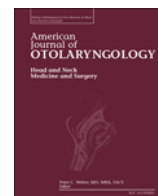




Contents lists available at ScienceDirect

American Journal of Otolaryngology–Head and Neck Medicine and Surgery

journal homepage: www.elsevier.com/locate/amjoto

Payer database and geospatial analysis to evaluate practice patterns in treating allergy in North Carolina

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ARTICLE INFO

Article history:

Received 11 May 2017

Available online xxxx

Keywords:

Allergy

Otolaryngology

Health services

Health care delivery

ABSTRACT

Objective: The objective of this study was to characterize the delivery of allergy care in North Carolina using a large payer charge database and visualization techniques.

Study design: Geospatial database analysis.

Setting: North Carolina State claims database.

Subjects & methods: Medical data from the 2013 FAIR Health National Private Insurance Claims (FH NPIC) database for North Carolina was mined for CPT codes and charges for allergy testing, and for the preparation and provision of allergen immunotherapy. Provider and patient variables were analyzed. Analyses were performed to compare differences in allergy care delivery. A visualization strategy complemented the analytic approach.

Results: 162,037 CPT charge entries were analyzed. Allergy-immunology specialists were the most common provider specialty to perform allergy immunotherapy treatments (68.9%, $p < 0.05$). Among other specialties, there were no significant differences between specialists performing immunotherapy when comparing otolaryngology, family practice, and internal medicine (16.3%; 4.6%; 2.6%; $p > 0.05$). Providers with an M.D. degree were the most common provider type. The three most commonly treated diagnoses were allergic rhinitis variants. Females were more likely to receive allergy treatments versus males (55.9% vs. 51.5%; $p < 0.001$), and were more likely to receive allergy testing (65.3% vs. 34.7%; $p < 0.005$). Internal medicine providers charged higher than any other specialist type ($p < 0.05$) for allergy immunotherapy.

Conclusions: Using a large payer database coupled with visualization techniques was an efficient approach to characterizing the state-wide provision patterns of allergy diagnostic and therapy services in North Carolina. This first tier approach to efficiently exploring questions and describing populations is valuable.

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1. Introduction

Health care delivery is influenced by myriad local, regional, and national contexts, and the study of health care delivery issues is critical for both identifying barriers and expanding access to patients. This is easier said than done. As healthcare continues to move into an electronically-based environment, it is important to deploy approaches and strategies to efficiently and effectively use available data to characterize populations of interest. It can be challenging to navigate a large dataset to identify patterns or characteristics of interest, thus the advent of complementing traditional analytic approaches with visualization tools. Novel visualization techniques can be used to explore care provision patterns and specific concerns with access to care.

To explore the utility of using a large database coupled with geospatial imaging visualization, a topic was selected. Allergy and

related conditions are often treated by otolaryngologists, thus the study of regional variation in allergy care may yield important insights into the care challenges and opportunities for otolaryngologists. The manifestations of allergy in the upper airway are a common reason for a patient consultation with an otolaryngologist. Allergy and immunology medical specialists have traditionally been a primary resource for the treatment of allergic patients. However, otolaryngologists have also provided this service for many years – some of the earliest English-language reports and treatise date back to the 1930s [1,2]. In contemporary practice, otolaryngology-head & neck surgery residency programs are now required to provide education and training in the treatment of allergic conditions [3,4].

When comparing the approach to work-up of nasal obstruction, allergists and otolaryngologists have been shown to evaluate nasal obstruction differently [5]. Otolaryngologists who are interested in allergy management utilize nasal endoscopy for evaluation of nasal anatomy and pathology. To the otolaryngologist, nasal endoscopy informs the decision regarding management of nasal allergy symptoms. Allergists have been shown to rely on allergy testing, whereas

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Table 1

Three most common diagnoses associated with allergy injections and allergy testing.

Treatment diagnosis	Total number of injections	Mean % (SD)	Testing diagnosis	Total number of tests	Mean % (SD)
Allergic rhinitis, pollen	72,327	48.6 (6.41)	Irritable bowel syndrome	2948	12.7 (9.40)
Allergic rhinitis, unspecified	25,517	16.4 (14.2)	Allergy, unspecified	2790	10.6 (3.58)
Allergic rhinitis, other	20,372	16.9 (5.38)	Dermatitis, food related	1967	8.70 (2.97)

SD: standard deviation.

otolaryngologists more frequently use nasal endoscopy [5]. A recent survey of allergists, otolaryngologists, and primary care physicians also noted other allergy practice trends between specialties differ [6]. Specifically, otolaryngologists were more likely to perform intradermal testing, however there was no significant difference in therapies prescribed including injection or sublingual immunotherapy between otolaryngologists and allergists. These studies underscore the potential for variation in the delivery of allergy care, and as of the writing of this manuscript little has been published that explores geospatial variability in allergy care between otolaryngologists and allergists.

