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Observational Study

Observational Study of the Distribution and Diversity of Interventional Pain Procedures Among Hospitals in the State of Iowa

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Background: Critical access hospitals represent 61% of hospitals in the rural United States, and 68% of hospitals in Iowa. The role of small hospitals, such as critical access hospitals, in providing interventional chronic pain procedures is unknown.

Objectives: We evaluated whether: a) the diversity of interventional pain procedures offered by hospitals is related to their size and is attributable principally to lumbosacral epidural injections; b) critical access hospitals contribute substantively to the count and diversity of pain procedures; and c) whether most interventional pain procedures performed at hospitals' facilities are performed by relatively few proceduralists or by the cumulative activity of many clinicians.

Study Design: This research involved an observational cohort design with a sample size of n = 283,940 interventional pain procedures.

Setting: Data were collected from hospital-owned facilities in the state of Iowa from July 2012 through September 2017.

Methods: The diversity of types of interventional pain procedures performed statewide was quantified in terms of the relative proportions of procedures at each hospital using the Herfindahl index. Bilinear weighted least squares regression quantified the relationship between the inverse of the Herfindahl and the percentage of procedures that were lumbar or caudal epidural. Kendall tau concordances quantified the relationship between counts of interventional pain procedures and hospital size. Using a blinded version of the National Provider Identifier of the clinician with primary responsibility for performing the principal procedure of the ambulatory visit, we calculated the percentage shares of interventional pain procedures performed by the 1% and 5% of proceduralists who performed the most procedures.

Results: The diversity of types of procedures substantively differentiated among hospitals. Heterogeneity among hospitals in the proportion of procedures that were lumbar or caudal epidural injections substantively contributed to the heterogeneity among hospitals ($P < .001$). Hospitals performing more procedures tended to have greater diversity of types of procedures ($P < .001$). However, the strength of the concordance was small (Kendall $\tau_b = 0.332$), showing substantial heterogeneity among hospitals. The 82 critical access hospitals statewide cumulatively accounted for 23.9% of interventional pain procedures. The critical access hospitals' procedures were mostly (67.7%) lumbar or caudal epidural injections ($P < .001$), greater than the 48.9% of the other 41 hospitals ($P < .001$). Procedures were concentrated among proceduralists. The 1.0% of the proceduralists performing the most procedures performed 64.8% of procedures. The 5.0% of proceduralists performing the most procedures performed 87.7% of procedures.

Limitations: The data are procedures were performed in hospital-owned facilities of Iowa.

Conclusions: Although busier pain programs, based on procedures per week, generally performed more types of procedures, the variability was so large that the number of procedures a pain program performs per week cannot validly be used to infer the diversity of the hospital's pain medicine practice. Hospitals with pain medicine programs that lack diversity in the types of procedures performed may provide limited options for patients and be susceptible to changes in payment for individual procedures. Relatively few proceduralists performed the vast majority of the procedures.

Key words: Critical access hospitals, Herfindahl, interventional pain procedures, managerial epidemiology, pain medicine, state outpatient procedure database, lumbar epidural

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Critical access hospitals are designated rural hospitals with no more than 25 inpatient beds and located more than 15 miles from any other hospital (1). Critical access hospitals represent 61% of hospitals in the rural United States (2) and constitute the majority of hospitals in Iowa. Given the rapid expansion of pain procedures over the last 2 decades (3), the role of small hospitals, such as critical access hospitals, in the provision of interventional chronic pain procedures is unknown.

We performed a PubMed search on August 8, 2018, seeking prior managerial epidemiological studies on the role of different hospital sizes, including critical access hospitals, in interventional chronic pain management procedures. There were zero articles obtained when searching ("interventional pain") AND ("State Ambulatory Surgery" OR "outpatient database" OR "managerial epidemiology"). In comparison, as a control, there were 117 studies when substituting "surgery" for "interventional pain".

There have been multiple studies of changes over time in national usage patterns of interventional pain procedures (3-5). For example, epidural injections (all spinal levels) accounted for 42% of interventional techniques for Medicare beneficiaries in 2016 (6). Whether there are differences according to hospital size, and whether these results differ substantively in rural states, for which most hospitals are designated as critical access (2), are unknown.

The state of Iowa contains 82 critical access hospitals and 37 small- to moderate-sized hospitals (7-9). The largest hospital offers the only accredited pain medicine fellowship in the state (9,10). In this paper, we evaluate whether: a) the diversity of interventional pain procedures offered by hospitals is related to their size; b) critical access hospitals contribute significantly to the count and diversity of pain procedures; and c) whether most interventional pain procedures performed at hospitals' facilities are done so by relatively few proceduralists or by the cumulative activity of many clinicians, who may or may not have postresidency fellowship training in pain medicine.

