Received: 30 December 2023 | Accepted: 8 March 2024

DOI: 10.1002/wjo2.179

RESEARCH PAPER

World Journal of Otorhinolaryngology-Head and Neck Surgery

Recovery rates of persistent post-COVID-19 olfactory dysfunction using psychophysical assessment: A longitudinal cohort study

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Funding information
National Institute on Deafness and Other Communication Disorders and the National Institutes of Health, Grant/Award Number: K23DC019678; National Center for Advancing Translational Sciences, National Institutes of Health, Grant/Award Number: UL1TR001873

Abstract

Objectives: Persistent olfactory dysfunction (OD) following loss of smell associated with SARS-CoV-2 infection is a major feature of long COVID. Perspectives on the prevalence of persistent OD predominantly rely on self-reported olfactory function. Few studies have tracked longitudinal rates of recovery using psychophysical assessment among patients presenting for evaluation of persistent OD beyond a window of acute recovery. Data anchored in standardized testing methods are needed to counsel patients who fail to acutely regain their sense of smell. This study aims to quantify the degree of persistent OD in post-COVID-19 patients who experience subjective and psychophysical OD.

Methods: We grouped participants presenting for OD evaluation into cohorts based on both subjective and psychophysical olfactory status at a baseline assessment and assessed their olfactory abilities with a visual analogue scale and the Sniffin' Sticks extended test at baseline and 1-year time points. Participants had confirmed a history of COVID-19 by lab evaluation or clinical diagnosis if lab evaluation was not available.

Results: Baseline olfactory evaluation was completed by 122 participants, 53 of whom completed the 1-year follow-up assessment. Among participants presenting with perceived OD, 74.5% had confirmed psychophysical OD at baseline, with 55.1% at 1-year follow-up. Participants had reliable trends in self-rated versus psychophysically tested olfactory function at both time points. The total threshold, discrimination, and identification (TDI) score improved by +3.25 points in the cohort with psychophysical OD ($p = 0.0005$), with this improvement largely attributable to an increase in median threshold scores (+2.75 points; $p = 0.0004$).

Note: Work related to this manuscript was conducted at the following address: Columbia University Department of Otolaryngology-Head & Neck Surgery, 180 Fort Washington Ave., New York, NY 10032, USA.

Conclusions: OD persists in a significant number of patients who fail to acutely recovery their sense of smell after COVID-19, with many demonstrating lingering deficits at 1-year. Improvements in threshold, but not discrimination or identification, most significantly mediate improvement of total TDI score at follow-up.

KEYWORDS
long COVID, olfaction, post-COVID condition, smell dysfunction

Key points

- 19.4% of individuals with persistent psychophysical olfactory dysfunction (OD) at a baseline assessment at least 3 months after acute loss of smell experience olfactory normalization at 1-year follow-up.
- Improvement in total threshold, discrimination, and identification score for patients with subjective and psychophysical OD appears to be mediated by increases in median threshold scores.
- Prevalence of persistent OD as part of long-COVID is further reinforced via psychophysical assessment when trended longitudinally across olfactory subdomains.

INTRODUCTION

Olfactory dysfunction (OD) and gustatory issues emerged as hallmark symptoms of severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2), with the majority of patients experiencing smell and taste issues during the early stages of the coronavirus disease 2019 (COVID-19) pandemic.[1,2] Chemosensory dysfunction improved for most patients within 30 days following COVID-19,[3] and the prevalence of smell and taste dysfunction seemed to be SARS-CoV-2 variant dependent.[4] Rates of reported chemosensory improvement depend on the method of evaluation, where those suffering from OD with acute SARS-CoV-2 infection tend to overestimate the extent of their recovery in the months following COVID-19. Approximately 5% of patients reported persistent OD at 6 months following infection, whereas up to 68.9% have evidence of OD upon psychophysical assessment at 6 months, 26.5%–42.0% screening for OD at 12 months, and 27.9% with OD at 24 months following infection.[3,5–8]

Assessment of longitudinal olfactory status among patients following SARS-CoV-2 infection has been conducted using a variety of methods ranging from self-report to several forms of psychophysical evaluation, including comprehensive Sniffin' Sticks threshold, discrimination, and identification (TDI) testing and tests examining fewer olfactory domains such as the smell identification test (SIT).[2,3,5,8,9] Although several studies examine post-COVID-19 OD with an identification (I) psychophysical assessment, the additional measurement of threshold (T) and discrimination (D) could yield important insight into the pattern of olfactory loss associated with SARS-CoV-2.[10] Moreover, SARS-CoV-2 may affect olfactory T most strongly,[8,11] further emphasizing the need for comprehensive psychophysical assessment, rather than assessment of an isolated olfactory domain, in the longitudinal evaluation of patients' olfaction.

