






ORIGINAL RESEARCH

The olfactory diary: Tracking awareness and consciousness of the sense of smell throughout the day

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Abstract

Objectives: The aim of the present study was to follow the daily course of patients with olfactory dysfunction and healthy controls and to assess (i) how many times a day, (ii) at which time, and (iii) in which aspect of daily life participants are conscious about their sense of smell.

Methods: In this longitudinal study, 49 patients with smell loss and 30 healthy participants were enrolled. Olfactory function was assessed using the Sniffin' Sticks. All participants received paper diaries designed for a 14-day period, featuring 12 rows representing 12 daily hours and six columns for various daily life aspects. They were instructed to mark their awareness of smell by indicating the relevant row and column in the diary. Following the return of the diaries, a second olfactory test was conducted within the patient group.

Results: On average, patients were consciously aware of their sense of smell around 8 times daily, while healthy participants noted it about 6.5 times a day. Both groups primarily focused on their sense of smell during activities related to "eating," followed by considerations in "social life" and "personal hygiene." Interestingly, distinct patterns emerged: patients peaked in awareness at 8 a.m. and 7 p.m., whereas healthy individuals showed peaks at 6 a.m., 12 p.m., and 7 p.m. Despite regular diary use, we observed no improvement in patients' olfactory function or related quality of life.

Conclusion: The olfactory diary is a valuable tool unveiling individual smell awareness patterns in patients with smell loss, aiding in counseling and patient management.

Level of Evidence: 4

KEYWORDS

hyposmia, olfaction, olfactory diary, smell, smell loss

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1 | INTRODUCTION

The sense of smell allows us to interact with our environment and contributes to our overall well-being.¹ Not surprisingly, patients with smell loss experience a decreased quality of life and even depression.^{2,3} When it comes to treatment, practical recommendations for managing smell disorders in daily life play a vital role in improving patient engagement.⁴ However, hourly patterns on the impact of smell loss on daily life are currently unknown. Credible information on temporal trends might help to improve our understanding of the impact of smell loss on daily life and therefore improve clinical counseling.

Although the “invisible” sense of smell plays a significant role in daily life, it is usually not until patients lose their olfactory sensitivity that they realize how important it is.⁵ This is further highlighted by studies showing that olfaction would be ranked the least important, when asking healthy subjects to rank their senses according to their importance.⁵ Patients with smell loss frequently report problems related to eating, cooking, communication, personal hygiene, detecting hazardous events, social life, or even depression.^{1,6,7} Previous studies have also highlighted its importance for intimate relationships and its role as a biomarker for neurodegenerative diseases.^{8–14} Indeed, smell loss as a common symptom of a COVID-19 infection has brought chemosensory disorders to the forefront of the scientific literature.^{15,16}

The causes of olfactory disorders are diverse and include inflammatory diseases of the nose and sinuses, head traumas, neurological diseases, infections to the upper respiratory tract (including COVID-19 smell loss), exposure to drugs and toxins, congenital reasons, or else it could be classified as idiopathic.⁴ Prognosis and treatment options for all of those etiologies are different, and also, the importance of smell loss to patients varies significantly, making a personalized approach to clinical counseling important.^{17,18}

This study aimed to delineate the hourly impact of smell loss on different aspects of daily life for 2 weeks based on a paper-based diary, which we named the “olfactory diary.”

2 | MATERIALS AND METHODS

2.1 | Subjects

This was a prospective, longitudinal (two visits), single-center study that included patients presenting with olfactory dysfunction to the Smell and Taste Clinic of the Department of Otorhinolaryngology, Head and Neck Surgery, Medical University of Vienna/Vienna General Hospital between March 2019 and April 2021. The reason for smell loss was classified based on the European Position Paper on olfactory dysfunction.⁴ Parosmia was assessed in all patients by asking whether they would “perceive odors differently than previous experiences” (binary answer: yes/no).¹⁹ Healthy participants with a self-reported normal sense of smell were recruited between February 2021 and June 2021 through flyers distributed across the university campus. Exclusion criteria for healthy participants were a Sniffin’ Sticks TDI

score in the hyposmic range (lower than 30.75),²⁰ a history of inflammatory sinus diseases, traumatic head injuries, neurodegenerative diseases, or active smoking. All patients and participants underwent a complete Ear, Nose, and Throat examination and provided written informed consent after a detailed explanation of the study protocol. The study was approved by the Ethics Committee of the Medical University of Vienna (ethics number 1195/2019) and procedures were carried out according to the Declaration of Helsinki.

