Original Study

# The Demographics of Menière's Disease: Selection Bias or Differential Susceptibility?

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**Objective:** To clarify whether the reported lack of racial and ethnic diversity among Menière's disease (MD) patients is representative of selection bias or disease susceptibility.
**Study Design:** Retrospective medical record review and population-level analyses.
**Setting:** Tertiary referral center.
**Patients:** Cohort of 1091 patients diagnosed with MD by the tertiary otology service.
**Main Outcome Measure:** Demographic and population-level characteristics (age, sex, race, insurance status, ZIP code, median income, education level) compared with local, regional, health system, and otolaryngology clinic demographics.
**Results:** Patients seen for MD were significantly older than those seen throughout the otolaryngology clinic (median, 65.0 versus 58.8 yr) or health system (65.0 versus 50.8 yr). A majority of patients with MD were of White race (92%), compared with 2.7% Black race and 0.5% Asian. Using population-level data, median income and having medical insurance were significantly correlated with care for MD. A disproportionate rate of care for MD was seen in ZIP codes outside urban areas as compared with other otologic and otolaryngologic conditions seen in the same clinic.
**Conclusion:** Patients with MD are of older age, more likely to be of White race, and disproportionately from rural locales. The demographic profile of patients diagnosed with MD by tertiary otology is better explained by differential susceptibility to MD than by selection bias.
**Key Words:** Healthcare disparities—Social determinants of health—Socioeconomic factors.

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## INTRODUCTION

Menière's disease (MD) causes hearing loss, dizziness, and tinnitus, and can impact overall function, mental health, and quality of life (1–3). Estimates in the United States suggest a prevalence of about 0.2% and incidence of more than 45,000 new cases per year (4,5). MD is reported as being more prevalent in women, those of White race, those of higher socioeconomic status, and those from rural locales (6,7).

It is important to understand the demographics of those affected by MD, as the impacts of MD may be disproportionately distributed across the population. These include reductions in work productivity, lost earnings, and need for disability benefits (8). Those of lower socioeconomic status may be impacted more strongly by MD because of proportionally higher shift workers and manual laborers, occupations less flexible to accommodating chronic vestibular disorders (9,10). With an increased prevalence of MD with age (4), risk for falls and secondary injury or death would also disproportionately impact the geriatric population. Other groups with an unequal MD burden may be female population and those residing in rural areas (7). Targeted prevention and patient education regarding MD requires that we understand whether patients seen for MD are representative of the susceptible population or whether they represent a select population with better access to specialty care.

Susceptibility to disease, treatment, and access to medical care are impacted by social determinants of health. Social determinants of health commonly reflect five domains within a community: economics, education, healthcare, environment,

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and social support. Diagnosis and treatment may be impacted, for example, by the economics of getting to a specialist or affording recommended medications. Similarly, susceptibility to disease may be impacted by environmental stressors or access to appropriate foods. Thus, observed demographic differences in prevalence may reflect the impact of some domains of social determinants of health. Race is not in itself a social determinant; however, in much of the United States, structural racism has led race to largely co-segregate with poorer measures of these domains (11,12). The challenge is to determine whether observed demographic differences in MD, particularly race, reflect disease susceptibility and inequalities due to social determinants, or are the product of selection bias within medical systems.

MD has been reported as having higher prevalence in those identified as White race (13) than those of Black race (7,14,15), but some studies are contradictory. For example, there is reported equivalent disease frequency among White and Black American racial populations (16) but variability in rates in sub-Saharan African populations (17–19). Furthermore, other studies suggest that characteristic MD patients are of White race, female, of higher economic status, and from more rural locales (7). As such, this study compares demographic and socioeconomic variables among those seen for MD with those seen for other disorders as well as those who live in the served population to identify whether an MD phenotype is reflective of selection bias or differential disease susceptibility.

## METHODS

Our department initiated a clinical data analysis platform in 2020 called OTO Clinomics to promote assessment of outcomes and the populations we serve. This platform uses the resources of the Clinical Research Data Warehouse, a component of the Clinical and Translational Science Institute of Southeast Wisconsin (UL1TR001436). Through the Clinical Research Data Warehouse, we can interrogate a monthly updated mirror of the entire electronic health record system stored in a Jupyterhub. Our center consists of three distinct clinical organizations and other associated academic institutions. As such, many projects obtain institutional review board approval in one locale, with the other organizations agreeing to rely on that organization's review. OTO Clinomics has been approved by our Children's Hospital Institutional Review Board (No. 1538127) with reliance agreements by the academic center, adult hospital, and regional state university.

