Received: 24 February 2021 | Revised: 22 May 2021 | Accepted: 22 June 2021

DOI: 10.1002/lio2.617

ORIGINAL RESEARCH

Laryngoscope Investigative Otolaryngology

Trends and patterns of neurotology drug prescriptions on a nationwide insurance database

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Funding information
National Center for Advancing Translational Sciences, Grant/Award Number: TL1TR001415; National Center for Research Resources, Grant/Award Number: TL1TR001415; National Institute of General Medical Sciences of the National Institutes of Health, Grant/Award Number: T32GM008620

Abstract

Objective: To examine neurotologists' 2013 to 2016 Medicare Part-D data and evaluate commonly prescribed medications, longitudinal changes in prescribing patterns, presumed associated pathologies, and cost distribution across United States.

Methods: Comprehensive prescription data of Part-D-participating neurotologists was quiered from the 2013 to 2016 Medicare Part-D database. Outcome variables consisted of the 25 most commonly prescribed + refilled medications, cost distribution per medication, presumed associated pathologies, and standardized prescription cost across United States.

Results: Of the 594 available U.S. neurotologists, 336 (57%) were found in the Medicare Part-D database. In 2016, total prescription costs were $4 483 268 with an averaged $13 343 ± $18 698 per neurotologist. The three most frequently filled drugs were fluticasone propionate, ciprofloxacin, and triamterene-hydrochlorothiazide. From 2013 to 2016, the greatest change in prescription pattern was observed with azelastine (+188%), montelukast sodium (+104%), mupirocin (+63%), and mometasone (−91%), whereas the greatest change in relative drug cost distribution was seen in ofloxacin, (+695.7%) neomycin-polymyxin-hydrocortisone (+262.1%), and mometasone (−83%). Triamterene-hydrochlorothiazide, prednisone, montelukast, amoxicillin-clavulanate, azelastine, spironolactone, and mupirocin had statistically significant increases in average number of prescriptions per physician, whereas ofloxacin and mometasone had significant decreases. Medications presumably treating Eustachian tube dysfunction, Meniere's disease, and vestibular migraine had the greatest percent changes across years. Cost distribution of four drugs increased upwards of 100%. Geographic analysis demonstrated that Southern and Midwest regions had higher standardized prescription costs.

Khodayar Goshtasbi, Mehdi Abouzari, and Arash Abiri contributed equally to this study.

Portions of this work have been presented at the 2019 Combined Otolaryngology Spring Meetings for the Triological Society, Austin, TX.

Conclusions: This study is the first to analyze neurotologists' trends in prescribing patterns, regional prescription cost distributions, and commonly treated pathologies. This can lead to better standardization of prescribing patterns and cost in the future.

KEYWORDS
drug benefit program, drug cost, Medicare, neurotology, otolaryngology, Part D, pharmaceutical, prescription

1 | INTRODUCTION

Understanding the prevailing trends in prescribing patterns and the cost of medications over time may help to identify interventions that can improve the delivery of cost-efficient health care. Until recently, data on these variables were limited to pharmaceutical companies that purchased them from pharmacies or pharmacy benefits administrators. Recently, Center for Medicare and Medicaid services (CMS) has released large amounts of data on the Medicare prescription drug benefit program, also known as Medicare Part-D.[1] This has facilitated efforts in promoting transparency in medical payments and transactions.[2] Insights into Medicare Part-D prescription data, which concern individuals 65 or older or receiving social security disability insurance, has led to important findings in the field of otolaryngology. Previous studies have utilized Part-D data to evaluate patterns of opioid prescription,[3,4] reflux medications,[5] and the association between industry payments and brand-name prescriptions.[6] Though previous studies have examined specific classes of prescription drugs, to date, no study has analyzed a large cohort of subspecialists to evaluate the longitudinal trends in that field's overall prescribed medications and treated pathologies over the years.