Although these studies yield a preliminary understanding of longitudinal olfactory trends after COVID-19,[12] there remains a need to clarify the prevalence of persistent OD in long-COVID. Specifically, data are needed to provide recovery prognostication for individuals who have failed to recover olfactory function within an anticipated window, where reporting of self-reported trends should be anchored in standardized psychophysical assessment. Individualized olfactory assessment and subsequent counseling on the most effective strategies for coping with persistent OD are both essential strategies in promoting patient satisfaction with the treatment of this condition.[13]

The aim of the present study is to provide further data on longitudinal olfactory recovery trends among individuals with persistent OD of at least 3 months following SARS-CoV-2 infection using combined self-report and comprehensive psychophysical assessment methods.

MATERIAL AND METHODS

Study design and population

Protocols for participant recruitment and study involvement (AAAT6202) were approved by an institutional review board through the CUIMC Human Research Protection Office. Written informed consent was obtained from all participants. Inclusion criteria were

participants of at least 18 years of age, noted subjective smell dysfunction following COVID-19 for at least 3 months since the time of initial infection, and confirmed diagnosis of COVID-19 by PCR positivity or validated positive serology to the SARS-CoV-2 nucleocapsid antibody. Individuals with the clinical diagnosis were accepted if diagnosed before widespread COVID-19 testing availability. Cases were recruited via Columbia University RecruitMe or following rhinologic evaluation in an ENT clinic for subjective smell and/or taste loss.

Exclusion criteria for groups consisted of the following: (1) pre-existing olfactory issues (congenital anosmia or ageusia, antecedent perceived smell or taste dysfunction); (2) individuals with rhinologic subdomain score greater than 21, representing more than a moderate problem for associated symptoms, and individuals noting a symptom represented more than a severe problem[14,15]; (3) pre-existing neurologic issues (stroke, TBI, repetitive concussion, and neurodegenerative disease) or other problems (history of autoimmune disease, history of nasal, or skull base surgery) that could independently contribute to OD.

Data collection and psychophysical olfactory assessment

Participants were evaluated at baseline time of presentation and again at 12-month interval following baseline assessment. Data were collected between April of 2021 and November of 2023. Participants underwent nasal endoscopy to rule out co-existent sinonasal disease using the Lund-Mackay and olfactory cleft endoscopy scale in determining eligibility. Demographics, general medical history, COVID-19 history, and self-reported olfactory status via visual analogue scale (VAS) were collected via the online Research Electronic Data Capture (REDCap) data management system. The VAS question read as follows: "Thinking about *TODAY*, rate how well you can smell," with a range from 0 (No sense of smell) to 100 (Excellent sense of smell). The evaluation was performed in a private, well-ventilated setting with personnel consisting only of the tester and subject. Orthonasal olfaction was assessed using the validated extended Sniffin' Sticks test battery (Burghart Messtechnik GmbH, Holm, Germany) including phenylethyl-alcohol (PEA) odor thresholds (T), discrimination (D), and identification (I).[16] Individual scores were summed into a comprehensive TDI score. Participants were classified as functional anosmics (TDI ≤ 16), hyposmics (TDI ≥ 16.25 and ≤30.5), and normosmics (TDI ≥ 30.75) according to previously established cutoffs.[17]

Participants were classified into one of three cohorts depending on their subjective and semi-objective/psychophysical olfactory status: (1) subject reports subjective OD (sOD), subject tests positive for psychophysical OD upon Sniffin' sticks evaluation (pOD) (Group 1: pOD); (2) subject reports sOD, subject tests negative for pOD upon Sniffin' Sticks evaluation (Group 2: sOD); (3) subject does not report sOD, subject tests negative for pOD upon Sniffin' Sticks evaluation (Group 3: Control). Individuals were classified within a cohort based on results from baseline psychophysical testing and remained in the same cohort at the 12-month time point. All individuals had a history of SARS-CoV-2 infection, regardless of cohort status.

SARS-CoV-2 strain classification

To infer the potential viral variant responsible for each participant's infection, we categorized the date of diagnosis into specific time windows, each associated with a predominant viral variant that was circulating globally and regionally during that period, according to the Centers for Disease Control and Prevention (CDC).[18] The classification was based on the following date ranges:

- Initial variant: From February 1, 2020 to December 28, 2020;
- Alpha (B.1.1.7 lineage): From December 29, 2020 to February 26, 2021;
- Epsilon (B.1.427/1.429): From February 27, 2021 to June 15, 2021;
- Delta (B.1.617.2 lineage): From June 16, 2021 to November 26, 2021;
- Omicron (B.1.1.529): From November 27, 2021 to October 25, 2023.

