Published in final edited form as:

Chemosens Percept. 2020 October ; 13(2): 152–158. doi:10.1007/s12078-019-09276-6.

Prescription Medication Use and Phantom Odor Perception Among US Adults

Kathleen E. Bainbridge, PhD, MPH^a, Danita Byrd-Clark, BBA^b

^aNational Institute on Deafness and Other Communication Disorders, National Institutes of Health, Bethesda, MD

^bSocial & Scientific Systems, Inc., Silver Spring, MD

Abstract

Introduction: Prescription medication use may be associated with phantom odor perception. We evaluated associations between number of prescription medications and their therapeutic class and phantom odor perception among U.S. adults.

Methods: Data were collected between 2011–2014 as part of the National Health and Nutrition Examination Survey (NHANES). A complex sampling design resulted in a nationally representative sample of 7,417 adults aged 40 years and older. During an in-home interview, participants were asked whether they had experienced an unpleasant, bad, or burning odor when nothing is there. Prescription medication use was assessed using validation with prescription bottles, when possible.

Results: Almost one quarter (23.3%) of adults uses 5 prescription medications. Use of five or more prescription medications is associated with 70% greater odds of phantom odor perception (OR 1.69 (1.09, 2.63)). Among adults 60 years and older, antidiabetic medications, antihyperlipidemic agents, and proton pump inhibitors are associated with 74–88% greater odds of report of phantom odor [OR=1.74 (1.09, 2.77), OR=1.85 (1.22, 2.80), and OR=1.88 (1.15, 3.07)], respectively.

Conclusions: Phantom odor perception may be a side effect of antidiabetic or antihyperlipidemic agents. Among people taking proton pump inhibitors, phantom odors may also be a consequence of gastric gas reflux.

Implications: Common prescription medications may be providing an olfactory stimulus.

Keywords

phantom odors; smell; olfaction; NHANES; epidemiology; medications

Introduction

Phantom odor perception is a condition reported by 6.5% of U.S. adults where individuals perceive a scent in the absence of an identifiable external stimulus (Bainbridge, Byrd-Clark, & Leopold, 2018; Leopold, 2002). Two-thirds of adults reporting phantom odors are female (Bainbridge et al., 2018). The prevalence of prescription medication use has increased over the last decade with a concomitant increasing trend in polypharmacy (use of five or more prescription medications) (Kantor, Rehm, Haas, Chan, & Giovannucci, 2015). Certain classes of prescription medications including chemotherapeutic agents, anti-hypertensive agents, antibiotics, thyroid medications, and antidepressants are understood to affect smell sensitivity (Hummel et al., 2017; Malaty & Malaty, 2013; Schiffman, 1983). Whether prescription medication use is associated with phantom odor perception has not been studied using population-based data.

Phantom odor perception is associated with poorer health and dry mouth symptoms, conditions that may be correlated with prescription medication use (Bainbridge et al., 2018; Villa et al., 2015). Dry mouth is a possible side effect of some diuretics, anti-depressants (Kakudate et al., 2014; Wang et al., 2018), antithrombotics, respiratory agents, neurologic agents, and antineoplastics (Smidt, Torpet, Nauntofte, Heegaard, & Pedersen, 2010). Phantom odor perception has been associated with high blood pressure and with elevated total cholesterol, but only among adults for whom current measurements were under general therapeutic targets (Bainbridge & Byrd-Clark, 2019). Among people with diabetes, phantom odor perception was more prevalent among those who use both insulin and oral medications compared to those who do not use medication (Bainbridge & Byrd-Clark, 2019). These observations suggest that phantom odor perception may be attributed to medication use, rather than the medical conditions being treated.

We used participant-reported information on prescription medication use in a nationally representative sample of U.S. adults to examine associations between prescription medication use and phantom odor perception. Specifically, our objectives were to determine whether 1) people reporting phantom odor perception report a greater number of prescription medications than those who don't report phantom odors, 2) phantom odor perception is associated with one or more therapeutic classes of prescription medication, and 3) the greater prevalence of phantom odor perception among females, those in poorer health, and among those who report persistent dry mouth remained after accounting for number of prescription medications used or any specific therapeutic class.