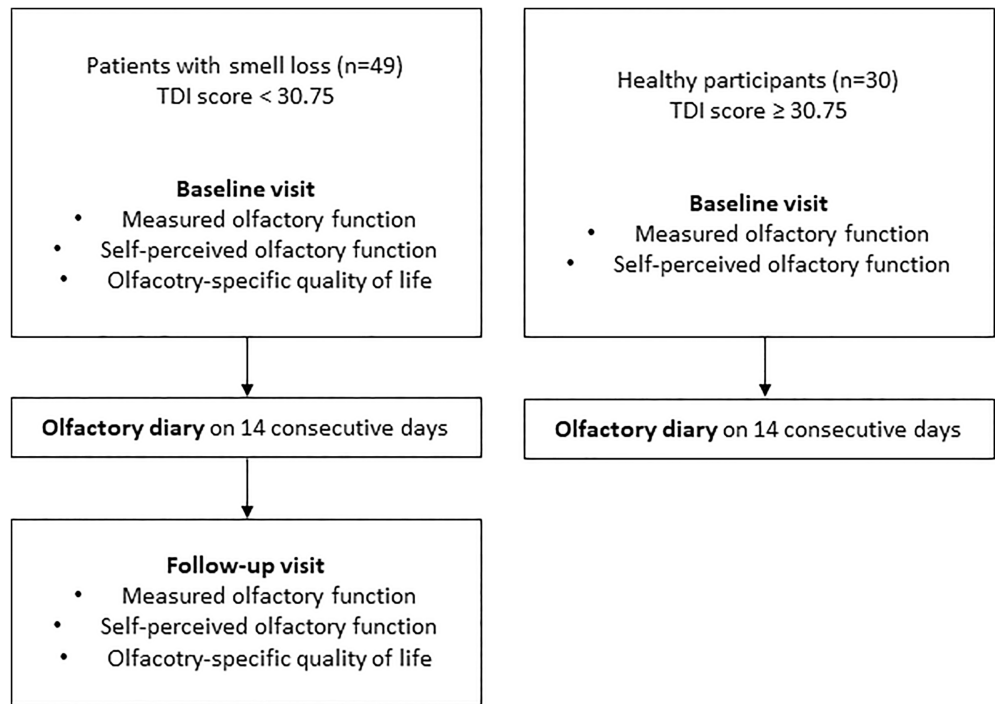
2.2 | Study protocol

A flowchart of the study protocol is provided in Figure 1. At the first/baseline visit, all patients and participants underwent olfactory testing using the Sniffin’ Sticks TDI test based on *n*-butanol for threshold testing.^{21,22} The TDI score was interpreted according to the most recent normative data as normosmia (equal or higher than 30.75), hyposmia (less than 30.75 and higher than 16), or anosmia (less or equal 16).²⁰ All patients also underwent gustatory testing based on the Taste Strips Test (TST)²³ and were asked to complete the Questionnaire of Olfactory Disorders (QOD)^{24,25} to assess the impact of smell loss on daily life. TST results were interpreted according to normative data as normogeusia (equal or higher than 9) or hypogeusia (less than 9). Hardcover diaries (“Olfactory diary,” Figure 2) A5 size spiral notebook with 14 pages were then handed out to all participants. Each page consisted of 12 rows (for every hour of the day, with two pages adding up 24 h of the day) and six columns, representing different areas in daily life^{1,6}: (i) eating, (ii) cooking, (iii) personal hygiene, (iv) social life, (v) gas/fire, and (vi) other. Patients and participants were instructed to complete the diary throughout the day on 14 consecutive days and to specify the number of times they thought/were conscious about their sense of smell per hour and category. For instance, when a participant or patient consciously directed their attention toward their olfactory perception twice during the breakfast period at 7:00 a.m., they were instructed to annotate the corresponding time slot under the category “eating” twice. A comprehensive illustration of a complete 24-h period detailing participant and patient responses is available in Figure S1. Participants were requested to return the diary upon its completion. A second visit was scheduled for all patients, with at least 14 days between visits. Patients handed in the completed diary, filled out the QOD, and underwent a subsequent olfactory test utilizing the Sniffin’ Sticks TDI Test. Instead of the regular Sniffin’ Sticks Identification test, the extended version of the Identification test with 16 new odors was used to avoid familiarity bias in identification testing.²⁶ We decided to use a paper-based olfactory diary and not an app-based version. Using a paper-based diary might bear some advantages, especially for elderly patients unfamiliar with electronic devices and applications.²⁷