The main objective of this study was to characterize the delivery of allergy care in North Carolina using a national procedure charge database to determine provision patterns, and the relative proportion of allergy care provided by otolaryngologists compared to other specialists. We also sought to demonstrate the utility of visualization techniques to complement traditional data analyses for analyzing patterns and trends in allergy care.

2. Methods

This study was reviewed by the Duke University Medical Center IRB and deemed exempt from formal review.

2.1. Database analysis

Medical data from the 2013 FAIR Health National Private Insurance Claims (FH NPIC) database for North Carolina was mined. The payers contributing to this database include health insurers from large national payers to small local and regional insurance companies. This database included records of CPT codes and charges for allergy testing (specific IgG, IgE quantitative or semi-quantitative), and for the preparation and provision of allergen immunotherapies (injections of allergenic extract). Associated with each CPT code and charge entry, the database included variables for ordering specialty, provider credentials, diagnosis, patient gender, patient health insurance plan type, and care provision service zip code.

2.2. Statistical analysis

T-tests and ANOVA analyses were performed to compare differences in allergy care delivery between provider specialty type, provider credential, charge amounts, diagnosis incidence, and patient gender. Means and standard deviation (SD) were reported where appropriate. To control for multiple comparisons, Tukey's honest significant difference (HSD) was used when performing multiple pairwise comparisons. Statistical analysis significance was set at $p < 0.05$.

2.3. Geospatial analyses

Using proprietary data visualization and insight discovery software (SynGlyphX, Arlington, Virginia), geospatial analyses were completed to qualitatively describe differences in the above variables. SynGlyphX software creates visual 'glyph' icons with different components (rings, rods) that represent different variables for instance. The creation of these glyphs allows for the visualization of complex datasets in a geospatial context. For example, on one map of North Carolina, one is able to demonstrate the market share of allergy service by different

provider types, the proportion of certain allergy CPT codes billed in a given population, and demographic variables for each city. The range of values in each variable are color-coded such that data extremes can be appreciated at-a-glance.

3. Results

3.1. Allergy care provision

162,037 CPT charge entries were analyzed comprising allergy testing and allergy injection therapy codes. The three most commonly treated diagnoses were allergic rhinitis variants (Table 1). Females were more likely to receive allergy treatments versus males (55.9% vs. 51.5%; SD 1.65 $p < 0.001$), and were more likely to receive allergy testing (65.3% vs. 34.7%; SD 6.4 $p < 0.005$). Providers with an M.D. degree were the most common provider type compared to physicians with doctor of osteopathy (D.O.) certification, nurse practitioners (NP), and physician assistants (PA) (96.4% SD 0.56%, 2.6% SD 0.69%, 0.2% SD 0.17%, and 0.3% SD 0.06% respectively; M.D. versus D.O. $p < 0.0001$, and D.O. vs. NP $p = 0.005$).

Allergy-immunology specialists were the most common provider specialty to perform allergy immunotherapy treatments (68.9% of total); when comparing allergy to otolaryngology ($p = 0.01$), family practice ($p = 0.001$), internal medicine ($p = 0.001$) (Table 2). Among other specialties, there were no significant differences between specialists performing immunotherapy when comparing otolaryngology, family practice, and internal medicine (16.3%; 4.6%; 2.6%; $p > 0.05$ for each combination). Allergy testing charges were billed by non-physician billers in this database, so we were unable to determine which specialty was more likely to refer patients for allergy testing.

Internal medicine providers charged higher than any other specialist type ($p < 0.05$) for allergy immunotherapy (Table 3). Allergy specialists charged the least amount, however this was not significantly different than family practice providers (allergy \$20.20/claim SD 4.86, family practice \$26.44/claim SD 12.25; $p > 0.05$).

3.2. Visual geospatial analyses

Using proprietary geospatial analysis software and the allergy treatment zip codes where the service was provided, we annotated a North Carolina state map with our variables (Fig. 1). In order to determine where in North Carolina otolaryngologists have a substantial market share, we filtered our data to highlight zip codes where the proportion

Table 2

Relative proportion of provider specialty types providing preparation and provision of injections of allergenic extract.

