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Comparison of Radiologists and Other Specialists in the Performance of Lumbar Puncture Procedures Over Time

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ABSTRACT

BACKGROUND AND PURPOSE: Lumbar punctures may be performed by many different types of health care providers. We evaluated the percentages of lumbar punctures performed by radiologists-versus-nonradiologist providers, including changes with time and discrepancies between specialties.

MATERIALS AND METHODS: Lumbar puncture procedure claims were identified in a 5% sample of Medicare beneficiaries from 2004 to 2017 and classified by provider specialty, site of service, day of week, and patient complexity. Compound annual growth rates for 2004 versus 2017 were calculated; *t* test and χ^2 statistical analyses were performed.

RESULTS: Lumbar puncture use increased from 163.3 to 203.4 procedures per 100,000 Medicare beneficiaries from 2004 to 2017 (overall rate, 190.3). Concurrently, the percentage of lumbar punctures performed by radiologists increased from 37.1% to 54.0%, while proportions performed by other major physician specialty groups either declined (eg, neurologists from 23.5% to 10.0%) or were largely unchanged. While radiologists saw the largest absolute increase in the percentage of procedures, the largest relative increase occurred for nonphysician providers (4.2% in 2004 to 7.5% in 2017; +78.6%). In 2017, radiologists performed most procedures on weekdays (56.2%) and a plurality on weekends (38.2%). Comorbidity was slightly higher in patients undergoing lumbar puncture by radiologists ($P < .001$).

CONCLUSIONS: Radiologists now perform most lumbar puncture procedures for Medicare beneficiaries in both the inpatient and outpatient settings. The continuing shift in lumbar puncture responsibility from other specialists to radiologists has implications for clinical workflows, cost, radiation exposure, and postgraduate training.

ABBREVIATIONS: CAGR = compound annual growth rate; CCI = Charlson Comorbidity Index; CPT = Common Procedural Terminology

Lumbar puncture is a vital procedure in the diagnostic evaluation of patients with a wide variety of neurologic conditions. Often performed electively in the diagnosis of inflammatory, neoplastic, and neurodegenerative conditions, lumbar puncture is also frequently performed emergently in patients with suspected central nervous system infection or subarachnoid hemorrhage.[1] Less commonly, the procedure is performed for therapeutic purposes (eg, to remove excess CSF or deliver intrathecal medications). With the introduction of lumbar puncture by Quincke in 1890, these procedures were typically performed without imaging guidance, using only palpation of anatomic landmarks.[2] Serious adverse complications are uncommon following lumbar puncture regardless of whether fluoroscopic guidance is used.[3,4] As recently as 1991, only about 10% of lumbar punctures in the Medicare beneficiary population were performed by radiologists.[5]

While lumbar puncture can be successfully performed in many patients without the need for real-time imaging, there are a number of reasons why fluoroscopic guidance may be used. Palpation of anatomic landmarks can be difficult or impossible in patients with obesity, and the rate of obesity is increasing in the US population.[6] Additionally, older patients are more likely to have spondylotic changes or previous spinal surgery, which can complicate needle access. Other factors that may influence referral of lumbar punctures to radiology include practice momentum, in which

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some health care providers are less comfortable across time with an infrequently performed procedure and new providers complete their training without mastering the technique,[7,8] as well as financial disincentives, given the relatively modest compensation for the procedure.

Although previous research has demonstrated a shift in lumbar puncture volume to radiologists,[5] several important questions must be answered to better understand the implications of this shift for clinical work flow, costs, and specialist training. First, it is not clear whether this trend has plateaued, continued at the previous pace, or even, as the authors' anecdotal experience suggests, accelerated. If the trend is continuing, in what practice settings is it most pronounced? Furthermore, it is unknown whether factors such as patient complexity or day of the week (ie, weekday versus weekend) influence which specialty performs lumbar punctures, though these questions have been evaluated for other tasks performed both by radiologists and nonradiology providers.[9-11] We evaluated the percentages of lumbar punctures performed by radiologists versus nonradiologist providers, including changes with time and discrepancies among specialties.

MATERIALS AND METHODS

This retrospective study was performed using Medicare administrative claims data in a Health Insurance Portability and Accountability Act–compliant manner, with prior approval by the Institutional Review Board of the American College of Radiology.