Methods

The National Health and Nutrition Examination Surveys (NHANES) use a stratified, multistage, probability cluster design that results in a nationally representative sample of the non-institutionalized, civilian U.S. population. During 2011–2014, a total of 7,418 eligible study participants aged 40 years and older were interviewed in their home. One individual was missing data on phantom odor perception, yielding an analytical sample of 7,417 participants. All participants provided informed consent.

Measures

Phantom odor perception was measured with a single question: “Do you sometimes smell an unpleasant, bad, or burning odor when nothing is there?” Age, sex, and family income were obtained during in-home interviews. Income-to-poverty ratio was defined as the ratio of reported total family income to the U.S. Census bureau poverty threshold, and we used a cutpoint of 3 to distinguish those of greater means from those of lesser means, based on family income. Participants assessed their general health status as excellent, very good, good, fair, or poor. A dichotomous variable was derived to distinguish those in fair or poor health from those in better health.

Aided by the Computer-Assisted Personal Interview (CAPI) system (Westat, Rockville, MD) participants were asked “In the past month, have you used or taken medication for which a prescription is needed?” Participants provided medication containers when available. Medication brand names were converted to generic equivalents and assigned nested three-level therapeutic classification codes using Lexicon Plus (Cerner Multum, Inc., North Kansas City, MO), a proprietary database of all prescription medications and some over-the-counter products available in the United States. This analysis examined all of the second-level therapeutic categories (e.g. antihyperlipid agents, anti-depressants, analgesics) and one third-level therapeutic category, antimigraine agents, which was nested within the analgesic category.

Trained interviewers ascertained history of medical conditions using audio computer-assisted self-interviewing software (ACASI, Westat, Rockville, MD). Questions included “has a doctor or other health professional ever told you you had coronary heart disease?” Participants reported high blood pressure and high blood cholesterol based on similarly worded questions. Persistent dry mouth experienced over the past 12 months and lifetime history of head trauma with loss of consciousness were recorded.

Trained physicians collected blood pressure readings according to a standard protocol (Centers for Disease Control and Prevention, 2013a). We defined high blood pressure as systolic blood pressure ≥ 140 mm Hg, diastolic blood pressure ≥ 90 mm Hg, self-reported diagnosis of high blood pressure or self-reported current use of antihypertensive medications (Chobanian et al., 2003). Among those who reported a doctor’s diagnosis or who reported use of antihypertensive medications, controlled blood pressure was defined as systolic blood pressure <140 mm Hg and diastolic blood pressure <90 mm Hg. Cholesterol levels were measured from venous samples according to a standard protocol (Centers for Disease Control and Prevention, 2013b). High cholesterol was defined as having total cholesterol ≥ 200 mg/dL, or self-reported diagnosis of high blood cholesterol or self-reported current use of cholesterol lowering medication. Among those who reported a high cholesterol diagnosis or cholesterol medication use, controlled high cholesterol was defined as total cholesterol <200 mg/dL and uncontrolled total cholesterol ≥ 200 mg/dL.

Statistical Analysis

Descriptive statistics such as median age and the frequency distribution of demographic characteristics and certain health characteristics were estimated. We ranked the top fifteen

second-level therapeutic drug categories among the 534 people who reported phantom odors and estimated the prevalence of use and corresponding 95% confidence intervals. We used multiple logistic regression to estimate associations between phantom odor perception and number of prescription medications or therapeutic class. We report the strength of these associations as odds ratio (*OR (95% CI)*). Analyses were performed using SAS version 9.4 (SAS Institute, Inc, Cary, NC) and SUDAAN version 11.0.0 (Research Triangle Institute, Research Triangle Park, NC) incorporating four-year sample weights.

