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Characteristics of COVID-19 smell and taste dysfunction in hospitalized patients

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ABSTRACT

The effects of severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) exist on a spectrum. Clinical symptoms of smell and taste dysfunction are prominent features of COVID-19. The objective of this study was to elucidate the factors associated with smell and taste dysfunction amongst hospitalized COVID-19 patients. A retrospective review of a multi-hospital health network’s COVID-19 database between March and June 2020 was performed. Patients with self-reported smell or taste loss were included. Demographic information, patient comorbidities, and mortality data was obtained. There were 2892 patients included in this analysis and 117 reported smell or taste loss (4.0%, 95% confidence interval [CI]: 3.4%–4.8%). The proportion of females with smell or taste loss was significantly higher than males (6.3% vs. 2.5%, \( P < 0.001 \)), whereas no differences existed between ethnicity or smoking status. When compared with age of 30–40 years, the age group of 10–20 years were most likely to present with smell or taste dysfunction (odds ratio [OR] 6.59, 95% CI 1.32–26.12; \( P = 0.01 \)). The majority of specific comorbidities were not associated with increased incidence of smell or taste dysfunction. Outpatient healthcare workers were more likely to present with smell or taste loss (OR 3.2, CI 1.8–5.47; \( P < 0.001 \)). The mortality rate among COVID-19 patients with smell or taste dysfunction was significantly lower than those without (0% vs. 20.3%; \( P < 0.001 \)). Smell or taste loss is more prevalent in women, younger age groups, and healthier individuals. It may be associated with lower mortality and a milder disease trajectory compared to the overall cohort.

1. Introduction

SARS-CoV-2, the causative agent of the COVID-19 pandemic, has gained traction for its diverse clinical presentation. There are groups with generally asymptomatic disease while others have a rapid progression towards respiratory failure, and there have been early attempts at cluster analysis [1]. Despite the initial connection between respiratory related symptoms and the virus, there has been a growing prevalence of confirmed COVID-19 patients reporting smell and taste dysfunction. Initial reports have suggested that smell loss in COVID-19 patients may be associated with a milder clinical course, as admitted patients are less likely to report smell dysfunction than those who are outpatients [2].

A potential mechanism of the neurotropism of COVID-19 may utilize the ACE2 receptor, which is present in high amounts in nasal epithelial cells, as an entry point [3]. While anosmia is not uncommon for viral infections in the presence of rhinorrhea, the anosmia secondary to COVID-19 appears to lack rhinorrhea [4]. Considering that smell and taste dysfunction can be present in the absence of rhinitis, they may represent the first and only manifestation of COVID-19 in some patients [5]. As such, smell and taste dysfunction may act as a prognostic indicator on disease severity and overall mortality rate. This study sought to
identify risk factors in the development of smell and taste dysfunction in hospitalized COVID-19 patients as well as investigate its possible link to disease severity.

2. Materials and methods

2.1. Data source

The data source utilized was a real-time database created by Hackensack Meridian Health (HMH), a large multi-hospital network including both community and tertiary hospitals operating in New Jersey. This database was populated with data extracted from the electronic health record of COVID-19 positive patients hospitalized at HMH hospitals, utilizing the Epic electronic medical records system. Data was extracted by diagnosis codes and reported symptoms. This study received approval by the HMH COVID-19 Research Review Committee.

2.2. Study cohort

We retrospectively reviewed all admitted patients with a confirmed COVID-19 diagnosis between March 22 and June 15, 2020. Data collection was obtained through patients self-reporting and standardized questions from clinicians. Patients younger than age 10 and older than age 90 were excluded from this analysis.

2.3. Outcomes/covariates

There were two primary variables, smell or taste dysfunction and mortality. The presence/absence of smell or taste dysfunction was then stratified based on demographic information including gender, decade of age, ethnicity, smoking status, and health care worker status. Smell and taste dysfunction were also compared relative to patient comorbidities including Diabetes Mellitus (DM), Chronic Obstructive Pulmonary Disease (COPD), Asthma, Hypertension, Cancer, Human Immunodeficiency Virus (HIV)/Hepatitis, Pregnancy, Renal Failure, Coronary Artery Disease (CAD), and Rheumatologic Disease.