2.3 | Questionnaire of olfactory disorders

The impact of olfactory dysfunction on daily life was assessed using the validated QOD.^{24,25,28} The used version consisted of three

FIGURE 1 Study flowchart.



	Eating	Cooking	Personal hygiene	Social life	Gas/Fire	Others		Eating	Cooking	Personal hygiene	Social life	Gas/Fire	Others
6:00 AM							6:00 PM						
7:00 AM							7:00 PM						
8:00 AM							8:00 PM						
9:00 AM							9:00 PM						
10:00 AM							10:00 PM						
11:00 AM							11:00 PM						
12:00 PM							12:00 AM						
1:00 PM							1:00 AM						
2:00 PM							2:00 AM						
3:00 PM							3:00 AM						
4:00 PM							4:00 AM						
5:00 PM							5:00 AM						

FIGURE 2 An illustrative example and guidance for participants depicting the layout of olfactory diaries for a typical day.

categories with 29 questions: (i) four questions on parosmia (QOD-PAR), (ii) two questions on positive statements (QOD-PS), and (iii) nineteen questions on complaints concerning loss of olfactory function (also called QOD-negative statements or QOD-NS). The first category aimed at answering whether the problem lies in perceiving odors differently compared to previous experiences, with higher scores indicating that odors smell differently. The QOD-PS aimed to

capture OD patient's ability to cope with smell loss, with higher scores indicating better coping abilities. The third and last category, QOD-NS was used to rate the impact of OD on daily life, with higher scores indicating higher problems. All questions were based on a four-point rating scale ranging from 0 (=not true at all) to 3 (=entirely true). Therefore, the maximum reachable score was 12, 6, and 57 for the above-mentioned categories, respectively.

2.4 | Statistical analysis

Continuous variables are presented as mean \pm standard deviation (SD) and range, whenever applicable. Categorical variables are presented as absolute numbers and percentages. Group differences were analyzed using *t*-tests, and a $p < 0.05$ was considered statistically significant. GraphPrism 9.5.0 (GraphPad Software, Inc., La Jolla, CA) was used for analysis and graphical visualization.

3 | RESULTS

3.1 | Descriptive results

We included 49 patients with smell loss (mean age \pm SD: 50.6 \pm 16.8 years, 15 male, 34 female). The most common reasons for smell loss were postinfectious ($n = 18$, 36.7%), followed by

TABLE 1 Demographics and clinical characteristics of patients and healthy participants.

Patients with smell loss ($n = 49$)	
Age in years, mean (SD)	50.6 (16.8)
Gender (N)	34F, 15M
Difference between visits in days, mean (SD)	25.5 (27.6)
Parosmia present at initial visit	7 (14.3%)
Idiopathic	15 (30.6%)
Postinfectious	18 (36.7%)
Posttraumatic	7 (14.3%)
Sinonasal	1 (2.0%)
Iatrogenic	6 (12.2%)
Congenital	1 (2.0%)
Neurodegenerative	1 (2.0%)
Healthy participants ($n = 30$)	
Age in years, mean (SD)	29.5 (12.9)
Gender (N)	17F, 13M

Note: Continuous data are presented as mean (standard deviation). Categorical data are presented as number (%).

idiopathic ($n = 15$, 30.6%), posttraumatic ($n = 7$, 14.3%), and iatrogenic ($n = 6$, 12.2%) reasons. We included one patient with sinonasal, congenital, and neurodegenerative smell loss, respectively. Based on TDI testing, 27 (55.1%) patients were hyposmic, followed by 18 (36.7%) anosmic and 4 (8.2%) normosmic patients. TST revealed normogeusia in 34 (69.4%) patients, while 15 (30.6%) were categorized as hypogeusic. Furthermore, we included 30 healthy participants (mean age \pm SD: 29.5 \pm 12.9, 13 male, 17 female) with normosmic TDI results based on Sniffin' Sticks testing as the reference group (Table 1).