The Iowa Hospital Association keeps a state outpatient database that includes all procedures performed at hospital-owned facilities statewide (i.e., not a study of one network) and regardless of payer (i.e., not restricted to Medicare) (11). This database was accessed to examine how, in practice, interventional pain management procedures are performed at hospital-owned facilities in the relatively rural state of Iowa.

Methods

The University of Iowa Institutional Review Board determined that this project (#20180807) does not meet the regulatory definition of human subjects research. This retrospective observational cohort study was performed using de-identified data. The earliest date studied matched the date of the Iowa Hospital Association's current method of patient de-identification.

The interventional pain procedures studied were those performed at all nonfederal hospital-owned surgical facilities in Iowa from July 1, 2012 through September 30, 2017 (11). The 2 federal hospitals excluded were the Veterans Affairs hospitals in Des Moines and in Iowa City. The Iowa Hospital Association data attributes each procedure to the hospital owning the facility where the procedure was performed (7); practically, most facilities are close to the hospital (12). The hospital data includes not only procedures performed at hospitals, but at facilities owned by hospitals (e.g., the medical office building used by the 5 pain medicine physicians of the state's sole accredited pain medicine program) (13). We henceforth refer to all the studied facilities as "hospitals."

Procedures were chosen from among those in the American Society of Interventional Pain Physicians' list of 2018 Ambulatory Surgery Center payment rates (14). Table 1 shows the common types of procedures that we considered interventional pain procedures (15). Table A in the supplemental content shows the uncommon types of procedures studied (16-20). Procedures performed by many specialties and that do not necessarily use image guidance (e.g., trigger point injections, major joint injections), and procedures that we considered

Table 1. *The most common types of interventional pain procedures performed in hospital-owned facilities in the state of Iowa.*

CPT	Count	Description
62311	97148	Lumbar epidural
64493	29293	Paravertebral facet joint or facet joint nerve; lumbar/sacral, 1st level
64483	27625	Lumbar or sacral transforaminal epidural injection, with imaging guidance, 1st level
62310	18914	Cervical or thoracic epidural
G0260	16673	Injection procedure for sacroiliac joint, arthrography
62323	15514	Lumbar/Caudal epidural with imaging guidance
64635	8331	Paravertebral facet joint neurolysis; lumbar/sacral, single level - neurolysis (previously 64622)
64636	8220	Paravertebral facet joint neurolysis; lumbar/sacral, each additional level (previously 64623)
64490	6800	Cervical or thoracic facet joint injections, 1st level
64450	6399	Other peripheral nerve or branch
64484	5846	Lumbar or sacral transforaminal epidural injection, with imaging guidance, each additional level
64405	4186	Greater occipital nerve
64400	3376	Injection, Trigeminal nerve
64612	3362	Chemodenervation of muscle(s); muscle(s) innervated by facial nerve
62321	3078	Cervical/Thoracic interlaminar epidural, with imaging guidance
63650	2284	Percutaneous implantation neuro-electrodes
64633	1877	Paravertebral facet joint neurolysis; cervical/thoracic, single level
64402	1756	Facial nerve
62273	1574	Epidural, blood patch
64613	992	Chemodenervation of neck muscle(s) (e.g., for spasmodic torticollis, spasmodic dysphonia)
62322	867	Lumbar/Caudal interlaminar epidural without imaging guidance

This table shows the 21 most common of the interventional pain procedures. There are 21 shown in this table to include the 5 considered lumbar or caudal epidural, as used in Fig. 1. These 5 are shown with highlighting of the rows. The other 47 Current Procedural Terminology (CPT) codes are provided in Supplemental Table A. Because the data were obtained from the Iowa Hospital Association, formally these are Healthcare Common Procedure Coding System (HCPCS) codes (15).

to be uncommonly performed by interventional pain physicians (e.g., trigeminal nerve ablation and spinal cord biopsy), were excluded.

Among the 283,940 interventional pain procedures performed at an Iowa hospital from July 2012 through September 2017, 3.0% were performed on the same date as an "invasive therapeutic surgical procedure" (21). These 3.0% of procedures (i.e., 8515 of 283,940) were excluded, leaving 275,425 interventional pain procedures studied. The 3.0% excluded likely were peripheral nerve or neuraxial anesthetic blocks for surgical care (e.g., caudal blocks performed for pediatric urological and orthopedic procedures). This exclusion did not influence results because all analyses involved relative relationships; none was based on raw counts.

The diversity of types of procedures performed at the hospitals was quantified using the relative proportions of procedures of each such codes, at each hospital (Figs. 1-2) (22-24). The sum of the squares of the proportions was each hospital's Herfindahl index (22). The Herfindahl index equals the probability that any 2 procedures selected at random, with replacement, from a list of all procedures performed at the hospital, are of the same type of procedure. The inverse of the Herfindahl is the "number of procedures of each type of procedure performed commonly" (22). This quantity is also referred to as the "effective number of different types of procedures" (25). Each increase in the number of different types of procedures commonly performed is associated, monotonically, with an increase in the inverse of the Herfindahl (22,26-28). There are several online tutorials using 1/Herfindahl as a measure of diversity (25,29-31). The inverse of the Herfindahl has been used in managerial epidemiological studies of the diversity of surgical procedures among hospitals (22-24).

