Health care reform policies have placed increased emphasis on patient outcomes to drive high-value, evidence-based care to orthopedic patients. Although prospective randomized controlled trials remain the gold standard in medical research, they are often limited by financial cost, statistical power, duration to completion, and ethical concerns. Furthermore, acquisition of funding can present a major roadblock to the initiation and maintenance of prospective trials, and grant providers such as the National Institutes of Health are subject to the politico-economic environment as well as budget crisis and spending reductions. Therefore, cost-efficient retrospective studies using large administrative databases serve a major purpose in providing evidence in current and future medical literature.

The Implications of Inaccuracy: Comparison of Coding in Heterotopic Ossification and Associated Trauma

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Abstract

Retrospective studies using large databases serve a major purpose in providing evidence in the current literature. However, the quality of medical coding is highly variable. This retrospective cohort study aimed to evaluate the documentation regarding the diagnosis of heterotopic ossification (HO) and the implications it may have for conducting retrospective research using electronic medical records (EMRs). A retrospective chart review using the EMR was performed to identify all patients with a diagnosis of HO within 7 university-affiliated hospital facilities. A limited data set request was conducted for all patients with HO-specific International Classification of Diseases, Ninth Revision (ICD-9) codes and additional nonspecific musculoskeletal codes to capture patients with HO who were improperly coded. A total of 522 patients were identified—26 patients with specific HO codes and 496 patients with nonspecific codes. Imaging and clinical notes were inspected for evidence and location of HO, and histories were reviewed for traumatic injury mechanism. Two-thirds of the patients with HO were discovered by reviewing miscellaneous musculoskeletal ICD-9 codes. Thirty-eight percent of the patients with an HO-specific ICD-9 code had no evidence of HO in their EMR. Thirty-three patients had a clinical history of a traumatic injury preceding HO formation, but only 16 of the 33 had documented ICD-9 codes for the injury. The utility of databases in retrospective research is dependent on the integrity of the coding. This study questions the use of retrospective reviews for patients with uncommon diagnoses and shows how painstaking verification may be necessary to ensure that research conclusions are based on accurate data. [Orthopedics. 2017; 40(4):237-241.]
purposes of billing and securing reimbursement from payers. Unlike lengthy and prohibitively costly prospective studies, retrospective studies conducted using these large digital databases, which offer ready access to longitudinal data on large numbers of patients, allow researchers a relatively inexpensive and efficient means of addressing important questions related to health care delivery and outcomes. However, inaccurate coding of patient diagnoses, procedures, and treatments is a widely reported phenomenon\textsuperscript{5-10} that threatens the validity of administrative database research. A growing number of studies have documented problems with the coding of orthopedic diagnoses and procedures.\textsuperscript{11-15} Researchers attempting to validate the complications associated with total hip and knee arthroplasty by examining the Centers for Medicare & Medicaid Services Limited Data Set found that standard International Classification of Diseases, Ninth Revision (ICD-9) codes were missing for well-known complications.\textsuperscript{16} Coding of readmission diagnoses following total joint arthroplasty at a single institution was frequently discordant with physician-derived diagnoses.\textsuperscript{17} The positive predictive value of an administrative database diagnosis of osteoarthritis was 62% for members of a Massachusetts health maintenance organization.\textsuperscript{18} The purpose of this study was to evaluate the adequacy of coding and documentation of traumatic heterotopic ossification (HO) diagnosis for patients treated within a safety net hospital network.

