

ORIGINAL RESEARCH

Factors associated with loss and recovery of smell and taste after COVID-19 infection

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Abstract

Objective: To identify predictors associated with loss and recovery of smell and taste after COVID-19 infection.

Methods: The Integrated Public Use Microdata Series (IPUMS) 2021 National Health Interview Series (NHIS) database was used to analyze factors associated with loss and recovery of smell and taste in respondents who had a previous COVID-19 infection. Significant variables from univariate analysis were included in a stepwise backward regression model to identify independent predictors.

Results: Of the 3844 individuals who answered yes to having contracted COVID-19, 51.1% and 48.9% reported losing smell and taste, respectively. 95.7% recovered smell and 97% recovered taste. Predictors associated with higher odds of reporting a loss of smell included younger age (odds ratio [OR] 0.98; 95% confidence interval [CI] 0.98–0.99), female sex (OR 1.38; CI 1.17–1.63), use of e-cigarettes (OR 1.59; CI 1.25–2.02), and Mexican ethnicity (OR 1.61; CI 1.22–2.11). Predictors of taste loss were younger age (OR 0.98; CI 0.98–0.99), female sex (OR 1.31; CI 1.08–1.58), and higher BMI (OR 1.02; CI 1.00–1.04). Female sex was associated with decreased odds of reporting a recovery of smell (OR 0.74; CI 0.59–0.92) and taste (OR 0.54; CI 0.42–0.69). Black/African American race (OR 1.44; CI 1.03–2.03) and non-Mexican Hispanic ethnicities (OR 1.55; CI 1.02–2.34) were associated with an increased likelihood of reporting the recovery of smell.

Conclusion: Various factors may be associated with the loss and recovery of smell and taste after COVID-19 infections. Clinicians may use this information to better counsel patients with these symptoms.

Level of evidence: 4.

KEYWORDS

anosmia, COVID-19, dysgeusia, smell loss, taste loss

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1 | INTRODUCTION

The coronavirus disease (COVID-19), caused by the novel coronavirus SARS-CoV-2, is known to negatively impact the respiratory, olfactory, and gustatory organ systems.^{1,2} Based on recently published systematic reviews and meta-analyses, the prevalence of olfactory dysfunction and gustatory dysfunction is estimated to be between 41–52.7% and 38.2–43.9% among patients who test positive for COVID-19, respectively.^{3–6} When combined, the prevalence of loss of smell and taste has an estimated prevalence of 35.1%.³

Individuals who experience loss of taste or smell due to COVID-19 face significant quality of life (QOL) declines, personal safety risks, and job performance challenges. Olfactory dysfunction particularly can lead to less hygiene awareness, loss of appetite, and inability to detect hazards, such as gas, fire, or smoke.^{7,8} Those with gustatory dysfunction have reported decreased enjoyment in eating, loss of appetite, and difficulty identifying spoiled foods.^{7,8} Additionally, many individuals have reported depression and reduced enjoyment of life associated with loss of smell and taste, and certain occupational groups have experienced limitations in job performance, leading to job insecurity, financial instability, and eventual search for alternative employment.^{7–10}

Recovery times from olfactory and gustatory dysfunction can vary among individuals. While most recover some sense of taste and smell within 3 months, an observational cohort study by McWilliams et al. found that after 2 years, 54.3% of individuals only partially recovered these senses, while 7.5% reported no recovery at all.¹¹ In a large single-institution study, Johnson et al. analyzed a wide array of potential predictors associated with smell and taste loss.¹² However, to the best of our knowledge, there appear to be no existing studies investigating comorbidities and social factors that influence recovery of smell and taste following loss due to COVID-19. In our study, we analyzed the 2021 National Health Interview Survey to identify predictors associated with loss and recovery of smell and taste after COVID-19 infection.

2 | METHODS

2.1 | Study design

This study was determined to be exempt from review by the University of Southern California's Institutional Review Board as the queried database contained no identifiable patient information. The Integrated Public Use Microdata Series (IPUMS) 2021 National Health Interview Series (NHIS) database was used as the data source for this study. The NHIS included data from 37,743 adults (≥ 18 years old) who completed the NHIS census questionnaire in 2021. The queried data is publicly available with all patients de-identified. The 2021 annual NHIS data file was utilized as this was the first iteration of the survey to include questions specific to COVID-19, and the NHIS database has been previously used by other research groups.^{13,14} The acquired NHIS data series included variables consisting of geography, core

demographics, ethnicity/nativity, education, profession, material hardships, general health, women's health, influenza, medical conditions, smoking, non-cigarette tobacco usage, anxiety, depression, and COVID-19.

Respondents who indicated having been diagnosed with COVID-19 after a positive test were further asked about suffering loss of taste or smell or experiencing phantom smells or tastes. Those who reported losing smell and/or taste were then asked about whether they experienced recovery of smell or taste, and whether this recovery was full, partial, or negligible. Respondents who did not report a previous history of coronavirus/COVID-19 according to a diagnostic test were excluded from this study. A complete list of survey variables that were assessed in this study can be found in Appendix S1.