Results

The median age of the study population was 56.0 years (Table 1). Of the 7417 people who participated in the study, slightly over one-half were female (52.8%). Just under one-half had an income-to-poverty ratio of less than 3 (300% of federally defined poverty level). One-fifth (20.5%) reported their general health as fair or poor. Persistent dry mouth symptoms and head trauma, known correlates of phantom odor perception, were reported by 13.1% and 15.6% of the sample, respectively. Seventy two percent of U.S. adults aged 40 years and older are taking one or more prescription medications. Almost one-fourth (23.3%) of these adults take five or more prescription medications.

The frequency distributions of number of prescription medications for adults who do and do not report phantom odors stratified by age and by report of dry mouth symptoms are depicted in Figure 1a and Figure 1b. Taking five or more medications is more prevalent among those reporting phantom odors, regardless of age group and symptoms of dry mouth. Among adults aged 40–59 years, about one-third of people who report phantom odors takes at least five prescription medications compared to 13% of those who don't report phantom odors. Among those aged 60 years and older, almost two-thirds (61.8%) of those who report phantom odors take at least five prescription medications compared to just over one third (34.8%) of those who do not report phantom odors. Among those who report dry mouth symptoms, 61% of people who also report phantom odors take 5 or more prescription medications, compared to 53% of those without phantom odors. Among those who do not report symptoms of dry mouth, 31% of those with phantom odors take 5 or more prescription medications compared to 18% of those who do not perceive phantom odors.

In Figure 2, we display the top fifteen classes of prescription medication used by adults reporting phantom odors and compare the prevalence of use for those who do and do not report phantom odor perception. Of these fifteen medication classes, nine had a prevalence of use significantly greater among those who report phantom odors: antihyperlipidemic agents, antidepressants, analgesics, antidiabetic agents, proton pump inhibitors, anticonvulsants, calcium channel blocking agents, the group of anxiolytic, sedatives, and hypnotics, and muscle relaxants.

We assessed the independent association of phantom odor perception with number of prescription medications. We observed a threshold effect whereby there is no increased odds of phantom odor perception among people who take 1–4 prescription medications (Table 2). People who take 5 or more prescription medications, however, have a 69% increased odds of reporting phantom odors (*OR 1.69 (1.09, 2.63)*). Females aged 40–59 years have over three

times the odds of phantom odor perception (OR 3.19 (2.24, 4.53)), adjusted for number of prescription medications and other correlates of phantom odor perception.

We evaluated whether the use of specific therapeutic classes of prescription medications would account for associations between poorer health, symptoms of dry mouth, controlled hypertension, and controlled hyperlipidemia. Among those aged 40–59 years, we did not observe an association between any specific class of prescription medication and phantom odor perception. (data not shown) Among those aged 60 years and older, however, we found that antidiabetic agents, antihyperlipidemic agents, and proton pump inhibitors were associated with 74–88% greater odds of phantom odor perception OR=1.74 (1.09, 2.77), OR=1.85 (1.22, 2.80), and OR=1.88 (1.15, 3.07), respectively (Table 3). After controlling for class of prescription medication, there remained a 62% increased odds of phantom odor perception among females aged 60 years and older (OR = 1.62, (1.09, 2.43)). Associations between dry mouth symptoms and fair or poor health remained robust to controlling for therapeutic class of prescription medication.

Conclusions

Medication-associated smell alterations are not as well documented as medication-associated taste alterations (Doty, Philip, Reddy, & Kerr, 2003; Naik, Shetty, & Maben, 2010). With an increasing trend in prescription drug use and polypharmacy, individuals may have a greater probability of medication-related side effects and drug interactions (Kantor et al., 2015). This analysis evaluated associations between prescription medication use and report of phantom odor perception among U.S. adults. We found a threshold of five or more prescription medications over which the likelihood of phantom odor perception increases. We examined fifteen separate therapeutic medication classes and identified use of proton pump inhibitors, antidiabetic agents, and antihyperlipidemic agents as independently correlated with report of phantom odors, among adults 60 years and older. We observed no associations between specific medications among younger adults likely because the prevalence of exposure to these medications is lower among younger adults; we have power to detect these associations among older adults. Another possible reason is that older adults are more sensitive to side effects (Gurwitz et al., 2003). Accounting for the greater medication use among females did not explain the greater prevalence of phantom odors among females compared to males (Bainbridge et al., 2018), however, we likely have some unmeasured confounding due to the inability to account for the prevalence of migraine headache which is also more prevalent among females and may be associated with phantom odors.