Quantification of diversity needs larger sample sizes than observed at some hospitals, making the standard errors and, consequently confidence intervals, wide (Figs. 1 and 2). Thus, we limited consideration to

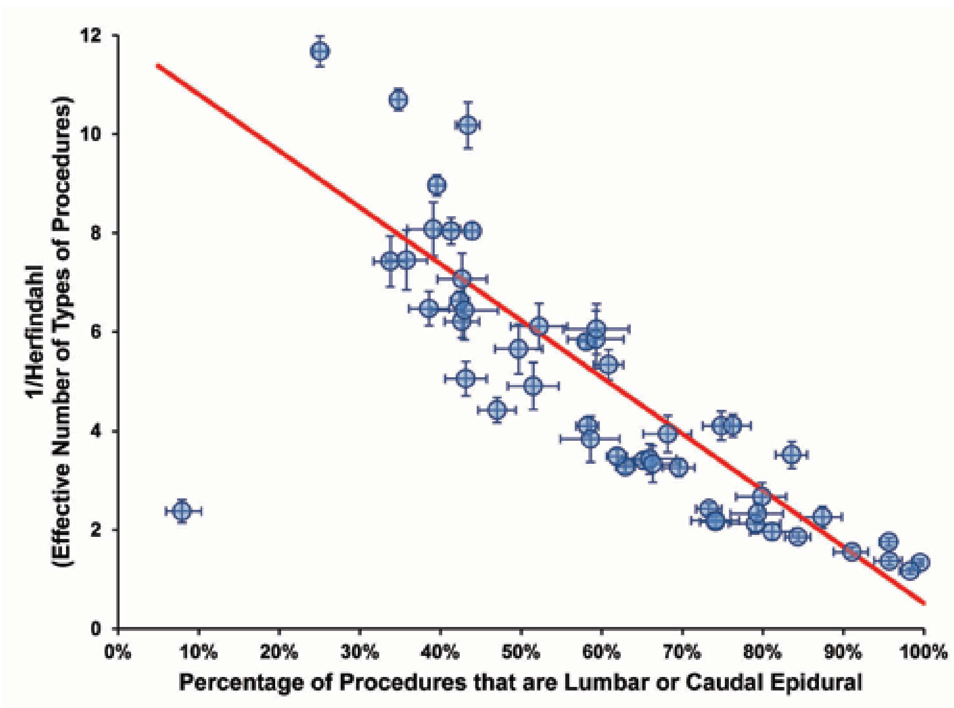

Fig. 1. *Relationship between hospitals' percentages of procedures that are lumbar or caudal epidural injection and their overall diversity of types of procedures performed. The bivariate weighted linear regression test of the slope being different from zero was significant with $P < .001$. The unweighted least squares Pearson $r = - 0.78$, $P < .001$. The Kendall $\tau_b = - 0.73$, $P < .001$. However, the error bars show 99% 2-sided confidence intervals and highlight significant heterogeneity from the least squares line. The largest hospital by beds in the state, with the sole pain medicine fellowship in Iowa, has the largest observed inverse of the Herfindahl, 11.7, with standard error (SE) 0.01, and the second smallest observed percentage of procedures that were lumbar or caudal epidural, 25.0% (SE 0.3%).*

the 50 hospitals that happened to have overall at least one interventional pain procedure performed every other day. Since the July 2012 through September 2017 period studied was 1918 days, Figs. 1 and 2 included hospitals that performed at least 959 procedures.

The most common interventional pain procedures were epidural injections for spinal pain (4). Consequently, we tested the hypothesis that the diversity of types of procedures among hospitals represented, in practice, heterogeneity in the percentage of procedures performed that were lumbar or caudal epidural injections. Table 1 shows the 5 types of procedures that we considered lumbar or caudal epidural injection. The 99% confidence intervals for the percentages were calculated using the Clopper-Pearson method.

We used linear least squares regression to test and quantify the relationship between the inverse of the Herfindahl and the percentage of procedures in the category of lumbar or caudal epidural. Although still limited to the n = 50 hospitals with overall at least one interventional pain procedure performed every other day, this linear regression was complicated by both variables having non-negligible standard error for some hospitals; see Fig. 1. For accurate estimation of parameters using regular least squares linear regression, both variables should be measured without substantial error (32-34). We therefore used bivariate weighted least squares regression (32-34). Inverse weighting was based on the squares of the standard errors of the (i) inverses of the Herfindahl and (ii) proportions of procedures that were lumbar or caudal epidural injections. The bivariate weighted least squares regression was performed using the iterative method described by York and Williamson (32). The equations are summarized by Cantrell (34) in his equation 5. As a sensitivity analysis, we also quantified the relationship between the 2 vari-