Specialty	Total number of procedures	Mean % (SD)
Allergy-immunology**	93,210	68.9 (12.7)
Otolaryngology ⁺	19,762	16.3 (15.6)
Family practice ⁺	4766	4.6 (1.6)
Internal medicine ⁺	2293	2.6 (1.4)
Pulmonology	2284	2.5 (2.8)
Pediatric medicine	2345	1.6 (0.4)

SD: standard deviation.

** $p < 0.05$ for T-Tests comparing allergy to otolaryngology ($p = 0.01$), family practice ($p = 0.001$), internal medicine ($p = 0.001$).⁺ No significant difference in T-Tests comparing each ($p > 0.05$ for each combination).

Table 3

Number of charges, and mean charges for providing preparation and provision of injections of allergic extract by specialty. For the connecting letters report, all levels not connected by same letter are significantly different ($p < 0.05$).

Provider specialty	Number of CPT charges	Mean charge per CPT code, \$USD (SD)	Connecting letters report			
Internal medicine	2293	60.98 (411.07)	A			
Pediatric medicine	1816	34.79 (177.4)		B		
Pulmonology	1651	29.57 (2.01)		B	C	
Family practice	1613	26.44 (12.25)		B	C	D
OHNS	6531	24.02 (6.29)			C	
Allergy	22,916	20.15 (4.86)				D

SD: standard deviation.

of allergy therapy claims by otolaryngologists who exceeded one-third of the zip codes' total allergy therapy claims (Fig. 2). We also determined which zip codes represented the 90th percentile or greater for allergy therapy charges by any specialty (Fig. 3). Please see online content for a video presentation and high-resolution images of the provided figures (Video 1).

4. Discussion

Health care data is plentiful, and rife with opportunities for analysis and discovery of clinically useful insights. However, large datasets with numerous variables can be difficult to analyze with traditional techniques. In particular, geospatial data that involve geographic elements can be difficult to interpret in static spreadsheet formats. The use of complementary analytic approaches with visualization tools used in this manuscript highlight the benefits of their use in analyzing care provision patterns and specific concerns with access to care in a geographic context. Our data demonstrate that allergy specialists performed significantly more allergy-related therapies than otolaryngologists, and that allergic rhinitis was the most common diagnosis treated. Given that otolaryngologists are well positioned to diagnose and treat non-allergic and allergic rhinitis, these results suggest that a national charge dataset provided insights on the provision of allergy care by otolaryngologists. The identification of these care patterns highlights opportunities to enhance patient access to allergy care in North Carolina.

Otolaryngologists have been taking care of the allergic patient since the inception of the specialty, with some of the earliest reports on the evaluation and treatment of these patients dating back to the beginning of the 20th century [1,2]. Despite this long track record of service, little has been published on otolaryngology practice trends as it relates to allergy. A recent web-based survey to allergists, otolaryngologists, and

primary care physicians noted that practice trends between specialties differ [6]. Otolaryngologists were more likely to report utilization of intradermal testing versus the other specialties, however there were no significant differences in the use of different therapy modalities such as injection or sublingual immunotherapy. In our one-year sample of claims data from 2013 in North Carolina, allergy-immunology physicians performed allergy immunotherapy treatments more frequently relative to otolaryngologists, family practice, internal medicine physicians. One possible explanation for the relatively lower provision of allergy care in North Carolina by Otolaryngologists may be due to a lack of training or desire to offer a clinical practice in allergy care. Treating allergies is an integral component of contemporary otolaryngology residents, though the quality and depth of training may vary between residency programs [3,4]. A recent survey of academic otolaryngology practices noted the majority of programs offer allergy services in the form of allergy testing and therapy and regularly return a profit on the provision of these services [7]. Data on the number of community otolaryngology practices offering allergy services was not available at the writing of this manuscript. Another plausible explanation for the gap in allergy care provision between otolaryngologists and allergists is a lack of public awareness of the expertise of otolaryngologists to treat allergic conditions affecting the upper airway. Unfortunately, we could not comment on the status of public awareness with our limited dataset. Further study is warranted to determine public's perceptions of the role of otolaryngologist in the medical treatment of allergy.