The data collection and analysis methods used in this study were similar to those in previous reports.[9-11] The 5% Research Identifiable Files from the Centers for Medicare & Medicaid Services from 2004 through 2017 were acquired under a data use agreement. This dataset includes all final action (Parts A and B) claims associated with a 5% nationally representative random sample of Medicare enrollees, totaling approximately 2.5 million beneficiaries each year, providing details such as patient demographic information, Current Procedural Terminology (CPT) codes associated with all procedures, procedure dates, and the self-reported specialties of health care providers.[12] Patient selection criteria for this study beyond inclusion in the 5% Research Identifiable File dataset from the Centers for Medicare & Medicaid Services included being at least 65 years of age, residence in the United States, enrollment in both Medicare hospital insurance and supplementary medical insurance, and lack of separate health maintenance organization insurance coverage for all 12 months of the year in question.

Lumbar puncture procedures were identified by CPT code 62270 (diagnostic lumbar puncture) and CPT code 62272 (therapeutic lumbar puncture), which were considered collectively in all analyses. All professional and globally billed services corresponding to these lumbar puncture CPT codes during the period of interest were identified within the dataset. CPT modifier codes for imaging guidance were not evaluated due to changes in coding during the study period and on the assumption that use of imaging guidance would be strongly associated with provider specialty. Aborted or unsuccessful lumbar punctures were identified via CPT modifier codes when present and made up only a small fraction of procedures (<3% of total lumbar punctures) and thus were not evaluated separately. With regard to identifying the specialty of the health care provider performing the lumbar puncture, radiologists were collectively identified using the Health Care Provider Taxonomy codes for diagnostic radiology (taxonomy code 30), interventional radiology (94), and nuclear medicine (36). The category of primary care was defined as internal medicine (11), family practice (8), and general practice (1). Other physician specialty groups were classified by their individual specialty taxonomy codes. Our category of nonphysician providers included physician assistants (97), nurse practitioners (50), certified registered nurse anesthetists (43), anesthesia assistants (32), and certified clinical nurse specialists (89). Provider groups performing ≥3% of all lumbar punctures between 2004 and 2017 were evaluated individually in each analysis; those specialties performing <3% of lumbar punctures were grouped collectively as "all others." For illustration purposes, only provider groups that performed ≥5% of lumbar punctures in each specific subanalysis during the study period as a whole were included individually in figures.

Lumbar puncture use on a per-100,000 beneficiary basis for each year of the analysis period was calculated using a separately acquired Medicare Fee-for-Service beneficiary enrollment file.[13] Weighted averages for the service volumes per 100,000 beneficiaries and proportions reported were calculated for the entire study sample, using each year's share of the overall patient population as weights, except when otherwise indicated. Due to the structure of the Medicare 5% Research Identifiable Files dataset, absolute procedural counts may be misleading (ie, multiplying the procedure count from the 5% sample by 20 does not accurately approximate the procedure count in the Medicare population as a whole for technical reasons), and the reporting of event rates better reflects use at the population level. Additional statistics evaluated for each specialty group included the percentage of lumbar punctures performed in each year and overall, the percentage of lumbar punctures performed on weekends versus weekdays, the percentage performed in various care settings, and the degree of medical comorbidity of patients undergoing the procedure. χ^2 tests were performed to assess differences in the change in proportion and distribution of lumbar punctures by specialty between 2004 and 2017. Compound annual growth rates (CAGR) were calculated using the 2004 and 2017 proportion of lumbar punctures performed by each specialty. Percentages of lumbar punctures performed by radiology were also calculated on a state-by-state level using the rates for radiology as a percentage of total lumbar puncture rates for a given state.

The Charlson Comorbidity Index (CCI), a weighted index of 19 diseases, is a validated surrogate for patient medical complexity and is widely used by health service researchers working with administrative databases.[14,15] Each beneficiary's prospective CCI was calculated using Medicare claims during the year before their lumbar puncture procedure following a standard method.[16] As a consequence, CCI information was available only for procedures performed between 2005 and 2017, because prior-year claims data were not available for the first year of the case-ascertainment period. Medicare beneficiaries without any claims filed during the year before the lumbar puncture were, by necessity, excluded from our CCI analysis. The mean CCI was compared for lumbar puncture procedures performed by different specialty groups.