2.2 | Statistical analysis

Univariate and multivariate analyses were utilized to investigate the association between potential predictor variables and loss and recovery of smell and taste in respondents who had a previous COVID-19 infection. Separate analyses were performed for loss of smell, loss of taste, recovery of smell, and recovery of taste. Univariate analysis consisted of Pearson's chi-squared test and Fisher's exact test for categorical variables, while the Shapiro-Francia test and Mann-Whitney *U* test were utilized for continuous variables. For multivariate analysis, variables that were found to be statistically significant ($p < .05$) on univariate analysis were included in a stepwise backward regression to evaluate their association with loss and recovery of smell and taste. Logistic regression was performed for loss of smell and taste, while ordinal regression was performed for recovery of smell and taste to assess associations with full recovery, partial recovery, or non-recovery of smell or taste. A Bonferroni correction was calculated and adjusted for the number of variables included in the backward stepwise regression to reduce the likelihood of false positives within our analysis. The entry variable significance level was set at 0.05 for every dependent variable, but the stay variable significance level was set to the variable set by the Bonferroni correction based on the total number of tests. All data analysis was performed in Stata/SE (v. 18.0, StataCorp. LLC, College Station, TX).

3 | RESULTS

There were 3844 respondents who reported testing positive for coronavirus/COVID-19. Of those who tested positive, 1963 (51.1%) and 1881 (48.9%) answered "Yes" to losing smell or taste, respectively, while 1692 (44.0%) individuals reported losing both smell and taste.

Of individuals who reported loss of smell, 1374 (70.0%) responded that they fully recovered their sense of smell, 505 (25.7%) reported partial recovery, while 83 (4.2%) reported no recovery at all. Among respondents who reported a loss of taste, 1403 (74.6%) responded that they fully recovered, 422 (22.4%) indicated partial recovery, while 54 (2.9%) reported no recovery (Table 1).

TABLE 1 Factors associated with loss of smell and taste.

Loss of smell due to COVID-19	Reported “Yes” (N = 1963)	Reported “No” (N = 1220)	Total (N = 3183)	p
Age				<.001
N	1961	1218	3179	
Mean (SD)	45 (16.4)	51.2 (18.1)	47.3 (17.3)	
Median (IQR)	43 (31, 57)	52 (36, 66)	46 (33, 60)	
Range	18, 85	18, 85	18, 85	
Sex				<.001
Male	814 (41.5%)	583 (47.8%)	1397 (43.9%)	
Female	1149 (58.5%)	637 (52.2%)	1786 (56.1%)	
Current marital status				.003
Married—Spouse present	907 (46.2%)	544 (44.6%)	1451 (45.6%)	
Married—Spouse not in household	55 (2.8%)	39 (3.2%)	94 (3.0%)	
Widowed	110 (5.6%)	113 (9.3%)	223 (7.0%)	
Divorced	247 (12.6%)	151 (12.4%)	398 (12.5%)	
Separated	40 (2.0%)	18 (1.5%)	58 (1.8%)	
Never Married	544 (27.7%)	313 (25.7%)	857 (26.9%)	
Hispanic ethnicity				<.001
Not Hispanic/Spanish origin	1472 (75.0%)	1002 (82.1%)	2474 (77.7%)	
Mexican	292 (14.9%)	117 (9.6%)	409 (12.8%)	
Other Hispanic	196 (10.0%)	96 (7.9%)	292 (9.2%)	
Body mass index				.031
N	1784	1113	2897	
Mean (SD)	28.8 (5.7)	28.2 (5.4)	28.6 (5.6)	
Median (IQR)	27.9 (24.7, 32.1)	27.5 (24.2, 31.4)	27.8 (24.4, 31.9)	
Range	17.2, 51	17.2, 48.9	17.2, 51	
Had ANY flu vaccine, past 12 months				.015
No	1078 (54.9%)	619 (50.7%)	1697 (53.3%)	
Yes	854 (43.5%)	587 (48.1%)	1441 (45.3%)	
Ever told had arthritis/rheumatoid arthritis/gout/lupus/ fibromyalgia				<.001
No	1554 (79.2%)	885 (72.5%)	2439 (76.6%)	
Yes	406 (20.7%)	335 (27.5%)	741 (23.3%)	
Ever told had cancer				<.001
No	1818 (92.6%)	1060 (86.9%)	2878 (90.4%)	
Yes	145 (7.4%)	159 (13.0%)	304 (9.6%)	
Ever told had high cholesterol				.013
No	1437 (73.2%)	844 (69.2%)	2281 (71.7%)	
Yes	521 (26.5%)	374 (30.7%)	895 (28.1%)	
Ever told you had dementia				.014
No	1955 (99.6%)	1206 (98.9%)	3161 (99.3%)	
Yes	8 (0.4%)	14 (1.1%)	22 (0.7%)	
Ever told had diabetes				.022
No or not mentioned	1769 (90.1%)	1069 (87.6%)	2838 (89.2%)	
Yes or mentioned	192 (9.8%)	151 (12.4%)	343 (10.8%)	
Ever told had hypertension				.004
No	1329 (67.7%)	766 (62.8%)	2095 (65.8%)	

(Continues)

TABLE 1 (Continued)