Neurotologists medically treat a variety of disorders including vertigo, Meniere's disease (MD), vestibular migraine (VM), chronic otitis, hearing loss, and tinnitus among others. To date, no study has analyzed Medicare Part-D data to evaluate the prescribing patterns of neurotologists. This cannot only show prescription trends of certain medications and their corresponding cost distributions, but it can also demonstrate possible etiologies most commonly being treated. Furthermore, such nationwide data can be analyzed regionally to determine the neurotologist-prescribed Part-D cost distributions across states, many of which may suffer from large hospital referral regions without neurotologists.[7]

2 | METHODS

This study did not require Institutional Review Board approval because of the use of publicly available data and lack of direct patient involvement or identifying information. We obtained a list of U.S. registered neurotologists by using the CMS[1] and National Plan and Provider Enumeration System (NPPES) database[8] of providers and querying for the term "neurotology" in their taxonomy descriptions. Only physicians that had "otology" or "neurotology" keywords under their National Provider Number (NPI) taxonomy specialty were considered for subsequent analyses. Year-specific lists of prescription drugs prescribed by individual physicians and paid for under the Medicare Part-D program were obtained from Data.CMS.gov Part-D Prescriber Public Use Files (PUFs) for years 2013 to 2016. By using the list of neurotologist NPIs obtained from the CMS NPPES Registry, we filtered these PUFs to include only prescription data from neurotologists. Using an in-house C# application, we organized the filtered PUFs into the following neurotologist-specific variables: number of new prescriptions and refills per drug, total cost of prescriptions per drug, number of patients receiving each drug, and state of practice. Brand and generic names of equivalent drugs were combined under one prescription and reported as the generic name. The 25 most commonly prescribed and refilled drugs were obtained based on the 2013 data, and the same list of drugs were used for data extraction in the 2014 to 2016 years. For each physician, the annual total number of prescriptions with refills of a specific drug had to be more than 10 in order for it to be reported by the CMS database, and anything below 10 were reported as zero. The presumed pathologies associated with each drug were extrapolated from the standard of practice of the senior author.

Annual distribution of each drug's cost (in percentage) was calculated via dividing that prescription's cumulative cost by the total cost of all neurotologist-prescribed Part-D drugs. In creating a U.S. heat map of neurotologist-prescribed Part-D drug cost distributions across the states, we utilized the 2016 state aggregated data for neurotologists and standardized each state's total monetary value by dividing it by the state's total number of Medicare Part-D Eligible residents. In comparing each drug's total number of prescriptions between 2013 and 2016, two-tailed unpaired *t*-test analyses were used with a threshold of $P < .05$ for significance. The PASW Statistics 18.0 software (SPSS Inc., Chicago, Illinois) was used for statistical analysis.

3 | RESULTS

Of the 594 neurotologists obtained by the CMS NPPES Registry, 336 (56.6%) were identified in Medicare's Part-D Prescriber PUFs by their NPIs. A total of 114 768 Part-D prescriptions were filled in 2016, 17.1% greater than the number of prescription fulfillments in 2013, whereas the number of neurotologists only increased by 3% in this time period (328-337). The total price of prescriptions by all

neurotologists and average price by each physician in 2016 were $4 483 268 and $13 343 ± $18 698 (median $7401; range $280-$142 578), respectively. These prescriptions consisted of over 200 distinct drugs. Analysis of the top 25 Part-D prescribed and refilled drugs during 2013 to 2016 years, along with their presumed indications, are demonstrated in Table 1. Fluticasone propionate, ciprofloxacin, and triamterene-hydrochlorothiazide were found to consistently be the three most frequently filled prescriptions. The greatest relative increases in prescription fulfillment from 2013 to 2016 were by azelastine (+187.7%) and montelukast sodium (+104.0%), whereas mometasone had the greatest decrease in prescription (−90.6%) (Table 2). Evaluating changes in the average number of prescriptions by neurotologists over time revealed that triamterene-hydrochlorothiazide, prednisone, montelukast, amoxicillin clavulanate, azelastine, spironolactone, and mupirocin had statistically significant increases, whereas ofloxacin and mometasone significantly decreased in number of prescriptions (Table 2).

A compilation of the number of Part-D prescription-fulfilled drugs based on the presumed treated pathologies demonstrated that the prescribed medications most commonly addressed Eustachian tube dysfunction (ETD), allergy, otitis, and MD (Table 3). Oral steroids were also in the top five most commonly prescribed medications. Between 2013 and 2016, there was a statistically significant increase in physician-averaged prescriptions for ototopical drops. Additionally, medications potentially addressing MD and VM had noticeable overall percent increases of 43% and 31%, respectively. The 2013 to 2016 longitudinal trends in Part-D prescription-treated pathologies is depicted in Figure 1.

