Evaluation of Electronic Medical Record Administrative Data Linked Database (EMRALD)

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Background: Primary care electronic medical records (EMRs) represent a potentially rich source of information for research and evaluation.

Objective: To assess the completeness of primary care EMR data compared with administrative data.

Study Design: Retrospective comparison of provincial health-related administrative databases and patient records for more than 50,000 patients of 54 physicians in 15 geographically distinct clinics in Ontario, Canada, contained in the Electronic Medical Record Administrative data Linked Database (EMRALD).

Methods: Physician billings, laboratory tests, medications, specialist consultation letters, and hospital discharges captured in EMRALD were compared with health-related administrative data in a universal access healthcare system.

Results: The mean (standard deviation [SD]) percentage of clinic primary care outpatient visits captured in EMRALD compared with administrative data was 94.4% (4.88%). Consultation letters from specialists for first consultations and for hospital discharges were captured at a mean (SD) rate of 72.7% (7.98%) and 58.5% (15.24%), respectively, within 30 days of the occurrence. The mean (SD) capture within EMRALD of the most common laboratory tests billed and the most common drugs dispensed was 67.3% (21.46%) and 68.2% (8.32%), respectively, for all clinics.

Conclusions: We found reasonable capture of information within the EMR compared with administrative data, with the advantage in the EMR of having actual laboratory results, prescriptions for patients of all ages, and detailed clinical information. However, the combination of complete EMR records and administrative data is needed to provide a full comprehensive picture of patient health histories and processes, and outcomes of care.

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For author information and disclosures, see end of text.

Although the United States and Canada have historically lagged behind other industrialized countries in the adoption of electronic medical records (EMRs) in primary care,[1] with the introduction of the Health Information Technology for Economic and Clinical Health Act in 2009 in the United States[2] and the establishment of Canada Health Infoway[3] and provincial EMR adoption support programs in Canada, the uptake of EMRs in both countries is rapidly increasing.[4] This development, especially in primary care physician practices, has resulted in a new, potentially rich source of clinical information not only for point-of-care clinical practice but also for secondary purposes such as research and quality performance evaluation.

Because of its single-payer healthcare system, Canada has comprehensive health-related administrative databases that cover the entire population. Complete, provincewide, population-level administrative databases have been shown to be highly accurate in capturing hospitalizations and prescriptions for Ontario residents 65 years and older.[5] Also in these databases, physician billing data accurately capture frequency of patient encounters, but the depth and details of patient clinical encounters are unavailable. Indeed, a previous study in the United States found that EMR data in community health centers were more complete than Medicaid claims data for assessing diabetes preventive care.[6]

Because use of primary care EMR data in Canada for secondary purposes is in its relative infancy, we set out to determine the completeness and comprehensiveness of the EMR data compared with administrative data.

METHODS

We developed the **E**lectronic **M**edical **R**ecord **A**dministrative data **L**inked **D**atabase (EMRALD) at the Institute for Clinical Evaluative Sciences (ICES). The Institute for Clinical Evaluative Sciences is a "prescribed entity" under provincial privacy legislation and thus is able to collect individual-level patient health information without patient consent based on policies and procedures in place to protect patient privacy and confidentiality.[7] EMRALD was developed using data from family phys-

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Take-Away Points

This study examined the comprehensiveness of primary care electronic medical record (EMR) data compared with administrative data.

- Primary care EMRs have reasonably comprehensive capture of primary care physician visits, laboratory tests, and prescriptions by the EMR physician.
- Laboratory tests and prescriptions by other providers may be missing; there is incomplete communication with specialists, and particularly poor communication between EMRs and hospitals.
- Until integrated systems with open communication channels between all aspects of the healthcare system are in place, the most comprehensive patient health histories can be achieved by combining information from complete EMR records and administrative data.

icians (FPs) in Ontario using Practice Solutions EMR, the market-leading EMR software vendor in Ontario.[8] All clinically relevant data are extracted from the participating physician's EMR and each patient is anonymously linked, using their scrambled health card number, to the health-related administrative databases for the province of Ontario housed at ICES.