Loss of smell due to COVID-19	Reported “Yes” (N = 1963)	Reported “No” (N = 1220)	Total (N = 3183)	p
Yes	632 (32.2%)	453 (37.1%)	1085 (34.1%)	
Ever been told you had COPD				.017
No	1873 (95.4%)	1142 (93.6%)	3015 (94.7%)	
Yes	86 (4.4%)	77 (6.3%)	163 (5.1%)	
Ever used e-cigarette				<.001
No	1489 (75.1%)	1022 (83.8%)	2511 (78.9%)	
Yes	421 (21.4%)	162 (13.3%)	583 (18.3%)	
Ever told you had any anxiety disorder				.001
No	1568 (79.9%)	1033 (84.7%)	2601 (81.7%)	
Yes	393 (20.0%)	187 (15.3%)	580 (18.2%)	
Severity of coronavirus/COVID-19 symptoms at their worst				<.001
No symptoms	43 (2.2%)	219 (18.0%)	262 (8.2%)	
Mild symptoms	700 (35.7%)	469 (38.4%)	1169 (36.7%)	
Moderate symptoms	791 (40.3%)	373 (30.6%)	1164 (36.6%)	
Severe symptoms	429 (21.9%)	159 (13.0%)	588 (18.5%)	
Loss of taste due to COVID-19	Reported “Yes” (N = 1881)	Reported “No” (N = 1316)	Total (N = 3197)	p
Age				<.001
N	1879	1314	3193	
Mean (SD)	45.3 (16.4)	50.3 (18.2)	47.4 (17.3)	
Median (IQR)	43 (32, 57)	51 (35, 64)	46 (33, 61)	
Range	18, 85	18, 85	18, 85	
Sex				<.001
Male	774 (41.1%)	631 (47.9%)	1405 (43.9%)	
Female	1107 (58.9%)	685 (52.1%)	1792 (56.1%)	
Current marital status				.007
Married—spouse present	879 (46.7%)	576 (43.8%)	1455 (45.5%)	
Married—spouse not in household	52 (2.8%)	42 (3.2%)	94 (2.9%)	
Widowed	107 (5.7%)	118 (9.0%)	225 (7.0%)	
Divorced	239 (12.7%)	161 (12.2%)	400 (12.5%)	
Separated	40 (2.1%)	19 (1.4%)	59 (1.8%)	
Never married	503 (26.7%)	358 (27.2%)	861 (26.9%)	
Hispanic ethnicity				.012
Not Hispanic/Spanish origin	1432 (76.1%)	1057 (80.3%)	2489 (77.9%)	
Mexican	263 (14.0%)	145 (11.0%)	408 (12.8%)	
Other Hispanic	183 (9.7%)	109 (8.3%)	292 (9.1%)	
Body mass index				.031
N	1707	1203	2910	
Mean (SD)	28.9 (5.8)	28.1 (5.3)	28.6 (5.6)	
Median (IQR)	28.1 (24.7, 32.4)	27.5 (24.2, 31.2)	27.8 (24.4, 31.9)	
Range	17.2, 51	17.2, 48.9	17.2, 51	
Ever told had arthritis/rheumatoid arthritis/gout/lupus/ fibromyalgia				.006
No	1472 (78.3%)	976 (74.2%)	2448 (76.6%)	
Yes	406 (21.6%)	340 (25.8%)	746 (23.3%)	

TABLE 1 (Continued)

Loss of taste due to COVID-19	Reported "Yes" (N = 1881)	Reported "No" (N = 1316)	Total (N = 3197)	p
Ever told had cancer				<.001
No	1731 (92.0%)	1157 (87.9%)	2888 (90.3%)	
Yes	150 (8.0%)	158 (12.0%)	308 (9.6%)	
Ever told had coronary heart disease				.038
No	1796 (95.5%)	1236 (93.9%)	3032 (94.8%)	
Yes	81 (4.3%)	78 (5.9%)	159 (5.0%)	
Ever had depression				.040
No	1494 (79.4%)	1082 (82.2%)	2576 (80.6%)	
Yes	387 (20.6%)	232 (17.6%)	619 (19.4%)	
Ever used e-cigarette				<.001
No	1431 (76.1%)	1092 (83.0%)	2523 (78.9%)	
Yes	399 (21.2%)	186 (14.1%)	585 (18.3%)	
Ever told you had any anxiety disorder				.002
No	1503 (79.9%)	1109 (84.3%)	2612 (81.7%)	
Yes	376 (20.0%)	207 (15.7%)	583 (18.2%)	
Severity of coronavirus/COVID-19 symptoms at their worst				<.001
No symptoms	41 (2.2%)	220 (16.7%)	261 (8.2%)	
Mild symptoms	648 (34.4%)	524 (39.8%)	1172 (36.7%)	
Moderate symptoms	768 (40.8%)	404 (30.7%)	1172 (36.7%)	
Severe symptoms	424 (22.5%)	167 (12.7%)	591 (18.5%)	
Difficulty smelling				<.001
No difficulty	620 (33.0%)	1081 (82.1%)	1701 (53.2%)	
A little difficulty	342 (18.2%)	90 (6.8%)	432 (13.5%)	
Moderate difficulty	262 (13.9%)	36 (2.7%)	298 (9.3%)	
A lot of difficulty	348 (18.5%)	39 (3.0%)	387 (12.1%)	
Cannot smell at all	265 (14.1%)	36 (2.7%)	301 (9.4%)	
Smell unpleasant odor				<.001
No	1498 (79.6%)	1224 (93.0%)	2722 (85.1%)	
Yes	333 (17.7%)	53 (4.0%)	386 (12.1%)	

