Capture of Osteoporosis and Fracture Information in an Electronic Medical Record Database from Primary Care

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Abstract

In a large database of EMR records, we explore: 1) completeness in capture of bone mineral density (BMD) T-scores required for diagnosis of osteoporosis; 2) concordance of BMD exam information with other osteoporosis information; and 3) evidence of osteoporosis screening among fracture patients. To explore completeness of exam capture, BMD exams in the EMR were related to a provincial billing database. To explore concordance of information and screening rates, 7500 EMR records were reviewed for osteoporosis and fracture details. Results show that 98% of exams billed to the province for EMR patients were found in the EMR. However, documented osteoporosis was substantiated with BMD results only 55.8% of the time. Of 151 charts for fragility fracture patients, 1 in 4 contained no evidence of osteoporosis investigation. In summary, while EMR information about osteoporosis is of variable quality, EMR records shed light on osteoporosis management indicators and completely capture BMD results.

Introduction

In 2005, the Ontario Ministry of Health and Long Term Care provided funding for the Ontario Osteoporosis Strategy with the goal of promoting appropriate osteoporosis care and preventing fractures in the province[1]. As a part of the Strategy, the Ontario Bone Mineral Density (BMD) Working group has been exploring utilization of BMD testing in the province, specifically. BMD tests provide information required to definitively diagnose osteoporosis[2]; this occurs when a patient's BMD T-score is found to be 2.5 standard deviations or more below the young adult mean. Clinical guidelines currently recommend that all patients over the age of 65 undergo BMD testing in order to screen for osteoporosis, as well as all individuals with a history of fragility fracture[2].

In Canada, some information about BMD testing is available in administrative databases, like the Ontario Health Insurance Plan (OHIP) records. However, while OHIP contains billing information for the province's BMD tests, it does not contain the results required to definitively diagnose osteoporosis (i.e. the BMD T-scores). Incidence of osteoporosis in the Ontario population, then, must instead be inferred from other administrative sources, like prescription information or hospital billings; these sources are known to provide limited accuracy[3]. Administrative data, moreover, does not provide adequate insight regarding about appropriate osteoporosis screening. Specifically, while administrative data indicate rates of post-fracture BMD testing to be low[4], these data cannot identify pathways of care among patients. This means that administrative data alone cannot determine where efforts to improve screening rates should best be targeted[4].

In part due to the limitations of administrative data, researchers have been increasingly turning to Electronic Medical Records (EMRs) in the hopes that these may provide better, more timely and comprehensive information about both osteoporosis incidence and management. EMR data have several advantages over administrative data in that the data include test results and are specific to management decisions that take place within a particular care pathway. The quality of data in EMRs, however, has tended to be variable in part because clinicians use EMRs in a wide variety of ways. For example, many physicians continue to use *both* paper records and EMR records[5]. A 2010 review of EMR usage highlighted the impact of such variability; completeness of blood pressure information captured in EMRs, for example, varied from 0.1% to 51% across studies[6]. EMR data also often has been found to contain misspelled words, missing diagnostic codes, or data that has been entered in incorrect or inconsistent database fields[7,8]. A lack of mature electronic interfaces to EMR has also hindered the completeness of data in Ontario's EMRs; according to the National Physician Survey, in 2010 approximately 40% of family physicians in Ontario

had an electronic interface to diagnostic imaging services[5]. Lack of diagnostic imaging results impacts the completeness of BMD results in EMRs, specifically; a 2005 of EMR records in the U.K. revealed limited capture of these results[9].

Study Objectives

The primary purpose of this study is to provide an updated assessment of data quality related to Bone Mineral Density (BMD) test results in EMRs and to explore the relationship of BMD data to other osteoporosis documentation by primary care physicians. To facilitate this assessment, we are using a large database of Ontario EMR records called the Electronic Medical Record Administrative data Linked Database (EMRALD) [10-12]. At the time of this study, EMRALD contained data from 296 family physicians at 31 practices who use Practice Solutions® EMR and is located at the Institute for Clinical and Evaluative Sciences in Toronto, Ontario. Records in EMRALD include comprehensive electronic patient records, consult notes, as well as diagnostic imaging and lab test results for more than 300,000 individual patients. The distribution of patients represented in EMRALD reflects the age and sex distributions of the province and the average duration of EMR usage by participating clinics was 4 years. Analysis based on EMRALD data therefore can be expected to represent relatively recent usage trends.