Dry mouth symptoms are associated with polypharmacy, and may be the result of drug interactions (Hopcraft & Tan, 2010). Prescription medication classes known to produce dry mouth symptoms in older populations include diuretics, antidepressants, anticholinergics, antihistamines, respiratory agents, neurological agents, and antineoplastics (Hopcraft & Tan, 2010; Liu, Dion, Jurasic, Gibson, & Jones, 2012; Nederfors, Isaksson, Mornstad, & Dahlof, 1997; Smidt, Torpet, Nauntofte, Heegaard, & Pedersen, 2011). Dry mouth symptoms are also associated with report of phantom odors (Bainbridge et al., 2018). The biological mechanism for this association is unknown. In the current study, the association between

phantom odors and dry mouth symptoms remained after accounting for number of prescription medications or therapeutic class.

Among adults aged 60 years and older, we observed an association between proton pump inhibitors and phantom odor perception. Proton pump inhibitors are not known to bind receptors on olfactory sensory neurons. Use of proton pump inhibitors may be serving as a proxy for gastric gas production which may be creating a stimulus for the olfactory sensory neurons. Kabadi *et al.* report greater taste and smell disturbances among people with gastrointestinal reflux disease as well as other digestive conditions (Kabadi, Saadi, Schey, & Parkman, 2017). We have demonstrated a greater prevalence of phantom odor perception among people with diabetes who use insulin with or without oral antidiabetic agents (Bainbridge & Byrd-Clark, 2019). The current analysis provides additional evidence that phantom odors experienced by people with diabetes are attributable to antiglycemic agents rather than dysglycemia or the complications of diabetes.

One quarter of U.S. adults uses a statin, a class of medications for which various drug interactions have been documented (Adedinsewo *et al.*, 2016; Thai *et al.*, 2016). We provide new evidence that phantom odor perception is associated with use of antihyperlipidemic agents. Shubert *et al.* have demonstrated that lipid lowering drugs are associated with a modestly decreased incidence of olfactory impairment among a cohort of community dwelling adults in Wisconsin. The protective effect was driven by the statin medications that cross the blood brain barrier. If lipid lowering agents are binding to neurons related to olfactory processing in aging adults (Schubert, Cruickshanks, Klein, Klein, & Nondahl, 2011), they may be creating some disordered signaling, resulting in odor perceptions that are undetectable to others.

Our study has strengths and weaknesses. The data come from a national health survey, with good external validity to infer that medication use is associated with phantom odor perception among the non-institutionalized population of U.S. adults. The prescription medication information was validated by viewing medication containers during in-home interviews. The data are limited, however, by an absence of information on dosage or duration of use. The analysis did not incorporate over-the-counter medications. We lack data on duration and severity of dry mouth symptoms, so we can not rule out residual confounding. Finally, there is no standard diagnostic criterion for phantosmia. We assessed phantom odor perception with a single question that did not assess severity, duration, or periodicity of symptoms, nor did our measure include pleasant sensations (Bainbridge *et al.*, 2018; Sjolund, Larsson, Olofsson, Seubert, & Laukka, 2017).

With these cross-sectional data, we do not infer the direction of observed associations. Given that proton pump inhibitors, antidiabetic agents and antihyperlipidemic agents are not used to treat phantosmia, it is not plausible to infer that phantom odor perception is leading to their use. The cross-sectional study design may have an inherent information bias. Anecdotal evidence suggests that antidepressants, anticonvulsants, and sedatives are used as treatments for olfactory distortions (Leopold, 2002; Saltagi, Rabbani, Ting, & Higgins, 2018). If medication use had been discontinued (or the dose adjusted) as a result of phantom odors, we might not have detected an association that may, in fact, exist.