Comparing 2013 and 2016 drug cost distributions showed that ofloxacin (+695.7%) and neomycin-polymyxin-hydrocortisone (+262.1%), both primarily used to manage otitis, had the greatest relative increases in percent cost per total cost of all drugs (Table 4). On the other hand, the greatest relative decreases in drug cost distributions were found among mometasone (−83.1%), fluticasone

TABLE 1 Medications prescribed by Medicare's Part-D-participating neurotologists

Drug	Annual total number of prescriptions filled with refills (% of total drugs prescribed)				% Change of number from 2013 to 2016 (% change of total drugs)
	2013	2014	2015	2016	
Fluticasone propionate	13 130 (13.4)	15 353 (14.5)	15 745 (14.2)	14 976 (13.0)	14.1 (−3.0)
Ciprofloxacin and dexamethasone	7576 (7.8)	7293 (6.9)	7272 (6.6)	8260 (7.2)	9.0 (−7.7)
Triamterene and Hydrochlorothiazide	5786 (5.9)	6718 (6.3)	7222 (6.5)	7415 (6.5)	28.2 (10.2)
Omeprazole	5601 (5.7)	5597 (5.3)	5404 (4.9)	4857 (4.2)	−13.3 (−26.3)
Diazepam	4057 (4.1)	4729 (4.5)	4916 (4.4)	4549 (4.0)	12.1 (−2.4)
Hydrocodone and acetaminophen	3649 (3.7)	3553 (3.3)	3163 (2.8)	3332 (2.9)	−8.7 (−21.6)
Ofloxacin	3310 (3.4)	3801 (3.6)	4544 (4.1)	3262 (2.8)	−1.5 (−17.6)
Mometasone	2938 (3.0)	2005 (1.9)	1056 (1.0)	277 (0.2)	−90.6 (−93.3)
Prednisone	2289 (2.3)	2552 (2.4)	3045 (2.7)	3465 (3.0)	51.4 (30.4)
Montelukast sodium	2215 (2.3)	2915 (2.7)	3732 (3.4)	4519 (3.9)	104.0 (69.6)
Ipratropium bromide	2055 (2.1)	2335 (2.2)	2604 (2.3)	2863 (2.5)	39.3 (19.0)
Clonazepam	2046 (2.1)	2394 (2.3)	2394 (2.2)	2216 (1.9)	8.3 (−9.5)
Meclizine hydrochloride	1885 (1.9)	2094 (2.0)	2083 (1.9)	2062 (1.8)	9.4 (−5.3)
Fluocinolone acetonide oil	1540 (1.6)	1472 (1.4)	1295 (1.2)	1299 (1.1)	−15.6 (−31.3)
Amoxicillin and clavulanate potassium	1489 (1.5)	1711 (1.6)	1743 (1.6)	2051 (1.8)	37.7 (20.0)
Hydrochlorothiazide	1484 (1.5)	1666 (1.6)	2049 (1.8)	1999 (1.7)	34.7 (13.3)
Methylprednisolone	1400 (1.4)	1446 (1.4)	1684 (1.5)	1854 (1.6)	32.4 (14.3)
Azelastine	1392 (1.4)	2112 (2.0)	2677 (2.4)	4005 (3.5)	187.7 (150.0)
Cephalexin	1256 (1.3)	1290 (1.2)	1466 (1.3)	1375 (1.2)	9.5 (−7.7)
Spironolactone	1213 (1.2)	1288 (1.2)	1484 (1.3)	1715 (1.5)	41.4 (25.0)
Neomycin and polymyxin and hydrocortisone otic	1115 (1.1)	1081 (1.0)	1288 (1.2)	1680 (1.5)	50.7 (36.4)
Acyclovir	1077 (1.1)	1123 (1.1)	954 (0.9)	1012 (0.9)	−6.0 (−18.2)
Mupirocin	1055 (1.1)	1395 (1.3)	1540 (1.4)	1723 (1.5)	63.3 (36.4)
Nortriptyline	983 (1.0)	1156 (1.1)	1275 (1.1)	1407 (1.2)	43.1 (20.0)

Note: Percentages in a column do not add up to 100% because this table contains only the top 25 medications.
Abbreviations: ETD, Eustachian tube dysfunction; FN, facial nerve paralysis; LPR, laryngopharyngeal reflux; MD, Meniere's disease; SHL, sudden hearing loss. STI, soft tissue infection; VM, vestibular migraine.