The specific research objectives of the present study are:

First, to assess the completeness of BMD exam capture in EMRs and the potential for exam results in the EMR to yield gold-standard diagnoses of osteoporosis based on collected BMD T-scores. To assess the completeness of exam capture, we relate BMD results in EMRALD for all patients over 40 to BMD exam billings in a provincial insurance database (OHIP). We also explore the number of tests that are stored in the EMR as text, and where machine-assisted identification of BMD T-scores can be expected to be relatively straightforward.

Second, to assess the relationship between the information about osteoporosis found in BMD results and osteoporosis information found elsewhere in patient charts. For this level of analysis, we manually reviewed 7500 randomly selected patient records in EMRALD to determine where and how osteoporosis information was coded across the sample.

Third, to explore the information that EMRALD may hold about screening for osteoporosis within primary practice and after fragility fracture. Analysis here focuses on the charts of 151 individuals who were identified in the subset of 7500 as fragility fracture patients. We explore the incidence of BMD screening in this group and characterize other information indicative of osteoporosis in the population.

Methods

Data Collection

To construct EMRALD, clinically relevant data fields from the EMRs of participating family physicians are extracted through a custom software 'plug-in' and securely transferred to ICES. Data are collected from each clinic every 6 months. At ICES, health card numbers for provincial insurance are partitioned from data and the remaining data undergoes de-identification as per standard ICES policies and procedures for maintaining privacy and confidentiality[13].

The research protocol was approved by the Research Ethics Board of the Sunnybrook Health Sciences Centre.

Completeness of BMD Exam Capture

To assess the completeness of EMRALD's capture of BMD exams, BMD results in EMRALD for all patients over 40 were related to billing records for BMD exams in OHIP.

To begin, records for all patients over age 40 as of December 31, 2011 were selected from EMRALD. The diagnostic imaging results for these patients were searched and exams that were both labeled 'BMD' and dated between December of 2011 and January of 2006 were recorded.

For the same group of patients, OHIP billing records were searched for BMD exam billings dated before the end of 2011 and after either January 1, 2006 or the date the patient first appeared in EMRALD (whichever was more recent). Of note is the fact that new fee codes for baseline BMD exams were introduced by OHIP in 2008. This means that exams in EMRALD dated after 2008 were matched with a slightly different set of OHIP billings than exams dated prior to 2008 (refer to Table 3 for OHIP billing codes).

To relate OHIP records to EMR records of BMD examination, bi-directional matches were performed. First, an attempt was made to pair each OHIP billing with a BMD exam in EMRALD that shared the *exact same date*. Because exams may appear in EMRALD several days post-billing to OHIP, a second attempt was also made to match OHIP billings with corresponding exams in EMRALD that were dated *up to 30 days after billings took place.* In the opposite direction, BMD exams found in EMRALD were paired with OHIP billings sharing the *same date* and also with billings that took place *up to 30 days prior* to the exam date recorded in EMRALD.

We report the number of tests located in both EMRALD and OHIP for the patients and the percentage of tests that could be matched between corresponding data sources. We also report the number of BMD tests that were stored in EMRALD in text format rather than as images, in an effort to gauge the potential to access numeric T-scores using computerized searches. Entries for BMD exams in EMRALD that were more than 200 characters in length or which contained instances of the word "T-score" were flagged as accessible.

Relationship Between BMD Results and Other Osteoporosis Information

To assess the relationship between BMD results and osteoporosis information found elsewhere in patient records, 7500 charts for individuals over age 20 were randomly selected from the database and manually reviewed by a trained nurse. Details regarding osteoporosis were abstracted from the machine-readable, structured portions of electronic records; these include patient profiles, notes from individual patient encounters, text-based (but not image-based) diagnostic imaging results, consult notes and lab tests. During abstraction, both content and location of pertinent information in the electronic charts were noted. Information that was abstracted included:

1. Basic Demographic Information, including the age and sex of patients;
2. Evidence of osteoporosis as documented in:
    a. BMD exam results;
    b. Patient summaries (e.g., in problem lists);
    c. Notes attached to individual patient exams (such as annual exams);
    d. Consult notes (e.g., hospital discharge notes, ER consult notes, notes from specialists);
    e. Other exam results (e.g., X-ray investigations).

Documentation that was considered indicative of osteoporosis included presence of BMD T-scores of the femoral neck or lumbar spine below -2.5, vertebral compression fracture as documented by x-ray investigation, documentation of osteoporosis in the patient profile, or a diagnosis attached to a patient exam, given in a consult note or on an imaging result. We report the number of patients identified as osteoporotic in the sample, and the distribution of osteoporosis documentation across the sample.

