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Olfactory Impairment in Adults: The Beaver Dam Experience

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Abstract

Olfactory function may be important for environmental and nutritional safety and enjoyment. Population-based epidemiologic studies of olfaction are needed to understand the magnitude of the health burden, identify modifiable risk factors and develop and test prevention and treatment strategies for olfactory impairment. However, measuring olfaction in large studies is challenging, requiring repeatable, efficient methods which can measure change over time. Two large cohort studies, the Epidemiology of Hearing Loss Study (EHLS) and the Beaver Dam Offspring Study (BOSS), included olfactory testing. In both studies, the San Diego Odor Identification Test (SDOIT) was used to measure olfaction. Subjects were asked to identify eight common household odors (such as coffee and chocolate). Olfactory impairment was defined as correctly identifying fewer than 6 out of 8 odorants after two trials. EHLS participants were age 53–95 years at the time of the first measurement (1998–2000) and participants in the BOSS were age 21–84 years. The prevalence of olfactory impairment in the EHLS was 25% overall, more common in men than women and increased with age. Five years later olfaction was measured a second time and the majority (84%) of EHLS participants were classified the same. Among those with impairment at the baseline nearly one-third (31%) improved to unimpaired. This heterogeneity in olfactory impairment has unique implications for data analyses and predicting outcomes and associations. Preliminary data from the BOSS suggest the prevalence of olfactory impairment may be lower in younger generations. All these factors point to a continuing need for epidemiological studies of olfaction.

Keywords

Olfaction; Epidemiology; Population-based; EHLS; BOSS

INTRODUCTION

Olfactory function may be important for environmental and nutritional safety, quality of life and enjoyment. In one study, participants with olfactory disorders reported more problems with paid employment, housework, social, and family life than controls and in another, participants with olfactory loss reported feeling impaired in their ability to detect smoke, gas leaks, or spoiled food.[1,2] Previous studies[3,4] have found that olfactory impairment is more common in older age groups and men but, until recently the prevalence of olfactory impairment in the general population was not known.[5] Similarly, olfactory impairment among people seeking

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diagnosis and treatment at clinics was associated with certain conditions and diseases but little was known about risk factors for impairment in the general population.[6,7] Therefore, population-based studies of olfaction are important to understand the magnitude of the health problem in the population in order to estimate the public health burden and to identify modifiable risk factors which could lead to prevention and treatment strategies.

Two large studies, the Epidemiology of Hearing Loss Study (EHLS, 1993-present), a longitudinal population-based study of sensory loss and aging in Beaver Dam, WI, and the Beaver Dam Offspring Study (BOSS) (2005-present), a study of the offspring of the EHLS participants, have included olfactory testing as part of their examinations and the methodological challenges from these studies and results are presented here.[5,8,9]

METHODOLOGICAL CONSIDERATIONS

There are some factors unique to olfactory testing in large population studies that need to be considered. First, the test selected needs to be acceptable to the participant. Subjects in population-based studies are invited to participate because they are residing within the area defined as the sampling frame for the study being conducted and, unlike clinic-based studies or studies in selected populations, participants are not identified because they have an underlying condition motivating them to participate; uncomfortable or extensive testing may discourage them from participating in the study. Second, population-based studies often involve many modalities and each one is limited in the amount of time available for testing. Therefore, in these studies it is important to keep participant burden low in order to maximize participation and maintain interest in participating in subsequent follow-up examinations. Third, the olfactory test selected must be time and cost efficient for a large number of participants. Above all, the reliability and repeatability of the olfactory test must be high so any change measured in olfactory function over time is likely true change and not measurement error.