### Patient Demographics and Study Design

Clinical and demographic data were extracted from the Jupyterhub for all patients older than 18 years diagnosed with MD (International Classification of Diseases—9th and 10th Revision codes: H81.01, H81.02, H81.03, H81.09, 386.0, 386.00, 386.01, 386.02, 386.03, 386.04) in our health system from 2009 to 2019. We distinguished those diagnosed with MD by one of four neurotologists who formed the tertiary otology service from those diagnosed by providers within the comprehensive otolaryngology service or community providers within our health system. Among the data extracted were diagnosis, age, race, ZIP code of residence, and insurance status. For further demographic comparisons, we extracted similar data for all patients in our adult health system and all of those treated within our clinic for any otolaryngologic condition over the same period of time.

Population-level data for each ZIP code were acquired from the 2014 US Census Bureau 5-year American Community Survey (i.e., the years 2010–2014, inclusive) and included median income, medical insurance rates, and education rates. This census period is roughly midway along the time interval we used for patient encounters and thus is a good representation of the mean population demographic between 2009 and 2019. To control for selection bias, we analyzed three increasingly diverse geographic regions from which our patients arise: the entire state, the eight counties designated as comprising southeast Wisconsin, and Milwaukee County, the most diverse county in the State and the site of our medical center. Utilization rate is the term we define as the number of unique patients diagnosed with MD by the tertiary otology service within a ZIP code divided by the Census Bureau–reported population of that ZIP code. This is akin to prevalence, but we make the distinction that we are not capturing all patients in a ZIP code with MD, just those that *use* our services.

### Statistical Analyses

Patient demographics and population-level data were compared using $\chi^2$ test among those diagnosed with MD by tertiary otology, those diagnosed by comprehensive otolaryngology, those seen for any condition within the otolaryngology clinics, those seen by any service within our health system, and the regional population. Independent continuous variables such as age were compared between groups using unpaired two-tailed *t* test. Univariate analyses were performed using the Kruskal-Wallis test. Correlation between unique patient visits for MD per ZIP code (e.g., utilization rate) and census sociodemographic data was performed using a multivariate linear regression model. The utilization rate per ZIP code was the dependent variable. Zip code–based college education rate, White race proportion, median income, and insured rate were used as independent variables. A $p$ value of less than 0.05 indicates that an independent variable has a significant effect on the proportion of the population from that ZIP code being seen for MD. All statistical tests were performed using R language (3.6.1).

## RESULTS

There were 1,091 adult patients diagnosed with MD by tertiary care neurotologists in our clinics between 2009 and 2019. This population had an average age of 65.0 years, and were 55.8% female, 92.0% White race, 2.7% Black race, 0.5% Asian, and 96.1% non-Hispanic (Table 1). The majority had private insurance (57.1%), and 40.8% had public insurance. This demographic profile was significantly different from that of patients seen in the entirety of our health system or living in the principal catchment area of southeast WI (Table 1). These 1,091 patients came from across the entire eastern portion of Wisconsin, a region that is largely of White race and may impart selection bias. We therefore assessed the demographics of MD patients diagnosed by tertiary otology from increasingly diverse regions surrounding our medical center (Table 2). MD patients from southeast WI (n = 840), an area that is 77.9% White race and 90.8% non-Hispanic, remained predominantly of White race (92.9%) and of similar age, sex, and insurance status as the full MD population. Selecting only MD patients from Milwaukee County (n = 286), the



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**TABLE 1.** *Comparison of patient characteristics among those seeing neurotology for Menière's disease, all those cared for in the ENT clinics and health system, and the population of all patients in southeast Wisconsin*