Physicians participate on a completely voluntary basis and are required to have had their EMR a minimum of 2 years to ensure that the EMR is adequately populated. Over the past decade Ontario has undergone major primary care reform such that the majority of all FPs in the province practice under one of the reform models that require "rostering" of patients (identification of patients with the 1 primary care provider who is most responsible for their care).[9] All of the EMRALD FPs practice under one of the various primary care reform models of care. This analysis was confined to data that were captured in 2008 for rostered patients of participating FPs who had at least 1 visit to their physician in the 2 years before January 1, 2008.

Family Physician Clinic Visits

To determine the capture of all FP visits by patients rostered to EMRALD physicians (regardless of whether the visit was to an EMRALD physician), FP outpatient visits billed to the Ontario Health Insurance Plan (OHIP) physician billing database were compared with visits recorded in the EMR to determine the capture of FP visits by patients rostered to EMRALD physicians. Visit comparison between OHIP and EMRALD was confined to EMRALD physician OHIP visits only, to assess how completely EMRALD physicians were documenting patient visits within their EMR.

Specialist Consultations and Hospitalizations

To determine the capture of specialist visits and hospitalizations within EMRALD, OHIP billings by specialists performed in an office setting for an initial consultation and hospitalizations, as recorded in the Canadian Institute for Health Information Discharge Abstract Database, were compared with consultation letters and hospital discharge summaries in EMRALD within 14 days and within 30 days of the specialist billing date or the hospital discharge date.

Laboratory Data

A frequency count of OHIP laboratory fee codes identified the 20 most common laboratory tests ordered. Comparisons were made between the laboratory tests recorded on the same day in EMRALD and in OHIP.

Prescription Data

The EMR records when a drug is prescribed to the patient by the EMR physician, and the Ontario Drug Database (ODB) records when a drug was dispensed at a pharmacy (regardless of the prescriber). The EMR may also list drugs prescribed to a patient by other providers (ie, specialists), but only if such data are manually updated by the EMR-using physician; thus, the EMR is variably populated with these data. The prescription field within EMRALD and the prescriptions dispensed in ODB in 2008 were used to compile 2 drugs lists for the top 50 dispensed Canadian medications,[10] grouped into 7 clinical categories. The 2 lists for each patient were compared. This analysis was confined to patients 65 years and older as of January 1, 2008, as the ODB only captures drugs universally for all Ontario residents 65 years and older.

Match Rates

Match rates were calculated for all parameters of comparison by calculating the mean match rate and standard deviation (SD) for all the clinics, giving each clinic equal weighting regardless of size.

This study received ethics approval from Sunnybrook Health Sciences Research Ethics Board.

RESULTS

Overall, there were 56,107 patients with an average age of 39.7 years from 54 physicians practicing in 15 geographically distinct clinics. The mean years since graduation of the physicians was 19.3 years (SD = 10.4 years). Seventy percent of the physicians were in urban practice, 56% were male, and 98% were in group practice. The average duration of time on the EMR was 4.5 years (SD = 2.6 years).

Family Physician Visits

Nearly 80% of the FP billings in OHIP that occurred in an office setting were captured in EMRALD. To determine

Table 1. Comparison of Visits, Laboratory Tests, Prescriptions, Initial Specialist Consultation Letters, and Hospital Discharge Summaries Recorded in EMRALD Versus Administrative Data[a]

Data Element	Number of Entries in EMRALD	Number of Entries in Admin	Number of Entries Matching	Match Rate EMRALD→Admin, Mean for All Clinics (SD)	Match Rate Admin→EMRALD, Mean for All Clinics (SD)
Visits in EMRALD vs any family physician outpatient visit in OHIP[b]	83,005	105,027	80,297	97.0% (2.20%)	78.7% (7.37%)
Visits in EMRALD vs only EMRALD physician visits in OHIP[b]	83,005	85,473	80,239	97.0% (2.17%)	94.4% (4.88%)
Top 20 laboratory tests in EMRALD vs OHIP	330,495	349,965	256,648	75.6% (33.02%)	67.3% (21.46%)
Top 50 medications in EMRALD vs ODB	19,060	24,128	16,674	87.4% (2.26%)	68.2% (8.32%)