The majority of diagnoses associated with immunotherapy charge claims were variants of allergic rhinitis. A major symptom of allergic rhinitis is nasal obstruction through allergen-stimulated cascades that result in mucosal and soft tissue inflammation. Allergists and otolaryngologists have been shown to evaluate nasal obstruction differently, as allergists have been shown to rely on allergy testing as initial

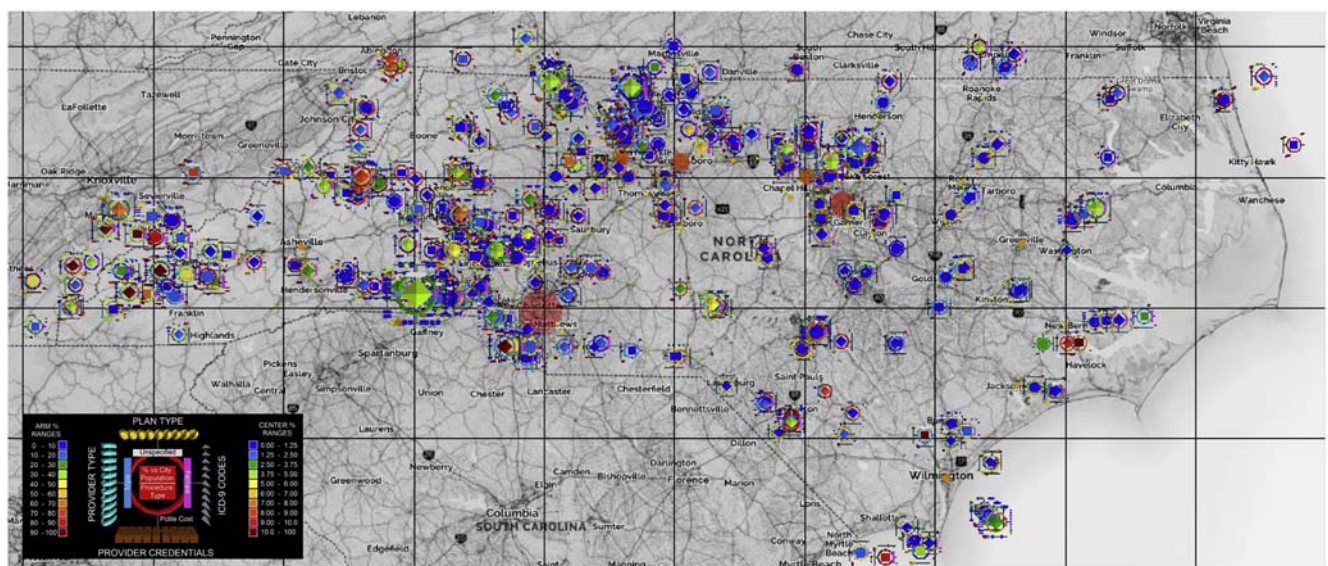


Fig. 1. Geospatial analysis integrating database variables for allergy therapy codes and charges for North Carolina, 2013. Inset legend defines the structure and variables of each data point.

