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Long-term recovery of taste and smell following acute COVID-19 infection in a New Jersey cohort

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Abstract

Loss of taste and smell is one of the most troubling symptoms of long COVID and may be permanent for some. Correlation between subjectively and objectively assessed olfactory and gustatory impairment is low, leading to uncertainty about how many people are affected, how many recover, and to what extent. We prospectively investigated the effects of COVID-19 on long-term chemosensory function in a university and hospital-based cohort in NJ. We followed 856 participants from March 2020 through April 2022, of which 58 were diagnosed with COVID-19 and completed the NHANES 2013–2014 taste and smell protocol, including a chemosensory questionnaire, whole-mouth taste tests, and an 8-item odor identification test at and/or before acute

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Methods: ethical approval and participant's consent

The Rutgers Institutional Review Board (Pro2020000679) approved all study activities. Prior to enrollment in the study, participants provided electronic informed consent.

CRediT authorship contribution statement

Samuel C.Z. Gautier: Writing – review & editing, Writing – original draft, Visualization, Formal analysis. **Vaishnavi Coneti:** Visualization, Formal analysis. **Daniel B. Horton:** Supervision, Funding acquisition, Conceptualization. **Patricia Greenberg:** Project administration, Data curation. **Tracy Andrews:** Project administration, Data curation. **Emily S. Barrett:** Methodology, Investigation, Funding acquisition, Conceptualization. **Jeffrey L. Carson:** Supervision, Funding acquisition, Conceptualization. **Martin J. Blaser:** Supervision, Funding acquisition, Conceptualization. **Reynold A. Panettieri:** Supervision, Funding acquisition, Conceptualization. **Shristi Rawal:** Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – review & editing.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

COVID-19 infection. Of these, 29 repeated taste and smell assessments at 6 months (183.0 ± 54.6) follow-up. Total overall smell score significantly improved from baseline to 6-month follow up (6.9 ± 1.4 vs 7.6 ± 0.8; $p = .01$). Taste intensity also improved across 6 months, but not significantly. Our study is the first to show psychophysically-assessed and self-reported long-term recovery of olfactory and gustatory function in the same population after acute COVID-19.

Keywords

COVID-19; Long COVID; Taste/gustation; Smell/olfaction; Cohort; New Jersey

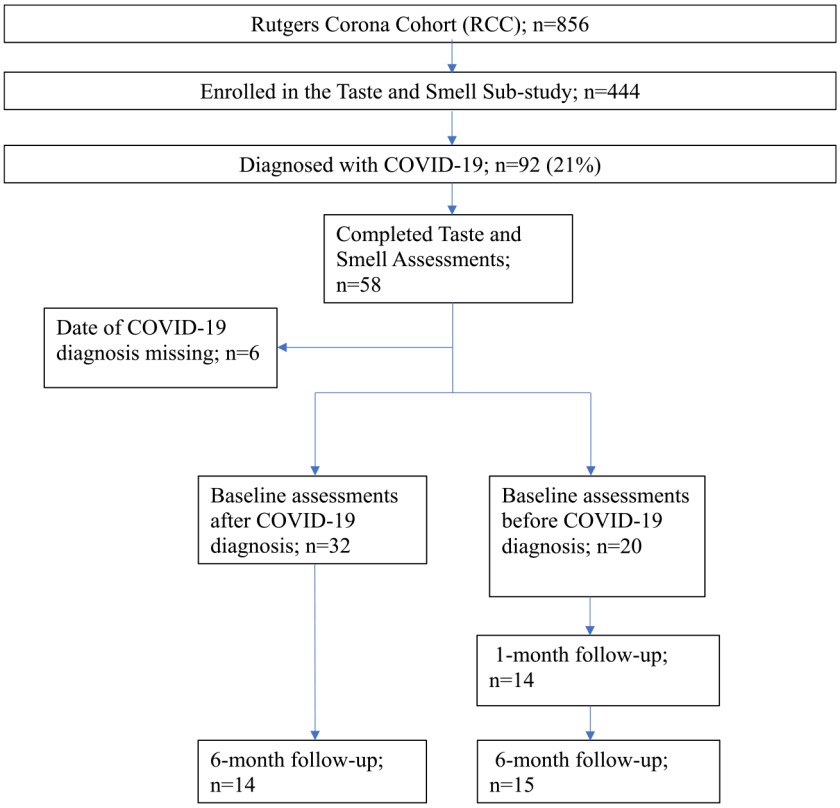

Fig. 1.
Flowchart of study participants.

