1.05,1.15)</td>
<td>1.22 (1.18,1.26)</td>
<td>1.18 (1.16,1.21)</td>
<td>1.16 (1.11,1.23)</td>
<td>1.08 (1.03,1.13)</td>
<td>1.1 (1.05,1.16)</td>
</tr>
<tr>
<td>Specialist (vs family MD)</td>
<td>0.03 (0.03,0.03)</td>
<td>0.02 (0.02,0.02)</td>
<td>0.02 (0.02,0.02)</td>
<td>0.10 (0.09,0.11)</td>
<td>0.14 (0.13,0.15)</td>
<td>0.1 (0.09,0.11)</td>
<td>0.1 (0.09,0.11)</td>
</tr>
</tbody>
</table>

This table presents the association of PC along with patient, index test, follow-up visit, and follow-up physician factors, expressed as adjusted ORs along with 95% confidence intervals. ORs >1 indicate that the factor was associated with an increased odds that tests were repeated at the follow-up visit. PC occurred when the follow-up visit was with the physician who ordered the index test. MD, physician; ER, emergency room; TSH, thyrotropin; HbA1C, glycated hemoglobin.
For example, specialists accounted for 72% to 87% of follow-up visits, although 47% of physicians in the study were specialists. These differences likely reflect the fact that a test was required to be done for inclusion in the study.

**EFFECT OF PC ON TEST REPETITION**

After adjusting for important patient, index test, follow-up visit, and follow-up physician variables, we found that PC was associated with significantly increased odds that tests were repeated at the follow-up visit (Table 2). For all tests, the odds that tests were repeated were 2.2 to 6.1 times higher when patients were seen in follow-up by the physician who had previously ordered the index test.

The association between PC and increased test repetition was consistent in most important strata (Fig. 2). After adjustment for all of the covariates listed in Table 1, PC was associated with an increased probability of test repetition for all tests when the index test was either normal or abnormal, the index test was done in the community or the hospital, the follow-up visit was in the community or the hospital, and when the follow-up physician was a family physician. In only 3 situations was PC associated with a decreased risk of test repetition: when the index test occurred in the emergency department (hemoglobin, sodium, and creatinine), when the follow-up visit occurred in the emergency department (sodium and creatinine), when the follow-up visit occurred in the community department (sodium and creatinine).

Fig. 2. Stratified adjusted association of PC with test repetition in important subgroups.

The horizontal axis in each plot presents the OR of test repetition at the follow-up visit when patients were seen by the physician who ordered the index test vs another physician. ORs exceeding one indicate an increased likelihood of test repetition. Estimates are adjusted for factors relating to the patient (age, sex, days in hospital, and number of physician visits in previous year), index test (normality and location), follow-up visit (location), and follow-up physician (age, sex, specialty, and years since graduation). 95% confidence intervals for the estimates are provided. Tests are color-coded (upper left corner): TSH, thyrotropin; Hg, hemoglobin; Cre, creatinine; HgA1c, glycohemoglobin; MD, physician.
nine), and when the follow-up physician was a specialist (thyrotropin).

EFFECT OF PATIENT, INDEX TEST, AND FOLLOW-UP FACTORS ON TEST REPETITION

Patient factors had a limited effect on test repetition (Table 2). Index test and follow-up visit factors had a stronger effect. All tests were significantly more likely to be repeated at the follow-up visit if the index test was abnormal. Compared with index tests in the community, those conducted in the emergency department and the hospital were significantly more likely to be repeated at the follow-up visit. Emergency room and hospital visits were associated with significantly increased odds of test repetition for the more common tests (including hemoglobin, creatinine, and sodium) but significantly decreased odds for the others.

Each physician factor was associated with test repetition at the follow-up visit (Table 2). Specialists were significantly less likely to repeat tests [odds ratio (OR) range, 0.02–0.14].

EFFECT OF TIME TO REPEAT VISIT ON PROBABILITY OF TEST REPETITION

After adjusting for all patient, test, visit, and physician factors in Table 2, the probability that tests were repeated at follow-up visits generally increased as time between the index test and the follow-up visit increased (Fig. 3). The repetition curves for hemoglobin, creatinine, and sodium rose rapidly, leveled off, and then slowly increased in the final months. In contrast, the adjusted probability of test repetition for the other tests never plateaus. The adjusted probability that tests were repeated at visits occurring 6 months after the index test varied between 5% and 17%.