Start and end dates were chosen to reflect the date at which a variant was labeled as a "Variant of Concern" or "Variant of Interest" by the CDC, as each of these classifications reflects a likelihood for increased transmissibility when compared to prior strains.[18] Cases diagnosed outside these specified date ranges were not assigned to any variant category. It is essential to note that this classification is a heuristic based on predominant strains during specific periods and does not confirm the actual viral lineage of each case.

Statistical analyses

Descriptive statistics were calculated as means and standard deviations for continuous variables. Statistical tests for the descriptive statistics are outlined in Table 1. Unpaired differences in psychophysical testing values between baseline and 1-year time points were assessed with a Mann–Whitney *U* test for the greater cohorts ($n = 122$ at baseline, $n = 53$ at follow-up). Paired differences for intra-individual changes from baseline to 1-year ($n = 53$) were evaluated with a Wilcoxon signed-rank test. The term "unpaired" will be applied to differences between the greater cohorts, whereas "paired" will be used to denote analyses for those 53 participants who completed evaluation at both time points. Evaluation of relatedness for Pearson's r between VAS and total TDI scores was conducted using a linear mixed-effects model analysis which examined the degree of change in the correlation between VAS and TDI when considering the addition of time. Intergroup comparisons for olfactory subdomains were performed using independent

TABLE 1 Descriptive statistics of the study population at each time point.

Characteristics	Time point		
	Baseline (n = 122)	1-year (n = 53)	p-Value
Age (years)			0.951
Mean (SD)	44 (16)	44 (14)	
Range	17–81	20–81	
Sex [female, n(%)]	93 (76.2)	34 (64.2)	0.082
Ever smoked			0.713
Yes [n(%)]	19 (16.5)	10 (19.6)	
No [n(%)]	96 (83.5)	41 (80.4)	
Not reported	7	2	
Active smoking			0.829
Daily [n(%)]	1 (0.9)	1 (2.0)	
Less than daily [n(%)]	2 (1.7)	1 (2.0)	
Not at all [n(%)]	113 (97.4)	49 (96.1)	
Not reported	6	2	
Days from COVID-19 diagnosis			
Mean (SD)	469 (285)	838 (236)	
Variant			0.476
Initial variant [n(%)]	70 (57.9)	34 (65.4)	
Alpha [n(%)]	15 (12.4)	8 (15.4)	
Epsilon [n(%)]	3 (2.5)	2 (3.9)	
Delta [n(%)]	8 (6.6)	1 (1.9)	
Omicron [n(%)]	25 (20.47)	7 (13.5)	
Not reported	1	1	
Smell cohort [n(%)]			0.783
Psychophysical OD (pOD)	87 (71.3)	37 (69.8)	
Subjective OD (sOD)	23 (18.9)	12 (22.6)	
Control	12 (9.8)	4 (7.5)	
Race/ethnicity [n(%)]			
White	66 (54.1)	30 (56.6)	0.760
Black/African American	6 (4.9)	4 (7.5)	0.491
Asian	8 (6.6)	4 (7.5)	0.812
Hispanic	20 (16.4)	6 (11.3)	0.662
Other	3 (2.5)	0 (0)	0.612
Prefer not to say/did not respond	7 (5.7)	2 (3.8)	0.385
Multiple races/ethnicities	12 (9.8)	7 (13.2)	0.510

Note: All participants included in the 1-year time point (n = 53) were also included in the Baseline time point (n = 122). Descriptive statistical tests involved: t-test (continuous variables), Kruskal–Wallis (ordinal variables), Fisher's exact test (binary variables), and chi-squared test (factors/multi-category variables). Values of $p < 0.05$ are statistically significant.

samples parametric t-test. All statistical analyses were conducted in R (version 2023.09.1+494, Posit Software, PBC, Vienna, Austria).

