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Coronavirus Pandemic

Impact of prolonged wearing of face masks – medical and forensic implications

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Abstract

Since December 2019, the global outbreak of coronavirus disease had a significant impact on humanity. Because of the large number of casualties worldwide, the WHO (World Health Organization) declared the coronavirus disease caused by SARS-CoV-2 a pandemic. Since the start of the pandemic, facial masks have become essential as well as mandatory to protect ourselves from COVID-19. As a result of the pandemic, healthcare professionals (HCPs) have been required to wear personal protective equipment (PPE) for extended periods. Wearing face masks for an extended period has been shown to have several negative effects on HCPs. Additionally, face masks have hampered the use of digital techniques for facial identification. This paper examines the effects of wearing face masks for an extended period, as well as the effect of wearing face masks on facial identification technology. The Web of Science, PubMed, and Scopus databases were searched and screened for relevant studies. According to the current review, prolonged use of masks was found to be associated with adverse effects on the face and skin, including acne, redness, rashes, and itching. The use of masks also resulted in headaches, hypoxic conditions, and changes in voice and speech parameters. This communication in no way intends to advocate the discontinuation of wearing masks, on the contrary, the primary goal of this article is to spread awareness about the adverse effects associated with prolonged use of facial masks (N95, KF94, or surgical). This will help in increasing compliance with mask mandates by helping to develop preventive solutions to the problems that tend to deter the general public. This also demonstrates how the use of masks has become a challenge for facial recognition technologies.

Key words: COVID-19; pandemic; face masks; health effects; forensic implications.

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Introduction

When a healthy person comes into contact with viral droplets from an infected person's cough or sneeze, the pathogens for communicable respiratory diseases are transmitted [1]. The global outbreak of viral diseases poses a serious threat to public health. Various viral epidemics of global importance have occurred in the past, including Spanish flu (1918-1919), Asian flu (1957-1958), Hong Kong flu (1968-1969), SARS-CoV in 2002/2003, swine flu in 2009, and MERS-CoV in 2012 [2,3]. The coronavirus disease (COVID-19) has been recognized as a global health disaster of the twenty-first century. There are several hundred viruses in the coronavirus family (*Coronaviridae* family) [4]. Coronaviruses have been known to infect humans, mammals, and birds. Only six coronaviruses have been identified as causing mild to severe RTI (respiratory tract infection) in humans, as shown in Figure 1. SARS-CoV and MERS-CoV are known to cause severe illness, whereas the other four are known to cause only mild illness [5,6].

In December 2019, a new viral respiratory disease, coronavirus disease (COVID-19), spread throughout the world [7]. SARS-CoV-2, as designated by the ICTV (International Committee on Taxonomy of Viruses), is the causative agent of the disease [8]. The impact of COVID-19 pandemic has had a massive global impact. A majority of countries globally have experienced the disease's first, second, and third waves [9]. The novel coronavirus, also known as SARS-CoV-2, was discovered in December 2019 in the Chinese city of Wuhan. The disease outbreak began in Wuhan, China [10]. This disease outbreak infected people in China as well as people in many other countries [11]. As per the latest data reported by World Health Organization (WHO) on 29 February 2022, the total count of confirmed COVID-19 cases worldwide is recorded at 418,650,474 with 5,856,224 deaths attributed to COVID-19 [12,13]. On January 2020, WHO (World Health Organization) declared it an “infectious disease pandemic” after thousands of cases were reported across the world [14]. The universal wearing of face

