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**Ear, nose, and throat manifestations of COVID-19 and its vaccines**

Al-Ani RM. ENT manifestations of COVID-19

Raid M. Al-Ani

**Raid M. Al-Ani,** Department of Surgery/Otolaryngology, University of Anbar, College of Medicine, Ramadi 31001, Anbar, Iraq

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**Corresponding author: Raid M. Al-Ani, MBChB, Full Professor,** Department of Surgery/Otolaryngology, University of Anbar, College of Medicine, AL-Thaela, Ramadi 31001, Anbar, Iraq. med.raed.alani2003@uoanbar.edu.iq

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**Abstract**

Coronavirus disease 2019 (COVID-19) is a highly infectious disease and was designated a pandemic by the World Health Organization (WHO) on March 11, 2020. There are no classical manifestations of the disease. The most prevalent symptoms include fever, cough, dyspnea, myalgia and headache. The main route of transmission of the severe acute respiratory syndrome coronavirus-2 is through the upper respiratory tract. Therefore, it is not strange to find different ear, nose and throat (ENT) symptoms in individuals infected with this virus. Olfactory dysfunction is a common feature of COVID-19; either it is the only presenting symptom or it accompanies other manifestations of the disease. Other otolaryngological features such as sudden sensorineural hearing loss (SSNHL), dysphonia, nasal obstruction, sore throat, *etc.* are less frequent manifestations of COVID-19. These features, in addition, to being presented early in the disease process, certain long-standing symptoms like parosmia, dysphonia, and persistent deafness, are other characteristics of the disease. Geographical variation in otorhinolaryngological prevalence is another problem with this debilitating disease. Local and systemic adverse effects (local site injection pain, fever, myalgia, headache, and others) of the COVID-19 vaccines are more frequent than otolaryngological side effects (anosmia, hyposmia, Bell’s palsy, SSNHL, *etc.*). We aimed in this review to summarize the early and persistent ENT symptoms of COVID-19 or after the various COVID-19 vaccines.

**Key Words:** COVID-19; Otorhinolaryngological features; Otological features; Rhinological features; Laryngological features; COVID-19 vaccines

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**Core Tip:** The most common otorhinolaryngological manifestations of coronavirus disease 2019 (COVID-19) are olfactory dysfunctions rather than other symptoms (sore throat, nasal obstruction, deafness, dysphonia, tinnitus, *etc.*). They might be present alone or associated with other common features of the disease (fever, cough, myalgia, headache and dyspnea). Adverse effects of the COVID-19 vaccines include local injection pain, fever, myalgia, headache, and others. Otorhinolaryngological side effects like Bell’s palsy, anosmia and deafness due to COVID-19 vaccines are reported in the literature as individual cases or small case series. We review the currently available evidence regarding the otorhinolaryngological features of COVID-19 or after vaccination.

**INTRODUCTION**

The coronavirus disease 2019 (COVID-19) is highly contagious and caused by the novel severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2)[1]. COVID-19 affects all medical and surgical specialties. Therefore, at the beginning of the COVID-19 pandemic, questions emerged in the mind of ear, nose and throat (ENT) surgeons. First, how can they protect themselves while performing routine tasks in outpatient clinics, wards, and theaters[2,3]. Second, how should they behave with patients who need surgical operations, particularly upper aero-digestive procedures[4]. Lastly, how they can use telemedicine to lessen the burden on health services[5].

COVID-19 has a diversity of presenting features, including classical (fever, cough, fatigue, dyspnea and headache) and nonclassical symptoms like smell and taste abnormalities[6]. It is considered a unique disease because not all affected individuals complain of the same clinical features, as well as long-standing persistence of some of these symptoms in certain patients. Furthermore, the features of the disease vary according to the ethnicity, geographical location, age of the patients, and waves of the disease[7-9].

Otorhinolaryngological symptoms like anosmia, ageusia, dysphonia, deafness, and others might be the only presenting symptom or accompany other features of COVID-19[10]. Patients with these symptoms are screened for the disease by reverse transcriptase polymerase chain reaction of naso- or oropharyngeal swabs to rule out or confirm the disease or quarantine them. Therefore, they play an essential role in controlling the disease[11].

At the beginning of 2021, several vaccines against COVID-19 were approved and given to people to achieve herd immunity to end this pandemic[12]. There is an appearance of certain clinical features, including general and otorhinolaryngological symptoms, following vaccination[13]. We aimed to summarize the various otorhinolaryngological features due to COVID-19 or following vaccination.