| | Menière's Disease (n = 1,091) | | ENT Clinic | | Compare With Menière's Disease | | Health System (n = 1,365,021) | | Compare With Menière's Disease | | SE Wisconsin (n = 2,083,474) | | Compare With Menière's Disease | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | No. | % | No. | Effect Size | *p* | % | No. | Effect Size | *p* | % | No. | Effect Size | *p* |
| Age, median (yr) | 65.0 | | 58.8 | | | <0.001 | 50.8 | | | <0.001 | 47.1 | | | <0.001 |
| Women, % (no.) | 55.8 | 609 | 52.9 | 50,597 | 1.12 | 0.059 | 50.2 | 685,240 | 1.25 | <0.001 | 50.7 | 1,056,113 | 1.23 | <0.001 |
| Race, % (no.) | | | | | | | | | | | | | | |
| White | 92.0 | 1,004 | 80.9 | 77,330 | 2.72 | <0.001 | 72.0 | 982,471 | 4.49 | <0.001 | 77.9 | 1,622,691 | 3.28 | <0.001 |
| Black | 2.7 | 29 | 12.0 | 11,478 | 0.20 | <0.001 | 15.6 | 213,399 | 0.15 | <0.001 | 13.8 | 288,362 | 0.17 | <0.001 |
| Asian | 0.5 | 5 | 1.7 | 1,603 | 0.27 | 0.002 | 2.2 | 29,474 | 0.21 | <0.001 | 2.4 | 49,721 | 0.19 | <0.001 |
| Other | 1.6 | 17 | 3.2 | 3,021 | 0.48 | 0.003 | 6 | 82,403 | 0.25 | <0.001 | 4.3 | 89,264 | 0.35 | <0.001 |
| Unknown | 3.3 | 36 | 2.2 | 2,127 | 1.50 | 0.017 | 0.7 | 9,751 | 4.74 | <0.001 | 1.6 | 33,436 | 2.09 | <0.001 |
| Insurance, % (no.) | | | | | | | | | | | | | | |
| Private | 57.1 | 623 | 52.0 | 49,647 | 1.23 | <0.001 | 49.8 | 680,346 | 1.34 | <0.001 | 56.1 | 1,169,000 | 1.04 | 0.508 |
| Public | 40.8 | 445 | 44.9 | 42,872 | 0.85 | 0.007 | 36.5 | 497,872 | 1.20 | 0.003 | 30.9 | 643,000 | 1.54 | <0.001 |
| Other | 0.5 | 5 | 0.8 | 792 | 0.55 | 0.178 | 1.2 | 16,357 | 0.38 | 0.025 | 3.6 | 74,000 | 0.13 | <0.001 |
| Self-pay | 0.3 | 3 | 1.3 | 1,201 | 0.22 | 0.004 | 3.8 | 52,065 | 0.07 | <0.001 | 7.5 | 157,000 | 0.03 | <0.001 |
| No record | 1.4 | 15 | 1.1 | 1,038 | 1.27 | 0.361 | 8.7 | 118,381 | 0.15 | <0.001 | | | | |
| Ethnicity | | | | | | | | | | | | | | |
| Hispanic | 1.1 | 12 | 3.5 | 3,310 | 0.31 | <0.001 | 4.6 | 63,232 | 0.23 | <0.001 | 9.2 | 191,095 | 0.11 | <0.001 |
| Non-Hispanic | 96.1 | 1,048 | 95 | 90,798 | 1.28 | 0.116 | 86.7 | 1,183,193 | 3.75 | <0.001 | 90.8 | 1,892,379 | 2.46 | <0.001 |
| Unknown | 2.8 | 31 | 1.5 | 1,451 | 1.9 | <0.001 | 8.7 | 118,596 | 0.31 | <0.001 | 0 | 0 | NA | NA |

most diverse county in the state at 63.2% White race, 27.6% Black race, and 16.4% Hispanic, continued to demonstrate an MD population that was predominantly of White race (87.4%), or seldomly of Black race (8.7%) or Hispanic ethnicity (2.5%), while of similar age, sex, and insurance status as the broader cohorts.

To further identify whether the demographics of those diagnosed with MD by tertiary otology is a product of selection bias (e.g., an underlying factor resulting in only those of a specific demographic being seen by tertiary otology for MD), we also compared the MD cohort to the rest of the otology service, MD patients seen by other providers, and other subspecialties and diagnoses within the same clinic (Tables 3 and 4). Compared with all tertiary otology patients (n = 22,431), MD patients were proportionately more of White race (effect size, 2.23; $p < 0.001$), privately insured (effect size, 1.31; $p < 0.001$), and non-Hispanic (effect size, 1.52; $p < 0.001$; Table 3). Compared with other subspecialty conditions representing patients seen in the same clinic and health system (Table 4), MD patients remained proportionately more of White race (effect size, 1.91–2.93; $p < 0.001$) and lower proportion of Black race (effect size, 0.16–0.26; $p < 0.001$). All disorders had similar proportions of Hispanic patients consistent with low representation in our health system.