Data Element	Number of Entries in EMRALD	Number of Entries in Admin	External Documents in EMRALD Within 14 Days, Mean for All Clinics (SD)	External Documents in EMRALD Within 30 Days, Mean for All Clinics (SD)
Specialist consultation letters in EMRALD vs OHIP	14,389	22,409	68.1% (9.78%)	72.7% (7.98%)
Discharge summaries in EMRALD vs CIHI	1968	3862	52.2% (16.05%)	58.5% (15.24%)

Admin indicates administrative data; CIHI, Canadian Institute for Health Information Discharge Abstract Database; EMRALD, Electronic Medical Record Administrative data Linked Database; ODB, Ontario Drug Benefit database; OHIP, Ontario Health Insurance Plan physician billing database.
[a]Based on data in 2008 from 56,107 patients of 54 physicians in 15 clinics.
[b]Billing data were not available for 3 clinics.

whether the remaining billings were missing because patients were seen elsewhere (eg, a walk-in clinic) and therefore their visits were not recorded in the EMR, we limited the comparison to OHIP billings made by EMRALD physicians. In that case, we found that nearly all the billings for patients had a corresponding progress note entry in the EMR. Thus, we concluded that the approximately 15% of billings missing from the EMR were because patients were seen elsewhere and that the EMRALD participating physicians were fully using the EMR to record their patient encounters (Table 1).

Specialist Clinical Encounters and Hospitalizations

On average, just over two-thirds of initial specialist visits resulted in a consultation letter captured in EMRALD within 14 days of the visit; this percentage increased by less than 5% when the interval was expanded to 30 days (Table 1). Just over half of the hospital discharges had documentation of the hospitalization within EMRALD (Table 1).

Laboratory Tests and Prescriptions

We found that on average approximately three-fourths of the laboratory tests captured in EMRALD were also billed in OHIP, and most clinics had a higher match rate. When the laboratory tests recorded in OHIP were compared with what was recorded in EMRALD, approximately two-thirds of the tests billed to OHIP were captured (Table 1). Urinalysis tests had the poorest capture of all the laboratory tests in OHIP compared with EMRALD (Table 2).

Capture of prescriptions in EMRALD compared with drugs dispensed in ODB was high. However, only just over two-thirds of the drugs dispensed in ODB were captured in EMRALD (Table 1). Antibiotics (as represented by amoxicillin) were the drug class that had the poorest capture rate. However, the capture rates for drugs to treat chronic conditions such as cardiovascular disease and endocrine diseases appeared to be relatively high (Table 3).

DISCUSSION

We found that primary care EMR data capture compared well with administrative data. Like previous US studies comparing EMR data with administrative data,[6,11] our results

Table 2. Comparison of Laboratory Test Capture in the Electronic Medical Record Versus Physician Billing Data by Type of Laboratory Test

Laboratory Test	Number of Tests in EMR	Number of Tests in OHIP	Number of Tests Matching	Match Rate EMR→OHIP, %	Match Rate OHIP→EMR, %
Hemoglobin	33,919	34,784	25,003	73.7	71.9
Creatinine	27,622	28,701	20,663	74.8	72.0
Glucose	30,654	29,503	22,324	72.8	75.7
Thyroid-stimulating hormone	18,534	21,799	16,116	87.0	73.9
Potassium	22,808	22,081	16,697	73.2	75.6
Total cholesterol	17,043	18,762	14,379	84.4	76.6
Alanine transaminase	17,484	18,683	13,784	78.8	73.8
Triglycerides	16,017	18,636	14,309	89.3	76.8
High-density lipoprotein cholesterol	15,897	18,364	14,210	89.4	77.4
Sodium	22,378	21,561	16,385	73.2	76.0
Alkaline phosphatase	15,495	17,017	12,355	79.7	72.6
Chloride	20,505	19,536	14,892	72.6	76.2
Urinalysis	5825	9831	3116	53.5	31.7
Aspartate aminotransferase	11,571	11,813	8354	72.2	70.7
Bilirubin	8033	9832	6524	81.2	66.4
Glycated hemoglobin	10,444	10,688	8633	82.7	80.8
Prothrombin time	12,529	10,758	8270	66.0	76.9
Ferritin	9656	11,266	8490	87.9	75.4
Uric acid	5723	6871	4814	84.1	70.1
Vitamin B_{12}	8358	9479	7330	87.7	77.3

EMR indicates electronic medical record; OHIP, Ontario Health Insurance Plan physician billing database.

support the idea that primary care process quality measures involving laboratory test ordering or prescriptions are better assessed through the EMR than through administrative data because the EMR is more likely to reflect what the primary care physician ordered or prescribed.