**Characteristics of SARS-CoV-2**

Coronaviruses contain several viruses that infect animals, which may be transmitted to humans and cause acute respiratory illnesses ranging from mild to severe and even critical forms. In 2002 and 2012, two fatal respiratory disease viruses in humans, SARS-CoV-1 and Middle East respiratory syndrome coronavirus, respectively, originated from animals. Therefore, new coronaviruses are considered a major health problem at the beginning of the 21st century[14]. The novel SARS-CoV-2 which emerged in Wuhan, China in December 2019, is a highly infectious virus from a group of coronaviruses. It is the causative agent of COVID-19[1].

Although SARS-CoV-2 is mostly transmitted through droplet or direct contact, transmission through aerosols, urine, mother-to-child, tears, and fecal–oral transmission are other routes[15–19]. The respiratory tract is the part of the body most commonly affected by SARS-CoV-2. However, any organ in the body can be infected by this virus[20]. The specific receptor, angiotensin-converting enzyme (ACE)-2, is distributed in the lungs, vascular endothelial cells, cardiac tissues, kidneys, brain, liver, intestine, pharynx, olfactory epithelium, and other sites and is the targeting receptor of the virus[20].

Similar to other RNA viruses, the novel SARS-CoV-2 has the continuous ability to mutate various genes. As a consequence, these mutating forms enhance the activity of the virus concerning transmissibility and infectivity. An obvious example is the appearance of the delta variant that infected millions of people across the globe[21].

As a result of the emergence of new variants, the Centers for Disease Control and Prevention and the World Health Organization (WHO) have independently developed a classification system for distinguishing various SARS-CoV-2 variants. This system divided these variants into variants of concern (VOCs) and variants of interest (VOIs)[22].

The VOCs are divided into five variants; alpha, beta, gamma, delta and omicron. All of them have mutations in the receptor-binding domain (RBD) and the N-terminal domain (NTD), of which the N501Y mutation located in the RBD is seen commonly in all types except the delta type. This enhances the affinity of the spike protein for the ACE-2 receptors, increasing the viral binding and thereby entrance into the host cells. Two new preprints found that a single mutation of N501Y alone enhances the affinity of the RBD to the ACE-2 receptors about 10-fold more than the ancestral strain (N501-RBD). The binding affinity of both beta and gamma variants with mutations N417/K848/Y501-RBD and ACE-2 receptors was lower than that of N501Y-RBD and ACE-2 receptors. Omicron was rapidly identified as a VOC due to > 30 changes to the spike protein of the virus as well as a sharp increase in the number of cases observed in South Africa. Various mutations were reported; for example A63T in the matrix; T91 in the envelope; Q498R in the RBD of the spike; R203K in the nucleocapsid protein; Y145del in the spike NTD; in addition to many other mutations in the non-structural and spike proteins. As a result, omicron has 13-fold more infectivity of the virus and is 2.8-fold more transmissible than the delta type[22].

VOIs are a group of variants with specific genetic markers that have been linked to changes that may cause increased virulence, inhibition of antibody neutralization as a result of an infection or vaccination, the ability to evade detection, or a decrease in the effectiveness of treatments or vaccination. Currently, the WHO has named eight VOIs, these are epsilon (B.1.427 and B.1.429), lambda (C.37), zeta (P.2), mu (B.1.621), iota (B.1.526), kappa (B.1.617.1), eta (B.1.525), and theta(P.3)[22].

**Clinical features of COVID-19**

It is well-known that the most common presenting symptoms of COVID-19 are fever, cough and shortness of breath[23]. However, one of the peculiar characteristics of COVID-19 is that there is no particular symptom that supports its diagnosis and differentiates it from other respiratory infections caused by other viruses.

As a result of the capability of the SARS-CoV-2 to infect the cells in various parts of the body through the ACE-2 receptor, diverse clinical features might be the presenting symptoms, either as an isolated symptom or a combination of complaints. The following, but not exclusively, headache, dizziness, cranial nerve palsy, nausea, vomiting, diarrhea, abdominal pain, and features of renal or heart failure, are manifestations of the disease[24]. Therefore, in the era of COVID-19, every complaint should be taken into consideration to rule out or confirm the diagnosis of this disease to prevent the transmission of the disease and treat the affected people promptly and early.

**Rhinological features of COVID-19**

Early research from various countries found that patients with this disease have olfactory and gustatory dysfunctions (OGDs). Therefore the WHO considers these abnormalities as official symptoms of the disease[25].

The possible mechanisms of the olfactory dysfunction include olfactory cleft obstruction, infection of the sustentacular supporting cells, which express ACE-2 receptors, and injury, either in the olfactory sensory cells *via* a neuropilin-1 receptor or the olfactory bulb[26,27]. A study by Xu *et al*[28] reported that the ACE-2 receptors are distributed in the tongue epithelial cells, explaining the possibility of the entrance of the virus through the buccal mucosa. However, an experimental study on a mouse model revealed that there is no such expression of ACE-2 in taste buds, but there is a significant distribution in the basal part of the filiform papillae[29]. Therefore, the possible mechanism of taste dysfunction due to COVID-19 is the direct destruction of the taste receptors due to the viral infection of the epithelial cells with associated inflammation.