3.2 | Olfactory function and olfactory-related QoL

All patients returned their diary for a second visit with a mean \pm SD duration of 25.5 \pm 27.6 days between visits. Olfactory testing revealed no significant difference in olfactory function and olfactory-related QoL between both visits in the patients group (all $p > 0.05$, Table 2).

3.3 | Daily awareness of olfactory perception

In the initial phase, our objective was to evaluate the frequency of daily thoughts or consciousness regarding the sense of smell among patients experiencing smell loss and healthy participants. To achieve this, we calculated the mean \pm SD representing the total frequency of thoughts about their sense of smell across all categories and within each specific category for both patients and participants. Subsequently, we conducted a comprehensive analysis of these frequencies across both groups, collectively assessing the data.

Patients were conscious about their sense of smell 8.0 \pm 4.6 (range: 0–26) times, while healthy participants thought about it 5.8 \pm 6.3 (range: 0–31) times. The most common area in daily life in which patients thought about their sense of smell was “eating” (2.5 \pm 1.4), followed by “social life” (2.3 \pm 1.9), “personal hygiene” (2.2 \pm 1.3), “others” (1.9 \pm 1.7), “cooking” (1.5 \pm 1.1), and “gas/fire” (0.8 \pm 1.5). Similarly, healthy participants also thought about their sense of smell most commonly in areas related to “eating” (1.6 \pm 1.7), followed by

First visit	Second visit	<i>p</i> -value	
Chemosensory function			
Sniffin' Sticks TDI test, mean (SD)	19.7 (7.5)	21.1 (8.2)	.495
Threshold, mean (SD)	3.6 (2.5)	4.2 (3.2)	.314
Discrimination, mean (SD)	8.1 (3.2)	8.2 (3.5)	.8485
Identification, mean (SD)	8.1 (3.5)	8.3 (3.2)	.862
Taste Strips Test, mean (SD)	9.9 (2.6)		
Olfactory-related quality of life			
QOD-NS, mean (SD)	18.8 (9.2)	18.3 (10.9)	.872
QOD-PS, mean (SD)	2.3 (1.7)	2.6 (1.8)	.265
QOD-PAR, mean (SD)	4.0 (3.2)	4.7 (3.5)	.293

TABLE 2 Chemosensory function and olfactory-related QoL between visits of all patients ($n = 49$).

TABLE 3 Descriptive statistics of the olfactory diary.

	Patients, mean (SD)	Healthy participants, mean (SD)
Across all categories	8.0 (4.6)	5.8 (6.3)
Eating	2.6 (1.4)	1.6 (1.7)
Cooking	1.5 (1.2)	0.5 (0.8)
Personal hygiene	2.2 (1.3)	1.2 (1.6)
Social activities	2.3 (1.9)	1.4 (2.4)
Fire/gas	0.8 (1.5)	0.2 (0.6)
Others	1.9 (1.7)	0.8 (1.3)

Note: Number of times patients and healthy participants thought about their sense of smell on a daily basis.

“social life” (1.4 ± 2.4), “personal hygiene” (1.2 ± 1.6), “others” (0.8 ± 1.3), “cooking” (0.5 ± 0.8), and “gas/fire” (0.2 ± 0.6). (Table 3).

Interestingly, even our case of congenital smell loss was conscious about the sense of smell 9.3 ± 1.7 times per day (range 7–12). The most common area in which the congenital smell loss patient thought about the sense of smell was “eating” (4.1 ± 1.4), followed by “personal hygiene” (2.7 ± 0.8), “social life” (1.7 ± 0.5), “gas/fire” (0.7 ± 0.5), “cooking” (0.2 ± 0.4), and “others” (0.2 ± 0.6).

3.4 | Olfactory function and smell loss throughout of the day

In the subsequent phase, our attention turned to analyzing the hourly impact of smell loss across all categories and within specific individual categories in daily life. We calculated the individual absolute number (mean \pm SD) representing how frequently patients and participants reflected on their sense of smell across all categories and individually for each category, considering each hour of the day. Subsequently, we analyzed both patient and healthy participant groups to examine these hourly trends.