2.4. Statistical analysis

The creation of the database required collection of diagnoses and symptoms from an electronic medical records system. For each of the analyses, elements with missing variables were excluded from the analyses. Demographic information and medical comorbidities were compared to the presence/absence of smell and taste dysfunction using Chi-squared or Fisher’s Exact test. Logistic regression for binary variables was performed with smell and taste loss as the dependent variable. Multiple logistic regression was performed to identify independent patient characteristics with statistically significant association with smell or taste loss. All p-values reported were 2-sided. A p-value of <0.05 was considered statistically significant. All statistical analyses were performed using R (R Foundation for Statistical Computing, Vienna, Austria) [6].

3. Results

3.1. Demographic trends

A total of 2892 patients were analyzed. There were 117 (4.0%, 95% confidence interval [CI]: 3.4%–4.8%) with reported smell or taste loss. There was a higher incidence of smell or taste dysfunction in female patients compared to male patients (6.3% vs 2.5%, $P < 0.001$). The incidence of smell or taste lose was highest between the 1st and 2nd decade of life (Fig. 1). There was no significant difference in smell and taste dysfunction rates between ethnicity or smoking status, however, it appears outpatient healthcare workers had a higher incidence when compared to other healthcare workers ($P < 0.001$) (Table 1).

3.2. Medical comorbidities

There was no significant difference in smell or taste dysfunction incidence between those with co-morbid COPD, Asthma, Cancer, Pregnancy, Renal Failure, or Rheumatologic disease. There was a significantly lower incidence of smell and taste dysfunction in patients with diabetes (2.3% vs. 4.7%, $P = 0.04$), hypertension (2.5% vs. 5.5%, $P < 0.001$), and coronary artery disease (1.4% vs. 4.4%, $P = 0.01$). There was a higher proportion of individuals with HIV that presented with smell and taste dysfunction ($P = 0.02$) (Table 2).

3.3. Morbidity and multivariate analysis

Compared to the COVID-19 positive patients without smell and taste loss, there was a significantly lower rate of mortality in those who exhibited smell or taste dysfunction (20.3% vs. 0%, $P < 0.001$) Table 3.
### Table 2
Demographics and smell or taste loss.

| Comorbidities                  | No smell loss | Smell or taste loss | P-value |
|--------------------------------|---------------|---------------------|---------|
| (n = 2775, 96.0%)              | (n = 117, 4.0%)|                     |         |
| **Gender**                     |               |                     |         |
| Female                         | 1102 (39.7%)  | 74 (63.2%)          | 0.000   |
| Male                           | 1673 (60.3%)  | 43 (36.8%)          | 0.000   |
| **Age group**                  |               |                     |         |
| (10,20)                        | 16 (0.6%)     | 3 (2.6%)            | 0.000   |
| (20,30)                        | 118 (4.3%)    | 19 (16.2%)          |         |
| (30,40)                        | 236 (8.5%)    | 13 (11.1%)          |         |
| (40,50)                        | 386 (13.9%)   | 25 (21.4%)          |         |
| (50,60)                        | 604 (21.8%)   | 29 (24.8%)          |         |
| (60,70)                        | 664 (23.9%)   | 21 (17.9%)          |         |
| (70,80)                        | 450 (16.2%)   | 5 (4.3%)            |         |
| (80,90)                        | 301 (10.8%)   | 2 (1.7%)            |         |
| **Ethnicity**                  |               |                     | 0.869   |
| African                        | 311 (11.8%)   | 10 (9.3%)           |         |
| Asian                          | 111 (4.2%)    | 5 (4.6%)            |         |
| Caucasian                      | 1316 (49.9%)  | 59 (54.6%)          |         |
| Hispanic                       | 588 (22.3%)   | 22 (20.4%)          |         |
| Other                          | 312 (11.8%)   | 12 (11.1%)          |         |
| **Smoking**                    |               |                     | 0.246   |
| Current                        | 116 (4.7%)    | 6 (5.5%)            |         |
| Former                         | 471 (17.1%)   | 14 (12.7%)          |         |
| Neithee (Non-Smoker)           | 1884 (76.2%)  | 90 (81.8%)          |         |
| **Healthcare Worker**          |               |                     | 0.000   |
| Yes ER                         | 2271 (85.7%)  | 68 (68.7%)          |         |
| Yes ICU                        | 7 (0.3%)      | 0 (0)               |         |
| Yes inpatient                  | 205 (7.7%)    | 9 (9.1%)            |         |
| Yes outpatient                 | 139 (5.2%)    | 19 (19.2%)          |         |