In this investigation, we assumed that diagnosis of MD by tertiary otology is the closest to an accurate diagnosis among all potential cohorts. For this reason, we used only this cohort for our final determination of a characteristic MD demographic. However, there were 1,277 patients given a diagnosis of MD by nontertiary otolaryngology providers (Table 3). We suspect that a larger proportion of these, than

**TABLE 2.** *Demographics of Meniere's disease across increasingly diverse geographic regions*

| | Entire State of Wisconsin(n = 1,091) | | Southeast Wisconsin(n = 840) | | Milwaukee County(n = 286) | |
|---|---|---|---|---|---|---|
| | % | No. | % | No. | % | No. |
| Age, median (yr) | 65.0 | | 65.3 | | 66.0 | |
| Women, % (no.) | 55.8 | 609 | 57.0 | 479 | 59.1 | 169 |
| Race, % (no.) | | | | | | |
| White | 92.0 | 1,004 | 92.9 | 780 | 87.4 | 250 |
| Black | 2.7 | 29 | 3.5 | 29 | 8.7 | 25 |
| Asian | 0.5 | 5 | 0.6 | 5 | 0.4 | 1 |
| Other | 1.6 | 17 | 1.4 | 12 | 1.8 | 5 |
| Unknown | 3.3 | 36 | 1.7 | 14 | 1.8 | 5 |
| Insurance, % (no.) | | | | | | |
| Private | 57.1 | 623 | 55.1 | 463 | 51.8 | 148 |
| Public | 40.8 | 445 | 43.1 | 362 | 45.8 | 131 |
| Other | 0.5 | 5 | 0.5 | 4 | 1.1 | 3 |
| Self-pay | 0.3 | 3 | 0.4 | 3 | 0.7 | 2 |
| No record | 1.4 | 15 | 1.0 | 8 | 0.7 | 2 |
| Ethnicity | | | | | | |
| Hispanic | 1.1 | 12 | 1.3 | 11 | 2.5 | 7 |
| Non-Hispanic | 96.1 | 1,048 | 97.1 | 816 | 96.2 | 275 |
| Unknown | 2.8 | 31 | 1.5 | 13 | 1.4 | 4 |



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**TABLE 3.** *Demographics of Menière's disease diagnoses by tertiary otology compared with other otologic encounters*

| | | | | A Versus B | | A Versus C | | B Versus C | |
|---|---|---|---|---|---|---|---|---|---|
| | A:Tertiary Otology,MD Diagnoses | B:ENT, Not otologyMD Diagnoses | C:Tertiary Otology, All Ear Disorders | Effect Size | *p* | Effect Size | *p* | Effect Size | *p* |
| No. of Patients | 1,091 | 1,277 | 22,431 | | | | | | |
| Age, median (yr) | 65.0 | 62.1 | 62.0 | | 0.001 | | <0.001 | | NS |
| Women, % (no.) | 55.8 (609) | 69.1 (882) | 56.0 (12,559) | 0.57 | <0.001 | 0.99 | 0.912 | 1.76 | <0.001 |
| Race, % (no.) | | | | | | | | | |
| White | 92.0 (1,004) | 89.6 (1,144) | 83.8 (18,801) | 1.34 | 0.041 | 2.23 | <0.001 | 1.66 | <0.001 |
| Black | 2.7 (29) | 5.2 (66) | 7.8 (1757) | 0.50 | 0.002 | 0.32 | <0.001 | 0.64 | <0.001 |
| Asian | 0.5 (5) | 1.2 (16) | 1.9 (419) | 0.36 | 0.04 | 0.24 | <0.001 | 0.67 | 0.11 |
| Other | 1.6 (17) | 1.7 (22) | 3.3 (748) | 0.90 | 0.754 | 0.46 | 0.001 | 0.51 | 0.00 |
| Unknown | 3.3 (36) | 2.3 (29) | 3.1 (706) | 1.47 | 0.127 | 1.05 | 0.779 | 0.72 | 0.08 |
| Insurance, % (no.) | | | | | | | | | |
| Private | 57.1 (623) | 57.2 (731) | 50.4 (11,302) | 0.99 | 0.945 | 1.31 | <0.001 | 1.32 | <0.001 |
| Public | 40.8 (445) | 40.1 (512) | 46.7 (10,473) | 1.03 | 0.731 | 0.79 | <0.001 | 0.76 | <0.001 |
| Other | 0.5 (5) | 0.5 (7) | 0.7 (162) | 0.84 | 0.759 | 0.63 | 0.311 | 0.76 | 0.47 |
| Self-pay | 0.3 (3) | 0.8 (10) | 0.8 (170) | 0.35 | 0.095 | 0.36 | 0.068 | 1.03 | 0.92 |
| No record, % (no.) | 1.4 (15) | 1.3 (17) | 1.4 (324) | 1.03 | 0.927 | 0.95 | 0.851 | 0.92 | 0.74 |
| Ethnicity | | | | | | | | | |
| Hispanic | 1.1 (12) | 1.3 (17) | 3.38 (759) | 0.82 | 0.61 | 0.32 | <0.001 | 0.39 | <0.001 |
| Non-Hispanic | 96.1 (1,048) | 96.6 (1,234) | 94.14 (21,116) | 0.85 | 0.457 | 1.52 | 0.008 | 1.79 | <0.001 |
| Unknown | 2.8 (31) | 2 (26) | 2.48 (556) | 1.41 | 0.202 | 1.15 | 0.453 | 0.82 | 0.32 |