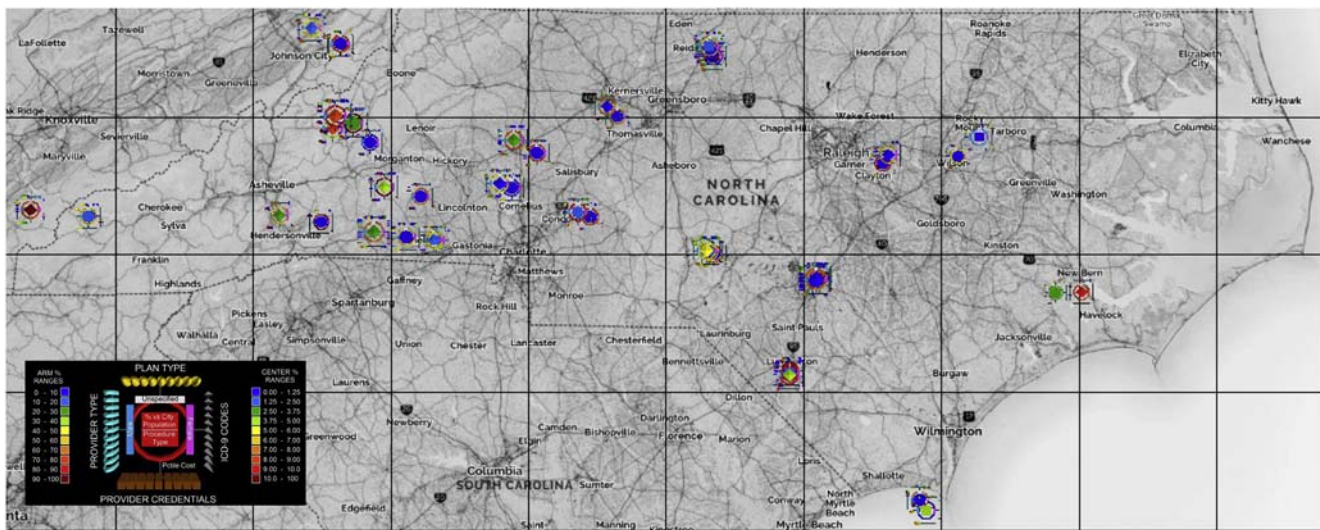


Fig. 2. Geospatial analysis outlining service zip codes that harbored otolaryngologists with greater than one-third of the allergy therapy charge entries for North Carolina, 2013. Inset legend defines the structure and variables of each data point.

work-up, whereas otolaryngologists more frequently use nasal endoscopy [5]. This specialized training may translate into different diagnostic and therapeutic approaches to allergy. In addition to a comprehensive history, otolaryngologists perform endoscopic evaluations which are crucial in elucidating specific causes for rhinological complaints. Nasal endoscopy has utility in the evaluation of other conditions that manifest with nasal obstruction that may co-present with allergies including sinusitis, polyps, or nasal septal deviation. Beyond surgical expertise, otolaryngologists also receive elaborate training in the medical management of sino-nasal disease including rhinitis in its myriad forms. Moreover, the ability to directly visualize the sino-nasal cavities provides otolaryngologists with the advantage over allergists as allergic rhinitis is only one potential diagnosis of nasal obstruction.

The burden, quality of life, and costs of allergic diseases such as allergic rhinitis have been widely studied, however variation in charges for allergy care by specialty type have not [8–13]. We found that internal medicine providers charged significantly higher than any other specialist type for immunotherapy per CPT charge claim, whereas allergy specialists and family practice providers charged the least. The charge

variation may be due to individuals' billing and coding routines, however the difference between the highest mean charge and next nearest was an increase by nearly 75%. Variation in charge could also be due to individual providers' contracts and billing agreements with local or regional insurers. The database does not indicate to which insurer each provider bills, thus we are only able to speculate on the possible influence of billing arrangements. However, given the marked difference in mean charge amounts for the same CPT codes, further exploration is warranted to determine why certain specialties or providers charge more for the provision of the same care.

Geospatial analysis is a relatively new technique for the analysis of health care delivery. Geospatial analysis permits the mapping and visualization of different variables of interest in regional, national, or international contexts. Geospatial analyses have been used to compare patient travel times to and from health care clinics and institutions for diabetes care, urban-rural health care work force distributions, as well as cross-border asthma encounters in emergency departments related to airborne pollution travel patterns [14–16]. Using geospatial analysis techniques for analyzing allergy care provision in North Carolina, we