Table 1

Demographic characteristics were similar (across all participants enrolled in the study, those that were diagnosed with COVID-19, and those diagnosed with COVID-19 who completed the 6-month follow up (all Ps >0.05).

Demographics	All participants (*n* = 444)	Diagnosed with COVID-19 (*n* = 92)	Followed up at 6 months (n = 29)
Age (years)	43.2 ± 12.8	42.3 ± 12.6	43.7 ± 13.0
Race/Ethnicity			

Demographics	All participants (n = 444)	Diagnosed with COVID-19 (n = 92)	Followed up at 6 months (n = 29)
Non-Hispanic White	290 (65.9%)	54 (60.7%)	21 (77.8%)
Non-Hispanic Asian	80 (18.2%)	14 (15.7%)	3 (11.1%)
Non-Hispanic Black	31 (7.1%)	12 (13.5%)	0 (0.0%)
Hispanic and Other Race – Including Multi-Racial	39 (8.9%)	9 (10.1%)	3 (11.1%)
Gender			
Male	146 (32.9%)	21 (22.8%)	5 (18.5%)
Female	297 (66.9%)	71 (77.2%)	22 (81.5%)
Other	1 (0.2%)	0 (0.0%)	0 (0.0%)
Marital status [a]			
Married	269 (60.6%)	56 (60.9%)	19 (70.4%)
Not Married	175 (39.4%)	36 (39.1%)	8 (26.6%)

[a]Marital status is dichotomized as married or living with a partner and not married (widowed, divorced, separated, or never married).

Table 2

Objective evaluation of taste and smell function prior to COVID-19 diagnosis and 1-month (38 ± 35 days) post-COVID-19 (n = 14).

NHANES Pocket Smell Test assessment	Prior to COVID-19 diagnosis		1 month after COVID-19 diagnosis		p-value[a]
	Mean Intensity	% correct identification	Mean Intensity	% correct identification	
Chocolate	48.5 ± 27.9	92.9%	47.5 ± 35.4	100%	0.62
Grape	60.0 ± 24.2	78.6%	51.0 ± 32.9	78.6%	0.12
Onion	66.8 ± 33.4	92.9%	55.1 ± 36.6	100%	0.06 *
Leather	53.4 ± 32.5	92.9%	52.6 ± 41.4	92.9%	0.59
Natural Gas	64.6 ± 31.1	92.9%	53.3 ± 37.9	71.4%	0.06 *
Smoke	65.3 ± 26.2	92.9%	42.1 ± 36.5	71.4%	0.01 **
Strawberry	44.1 ± 28.8	92.9%	48.6 ± 36.2	85.7%	0.96
Soap	53.7 ± 34.7	92.9%	50.7 ± 32.6	85.7%	0.42
Total smell score (on a scale of 8)	7.8 ± 0.3	–	6.9 ± 1.3	–	0.03 **
Average smell intensity	57.1 ± 23.4	–	46.2 ± 32.6	–	0.11
NHANES Whole-mouth Taste Test	**Mean Intensity**	**% Correct Identification**	**Mean Intensity**	**% Correct Identification**	**p-value[a]**
Bitter (1 mM Quinine)	77.9 ± 15.3	85.7%	67.6 ± 29.6	85.7%	0.07 *
Salt (1 M NaCl)	76.8 ± 19.8	92.9%	72.9 ± 24.5	92.9%	0.21
Average taste intensity	77.3 ± 16.3	–	70.2 ± 24.7	–	0.08 *

[a]p-value is obtained by paired t-test comparing smell/taste intensities (scale 0–100) or smell score (scale 0–8) pre- and post-COVID19 diagnosis.

** Indicates significant at $p \leq .05$ level.

* Indicates significant at $p \leq .10$ level.