OGDs start early during the disease course, either presenting alone or associated with other features of COVID-19. OGDs due to SARS-CoV-2 are more common than other viral causes of upper respiratory tract infections. OGDs are classified into quantitative (hyposmia, hypogeusia, anosmia or ageusia) or qualitative (dysgeusia, parosmia or phantosmia). The majority of these symptoms resolve within a short time, but some might persist for longer, even following the resolution of respiratory manifestations[30]. Of note, from the author’s experience, at the beginning of the first wave of COVID-19 in June 2020 in Ramadi City, Iraq, many patients with quantitative OGDs of short duration were seeking advices in public or private clinics. Most of them were resolved spontaneously within a short period (within 2 wk). The first case of parosmia was seen at the end of July 2020 in a 20-year-old woman for 5 mo. This patient acquired COVID-19 on March 1, 2020, in Baghdad City. The number of OGDs decreased in subsequent waves. On the contrary, duration of qualitative OGDs for an average of 6 mo was relatively more frequent. This could be due to either the first variant of the COVID-19 having a greater propensity to attack the chemosensory regions; people were developing herd immunity from infection of a large population; or COVID-19 vaccination.

Other various rhinological manifestations, such as nasal obstruction, rhinorrhea and sneezing, may be symptoms of COVID-19 but less frequent than OGDs. COVID-19 patients with a history of chronic illness such as diabetes mellitus, hypertension, or cardiac problems are specifically in danger of developing complications such as rhinocerebral mucormycosis[31].

**Otological features of COVID-19**

Several otological manifestations might be a feature of COVID-19 patients, such as sudden sensorineural hearing loss (SSNHL), tinnitus, vertigo, dizziness, otalgia, Bell’s palsy, *etc.* They are either single or multiple presenting symptoms and either alone or accompanied by other features of COVID-19[11,32].

A lot of investigations from different geographical areas have reported that dizziness is one of the main manifestations of COVID-19. A prior study from China, reported that dizziness was the main neurological manifestation of the disease[33]. Dizziness is postulated to result from the neuroinvasive nature of SARS-CoV-2. There are five possible mechanisms for SARS-CoV-2 to affect neuronal tissues: the virus reaches the nerve tissues through the blood, which in turn binds with ACE-2 receptors that are present in the capillary endothelium; hypoxia; direct invasion; immune-mediated insult; and hypercoagulopathy[34,35].

Hearing impairment, whether conductive or sensorineural, might be due to COVID-19. Conductive hearing loss is mostly due to Eustachian tube dysfunction. However, direct invasion of the middle ear is another possible cause. Direct invasion of the inner ear results in the initiation of inflammation, which leads to its destruction and superadded infection by microorganisms like bacteria and fungi[11]. This consequence process results in sensorineural deafness. SNHL due to COVID-19 has been reported[11,36,37], but, the causal relationship between its occurrence and the exact pathogenesis is hardly explained owing to two points. First, there was only a low number of studies that presented as case reports or a small number of cases. Second, other studies found that there was no change in the prevalence of the SSNHL between the pre-pandemic and pandemic periods[38]. However, a recent study from Italy found that there was a significantly higher average pure-tone and vestibular involvement in patients with SSNHL in the COVID-19 period in comparison with the pre-pandemic era[38]. Therefore, we recommend further study to explore the role of this disease in the prevalence and mechanisms of SSNHL. Ear problems during this pandemic should be taken into consideration, particularly if they are not associated with other features to rule out or confirm the disease for better prevention and control of the COVID-19.

**Throat features of COVID-19**

SARS-CoV-2 affects the upper aerodigestive tissues *via* ACE-2 or transmembrane protease/serine subfamily member 2 receptors[39], leading to different manifestations like dysgeusia, sore throat, hoarseness, dysphagia and odynophagia. Moreover, this virus infection can present with acute laryngitis either as acute epiglottitis in adulthood or croup in infants[40,41]. Although COVID-19-induced acute laryngitis is uncommon, being aware of laryngeal difficulties has the following benefits: participation in early disease diagnosis, infection isolation and control, prevention of infection progression, and correct treatment of airway obstruction[40].