TABLE 2 Longitudinal trends in prescribed drugs by Part-D-participating neurotologists

Drug	Presumed pathology	Means and SD per physicians with at least 10 prescriptions[a] (2013 vs 2016)	*P*-value
Fluticasone propionate	ETD/Allergy	56.6 ± 75.3 vs 64.2 ± 85.4	.319
Ciprofloxacin and dexamethasone	Otitis	38.1 ± 43.3 vs 44.5 ± 49.1	.139
Triamterene and Hydrochlorothiazide	MD	33.1 ± 38.0 vs 42.4 ± 47.5	**.047**
Omeprazole	LPR	61.1 ± 91.6 vs 51.2 ± 70.3	.420
Diazepam	Vertigo/Tinnitus	33.8 ± 66.5 vs 39.9 ± 87.1	.552
Hydrocodone and acetaminophen	Pain	23.0 ± 19.0 vs 20.3 ± 18.5	.220
Ofloxacin	Otitis	18.6 ± 18.9 vs 22.8 ± 19.6	**.027**
Mometasone	ETD/Allergy	33.6 ± 38.5 vs 3.2 ± 8.0	**<.001**
Prednisone	Multiple[a]	17.2 ± 25.1 vs 26.4 ± 39.6	**.027**
Montelukast sodium	ETD/Allergy	28.3 ± 47.4 vs 58.7 ± 86.1	**.007**
Ipratropium bromide	ETD/Allergy	29.6 ± 44.6 vs 41.1 ± 50.2	.157
Clonazepam	Vertigo/Tinnitus	52.1 ± 122.4 vs 56.0 ± 104.4	.879
Meclizine hydrochloride	Vertigo	23.4 ± 33.2 vs 25.8 ± 25.1	.613
Fluocinolone acetonide oil	Itching of ear	20.8 ± 21.7 vs 17.0 ± 20.0	.269
Amoxicillin and clavulanate potassium	Otitis/sinusitis/STI	14.4 ± 15.4 vs 20.2 ± 15.3	**.009**
Hydrochlorothiazide	MD	31.9 ± 47.0 vs 42.3 ± 66.1	.386
Methylprednisolone	Multiple[a]	15.8 ± 19.8 vs 21.35 ± 23.6	.103
Azelastine	ETD	16.8 ± 27.4 vs 47.7 ± 61.9	**<.001**
Cephalexin	STI	17.4 ± 12.2 vs 18.5 ± 15.6	.645
Spironolactone	MD	18.5 ± 20.7 vs 54.6 ± 112.5	**.022**
Neomycin and polymyxin and hydrocortisone otic	Otitis	18.5 ± 20.7 vs 29.4 ± 24.3	**.012**
Acyclovir	FNP	99.3 ± 181.5 vs 89.1 ± 145.3	.886
Mupirocin	STI	16.3 ± 20.2 vs 26.9 ± 27.8	**.014**
Nortriptyline	VM	28.1 ± 30.4 vs 38.4 ± 45.3	.276

Note: Physicians with <10 prescriptions and refills for the respective medications were not included for this analysis. Percentages in a column do not add up to 100% because this table contains only the top 25 medications.
[a]Multiple: oral steroids could be used for treating a variety of conditions such as SHL, vertigo, FNP, ETD, and so forth.
Bold values represent statistical significance ($p < 0.05$).

TABLE 3 Longitudinal trends in presumed pathologies prescribed by Medicare Part-D-participating neurotologists

