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Variation in Patients' Travel Times among Imaging Examination Types at a Large Academic Health System

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Rationale and Objectives: Patients' willingness to travel farther distances for certain imaging services may reflect their perceptions of the degree of differentiation of such services. We compare patients' travel times for a range of imaging examinations performed across a large academic health system.

Materials and Methods: We searched the NYU Langone Medical Center Enterprise Data Warehouse to identify 442,990 adult outpatient imaging examinations performed over a recent 3.5-year period. Geocoding software was used to estimate typical driving times from patients' residences to imaging facilities. Variation in travel times was assessed among examination types.

Results: The mean expected travel time was 29.2 ± 20.6 minutes, but this varied significantly ($p < 0.001$) among examination types. By modality, travel times were shortest for ultrasound (26.8 ± 18.9) and longest for positron emission tomography-computed tomography (31.9 ± 21.5). For magnetic resonance imaging, travel times were shortest for musculoskeletal extremity (26.4 ± 19.2) and spine (28.6 ± 21.0) examinations and longest for prostate (35.9 ± 25.6) and breast (32.4 ± 22.3) examinations. For computed tomography, travel times were shortest for a range of screening examinations [colonography (25.5 ± 20.8), coronary artery calcium scoring (26.1 ± 19.2), and lung cancer screening (26.4 ± 14.9)] and longest for angiography (32.0 ± 22.6). For ultrasound, travel times were shortest for aortic aneurysm screening (22.3 ± 18.4) and longest for breast (30.1 ± 19.2) examinations. Overall, men (29.9 ± 21.6) had longer ($p < 0.001$) travel times than women (27.8 ± 20.3); this difference persisted for each modality individually ($p \leq 0.006$).

Conclusions: Patients' willingness to travel longer times for certain imaging examination types (particularly breast and prostate imaging) supports the role of specialized services in combating potential commoditization of imaging services. Disparities in travel times by gender warrant further investigation.

Key Words: travel time; commoditization; screening services; radiology facilities.

INTRODUCTION

Much concern has been expressed of the threat of commoditization of radiology services (1–4). This in part relates to a fairly consistent patient experience for imaging examinations performed across imaging facilities as well as the lack of face-to-face interaction with radiologists for most noninvasive imaging encounters. As a result, patients may misperceive receiving an imaging examination with a professional interpretation as analogous to undergoing a basic laboratory test. In this case, patients may

not necessarily recognize differences in both technical and radiologist quality when having an opportunity to select among imaging facilities, and instead make their decisions largely based on cost or convenience (5). Such a reality would encourage radiology practices to focus on the latter considerations and disincentivize investments in quality (5).

The risk of commoditization in radiology is unlikely to be homogeneous across imaging examinations. Radiology encompasses a range of distinct imaging modalities, as well as more granular specific examination types within individual modalities. Such imaging services vary in terms of the abundance and availability of performing facilities within a given region, as well as the nature of the patient experience during an examination. These factors in turn impact patients' perception of differentiation of a given service.

Objectively studying variation in patients' perspectives regarding distinct imaging services is challenging. While patients have been subjectively surveyed regarding their perceptions of the value of imaging (6), little actual data exist regarding patients' behavior in selecting from a range of imaging facilities across a spectrum of examination types. In the business world, services' degree of commoditization versus differentiation are often defined in terms of variation in consumers'

willingness to pay (7). However, such an approach may be suboptimal for healthcare services given that current insurance systems shield patients from paying a large fraction of their own costs. Additionally, the complexity of medical billing makes it difficult for patients to understand the exact costs of the care that they receive (8–11). Nonetheless, indirect costs exist for patients to undergo imaging in the form of the time needed to travel to an imaging facility for their examinations. Prior work has demonstrated that patients commonly elect to travel to an imaging facility further than the closest option (12), and that this tendency to travel further than the minimal distance varies systematically among modalities in breast imaging (13). Such variation has been attributed to differences in patients' willingness to travel longer distances for certain imaging services (13) and in turn could serve as a marker of variation in patients' perceptions of the degree of differentiation of such services. This study was therefore conducted to compare patients' travel times for a range of imaging examinations performed at a large academic health system.