A recent multicenter study from Saudi Arabia identified sore throat in 20.9% of the total COVID-19 confirmed cases (1734), ageusia in 11.4% and odynophagia in 9.6%[42]. Sore throat was identified in 153 of 1099 (13.9%) of laboratory-confirmed COVID-19 patients from 552 hospitals in China during the early stages of the pandemic[16]. In 1420 confirmed cases of mild to moderate COVID-19 from 18 European hospitals, taste dysfunction was reported in 54.2%, sore throat in 52.9%, dysphonia in 28.4% and dysphagia in 19.3%[43]. We may conclude from the studies stated above that throat symptoms are common in COVID-19 patients and that the distribution of these manifestations varies geographically. Specific symptoms such as dysphonia and dysphagia may have emerged as a consequence of COVID-19 treatment, particularly in patients who require breathing support[44].

**Otorhinolaryngological Features following Various COVID-19 Vaccines**

A vaccine is defined as a preparation of biological material that gives an active acquired immunity against a specific infectious agent. This happens by stimulating an immune response to an antigen (molecule of the microorganism)[45]. The first vaccine was developed by Edward Jenner in 1796 against smallpox[46]. Vaccination is the most effective method for long-term prevention and control of any infectious disease. Scientists in various countries since the beginning of the COVID-19 pandemic have mobilized to find effective vaccines to control COVID-19. These efforts have resulted in the development of many vaccines against SARS-CoV-2. The Pfizer COVID-19 vaccine (BNT162b2) was the first vaccine to be approved by the WHO for emergency use on December 31, 2020. Other vaccines were developed later, such as Astra-Zeneca/Oxford COVID-19, Ad26.COV2.S, *etc.*[47].

The COVID-19 vaccines have both local and systemic adverse effects, including headache, fatigue, muscular soreness, malaise, chills, and joint discomfort. Klugar *et al*[48] found that the majority of participating healthcare workers (*n* = 599) experienced at least one of the symptoms listed above. Furthermore, the study found that mRNA-based immunizations had a higher incidence of local adverse effects than viral vector-based immunizations (78.3% *vs* 70.4%; *P* = 0.064). The opposite was true for systemic adverse effects (87.2% *vs* 61%; *P* = 0.001). The majority of these adverse reactions subsided 1-3 d after immunization[48].

Although local and systemic manifestations are common following COVID-19 immunizations, otorhinolaryngological symptoms, such as anosmia, ageusia, SSNHL, Bell's palsy, and others, are rarely documented in the literature (Table 1)[25,49-54].

**CONCLUSION**

COVID-19 has a wide range of symptoms experienced by those who are infected. Smell and taste abnormalities are the most common ENT symptoms of the disease. They are either the only presenting symptom or associated with other clinical features of COVID-19. Other ENT manifestations such as SSNHL, dysphonia, nasal obstruction, *etc.* are less common than OGDs. COVID-19 is characterized by geographical diversity in symptomatology as well as long-term symptoms. The identification of ENT symptoms is critical in illness prevention and control. The side effects of several COVID-19 vaccinations include anosmia, bell’s palsy, SSNHL, tinnitus, and others; however they are less common than the local and systemic signs that occur after vaccination.

**REFERENCES**

1 **Hu B**, Guo H, Zhou P, Shi ZL. Characteristics of SARS-CoV-2 and COVID-19. *Nat Rev Microbiol* 2021; **19**: 141-154 [PMID: 33024307 DOI: 10.1038/s41579-020-00459-7]

2 **Cheng X**, Liu J, Li N, Nisenbaum E, Sun Q, Chen B, Casiano R, Weed D, Telischi F, Denneny JC 3rd, Liu X, Shu Y. Otolaryngology Providers Must Be Alert for Patients with Mild and Asymptomatic COVID-19. *Otolaryngol Head Neck Surg* 2020; **162**: 809-810 [PMID: 32286913 DOI: 10.1177/0194599820920649]

3 **Vukkadala N**, Qian ZJ, Holsinger FC, Patel ZM, Rosenthal E. COVID-19 and the Otolaryngologist: Preliminary Evidence-Based Review. *Laryngoscope* 2020; **130**: 2537-2543 [PMID: 32219846 DOI: 10.1002/lary.28672]

4 **Workman AD**, Jafari A, Welling DB, Varvares MA, Gray ST, Holbrook EH, Scangas GA, Xiao R, Carter BS, Curry WT, Bleier BS. Airborne Aerosol Generation During Endonasal Procedures in the Era of COVID-19: Risks and Recommendations. *Otolaryngol Head Neck Surg* 2020; **163**: 465-470 [PMID: 32452739 DOI: 10.1177/0194599820931805]

5 **Pollock K**, Setzen M, Svider PF. Embracing telemedicine into your otolaryngology practice amid the COVID-19 crisis: An invited commentary. *Am J Otolaryngol* 2020; **41**: 102490 [PMID: 32307192 DOI: 10.1016/j.amjoto.2020.102490]