Pathology	Annual total number of medications filled with refills				% Change from 2013 to 2016	Means and SD per physician[a] (2013 vs 16)	*P*-value
	2013	2014	2015	2016			
ETD	21 730	24 720	25 814	26 640	22.6	70.9 ± 120.0 vs 86.8 ± 153.4	.157
Allergy	20 338	22 608	23 137	22 635	11.3	66.3 ± 110.0 vs 73.7 ± 128.2	.447
Otitis	13 490	13 886	14 847	15 253	13.1	50.0 ± 58.1 vs 61.6 ± 68.8	**.025**
MD	8483	9672	10 755	11 129	31.2	27.6 ± 63.2 vs 34.2 ± 78.4	.253
Vertigo	7988	9217	9393	8827	10.5	25.4 ± 78.4 vs 28.8 ± 82.5	.601
LPR	5601	5597	5404	4857	−13.3	18.2 ± 57.1 vs 15.3 ± 44.9	.483
Pain	3649	3553	3163	3332	−8.7	11.7 ± 17.8 vs 10.4 ± 16.7	.363
FNP	1077	1123	954	1012	−6.0	3.6 ± 38.0 vs 3.2 ± 31.3	.896
VM	983	1156	1275	1407	43.1	3.2 ± 13.4 vs 4.3 ± 19.3	.392

Abbreviations: ETD, Eustachian tube dysfunction; FNP, facial nerve paralysis; LPR, laryngopharyngeal reflux; MD: Meniere's disease; VM, vestibular migraine.
[a]All physicians included even those who prescribed <10 (recorded as 0) of the respective medications.

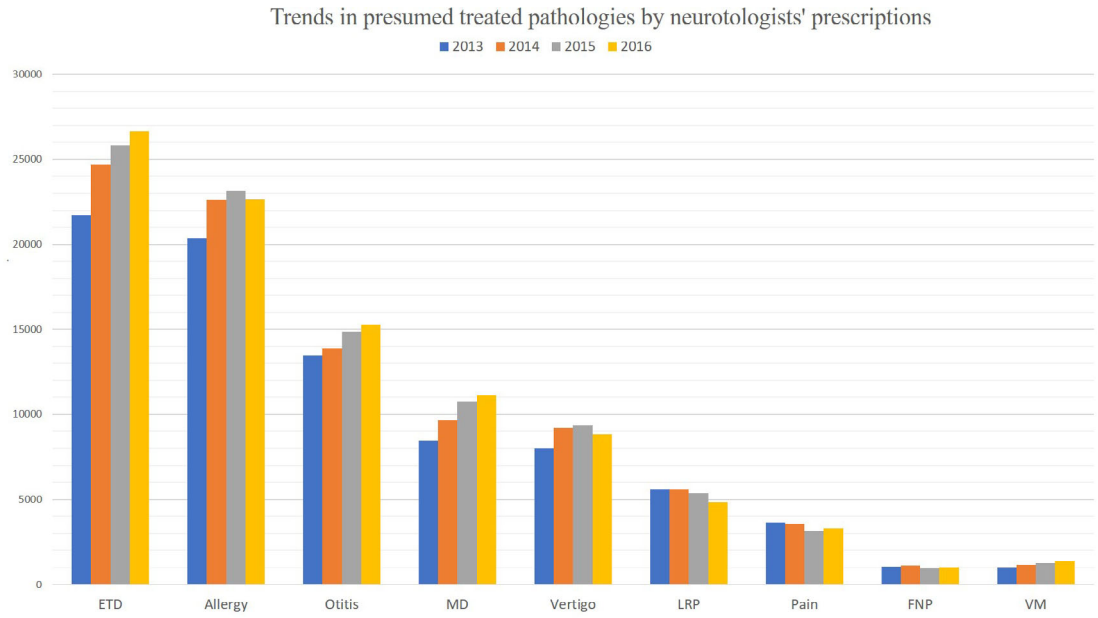

FIGURE 1 Graph of trends in treated pathologies by neurotologist-prescribed for Part-D patients. Numeric values are calculated via adding all drugs for pathology as shown in Table 1

TABLE 4 Trends in cost distribution of drugs prescribed by Part-D-participating neurotologists