RESULTS

A total of 122 participants (29 males and 93 females) completed baseline psychophysical assessment. Among these participants, 53 completed a 1-year follow-up psychophysical evaluation (19 males and 34 females). The average age of the participants was 44 years old at baseline and follow-up. Participants reported a low rate of active smoking, with only three individuals reporting regular cigarette usage and one reporting regular e-cigarette consumption at baseline. Approximately 16% of the baseline and follow-up populations reported smoking cigarettes at least once in the past. The time from COVID-19 diagnosis to baseline psychophysical assessment was approximately 469 days for the 122 participants completing an initial assessment. The 1-year psychophysical evaluation took place approximately 838 days following SARS-CoV-2 infection. The distribution of SARS-CoV-2 strains inferred from the timing of participants' COVID-19 diagnosis was not significantly different between the two time points. Additionally, the cohort distribution according to subjective and semi-objective OD status was similar between baseline and 1-year follow-up. There was no difference in the breakdown of racial categories between the time points (Table 1).

OD was noted in 82 participants (74.5%) upon baseline psychophysical testing, with 14 participants (12.7%) meeting the criteria for functional anosmia (Figure 1A). At 1-year follow-up, 55.1% of participants still exhibited some degree of pOD, with 4.1% of the total 1-year population screening for anosmia (Figure 1B). Participants screening for pOD at baseline experienced the greatest improvement in TDI score at the 1-year follow-up assessment (Figure 2), where the pOD cohort had an overall improvement of +3.25 points in TDI score (Table 2; $p = 0.0005$). The two cohorts without pOD at baseline (sOD and control) showed no significant change in TDI score at follow-up (Table 2).

Examination of individual T, D, and I scores across cohorts was performed (Figure 3). Statistically significant changes in olfactory subdomain scores were observed in the pOD and sOD cohorts (Table 2). The pOD cohort had a +2.75 points gain in T which achieved significance for both unpaired and paired Wilcoxon tests ($p = 0.0004$ and $p = 0.0013$, respectively). This cohort also had a +1 point gain in D, a finding that was significant via unpaired Wilcoxon analysis ($p = 0.0136$) but not significant upon examination of composite intra-individual changes in the paired Wilcoxon test. There was also a +1 point gain in identification that was nonsignificant.

The sOD group showed a small increase in T score (+1.5 points), although this did not achieve significance (Table 2). This cohort experienced a decline in median D score of −1 points, a change found to be narrowly insignificant via both Wilcoxon analyses (paired $p = 0.0.0535$, unpaired $p = 0.0516$). There was a +0.5 point gain in identification for this cohort that was nonsignificant. Due to the pOD

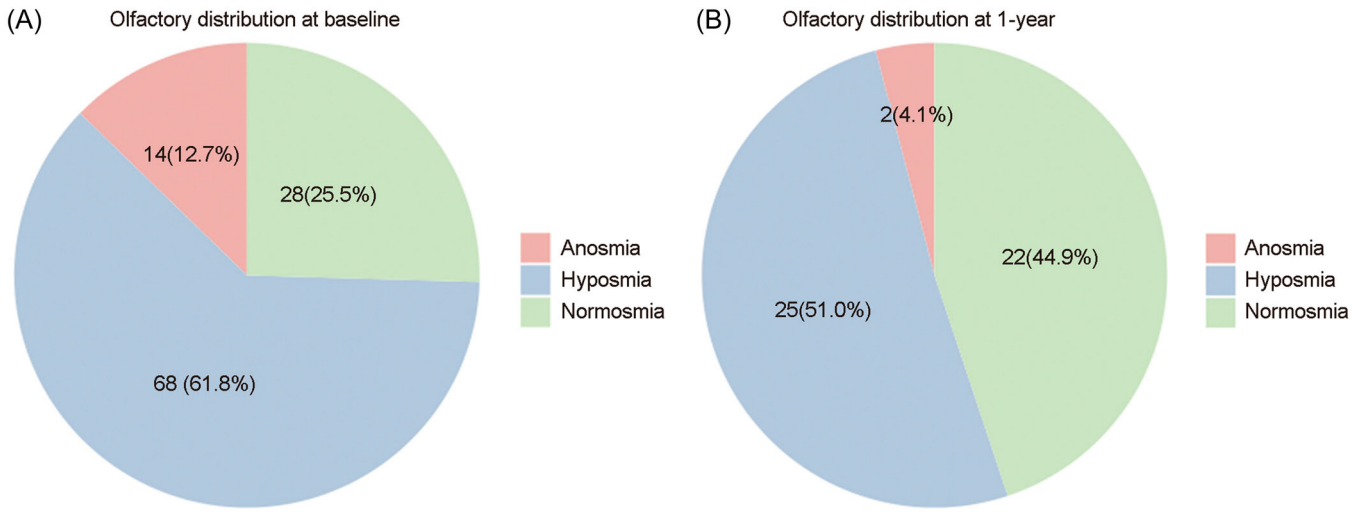


FIGURE 1 Pie charts with pooled subjective olfactory dysfunction (sOD) and psychophysical olfactory dysfunction (pOD) participants (no controls) showing overall distribution of olfactory status at (A) baseline and (B) 1-year psychophysical assessment according to threshold, discrimination, and identification (TDI) score groupings (TDI < 16: anosmia; TDI ≥ 16.25 and ≤ 30.5: hyposmia; TDI ≥ 30.75: normosmia).