MD indicates Menière's disease.

in the tertiary otology cohort, are misdiagnosed, particularly regarding distinguishing vestibular migraine (VM). This is evidenced by the much higher proportion of female individuals in the non-specialist cohort (69.1% versus 55.8%), as migraine has higher female prevalence. Even with this inherent error, this MD cohort showed similar racial demographics to tertiary otology, namely, the higher proportion of White race, age over 60 years, and privately insured.

We evaluated the ZIP code of origin of patients with MD as compared with other disorders and with population-level data (Fig. 1). We determined utilization rate, the proportion of patients from each ZIP code diagnosed with MD by our tertiary otology service. This is akin to prevalence in so far as the numerator (i.e., number of patients with a disease) is represented by the number of unique patients diagnosed in our clinic. Areas of higher relative utilization (darker color)

**TABLE 4.** *Comparison of patient characteristics among those seeing tertiary otology for Meniere's disease to those seen by subspecialties for specific nonotologic disorders*

| | Meniere's Disease (n = 1,091) | | Vocal Fold Paralysis (n = 1,490) | | | | Chronic Rhinosinusitis (n = 8,325) | | | | Dysphonia (n = 7,066) | | | | Aerodigestive Tract Cancer (n = 3,137) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % | No. | % | No. | Effect Size | *p* | % | No. | Effect Size | *p* | % | No. | Effect Size | *p* | % | No. | Effect Size | *p* |
| Age, median (yr) | 65.0 | | 61.0 | | | | 58.9 | | | | 62.0 | | | | 72.2 | | | |
| Women | 55.8 | 609 | 58.0 | 862 | 0.92 | 0.303 | 57.6 | 4,799 | 0.93 | 0.252 | 63.7 | 4,499 | 0.72 | <0.001 | 31.9 | 1,000 | 2.70 | <0.001 |
| Race | | | | | | | | | | | | | | | | | | |
| White | 92.0 | 1,004 | 84.9 | 1,266 | 2.04 | <0.001 | 85.0 | 7,079 | 2.03 | <0.001 | 79.7 | 5,635 | 2.93 | <0.001 | 85.8 | 2,692 | 1.91 | <0.001 |
| Black | 2.7 | 29 | 11.0 | 164 | 0.22 | <0.001 | 9.3 | 778 | 0.26 | <0.001 | 14.9 | 1,053 | 0.16 | <0.001 | 9.7 | 303 | 0.26 | <0.001 |
| Asian | 0.5 | 5 | 1.6 | 24 | 0.28 | 0.006 | 1.3 | 109 | 0.35 | 0.016 | 1.1 | 75 | 0.43 | 0.06 | 0.6 | 20 | 0.72 | 0.506 |
| Other | 1.6 | 17 | 1.5 | 23 | 1.01 | 0.976 | 2.5 | 205 | 0.63 | 0.064 | 2.6 | 185 | 0.59 | 0.036 | 1.8 | 55 | 0.89 | 0.668 |
| Unknown | 3.3 | 36 | 0.9 | 13 | 3.88 | <0.001 | 1.8 | 154 | 1.81 | 0.001 | 1.7 | 118 | 2.01 | <0.001 | 2.1 | 67 | 1.56 | 0.032 |
| Insurance | | | | | | | | | | | | | | | | | | |
| Private | 57.1 | 623 | 44.4 | 662 | 1.67 | <0.001 | 60.0 | 4,994 | 0.89 | 0.068 | 47.7 | 3,368 | 1.46 | <0.001 | 33.1 | 1,038 | 2.69 | <0.001 |
| Public | 40.8 | 445 | 54.5 | 812 | 0.58 | <0.001 | 38.1 | 3,168 | 1.12 | 0.081 | 50.2 | 3,545 | 0.68 | <0.001 | 63.7 | 1998 | 0.39 | <0.001 |
| Other | 0.5 | 5 | 0.9 | 13 | 0.52 | 0.212 | 0.9 | 75 | 0.51 | 0.134 | 0.6 | 42 | 0.77 | 0.58 | 1.5 | 46 | 0.31 | 0.009 |
| Self-pay | 0.3 | 3 | 0.1 | 2 | 2.05 | 0.422 | 0.6 | 54 | 0.42 | 0.135 | 0.5 | 34 | 0.57 | 0.345 | 1.4 | 45 | 0.19 | 0.002 |
| No record | 1.4 | 15 | 0.1 | 1 | 20.76 | <0.001 | 0.4 | 34 | 3.40 | <0.001 | 1.1 | 77 | 1.27 | 0.406 | 0.3 | 10 | 4.36 | <0.001 |
| Ethnicity | | | | | | | | | | | | | | | | | | |
| Hispanic | 1.1 | 12 | 2.3 | 35 | 0.46 | 0.019 | 2.7 | 223 | 0.40 | 0.002 | 3.0 | 211 | 0.36 | <0.001 | 1.7 | 54 | 0.63 | 0.154 |
| Non-Hispanic | 96.1 | 1,048 | 97.4 | 1,451 | 0.66 | 0.058 | 95.9 | 7,987 | 1.03 | 0.852 | 96.2 | 6,797 | 0.96 | 0.829 | 97.1 | 3,045 | 0.74 | 0.103 |
| Unknown | 2.8 | 31 | 0.3 | 4 | 10.86 | <0.001 | 1.4 | 115 | 2.09 | <0.001 | 0.8 | 58 | 3.53 | <0.001 | 5.1 | 159 | 0.55 | 0.002 |