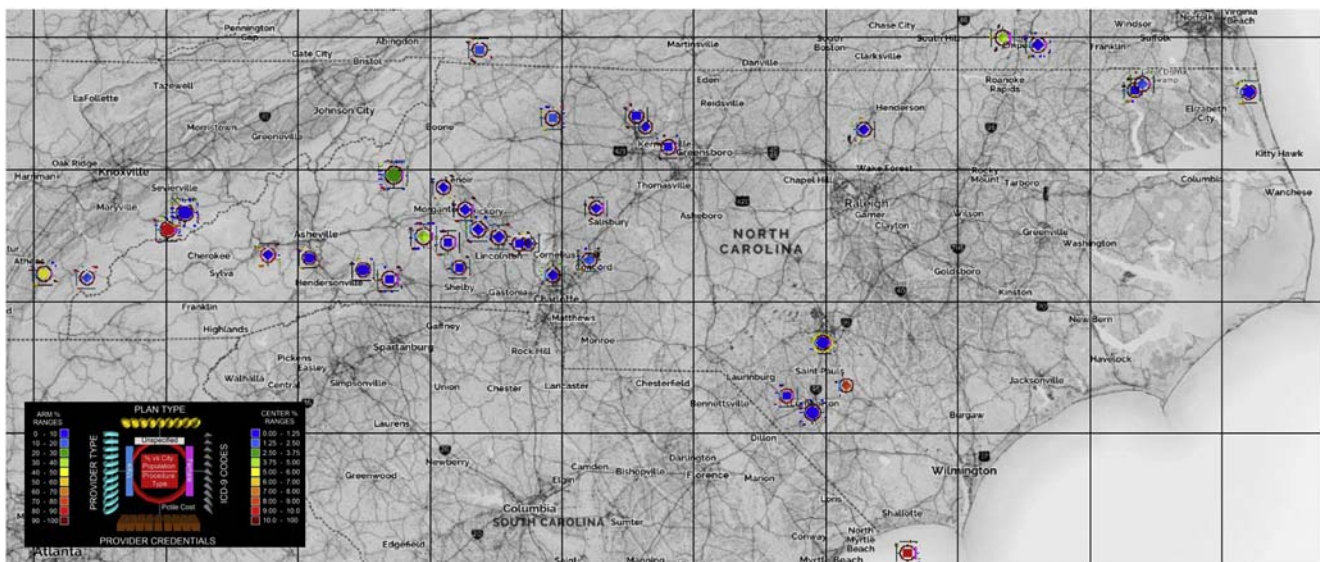


Fig. 3. Geospatial analysis outlining service zip codes that harbored charge entries in the 90th percentile for North Carolina, 2013. Inset legend defines the structure and variables of each data point.

were able to qualitatively describe practice patterns. Specifically, we visualized specific zip codes that harbored otolaryngologists who performed more than one-third of the regions allergy therapy codes. Compared to the provision of care by all specialty types, the distribution of otolaryngologists who had sizeable market-share for allergy care were limited. These practice sites appeared to be located outside of all metro centers, and along major interstates or highways. In North Carolina, the major academic medical centers (University of North Carolina-Chapel Hill, Duke University Medical Center, Wake Forest, and East Carolina University and their affiliates) are located in suburban or urban environments. Considering the distribution of high-market share otolaryngology practices in our analysis, it is possible that the density of health care providers in these urban and suburban environs wash out the otolaryngology allergy practice market shares.

We also determined the relative locations for practices that were in the 90th percentile for allergy care charges. Similar to the distribution seen in otolaryngology market share, these practices were largely outside of the major metro areas, however there appeared to be a cluster of high-charging practices north of Charlotte, and Greensboro.

There are limitations to both the FAIR Health database and our methodology. First, the FAIR Health database provides an impressive array of variables associated with charge entries for CPT codes over a variety of conditions. However, the database was not structured to link individual CPT code charge entries to other CPT codes that could comprise a single encounter. This limits our ability to form a comprehensive perspective of all care provided at a given encounter. For example, we were unable to determine if patients who received allergy care through otolaryngologists also received flexible or rigid nasal endoscopy as part of their evaluation. An incomplete perspective of patients' encounters limited our ability to explore if otolaryngologists offered additional diagnostic or therapeutic capabilities versus their competitors. Second, the database is comprised of claims submissions from third party payers, and many of the charge entries do not report all of the variables. It is possible that a systemic bias exists that selects for a certain population type (i.e. that have third-party insurance), provider specialty type (i.e. if provider types have different payer mixes) and payer type (i.e. certain payers in North Carolina surrendering providing data). The presence of one or more of these selection biases has the ability to significantly alter the observed data and relationships. Third, the allergy testing charge entries were most frequently submitted by non-physician entrants. Presumably, a laboratory completing the allergy testing would submit the claim for the test performed. We were unable to explore differences in allergy testing recommendations or referrals by specific specialty types as a result.

5. Conclusion

Claims databases are useful for surveying health care provision. Through the analysis of a state-wide charge database to characterize patient and provider variables associated with allergy care delivery, we demonstrate the utility of visualization techniques to complement traditional data analyses for analyzing patterns and trends in allergy care. Specifically, allergy specialists performed significantly more allergy-related therapy than otolaryngologists, and allergic rhinitis was the most common diagnosis treated. Otolaryngologists possess a wide skillset to diagnose and treat allergic conditions of the upper airway, however our data suggest a relative gap in care provision compared to allergists. Given the complexity of geographic health care delivery data, advanced imaging techniques used to complement traditional

forms of data analysis are helpful in identifying potentially interesting patterns. The further study of regional variation in other topics relevant to otolaryngology coupled with advanced analytic techniques may yield additional health care delivery challenges and opportunities.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amjoto.2017.10.004>.

Acknowledgements

The authors would like to thank FAIR Health Inc., for the provision of the dataset used in this study. Research for this article is based upon healthcare charge data compiled and maintained by FAIR Health, Inc. The named authors solely responsible for the research and conclusions reflected in this article. FAIR Health, Inc. is not responsible for the conduct of the research or for any of the opinions expressed in this article. The authors would also like to thank SynGlyphX for their assistance in performing the geospatial analyses.

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