The mean age of respondents who reported a loss of smell or taste due to COVID-19 was 45 years in both groups. Females comprised 58.5% and 58.9% of respondents who lost their smell and taste, respectively. Younger age and female sex were both found to be significantly associated with loss of smell ($p < .001$) and loss of taste on univariate analysis ($p < .001$) (Table 1). Of respondents who reported a recovery of smell and taste, the mean age for "Fully recovered," "Partially recovered," and "Not recovered at all" was 44.1, 47.1, and 45.6, respectively (Table 2). The complete list of significant factors from the univariate analysis for COVID-19-related loss and recovery of smell and taste can be found in Tables 1 and 2. Factors found to be non-significant on univariate analysis are reported in Appendix S1.

For loss of smell due to COVID-19, older age (odds ratio [OR] 0.98; 95% confidence interval [CI] 0.98–0.99) and history of cancer (OR 0.75; 95% CI 0.56–1.00) were identified as protective factors (Table 3). Female sex (OR 1.38; 95% CI 1.17–1.64), Mexican ethnicity

(OR 1.61; 95% CI 1.22–2.11), married with a spouse present (OR 1.21; 95% CI 1.02–1.43), history of e-cigarette use (OR 1.57; 95% CI 1.23–1.99), and severe COVID symptoms at worst (OR 15.29; 95% CI 10.08–23.21) were associated with higher odds of reporting a loss of smell (Table 3).

For loss of taste due to COVID-19, older age (OR 0.98; 95% CI 0.98–0.99) and a history of arthritis/RA/gout/lupus/fibromyalgia (OR 0.76; 95% CI 0.59–0.97) were identified as protective factors (Table 3). Female sex (OR 1.34; 95% CI 1.12–1.61), higher body mass index (BMI) (OR 1.02; 95% CI 1.01–1.04), severe COVID-19 symptoms at worst (OR 9.36; 95% CI 5.80–15.11), inability to smell (OR 11.24; 95% CI 7.48–16.89), and smell of unpleasant odor (OR 2.32; 95% CI 1.62–3.33) were associated with higher odds of reporting a loss of taste (Table 3).

For recovery of smell, younger age (OR 0.99; 95% CI 0.99–1.00) Black/African American race (OR 1.43; 95% CI 1.02–2.01), and

TABLE 2 Factors associated with recovery of smell and taste.

Recovered loss of smell due to COVID-19	Reported “Fully recovered” (N = 1374)	Reported “Partially recovered” (N = 505)	Reported “Not recovered at all” (N = 83)	Total (N = 1962)	p
Urban–rural county classification					.035
Large central metro	457 (33.3%)	133 (26.3%)	21 (25.3%)	611 (31.1%)	
Large fringe metro	310 (22.6%)	116 (23.0%)	17 (20.5%)	443 (22.6%)	
Medium and small metro	390 (28.4%)	153 (30.3%)	26 (31.3%)	569 (29.0%)	
Nonmetropolitan	217 (15.8%)	103 (20.4%)	19 (22.9%)	339 (17.3%)	
Age					.001
N	1374	503	83	1960	
Mean (SD)	44.1 (16.5)	47.1 (15.9)	45.6 (16.8)	45.0 (16.4)	
Median (IQR)	42 (31, 56)	47 (34, 59)	42 (32, 59)	43 (31, 57)	
Range	18, 85	18, 85	19, 84	18, 85	
Sex					.001
Male	607 (44.2%)	174 (34.5%)	33 (39.8%)	814 (41.5%)	
Female	767 (55.8%)	331 (65.5%)	50 (60.2%)	1148 (58.5%)	
Self-reported race					.003
White only	981 (71.4%)	399 (79.0%)	64 (77.1%)	1444 (73.6%)	
Black/African American	163 (11.9%)	43 (8.5%)	7 (8.4%)	213 (10.9%)	
American Indian/Alaskan Native only	12 (0.9%)	5 (1.0%)	1 (1.2%)	18 (0.9%)	
Asian Only	53 (3.9%)	10 (2.0%)	1 (1.2%)	64 (3.3%)	
Other Race and Multiple Race (2019-forward: Excluding American Indian/Alaska Native)	16 (1.2%)	9 (1.8%)	1 (1.2%)	26 (1.3%)	
American Indian/Alaska Native and Any Other Race	9 (0.7%)	8 (1.6%)	4 (4.8%)	21 (1.1%)	
Hispanic ethnicity					.005
Not Hispanic/Spanish origin	998 (72.6%)	406 (80.4%)	68 (81.9%)	1472 (75.0%)	
Mexican	225 (16.4%)	56 (11.1%)	10 (12.0%)	291 (14.8%)	
Other Hispanic	149 (10.8%)	42 (8.3%)	5 (6.0%)	196 (10.0%)	
Health status					.006
Excellent	351 (25.5%)	94 (18.6%)	20 (24.1%)	465 (23.7%)	
Very Good	450 (32.8%)	190 (37.6%)	30 (36.1%)	670 (34.1%)	
Good	404 (29.4%)	140 (27.7%)	19 (22.9%)	563 (28.7%)	
Fair	135 (9.8%)	63 (12.5%)	8 (9.6%)	206 (10.5%)	
Poor	33 (2.4%)	18 (3.6%)	6 (7.2%)	57 (2.9%)	
Ever told had arthritis/rheumatoid arthritis/gout/lupus/fibromyalgia					.003