Drug	Distribution of drug costs (%) over time				% Change 2013 to 2016	Presumed Pathology
	2013	2014	2015	2016		
Fluticasone propionate	8.26	6.07	4.27	4.08	−50.6	ETD/Allergy
Ciprofloxacin and dexamethasone	21.32	20.90	23.10	24.73	16.0	Otitis
Triamterene and Hydrochlorothiazide	1.68	1.80	1.87	2.04	21.4	MD
Omeprazole	3.05	2.06	1.67	1.59	−47.9	LPR
Diazepam	0.47	0.55	0.58	0.56	19.1	Vertigo
Hydrocodone and acetaminophen	0.75	0.97	0.81	0.90	20.0	Pain
Ofloxacin	0.37	0.31	0.35	2.92	689.2	Otitis
Mometasone	11.10	8.85	5.99	1.88	−83.1	ETD/Allergy
Prednisone	0.25	0.39	0.47	0.50	100.0	Multiple[a]
Montelukast sodium	2.12	1.80	1.32	1.63	−23.1	ETD/Allergy
Ipratropium bromide	1.14	1.49	1.60	1.71	50.0	ETD/Allergy
Clonazepam	0.47	0.47	0.48	0.55	17.0	Vertigo/Tinnitus
Meclizine hydrochloride	0.94	0.92	0.87	0.79	−16.0	Vertigo
Fluocinolone acetonide oil	2.18	5.55	4.87	4.39	101.4	Itching of Ear
Amoxicillin and clavulanate potassium	0.84	0.70	0.59	0.69	−17.9	Otitis/Sinusitis/ STI
Hydrochlorothiazide	0.23	0.23	0.27	0.27	17.4	MD
Methylprednisolone	0.73	0.65	0.70	0.65	−11.0	Multiple[a]
Azelastine	2.40	3.08	3.69	4.45	85.4	ETD
Cephalexin	0.19	0.17	0.17	0.18	−5.3	STI
Spironolactone	0.38	0.32	0.30	0.36	−5.3	MD
Neomycin and polymyxin and hydrocortisone otic	0.58	0.58	0.82	1.77	262.1	Otitis
Acyclovir	0.97	1.03	0.92	0.90	−7.2	FNP
Mupirocin	0.35	0.39	0.43	0.35	0	STI
Nortriptyline	0.26	0.29	0.32	0.41	57.7	VM

Abbreviations: ETD, Eustachian tube dysfunction; FN, facial nerve paralysis; LPR, laryngopharyngeal reflux; MD, Meniere's disease; SHL, sudden hearing loss. STI, soft tissue infection; VM, vestibular migraine.

[a]Multiple: oral steroids could be used for treating a variety of conditions such as SHL, vertigo, FNP, ETD, and so forth.

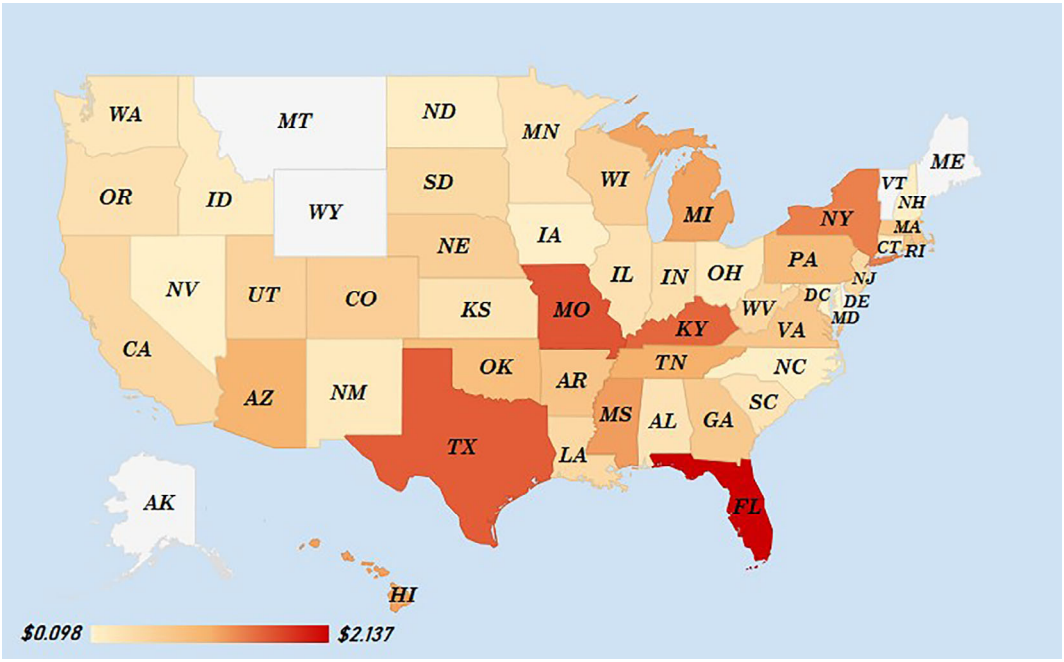

FIGURE 2 U.S. heat map of 2016 Part-D neurotologist-prescribed cost distributions. The cost was standardized by dividing the state's total cost by the number of Part-D eligible residents in that state. Of the states with neurotologists data, this cost ranged between $0.10 and $2.14 per eligible resident