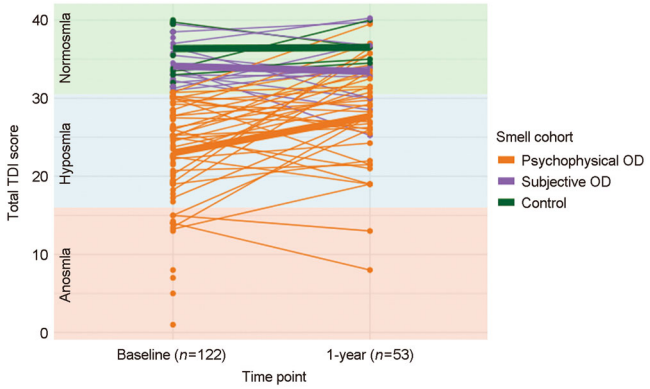


FIGURE 2 Spaghetti plot representing trends in participant threshold, discrimination, and identification (TDI) scores from baseline to 1-year psychophysical assessment. Thin lines represent trends for specific participants. Bold lines represent trends for larger olfactory cohorts. Olfactory groupings represented by color blocks: green (normosmia), blue (hyposmia), and red (anosmia). OD, olfactory dysfunction.

and sOD groups having the most robust numbers of participants at Baseline and 1-year, an intergroup parametric *t*-test was performed to evaluate whether the difference in 1-year values was significantly different from one another for each olfactory subdomain. Results show that only the I subdomain was significantly different between pOD and sOD groups at 1-year ($p = 0.01$), although the difference in T was close to achieving statistical significance ($p = 0.06$, Figure 3).

There were no notable changes in the magnitude of subdomain scores for the control cohort, nor did any variable achieve statistical significance for this group when moving from Baseline to 1-year psychophysical assessment (Table 2). Lastly, the relationship between olfactory VAS and TDI scores was assessed to verify the reliability of this study's intention-to-treat cohort designation based on subjective and psychophysical olfactory status (Figure 4). VAS scores were strongly correlated with TDI scores at Baseline and 1-year (Figure 4), with linear mixed-effects modeling analysis showing a nonsignificant change in Pearson's *r* from Baseline to 1-year (Table 3).

DISCUSSION

This study highlights the overall prevalence of persistent OD using self-report and psychophysical testing methods 12 months after initial evaluation among individuals suffering from limited olfactory recovery as part of long-COVID. Nearly 74.5% of this study's participants showed signs of pOD upon baseline psychophysical assessment, with 55.1% experiencing persistent OD 12 months thereafter, and yet many of these individuals exhibited statistically significant improvement in their TDI scores. Evaluation of changes within Sniffin' Sticks subdomains showed that this overall trend was primarily mediated by improvement in threshold (T), but not discrimination (D) or identification (I). Moreover, the improvement in T for the pOD cohort achieves the minimal clinically important difference (MCID) for this subdomain (2.5 points), indicating a robust improvement that should be perceivable by participants.[19,20] However, these participants did not reach MCID for the total TDI score (5.5 points) primarily due to marginal improvement in the D and I components.[20] Understanding the pattern of olfactory domains affected by COVID-19 is important, given that different disease states generate a unique pattern of olfactory loss.[10] This study supports a pattern of threshold rather than recovery of olfactory discrimination or identification abilities for most individuals with COVID-19-associated OD.[17]

It is interesting to note the decline in the discrimination performance among the sOD group over the course of 1-year. Although the decline was modest (−1 point, paired *p*-value = 0.0516),

TABLE 2 Breakdown of median olfactory scores by smell cohort at Baseline and 1-year psychophysical assessment.