In the EHLS and BOSS, the San Diego Odor Identification Test (SDOIT) was used to measure olfaction. The SDOIT consists of eight common household odorants that are wrapped in gauze and placed in opaque jars. The odorants are presented in a random order to participants, who are asked to close their eyes prior to having the odorant placed under their nose. Participants are able to smell the odorant as long as they want, usually about 3–5 seconds. Participants are then told they may open their eyes and identify the odor by using a picture array that contains the 8 odorants plus 12 distracters. There is a 45 second delay between odorant presentations to allow for adaptation. Participants who misidentify an odorant are told the correct identification of the odor and the odorant is presented again later in the testing process. The score for the test is the sum of the number of correctly identified odorants after two trials. Olfactory impairment is defined as identifying fewer than 6 of the 8 odorants correctly. These methods have been published elsewhere.[5,10]

The SDOIT is an efficient test, both in terms of time and cost and is well received by participants. In the EHLS and the BOSS the average administration time for the SDOIT is about 15 minutes including the time between odors which can be used for the administration of questionnaires. The SDOIT is a very reliable and repeatable odor identification test. In previous research, children and Down's syndrome patients tested a mean of 5.4 days apart showed a test-retest reliability of 0.86 and more recently, in a study of adults, the SDOIT had a concordance correlation coefficient of 0.85 in people age 50–70 years with a mean time between tests of three weeks.[10,11]

RESULTS and DISCUSSION

Olfaction was measured at the 5- and 10-year examinations of the EHLS (n=2800 age 53–95 years in 1998–2000 and n=2395 in 2003–2005, respectively).[9] The prevalence of olfactory impairment in the EHLS population was 24.5 % overall, increased with age and was more common in men than women (Figure 1).[5] Factors associated with the prevalence of olfactory impairment were older age, being male, a current smoker, nasal congestion or upper respiratory infection during the week preceding the testing, or a history of epilepsy or stroke.[5] The EHLS is the only population-based study in the United States to measure olfaction and it provides much needed data on the prevalence of olfactory impairment, as well as factors associated with impairment, in a general population of older adults.

In addition, in the EHLS, olfactory impairment was associated with the 5-year incidence of cognitive impairment. Compared to participants without olfactory impairment, participants with an olfactory impairment at the baseline olfactory examination were more likely to have developed cognitive impairment at the examination five years later (Odds Ratio (OR) = 3.33, 95% Confidence Interval (CI)=2.04, 5.42).[12] However, despite this strong association, most of the participants with olfactory impairment (84%) at the baseline examination did not develop cognitive impairment during the 5-year period and the sensitivity of the SDOIT was only 55.1% for cognitive impairment.[12]

Now, for the first time, there is information on the change in olfaction in a general population of older adults followed for five years. There were 1901 participants in the EHLS who had olfaction measured at two examinations five years apart. The majority of these participants, (84%) had no change in their olfactory classification at the five-year follow-up examination.

An interesting finding of this study was that 31% of participants who had olfactory impairment, as measured by the SDOIT, at the baseline examination were unimpaired at the 5-year follow-up examination. The percent of olfactory improvement is shown in Table 1 by age and sex. There was no overall difference between men and women in the percent improving but there was less improvement in the oldest age group.

In table 2, the distribution of olfactory improvement is shown by the baseline SDOIT score. The majority of participants who changed classification did so by increasing their score by 1–3 units between the baseline SDOIT and follow-up, whereas only 11.2% increased their score by 4 or 5 units.

To further explore the factors associated with olfactory improvement, multivariate logistic regression analyses were done. These analyses found the risk for olfactory improvement decreased with increasing age (OR = 0.80 per 5 years of age, 95% CI = 0.68, 0.92) and increased with the use of nasal steroids at the baseline olfactory examination (OR = 3.19, 95% CI = 1.15, 8.90) in a model adjusted for impaired cognition, anti-anxiety medication use, history of a cold, stuffy nose or sinus problems in the 7 days before the exam or a history of a doctor-diagnosed sinus infection or chronic sinusitis (Table 3). Therefore, older participants were much less likely to experience improvement in their olfactory ability while those who reported using nasal steroids at baseline were more likely to improve. Nasal steroids have been shown to have some success in improving olfactory function when prescribed for treatment of sinus or nasal disease.[13,14]

ANALYTICAL CONSIDERATIONS

Whenever a cut-point is assigned to a scale or score for purposes of classification it must be considered whether any change in classification detected with repeat testing is due only to movement around the cut-point, which could be considered measurement error, or if it is due

to true change in function. To ensure the risk factors associated with olfactory improvement in these analyses were not due to bias around the cut-point, the multivariate logistic regression analysis was repeated excluding those participants whose impairment classification improved to unimpaired by only one point (from a score of 5 to a score of 6). The results of this sensitivity subset analysis (Table 3, third column) were similar to the original analysis and indicate the associations found using the full data set were not driven by measurement error. Additionally, in a test- retest study (n=90), the total agreement of the SDOIT classification was 96%, suggesting any measurement error would be minimal.[11]