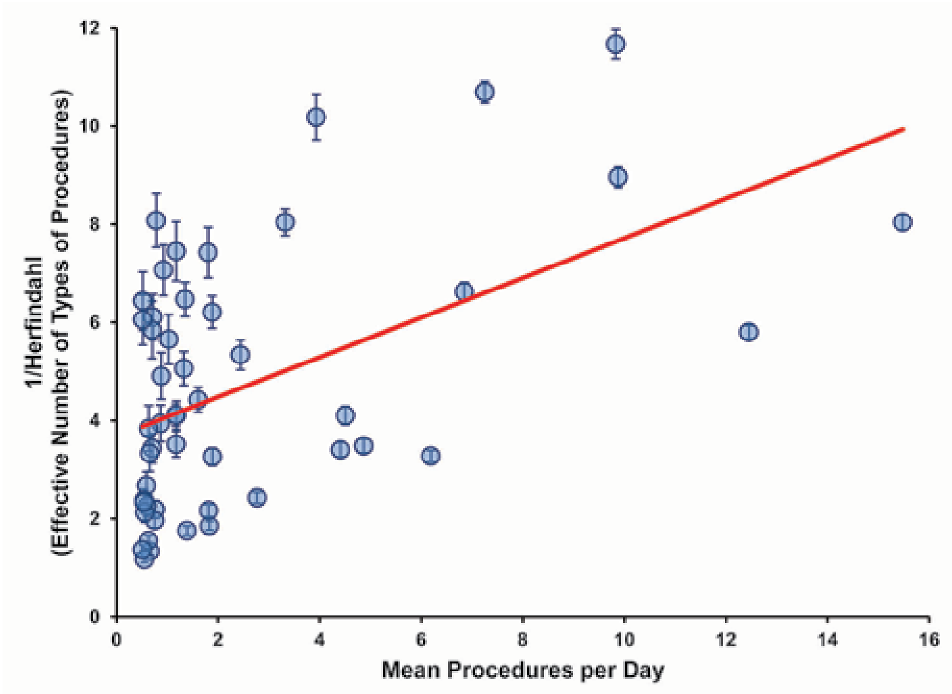

Fig. 2. *Relationship between interventional pain procedures performed and overall diversity of types of procedures performed. The 50 hospitals shown are those with overall at least one interventional pain procedure performed every other day; the vertical axis and the 50 hospitals match those of Fig. 1. The horizontal axis has the same units as Fig. 3, but a wider scale in Fig. 3 because more hospitals are included (see Methods). The least squares Pearson r = 0.511 (SE 0.093), P < .001. The Kendall* τ_b *= 0.332 (SE 0.090), P < .001, confirms the positive association, but highlights the considerable heterogeneity among hospitals, particularly the hospitals performing few procedures per day. The correlation was no greater (i.e., appears potentially weaker) between diversity and hospital beds (Fig. 3), Kendall* τ_b *= 0.205 (SE 0.109), P = .050.*

ables using Kendall's rank correlation coefficient. The *P* value for the test of the difference of the estimated rank correlation from zero was calculated using Monte-Carlo simulation (StatXact 11.1, Cytel Inc., Cambridge, MA). Variability around the regression line was quantified similarly using Kendall τ_b correlation. We calculated the standard errors asymptotically (StatXact 11.1).

Next, we examined the relationship between counts of interventional pain procedures and hospital size quantified by staffed beds (7,9). Since there was large heterogeneity among hospitals in both variables, log scales were used on both axes (Fig. 3). Consequently, we needed to choose a lower bound for overall procedures per day (i.e., it could not be zero). Since we were using $\log_{10}$ scale, we used one-tenth of the threshold from Fig. 1, which was 95.9 procedures over the 1918 days (i.e., ≅ 1 procedure every 3 weeks). With that threshold, Fig. 3 included 99.8% (274,979) of the 275,425 procedures, 84.6% (104) of the 123 hospitals statewide, and 84.2% (69) of the 82 critical access hospitals statewide. By statute, a critical access hospital may not have more than 25 inpatient beds (1).

In our analyses of the Iowa Hospital Association data, we also used a blinded version of the National Provider Identifier for the clinician with primary responsibility for performing the principal procedure of the ambulatory visit (35). The cumulative probability distribution of procedures among proceduralists was calculated (Fig. 4). As specified in the Institutional Review Board protocol, no relationship was made between the proceduralists and the hospitals, because doing so for small hospitals would have named the proceduralist when combined with publicly available secondary material (e.g., hospital website). Correspondingly, Fig. 4 was deliberately not combined with Figs. 1-3.