The *t* test was used to evaluate differences in mean CCI by provider group. Analyses were performed using SAS, Version 9.4 software (SAS Institute) and Excel 2016 (Microsoft).

RESULTS

Lumbar Puncture Volume and Performing Specialty

For the entire 2004–2017 period, the total lumbar puncture procedure count in the 5% Research Identifiable Files sample was 37,026, and the overall lumbar puncture use rate was 190.3 per 100,000 Medicare beneficiaries, with annual lumbar puncture use rates varying from a low of 163.3 per 100,000 in 2004 to a high of 203.4 per 100,000 in 2017. When evaluating procedures regardless of year, provider groups performing ≥3% of lumbar punctures were radiologists (46.9%), emergency physicians (18.5%), neurologists (14.6%), nonphysician providers (4.6%), neurosurgeons (4.4%), primary care physicians (3.8%), and anesthesiologists (3.6%). The remaining 3.5% of all lumbar puncture procedures were performed by all other specialties collectively. Annual lumbar puncture counts, rates, and percentages of procedures by provider specialty with time are shown in Online Supplemental Data. Between 0.4% and 1.8% of lumbar punctures performed by radiologists were reported as aborted or incomplete in each year, while among all other providers collectively, the annual rate of procedures reported as aborted or incomplete ranged from 1.0% and 2.7%. Among radiologists, the percentage of lumbar punctures performed by providers with self-reported specialty taxonomy codes for diagnostic radiology varied between 92.0% and 96.0%; for interventional radiology, between 4.0% and 7.6%; and for nuclear medicine, no more than 0.4% in any year. Given that self-identified specialty codes often do not match actual radiologist clinical practice patterns,[17,18] these radiology provider groups were considered collectively in all subsequent analyses.

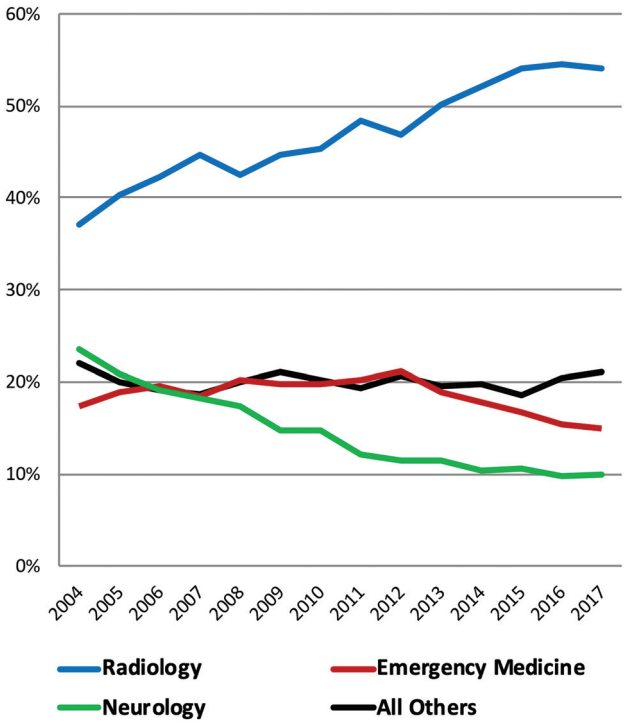

FIG 1. Percentage of lumbar puncture procedures performed by specialty across time.

The Online Supplemental Data display the percentage of lumbar punctures performed by provider type in each year and associated 2004-versus-2017 CAGR. The percentage of lumbar punctures performed by radiologists rose from a low of 37.1% in 2004 to a high of 54.5% in 2016 before falling slightly to 54.0% in 2017, representing a relative increase of 45.6% between 2004 and 2017. The percentage of lumbar punctures performed by nonphysician providers was from 4.2% in 2004 to 7.5% in 2017, an increase of 78.6%. The provider group with the largest decrease in the percentage of lumbar punctures performed was neurologists, from a high of 23.5% in 2004 to a low of 9.8% in 2016, increasing slightly to 10.0% in 2017, representing a decrease of 57.5% between 2004 and 2017. The increase in radiologist-performed lumbar punctures, for years 2004 and 2017, relative to all other specialties combined was statistically significant ($P < .001$) as was the change in the distribution of lumbar punctures across all specialties ($P < .001$). Figure 1 illustrates trends in the percentages of lumbar punctures performed by the 3 specialties that individually performed >5% of procedures during the entire period.