6 **Sattler A**, Angermair S, Stockmann H, Heim KM, Khadzhynov D, Treskatsch S, Halleck F, Kreis ME, Kotsch K. SARS-CoV-2-specific T cell responses and correlations with COVID-19 patient predisposition. *J Clin Invest* 2020; **130**: 6477-6489 [PMID: 32833687 DOI: 10.1172/JCI140965]

7 **Jones J**, Sullivan PS, Sanchez TH, Guest JL, Hall EW, Luisi N, Zlotorzynska M, Wilde G, Bradley H, Siegler AJ. Similarities and Differences in COVID-19 Awareness, Concern, and Symptoms by Race and Ethnicity in the United States: Cross-Sectional Survey. *J Med Internet Res* 2020; **22**: e20001 [PMID: 32614778 DOI: 10.2196/20001]

8 **Elizondo V**, Harkins GW, Mabvakure B, Smidt S, Zappile P, Marier C, Maurano MT, Perez V, Mazza N, Beloso C, Ifran S, Fernandez M, Santini A, Perez V, Estevez V, Nin M, Manrique G, Perez L, Ross F, Boschi S, Zubillaga MN, Balleste R, Dellicour S, Heguy A, Duerr R. SARS-CoV-2 genomic characterization and clinical manifestation of the COVID-19 outbreak in Uruguay. *Emerg Microbes Infect* 2021; **10**: 51-65 [PMID: 33306459 DOI: 10.1080/22221751.2020.1863747]

9 **Yuki K**, Fujiogi M, Koutsogiannaki S. COVID-19 pathophysiology: A review. *Clin Immunol* 2020; **215**: 108427 [PMID: 32325252 DOI: 10.1016/j.clim.2020.108427]

10 **Al-Ani RM**, Acharya D. Prevalence of Anosmia and Ageusia in Patients with COVID-19 at a Primary Health Center, Doha, Qatar. *Indian J Otolaryngol Head Neck Surg* 2020: 1-7 [PMID: 32837952 DOI: 10.1007/s12070-020-02064-9]

11 **Yaseen NK**, Al-Ani RM, Ali Rashid R. COVID-19-related sudden sensorineural hearing loss. *Qatar Med J* 2021; **2021**: 58 [PMID: 34745911 DOI: 10.5339/qmj.2021.58]

12 **Pfattheicher S**, Petersen MB, Böhm R. Information about herd immunity through vaccination and empathy promote COVID-19 vaccination intentions. *Health Psychol* 2022; **41**: 85-93 [PMID: 34570535 DOI: 10.1037/hea0001096]

13 **Canas LS**, Österdahl MF, Deng J, Hu C, Selvachandran S, Polidori L, May A, Molteni E, Murray B, Chen L, Kerfoot E, Klaser K, Antonelli M, Hammers A, Spector T, Ourselin S, Steves C, Sudre CH, Modat M, Duncan EL. Disentangling post-vaccination symptoms from early COVID-19. *EclinicalMedicine* 2021; **42**: 101212 [PMID: 34873584 DOI: 10.1016/j.eclinm.2021.101212]

14 **Cui J**, Li F, Shi ZL. Origin and evolution of pathogenic coronaviruses. *Nat Rev Microbiol* 2019; **17**: 181-192 [PMID: 30531947 DOI: 10.1038/s41579-018-0118-9]

15 **Lu CW**, Liu XF, Jia ZF. 2019-nCoV transmission through the ocular surface must not be ignored. *Lancet* 2020; **395**: e39 [PMID: 32035510 DOI: 10.1016/S0140-6736(20)30313-5]

16 **Guan WJ**, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, Liu L, Shan H, Lei CL, Hui DSC, Du B, Li LJ, Zeng G, Yuen KY, Chen RC, Tang CL, Wang T, Chen PY, Xiang J, Li SY, Wang JL, Liang ZJ, Peng YX, Wei L, Liu Y, Hu YH, Peng P, Wang JM, Liu JY, Chen Z, Li G, Zheng ZJ, Qiu SQ, Luo J, Ye CJ, Zhu SY, Zhong NS; China Medical Treatment Expert Group for Covid-19. Clinical Characteristics of Coronavirus Disease 2019 in China. *N Engl J Med* 2020; **382**: 1708-1720 [PMID: 32109013 DOI: 10.1056/NEJMoa2002032]

17 **Nishiura H**, Linton NM, Akhmetzhanov AR. Initial Cluster of Novel Coronavirus (2019-nCoV) Infections in Wuhan, China Is Consistent with Substantial Human-to-Human Transmission. *J Clin Med* 2020; **9** [PMID: 32054045 DOI: 10.3390/jcm9020488]