Cohort	Variable	Baseline (median)	1-year (median)	Unpaired *p*-value	Paired *p*-value
Psychophysical OD	Threshold	5	7.75	0.0004	0.0013
$N = 87 \rightarrow N = 37$	Discrimination	10	11	0.0136	0.1560
	Identification	9	10	0.1160	0.3760
	Total TDI	25	28.25	0.0005	0.0032
Subjective OD	Threshold	8.5	10	0.1860	0.0991
$N = 23 \rightarrow N = 12$	Discrimination	13	12	0.0535	0.0516
	Identification	12	12.5	0.9720	0.4430
	Total TDI	33	33.38	0.7940	0.4330
Control	Threshold	11.25	10.25	0.3300	0.8750
$N = 12 \rightarrow N = 4$	Discrimination	13.5	13.5	0.8520	0.8500
	Identification	12.5	13.5	0.3890	0.4610
	Total TDI	37	35.75	0.7150	0.5810

Note: Number of participants at baseline → 1-year shown below cohort label. "Unpaired *p*-value" column represents the Mann–Whitney *U* test conducted on pooled populations at Baseline and 1-year. "Paired *p*-value" column represents the Wilcoxon signed-rank test conducted to assess changes in matched pairs over time (i.e., change in individual participant scores at Baseline and 1-year). Values of $p < 0.05$ are statistically significant.

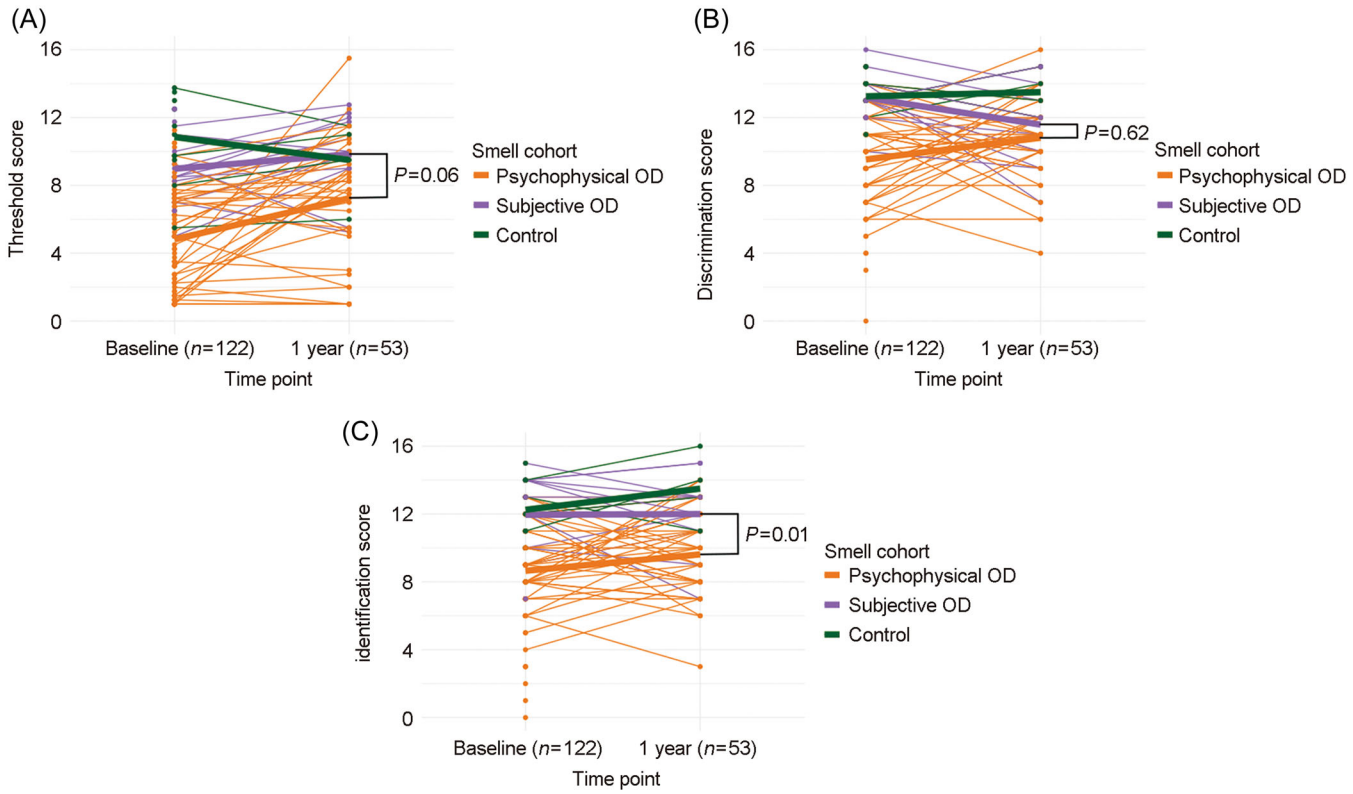
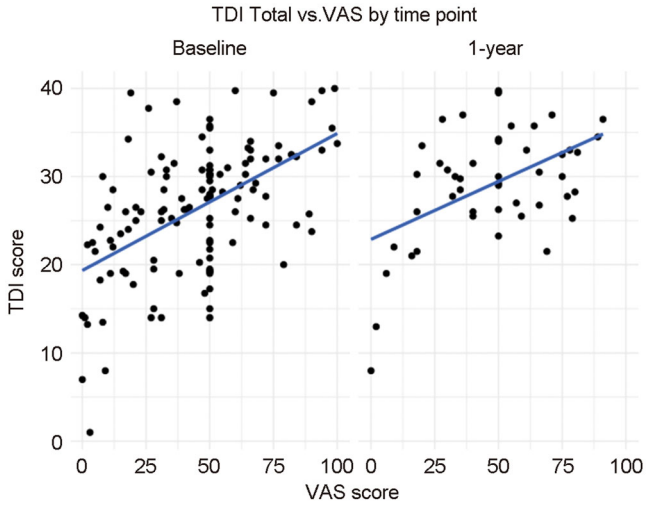