### Table 3
Mortality outcomes.

| No smell or taste loss | Smell or taste loss | P-value |
|------------------------|---------------------|---------|
| (n = 2775, 96.0%)      | (n = 117, 4.0%)     |         |
| **Gender**             |                     |         |
| Male vs female         | 0.38 (0.25, 0.55)   |         |
| African American       |                     |         |
| Caucasian              | 1.50 (0.46, 4.37)   | 0.47    |
| Hispanic               | 1.44 (0.75, 3.04)   | 0.3     |
| Other                  | 0.91 (0.43, 2.05)   | 0.81    |
| **Smoking**            | 1.04 (0.44, 2.51)   | 0.93    |
| Former                 | 0.93 (0.36, 2.73)   | 0.89    |
| Neithee (Non-Smoker)   | 1.02 (0.47, 2.69)   | 0.96    |
| **Healthcare Worker**  |                     |         |
| Yes ER                 | 2.14 (0.49, 6.54)   | 0.24    |
| Yes ICU                | 0.00 (NA, 0.9e+15)  | 0.98    |
| Yes inpatient          | 1.29 (0.59, 2.51)   | 0.49    |
| Yes outpatient         | 3.20 (1.80, 5.47)   | <0.001  |
| **Diabetes**           | 0.69 (0.40, 1.14)   | 0.16    |
| **Asthma**             | 0.93 (0.48, 1.87)   | 0.83    |

After age-adjustment, the variable that conferred the highest risk of developing smell or taste dysfunction was outpatient healthcare worker (OR 30.20; CI 1.80–5.47; P < 0.001) Table 4.

Multivariate analysis compared to our reference group (Age 30–40 years, Non-healthcare worker, no HIV/Hepatitis) demonstrated that age group 10–20 was more likely to exhibit smell and taste dysfunction (OR 6.59; CI 1.32–26.12; P = 0.01), whereas age groups 70–80 and 80–90 were less likely (OR 0.22; CI 0.06–0.69; P = 0.01 and OR 0.18; CI 0.03–0.71; P = 0.03). Males were less likely to exhibit smell and taste dysfunction (OR 0.39; CI 0.25–0.61; P < 0.001). Outpatient healthcare workers were more likely to develop smell and taste dysfunction (OR 2.70; CI 1.46–4.79; P < 0.001). HIV positive status conferred a higher risk of smell and taste dysfunction (OR 7.27; CI 1.07–30.03; P = 0.01) Table 5.

### Table 4
Analysis lost smell or taste.

| Age-adjusted OR (95% CI) | P-value |
|--------------------------|---------|
| **Gender**               |         |
| Male vs. female          | 0.38 (0.25, 0.55) |         |
| African American         |         |
| Caucasian                | 1.50 (0.46, 4.37) | 0.47    |
| Hispanic                 | 1.44 (0.75, 3.04) | 0.3     |
| Other                    | 0.91 (0.43, 2.05) | 0.81    |
| **Smoking**              | 1.04 (0.44, 2.51) | 0.93    |
| Former                   | 0.93 (0.36, 2.73) | 0.89    |
| Neithee (Non-Smoker)     | 1.02 (0.47, 2.69) | 0.96    |
| **Healthcare Worker**    |         |
| Yes ER                   | 2.14 (0.49, 6.54) | 0.24    |
| Yes ICU                  | 0.00 (NA, 0.9e+15) | 0.98    |
| Yes inpatient            | 1.29 (0.59, 2.51) | 0.49    |
| Yes outpatient           | 3.20 (1.80, 5.47) | <0.001  |
| **Diabetes**             | 0.69 (0.40, 1.14) | 0.16    |
| **Asthma**               | 0.93 (0.48, 1.87) | 0.83    |