18 **Sun SH**, Chen Q, Gu HJ, Yang G, Wang YX, Huang XY, Liu SS, Zhang NN, Li XF, Xiong R, Guo Y, Deng YQ, Huang WJ, Liu Q, Liu QM, Shen YL, Zhou Y, Yang X, Zhao TY, Fan CF, Zhou YS, Qin CF, Wang YC. A Mouse Model of SARS-CoV-2 Infection and Pathogenesis. *Cell Host Microbe* 2020; **28**: 124-133.e4 [PMID: 32485164 DOI: 10.1016/j.chom.2020.05.020]

19 **Amirian ES**. Potential fecal transmission of SARS-CoV-2: Current evidence and implications for public health. *Int J Infect Dis* 2020; **95**: 363-370 [PMID: 32335340 DOI: 10.1016/j.ijid.2020.04.057]

20 **Jain U**. Effect of COVID-19 on the Organs. *Cureus* 2020; **12**: e9540 [PMID: 32905500 DOI: 10.7759/cureus.9540]

21 **Kannan SR**, Spratt AN, Cohen AR, Naqvi SH, Chand HS, Quinn TP, Lorson CL, Byrareddy SN, Singh K. Evolutionary analysis of the Delta and Delta Plus variants of the SARS-CoV-2 viruses. *J Autoimmun* 2021; **124**: 102715 [PMID: 34399188 DOI: 10.1016/j.jaut.2021.102715]

22 **Aleem A**, Akbar Samad AB, Slenker AK. Emerging Variants of SARS-CoV-2 And Novel Therapeutics Against Coronavirus (COVID-19). 2022 May 12. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan- [PMID: 34033342]

23 **Abayomi A**, Odukoya O, Osibogun A, Wright O, Adebayo B, Balogun M, Abdus-Salam I, Bowale A, Mutiu B, Saka B, Adejumo M, Yenyi S, Agbolagorite R, Onasanya O, Erinosho E, Obasanya J, Adejumo O, Adesola S, Oshodi Y, Akase IE, Ogunbiyi S, Lajide D, Erinoso F, Abdur-Razzaq H. Presenting Symptoms and Predictors of Poor Outcomes Among 2,184 Patients with COVID-19 in Lagos State, Nigeria. *Int J Infect Dis* 2021; **102**: 226-232 [PMID: 33075534 DOI: 10.1016/j.ijid.2020.10.024]

24 **Özçelik Korkmaz M**, Eğilmez OK, Özçelik MA, Güven M. Otolaryngological manifestations of hospitalised patients with confirmed COVID-19 infection. *Eur Arch Otorhinolaryngol* 2021; **278**: 1675-1685 [PMID: 33011957 DOI: 10.1007/s00405-020-06396-8]

25 **Konstantinidis I**, Tsakiropoulou E, Hähner A, de With K, Poulas K, Hummel T. Olfactory dysfunction after coronavirus disease 2019 (COVID-19) vaccination. *Int Forum Allergy Rhinol* 2021; **11**: 1399-1401 [PMID: 34047498 DOI: 10.1002/alr.22809]

26 **Moein ST**, Hashemian SM, Mansourafshar B, Khorram-Tousi A, Tabarsi P, Doty RL. Smell dysfunction: a biomarker for COVID-19. *Int Forum Allergy Rhinol* 2020; **10**: 944-950 [PMID: 32301284 DOI: 10.1002/alr.22587]

27 **Hopkins C**, Lechien JR, Saussez S. More that ACE2? NRP1 may play a central role in the underlying pathophysiological mechanism of olfactory dysfunction in COVID-19 and its association with enhanced survival. *Med Hypotheses* 2021; **146**: 110406 [PMID: 33246692 DOI: 10.1016/j.mehy.2020.110406]

28 **Xu H**, Zhong L, Deng J, Peng J, Dan H, Zeng X, Li T, Chen Q. High expression of ACE2 receptor of 2019-nCoV on the epithelial cells of oral mucosa. *Int J Oral Sci* 2020; **12**: 8 [PMID: 32094336 DOI: 10.1038/s41368-020-0074-x]

29 **Wang Z**, Zhou J, Marshall B, Rekaya R, Ye K, Liu HX. SARS-CoV-2 Receptor *ACE2* Is Enriched in a Subpopulation of Mouse Tongue Epithelial Cells in Nongustatory Papillae but Not in Taste Buds or Embryonic Oral Epithelium. *ACS Pharmacol Transl Sci* 2020; **3**: 749-758 [PMID: 32821883 DOI: 10.1021/acsptsci.0c00062]

30 **Mastrangelo A**, Bonato M, Cinque P. Smell and taste disorders in COVID-19: From pathogenesis to clinical features and outcomes. *Neurosci Lett* 2021; **748**: 135694 [PMID: 33600902 DOI: 10.1016/j.neulet.2021.135694]