FIGURE 3 Spaghetti plots representing trends in olfactory subdomains of T (A), D (B), and I (C) from baseline to 1-year psychophysical assessment. Thin lines represent trends for specific participants. Bold lines represent trends for larger olfactory cohorts. There is overlap for some data points in the graphs given that threshold scores have a finite number of possibilities ranging from 1 to 16, and discrimination and identification test scores are integers ranging from 0 to 16. *p*-Values represent post hoc Tukey's HSD comparison of psychophysical olfactory dysfunction (pOD) and subjective olfactory dysfunction (sOD) groups at 1-year.



	Pearson's r	p-value
Baseline	0.527	<0.0001
1-year	0.495	0.0004

FIGURE 4 Correlation between visual analogue scale (VAS) score for olfactory status and psychophysically measured threshold, discrimination, and identification (TDI) score for study participants at Baseline and 1-year assessment.

TABLE 3 Results from linear mixed-effects model analysis examining the relationship of VAS scores and time with TDI scores and the interaction [VAS:timepoint(1-year)] of VAS scores and time with TDI scores. Significance codes: *** | $p < 0.001$, ** | $p < 0.01$, * | $p < 0.05$.

Interaction terms	Estimate	Std. error	*p*-Value
VAS	0.15631	0.02181	<0.0001***
timepoint (1-year)	4.12227	1.94590	0.0372*
VAS:timepoint (1-year)	−0.03857	0.03729	0.3040

it could be indicative of an individual's ability to predict olfactory decline before having a psychophysical test with evidence of OD. This trend has been observed in other studies, specifically looking at identification performance, which has shown that subjective olfactory loss predicts psychophysical olfactory decline upon subsequent testing.[21] These results suggest that individuals who report subjective OD but display clinical normosmia upon baseline psychophysical testing might accurately predict a decline in at least one olfactory domain in the future. This finding emphasizes the importance of patients' self-reported olfactory status both in appreciating current disease and anticipating OD that could arise in a delayed manner.

This study's finding that improvement in OD among post-COVID participants is primarily driven by recovery of olfactory threshold is corroborated by other literature.[11] Vandersteen et al.[11] reported that post-COVID patients who used olfactory training (OT) have normalization of their olfactory threshold scores at 6 months following baseline assessment. Importantly, their study did not include a control group, making it difficult to ascertain whether their report of improvement in the olfactory threshold alongside OT was due to OT or simply from spontaneous recovery, as observed in the present study. Additionally, the Vandersteen et al.[11] study raises important questions on the utility of OT to improve olfactory performance in domains without strong evidence of spontaneous recovery—D and I. The present study suggests that there is spontaneous improvement in olfactory threshold thus implying that a therapy targeted at D and I would be of greatest benefit to those suffering from persistent OD following COVID-19. OT would be a logical therapeutic option when evaluating this clinical profile, given its propensity to improve D and I olfactory domains in other studies examining post-viral OD.[22] However, these domains appear to be unaffected by OT when used for persistent post-COVID OD.[11] Further investigation into novel therapeutics for persistent OD is needed, given the limited efficacy of OT for this condition.