The percentage of lumbar punctures performed by radiologists and the degree of change with time varied by state. Figure 2 shows the percentage of lumbar punctures performed by radiology in each state in 2004 and 2017. Among the 5 most populous states, the percentages of lumbar punctures performed by radiologists in 2004 and 2017 were 33.5% versus 45.9% in California (37.0% increase), 55.2% versus 67.8% in Texas (22.8% increase), 50.4% versus 58.9% in Florida (16.9% increase), 24.7% versus 43.5% in New York (76.1% increase), and 29.3% versus 56.4% in Pennsylvania (92.5% increase).

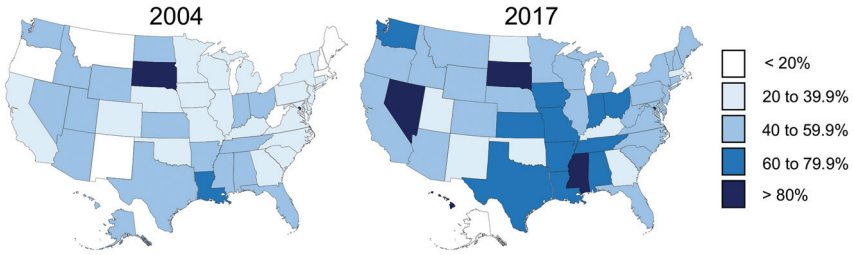

FIG 2. Heat maps by state showing the percentage of lumbar punctures performed by radiologists in 2004 and 2017.

Lumbar Puncture Volume by Performing Specialty and Site of Service

Across the entire analysis period, most lumbar punctures were performed in the inpatient hospital setting (45.9%), followed by the outpatient setting (30.3%), and then the emergency department (22.7%). Only a small percentage was performed in any other practice setting (1.0%). Figure 3 illustrates the percentages of lumbar punctures performed