Documentation of Osteoporosis among Post-Fracture Patients

Current guidelines recommend that all patients who have undergone a recent fragility fracture should be screened for osteoporosis; the gold standard for diagnosis of osteoporosis is based on the result of a BMD examination[2].

To explore consideration of osteoporosis among fragility fracture patients, the subset of 7500 records described above was additionally reviewed for fragility fracture evidence. Evidence that was considered indicative of a fracture history included radiological evidence of fracture (X-rays, CT scans, etcetera),

documentation of a fracture in patient profiles, hospital discharge notes, or mentions of fractures in consult notes from specialists. If fractures were specifically indicated as “fragility fractures” in charts, this was noted. Fractures of the head, foot, toe, hand and finger were excluded from analysis.

We report the number of patients identified as having a history of fracture in the sample, the number with specific mention of “fragility fractures”, and the percentage of fragility fractures patients for whom there is evidence to suggest consideration of, or screening for, osteoporosis.

Results

Completeness of BMD Exam Capture

Records for 79,740 patients over age 40 were located in EMRALD.

OHIP billing records indicated that 14,536 of these individuals had one or more BMD tests after their appearance in EMRALD, resulting in a total of 20,174 OHIP billings for BMD tests, or 1.39 billings per patient (on average) between 2006 and 2011. A summary of the BMD tests as recorded by the OHIP billing database is presented in Table 1.

Table 1. Distribution of BMD billings in OHIP for EMRALD patients over age 40.

OHIP Fee Codes	**Fee Code Description**	**# (%)**
X146*, X145*	Baseline BMD test	1996 (9.9%)
X152, X153	Second BMD test, low risk patient	5250 (26.0%)
X142, X148	Subsequent BMD test, low risk patient	75 (0.4%)
X149, X145	Subsequent BMD test, high risk patient	12,853 (63.7%)
Total billings for tests		**20,174 (100%)**

**indicates a fee code that was added in 2008.*

Of the 20,174 BMD tests that were identified in OHIP, 89.8% could be matched with a corresponding test in EMRALD that shared the exact same date. When matching constraints were relaxed to allow for correspondences between billings and exams in EMRALD dated up to 30 days post-billing, the match rate increased to 97.9%.

In EMRALD, a total of 21,553 BMD exams were located for 15,365 patients, resulting in an average of 1.4 BMD tests per patient between 2006 and 2011. Of these tests, 84.1% could be matched with an OHIP billing that shared the exact same date. Using relaxed matching constraints (i.e., when allowing matches with billings prior to EMR dates), the match rate increased to 91.7%. 829 patients with BMD tests in EMRALD (5.4% of all patients with BMD tests in EMRALD) were found to have no corresponding billings for BMD tests in OHIP.

A total of 72.6% of the BMD tests in EMRALD were stored as text and 66.5% contained the word ‘T-score’ specifically. However, the number of BMD tests stored as text varied widely from practice to practice. The mean percentage of tests stored as text at each clinic was 65% with a standard deviation over 35% and a range that spanned 0% to 100%.

Relationship Between BMD Results and Other Osteoporosis Information

The randomly selected group of 7500 electronic records represented a group of patients with a mean age of 49.6 years, 57.3% of whom were female.

A total of 441 charts (5.9% of the total) were found to contain evidence of osteoporosis. The average age of the patients in the group with osteoporosis was 71.0 years, and 87.3% were female. By far the most common way of documenting osteoporosis was in the context of individual patient exam entries (such as in

an entry for a recent annual exams). A total of 398 cases of osteoporosis, or 90.2% of the total, were documented this way. Only 246 charts, or 55.8% of the osteoporotic group, were found to have evidence of osteoporosis that was substantiated with results from BMD exams. A total of 277 (or 62.8% of the group) contained a diagnosis of osteoporosis in an electronic patient profile.

Results are summarized in Table 2.

Table 2. Documentation of patients with osteoporosis (n = 441)

Documentation found in:	**# (%)**
Notes for Patient Exam(s)	398 (90.2%)
Patient Profiles	277 (62.8%)
BMD Exam Result	246 (55.8%)
Consultation Note (Specialist Consult Note, Emergency Consult Note, etc.)	38 (8.6%)

Documentation of Osteoporosis among Post-Fracture Patients

A total of 1473 fractures were documented in the charts; these were found in the charts of 1048 individual patients (15.9% of the sample). Charts for 151 of these individuals *specifically* mentioned a history of low-trauma fracture; these patients were therefore labeled "fragility fracture" patients. Of these patients, no record of BMD investigation could be located for 55, or 36.4% of the group. For several of these patients, however, alternative evidence was located to indicate consideration of osteoporosis (i.e. notes in patient profiles, consult notes, etcetera). There were a total of 36 fracture patients (23.8% of all fragility fracture patients) for whom no evidence of osteoporosis consideration could be located (i.e. no BMD results or other charted notes).

