An Administrative Data-based Surrogate Definition Identifies Children Evaluated Beyond Physical Examination for Suspected Appendicitis

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INTRODUCTION

Appendicitis is the most common surgical emergency in children, but relatively little is known about resource utilization during the evaluation of patients suspected of having appendicitis. Various identifiers have been used to retrospectively search for patients evaluated for appendicitis, including diagnostic imaging tests, hospital admission, or the use of diagnostic algorithms in the electronic health record (EHR). However, not all patients evaluated for suspected appendicitis beyond physical examination by a physician can be retrospectively identified with high specificity by chief complaints, diagnoses, laboratory tests, or imaging tests highly specific for appendicitis (like a focused diagnostic ultrasound of the vermiform appendix).

Therefore, a retrospective method for identifying patients who underwent evaluation for appendicitis beyond physical examination is necessary to enable the study of health care resource utilization in this population.

Others have used prospective study methods with research assistants in the emergency department (ED) to identify patients evaluated for suspected appendicitis. While powerful, these efforts require significant human effort and real-time surveying of busy clinical caregivers to understand intent. However, prospective studies capture clinical data (such as history and examination findings) not easily queried retrospectively from databases. Using only chief complaints of abdominal pain to define a population of patients evaluated for suspected appendicitis requires manual chart review.
also requires a significant time commitment from staff with adequate clinical expertise. Over time, this commitment must be repeated each time utilization review, research, or quality improvement efforts are conducted on different patients.

Hospital administrative data are collected during routine hospital operations. With near-universal use of an EHR, these data are readily available. Natural language analytics are increasingly utilized to identify patients with specific characteristics from free-text documentation. A retrospective method using available administrative data and EHR capabilities could provide a reusable tool for retrospective insight into physicians’ practice patterns evaluating patients for suspected appendicitis.

Our objectives were to develop an administrative data-based surrogate definition to identify patients who received diagnostic evaluation beyond physical examination for suspected appendicitis for quality improvement efforts and health care resource utilization review. We also describe the performance characteristics of this surrogate definition’s ability to identify these patients compared with manual chart review retrospectively.

METHODS
The institutional review boards of the University of Utah and Intermountain Healthcare (Salt Lake City, UT) approved this study and granted a waiver of informed consent. The study was conceived and carried out at Primary Children’s Hospital, a level 1 trauma and regional referral center managed by Intermountain Healthcare with an ED staffed by pediatric emergency medicine faculty of the University of Utah. The authors met with general surgery, radiology, and pediatric emergency medicine colleagues. They used a modified Delphi-method to develop a surrogate definition for suspected appendicitis based on chief complaint, laboratory study, diagnostic right lower quadrant ultrasound, and free-text data available in the Intermountain Healthcare electronic data warehouse administrative database. The output of this initial effort was an administrative data-based surrogate definition for suspected appendicitis shown in Figure 1. Appendicitis was “suspected” if the patient underwent an ultrasound of the appendix or had a chief complaint of abdominal pain with both complete blood count with differential performed and the word “appendicitis” in the ED provider note. The surrogate definition identifies patients as not suspected if an appendectomy procedure was performed previously, as identified in our case-mix diagnoses table by surgical procedure codes (ICD-9 47.01, 47.09, 47.11, 47.19). The database query was performed in the Intermountain Healthcare electronic data warehouse using SQL v2016 and queried for ED chief complaint, complete blood count lab test codes, focused appendix ultrasound studies performed, and search for the word “appendicitis” in ED physician notes at Primary Children’s Hospital (Fig. 1). Limiting the query to data from Primary Children’s Hospital was consistent with the single-institution focus at that time of quality-improvement and resource utilization efforts.

Testing of Surrogate Definition
To determine the surrogate definition’s performance characteristics, 1 of the study authors (S.R.) performed an initial detailed retrospective review of 498 encounters out of a total of all 3,313 ED encounters at our facility in June 2014. This review was validated by the senior author (EG) performing a detailed review of 96 of the 498, among which no disagreement was identified. The authors (S.R. and E.W.G.) classified these patients as “evaluated for suspected appendicitis” beyond physical examination and “not evaluated for suspected appendicitis” beyond physical examination based upon the diagnostic workup performed, documented physical examination findings, and documented assessments in medical decision making portions of the ED note.

Inclusion Criteria
The authors selected these 498 encounters for manual review because their chief complaints and disposition diagnoses indicated that the treating physician could have evaluated the patient for appendicitis, beyond physical examination. Table 1 displays the chief complaints and principal disposition diagnoses of these 498 patients. The authors then applied the surrogate definition for suspected appendicitis to these 498. The authors did not exclude patients with chronic diseases like inflammatory bowel disease, as these patients may also have acute appendicitis. Nor did the authors exclude patients of young age.
positive predictive value was 83.3%, and the negative predictive value was 95.3% (Table 2). Of the 90 identified positively by the surrogate definition, 50 were identified by the ultrasound arm (Fig. 1) and 40 by the clinical arm.