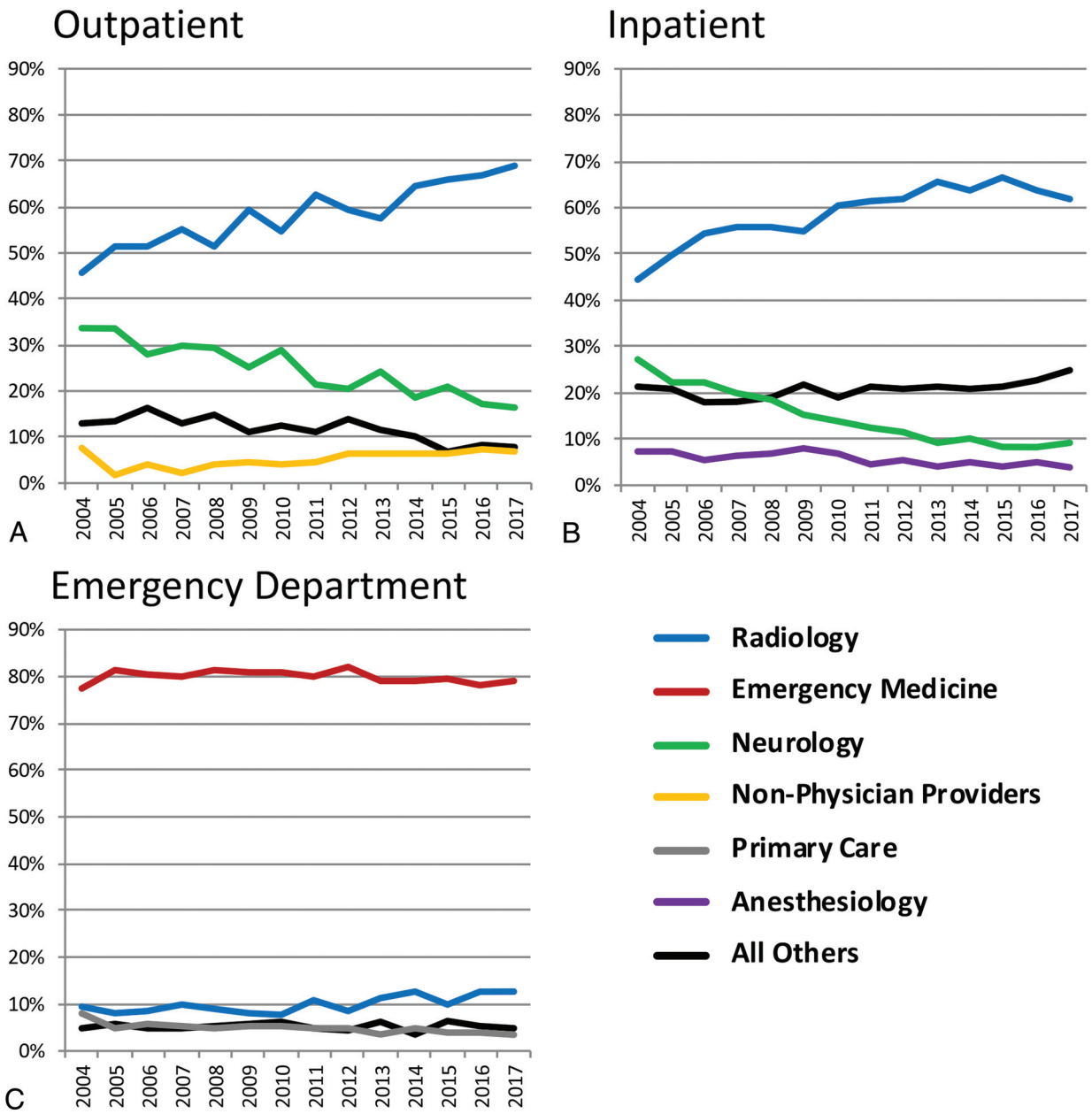

FIG 3. Percentage of lumbar puncture procedures performed by specialty across time in outpatient (*A*), inpatient (*B*), and emergency department (*C*) settings.

by the predominant providers in the inpatient, outpatient, and emergency department settings.

Of lumbar punctures performed in the inpatient hospital setting, radiologists were the most frequent providers in every year, with an increasing proportion from a low of 44.4% in 2004 to a maximum of 66.5% in 2015, before falling slightly to 62.0% in 2017 (2004 versus 2017, CAGR = 2.6%). The share of inpatient lumbar punctures performed by neurologists fell from 27.2% to 9.3% during this period (2004 versus 2017, CAGR = −7.9%). Nonphysician providers performed an increasing share of inpatient lumbar punctures across time, from only 3.1% in 2004 to 8.8% in 2017 (2004 versus 2017, CAGR = 8.4%). In the outpatient setting, radiologists and neurologists were the predominant providers of lumbar punctures, collectively performing between 79.3% and 86.9% in each year. However, the percentage of outpatient lumbar punctures performed by radiologists increased from a low of 45.7% in 2004 to a high of 68.9% in 2017 (2004 versus 2017, CAGR = 3.2%), while the percentage performed by neurologists fell from a high of 33.7% to a low of 16.4% during this same interval (2004 versus 2017, CAGR = −5.4%). Lumbar punctures performed in the emergency department were predominantly performed by emergency medicine physicians, who performed between 77.4% and 82.0% of the emergency department lumbar punctures in each year.

Lumbar Puncture Volume by Performing Specialty and Day of Week

For the entire period, most lumbar punctures (86.8%) were performed on weekdays, with use rates of 165.1 per 100,000 Medicare