TABLE 2 (Continued)

Recovered loss of smell due to COVID-19	Reported “Fully recovered” (N = 1374)	Reported “Partially recovered” (N = 505)	Reported “Not recovered at all” (N = 83)	Total (N = 1962)	p
No	1115 (81.1%)	379 (75.0%)	59 (71.1%)	1553 (79.2%)	
Yes	257 (18.7%)	125 (24.8%)	24 (28.9%)	406 (20.7%)	
Ever told had high cholesterol					.019
No	1029 (74.9%)	345 (68.3%)	62 (74.7%)	1436 (73.2%)	
Yes	342 (24.9%)	158 (31.3%)	21 (25.3%)	521 (26.6%)	
Ever had depression					<.001
No	1131 (82.3%)	378 (74.9%)	58 (69.9%)	1567 (79.9%)	
Yes	243 (17.7%)	126 (25.0%)	25 (30.1%)	394 (20.1%)	
Ever had any chronic liver condition					.001
No	1363 (99.2%)	496 (98.2%)	79 (95.2%)	1938 (98.8%)	
Yes	10 (0.7%)	8 (1.6%)	4 (4.8%)	22 (1.1%)	
Ever smoked 100 cigarettes in life					.008
No	913 (66.4%)	299 (59.2%)	51 (61.4%)	1263 (64.4%)	
Yes	424 (30.9%)	194 (38.4%)	29 (34.9%)	647 (33.0%)	
Ever told you had any anxiety disorder					<.001
No	1137 (82.8%)	372 (73.7%)	58 (69.9%)	1567 (79.9%)	
Yes	235 (17.1%)	133 (26.3%)	25 (30.1%)	393 (20.0%)	
Severity of coronavirus/COVID-19 symptoms at their worst					<.001
No symptoms	36 (2.6%)	6 (1.2%)	1 (1.2%)	43 (2.2%)	
Mild symptoms	538 (39.2%)	143 (28.3%)	19 (22.9%)	700 (35.7%)	
Moderate symptoms	516 (37.6%)	233 (46.1%)	42 (50.6%)	791 (40.3%)	
Severe symptoms	284 (20.7%)	123 (24.4%)	21 (25.3%)	428 (21.8%)	
Recovered loss of taste due to COVID-19	Reported “Fully recovered” (N = 1403)	Reported “Partially recovered” (N = 422)	Reported “Not recovered at all” (N = 54)	Total (N = 1879)	p
Age					<.001
N	1402	421	54	1877	
Mean (SD)	44.0 (16.2)	49.4 (16.2)	47.2 (16.7)	45.3 (16.4)	
Median (IQR)	41.5 (31, 56)	49 (37, 61)	49 (31, 61)	43 (32, 57)	
Range	18, 85	18, 85	19, 74	18, 84	
Sex					<.001
Male	623 (44.4%)	133 (31.5%)	17 (31.5%)	773 (41.1%)	

(Continues)

TABLE 2 (Continued)

Recovered loss of taste due to COVID-19	Reported “Fully recovered” (N = 1403)	Reported “Partially recovered” (N = 422)	Reported “Not recovered at all” (N = 54)	Total (N = 1879)	p
Female	780 (55.6%)	289 (68.5%)	37 (68.5%)	1106 (58.9%)	
Current marital status					.007
Married—spouse present	641 (45.7%)	209 (49.5%)	28 (51.9%)	878 (46.7%)	
Married—spouse not in household	39 (2.8%)	10 (2.4%)	3 (5.6%)	52 (2.8%)	
Widowed	67 (4.8%)	35 (8.3%)	5 (9.3%)	5 (0.3%)	
Divorced	170 (12.1%)	63 (14.9%)	5 (9.3%)	238 (12.7%)	
Separated	33 (2.4%)	7 (1.7%)	0 (0.0%)	40 (2.1%)	
Never married	404 (28.8%)	87 (20.6%)	12 (22.2%)	503 (26.8%)	
Self-reported race					.015
White only	1019 (72.6%)	338 (80.1%)	41 (75.9%)	1398 (74.4%)	
Black/African American	173 (12.3%)	36 (8.5%)	4 (7.4%)	213 (11.3%)	
American Indian/Alaskan Native only	11 (0.8%)	5 (1.2%)	2 (3.7%)	18 (1.0%)	
Asian only	50 (3.6%)	7 (1.7%)	1 (1.9%)	58 (3.1%)	
Other race and multiple race (2019-forward: excluding American Indian/Alaska Native)	15 (1.1%)	6 (1.4%)	1 (1.9%)	22 (1.2%)	
American Indian/Alaska Native and any other race	11 (0.8%)	7 (1.7%)	2 (3.7%)	20 (1.1%)	
Health status					<.001
Excellent	359 (25.6%)	68 (16.1%)	15 (27.8%)	442 (23.5%)	
Very Good	469 (33.4%)	141 (33.4%)	16 (29.6%)	626 (33.3%)	
Good	400 (28.5%)	135 (32.0%)	11 (20.4%)	546 (29.1%)	
Fair	142 (10.1%)	61 (14.5%)	8 (14.8%)	211 (11.2%)	
Poor	32 (2.3%)	17 (4.0%)	4 (7.4%)	53 (2.8%)	
Ever told had arthritis/rheumatoid arthritis/gout/lupus/fibromyalgia					<.001
No	1132 (80.7%)	301 (71.3%)	37 (68.5%)	1470 (78.2%)	
Yes	269 (19.2%)	120 (28.4%)	17 (31.5%)	406 (21.6%)	
Ever told had cancer					.017
No	1306 (93.1%)	377 (89.3%)	47 (87.0%)	1730 (92.1%)	
Yes	97 (6.9%)	45 (10.7%)	7 (13.0%)	149 (7.9%)	
Ever told had coronary heart disease					.028
No	1349 (96.2%)	393 (93.1%)	52 (96.3%)	1794 (95.5%)	
Yes	51 (3.6%)	28 (6.6%)	2 (3.7%)	81 (4.3%)	
Ever told had high cholesterol					.024
No	1019 (72.6%)	285 (67.5%)	45 (83.3%)	1349 (71.8%)	