Additionally, it is important to consider the impact of short-term versus long-term olfactory impairment and how it may affect analyses when evaluating etiological factors related to impairment. As demonstrated in this study, in a general population there is heterogeneity in olfactory function over time, some people stay impaired and others improve. This highlights the need to have olfactory testing at more than one time point to determine if olfactory impairment is chronic or temporary. Fluctuations in olfactory status may not affect prevalence or incidence rates, but it could still diminish the ability to predict other outcomes and associations with olfactory impairment.

FUTURE DIRECTIONS

Preliminary analyses comparing the BOSS cohort to the EHLS population indicates that the prevalence of olfactory impairment may be decreasing in more recent generations. The prevalence of olfactory impairment for those aged 60–69 years in 1998–2000 was 17.3% (EHLS cohort) whereas the prevalence was only 9.7% in those aged 60–69 years in 2005–2008 (BOSS cohort). Therefore, in these two cohorts, people born approximately 10 years later had less olfactory impairment at the same age. Further explorations of these data will be done to determine if birth cohort differences in lifestyle, health or environmental factors are associated with this difference.

Conclusion

As demonstrated, it is possible to test olfaction in large epidemiological studies and obtain reliable and important information about olfactory impairment in the general population. From the EHLS it has been shown that olfactory impairment is common in aging and there may be modifiable risk factors as well as treatment opportunities available. Recent preliminary data from the BOSS study indicate a lower prevalence of olfactory impairment may exist in younger cohorts (generations) and further analyses of these data may lead to new information on the etiology of olfactory impairment.

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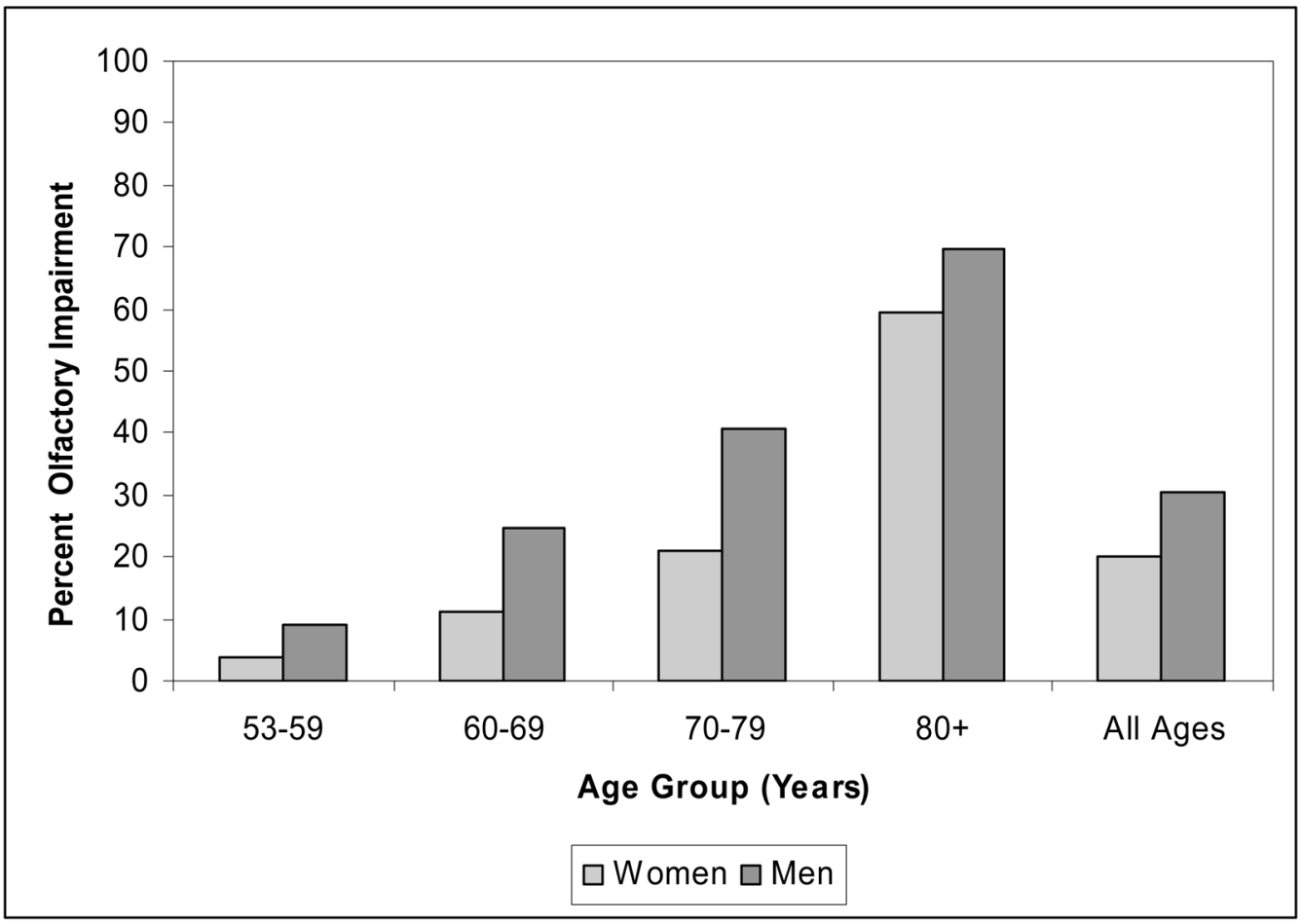