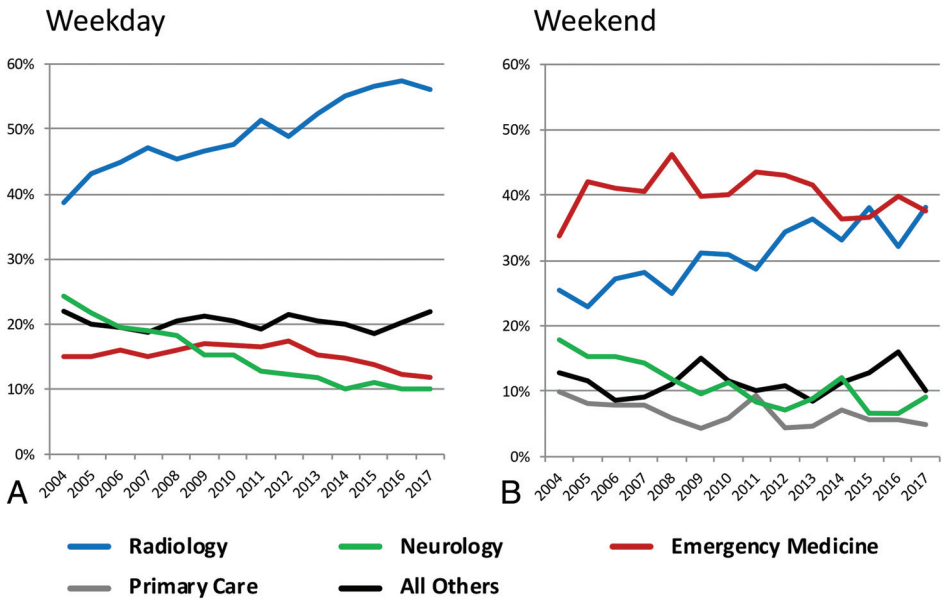

FIG 4. Percentage of lumbar puncture procedures performed by specialty across time on weekdays (*A*) and weekends (*B*).

beneficiaries on weekdays versus 25.2 per 100,000 on weekends. The overall rates of lumbar punctures performed by radiologists were 81.5 per 100,000 Medicare beneficiaries on weekdays and 7.8 per 100,000 on weekends, while the rates performed by all other specialties collectively were 83.6 and 17.5 per 100,000, respectively. Emergency medicine physicians had the smallest relative decline in lumbar puncture procedure rates on weekends, performing 25.1 per 100,000 on weekdays to 10.2 per 100,000 on weekends. Figure 4 shows the distribution of weekday and weekend lumbar punctures performed by different specialty groups across time. The percentage of weekday lumbar punctures performed by radiologists increased from 38.7% in 2004 to 56.2% in 2017 (2004 versus 2017, CAGR = 2.9%). Neurologists saw the greatest coinciding decrease in the percentage of weekday lumbar punctures, from 24.3% in 2004 to 10.1% in 2017 (2004 versus 2017, CAGR = −6.6%). Of the 13.2% of lumbar punctures performed on weekends, emergency physicians performed a plurality of procedures for the 2004 through 2017 period as a whole (40.3%). However, the percentage of weekend lumbar punctures performed by radiologists rose from 25.5% to 38.2% during this period (2004 versus 2017, CAGR = 3.1%), with radiologists performing the plurality in 2015 and 2017.

Lumbar Puncture Volume by Performing Specialty and Patient Complexity

A CCI could be determined for >99% of the patient group in each year, 2005 through 2017. The mean patient CCI during this entire period for lumbar punctures performed by radiologists was 2.6 [SD, 2.8], modestly but statistically significantly higher than the mean CCI of 2.4 [SD, 2.6] in patients who underwent lumbar punctures performed by all nonradiology providers collectively ($P < .001$). Mean CCI figures for individual nonradiologist provider groups were 2.3 [SD, 2.5] for neurologists, 2.2 [SD, 2.5] for neurosurgeons, 2.4 [SD, 2.6] for emergency medicine physicians, 2.6 [SD, 2.8] for nonphysician providers, 2.5 [SD, 2.6] for primary care physicians, 2.4 [SD, 2.6] for anesthesiologists, and 2.7 [SD, 2.8] for all other providers.

The Online Supplemental Data report the mean patient CCI for lumbar punctures performed by radiologists versus all other specialties across time and associated 2005-versus-2017 CAGR. The mean CCI of patients undergoing lumbar puncture by radiologists increased from 2.0 in 2005 to 3.1 in 2017. While the mean CCI of patients undergoing lumbar punctures by nonradiologists also increased from 1.8 to 2.9 during the period, the mean CCI score of patients undergoing lumbar puncture by radiologists was significantly higher ($P < .05$) overall and in 9 of these 13 years individually.