The distribution of procedures among procedur-

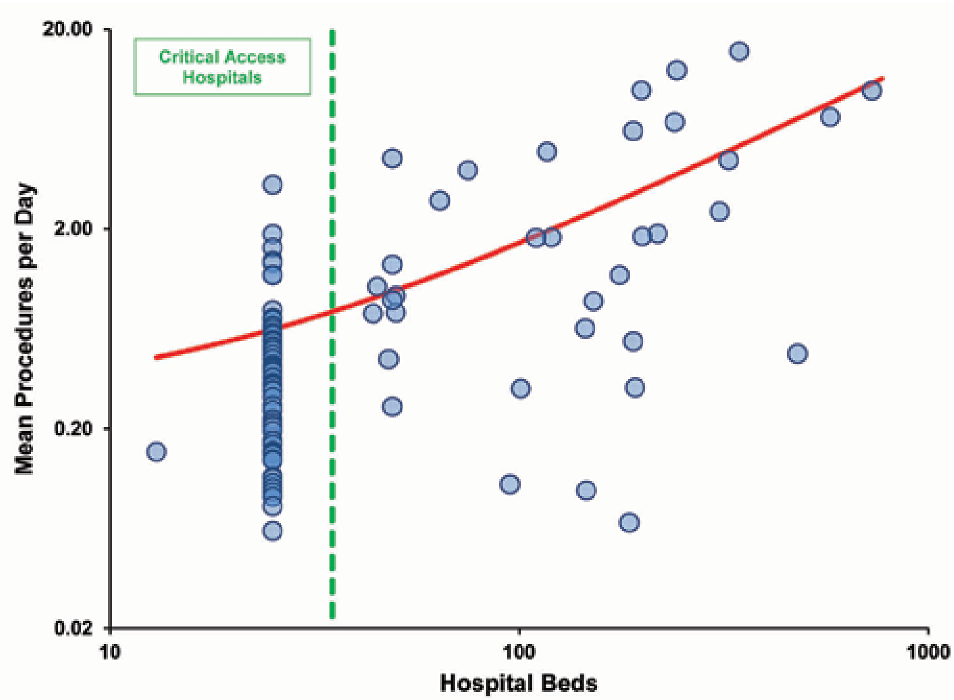

Fig. 3. *Relationship between hospital size measured by beds and interventional pain procedures. The red line is linear in the arithmetic scale, fit using least squares regression. The line appears curved because both axes in the figure are logarithmic, base 10. The Pearson correlation r = 0.650 (SE 0.075), P < .001. The Kendall τ_b = 0.417 (SE 0.071), P < .001. As explained in the Methods, this figure includes the 99.8% of interventional pain procedures performed at the 84.6% (104) of the 123 hospitals statewide, and 84.2% (69) of the 82 critical access hospitals statewide, with overall at least one procedure every 20 days. As required by statute, all 69 of the critical access hospitals had 25 or fewer beds (1). The other 35 hospitals had 44 to 728 beds (i.e., none had 25 or fewer beds). The hospital of the sole pain medicine fellowship in Iowa was the largest with 728 beds.*

alists was studied inferentially using the Stata *pshare* command (36; Stata 15.1, StataCorp LP, College Station, TX). Specifically, we calculated the percentage of the interventional pain procedures performed by the 1% and 5% of proceduralists who performed the most procedures. Standard errors were estimated using Taylor linearization (i.e., analytical method). As sensitivity analyses, the standard errors were also calculated using the bias-corrected and accelerated bootstrap method with 1000 replications (36,37). These calculations took into account that the 1% and 5% busiest proceduralists were themselves determined from the data.

Results

Figure 1 shows that the diversity of types of procedures substantively differentiated among hospitals. The figure also shows that heterogeneity among hospitals in the proportion of procedures that were lumbar or caudal epidural injections substantively contributed to the differences in diversity among hospitals (*P* < .001). For 32 of the 50 hospitals in which at least one interventional pain procedure overall was performed every other day, at least half of the observed types of procedures were lumbar or caudal epidural injections.

Hospitals performing more procedures tended to have greater diversity of types of procedures (Fig. 2; *P* < .001). However, there was substantial scatter (Kendall τ_b = 0.332). The figure shows that hospitals' interventional pain medicine programs were highly differentiable when their diversities of types of procedures and numbers of procedures were combined.