31 **Alekseyev K**, Didenko L, Chaudhry B. Rhinocerebral Mucormycosis and COVID-19 Pneumonia. *J Med Cases* 2021; **12**: 85-89 [PMID: 33984095 DOI: 10.14740/jmc3637]

32 **Saniasiaya J**, Kulasegarah J, Narayanan P. New-Onset Dysphonia: A Silent Manifestation of COVID-19. *Ear Nose Throat J* 2021: 145561321995008 [PMID: 33645290 DOI: 10.1177/0145561321995008]

33 **Mao L**, Jin H, Wang M, Hu Y, Chen S, He Q, Chang J, Hong C, Zhou Y, Wang D, Miao X, Li Y, Hu B. Neurologic Manifestations of Hospitalized Patients With Coronavirus Disease 2019 in Wuhan, China. *JAMA Neurol* 2020; **77**: 683-690 [PMID: 32275288 DOI: 10.1001/jamaneurol.2020.1127]

34 **Baig AM**, Khaleeq A, Ali U, Syeda H. Evidence of the COVID-19 Virus Targeting the CNS: Tissue Distribution, Host-Virus Interaction, and Proposed Neurotropic Mechanisms. *ACS Chem Neurosci* 2020; **11**: 995-998 [PMID: 32167747 DOI: 10.1021/acschemneuro.0c00122]

35 **Wu Y**, Xu X, Chen Z, Duan J, Hashimoto K, Yang L, Liu C, Yang C. Nervous system involvement after infection with COVID-19 and other coronaviruses. *Brain Behav Immun* 2020; **87**: 18-22 [PMID: 32240762 DOI: 10.1016/j.bbi.2020.03.031]

36 **Koumpa FS**, Forde CT, Manjaly JG. Sudden irreversible hearing loss post COVID-19. *BMJ Case Rep* 2020; **13** [PMID: 33051251 DOI: 10.1136/bcr-2020-238419]

37 **Mustafa MWM**. Audiological profile of asymptomatic Covid-19 PCR-positive cases. *Am J Otolaryngol* 2020; **41**: 102483 [PMID: 32307189 DOI: 10.1016/j.amjoto.2020.102483]

38 **Parrino D**, Frosolini A, Toninato D, Matarazzo A, Marioni G, de Filippis C. Sudden hearing loss and vestibular disorders during and before COVID-19 pandemic: An audiology tertiary referral centre experience. *Am J Otolaryngol* 2022; **43**: 103241 [PMID: 34555789 DOI: 10.1016/j.amjoto.2021.103241]

39 **Sato T**, Ueha R, Goto T, Yamauchi A, Kondo K, Yamasoba T. Expression of ACE2 and TMPRSS2 Proteins in the Upper and Lower Aerodigestive Tracts of Rats: Implications on COVID 19 Infections. *Laryngoscope* 2021; **131**: E932-E939 [PMID: 32940922 DOI: 10.1002/lary.29132]

40 **Iwamoto S**, Sato MP, Hoshi Y, Otsuki N, Doi K. COVID-19 presenting as acute epiglottitis: A case report and literature review. *Auris Nasus Larynx* 2021 [PMID: 34986973 DOI: 10.1016/j.anl.2021.12.007]

41 **Venn AMR**, Schmidt JM, Mullan PC. Pediatric croup with COVID-19. *Am J Emerg Med* 2021; **43**: 287.e1-287.e3 [PMID: 32980228 DOI: 10.1016/j.ajem.2020.09.034]

42 **Telmesani LM**, Althomaly DH, Buohliqah LA, Halawani RT, Ashoor MM, Alwazzeh MJ, Al Mubarak SA, AlHarbi MA, AlMuslem RF, Arabi SS, Saleh WE, ALYosif AY, Al Eid MR, Telmesani LS, AlEnazi AS. Clinical otorhinolaryngological presentation of COVID-19 patients in Saudi Arabia: A multicenter study. *Saudi Med J* 2022; **43**: 266-274 [PMID: 35256494 DOI: 10.15537/smj.2022.43.3.20210501]

43 **Lechien JR**, Chiesa-Estomba CM, Place S, Van Laethem Y, Cabaraux P, Mat Q, Huet K, Plzak J, Horoi M, Hans S, Rosaria Barillari M, Cammaroto G, Fakhry N, Martiny D, Ayad T, Jouffe L, Hopkins C, Saussez S; COVID-19 Task Force of YO-IFOS. Clinical and epidemiological characteristics of 1420 European patients with mild-to-moderate coronavirus disease 2019. *J Intern Med* 2020; **288**: 335-344 [PMID: 32352202 DOI: 10.1111/joim.13089]