Although our results may seem to indicate that administrative data have superior capture of laboratory results, both administrative data and the EMR have their weaknesses. Unlike administrative data, the EMR has actual laboratory results available. However, the EMR often misses tests that were not ordered by the primary care provider. There was a larger SD for the lab results compared with the other assessed data elements because 2 clinics had much lower than average match rates. These 2 low-match-rate clinics both had far more laboratory test data in the EMR than in the administrative data and were likely clinics where the patients used a hospital-based laboratory, which is not currently captured in provincial administrative databases.

Prescription data within the EMR contain prescriptions for patients of all ages (rather than just the elderly and/or those on social assistance, as in our provincial drug database), whereas the administrative data provide information on medications dispensed regardless of the prescriber. Because administrative data show the prescriptions dispensed while the EMR data shows the prescriptions prescribed, the match rates should be considered in light of previous studies indicating that approximately 10% of prescriptions do not get filled.[12] The relatively low capture rate for antibiotics may reflect the use of walk-in clinics or the emergency department for the treatment of acute infectious conditions. An additional advantage of EMR data is the capture of prescribed medications that are over the counter or that are not on the provincial drug formulary.

We found that nearly three-fourths of specialist consultation letters were captured in the EMR, but hospital discharge summaries were less than optimally captured. These findings are similar to previous findings in the United States[13] and highlight the need for improvements in communications between providers to ensure completeness of primary care EMRs.

Uncertainty regarding generalizability of our findings arises from the variability across provider users and across EMR systems.[14] Each EMR software package has its own unique data structure. Until Canadian standards are developed, implemented, and enforced for entering and exporting EMR data

Table 3. Comparison of Drug Capture in the Electronic Medical Record Versus Ontario Drug Benefit Data by Specific Medication and Type

Drug Name	Number of Drugs in EMR	Number of Drugs in ODB	Number of Drugs Matching	Match Rate EMR→ODB,%	Match Rate ODB→EMR,%
Overall total for antibiotic drugs	297	848	245	82.5	28.9
Amoxil, Novamoxin, amoxicillin	297	848	245	82.5	28.9
Overall total for analgesia/rheumatic drugs	2011	2639	1611	80.1	61.1
Tylenol 3 (acetaminophen with codeine), Lenoltec 3 (acetaminophen with codeine and caffeine)	623	992	523	84.0	52.7
Celebrex, celecoxib	311	316	227	73.0	71.8
Percocet, Oxycocet (oxycodone and acetaminophen)	246	300	143	58.1	47.7
Anaprox, Naprosyn, naproxen	237	235	167	70.5	71.1
Prednisone	356	498	323	90.7	64.9
Allopurinol	238	298	228	95.8	76.5
Overall total for cardiovascular drugs	9437	12,287	8967	95.0	73.0
Lipitor, atorvastatin	1759	2170	1697	96.5	78.2
Crestor, rosuvastatin	484	620	456	94.2	73.6
Norvasc, amlodipine	909	1156	880	96.8	76.1
Adalat, nifedipine	249	335	239	96.0	71.3
Metoprol, metoprolol	670	847	628	93.7	74.1
Monocor, bisoprolol	259	350	254	98.1	72.6
Altace, ramipril	1483	1835	1429	96.4	77.9
Coversyl, perindopril	192	259	182	94.8	70.3
Avapro, irbesartan	176	217	168	95.5	77.4
Diovan, valsartan	218	254	206	94.5	81.1
Atacand, candesartan	255	298	229	89.8	76.9
Lasix, furosemide	665	886	623	93.7	70.3
Hydrochlorothiazide	1184	1967	1123	94.9	57.1
Plavix, clopidogrel	351	362	280	79.8	77.4
Coumadin, warfarin	583	731	573	98.3	78.4
Overall total for endocrinologic drugs	2921	2931	2202	75.4	75.1
Synthroid, Eltroxin, levothyroxine	972	1246	961	98.9	77.1
Actonel, risedronate	429	544	390	90.9	71.7
Premarin, conjugated equine estrogen	204	213	115	56.4	54.0
Glucophage, metformin	764	928	736	96.3	79.3
Alesse, ethinyl estradiol and levonorgestrel	1	0	0	0	0
Calcite 500 + D, Caltrate, calcium carbonate with vitamin D	551	0	0	0	0
Overall total for gastrointestinal drugs	2021	2468	1709	84.6	69.2
Pantoloc, pantoprazole	322	442	282	87.6	63.8
Nexium, esomeprazole	86	0	0	0.0	0.0
Prevacid, lansoprazole	201	256	169	84.1	66.0
Losec, omeprazole	373	447	328	87.9	73.4
Pariet, rabeprazole	827	1061	756	91.4	71.3
Flomax, tamsulosin	212	262	174	82.1	66.4
Overall total for mental health drugs	1395	1798	1219	87.4	67.8
Effexor, venlafaxine	196	247	182	92.9	73.7
Seroquel, quetiapine	38	92	35	92.1	38.0
Ativan, lorazepam	669	823	559	83.6	67.9
Elavil, amitriptyline	354	407	311	87.9	76.4
Oxazepam	138	229	132	95.7	57.6
Overall total for respiratory drugs	978	1157	721	73.7	62.3
Ventolin, salbutamol	564	781	479	84.9	61.3
Flovent, fluticasone	298	371	242	81.2	65.2
Nasonex, mometasone furoate	116	5	0	0.0	0.0