Our analysis revealed distinct patterns of awareness peaks related to the sense of smell among patients and healthy participants. Patients demonstrated two peaks, at 8 a.m. and 7 p.m., while healthy participants exhibited three peaks at 6 a.m., 12 p.m., and 7 p.m. (Figure 3). Delving into individual categories within patients with smell loss, we observed three awareness peaks for activities like “eating” and “cooking” during the early morning (8 a.m.), noon (1 p.m.), and evening (7 p.m.). For categories such as “personal hygiene” and “social activities,” two peaks were identified, occurring in the early morning (8 a.m.) and evening (8 p.m.) for “personal hygiene,” and in the morning (10 a.m.) and afternoon (3 p.m.) for “social activities” (Figure 4 and Table S1).

Similarly, healthy participants also displayed three awareness peaks for the categories of “eating” and “cooking,” while showing two peaks for “social activities” and “personal hygiene” (Figure 4 and Table S1).

4 | DISCUSSION

Olfactory disorders have emerged as a significant global health issue, particularly highlighted by the impact of the COVID-19 pandemic. Consequently, this topic holds immense importance for both clinical practice and scientific research. Otolaryngologists frequently encounter patients presenting with smell loss, often reporting difficulties in various aspects of daily life, such as eating, cooking, personal hygiene, and social interactions, due to their diminished ability to engage with their environment. This study aimed to quantify how frequently patients thought about their sense of smell in daily life, particularly within different situations of everyday life. A reference group of healthy participants was included to discern potential issues associated with the disease. We found that patients were reminded about their sense of smell around 8 times per day, while healthy participants thought about it around 6.5 times. In addition, we found that the most prevalent areas where patients and healthy participants contemplated their sense of smell were primarily “eating,” followed by “social life” and “personal hygiene.” Moreover, we found distinct patterns of awareness peaks related to the sense of smell. Patients demonstrated two peaks, occurring at 8 a.m. and 7 p.m., while healthy participants exhibited three peaks at 6 a.m., 12 p.m., and 7 p.m. Using the olfactory diary and being conscious about the sense of smell for the short period of around 3 weeks did not improve olfactory function nor did it change olfactory-related quality of life in our patients.

There is abundant evidence showing that olfactory dysfunction significantly impacts the quality of life of affected individuals. For example, there are quantitative studies showing that smell loss is associated with a wide array of disabilities, ranging from decreased food enjoyment, social life problems, problems related to personal hygiene, the fear to not perceiving fire or gas, or even major depressive disorders.^{1,2,6} In fact, it has been shown that symptoms of depression might even worsen with the degree of olfactory dysfunction.^{3,29} Additionally, there are also qualitative studies—resembling a daily diary—showing how smell loss impacts their daily life.³⁰ Nonetheless, no previous study has assessed the consciousness and awareness of the sense of smell in these olfactory-related areas quantitatively during the course of the day.

A previous study of patients and participants counted the conscious perception of odors naturally occurring in the environment. The authors found that participants reported from 0 up to 362 olfactory perceptions per day.³¹ In a subanalysis dividing the patient and reference groups by the number of interpersonal encounters (many vs. few), environment (indoor vs. outdoor vs. indoor/outdoor), and sex (men/women), the authors found that patients reported a mean range of 4.63–35.02 odor perceptions per day, while the reference group reported a mean range of 24.72–44.80 odor perceptions. Interestingly, the authors also found that women reported to perceive significantly more odors than men. However, this difference was also driven by the patients' group, while in the reference group, there was no gender difference. The authors concluded that women with smell loss might be motivated to pay more attention to odors in the