Discussion

To our knowledge, this study is the most complete assessment of PC and test repetition at a population-based level. In contrast to previous suspicions, we found that PC was independently associated with a significantly increased risk of test repetition, with adjusted ORs of 2.2 to 6.1. This association was consistent in most subgroups.

The role that PC plays in test repetition is important for understanding and modifying laboratory utilization. Repeat laboratory utilization is a significant component of laboratory utilization, because many tests are repeated within 30 days (13). Patients are frequently treated by multiple physicians (33), communication between physicians can be poor (34), and interventions that increase dissemination of previous laboratory test results can decrease overall utilization (22). If continuity of care decreased test repetition, then improved dissemination of test results would likely decrease laboratory utilization.

Our study came to the opposite conclusion for several reasons. First, patient monitoring is a common reason for test ordering (22) and, for a particular health problem, is usually the domain of a single physician. Because physicians use laboratory tests to monitor patients over time, patients will frequently have repeat testing when they see the same physician in follow-up. Such an incident will help explain why PC is associated with repeat testing. Because monitoring is one of the more common reasons for laboratory utilization (22), especially in chronically ill
patients, this could be a major reason explaining why PC is associated with increased test repetition. Second, tests may be repeated by the ordering physician to confirm an abnormality or because the result is incongruent with the rest of the clinical scenario (14, 15). Third, physician habit—or laboratory test ordering perseverance (35)—will increase test repetition by the same physician. Finally, new physicians may not repeat the index test because of “compartmentalization” of patient care. Different physicians frequently treat a component of the patient’s health burden that is distinct from that of previous physicians, thereby not requiring test repetition. Such compartmentalization of patient care would help explain why specialists were significantly less likely to repeat tests ordered by other physicians.

Our results are surprising given previous literature regarding PC and laboratory utilization. Two studies have found that missing laboratory information from previous physician visits is relatively common. Smith et al. (28) surveyed 253 family physicians regarding 1614 patient visits and found that previous laboratory results were missing 6.1% of the time. We surveyed physicians regarding 1002 emergency room visits and found that laboratory results from previous encounters were missing in 9.4% of patients (29). Although these 2 studies show that laboratory data from previous physician visits are frequently missing at subsequent encounters, they do not specifically assess what effect this lack of knowledge has hadon subsequent utilization. According to a survey of 131 family physicians that measured the effect overall previous knowledge of the patient had on laboratory utilization, for 1025 patient visits, family physicians had the impression that laboratory utilization was 10 times more likely when their previous knowledge of the patient was limited (27). This study, however, could not determine whether the increased laboratory utilization resulted from a lack of access to previous test results per se, or a need for the physician to collect baseline information about the patient. To our knowledge, only one previous study quantitatively measured the association of PC on laboratory test repetition (30). This analysis, conducted in a single teaching hospital, matched 254 duplicate profile tests (defined as those being repeated within 24 h of a previous profile) with a nonduplicated profile from the same patient. After control for 2 other covariates, the odds of duplicate testing were 3.3 times higher if the ordering physician had not ordered the previous test. Although this result could indicate that test repetition is more likely with decreased PC, it also could have occurred because of an acute deterioration in the patient’s condition, which would explain why a new physician was now treating the patient and account for the more frequent testing. In contrast, our study had a significantly larger sample size, used a cohort methodology, controlled for a greater number of covariates, did not require an arbitrary definition of duplicate testing, and was not isolated to a single inpatient teaching center.

Because we collected information for almost all patients and physicians for an entire year in a large geographical area for all health sectors, we generated a complete picture of laboratory test repetition and its contributing factors. Using population-based administrative databases, we could simultaneously examine the effects of patient, test, visit, and physician factors on test repetition. We used valid statistical methods that considered the clustering of tests within patients to avoid biased estimates. Most importantly, our study results essentially avoid the influence of important remunerative factors (36) on test ordering decisions, because neither ordering physicians nor their organization would benefit financially from test utilization.