We found phantom odor perception to be associated with polypharmacy, and among adults 60 years and older, with use of proton pump inhibitors, antidiabetic and antihyperlipidemic agents, regardless of age, sex, and health status.

Acknowledgements

The National Institute on Deafness and Other Communication Disorders provided support for NHANES chemosensory data collection via Interagency Agreement funding with the National Center for Health Statistics of the Centers for Disease Control and Prevention and the University of Connecticut. Support for the statistical analysis was provided by Social & Scientific Systems, Inc. under Contract No. GS-00F-173CA, Task Order HHSN275201700074U. The views expressed in this report represent those of the authors and do not necessarily represent the agencies or institutions for which they work. The authors have no financial conflicts of interest to declare and have no other relationships that might lead to a conflict of interest. The authors thank Dr. Debara Tucci, National Institute for Deafness and Other Communication Disorders, for helpful comments.

References

- Adedinsawo D, Taka N, Agasthi P, Sachdeva R, Rust G, & Onwuanyi A (2016). Prevalence and Factors Associated With Statin Use Among a Nationally Representative Sample of US Adults: National Health and Nutrition Examination Survey, 2011–2012. *Clin Cardiol*, 39(9), 491–496. doi:10.1002/clc.22577 [PubMed: 27505443]
- Bainbridge KE, & Byrd-Clark D (2019). Phantom odor perception and vascular conditions among adults in the United States: National Health and Nutrition Examination Survey 2011–2014. *Laryngoscope*. doi:10.1002/lary.27936
- Bainbridge KE, Byrd-Clark D, & Leopold D (2018). Factors Associated With Phantom Odor Perception Among US Adults: Findings From the National Health and Nutrition Examination Survey. *JAMA Otolaryngol Head Neck Surg*, 144(9), 807–814. doi:10.1001/jamaoto.2018.1446 [PubMed: 30128498]
- Centers for Disease Control and Prevention. (2013a). National Health and Examination Survey (NHANES) Physician Examination Procedures Manual.
- Centers for Disease Control and Prevention. (2013b). National Health and Nutrition Examination Survey (NHANES) MEC Laboratory Procedures Manual.
- Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr.,... National High Blood Pressure Education Program Coordinating, C. (2003). Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension*, 42(6), 1206–1252. doi:10.1161/01.HYP.0000107251.49515.c2 [PubMed: 14656957]
- Doty RL, Philip S, Reddy K, & Kerr KL (2003). Influences of antihypertensive and antihyperlipidemic drugs on the senses of taste and smell: a review. *J Hypertens*, 21(10), 1805–1813. doi:10.1097/01.hjh.0000084769.37215.16 [PubMed: 14508182]
- Gurwitz JH, Field TS, Harrold LR, Rothschild J, Debellis K, Seger AC, ... Bates DW (2003). Incidence and preventability of adverse drug events among older persons in the ambulatory setting. *JAMA*, 289(9), 1107–1116. doi:10.1001/jama.289.9.1107 [PubMed: 12622580]
- Hopcraft MS, & Tan C (2010). Xerostomia: an update for clinicians. *Aust Dent J*, 55(3), 238–244; quiz 353. doi:10.1111/j.1834-7819.2010.01229.x [PubMed: 20887509]
- Hummel T, Whitcroft KL, Andrews P, Altundag A, Cinghi C, Costanzo RM, ... Welge-Luessen A (2017). Position paper on olfactory dysfunction. *Rhinol Suppl*, 54(26), 1–30. [PubMed: 29528615]
- Kabadi A, Saadi M, Schey R, & Parkman HP (2017). Taste and Smell Disturbances in Patients with Gastroparesis and Gastroesophageal Reflux Disease. *J Neurogastroenterol Motil*, 23(3), 370–377. doi:10.5056/jnm16132 [PubMed: 28147345]
- Kakudate N, Muramatsu T, Endoh M, Satomura K, Koseki T, Sato Y, ... Kakinoki Y (2014). Factors associated with dry mouth in dependent Japanese elderly. *Gerodontology*, 31(1), 11–18. doi:10.1111/j.1741-2358.2012.00685.x [PubMed: 22672112]
- Kantor ED, Rehm CD, Haas JS, Chan AT, & Giovannucci EL (2015). Trends in Prescription Drug Use Among Adults in the United States From 1999–2012. *JAMA*, 314(17), 1818–1831. doi:10.1001/jama.2015.13766 [PubMed: 26529160]