EMR indicates electronic medical record; ODB, Ontario Drug Benefit database.

elements, the quality of the data captured and the ability to identify discrete data elements in the EMR may not be the same across EMR software packages from different vendors. For instance, highly flexible, free-text-based EMR systems allow for multiple ways to enter data, requiring the identification of all options for denoting prescence of disease conditions.

It is possible that we did not capture all typographical errors for prescription information or all the different naming conventions for the same laboratory test. Therefore, our results might have underestimated EMR capture. Practice Solutions EMR software is very free-text based and has good searching capabilities; thus, physicians tend to scan external documents such as diagnostic tests and consultation letters in an optical character recognition format to allow the text within those documents to be searched. In addition, types of external documents are classified as a consultation letter from a particular type of specialist and can be found under that specific variable (ie, consultation letter from a cardiologist). Not all EMR software is structured in this way, so some EMRs' external documents are not classified and external documents are entered in PDF or TIFF format, which is a picture-like format that cannot be searched or de-identified. Thus, the detailed information that can be found in these documents may not be accessible.

Although highly promising,[15] using EMR data for secondary purposes is not straightforward.[16,17] Full and accurate data availability may be possible in the case of integrated systems with health information technology that allows for a seamless, shared electronic record (as in Kaiser Permanente and the Veterans Health Administration).[18] Policies and programs developed to improve seamless communication in large geographic areas between primary care EMRs and other parts of the healthcare system are needed. These automated electronic communication channels would further enhance the comprehensiveness of information captured within the EMR, which could lead to more efficient and informed patient care as well as improvement in the quality of the information for research and analytic purposes. Canada has no practices or polices in place for standardizing data entry into EMRs, and with limited pay-for-performance programs that would incentivize physicians to accurately code diagnostic information in structured data fields, analyzing EMR data will continue to have challenges.

Despite these limitations of EMR data for secondary purposes, the potential benefits include the ability to objectively study processes and outcomes of care, use the EMR data as a reference standard for administrative data validation, perform quality-of-care measures, give performance feedback to physicians, and efficiently identify cohorts of patients for clinical trials or other analyses. Important benefits of the combination of administrative data with EMR data are the combination of both financial and clinical data, and the ability to assess outcomes and outcomes per healthcare dollar spent.

A broader view of individual patients will include behavioral, environmental, and genomics data. However, in the absence of a well-established integrated system, use of EMR data that are linked with administrative data (as in EMRALD) offers an important first step toward providing a comprehensive picture of patient health histories across the spectrum of care.

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