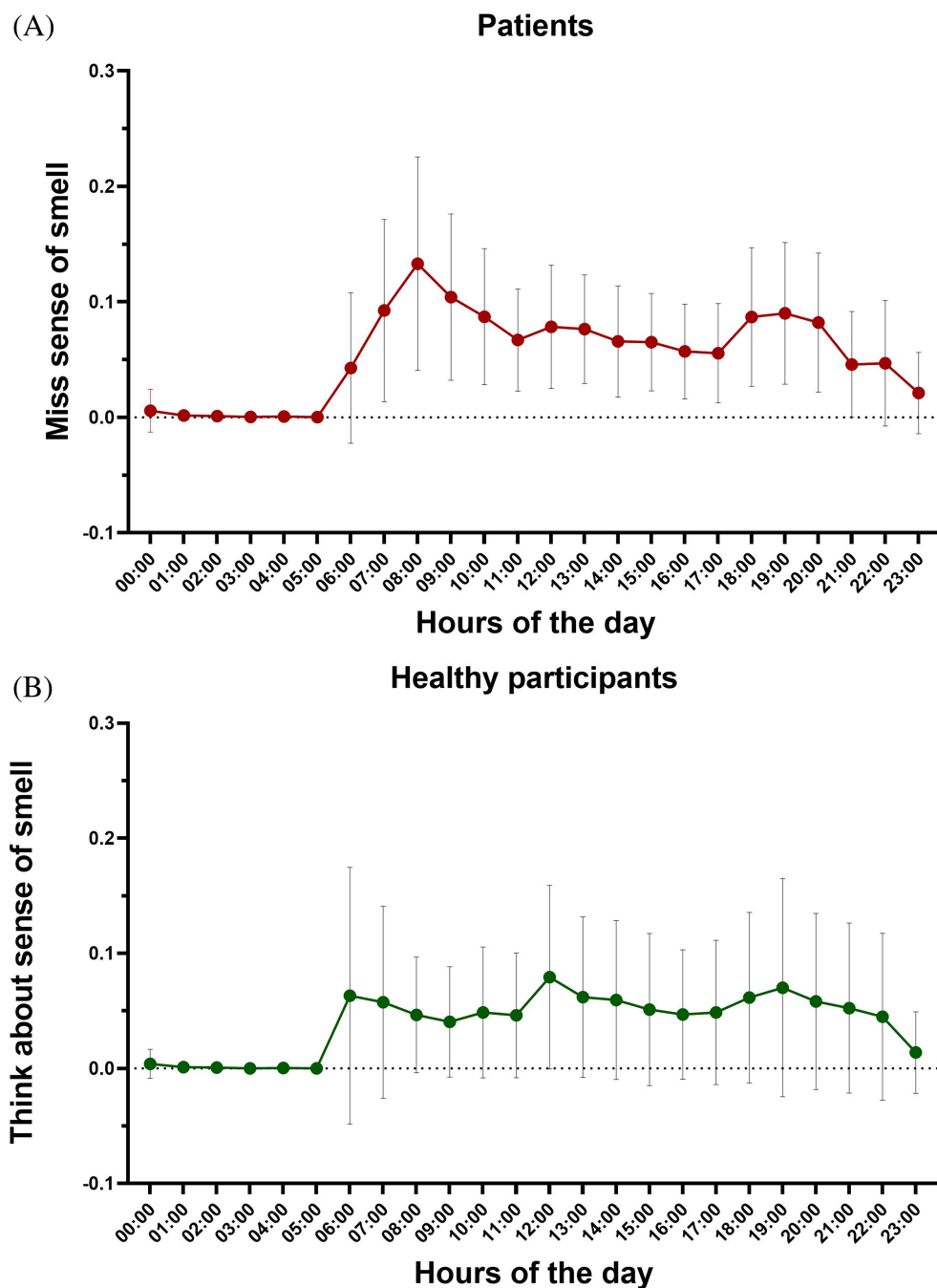


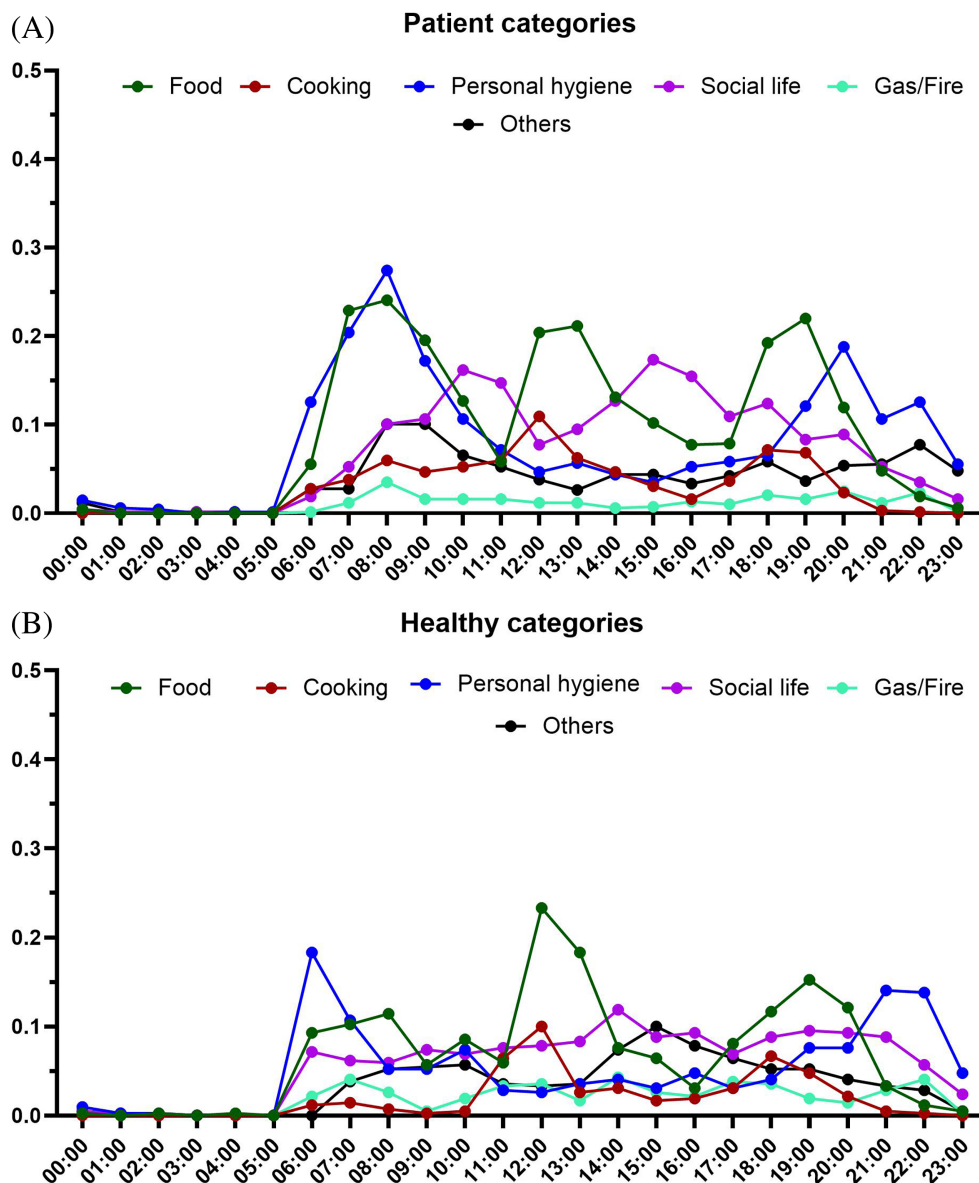
FIGURE 3 Olfactory function and smell loss during the course of the day across all categories. The dots represent the mean, the bars represent the standard deviation. The Y-axis denotes the average frequency of smell awareness for both patients and healthy participants, while the X-axis signifies the hour of the day.

environment and also suggested that 40 conscious perceptions of odors might be the upper limit for healthy participants. In line with this finding, we also found that healthy participants in our cohort reported a range of up to 31 conscious odor perceptions in everyday life. However, we found that our patient and reference groups perceived fewer odors consciously on a daily base. This discrepancy might be explained how odors were counted in both studies. In the previous study, participants were asked to count odor perceptions using a finger counter that was worn throughout the day. In contrast, participants in our study were asked to fill in a paper-based diary. There are a couple of potential reasons behind this phenomenon. First, utilizing a paper-based diary might have presented an additional hurdle in documenting every odor perception. The need to retrieve

the diary and physically write down entries with a pen could have hindered accurate tracking. Second, wearing a finger counter throughout the day could have heightened overall awareness of odors. This heightened consciousness might clarify why these participants reported perceiving more odors.