### MATERIALS AND METHODS

A retrospective electronic medical record (EMR) review was performed from April 2008 to March 2013 to identify all orthopedic trauma patients who developed HO within 7 university-affiliated hospitals, including 1 level 1 trauma center and 6 community-based hospitals. During this period, all patient data at the 7 hospitals were owned by a single health care data management entity. To capture all patients with a possible diagnosis of HO, those with an ICD-9 code specific to HO (728.11, 728.12, or 728.13) as well as those with a miscellaneous musculoskeletal ICD-9 code (728.10, 728.19, and 733.99) were identified from an administrative database and included in the sample. All patients with 1 of the eligible ICD-9 codes were included in the study regardless of whether the identified code was a primary or a secondary diagnosis. A total of 522 patients had 1 of the 6 prespecified ICD-9 diagnosis codes during the study period. A manual review of the EMRs for these 522 patients, including all imaging, clinical histories, and clinical notes throughout patient charts, was performed to identify clinical and radiographic evidence of HO and documentation of traumatic injury mechanism. Imaging reports or orthopedic clinical notes containing the terminology “heterotopic ossification,” “myositis ossificans,” “heterotopic bone,” “ectopic bone,” or “ossification” were considered as positive evidence for HO diagnosis. Two physician authors (H.M., V.D.) reviewed patients meeting the criteria above plus all of those with mention of suspicious masses or calcifications to make a final determination of their classification. After identifying a cohort of patients with HO diagnosis, the patient history within the clinical notes was reviewed for description of trauma at the location corresponding to the identified HO. If a traumatic event was identified, the ICD-9 diagnosis list was reviewed for documentation of the traumatic injury.

### RESULTS

Of the 522 patients identified by the ICD-9 search criteria, 26 had HO-specific ICD-9 codes and 496 had miscellaneous musculoskeletal ICD-9 codes (Table 1). Manual review of the EMRs of the 26 patients with HO-specific ICD-9 codes revealed that 16 had supporting radiographic or clinical evidence of HO while 10 had no evidence of HO. Among the 496 patients with 1 of the miscellaneous musculoskeletal ICD-9 codes, 32 had radiographic or clinical evidence of HO without having an HO-specific ICD-9 diagnosis code. Thus, the prevalence of HO, based on clinical or radiographic evidence of the disease in the EMR, was 9.2% (48 of 522). Table 2 shows the distribution of ICD-9 codes for the 48 patients with radiographic or clinical evidence supporting a diagnosis of HO.

Table 3 summarizes the accuracy of an HO-specific ICD-9 code for individual hospitals within the network and the overall hospital network. The sensitivity of an HO-specific ICD-9 diagnosis code was 33% for the hospital network and ranged

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**Table 1**

<table>
<thead>
<tr>
<th>ICD-9 Code</th>
<th>Description</th>
<th>No. (%) of Patients With Diagnosis Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>728.10</td>
<td>Calcification and ossification unspecified</td>
<td>31 (6)</td>
</tr>
<tr>
<td>728.11</td>
<td>Progressive myositis ossificans</td>
<td>7 (1)</td>
</tr>
<tr>
<td>728.12</td>
<td>Traumatic myositis ossificans</td>
<td>11 (2)</td>
</tr>
<tr>
<td>728.13</td>
<td>Postoperative heterotopic ossification</td>
<td>8 (2)</td>
</tr>
<tr>
<td>728.19</td>
<td>Other calcification and ossification</td>
<td>0 (0)</td>
</tr>
<tr>
<td>733.99</td>
<td>Other and unspecified disorders of bone and cartilage</td>
<td>465 (89)</td>
</tr>
<tr>
<td>All diagnoses</td>
<td>522</td>
<td></td>
</tr>
</tbody>
</table>

*Abbreviation: ICD-9, International Classification of Diseases, Ninth Revision.*
from 0% to 75% among the 7 hospitals. The positive predictive value of an HO-specific ICD-9 code was 62% within the hospital system.

Of the 48 patients with radiographic or clinical evidence supporting a diagnosis of HO, 33 had clinical notes describing a traumatic injury preceding HO formation; only 16 of these 33 cases (52%) had documented ICD-9 codes for the injury (Table 4). There was considerable variation in trauma documentation across hospitals. At the major level 1 trauma center, 18 patients were diagnosed with traumatic HO, of whom 13 (72%) had an associated ICD-9 trauma injury code in their medical record. The remaining 6 hospitals combined had 15 traumatic HO cases; 3 (20%) of these cases had an associated ICD-9 trauma injury code. Of the 23 total traumatic ICD-9 codes, 19 were assigned by the level 1 trauma center and 57% (13 of 23) were “other” or “unspecified” injury codes.

**DISCUSSION**

This study revealed poor accuracy of EMR coding for the diagnosis of HO in 7 hospitals within a university-based hospital network. Heterotopic ossification-specific ICD-9 codes identified only 33% of patients who had documentation supporting a diagnosis of HO in their medical charts, and only 62% of patients with an HO-specific ICD-9 code had documentation of the disease in their charts. Thus, ICD-9 codes failed to identify two-thirds of patients with evidence supporting a diagnosis of HO, and 38% of patients with an HO-specific ICD-9 diagnosis lacked evidence in their charts to support the diagnosis. Among patients with traumatic HO as confirmed by medical record review and a clinical history of preceding trauma, 52% did not have an associated ICD-9 traumatic injury code.