TABLE 2 (Continued)

Recovered loss of taste due to COVID-19	Reported “Fully recovered” (N = 1403)	Reported “Partially recovered” (N = 422)	Reported “Not recovered at all” (N = 54)	Total (N = 1879)	p
Yes	381 (27.2%)	135 (32.0%)	9 (16.7%)	525 (27.9%)	
Ever had depression					.007
No	1138 (81.1%)	314 (74.4%)	40 (74.1%)	1492 (79.4%)	
Yes	265 (18.9%)	108 (25.6%)	14 (25.9%)	387 (20.6%)	
Ever told had hypertension					.002
No	966 (68.9%)	256 (60.7%)	30 (55.6%)	1252 (66.6%)	
Yes	436 (31.1%)	165 (39.1%)	24 (44.4%)	625 (33.3%)	
Ever been told you had COPD					.018
No	1346 (95.9%)	392 (92.9%)	49 (90.7%)	1787 (95.1%)	
Yes	55 (3.9%)	28 (6.6%)	5 (9.3%)	88 (4.7%)	
Number cigarettes per day (daily smokers)					.021
N	76	29	1	106	
Mean (SD)	12.5 (7.5)	12.7 (7.7)	10 (N/A)	12.5 (7.5)	
Median (IQR)	10 (5.5, 20)	10 (8, 20)	10 (10, 10)	10 (6, 20)	
Range	1, 40	4, 40	10	1, 40	
Number cigarettes per day (some day smokers)					.033
N	39	13	2	54	
Mean (SD)	2.9 (2.5)	7 (6.6)	1.5 (0.7)	3.9 (4.2)	
Median (IQR)	2 (1, 4)	4 (2, 10)	1.5 (1, 2)	2 (1, 5)	
Range	1, 10	2, 20	1, 2	1, 20	
Ever told you had any anxiety disorder					.005
No	1145 (81.6%)	315 (74.6%)	41 (75.9%)	1501 (79.9%)	
Yes	256 (18.2%)	107 (25.4%)	13 (24.1%)	376 (20.0%)	
Severity of coronavirus/COVID-19 symptoms at their worst					<.001
No symptoms	31 (2.2%)	8 (1.9%)	2 (3.7%)	41 (2.2%)	
Mild symptoms	524 (37.3%)	112 (26.5%)	12 (22.2%)	648 (34.5%)	
Moderate symptoms	558 (39.8%)	184 (43.6%)	25 (46.3%)	767 (40.8%)	
Severe symptoms	290 (20.7%)	118 (28.0%)	15 (27.8%)	423 (22.5%)	
Difficulty smelling					<.001
No difficulty	555 (39.6%)	57 (13.5%)	8 (14.8%)	620 (33.0%)	
A little difficulty	248 (17.7%)	92 (21.8%)	2 (3.7%)	342 (18.2%)	
Moderate difficulty	165 (11.8%)	95 (22.5%)	2 (3.7%)	262 (13.9%)	
A lot of difficulty	216 (15.4%)	117 (27.7%)	13 (24.1%)	346 (18.4%)	

(Continues)

TABLE 2 (Continued)

Recovered loss of taste due to COVID-19	Reported "Fully recovered" (N = 1403)	Reported "Partially recovered" (N = 422)	Reported "Not recovered at all" (N = 54)	Total (N = 1879)	p
Cannot smell at all	182 (13.0%)	55 (13.0%)	28 (51.9%)	265 (14.1%)	
Smell unpleasant odor					<.001
No	1162 (82.8%)	296 (70.1%)	38 (70.4%)	1496 (79.6%)	
Yes	200 (14.3%)	119 (28.2%)	14 (25.9%)	333 (17.7%)	

non-Mexican Hispanic ethnicity (OR 1.53; 95% CI 1.01–2.33) were found to be associated with recovery. Female sex (OR 0.74; 95% CI 0.60–0.92), other self-reported race (excluding White, Black/African American, and Asian race) (OR 0.51; 95% CI 0.31–0.86), history of chronic liver condition (OR 0.31; 95% CI 0.12–0.79), history of anxiety disorder (OR 0.67; 95% CI 0.52–0.85), and severe COVID-19 symptom severity at worst (OR 0.64; 95% CI 0.48–0.85) were associated with a decreased likelihood of reporting a recovery of smell (Table 3).