Our current study describes and reflects the consciousness of the sense of smell of patients with multiple causes of smell loss. We found that the areas related to eating/food were the areas in which patients were most conscious, followed by social activities and personal hygiene. These results align with a previous review on daily life problems in patients with smell loss in which the prevalence of problems in each area of everyday life (i.e., food, personal hygiene, social life) among patients with smell loss was summarized.¹ In that review, the

FIGURE 4 Olfactory function and smell loss during the course of the day in individual categories. The Y-axis denotes the average frequency of smell awareness for both patients and healthy participants, while the X-axis signifies the hour of the day.



authors showed that most patients (around 70%) complained about decreased enjoyment of food, followed by problems related to cooking, risk of failure to perceive fire or gas, personal hygiene, and social life. This is a very interesting finding showing that there is congruency between the momentary assessment (i.e., using a diary) vs. a one-time cross-sectional assessment of affected areas, providing evidence that the recall bias—error in the recall of information (i.e., related to mood, setting, and recency)—on problems related to daily life in patients with smell loss is only minimal. The finding that eating/food was the area for which the patients were most conscious was not surprising, considering the significant role of our sense of smell in flavor perception.^{32,33} In fact, we have previously shown that self-perceived taste/flavor loss might be more strongly associated with olfactory-related quality of life compared to the isolated loss of the sense of smell in patients with olfactory dysfunction.²⁵

The utilization of olfactory diaries presents an invaluable approach for acquiring more granular data on olfactory perception and consciousness, thus offering profound insights into individual

experiences and behaviors across the day. Through the elucidation of daily fluctuations and patterns in olfactory awareness, our study significantly advances the comprehension of consciousness's role in olfactory perception, thereby bearing implications for both clinical practice and research. The detailed documentation provided by the diary format offers a rich source of data for further analysis and interpretation. Future studies can build upon our findings by exploring additional factors influencing olfactory consciousness, such as environmental stimuli, emotional states, and cognitive processes. Additionally, the development of standardized protocols and tools for olfactory diary collection may enhance the consistency and comparability of results across studies, ultimately advancing our understanding of olfactory perception and its significance in various contexts.

The findings of the present investigation hold significant implications for guiding and enhancing clinical counseling for patients experiencing smell loss. Given the substantial effects of sudden loss of smell across various causes, it becomes crucial not only to diagnose and prescribe appropriate therapies but also to provide

comprehensive guidance on coping with smell loss in various aspects of daily life. This could involve advising patients to consistently carry deodorant, avoid consuming food that has been stored for too long in the fridge, or even consider installing a smoke detector for added safety precautions. Indeed, we have previously shown that the individual importance to the sense of smell decreases with the duration of smell loss.³⁴ Exploring further, the olfactory diary could serve as a valuable tool in longitudinal studies, offering insights into the evolving awareness of the sense of smell throughout the course of therapy spanning several months. This could provide a comprehensive understanding of changes in olfactory perception over time. Using an olfactory diary in clinical routine might make it more transparent for patients and involved physicians which categories of smell perception are compromised most in an individual case. Consequently, guidance toward specific measures as described above might be more efficient. Moreover, our methodology serves as a noteworthy exemplar for employing diaries in chronic diseases that profoundly impact quality of life, extending its applicability beyond olfactory dysfunction to diverse healthcare contexts.

Nevertheless, it is essential to interpret our study's findings in light of certain limitations. Primarily, our reliance on a paper-based diary to capture the hourly influence of smell loss on various daily life aspects might have introduced limitations. Retrieving and noting down olfactory sensations in the diary could have posed challenges, potentially leading our participants to miss documenting their perceived smells occasionally. Second, the inclusion of patients experiencing olfactory dysfunction in a study focused on consciousness regarding the sense of smell may introduce a potential limitation in the form of heightened awareness, thereby impacting the comparability of results. However, the integration of a control group within the study design allows for a direct comparison, mitigating the risk of bias and enhancing the validity of the findings. Furthermore, unlike app-based diaries, the paper-based format lacked reminder functions, possibly impacting the reported levels of consciousness toward olfactory sensations.

5 | CONCLUSION

To sum up, the olfactory diary emerges as a straightforward method for uncovering individualized patterns of olfaction awareness among patients experiencing smell loss. Its potential extends notably to aiding in counseling sessions and streamlining patient management strategies. The prominence of increased awareness regarding the sense of smell in aspects primarily linked to "food" underscores the pivotal significance of flavor perception for both patients and healthy participants. This emphasizes the crucial need for clinical counseling to prioritize methods that enhance the daily experiences of our patients, especially concerning their sense of smell.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interests regarding the publication of this article.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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