Results are summarized in Table 3.

Table 3. Osteoporosis documentation among patients with fragility fractures

	# (%)
Patients with fragility fracture	151 (100%)
Fragility fracture patients without evidence of BMD investigation	55 (36.4%)
Fragility fracture patients without evidence of OP investigation	36 (23.8%)

Discussion

Completeness of BMD Exam Capture

The present study indicates that EMR records capture BMD results completely relative to administrative data sources, and that the information required for 'gold-standard' diagnosis of osteoporosis is readily accessible to machine-assisted interpretation in a significant proportion of these results.

In a 2005 study of osteoporosis information in EMRs, a relative shortage of BMD tests was found across the EMR records for 78 practices[9]. In that prior work, only two practices could be located with more than 200 BMD test records on file[9]. Our study of data from 31 clinics, by contrast, identified several comparable practices averaging more than 200 BMD tests over similar stretches of time. More importantly, our results indicate that EMRALD captures BMD exams found in the OHIP database, which are the majority of those that take place in the province. In addition, EMRALD was found to capture records of some BMD tests that do *not* appear in OHIP billing records. Errors in test categorization and a lack of perfect synchronization between the EMR and OHIP may account for some of these extra tests, but EMRALD likely captures additional valid test results, such as those for tests performed outside of Ontario or billed to alternate insurers.

This evidence suggests that key details regarding BMD tests are reliably being provided to and/or labeled in Ontario's EMRs. The fact that 97% of OHIP billings for BMD tests could be matched with exam data in EMRALD contrasts with recent analyses of EMRALD's capture of laboratory tests and prescription information; roughly 67% of EMRALD's data could be matched with administrative records for these services[4]. BMD exams are, however, somewhat unusual in that they are typically ordered directly by family physicians while other imaging and laboratory services (like x-rays) may be ordered by specialists. Increasing comfort with EMRs on the part of clinicians and improvements in interfaces between EMRs and diagnostic imaging labs are likely contributors to the BMD exam coverage in EMRALD. According to the National Physician Survey, in 2010, 40% of family physicians in Ontario reported an electronic interface to diagnostic imaging services and this percentage is climbing[5].

In the 2005 study, moreover, BMD exams could not be associated with the numeric T-scores required for diagnosis of osteoporosis[9]. Results from our study, however, indicate T-scores to be somewhat more accessible, as the word 'T-score' could be automatically drawn from more than 65% of EMRALD's entries for BMD exams. Promising related work has taken additional steps toward automated BMD exam result interpretation: in a study of EMR records for post-menopausal female veterans from the U.S., T-scores were not only pulled from 63% of the exams stored in an EMR but were correctly associated with regions of interest and diagnoses more than 80% of the time[14]. Like the 2005 study, however, the present study documents variation of T-score accessibility by practice. The percentage of BMD reports stored as images rather than text at each practice ranged the entire spectrum (from 0 to 100%).

In summary, EMRALD was found to record incidence of BMD testing comprehensively relative to administrative data; accessibility of the T-scores in test results means that EMRALD may soon be able to contribute to the estimation of key health status indicators in the Canadian population, including prevalence of both BMD test outcomes and osteoporosis[15]. Related research to validate the Canadian Association of Radiologists and Osteoporosis Canada guidelines in the Canadian population required BMD data from roughly 4,000 Manitoban patients per year (or 16,000 patients across 4 years)[16]. The size of population accessible to diagnosis of osteoporosis via BMD results in EMRALD is slightly smaller but comparable.

Relationship Between BMD Results and Other Osteoporosis Information

While BMD results were captured completely by EMRALD, they were not found in all charts of patients with a diagnosis of osteoporosis. By far the most common way in which osteoporosis was documented was in the notes for individual patient exams, like annual exams. About 63% of the time osteoporosis information was found in patient profiles and only about 56% of the time the diagnosis was substantiated with a BMD result.

This is not a surprising result, as some patient charts in EMRALD span a relatively short period of time. Many individuals were likely investigated for osteoporosis prior to their appearance in EMRALD; results substantiating their diagnosis may not be available to the EMR in electronic form. The BMD records in EMRALD, then, may potentially identify osteoporotic individuals with sensitivity, but not with specificity. As EMR usage continues, however, it will most likely capture more of the BMD information required to substantiate those diagnoses of osteoporosis that are on file.