Our study has several important limitations that should be considered when interpreting its results. We did not examine diagnostic imaging studies, and we had limited clinical information about the nature of the physician encounter or the patient. Factors such as patient severity of illness could influence test utilization but were not specifically measured in this study. We believe that the major limitation of this study was its inability to measure the appropriateness of test repetition. Measuring test appropriateness is a difficult task even when primary data are available (16), however, and laboratory utilization is important to itself because of its costs (1–6). We do not have any diagnostic information for the physician visits or data regarding the clinical context under which testing was performed. Such information would be helpful to further elucidate how PC influences test repetition. Finally, PC is only one component of overall continuity of care. We did not measure or account for information continuity. The exchange of information regarding laboratory utilization between physicians treating the same patient would decrease test repetition when patients are seen by physicians who did not order the index test.

In contrast to previous suppositions, our study shows that PC is associated with increased test repetition. Although tests are undoubtedly repeated by different physicians who are unaware that the test was previously ordered by another physician (25, 37), our results suggest that the bulk of test repetition is generated by physicians who ordered the test previously. This finding suggests that disseminating previous patient test results to all treating physicians may not decrease test repetition as much as would otherwise be expected. We believe that further studies in different populations using different study methods are needed to determine if our results are consistent in other patient populations. Ultimately, we believe that the best study for determining what effect continuity of care has on test repetition is a randomized trial of new strategies to increase information continuity.

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collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript. Dr. Austin is supported by a New Investigator Award from the Canadian Institutes of Health Research. Dr. van Walraven was an Ontario Ministry of Health Career Scientist.

References


Appendix A: Members of the Network of Eastern Ontario Medical Laboratories (NEO-MeL)

PRIVATE MEDICAL LABORATORIES:
• Bio-Test Laboratory Inc.
• Canadian Medical Laboratories Limited
• Gamma-Dynacare Medical Laboratories
• MDS International

HOSPITALS:
• Ottawa Hospital–Civic, General, and Riverside Campus
• Queensway-Carleton Hospital
• Children’s Hospital of Eastern Ontario
• Montfort Hospital, Ottawa
• Arnprior and District Memorial Hospital
• Almonte General Hospital
• Carleton Place and District Memorial Hospital
• Perth and Smiths Falls District Hospital
• Winchester District Memorial Hospital
• Glengarry Memorial Hospital
• Kingston General Hospital
• Hotel Dieu Hospital, Kingston
• Quinte Health Care Belleville General, Belleville
• Quinte Health Care Trenton Memorial, Trenton
• Prince Edward County Memorial Hospital, Picton

Appendix B: Details of Exclusions for Each Study Test

Table 3. Appendix B. Details of exclusions for each study test.

<table>
<thead>
<tr>
<th></th>
<th>HG</th>
<th>Sodium</th>
<th>Cre</th>
<th>TSH</th>
<th>Cholesterol</th>
<th>Ferritin</th>
<th>HgA1C</th>
<th>TOTAL</th>
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<tr>
<td>Index tests, n</td>
<td>1,177,650</td>
<td>671,434</td>
<td>859,734</td>
<td>361,212</td>
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<td>93,385</td>
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<td>68,373</td>
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<td>9,682</td>
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<td>791,361</td>
<td>350,468</td>
<td>369,060</td>
<td>89,177</td>
<td>114,923</td>
<td>3,404,338</td>
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<td>3,951,361</td>
<td>2,529,090</td>
<td>3,259,967</td>
<td>1,831,998</td>
<td>1,718,462</td>
<td>535,476</td>
<td>595,446</td>
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<td>68,467</td>
<td>76,905</td>
<td>10,522</td>
<td>6,096</td>
<td>3,123</td>
<td>4,861</td>
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<td>3,183,062</td>
<td>1,821,476</td>
<td>1,712,366</td>
<td>532,353</td>
<td>590,585</td>
<td>14,156,251</td>
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<td>Not randomly selected</td>
<td>2,555,786</td>
<td>1,160,623</td>
<td>1,883,062</td>
<td>521,476</td>
<td>412,366</td>
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<td>1,300,000</td>
<td>1,300,000</td>
<td>1,300,000</td>
<td>1,300,000</td>
<td>532,353</td>
<td>590,585</td>
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