### Table 5
Multivariate analysis demographic and comorbidities with lost smell or taste.

| Multivariate-adjusted OR (95% CI) | P-value |
|-----------------------------------|---------|
| Age group                         |         |
| (10,20)                           | 0.06 (0.03, 0.11) | <0.001 |
| (20,30)                           | 6.59 (1.32, 26.12) | 0.01   |
| (30,40)                           | 2.22 (0.93, 5.43)  | 0.07   |
| (40,50)                           | 1.43 (0.66, 3.28)  | 0.38   |
| (50,60)                           | 1.01 (0.48, 2.28)  | 0.97   |
| (60,70)                           | 0.65 (0.29, 1.51)  | 0.29   |
| (70,80)                           | 0.22 (0.06, 0.69)  | 0.01   |
| (80,90)                           | 0.18 (0.03, 0.71)  | 0.03   |
| **Sex**                           |         |
| Male vs. female                   | 0.39 (0.25, 0.61) | <0.001 |
| **Healthcare Worker**             |         |
| Yes ER                            | 1.95 (0.44, 6.02) | 0.3    |
| Yes ICU                           | 0 (NA, 3.5e+15)   | 0.98   |
| Yes inpatient                     | 1.1 (0.47, 2.23)  | 0.81   |
| Yes outpatient                    | 2.7 (1.46, 4.79)  | <0.001 |
| **HIV/hepatitis**                 |         |
| Yes hepatitis                     | 2.77 (0.43, 9.93) | 0.18   |
| Yes HIV                           | 7.27 (1.07, 30.03)| 0.01   |
| Yes HIV and hepatitis             | 0 (NA, 9.1e+64)   | 0.99   |

Reference group: age - 30–40 years; healthcare worker - no; HIV/hepatitis - no.
4. Discussion

The COVID-19 pandemic has posed a global threat to healthcare systems, and there continues to be debate on how to manage patients and medical resources effectively [7]. Due to the heterogeneous nature of this disease and its presentations, there have been attempts to understand the symptoms and time course of the disease to help better stratify those who are at risk for requiring a higher level of care [1]. Smell and taste dysfunction have been implicated as one of the many presentations of COVID-19, and may represent an early marker of the disease process [5,8,9]. The exact mechanism of COVID-19 induced smell dysfunction is unclear, but is suspected to involve ACE2 expression in the neuro-epithelial cells within olfactory mucosa [10]. The goal of this study was to determine which clinical features placed hospitalized COVID-19 patients at a higher risk to experience the neurotropic effects from the virus.

Literature has documented the significant prevalence of anosmia in COVID-19 positive patients, with one meta-analysis indicating a 62% prevalence of olfactory dysfunction within this cohort [8,11]. Many of these studies looked at population wide data, so it can be surmised that at the outpatient level the prevalence of smell and taste dysfunction was higher where the clinical disease burden was lower. In a study out of Spain that compared the frequency of smell loss between hospitalized and non-hospitalized patients, there was a significantly higher rate of smell loss amongst the non-hospitalized patients [12]. In our inpatient study, 4% of the cohort experienced smell or taste dysfunction. These results are similar to previous studies looking at hospital inpatients, including a study by Mao et al. [13], in which olfactory and gustatory dysfunction was reported in 5.6% and 5.1% of their hospital inpatient population.

Consistent with a previous study performed using a European cohort by Lechien et al. [4], our study demonstrated the gender predilection for smell and taste disturbance towards females. It was shown that there was a significantly higher proportion of females with COVID-19 exhibiting smell and taste loss, 63.2% compared to only 36.8% of males. Emergent research is beginning to show the proclivity for the male gender to possess a higher incidence of severe disease and mortality from COVID-19 in comparison to females [14,15]. A cross-sectional analysis comparing the prevalence of olfactory dysfunction in hospitalized vs non-hospitalized COVID-19 patients noted smell dysfunction predominated in younger patients, males and those lacking comorbidities [16]. These findings in conjunction with the idea that smell and taste dysfunction correlate with a milder course may explain the increased incidence of these symptoms in our female population. From a pathogenesis standpoint, data on the differential expression of ACE2 between genders remains ambiguous and future studies are needed to explain these differences.

To further identify susceptible populations for smell and taste dysfunction, we analyzed the relationship between medical comorbidities and the presence/lack of smell and taste. Of the 4% who reported smell or taste dysfunction, the majority lacked medical comorbidities. In a systematic review of 841 hospitalized patients performed by Romero-Sanchez et al. [17], anosmia was present in 4.9% of their cohort, and most frequent in less severe cases. Previous analyses have classified patients with severe disease from COVID-19 as those with comorbidities, including Hypertension and Coronary Artery Disease [2,18]. In our study, those with comorbid hypertension, coronary artery disease and diabetes had a significantly lower rate of smell and taste dysfunction. Only patients with HIV/Hepatitis with COVID-19 had a higher rate of smell and taste dysfunction. This prevalence may be due to the suspected predisposition for smell complaints in HIV patients [19]. While the presence of anosmia has been identified as a frequent manifestation of COVID-19 in asymptomatic patients and patients with a mild course of disease, the findings in our cohort further the notion that smell and taste dysfunction are predictive of mild disease.