- Leopold D (2002). Distortion of olfactory perception: diagnosis and treatment. *Chem Senses*, 27(7), 611–615. [PubMed: 12200340]
- Liu B, Dion MR, Jurasic MM, Gibson G, & Jones JA (2012). Xerostomia and salivary hypofunction in vulnerable elders: prevalence and etiology. *Oral Surg Oral Med Oral Pathol Oral Radiol*, 114(1), 52–60. doi:10.1016/j.oooo.2011.11.014 [PubMed: 22727092]
- Malaty J, & Malaty IA (2013). Smell and taste disorders in primary care. *Am Fam Physician*, 88(12), 852–859. [PubMed: 24364550]
- Naik BS, Shetty N, & Maben EV (2010). Drug-induced taste disorders. *Eur J Intern Med*, 21(3), 240–243. doi:10.1016/j.ejim.2010.01.017 [PubMed: 20493431]
- Nederfors T, Isaksson R, Mornstad H, & Dahlof C (1997). Prevalence of perceived symptoms of dry mouth in an adult Swedish population--relation to age, sex and pharmacotherapy. *Community Dent Oral Epidemiol*, 25(3), 211–216. [PubMed: 9192149]
- Saltagi MZ, Rabbani CC, Ting JY, & Higgins TS (2018). Management of long-lasting phantosmia: a systematic review. *Int Forum Allergy Rhinol*, 8(7), 790–796. doi:10.1002/alr.22108 [PubMed: 29485754]
- Schiffman SS (1983). Taste and smell in disease (first of two parts). *N Engl J Med*, 308(21), 1275–1279. doi:10.1056/NEJM198305263082107 [PubMed: 6341841]
- Schubert CR, Cruickshanks KJ, Klein BE, Klein R, & Nondahl DM (2011). Olfactory impairment in older adults: Five-year incidence and risk factors. *Laryngoscope*. doi:10.1002/lary.21416
- Sjolund S, Larsson M, Olofsson JK, Seubert J, & Laukka EJ (2017). Phantom Smells: Prevalence and Correlates in a Population-Based Sample of Older Adults. *Chem Senses*. doi:10.1093/chemse/bjx006
- Smidt D, Torpet LA, Nauntofte B, Heegaard KM, & Pedersen AM (2010). Associations between labial and whole salivary flow rates, systemic diseases and medications in a sample of older people. *Community Dent Oral Epidemiol*, 38(5), 422–435. doi:10.1111/j.1600-0528.2010.00554.x [PubMed: 20545715]
- Smidt D, Torpet LA, Nauntofte B, Heegaard KM, & Pedersen AM (2011). Associations between oral and ocular dryness, labial and whole salivary flow rates, systemic diseases and medications in a sample of older people. *Community Dent Oral Epidemiol*, 39(3), 276–288. doi:10.1111/j.1600-0528.2010.00588.x [PubMed: 21070322]
- Thai M, Reeve E, Hilmer SN, Qi K, Pearson SA, & Gnjdjic D (2016). Prevalence of statin-drug interactions in older people: a systematic review. *Eur J Clin Pharmacol*, 72(5), 513–521. doi:10.1007/s00228-016-2011-7 [PubMed: 26790666]
- Villa A, Wolff A, Aframian D, Vissink A, Ekstrom J, Proctor G, ... Pedersen AM (2015). World Workshop on Oral Medicine VI: a systematic review of medication-induced salivary gland dysfunction: prevalence, diagnosis, and treatment. *Clin Oral Investig*, 19(7), 1563–1580. doi:10.1007/s00784-015-1488-2
- Wang SM, Han C, Bahk WM, Lee SJ, Patkar AA, Masand PS, & Pae CU (2018). Addressing the Side Effects of Contemporary Antidepressant Drugs: A Comprehensive Review. *Chonnam Med J*, 54(2), 101–112. doi:10.4068/cmj.2018.54.2.101 [PubMed: 29854675]

