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Imaging Practice Patterns: Referral Network Analysis of a Single State of Origination

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Abstract

Purpose: The aim of this study was to examine the referral pattern of imaging studies requested in a single state compared with the potential location of interpretation.

Methods: Analysis of Medicare patients in a DocGraph data set was performed to identify sequential different physician services claims for the same patient for which the second claim was for services provided by a radiologist.

Results: In the 2011 Medicare population, radiology referrals from physicians practicing in Georgia resulted in 76.5% of radiology interpretations by radiologists inside the state of Georgia. The states bordering Georgia accounted for 11.6% of interpretations in the Georgia market. The remaining interpretations were distributed throughout the remainder of the country.

Conclusions: A significant proportion of routine imaging interpretation occurs outside the state in which an examination is performed. Additional studies are needed to identify complex drivers of imaging referral patterns, such as patient geographic location and demographics, radiologist workforce distribution, contractual obligations, and social relationships.

Key Words: Social network analysis, radiology, teleradiology

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INTRODUCTION

Physician referral patterns are complex decisions that often involve physicians' personal relationships, patient preferences, and contractual relationships. Radiology practice patterns are unique compared with evaluation and management services because the performance of an imaging service (technical services) and the interpretation (professional services) can be separated in time and distance. In the mid-1990s, the analog circuit rider and film era gave way to digital images. Patients could be imaged in their home communities, and their digital images could be read locally by radiologists or transmitted to other locations to be read by radiologists at those locations: teleradiologists. Digitization made images more accessible for interpretation at more distant sites.

The actual volume of radiologic studies read primarily through this model is difficult to measure. A 2008 survey [1] of radiology groups showed 40% using after-hours coverage through teleradiology, although it represented a small portion of their practice. It has been suggested [2] that this model peaked in 2010 and has been declining. The ACR's 2014 workforce survey [3] identified 2% to 3% of US radiologists as teleradiologists. In 2015, the teleradiology company Radisphere was purchased by AMSURG, an operator of ambulatory surgery centers. After its acquisition, the operations of Radisphere were combined with AMSURG's Sheridan physician services division. This newly combined radiologic service provider operates in 25 states and interprets more than three million studies per year [4].

As health care consolidates, referral patterns will change. Radiology referral patterns may also reflect practice-level decisions and contractual obligations, including performance metrics. It will be important for radiologists to understand sources of referrals as well as patterns of referrals and how they could change over time. As a first step, we describe imaging practice patterns of a state and its border states, where the initial referral from imaging is assumed to originate within the state of Georgia.

METHODS

Trotter [5] released National Provider Identifier (NPI)-indexed provider relationships for Medicare patients under

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a crowd-funding model called DocGraph. By connecting claims on the same patient submitted by sequential physicians, a referral relationship was implied. We used the DocGraph data to study the 2011 physician referral patterns of more than one million referrals in the ultrasound. This referral database allowed the analysis of temporally sequential physician services claims such that the first provider was the referring or ordering physician, and the second provider was the recipient of a referral from the first provider. In the special case in which the second provider was a radiologist, the service provided would be an interpretation or a procedure. Although very useful, DocGraph does not provide procedure-level detail, identify primary care relationships, or indicate the location at which the services were provided.

We next obtained the National Plan and Provider Enumeration System (NPPES) data file (September 2014) from CMS. This data file, indexed by NPI, provides all the NPPES information for a provider, including the provider's contact information (address, city, and state) and taxonomy code(s). The NPPES data file, containing more than four million (4,441,496) individual records, each containing more than 300 information fields, was uploaded into Delimit (www.delimitware.com) to allow examination, cleaning, and extraction. The use of Delimit was required because of the extremely large data file obtained from the NPPES.

After cleaning up the NPPES data file to eliminate blank rows and rows without provider identification, the remaining 3,328,106 records were extracted into two data files corresponding to ordering (from) and receiving (to) providers. The first extracted file we named "NPIExtractGAOnly." This file was created from the cleaned NPPES file just described by filtering on the state data column to only include the rows for providers located in Georgia. Our filtering process resulted in 77,124 records. The second extracted file from the NPPES cleaned file we named "NPIExtractTaxCodeMatch." This file was created by filtering the primary taxonomy code column to include only rows with the taxonomy codes listed in Table 1 and selecting corresponding columns related to NPI, state, and taxonomy code. Our filtering process resulted in 328,267 records. Last, we performed two database inner joins, as depicted in Figure 1, with one join between the 2011 physician referral patterns data file (DocGraph) from (ordering) NPI to the NPIExtractGAOnly NPI column and a simultaneous second inner join between the 2011 physician referral patterns data file (DocGraph) to (receiving) NPI to the NPIExtractTaxCodeMatch NPI column. The resulting data were then exported to commercially available spreadsheet software (Excel; Microsoft Corporation,

Table 1. Physician codes

- **2085R0202X Diagnostic Radiology**
A radiologist who utilizes x-ray, radionuclides, ultrasound, and electromagnetic radiation to diagnose and treat disease.

- **2085N0700X Neuroradiology**
A radiologist who diagnoses and treats diseases utilizing imaging procedures as they relate to the brain, spine and spinal cord, head, neck, and organs of special sense in adults and children.

- **2085N0904X Nuclear Radiology**
A radiologist who is involved in the analysis and imaging of radionuclides and radiolabeled substances in vitro and in vivo for diagnosis and the administration of radionuclides and radiolabeled substances for the treatment of disease.

- **2085P0229X Pediatric Radiology**
A radiologist who is proficient in all forms of diagnostic imaging as it pertains to the treatment of diseases in the newborn, infant, child and adolescent. This specialist has knowledge of both imaging and interventional procedures related to the care and management of diseases of children. A pediatric radiologist must be highly knowledgeable of all organ systems as they relate to growth and development, congenital malformations, diseases peculiar to infants and children and diseases that begin in childhood but cause substantial residual impairment in adulthood.

- **2085R0204X Vascular & Interventional Radiology**
A radiologist who diagnoses and treats diseases by various radiologic imaging modalities. These include fluoroscopy, digital radiography, computed tomography, sonography, and magnetic resonance imaging.

Redmond, Washington), and we used Excel Pivot Tables and Charts in addition to JMP Charts (SAS Institute, Cary, North Carolina) to examine the relationships in the data.

In our referral network analysis of physician referral patterns, the nodes are ordering physicians and interpreting radiologists, and the ties are the referral or assignment of the examination interpretation. In studying the relationship, the ordering physician could be any physician in Georgia, whereas
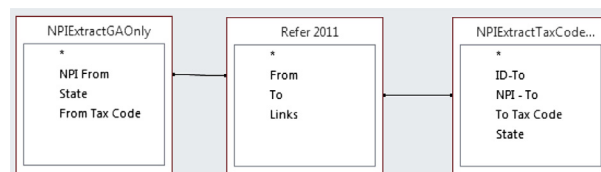

Fig 1. Database query design view. NPIExtractGAOnly is a data file describing ordering providers located in Georgia. "Refer 2011" represents the 2011 physician referral patterns database connecting providers through sequential same-patient claims. NPIExtractTaxCodeMatch is a data file describing receiving providers across the United States. NPI = National Provider Identifier.