Meniere's disease demographics were significantly different from other disorders in proportions of race and insurance.



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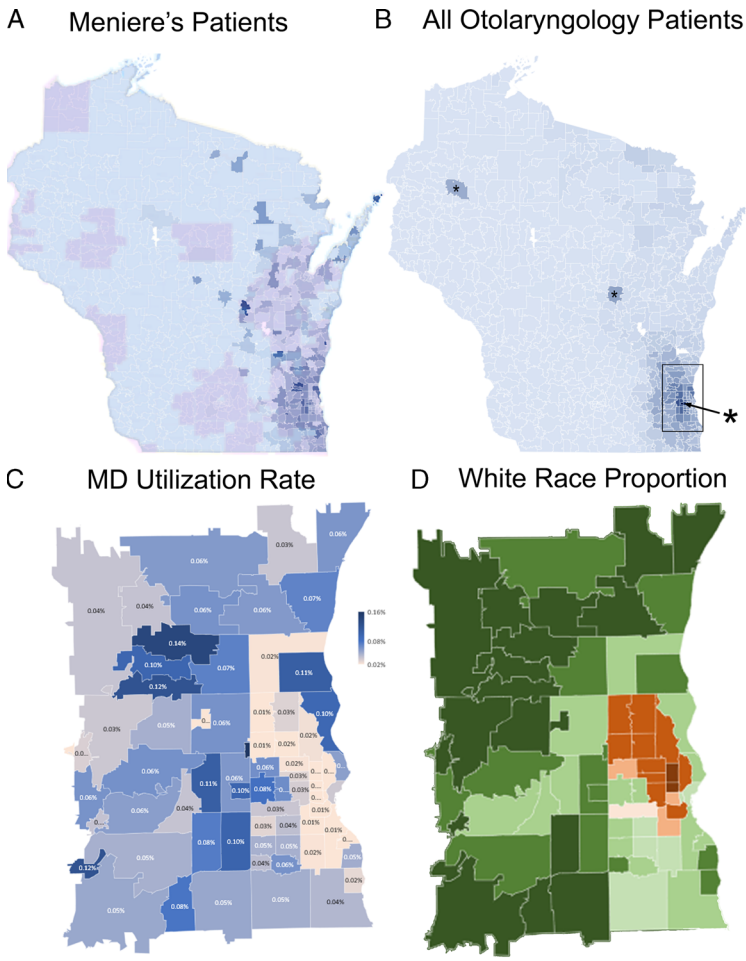


**FIG. 1.** Geographic representation of rates of care for MD per ZIP code across Wisconsin and in the Milwaukee County region. *A*, Rate of care for MD overlaid on designated urban commuting areas (pink). A large proportion of MD patients are from exurban regions; *B*, Rates of care per ZIP code for 95,559 patients seen in the entire otolaryngology clinic for all conditions. The two outlying ZIP codes (small asterisks) are regions with extremely small total populations and show artifactually high rates. The arrow with large asterisk denotes the location of the main medical center and ENT clinic. The rectangle is the area of focus for *C* and *D*. *C* represents local rates of MD care in direct comparison to racial populations in the region, which includes Milwaukee County (*D*). MD indicates Menière's disease.