**DISCUSSION**

Health systems can retrospectively identify patients evaluated beyond physical examination for appendicitis using a surrogate definition, discrete administrative data, and a word search of clinical notes. This approach may enable quality improvement efforts and health care resource utilization review for the diagnosis of appendicitis beyond physical examination.

We believe the sensitivity of our surrogate definition at 79.8% does not detract from its usability in resource utilization and quality improvement efforts. In these efforts generally, the need for a dataset with high specificity (96.3%) outweighs the desire for optimal sensitivity. Furthermore, many of the cases the surrogate definition failed to identify were transferred, thus not the population of most significant interest when studying resource utilization in evaluation for suspected appendicitis at one’s facility. Our facility is a referral center that receives many of our patients from transferring EDs. The majority (12 of 19) of the patients evaluated for suspected appendicitis not identified by the surrogate definition were transferred from outside facilities. The surrogate definition did not identify them (false-negatives in the sensitivity analysis) because it included laboratory tests and appendix ultrasound tests ordered only from our facility. In our practice, we do not routinely repeat studies performed from outside facilities, especially if found to be conclusive and consistent with the patient’s physical exam and presentation at our facility. If one wanted to evaluate a multi-hospital health system’s care of patients evaluated for suspected appendicitis, a surrogate definition could identify a population with improved sensitivity if it were to be applied to administrative data from the transferring hospitals as well. This approach may be difficult for any hospital like ours, which receives transfers from hospitals both part of Intermountain Healthcare using our same EHR and from other hospitals not part of our system that use various other EHRs.
The surrogate definition included both a clinical arm and an ultrasound arm for multiple reasons. Not all patients at our institution receive an ultrasound of the appendix. Some patients receive imaging tests before being transferred, and some patients with PAS scores ≥ 8 are taken to surgery based on physical examination and laboratory testing alone. However, the ultrasound arm is crucial because, in our system, a focused ultrasound of the appendix is increasing in use as the only diagnostic test in evaluating patients for suspected appendicitis.12 Local practice patterns (such as the use of a primary imaging modality for suspected appendicitis other than ultrasound) or changing patterns over time (if another imaging modality13 were to become commonly used to diagnose appendicitis) would dictate the need for nuanced alteration of the surrogate definition. As for the patients in this study, 50 of the 90 identified by the surrogate definition were evaluated for suspected appendicitis beyond physical examination and received an ultrasound at our institution. In the development of the surrogate definition clinical arm (Fig. 1), the authors questioned the need to include the criterion of the word “appendicitis” appearing in the ED physician note. However, removing this criterion results in an increase of false-positive results and a resultant drop in specificity from 96% to 75%. Therefore, the surrogate definition retains this chart text data criterion. We did not search for variations on the word “appendicitis” because medical transcriptionists exclusively transcribed our clinical notes, and typed variations or errors in recognition software did not apply. Including this criterion in our data, today would require a more expansive search terminology.

This study’s strengths include a manual chart review to establish the reference population of patients evaluated and not evaluated for appendicitis beyond the physical exam. During the study period, provider staffing (attending physician, fellow, and nurse practitioner) was consistent. Also, no changes occurred during this study period in the availability of factors that may influence the evaluation of suspected appendicitis, including 24 hours per day appendix ultrasound and in-house surgical consultation. Limitations include those inherent in administrative database research and retrospective chart review in determining whether patients were evaluated beyond physical examination for suspected appendicitis. However, these limitations were minimized by the consistent laboratory, chief complaint, and ultrasound codes during the study period. Chief complaints of abdominal pain alone are nonspecific and not highly sensitive14 for whether a patient was evaluated for suspected appendicitis (Table 1).

Nonetheless, chief complaints are among the few commonly available administrative data that can be used to identify populations of patients suspected of having a disease when no specific and universally utilized test exists. In a hospital or system that utilizes CT primarily as the initial diagnostic test for appendicitis, the surrogate definition may need to include that in addition to, or in place of the ultrasound arm.

The use of simple word search methods for the word “appendicitis” in the clinical notes does not discern meaning. A further improvement could be utilizing natural language processing methodology (ie, appendicitis was suspected versus was not suspected). We did not go this additional step because, with specificity 96.3%, the gains of a natural language processing approach were assessed to be minimal.

CONCLUDING SUMMARY

Children with abdominal pain who receive an evaluation for suspected appendicitis beyond physical examination in the ED can be retrospectively identified with high specificity using an administrative data-based surrogate definition. This method may empower research and quality improvement efforts measuring health care utilization in these patients, such as trends in imaging study use and hospital admission after application of diagnostic algorithms for children with acute abdominal pain.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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