Larger hospitals (i.e., more beds) had larger interventional pain programs (Fig. 3; *P* < .001). However, there was also substantial scatter (τ_b = 0.417). The 82 critical access hospitals statewide cumulatively accounted for 23.9% (65,901 of 275,425) of the interven-

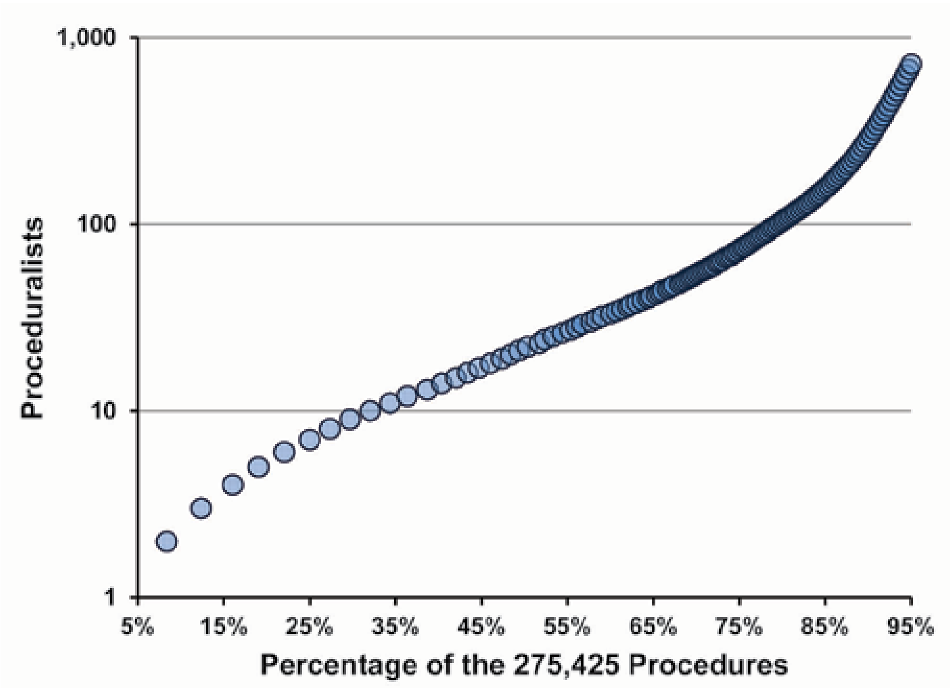

Fig. 4. *Distribution of procedures among proceduralists. The figure shows substantial concentration of the procedures performed among relatively few of all attributed proceduralists. Proceduralist 1 performed the most procedures, and so forth. The units of 10, 100, and 1000 proceduralists would not be generalizable beyond Iowa, because it would depend on the state's population. As context, there were 224 proceduralists meeting the threshold of > 95.9 procedures used in Fig. 3. However, these numbers have relevance to the authors' institution, because it is the state's sole pain medicine fellowship, but realistically to few readers. In 2018, there were 26 physicians in the state certified in Pain Medicine (see Discussion). In the Results, we perform inferential analysis based on percentile shares of procedures among the 1% and 5% most active proceduralists; those results are the generalizable findings.*

tional pain procedures. As displayed in Figs. 1-3, the critical access hospitals' procedures were mostly (67.7%; 44,606 of 65,901) lumbar or caudal epidural injections ($P < .001$). Fewer of the other 41 hospitals' procedures (48.9%; 102,394 of 209,524) were of this type ($P < .001$).

Procedures were concentrated among proceduralists (Fig. 4). The 10 and 100 proceduralists performing the most procedures accounted for 32.0% and 79.7%, respectively, of procedures statewide. Generalizing this relationship, the 1.0% of proceduralists performing the most procedures performed 64.8% of procedures (analytic and bootstrap standard errors, 2.9%). The 5.0% of proceduralists performing the most procedures performed 87.7% of procedures (analytic standard error, 1.4%; bootstrap standard error, 1.5%).

Discussion

Diversity of Procedures

Pain medicine practices at hospitals differed substantially not only in terms of counts of procedures performed, but in the diversity of types of procedures. Most hospital-based pain medicine practices (> 50%) were principally devoted to lumbar or caudal epidural injections for lower back pain, especially at critical access hospitals. Hospital facilities performing a greater diversity of interventional pain procedures were those more often performing procedures other than lumbar or spinal epidural steroid injections (Fig. 1). Inversely, hospitals performing mostly lumbar or caudal epidural injections generally had a small diversity of procedures. Although most small hospitals performed fewer procedures and types of procedures (i.e., had less diversity), hospital size poorly predicted both endpoints (Figs. 2 and 3). Thus, our results show that how busy a hospital-affiliated pain program is – based on procedures per day – cannot validly be used to infer the diversity of the pain medicine procedures performed. In addition, expectations that a large hospital will be offering more options for interventional pain procedures would be inaccurate in this population.

Proportions of Proceduralists

As of September 2018, there were approximately 26 physicians in the state of Iowa who hold current a Pain Medicine certification (from the American Board of Medical Specialties). While we did not study individual clinician characteristics, we found that vastly more than 100 unique clinicians were performing interventional pain procedures (Fig. 4). This suggests that procedures in Iowa are being performed by physicians without pain medicine certification or by nonphysicians (38). Since the interventional pain management specialty code 09 is self-designated within national Medicare data, it is unlikely that these results can be compared directly with findings using code 09 (Interventional Pain Management) (39). Because 5% of proceduralists performed 87.7% of procedures (i.e., there was substantial concentration), estimation of state workforce needs for pain medicine physicians could be done with a relatively easy survey. In addition, sample sizes would be sufficient for analyses of guideline usage by clinicians. Future studies should investigate the influence of use of physicians or nonphysicians not certified in interventional pain medicine, and specifically the 95% of clinicians performing only 12.3% of procedures, on appropriateness of pain medicine care (e.g., following guidelines on procedures).