propionate (−50.6%), and omeprazole (−47.9%), which are primarily used to treat allergic rhinitis or ETD, and laryngopharyngeal reflux, respectively. Figure 2 demonstrates a U.S. heat map of neurotologist-prescribed Part-D cost distributions, where Florida ($2.14), Missouri ($1.65), Texas ($1.60), Kentucky ($1.55), and New York ($1.39) had the highest adjusted costs per Part-D eligible resident.

4 | DISCUSSION

This is the first study to utilize the CMS Part-D database to analyze the longitudinal patterns and trends in drug prescriptions, cost distributions, and medical conditions treated by an otolaryngology subspecialty. Our results demonstrate that although fluticasone, ciprofloxacin, triamterene-hydrochlorothiazide, and omeprazole have been consistently the most commonly prescribed medications overall, there exists a significant increase in oral steroids as well as medications presumably addressing otitis between 2013 and 2016. Also, medications potentially utilized for VM, MD, and ETD had nonsignificant physician-averaged, yet noticeable overall increases. We further demonstrated a statistically significant increase in prescribing patterns of medications such as triamterene-hydrochlorothiazide, prednisone, montelukast, amoxicillin clavulanate, and azelastine, whereas prescribing patterns for ofloxacin and mometasone had significantly decreased over the years. It was observed that the cost distribution of many drugs, such as ofloxacin, neomycin, fluocinolone acetonide, mometasone, and fluticasone, had changed noticeably over time. This bird's eye view of the prescription practice and temporal changes among U.S. neurotologists can help otolaryngologists who prescribe ear- and balance-related medications to compare their current prescribing records with these nationwide results. This has potential to identify opportunities to reduce unnecessary medical cost, or consider whether they may be under- or over-treating certain disease processes compared to a cross-sectional nationwide overview.

According to 2016 CMS reports, 39.5 million people consisting of 58% female and 17% under-65 disabled individuals were enrolled in the Medicare Part-D program.[9] This approximate 15% increase in number of part-D beneficiaries since 2013 is in-line with our demonstrated 17% increase in overall prescriptions, though many specific drugs' percent change in number and price are vastly different. According to ProPublica's reports of recent Part-D data, 1.4 million providers accounted for the $137.4 billion total cost for all prescriptions.[10] The evaluated 337 neurotologists with a relatively modest upper range of $142 000 and a mean prescription price of $13 300, constituted around 0.02% of overall providers in the database (physicians, nurse practitioners, and physician assistants) while accounting for 0.003% of total drug costs. This is in-line with the logical assumption that neurotologists do not prescribe many medications compared to most other medical specialties, and what they do prescribe is relatively inexpensive. There were however a few anomalies in our price analyses that encourage future discussions and speculations, such as ofloxacin's price increase by almost seven times or Ciprofloxacin and dexamethasone's substantial proportion of the overall annual medications (more than 20% consistently). Previous research on the ratio and regional variation of U.S. neurotologists has suggested a scarcity of

neurotologists in certain hospital referral regions.[7] Though the presented results are not meant to reverse-engineer disease epidemiologies, practical information regarding prescription patterns, drug costs, and potential trending prevalence of medical pathologies can be deduced. Such approach can play a role in better resource and expert allocation by evaluating potentially over- or under-utilized medications, underserved regions, and the prevailing pathologies most commonly presented to neurotologists by Medicare patients.

In this study, the most common medically treated diseases by neurotologists, presumed by the classes of prescribed medications, were described and potential longitudinal trends were explored. Prior research has suggested that some of the most commonly treated neurotological diseases, such as otitis and MD, are less frequently being researched.[11-13] Unfortunately, epidemiological data regarding many of the mentioned conditions such as ETD, VM, MD, and vertigo have been limited.[14-18] We made significant assumptions regarding the presumed pathologies treated by various medications. These assumptions were made based on the most common conditions for which the medications would be prescribed. However, some medications are used for other purposes. For instance, some clinicians use acyclovir for SHL or MD despite lack of evidence, whereas we assumed most neurotologists use acyclovir for acute facial paralysis. Therefore, caution is required when looking at trends for medications that could be used for multiple conditions. Other medications such as eardrops are categorized with more certainty since they are most likely used to treat chronic ottis media or otitis externa.