DISCUSSION

In recent years, radiologists have become majority providers of lumbar punctures for Medicare Fee-for-Service beneficiaries, and the percentage of lumbar punctures performed by radiologists has increased in almost every practice setting and patient group. A dramatic shift in lumbar puncture procedures in the Medicare population to radiologists had been previously demonstrated using aggregate claims data, which reported that in 1991, only 10% of lumbar punctures were performed by radiologists, increasing to >45% by 2011.[5] The present study uses a different and more detailed patient encounter-level Medicare dataset with procedural information through 2017 and confirms that this trend has continued. It additionally provides insight into discrepancies between specialty in factors such as place of service, day of week, and patient comorbidity.

Potential causes for the shift in lumbar punctures to radiology in Medicare beneficiaries can be conceptually subdivided into patient-level and provider-level factors. Patient-level factors include issues that impact the feasibility of lumbar puncture or increase the need for imaging guidance, including but not limited to patient habitus, scoliosis or spondylotic changes, and other medical comorbidities. Provider-level factors are issues that impact the ability or desire of medical practitioners to perform lumbar punctures themselves rather than refer the procedure to other providers. Provider-

level factors include practice environment, which may or may not be conducive to bedside procedures, personal ability or confidence in performing lumbar punctures, and economic considerations.

In this study, the findings regarding lumbar punctures performed in the emergency department setting may provide insight into the relative importance of patient-specific and provider-specific factors in influencing what specialty group performs the procedure. In the emergency department, emergency medicine physicians performed most lumbar punctures, and this proportion remained steady during the study. However, there was minimal difference in the CCI between patients undergoing lumbar punctures by emergency medicine physicians and radiologists. While the CCI imperfectly captures patient-level factors that may make lumbar puncture technically challenging, the modest difference in comorbidity supports the hypothesis that lesser case complexity is not the primary factor behind the low proportion of lumbar punctures performed by radiology in the emergency department. Thus, the high percentage of emergency department lumbar punctures performed by emergency medicine physicians suggests that the procedure is technically feasible without fluoroscopic guidance in many patients, even within a typically older Medicare beneficiary population. The logical implication is thus that the shift of lumbar punctures to radiology from other specialties in the outpatient and hospital inpatient practice settings is likely due to provider-related factors rather than technical necessity.

If lumbar puncture practice is driven by provider-level factors, it is possible that the trend could reverse if those factors change. However, we believe that the chance of this happening decreases with time. For example, if extrinsic factors regularly interfere with nonradiology providers performing lumbar punctures, across time, those same providers may be less inclined to perform lumbar punctures due to limited recent experience. In surveys conducted by the American College of Physicians, 73% of internal medicine physician respondents in 1986 reported that performing lumbar punctures was part of their clinical practice, with a median of 5 lumbar punctures performed in the year preceding the survey; by 2004, only 26% of respondents performed lumbar punctures, and even this group reported a decrease in case numbers, to a median of 3 per year.[19] In the present study, by 2017, just 2.6% of lumbar punctures in the Medicare population were performed by primary care specialties collectively, despite internists and family and general practitioners representing by far the largest physician specialty groups in the United States, illustrating the long-term consequences of these practice trends.[20]

Ultimately, the determinant of whether specialties other than radiology and emergency medicine will continue to perform lumbar punctures in a meaningful capacity will be specialty training. If residents do not become facile with lumbar puncture during training, either because of expectations that the procedure should be performed by others or because their supervising faculty are themselves uncomfortable performing and teaching the procedure,[8,21] they are not likely to develop the skill thereafter. Neither neurology residency nor internal medicine residency training have a specific Accreditation Council for Graduate Medical Education–mandated number of lumbar punctures necessary for graduation, so it is likely that expectations vary greatly among programs. Furthermore, in internal medicine certification, the American Board of Internal Medicine no longer mandates demonstration of procedural skill for lumbar punctures, but simply, the cognitive competence of understanding procedural indications, technique, complication recognition and management, and other information needed to obtain informed consent.[22] As might be expected, a recent publication found that 84% of lumbar punctures performed on internal medicine service inpatients at a single tertiary academic medical center were performed by radiology or a dedicated hospital procedural service rather than by the primary team.[23] To the authors' knowledge, no similar studies have been published evaluating the performance of lumbar punctures on inpatients by neurology services.