Table 3

Objective evaluation of smell and taste recovery at baseline and 6 months (183.0 ± 53.6 days) following acute COVID-19 (n = 29).

NHANES Pocket Smell Test					
	Baseline		**6-month follow up**		**p-value**
	Mean Intensity	**% correct identification**	**Mean Intensity**	**% correct identification**	
Chocolate	47.0 ± 29.8	85.2%	59.9 ± 25.2	100.0%	0.14
Grape	47.1 ± 30.5	63.0%	63.3 ± 27.5	88.9%	0.02 **
Onion	57.0 ± 31.7	85.2%	60.8 ± 23.8	100.0%	0.76
Leather	48.5 ± 31.7	74.1%	62.1 ± 22.5	92.6%	0.08 *
Natural Gas	56.1 ± 28.1	74.1%	65.1 ± 24.1	92.6%	0.28
Smoke	49.4 ± 24.5	70.4%	62.7 ± 21.1	92.6%	0.12
Strawberry	49.2 ± 26.5	77.8%	57.2 ± 30.0	96.3%	0.51
Soap	50.4 ± 31.2	81.5%	65.7 ± 31.6	96.3%	0.04 **
Total smell score (on a scale of 8)	6.9 ± 1.4	–	7.6 ± 0.8	–	0.01 **
Average smell intensity	51.0 ± 25.0	–	62.1 ± 21.0	–	0.06 *
NHANES Whole-Mouth Taste Test					
	Baseline		**6-month follow up**		**p-value**
Bitter	67.9 ± 24.7	83.3%	74.2 ± 16.9	88.5%	0.23
Salt	74.8 ± 18.2	100.0%	79.3 ± 11.5	96.2%	0.17
Average taste intensity	71.3 ± 18.3	–	76.8 ± 12.3	–	0.14

p-value is obtained by paired t-test comparing smell/taste intensities (scale 0–100) or smell score (scale 0–8) between baseline- and 6-month follow up post-COVID-19 diagnosis.

** Indicates significant at p ≤ .05 level.

* Indicates significant at $p \leq .10$ level.

Table 4

Subjective evaluation of smell and taste recovery via NHANES Taste and Smell Questionnaire prior to COVID-19 diagnosis and 1-month (38 ± 35 days) post-COVID-19 (n = 14).

Olfactory/Gustatory questions	**Prior to COVID-19 diagnosis**	**1-month after COVID- 19 diagnosis**
In the last 12 months, have you noticed any changes in your sense of taste? (Response: Yes)	0 (0%)	6 (42.9%)
In the last 12 months, have you noticed any changes in your sense of smell? (Response: Yes)	0 (0%)	7 (50.0%)
In the last 12 months, have you noticed that a food tastes different than it used to? (Response: Yes)	0 (0%)	4 (28.6%)
In the last 12 months, have you noticed that a food smells different than it used to? (Response: Yes)	0 (0%)	4 (28.6%)

Olfactory/Gustatory questions	Prior to COVID-19 diagnosis	1-month after COVID- 19 diagnosis
In the last 12 months, have you had a problem with your ability to smell, such as not being able to smell things or things not smelling the way they are supposed to? (Response: Yes)	0 (0%)	5 (35.7%)
In the last 12 months, have you had a problem with your ability to taste sweet, sour, salty or bitter foods and drinks? (Response: Yes)	0 (0%)	4 (28.6%)
In the last 12 months, have you had persistent taste in mouth? (Response: Sometimes/Often)	0 (0%)	2 (14.3%)
Subjects reporting smell changes in the last 12 months and/or trouble with smell	0 (0%)	7 (50.0%)
Subjects reporting taste changes in the last 12 months and/or trouble with taste	0 (0%)	8 (57.1%)

Table 5

Subjective evaluation of smell and taste recovery via NHANES Taste and Smell Questionnaire at 6 months (183.0 ± 54.6 days) following acute COVID-19 (n = 15).