While olfactory decay is a common manifestation with aging and present in as many as 75% of those over 80 years old, smell and taste dysfunction in COVID-19 is more prevalent in younger ages [20]. Our study illustrated that age group 10–20 had the highest proportion of smell and taste loss. On multivariate analysis those in age group 10–20 were significantly more likely to present with taste and smell loss, with age group 20–30 closely approaching significance as well. This was also demonstrated by Izquierdo-Domingues et al. [12] who found that older patients (<60) had a 63% reduced risk of smell loss compared to younger patients (<40) with COVID-19. The explanation for the bias of smell and taste disturbances from this virus in younger decades is not yet understood.

COVID-19 is believed to be transmitted through expelled respiratory droplets from an infected individual [21]. This mode of transmission leaves healthcare workers at a potential risk due to both direct and indirect exposure. Risk factors for healthcare workers to contract COVID-19 include lack of personal protective equipment (PPE), exposure to COVID-19 positive patients, workload and pre-existing conditions [22]. Our analysis revealed that outpatient healthcare workers specifically had a higher incidence of smell and taste dysfunction in comparison to other healthcare workers. The reasoning behind this is not clear. It may be surmised that the healthcare workers presenting with smell loss follow the patterns outlined within this study. Although research pertaining to the distribution of COVID-19 symptoms in the different healthcare subdivisions remains scant, healthcare workers with the greatest risk of contracting COVID-19 are those who are exposed to respiratory droplets for a prolonged period of time [23]. Further studies comparing the symptoms and demographics of COVID-19 positive inpatient and outpatient healthcare workers should be conducted.

Smell and taste dysfunction have been looked at as potential early clinical symptoms of a COVID-19 infection [24,25]. Yan et al. [2] examined outpatients with positive COVID-19 tests and analyzed predictive factors for hospital admission. They found that normosmia in COVID-19 positive patients was an independent predictor of hospital admission, and anosmia was strongly associated with outpatient care. Similarly, Paderno et al. [16] demonstrated a significantly higher prevalence of at-home COVID-19 patients with smell dysfunction compared to hospitalized patients. In our study, we examined patients already admitted into the hospital, representing individuals with at least moderate disease severity. In comparing those patients with smell or taste dysfunction to those without, we found a significant difference in mortality, 0% in the smell or taste dysfunction group and 20.3% in the group that did not report these symptoms. This suggests that indeed those with smell or taste loss may represent a milder form of the disease process. Other literature has also noted the inverse relationship between anosmia and COVID-19 in severity, as hospitalized patients have been less likely to report anosmia compared to ambulatory patients [4]. This inverse relationship is believed to correlate with the low prevalence of smell and taste dysfunction amongst the hospitalized cohort used in this study. Additionally, prevalent COVID-19 symptoms of fever, cough and dyspnea have been less likely to be reported in those with anosmia/augestia [26].

Limitations of this study are those inherent to many retrospective database studies, including the potential for selection, information, and recall bias, as well as unmeasured confounding. The mechanism of data gathering for the database utilized in this study required extracting diagnoses and symptoms from an electronic medical records system. Therefore, some of the values for specific study variables were missing and had to be excluded from the analysis. The higher rate of smell disturbance as one cohort due to their high association, however it is possible that in larger studies differences can be gleaned between each individual cohort (smell and taste) [27]. Another potential limitation may include the self-reporting of smell and taste dysfunction by the patients. Patients with severe symptoms upon presentation or admission into the hospital may have been in too distressed of a state to adequately report symptoms of smell and taste loss. This may have resulted in analyses of individuals with less severe disease which may have
contributed to the low mortality rate. Sample size for some of the subgroup analysis was also relatively small, leading to lower power in some of the analyses.

5. Conclusion

The findings of this study suggest that smell and taste dysfunction have a higher incidence amongst women, younger age groups, and individuals without comorbidities. The manifestation of these symptoms may be associated with a lower mortality rate and an overall milder disease trajectory compared to the overall hospitalized cohort. As the neurotropism of COVID-19 affects various demographics disproportionately, further studies to investigate the neuropathogenesis in susceptible populations should be conducted.

Financial disclosures

None.

Declaration of competing interest

None.

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