After per capita standardization, our data demonstrated distinct geographic differences among prescription costs across U.S. regions. Namely, we observed a higher standardized cost allocated in the Southern (Florida, Texas, Kentucky) and Midwest (Michigan and Missouri) states. A similar trend has been reported by other CMS studies in otolaryngology or other medical specialties. Svider et al reported that otolaryngologists in the Midwest had the greatest opioid prescription, vs Northeast's otolaryngologists with the fewest opioid prescriptions.[4] An increase in opioid prescribing amongst sinus surgeons practicing in the South has also been observed.[3] These regional differences have also been reported in other classes of drugs, as greater quantities of oral antibiotics and proton pump inhibitors have been prescribed to residents in the Midwest or Southern U.S. states.[19-21] These data signal that the volume and cost per capita of some medications, including those prescribed by neurotologists, may be more concentrated in Central and Southern U.S. regions, warranting further investigation into the possible rationale.

Though we took great care in appropriate extraction and analysis of data, this study contains a number of important limitations. First, the data pertains to a specific population (Medicare Part-D beneficiaries) and generalizing the results for the overall population is thus cautioned. Second, the prescription-associated pathologies were based on the senior author's standard of care practice, some of which may be different from other neurotologists' preferences. In that case, the detailed quantitative data are provided for readers to make other subjective deductions. Third, this research did not provide physician characteristics such as academic position or number of years in practice, which may influence prescribing trends.[3] Furthermore, there has been evidence that physician prescribing patterns may be influenced by government regulations,[22] brand-names,[23] and industry incentives,[24,25] which was beyond the scope of this study. Fourth, some neurotologists employ mid-level providers or work with residents who write prescriptions under their own name and NPI number, which may not be reflected in the Medicare database as a prescription given by a neurotologist. Furthermore, we were limited by the years that Part-D data have become public, thus future longitudinal studies with more available years of data are warranted. Lastly, it is unclear whether all the included physicians were fellowship-trained neurotologists who exclusively treated otology & neurotology disorders, or whether it also included physicians that treated otology and neurotology disorders as part of a more comprehensive practice. Despite these limitations, we believe this study still provides valuable information for the field to consider in terms of nationwide prescription trends, practice patterns, and regional distributions over a four-year period.

5 | CONCLUSION

In this examination of U.S. neurotologists' 2013 to 2016 Medicare Part-D prescription data, we demonstrated an increase in prescribing triamterene-hydrochlorothiazide, prednisone, montelukast, amoxicillin clavulanate, and azelastine, and a decrease in oflaxacin and mometasone. Physicians had a statistically significant increase in averaged prescriptions of oral steroids and medications presumably treating otitis, where those presumably treating VM, MD, and ETD had noticeable overall percent increases as well without reaching statistical significance. The greatest increase in relative price was observed with ofloxacin and neomycin-polymyxin-hydrocortisone, whereas the greatest relative price decreases were seen in mometasone and fluticasone propionate. With an overall prescription cost of $4.5 million among Part-D beneficiaries in 2016, a higher standardized cost allocation was observed in Southern and Midwest regions.

ACKNOWLEDGMENTS

Mehdi Abouzari is supported by the National Center for Research Resources and the National Center for Advancing Translational Sciences, National Institutes of Health, through Grant TL1TR001415. Arash Abiri is supported by the National Institute of General Medical Sciences of the National Institutes of Health under award number T32GM008620. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

CONFLICT OF INTEREST

Hamid R. Djalilian holds equity in MindSet Technologies and Cactus Medical LLC, and is on the advisory board of Novus Therapeutics.

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How to cite this article: Goshtasbi K, Abouzari M, Abiri A, et al. Trends and patterns of neurotology drug prescriptions on a nationwide insurance database. *Laryngoscope Investigative Otolaryngology*. 2021;6(5):1096-1103. https://doi.org/10.1002/lio2.617