Implications

Prescription medications may be providing a stimulus to olfactory sensory neurons or to olfactory processing regions of the brain. The current data do not identify specific active agents present in these prescription medications. Improved understanding of the actions of these medications on olfactory function may lead to treatments of the disordered sense of smell in older adults.

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Figure 1. Frequency distribution of number of prescription medications by phantom odor perception (yes/no) stratified by a) age group and b) dry mouth symptoms, U.S. population aged 40 years – NHANES 2011–2014.

Figure 2. Unadjusted prevalence (95% confidence interval) of prescription medication use by phantom odor perception among U.S. adults aged 40 years, NHANES 2011–2014. Boldface type indicates non-overlapping 95% confidence intervals.

Table 1.

Characteristics of the U.S. population aged 40 years – NHANES 2011–2014 (n=7417)

	^a n	Weighted %
Age, years (median, IQR)	7417	56.0 (47.5, 65.5)
Sex		
Male	3555	47.2
Female	3862	52.8
Income-to-poverty ratio		
<3	4123	47.4
3	2625	52.6
General health		
Excellent/very good/good	4704	79.5
Fair/poor	1793	20.5
Persistent dry mouth		
Yes	1115	13.1
No	6302	86.9
Head trauma		
Yes	948	15.6
No	6469	84.4
Number of prescription medications		
0	2168	28.0
1	1106	16.9
2	844	12.7
3	766	10.5
4	652	8.6
5	1881	23.3

^a missing data account for totals that do not equal n=7417

IQR=interquartile range

Table 2.

Multivariable-adjusted^a odds ratios (95% CI^b) for the independent association of phantom odor perception and number of prescription medications, age, sex, general health, and dry mouth symptoms U.S. adults aged 40 years and older (n=5963)—NHANES 2011–2014.

Odds Ratio (95% CI)		
# prescription medications		
0	Ref	
1	0.83 (0.46, 1.49)	
2	0.87 (0.49, 1.54)	
3	1.01 (0.59, 1.73)	
4	1.30 (0.66, 2.55)	
5	1.69 (1.09, 2.63)	
Age, years		
40–59		
Males	1.41 (0.85, 2.32)	
Females	3.19 (2.24, 4.53)	
60		
Males	Ref	
Females	1.37 (0.93, 2.02)	
General health		
Fair/poor	1.76 (1.24, 2.49)	
Good/very good/excellent	Ref	
Dry mouth symptoms		
Yes	2.56 (1.81, 3.62)	
No	Ref	

^aAdjusted for income-to-poverty ratio and history of head trauma

^b95% CI =95% Confidence interval

Table 3.

Multivariable-adjusted^a odds ratios (95% CI^b) for the independent association of phantom odor perception and sex, health status, and class of prescription medication use among U.S. adults ≥60 years (n=3268)—NHANES 2011–2014.

Odds Ratio (95% CI)		
Sex		
Female	1.62	(1.09, 2.43)
Male	Ref	
General health		
Fair/poor	1.96	(1.29, 2.98)
Good/very good/excellent	Ref	
Dry mouth symptoms		
Yes	2.67	(1.82, 3.91)
No	Ref	
Antidiabetic agents		
Yes	1.74	(1.09, 2.77)
No	Ref	
Antihyperlipidemic agents		
Yes	1.85	(1.22, 2.80)
No	Ref	
Proton pump inhibitors		
Yes	1.88	(1.15, 3.07)
No	Ref	

^a adjusted for age

^b 95% CI=confidence interval