Smell Questions			Taste Questions		
Question (Response)	**Baseline**	**6-month follow up**	**Question (Response)**	**Baseline**	**6-month follow up**
“In the last 12 months, have you noticed any changes in your sense of smell?” (Yes)	5 (33.3%)	3 (21.4%)	“In the last 12 months, have you noticed any changes in your sense of taste?” (Response: Yes)	2 (13.3%)	1 (7.1%)
“In the last 12 months, have you noticed that a food smells different than it used to?” (Yes)	2 (13.3%)	0 (0.0%)	“In the last 12 months, have you noticed that a food tastes different than it used to?” (Response: Yes)	2 (13.3%)	1 (7.1%)
“In the last 12 months, have you had a problem with your ability to smell, such as not being able to smell things or things not smelling the way they are supposed to? (Yes)”	8 (53.3%)	2 (14.3%)	“In the last 12 months, have you had a problem with your ability to taste sweet, sour, salty or bitter foods and drinks? (Response: Yes)”	3 (20.0%)	0 (0.0%)
Subjects reporting smell changes in the last 12 months and/or trouble with smell	9 (60.0%)	3 (21.4%)	“In the last 12 months, have you had persistent taste in mouth?” (Response: Sometimes/ Often)	1 (6.7%)	0 (0.0%)
			Subjects reporting taste changes in the last 12 months and/or trouble with taste	3 (20.0%)	1 (7.1%)

Of 29, people followed up at 6 months following a COVID-19 diagnosis, only 15 participants were administered the NHANES Taste and Smell Questionnaire.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Biographies

Samuel C Z Gautier is a graduate student in public health nutrition at Rutgers, the State University of New Jersey. He has worked in the labs of various Rutgers professors, including Dr. Shauna Downs, Dr. Laura Pizzi, and Dr. Shristi Rawal, with whom he collaborated for this research. His research interests include food systems, food policy, and nutrition. This was his first real oral presentation, and he thanks the conference committee for making it possible for him.

Vaishnavi Coneti is a Statistical Programmer with extensive experience in SAS programming and clinical trial analysis. She has experience delivering statistical outputs and ADaM datasets for various therapeutic areas. Vaishnavi is adept at conducting data compliance checks, and ensuring data integrity. She holds a Master's in Health Informatics from Rutgers School of Health Professions. Connect with her on LinkedIn: https://www.linkedin.com/in/vaishnavi-coneti/.

Dr. Daniel B Horton (MSCE, Clinical Epidemiology, University of Pennsylvania, 2015; MD, Harvard Medical School, 2008; AB, Harvard College, 2001) is a board-certified pediatric rheumatologist and physician-scientist with research training in pharmacoepidemiology. Dr. Horton's research focuses on the utilization, effectiveness, and safety of drugs in large pediatric populations and the origins and management of juvenile idiopathic arthritis (JIA), with a focus on the microbiome and microbiome-altering medicines. He has also been involved in a variety of research efforts on COVID-19 and multisystem inflammatory syndrome in children. Dr. Horton serves as Consultant to the Food and Drug Administration Drug Safety and Risk Management Advisory Committee as well as Associate Editor for Pharmacoepidemiology and Drug Safety.

Patricia Greenberg, MS is both the Administrative Manager and a Senior Biostatistician for the Rutgers University Biostatistics & Epidemiology Services (RUBIES) center which sits within the Rutgers Health network and the Rutgers School of Public Health. The RUBIES consulting team provides statistical support, including study design, programming, data management, and data analysis, to investigators throughout all of Rutgers University and the Robert Wood Johnson Barnabas Health system. (https://sph.rutgers.edu/centers/rubies/).

Tracy Andrews joined Rutgers in May 2019 with over 15 years of experience working as a biostatistician in both the behavioral/ social and medical sciences. During this time, she has worked for the government, in think tanks, and in academic and hospital-based clinical research settings, giving her a broad base of experience. She has collaborated with researchers from a wide-range of medical disciplines, including but not limited to those in Oncology/Transplant, Pediatrics, Neonatology, Trauma, Cardiology, Basic Science, and Surgery. As a sociologist and demographer, she has also studied the health and well-being of low-income families, children, and the elderly and evaluated the effectiveness of interventions and programs designed to support these populations. In addition to her experience with quantitative data, Tracy is also a trained qualitative researcher. Her research has been published in peer-reviewed journals and presented at national meetings. She encourages researchers to reach out to a biostatistician early in the planning phases of a research project; we are here to help and be part of the team!