For recovery of taste, older age (OR 0.98; 95% CI 0.97–0.99), female sex (OR 0.55; 95% CI 0.43–0.70), other self-reported race (excluding White, Black/African American, and Asian race) (OR 0.47; 95% CI 0.26–0.85), inability to smell (OR 0.22; 95% CI 0.15–0.33), and smell of unpleasant odor (OR 0.57; 95% CI 0.44–0.70) were associated with a decreased likelihood of reporting a recovery of smell (Table 3).

4 | DISCUSSION

This is the first study to analyze a large national survey in order to determine factors associated with loss and recovery of smell and taste after COVID-19 infection in the United States. We identified various factors which may influence the loss and recovery of smell and taste after COVID-19 infection. Clinicians may use this information to counsel patients on healing expectations after experiencing sensory losses after COVID-19 infection.

Like previously published papers, our findings suggest female sex is associated with an increased likelihood of losing smell and taste due to COVID-19 and decreased odds of reporting recovery of smell and taste.^{5,15–18} Although males may have higher exposure rates to certain infections, females may potentially have a heightened immune response compared with males due to differences in sex-chromosome-linked genes that regular immune function.^{19,20} A more robust immune response can lead to increased disease symptom severity and injury to the olfactory nerves.

We found that older patients have a decreased likelihood of losing smell and taste, but also lower likelihood of recovering smell and taste once these senses are lost.^{12,17,18} Younger patients have better immunological function compared with older adults, which could be responsible for the improved recovery rates demonstrated in our

analysis.^{21–23} Despite the high prevalence of olfaction decay in the elderly population, no hypothesis has been established regarding the increased propensity for COVID-19 to alter olfaction at younger ages.²⁴ It is possible that younger populations are at an increased risk for exposure.

Additionally, our study identified that individuals of Mexican ethnicity may have an increased likelihood of olfactory dysfunction secondary to COVID-19. This might be attributed to the fact that Hispanic groups in the United States have a lower likelihood of seeking or receiving healthcare compared to the general population which might be due to lower health insurance coverage and language barriers.^{25–27}

History of e-cigarette use was also found to be associated with increased likelihood of losing smell due to COVID-19. This might be due to evidence suggesting that e-cigarette flavors and aerosol compounds reduce main olfactory epithelium (MOE) sensitivity through adaptation and cytotoxic damage to the barrier.^{28,29} Disruption of MOE from e-cigarette use could exacerbate the loss of smell when in conjunction with a COVID-19 infection. Of note, a large number of survey respondents (18.3%) who reported testing positive for COVID-19 also reported current or previous use of an e-cigarette, highlighting the increased popularity of these devices in the United States.

A history of anxiety disorder may contribute to reduced rates of recovery after olfactory loss. Anxiety disorders have been previously recognized to exacerbate the immune system's response to COVID-19.³⁰ In addition, Speth et al. have hypothesized that emotional well-being disturbances might be secondary to central nervous system involvement of COVID-19.³¹ Further studies are needed to determine if anxiety stems directly from the coronavirus infection, QOL distress from loss of smell, or if the prior history of anxiety is responsible for worsened recovery rate.

Increasing BMI was found to be correlated with loss of taste in our study. There have been reports of pre-existing lower sensitivity for taste and decreased smell perception in obese patients compared to controls that could potentially confound virus-associated loss of either of these senses.^{32–35} Nonetheless, it has been hypothesized that COVID-19 induced dysregulations in ghrelin and leptin, and inflammation involving IL-6 and TNF- α , are responsible for the dysregulated immune response which may result in decreased loss of taste perception.^{36–38}

TABLE 3 Association of various factors with smell and taste loss and recovery on backwards stepwise regression.

Loss of smell due to COVID-19 (N = 2759)		
	OR (95% CI)	p
Age	0.98 (0.98–0.99)	<.001
Sex		
Male	Ref	
Female	1.38 (1.17–1.64)	<.001
Current marital status		
Never married	Ref	
Married—spouse present	1.21 (1.02–1.43)	.028
Hispanic ethnicity		
Not Hispanic/Spanish origin	Ref	
Mexican	1.56 (1.19–2.04)	.001
Ever told had cancer		
No	Ref	
Yes	0.75 (0.56–1.00)	.050
Ever used e-cigarette		
No	Ref	
Yes	1.57 (1.23–1.99)	<.001
Severity of coronavirus/COVID-19 symptoms at their worst		
No symptoms	Ref	
Mild symptoms	7.53 (5.12–11.08)	<.001
Moderate symptoms	10.87 (7.37–16.02)	<.001
Severe symptoms	15.29 (10.08–23.21)	<.001
Loss of taste due to COVID-19 (N = 2771)		
	OR (95% CI)	p
Age	0.98 (0.98–0.99)	<.001
Sex		
Male	Ref	
Female	1.34 (1.12–1.61)	.002
Body mass index	1.02 (1.01–1.04)	.008
Ever told had arthritis/RA/gout/lupus/fibromyalgia		
No	Ref	
Yes	0.76 (0.59–0.97)	.030
Severity of coronavirus/COVID-19 symptoms at their worst		
No symptoms	Ref	
Mild symptoms	5.46 (4.28–7.47)	<.001
Moderate symptoms	6.06 (3.87–9.49)	<.001
Severe symptoms	9.36 (5.80–15.11)	<.001
Difficulty smelling		
No difficulty	Ref	
A little difficulty	5.66 (4.28–7.47)	<.001
Moderate difficulty	10.94 (7.37–16.24)	<.001
A lot of difficulty	11.47 (7.90–16.63)	<.001