for MD were widely distributed across the eastern half of the state (Fig. 1A). This wide distribution is distinct from the geographic distribution of all 95,559 patients seen in our otolaryngology clinic over a similar time period (Fig. 1B) in which most patients were from our local catchment area in southeast WI. MD care was commonly seen in ZIP codes outside, or on the fringes of, designated urban commuter areas (Fig. 1A, pink zones). Rates of care were also assessed in the more diverse local region around the medical center (Fig. 1C). Higher rates of care were noted outside central Milwaukee in areas of higher proportions of White race (Fig. 1, C and D).

Race in our region often segregates with socioeconomic measures, and multivariate linear regression was used to evaluate the relationship between presenting with MD and local socioeconomics. Proportionally more patients were seen for MD from ZIP codes with higher median incomes, higher proportions of White race, higher rates of college education, and higher rates of private insurance. When controlling for the interaction between these variables, only median income and having any form of insurance were statistically significantly correlated with the rate of being seen for MD (Table 5).

## DISCUSSION

The primary objective of this study was to clarify the reported prevalence of MD in differing sociodemographic groups. We used a cohort of patients seen by the tertiary otology service to ensure as accurate a diagnosis of MD as possible. To account for selection bias in our cohort and respective demographic profile, we compared this cohort with other patients in the same clinic, the health system, and the geographic region from which the patient population originated. We identified unique social and demographic patterns among patients diagnosed with MD that were notably disparate from these comparator populations. Because of the magnitude of demographic differences unique to the MD population, we



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**TABLE 5.** *Multivariate regression analyses of predictors of utilization for Menière's disease in southeast Wisconsin*

| Variable | Coefficient | Standard Error | Lower Bound | Upper Bound | *p* |
|---|---|---|---|---|---|
| College education rate | 0.000223 | 2.52E−04 | 0.000717012 | −0.000271612 | 0.3793 |
| White % | 6.08E−05 | 1.54E−04 | 0.000362836 | −0.000241236 | 0.694 |
| Median income in $ | 5.02E−09 | 2.26E−09 | 9.45556E−09 | 5.9244E−10 | 0.02861 |
| Insured versus uninsured % | 0.00261 | 9.20E−04 | 0.004412396 | 0.000805604 | 0.00558 |

suggest that there is an environmental and/or hereditary predisposition to MD for some populations. Our results indicate that patients with MD tend to be older and of White race, and from more affluent and nonurban locales.

The proportion of Black race patients diagnosed with MD by tertiary otology was notably smaller than the proportion of White race patients in the same cohort. Furthermore, the proportion of Black race patients seen in the department for other ENT conditions and the proportion of those seen in the entire health system were over five times the proportion diagnosed by otology with MD. The colocation of the otology practice with all other ENT subspecialties and the shared processes for scheduling and referrals make lack of access to otology for patients of Black race an unlikely explanation for relatively low representation.

We are not arguing that access plays no role in this disparity, as the entire otolaryngology clinic sees proportionally fewer Black race patients than the health system (12.0% versus 15.6%). However, the degree of disparity is far greater than that seen for other otologic and otolaryngologic conditions in our clinic. Furthermore, when we looked at the subcohort of MD patients originating from more diverse geographic areas, the proportion of White patients remained equally disproportionate. As such, we propose that the low proportion of Black race, or very high proportion of White race, seen among the MD study cohort represents a low prevalence of MD in the Black race population, or a higher susceptibility in White race populations.

Studies exploring the potential impact of genetics in familial MD suggest differential susceptibility for MD in White race populations (20–25). Many of these studies may suffer from selection bias, being performed only among Europeans. However, a genetic analysis to identify ancestry in a large cohort of MD patients also suggested higher susceptibility in those of Caucasian genealogy as opposed to those of Black race, or Hispanic or Asian genealogies (14). Temporal bone histological analyses of the cochlea and vestibular organs also suggest that racial susceptibility to MD is inversely proportional to degrees of melanin pigmentation (26,27).

Our data are consistent with previous reports that show MD has increasing prevalence with age (4,8,28,29). The median age of MD patients was significantly higher than the age of patients seen in the otolaryngology clinic overall, than those seen in the respective healthcare system, and than the adult population of the surrounding counties. As only 10% of patients older than 65 years reportedly experience initial onset of MD (30), the high prevalence correlating with age raises concern for continued disease burden through adulthood, or reactivation of remittent disease in the geriatric population (31).