METHODS

This retrospective Health Insurance Portability and Accountability Act (HIPAA) compliant study was approved by the local institutional review board. The requirement for written informed consent was waived.

The NYU Langone Medical Center (NYULMC) Medical Center is located in the New York metropolitan area, which has an area of 9212 square miles and a population in 2015 of approximately 20.2 million individuals, ranking first among all U.S. metropolitan statistical areas in terms of population and population density (14,15). At least seven additional integrated academic medical centers, as recognized by the Association of American Medical Colleges (16), are located within an approximately 180-minute driving distance of NYULMC. The NYULMC Enterprise Data Warehouse (EPIC) was searched for adult outpatient imaging examinations performed from January 2013 through June 2016 for the following modalities: computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, mammography, positron emission tomography-computed tomography (PET/CT), and interventional radiology. Only examinations performed at an imaging facility located within the institution's main campus (considered to be all institutional facilities within the 10016 zip code) were included. Only imaging examinations performed within the radiology department were included (e.g., examinations performed by other departments such as cardiology and orthopedic surgery were excluded). Secondary interpretations of imaging examinations originally performed at other institutions were also not included so that our sample only included imaging encounters in which the patient physically traveled to a health system facility.

Identifiable data fields included patients' home addresses as well as the specific facilities where their examinations were performed. Geocoding software was used to determine the typical expected driving travel time in minutes between these two locations (*placement* package; the R programming environment, www.r-project.org). Applying methodology used by prior investigators, examinations were excluded if it was not possible to determine expected driving time or if the driving time was greater than 180 minutes (12,13).

Data fields also included an examination description for each imaging examination using institutional examination codes. Based on these codes, each examination was assigned to a modality [CT, MRI, ultrasound, mammography, PET/CT, and invasive (which included invasive examinations initially associated with one of the other modalities in the original search results)].

Examinations within several modalities were then assigned to more granular service types as follows:

- CT: angiography, colonography, lung cancer screening, coronary artery calcium scoring, and other;
- MRI: breast, body, cardiac, extremity (vascular), extremity (musculoskeletal), neuro, prostate, spine, and other;
- mammography: screening, diagnostic, not specified;
- ultrasound: breast, musculoskeletal, obstetrical, abdominal aortic aneurysm screening, and other.

These specific examination types were selected based on an anticipated potential for variation in travel time among these.

The mean and standard deviation of travel times were determined for the entire cohort, as well as for each modality and specific examination type. Following initial assessment suggesting potential patient gender influencing travel times, travel times were also summarized for both genders across all examinations (excluding mammography, breast and prostate MRI, breast ultrasound, obstetrical ultrasound, and examinations performed at a dedicated women's imaging center located on the main campus), as well as across examinations stratified by modality, incorporating the previously noted exclusions. The R programming environment was used to compare expected travel times among modalities and examination types, as well as to compare times between genders, based on analysis of variance; subject-level data were used for such analyses by determining patients' average travel time when undergoing multiple of a given examination under comparison. Excel for Macintosh (Microsoft; Redmond, WA) was used for remaining assessments.

RESULTS

The final cohort included 442,990 adult outpatient imaging examinations. The mean expected travel time from patients' homes to imaging facilities was 29.2 ± 20.6 minutes. Times varied significantly by modality ($p < 0.001$), being shortest for ultrasound (26.8 ± 18.9 minutes) and longest for PET/CT (31.9 ± 21.5 minutes) and mammography (30.9 ± 19.3 minutes). Travel times also varied significantly (all $p < 0.001$) for individual examination types among CT, MRI, and ultrasound. For CT examinations, travel times were shortest for colonography, coronary calcium artery scoring, and lung cancer screening (range, 25.5 ± 20.8 to 26.4 ± 14.9 minutes) and longest for angiography (32.0 ± 22.6 minutes). For MRI, travel times were shortest for musculoskeletal extremity (26.4 ± 19.2 minutes) and spine (28.6 ± 21.0 minutes)