The fact that entries for individual exams proved to be the most common form of osteoporosis documentation is somewhat troubling, perhaps, as notes from individual patient exams tend to become buried over time[17]. Patient summaries, by contrast, were specifically designed to hold persistent clinical information in an accessible fashion and have recognized potential to facilitate coordination of care related to chronic conditions[17]. However, osteoporosis diagnoses were found in this location only 63% of the time.

Documentation of Osteoporosis among Post-Fracture Patients

In the 2005 study of osteoporosis and fracture information in EMR records, few if any fragility fractures were identified[9]. In this study, by contrast, a significant number of fractures were identified but less than 15% could reliably be identified as fragility fractures.

In the present study, 36 of those individuals identified as fracture patients were found to have no documented consideration of osteoporosis in their charts; documentation was defined to include BMD test results and other clinical notes. This is somewhat concerning as currently guidelines state that all fracture patients should be screened for osteoporosis; those without a history of BMD testing should receive a BMD test[2]. However, the result is consistent with evidence that suggests fragility fracture patients are inadequately screened in general. In a 2005 review of osteoporosis management after fracture, for example, less than 50% of patients with fragility fractures followed up with a doctor and investigations for osteoporosis were performed in less than 15% of the group[18]. In a more recent analysis of Ontario's BMD testing rates, less than 20% of fragility fracture patients received a BMD test within 6 months of their fracture[4].

These prior results, however, were not specific to patients in the care of a family physician and of known fracture status. The fact that the current study focuses on a specific care pathway may partly account for the high proportion of fracture patients in EMRALD with records of BMD testing (63.5%) relative to the proportion reported for the Ontario population[4]. Moreover, evidence tells us that testing rates for this population and within this care pathway can be altered using electronic reminders. A 2006 study of fracture patients identified using HMO billings found 40% were tested at six months post-fracture when family physicians received electronic reminders; without reminders testing rates were under 2%[19]. The population focus in the current study, however, focuses on fractures known to family physicians, known to be low-trauma, and identified based on annotations within EMR records.

Limitations

There are several limitations to the current study. For one, while we know that BMD capture in EMRALD records is complete, we do not know the accuracy of any other information about osteoporosis or fracture. Documentation of fractures in the EMR records is particularly problematic, as fragility fractures can be very difficult to characterize. Vertebral fractures, for example, may be difficult to determine given both the lack of fracture recognition by clinicians and the ambiguous terminology in radiology reports[20]. Doctors and patients may also note fractures less forcefully and frequently, as they are transient conditions[21]. Many fragility fractures found in administrative data may therefore be missing from EMRALD records. It seems relatively probable, however, that those fractures specifically noted in EMRALD as "fragility fractures" are indeed the result of low-impact events.

EMRALD's documentation of fragility fractures is also limited in that it often excludes specific fracture dates. History of fracture is sometimes noted in patients' problem lists, for example; dates provided here may be vague or in the relatively distant past. This limits our ability to determine if BMD exams were ordered after a given fracture as guidelines recommend. Direct validation of the fractures documented in EMRALD against administrative data sources, like emergency room records and physician billings, is subject for future research; this will include validation of fracture dates.

In addition, some patients may have been screened for osteoporosis at clinics not represented in EMRALD or at times prior to the commencement of their EMR record such that these BMD results may not be present in EMRALD as a result. This is likely why many diagnoses could not be substantiated by a corresponding BMD result, despite the fact that EMRALD's coverage of BMD results after 2006 is complete.

Finally, the sample of EMR records in EMRALD only reflects practices that make use of a single EMR system (Practice Solutions); results from EMRALD may therefore not generalize to data from other EMR databases. However, EMRALD has been shown to accurately capture the presence of other medical conditions in a way that reflects province-wide rates[22].

Despite these limitations, EMRALD remains a promising source of information about osteoporosis and fracture in the Ontario population, and it holds the potential to contribute to the estimation of important health status indicators. Coverage of BMD results, in particular, is significantly more complete than it appeared to be in 2005 and T-scores required for diagnosis are accessible to machine assisted interpretation

in a significant proportion of these. Moreover, data in EMR charts may shed light on key osteoporosis management indicators in the context of primary care. Results presented here, for example, demonstrate the EMR records to contain information about screening for osteoporosis among fracture patients and on the part of family physicians.

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