Emily S Barrett, Ph.D., is a professor and director of the Epidemiology concentration in the Department of Biostatistics and Epidemiology at the Rutgers School of Public Health. Dr. Barrett is also a member of the Environmental and Occupational Health Sciences Institute, where she co-directs the Maternal-Child Environmental Health Lab and the Human Exposures and Outcomes Research Core. Dr. Barrett received her doctoral degree in biological anthropology from Harvard University and completed post-doctoral training at the

Center for Healthier Children, Families, and Communities at University of California, Los Angeles.

Jeffrey L Carson is the Richard C. Reynolds, MD, Chair in General Internal Medicine and Distinguished Professor of Medicine at Robert Wood Johnson Medical School. Carson is an active clinician and has been named to a “best doctors” list annually since 1998. He was a member and chair of the Clinical Trials Review Committee at the National Heart, Lung, and Blood Institute. The focus of his research is determining the indications for red blood cell transfusion. Carson is currently the study chair of MINT (Myocardial Ischemia and Transfusion), a National Institutes of Health-supported trial that is evaluating transfusion thresholds in 3500 patients with acute myocardial infarction, conducted worldwide in over 140 centers. His research has been recognized by numerous local and national organizations including the American Association of Physicians, National Heart, Lung, and Blood Institute, Association for the Advancement of Blood and Biotherapies, and American College of Physicians.

Martin J Blaser holds the Henry Rutgers Chair of the Human Microbiome at Rutgers University, where he also serves as Professor of Medicine and Pathology & Laboratory Medicine, and as Director of the Center for Advanced Biotechnology and Medicine. Previously, he served as Chair of the Department of Medicine at New York University. A physician and microbiologist, Dr. Blaser has been studying the relationships we have with our persistently colonizing bacteria. His work over 30 years focused on Campylobacter species and *Helicobacter pylori*, which also are model systems for understanding the interactions of residential bacteria with their hosts. Over the last 20 years, he has also been actively studying the relationship of the human microbiome with health and important diseases including asthma, obesity, diabetes, and cancer. Dr. Blaser has served as the advisor to many students, post-doctoral fellows, and junior faculty. He currently serves as Chair of the Presidential Advisory Council for Combating Antibiotic Resistant Bacteria (PACCARB). He holds 28 U.S. patents, and has authored over 600 original articles. He wrote Missing Microbes, a book targeted to general audiences, now translated into 20 languages.

Reynold A Panettieri, Jr., MD, is Professor of Medicine, Vice Chancellor for Translational Medicine and Science, and the Director of the Rutgers Institute for Translational Medicine and Science. He is the recipient of numerous honors and awards, including the Robert E. Cooke Memorial Lectureship at the American Academy of Allergy, Asthma and Immunology, the Joseph R. Rodarte Award for Scientific Distinction and the Recognition Award for Scientific Accomplishments from the American Thoracic Society. Dr. Panettieri is principal investigator on several NIH-sponsored grants and industry-sponsored clinical studies, director of a program project grant examining novel approaches in modulating G protein-coupled receptor function, and is Principal Investigator of New Jersey's CTSA Hub 'New Jersey Alliance for Clinical and Translational Science'. He has authored over 525 peer-reviewed publications. Dr. Panettieri manages the clinical care of patients with asthma and is engaged in clinical investigations focused on the management of asthma and COPD.

Shristi Rawal's research takes a life-course epidemiological approach to examine the nutritional and biopsychosocial risk factors of cardiometabolic diseases, with a focus on pregnancy as a critical life event that influences the short- and long-term cardiometabolic health of women and their children. Primarily, her research emphasis has been on identifying early biomarkers and dietary and lifestyle determinants of gestational diabetes as well as risk factors for its progression to type 2 diabetes and other cardiometabolic complications such as renal dysfunction. Rawal is a principal investigator on two pregnancy cohort studies, in Dhulikhel, Nepal, and Newark, New Jersey. She also serves as a principal investigator on an NIH-funded study that aims to develop and test a mobile health application for self-management and treatment of gestational diabetes among pregnant women in Nepal.

Data availability

The authors do not have permission to share data.

Further reading

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