Previous studies denote a higher prevalence of MD diagnosis in female than male patients, although some note equal prevalence between male and female patients (4,29,32–34). In our study, women made up a higher proportion of MD patients than those living in the surrounding area or cared for in the local health system overall. However, compared with other subspecialty disorders seen in our clinic, the female proportion was not particularly disparate. Tyrrell and colleagues (6) analyzed 1,376 MD patients and over 500,000 control subjects, showing higher proportions of female patients with MD, with an odds ratio of 1.4, comparable to a calculated odds ratio in our study of 1.25. Studies have suggested that estrogen receptors present in the inner ear may affect sensory processing in the auditory system, and that lack of estrogen may be associated with hearing disorders (35).

A confounder in determining sex-related prevalence in MD is the substantial overlap in clinical presentation between MD and VM, and the preponderance for VM among the female population (36). A meta-analysis by Parker and co-workers (37) showed proportionally more diagnoses of MD relative to VM in the nonspecialty setting than in the specialty setting. We saw a similar trend with female population comprising 69% of those diagnosed with MD by general otolaryngologists as opposed to comprising 56% of those diagnosed by otologists. One explanation for this difference would be misdiagnosis in female patients skewed toward MD by nonspecialists. The core data we are using to establish a demographic profile of MD patients come from diagnoses made in a tertiary subspecialty otology clinic. As such, we feel that misdiagnosis is of minimal impact and our findings accurately reflect a slight preponderance of female patients seen for MD.

Median income and having any form of insurance were significant independent factors associated with being seen by tertiary otology for MD. Similar to Simo and colleagues (7), our study found that the rates of being seen for MD were highest in those coming from ZIP codes with high median incomes. Rates of being seen for MD more than doubled for patients from ZIP codes with higher than $59.3k median income than for patients from ZIP codes below that income level. When controlling for income, race, and education, insurance status was the strongest predictor of being seen in tertiary otology, with a 0.26% increase in MD care for every 1% increase in insurance rate. This contrasts with a 0.02% increase in MD care for every 1% increase in college education rate and lower levels of increase with income and White race.

In our study, ZIP codes with higher utilization of otologic care for MD were notably distributed outside, or at the periphery of, urban areas. These results may add clarify to previous studies with unique cohorts, which may exacerbate



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selection bias. For example, Simo and colleagues (7) found a significantly higher prevalence of MD in those living in nonmetropolitan locales. However, their population consisted of inpatients, which raises concern for misdiagnosis as MD patients rarely need hospitalization. Adams and co-workers (38) showed that the odds of receiving a diagnosis of MD did not differ based on urban versus rural locale when controlling for sociodemographics (e.g., age, race). This study may also misrepresent the full population of MD patients as only Medicare and Medicaid patients were included.

Limitations of this study include dependence on EHR diagnostic data fields for data extraction. We have previously confirmed the accuracy of this methodology via manual extraction of subpopulations of patients. Population-level data (i.e., income, education level, median income) are based on the ZIP code of origin of the patient with the assumption that multiple patients from the same region will approximate the mean of that locale, but individual patient income and education measures are lacking. Another potential limitation is the possibility of misdiagnosis of MD or bias in the diagnosis of MD in underrepresented populations, although this is expected to be lower than many previous studies as we used diagnoses made only by tertiary care neurotologists. Our neurotology group followed the diagnostic criteria for MD as defined in the early years of this study by American Academy of Otolaryngology–Head and Neck Surgery Foundation criteria and in the later years by the multisociety consensus of 2015 (39). The potential for provider bias in making a diagnosis of MD in populations not typically considered to be characteristic of MD is acknowledged but is unlikely to account for the degree of difference in racial demographics observed.

## CONCLUSIONS

Patients diagnosed with MD by the tertiary otology service tended to be older, of White race, and privately insured. There was a greater proportion of patients from more rural portions of the state than typically seen in the clinic. In addition, patients were more likely to originate from ZIP codes with higher-college-educated populations and higher-median-income households. Many of these features are interdependent, and when controlling for such inequities, only median household income and insurance status significantly correlated with rates of care for MD patients. The disproportionately low proportion of Black race patients among those with MD raises consideration of lower disease susceptibility, although whether this is biological or environmental was not investigated. This study suggests that MD susceptibility is highest in populations that are older, of White race, and from rural locales and areas of higher income.

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