Proportion of Lumbar or Caudal Epidural Injections Performed

Among Medicare patients nationally, epidural injections (all spinal levels) account for 42% of interventional procedures (6); however, for most critical access hospitals, lumbar and caudal epidural injections account for a significantly larger proportion of procedures (e.g., 67.7% at critical access hospitals). Possible explanations include procedural reimbursement patterns, lack of access to a fellowship-trained interventional pain physician, lack of facilities for more advanced procedures, lack of recognition of pain problems not amenable to lumbar epidural injection, or referral of these patients to larger hospitals for more specialized care. The outcomes and cost-effectiveness for these procedures at those hospitals are unknown.

The relatively large frequency of lumbar or caudal epidural injections suggests potential sensitivity of many smaller hospitals' procedural caseloads to payers' policies, as often the highest payments for interventional pain procedures are made to hospital outpatient departments compared to physician offices or ambulatory surgery centers (40). Lumbar epidural steroid injections (inclusive of interlaminar and transforaminal) provide small gains in quality-adjusted life years (41), probably because of the overall brief duration of significantly improved functioning due to interlaminar injection versus placebo (42,43). Caudal epidural steroid injection does not provide benefit relative to sham or placebo, either for brief or long-term periods (44). Nevertheless, it was included in the codes of commonly performed procedures (Table 1), providing insight into its use.

As previously noted, we are aware of no prior managerial epidemiological studies of interventional pain procedures among individual facilities, highlighting the novelty of our work. As a rural state, Iowa has a land area 12% larger than England, but a population 22% of that of London. The results increase our understanding of how rural populations may be accessing interventional pain procedures. We hope that our research motivates other investigators to perform comparable studies of other geographic areas. We think that our analyses provide information necessary to plan future studies with specific testable hypotheses.

Other Limitations

In addition to our study being only of one state, Iowa, the data from the Iowa Hospital Association are limited to procedures performed in hospital-owned facilities. Although not a limitation for the physicians in the state's sole accredited pain medicine fellowship (13), the data do not represent all pain procedures performed statewide. Raw counts in Table 1 and in the supplemental content (Table A) underestimate the counts of procedures performed by individual clinicians who may practice at both hospital-owned and nonhospital-owned facilities. We do not know the extent to which our data underestimate counts, but it may be substantial (4). In 2014, nationwide, hospital outpatient departments performed only 29.4% of epidural injections (4). Furthermore, the percentage of procedures performed in hospital outpatient departments has been decreasing (4). Because of this limitation, we were careful to restrict our results to analyses of relative relationships.

Another related limitation is that, for each hospital, it was unknown where the procedure was performed: hospital building, ambulatory surgery center, or office (7). (Again, the study was of facilities owned by the hospital, not hospitals per se). Because most hospital-owned procedure centers are physically close to the hospital (12), especially relative to the substantial distances patients travel in a rural state, this limitation probably would not affect future studies of patient access to care. Because each hospital's annual financial report for public disclosure combines its owned facilities, reasonably so because costs are shared, this limitation probably would not affect future studies of the costs of providing patients with interventional pain procedures.

Conclusions

Although busier (based on procedures per week) pain programs tended to perform more types of procedures, the relationship was so weak that how busy a pain program is cannot validly be used to infer the diversity of the hospital's pain medicine practice. Practically, this reflects the extent to which types of procedures other than lumbar or caudal epidural injections are routinely being performed. Generally, larger hospitals have larger pain medicine programs and perform more types of procedures. However, those relationships are also too weak to be useful for referral decisions regarding individual patients. Hospitals with pain medicine programs that lack diversity in types of procedures may provide limited options for patients and be susceptible to changes in payment for individual procedures. Finally, procedures were highly concentrated among proceduralists, suggesting relatively easy opportunity to estimate state workforce needs for pain medicine physicians.

Acknowledgments

The data used in this study can be obtained from the Iowa Hospital Association (11).

Craig Jarvie, MMR, Senior Planning Analyst at University of Iowa Health Care, manages the Iowa Hospital Association data at the University of Iowa and prepared the data fields for us.

The funding for this project was departmental. Funding was provided solely from departmental sources.

Supplemental Table A. The 22nd to 68th most common types of interventional pain procedures performed in hospital-owned facilities in the state of Iowa.