Figure 1. Prevalence of Olfactory Impairment at the Baseline Examination by Age and Sex: EHLS 1998–2000. †

†Figure based on data from (5): Murphy C., C.R. Schubert, K.J. Cruickshanks et al. 2002. Prevalence of Olfactory Impairment in Older Adults. JAMA 288(18);2307–2312.

Table 1

Percent of participants with olfactory impairment at baseline who were unimpaired five years later (improvers).

	Olfaction impaired at baseline	Olfaction not impaired at 5-years		
Baseline Age (Years)	N at risk	Men (%)	Women (%)	All (%)
53–59	27	25.0	45.5	33.3
60–69	116	42.9	35.9	40.5
70–79	125	26.4	39.6	32.0
80–97	77	19.4	10.9	14.3
All ages	345	31.6	30.2	31.0

Table 2

Distribution of olfactory improvement by baseline San Diego Odor Identification Test (SDOIT) score.

SDOIT Score at Baseline*	Olfaction Impaired at baseline N	Remained Impaired at 5 years (Score 0–5) n (%)	Improved to unimpaired at 5 years, n (%)
0	14	14 (100)	0
1	19	19 (100)	0
2	36	31 (86.1)	5 (13.9)
3	49	44 (89.8)	5 (10.2)
4	87	63 (72.4)	24 (27.6)
5	140	67 (47.9)	73 (52.1)
Total	345	238 (69.0)	107 (31.0)

* Number of correctly identified odorants; olfactory impairment is defined as <6 of 8 odorants correctly identified.

Table 3

Multivariate Logistic Regression estimates for Olfactory Improvement

	Using Full Dataset (n=330)	Using Sensitivity Subset* (n=300)
Baseline Covariate	**Odds Ratio† (95% Confidence Interval)**	**Odds Ratio† (95% Confidence Interval)**
Age, effect of each 5 years older	0.79 (0.68, 0.92)	0.80 (0.68, 0.95)
Men vs. women	0.86 (0.52, 1.41)	1.00 (0.57, 1.77)
Nasal steroid use	3.19 (1.15, 8.90)	3.85 (1.30, 11.39)

† Adjusted for: Upper respiratory infection/stuffy nose/sinus problems in week prior to testing, history of sinus infection/chronic sinusitis, impaired cognition, taking anti-anxiety medications.

* Sensitivity Subset: Excludes participants who correctly identified 5 odorants at baseline and 6 odorants at follow-up.