The finding of improvement in T and a lack of improvement in both D and I for the pOD cohort is not universal among studies utilizing psychophysical testing with longitudinal follow-up for post-COVID-19 patients. Boscolo-Rizzo et al.[8] found that D and I, not T, improved in post-COVID-19 patients. They show that T is the most strongly impacted olfactory domain affected following COVID-19 and use this observation to explain the finding of nonsignificant threshold improvement over time.[7] Although evaluating different etiologies of OD, the findings from the present study support the hypothesis proposed by Bsteh et al.[23] that a decline in olfactory T represents a transient inflammatory activity which would be expected to resolve, albeit over a prolonged time course, for some post-COVID-19 patients. The improvement in olfactory T is corroborated by Schepens et al.,[24] where a similar prospective cohort design was executed to assess longitudinal recovery rates for individuals with post-COVID smell loss. There are few published studies that have incorporated a longitudinal cohort design in assessing olfactory recovery in post-COVID-19 patients. This is especially true with respect to longitudinal trends in olfactory subdomains like T, D, and I. As observed, individual studies have shown disparate patterns regarding the recovery rates of olfactory subdomains.[8,24] Thus, there is a need for additional investigation into the longitudinal course of post-COVID-19 olfactory recovery along with systematic analysis of the existing literature—such works could provide important benchmarks for post-COVID-19 olfactory prognostication.

This study provides insight into longitudinal olfactory recovery trends using psychophysical assessment among individuals who do not experience appreciable acute recovery of their sense of smell following COVID-19. The present study is unique in its classification of patient cohorts based on labels of both subjective and psychophysical olfactory status applied in an intention-to-treat manner upon baseline psychophysical assessment. Additionally, our study population presented at a mean of 469 days following COVID-19 diagnosis for baseline psychophysical assessment, adding to the strength of our results in delineating trends in *persistent* post-COVID-19 OD. The limitations of this study include a lack of pre-COVID olfactory assessment, limited numbers of participants within some of the

longitudinal cohort groupings (i.e., control group), and potential biases imparted by recruitment into the study from an Otolaryngology clinic specializing in olfactory disorders.

CONCLUSIONS

This study adds to the current literature in reporting the prevalence of psychophysically tested OD in long-COVID patients at baseline and 1-year assessment time points. Additionally, these results provide important information on the trajectory of recovery for individuals reporting subjective and/or psychophysical OD while also investigating trends in the olfactory subdomains stratified by cohort. While patients with post-COVID-19 OD show evidence of olfactory recovery with the passage of time, a significant number of individuals experience persistent OD at 12 months following baseline psychophysical assessment.

AUTHOR CONTRIBUTION

The work in this paper has not been published or submitted for publication elsewhere. All listed authors have contributed significantly to the development of this manuscript. Author roles are as follows: *Methodology, data curation, statistical analysis, writing—original draft, and conceptualization*: Jeremy P. Tervo. *Conceptualization, data curation, writing—review and editing*: Patricia T. Jacobson. *Conceptualization, data curation, writing–review and editing*: Brandon J. Vilarello. *Conceptualization and data curation*: Francesco F. Caruana. *Conceptualization and data curation*: Liam W. Gallagher. *Conceptualization and data curation*: Tiana M. Saak. *Conceptualization and data curation*: Joseph B. Gary. *Supervision, project administration, writing—review and editing*: David A. Gudis. *Project administration, writing—review and editing*: Paule V. Joseph. *Project administration, writing—review and editing*: Terry E. Goldberg. *Project administration, writing—review and editing*: D. P. Devanand. *Methodology, conceptualization, writing—review and editing, supervision, and project administration*: Jonathan B. Overdevest.

ACKNOWLEDGEMENTS

Support for this study and for Dr. Overdevest were provided by grant K23DC019678 from the National Institute on Deafness and Other Communication Disorders and the National Institutes of Health, with additional support provided through grant UL1TR001873 [Clinical and Translational Science Award Program at Columbia University Irving Medical Center] from the National Center for Advancing Translational Sciences, National Institutes of Health. The content of this study is solely the responsibility of the authors and does not necessarily represent the official views of the NIH. The funders did not play a role in study design, data collection/analysis, decision to publish, or manuscript preparation.

CONFLICT OF INTEREST STATEMENT

Professor David A. Gudis is a member of World Journal of Otorhinolarygology—Head & Neck Surgery (WJOHNS) editorial board and is not involved in the peer review process of this article. The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

ETHICS STATEMENT

This study was approved by the CUIMC IRB #AAAT6202.

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How to cite this article: Tervo JP, Jacobson PT, Vilarello BJ, et al. Recovery rates of persistent post-COVID-19 olfactory dysfunction using psychophysical assessment: a longitudinal cohort study. *World J Otorhinolaryngol Head Neck Surg*. 2024;10:79-87. doi:10.1002/wjo2.179