CPT	Count	Description
64421	840	Intercostal, multiple, regional block
62368	669	Electronic analysis of programmable pump with reprogramming
64425	666	Ilioinguinal, Iliohypogastric block
62290	659	Lumbar discography, each level
64445	590	Sciatic nerve block
64614	586	Chemodenervation of muscle(s); extremity(s) and/or trunk muscle(s) (e.g., for dystonia)
64479	565	Transforaminal epidural; cervical/thoracic, single level, with imaging guidance
22514	512	Percutaneous vertebroplasty and vertebral augmentation, lumbar
22513	468	Percutaneous vertebroplasty and vertebral augmentation, thoracic
64640	456	Destruction by neurolytic Agenta, other peripheral nerve or branch
63688	431	Revise/remove neuroreceiver
64510	423	Injection, Stellate ganglion (cervical sympathetic)
62362	406	Implant spine infusion pump
64418	348	Suprascapular nerve injection
64420	291	Intercostal injection, single
22523	277	Vertebral augmentation, thoracic
22511	203	Vertebroplasty (Lumbosacral)
62350	201	Tunneled intrathecal or epidural catheter
22510	190	Vertebroplasty (Cervicothoracic)
22520	181	Vertebroplasty (Thoracic)
62320	169	Cervical/Thoracic epidural without imaging guidance
63661	165	Remove spine electrode percutaneous array
22521	160	Vertebroplasty (Lumbar)
62319	141	Catheterization, epidural, lumbar/sacral
64480	127	Transforaminal epidural; cervical/thoracic, each additional level, with imaging guidance
62367	99	Electronic analysis of programmable pump
63663	94	Remove spine electrode percutaneous array
64505	92	Injection, sphenopalatine ganglion
22525	84	Vertebral augmentation, each additional level
64530	81	Injection, celiac plexus
62327	50	Continuous interlaminar epidural catheterization, lumbar/sacral with imaging guidance
62365	46	Remove spine infusion device
64680	45	Celiac plexus neurolysis
62325	37	Continuous interlaminar epidural catheterization, cervical/thoracic, with imaging guidance
62318	31	Epidural or subarachnoid, catheterization, cervical/thoracic
64461	19	Paravertebral injection
62360	13	Implant or replacement of device for intrathecal or epidural drug infusion; subcutaneous reservoir
62355	10	Removal or previously implanted intrathecal or epidural catheter
62361	9	Implantation or replacement of device for epidural drug infusion; non-programmable pump
62324	7	Continuous interlaminar epidural catheterization, cervical/thoracic, without imaging guidance

Supplemental Table A con't. The 22nd to 68th most common types of interventional pain procedures performed in hospital-owned facilities in the state of Iowa.

CPT	Count	Description
62326	7	Continuous interlaminar epidural catheterization, lumbar/sacral, without imaging guidance
62268	4	Percutaneous aspiration, spinal cord cyst or syrinx

This table shows the 47 least common of the interventional pain procedures studied. The 21 most commonly observed types of procedures are shown in Table 1. CPT represents Current Procedural Terminology. CPT 64470, 64475, 64622, and 64626 had counts of 0 and so are not listed in the table. Also, we did not include CPT 62263 or 62264, percutaneous lysis of epidural adhesions, when we obtained the Iowa Hospital Association data. In Iowa, the largest commercial insurer in the state, Wellmark BlueCross BlueShield of Iowa, has 82% of the individual market, 57% of the small group market (i.e., 2 to 50 employees), and 76% of the large group market, the percentages based on covered lives (16). Wellmark does not pay for epidural adhesiolysis (17). In Iowa, Medicaid participants can choose between 2 plans (18). Neither UnitedHealthcare nor Amerigroup pays for epidural adhesiolysis (19,20). UnitedHealthcare is also the second larger insurer in the small and large group markets (19).

Supplemental Table B. STROBE Statement—Checklist of items that should be included in reports of cohort studies.

	Page	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	3	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	5	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Patients	5	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(b) For matched studies, give matching criteria and number of exposed and unexposed
Variables	6	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	6	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	6	Describe any efforts to address potential sources of bias
Study size	5	Explain how the study size was arrived at
Quantitative variables	6	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	7	(a) Describe all statistical methods, including those used to control for confounding
		(b) Describe any methods used to examine subgroups and interactions
		(c) Explain how missing data were addressed
		(d) If applicable, explain how loss to follow-up was addressed
		(e) Describe any sensitivity analyses
Results		
Participants	5	(a) Report numbers of individuals at each stage of study—e.g., numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram

Supplemental Table B (cont.). STROBE Statement—Checklist of items that should be included in reports of cohort studies.

	Page	Recommendation
Descriptive data	20, Supp 1	(a) Give characteristics of study participants (e.g., demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (e.g., average and total amount)
Outcome data	N/A	Report numbers of outcome events or summary measures over time
Main results	9 and 22	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(b) Report category boundaries when continuous variables were categorized
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	9	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	10 and 11	Summarise key results with reference to study objectives
Limitations	12	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	13	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	12	Discuss the generalisability (external validity) of the study results
Other information		
Funding	14	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

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