The poor accuracy of diagnostic coding observed in this study has implications for research based on EMR data. Relying on ICD-9 diagnoses to identify a sample with HO would fail to find two-thirds of cases. In addition to the inefficiency of missing such a large proportion of cases, patients with HO who have an appropriate ICD-9 diagnosis may be different from those who lack an appropriate diagnostic code, which would limit the generalizability of study findings. The low positive predictive value of an HO-specific ICD-9 code raises questions about the validity of research based on a sample identified using ICD-9 codes, as findings from such a study may be influenced by the inclusion of patients with no evidence of HO.

The accuracy of HO-specific ICD-9 codes and trauma documentation varied widely across hospitals. The major level 1 trauma center (hospital 1) was more likely than the other facilities to code a traumatic injury associated with HO. For trauma-related research using administrative claims data, coding from level 1 trauma centers may provide more reliable data than coding from other health care settings.

There was marked variation in the specificity of traumatic injury codes associated with HO, and the high prevalence of nonspecific codes (57%) may hinder injury-based research. For example, one patient with a closed fracture of the humeral neck and another patient with a closed comminuted distal humerus fracture were both diagnosed with the ICD-9 code 812.20 (closed fracture of an unspecified part of the humerus). Although this diagnosis is not factually incorrect for either patient, assignment of a code within the 812.0 family (closed fractures of the upper end of the humerus) or the 812.4 family (closed fractures of the lower end of the humerus) would have been more specific.
specific. This example illustrates how lack of specificity in diagnosis coding creates inefficiencies in research: for a study seeking to evaluate distal humerus fractures, a much broader range of humerus-related diagnoses would need to be queried and then a manual chart review conducted to ensure the capture of all distal humerus injuries. Accurate injury diagnostic coding is also important in outcomes-based research, as certain risks, treatments, and complications are associated with specific injury patterns. There is an elevated risk of developing posttraumatic HO following distal but not proximal humerus fractures, which may prompt physicians to prescribe prophylactic therapy with non-steroidal anti-inflammatory drugs. In this new era of outcomes measurement, coding may impact physician and hospital reimbursement by properly identifying the varying risks and complications of diagnoses that may currently be indistinguishable based on vague coding practices.

This study had several limitations. Data within the EMR were used to determine the accuracy of ICD-9 diagnosis codes. It is possible that supporting evidence for HO would have been found by examining the paper records at the hospitals, which could have altered the study findings. Considerable variation in the accuracy of coding was noted across the 7 hospitals in the single network that was the focus of this study, suggesting that a multitude of factors may affect the accuracy of coding within a single health care facility. Because the study was conducted within a single university-based hospital network, results may not be generalizable to all hospitals throughout the country.

The findings of this study highlight the importance of adequate documentation at the hospital level and reveal the potential implications for retrospective research. Researchers conducting retrospective studies may pool data from multiple hospitals or geographic regions to increase the sample size and generalizability of results, but this is done at the cost of introducing greater variation in record keeping.

In addition to the impact of poor coding on research, inaccurate diagnoses may have significant ramifications for patients’ future care. For trauma-related research using administrative claims data, coding from level 1 trauma centers may provide more reliable data than coding from other health care settings. However, clinicians should strive to improve the specificity of coding to assist injury-based research.

## Conclusion

Retrospective research using administrative claims data plays a pivotal role in evidence-based decision making. The ability to use large databases and the EMR of hospital systems for data extraction and analysis is highly dependent on the accuracy and specificity of coding at the hospital level. This study questioned the use of retrospective reviews for patients with uncommon diagnoses, as well as the use of trauma codes outside of a designated trauma database. When retrospectively using records from safety-net hospitals, which are relatively underfunded, pains-taking verification may be necessary to ensure that research conclusions are based on accurate data. To improve the quality of patient care, effective documentation is paramount to researchers and clinicians.

## References


2. Hilibrand AS, Spindler K, O’Keefe RJ.