44 **Naunheim MR**, Zhou AS, Puka E, Franco RA Jr, Carroll TL, Teng SE, Mallur PS, Song PC. Laryngeal complications of COVID-19. *Laryngoscope Investig Otolaryngol* 2020; **5**: 1117-1124 [PMID: 33364402 DOI: 10.1002/lio2.484]

45 **Sell S**. How vaccines work: immune effector mechanisms and designer vaccines. *Expert Rev Vaccines* 2019; **18**: 993-1015 [PMID: 31594419 DOI: 10.1080/14760584.2019.1674144]

46 **Ellis H**. James Phipps, first to be vaccinated against smallpox by Edward Jenner. *J Perioper Pract* 2021; **31**: 51-52 [PMID: 33251953 DOI: 10.1177/1750458920950165]

47 **Francis AI**, Ghany S, Gilkes T, Umakanthan S. Review of COVID-19 vaccine subtypes, efficacy and geographical distributions. *Postgrad Med J* 2022; **98**: 389-394 [PMID: 34362856 DOI: 10.1136/postgradmedj-2021-140654]

48 **Klugar M**, Riad A, Mekhemar M, Conrad J, Buchbender M, Howaldt HP, Attia S. Side Effects of mRNA-Based and Viral Vector-Based COVID-19 Vaccines among German Healthcare Workers. *Biology (Basel)* 2021; **10** [PMID: 34439984 DOI: 10.3390/biology10080752]

49 **Colella G**, Orlandi M, Cirillo N. Bell's palsy following COVID-19 vaccination. *J Neurol* 2021; **268**: 3589-3591 [PMID: 33611630 DOI: 10.1007/s00415-021-10462-4]

50 **Repajic M**, Lai XL, Xu P, Liu A. Bell's Palsy after second dose of Pfizer COVID-19 vaccination in a patient with history of recurrent Bell's palsy. *Brain Behav Immun Health* 2021; **13**: 100217 [PMID: 33594349 DOI: 10.1016/j.bbih.2021.100217]

51 **Keir G**, Maria NI, Kirsch CFE. Unique Imaging Findings of Neurologic Phantosmia Following Pfizer-BioNtech COVID-19 Vaccination: A Case Report. *Top Magn Reson Imaging* 2021; **30**: 133-137 [PMID: 34096896 DOI: 10.1097/RMR.0000000000000287]

52 **Lechien JR**, Diallo AO, Dachy B, Le Bon SD, Maniaci A, Vaira LA, Saussez S. COVID-19: Post-vaccine Smell and Taste Disorders: Report of 6 Cases. *Ear Nose Throat J* 2021: 1455613211033125 [PMID: 34467793 DOI: 10.1177/01455613211033125]

53 **Wichova H**, Miller ME, Derebery MJ. Otologic Manifestations After COVID-19 Vaccination: The House Ear Clinic Experience. *Otol Neurotol* 2021; **42**: e1213-e1218 [PMID: 34267103 DOI: 10.1097/MAO.0000000000003275]

54 **Jeong J**, Choi HS. Sudden sensorineural hearing loss after COVID-19 vaccination. *Int J Infect Dis* 2021; **113**: 341-343 [PMID: 34670143 DOI: 10.1016/j.ijid.2021.10.025]

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**Table 1** **Following coronavirus disease 2019 immunizations, some studies observed otorhinolaryngological problems**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Ref.** | **Country** | **Date** | **Number of cases** | **Symptoms** | **Vaccine** |
| Colella *et al*[49] | Italy | February 2021 | 1 | Left Bellʼs palsy | First dose of Pfizer |
| Repajic *et al*[50] | United States | February 2021 | 1 | Left Bellʼs palsy | Second dose of Pfizer |
| Konstantinidis *et al*[25] | Greece Germany | May 2021 | 2 | Hyposmia | Second dose of Pfizer |
| Keir *et al*[51] | United States | June 2021 | 1 | Phantosmia | Second dose of Pfizer |
| Lechien *et al*[52] | France Belgium Italy | September 2021 | 6 | Smell abnormalities (*n* = 5); taste abnormality (*n* = 1) | The first injection of AstraZeneca (*n* = 4); a second injection of Pfizer (*n* = 2) |
| Wichova *et al*[53] | United States | October 2021 | 30 | Hearing loss (25), vertigo (5), dizziness (8), tinnitus (15) | Moderna (*n* = 18), Pfizer (*n* = 12) |
| J. Jeong and H. S. Choi[54] | Korea | December 2021 | 3 | SSNHL | One case after Oxford-AstraZeneca, 2 cases after Pfizer |

SSNHL: Sudden sensorineural hearing loss.



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