The potential for improvement in resident procedural training is well-recognized, and efforts are underway to improve trainee access to procedure opportunities.[24,25] In fact, some movement in this direction may already be occurring. In the hospital inpatient setting, the trend toward performance of lumbar punctures by radiology appears to have reached a plateau or even reversed slightly, with the proportion of lumbar punctures performed by radiology decreasing in 2016 and 2017. While future research will be needed to establish whether this reversal is a durable trend, it could plausibly be explained by some of the measures noted above.

Aside from radiologists, the only provider group that performed an increasing percentage of lumbar punctures across time was nonphysician providers. Although they performed only 7.5% of lumbar punctures in 2017, the most recent year of analysis, that was sufficient to make them the fourth most common provider group overall. Medicare claims by nonphysician providers are insufficient to determine their practice affiliations, and it is unclear what proportion are working within radiology groups to perform imaging-guided lumbar punctures versus performing bedside lumbar punctures in other settings. Increased collaboration between radiologists and nonphysician providers may represent a potential strategy for dealing with the demand for lumbar puncture.

Several potentially disadvantageous consequences of the shift in lumbar puncture performance to radiology merit discussion. From a patient care standpoint, it is often desirable to obtain CSF as expeditiously as possible, such as before or soon after the initiation of antibiotics for suspected bacterial meningitis or when ruling out subarachnoid hemorrhage. When one accounts for logistical considerations such as procedure scheduling, patient transportation, and fluoroscopy room preparation, even the most efficient radiology service is unlikely to rival the speed with which CSF can be collected at the bedside by an experienced provider. From a health system use-of-resources perspective, a lumbar puncture under fluoroscopic guidance requires the presence of both a radiologist and a radiologic technologist as well as use of a fluoroscopy suite, all increasing the per-procedure cost relative to bedside lumbar puncture. This cost is undoubtedly justified when lumbar puncture cannot be successfully performed without imaging, but may not be appropriate in all circumstances. Furthermore, the diversion of radiologists from other tasks to lumbar punctures carries significant opportunity cost. As of 2020, performing a lumbar puncture with imaging guidance yields 1.73 work-relative value units, less than that for interpretation of an MR imaging of the brain with and without contrast, which yields 2.29 work-relative value units. Last, although the radiation dose to the patient and provider associated with a lumbar puncture is

generally quite low, we must ask if even this minimal dose is justified by the corresponding benefits.[26]

The primary limitations of this study are that it is restricted to the Medicare beneficiary population and that the administrative Medicare dataset does not contain all clinical variables that would be of interest. It is possible that the observed trend toward increased lumbar puncture performance by radiologists is less pronounced in younger adults, and particularly in children. In the pediatric population, lumbar punctures are often performed by pediatricians, though even in this group, the reported success rate of lumbar punctures is variable.[27,28] With regard to potentially relevant information not fully captured by the Medicare dataset, patient-level variables such as body mass index, the presence of scoliosis, and history of spine surgery would be indicators of lumbar puncture difficulty and would likely be superior to the CCI for this purpose. Additionally, aborted or incomplete lumbar punctures are likely under-reported, so the true rates of procedural success by specialty and the proportion of patients in whom lumbar puncture was attempted by other services before radiology referral cannot be determined. In light of these limitations, future studies in other patient populations will be necessary to fully understand practice patterns in lumbar puncture performance.

CONCLUSIONS

Radiologists now perform most lumbar punctures in the Medicare beneficiary population in the United States. Even if the long-term trend toward steadily increasing performance of lumbar puncture by radiologists were to plateau, the US Census Bureau projects that the number of adults 65 years of age and older, the demographic group included in this study, will increase from approximately 56 million in 2020 to almost 95 million by 2060.[29] Barring unforeseen changes in medical practice, radiologists will continue to be asked to fill this growing clinical void. In preparation, it will be necessary for radiology residency programs to produce graduates able to perform this vital service without the need for additional fellowship training. Furthermore, radiology practices will need to consider how to appropriately triage lumbar puncture requests from referring providers, and they may need to develop operational infrastructures to perform lumbar punctures in ever-increasing numbers.

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