(Continues)

TABLE 3 (Continued)

Loss of taste due to COVID-19 (N = 2771)		
	OR (95% CI)	p
Cannot smell at all	11.24 (7.48–16.89)	<.001
Smell unpleasant odor		
No	Ref	
Yes	2.32 (1.62–3.33)	<.001
Recovered loss of smell due to COVID-19 (N = 1770)		
	OR (95% CI)	p
Age	0.99 (0.99–1.00)	.014
Sex		
Male	Ref	
Female	0.74 (0.60–0.92)	.006
Self-reported race		
White only	Ref	
Black/African American only	1.43 (1.02–2.01)	.041
Other race ^a (including American/Alaskan Native)	0.51 (0.31–0.86)	.010
Hispanic ethnicity		
Not Hispanic/Spanish origin	Ref	
Other Hispanic	1.53 (1.01–2.33)	.043
Ever had any chronic liver condition		
No	Ref	
Yes	0.31 (0.12–0.79)	.014
Ever told you had any anxiety disorder		
No	Ref	
Yes	0.67 (0.52–0.85)	.001
Severity of coronavirus/COVID-19 symptoms at their worst		
No symptoms	Ref	
Moderate symptoms	0.59 (0.46–0.74)	<.001
Severe symptoms	0.64 (0.48–0.85)	.002
Recovered loss of taste due to COVID-19 (N = 1658)		
	OR (95% CI)	p
Age	0.98 (0.97–0.99)	<.001
Sex		
Male	Ref	
Female	0.55 (0.43–0.70)	<.001
Self-reported race		
White only	Ref	
Other race ^a (including American/Alaskan Native)	0.47 (0.26–0.85)	.012

(Continues)

TABLE 3 (Continued)

Recovered loss of taste due to COVID-19 (N = 1658)	OR (95% CI)	p
Severity of coronavirus/COVID-19 symptoms at their worst		
No symptoms	Ref	
Mild symptoms	1.40 (1.09–1.81)	.009
Difficulty smelling		
No difficulty	Ref	
A little difficulty	0.38 (0.26–0.55)	<.001
Moderate difficulty	0.26 (0.18–0.38)	<.001
A lot of difficulty	0.25 (0.17–0.34)	<.001
Cannot smell at all	0.22 (0.15–0.33)	<.001
Smell unpleasant odor		
No	Ref	
Yes	0.57 (0.44–0.70)	<.001

Note: Bold values indicate significance ($p < 0.050$).

Abbreviations: CI, confidence interval; OR, odds ratio.

^aOther Race excluded White, Black/African American, Asian race.

By contrast, higher income and history of inflammatory musculoskeletal (MSK) disorders may be associated with decreased odds of losing taste. As might be expected, higher income could allow for more flexibility to get tested and treated sooner due to job stability and the likelihood of having medical insurance, resulting in reduced disease severity and sensory dysfunction. The association between MSK disorders and reduced rates of smell loss may be due to the prevalence of anti-inflammatory medications, such as corticosteroids, used to treat inflammatory MSK disorders. As an indirect effect, the user may experience benefits from the neuroprotective and anti-inflammatory actions, thus potentially reducing the likelihood of report loss of taste.³⁹

This cross-sectional national database study is subject to several limitations. The absence of patient-level data means that there are many clinical data points we could not capture, including differences in medical history and medication use, which could explain variations in sensory dysfunction between individuals. Due to the cross-sectional nature of this study, we are also unable to establish causality to determine direct relationships between COVID-19 and the loss or recovery of smell and taste. Additionally, as with any survey, there is potential for selection bias that occurs if the sample population is not an accurate representation of the broader population. As a result, data might be skewed or unrepresentative. Another limitation is our inability to provide temporal data that would allow us to identify the recovery rate between COVID-19 diagnosis, initial presentation of gustatory and olfactory dysfunction, and the onset of recovery. Although we are unable to provide information on the recovery

timeline and its variability with individual predictors, other research groups have found general individual recovery rate timelines for smell and taste dysfunction.^{15,40} Lastly, the self-reported data from the national database survey is inherently limited to recall bias and social desirability bias. The data may have potential inaccuracies, which can lead to underreporting or overreporting of certain survey responses.

5 | CONCLUSION

This is the first study to analyze a large national survey in order to identify patient characteristics associated with loss and recovery of smell and taste after COVID-19 infection. Factors including sex, age, ethnicity, BMI, income, as well as history of anxiety and e-cigarette use may influence sensory dysfunction after infection with SARS-CoV-2, and clinicians may use this information to counsel patients on healing expectations after experiencing sensory losses. This improved guidance can be crucial for patient care, as the impact of losing smell and taste can significantly affect QOL and patient well-being.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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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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