masks and physical or social distancing [15,16] is safeguarding the world population. This is because the mode of transmission of COVID-19 is airborne, as the viral particles are shed from the nose and mouth of asymptomatic and infected person through respiratory droplets [17]. Therefore, all frontline workers or healthcare professionals have been instructed to wear PPE (personal protective equipment). The PPE kit comprises of face shields, face masks, gloves, gowns, etc. [18]. The general public has also been mandated to wear face masks in public and working places [19]. The wearing of face masks has become a common practice in our everyday routine. At present, the use of face masks remains a common practice globally, with the numbers of COVID-19 cases again on the rise, even after the second and third waves in many countries [20]. The consistent increase in COVID-19 cases has created an alarming situation. In addition, significant mutations in SARS-CoV-2 have been observed since its emergence in December 2019, resulting in new variants frequently appearing, that surpass existing variants [21]. This points to a terrifying situation in the future, with the development of several 'super'-mutants of SARS-CoV-2. Social distancing, mask use, proper isolation of infected patients, and other measures have been shown to adequately manage virus transmission and widen the curve [22]. According to the studies, there are tens of thousands of SARS-CoV-2 variants that differ from one another by at least one mutation. Global researchers are constantly monitoring their mutation and transmission [23]. Six of the variants have emerged to be of medical importance since the pandemic's emergence and have spread globally [24]. A new variant, 'Omicron (B.1.1.529),' has recently been reported, posing a threat to nations' more serious efforts to contain this global pandemic (Figure 2). South Africa was the first to report the Omicron variant to World Health Organization on 24 November 2021 [25]. WHO has designated five of the variants as SARS-CoV-2 Variants of Concern (VOC), namely 'alpha,' 'beta,' 'gamma,' 'delta,' and 'omicron.' According to reports, the SARS-CoV-2 will continue to evolve, with Omicron being the last Variant of Concern (VOC) [26].

Figure 1. Coronavirus family strains.

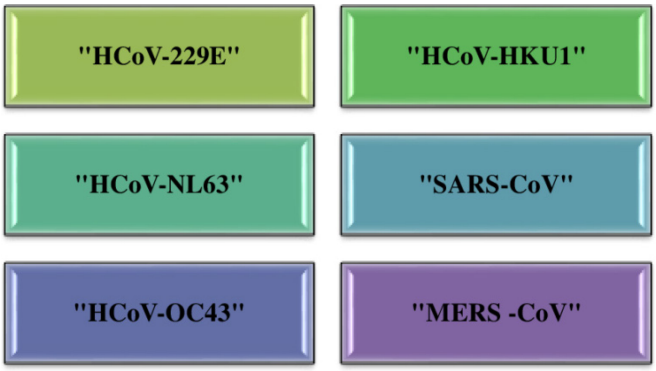
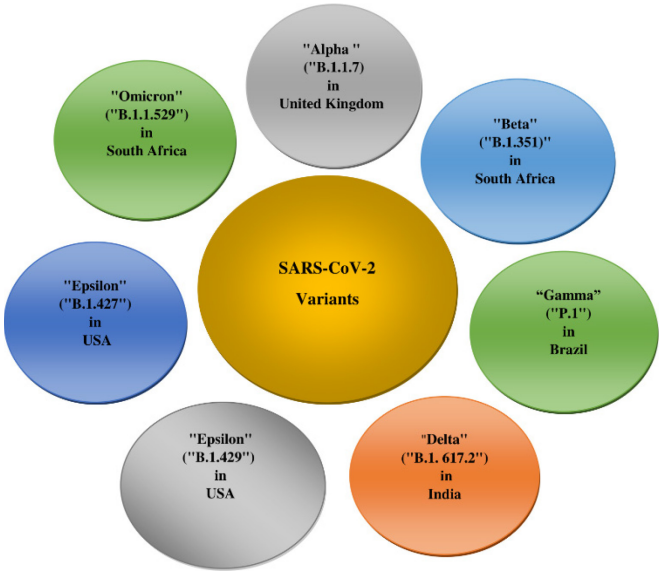


Figure 2. Detected SARS-CoV-2 variants.



Prolonged wearing of face masks

Earlier, the wearing of masks was most common in workplaces such as laboratories, hospitals, mines, and polluted areas. However, since the spread of COVID-19 around the world, face masks have become a part of our daily life, and people are wearing masks for longer periods than usual. Wearing masks for an extended period may have negative consequences. Face masks with insufficient ventilation cause hypoxia or lack of oxygen. Hypoxia may lead to increased stress in people [27,28]. A Polish surgeon, Jan Antoni Mikulicz-Radecki was the first to introduce cotton face masks during surgery [29]. After the WHO declared COVID-19 a global pandemic [30], the use of face masks for longer periods has become a common practice. Undoubtedly, personal protective equipment used by health care professionals protects them from infection. However, it can also harm their skin, causing itching and other skin ailments [31]. There is a paucity of research on the long-term use of face masks and their negative effects. However, adverse effects of face masks on respiratory physiology as well as psychological consequences have been mentioned in the literature.

In this article, the impact related to the prolonged wearing of face masks and other physiological effects among healthcare professionals and the general public have been reviewed. The article also discusses the

forensic implications of wearing face masks and the challenges presented for facial identification thereof.

Methodology

A comprehensive literature search was conducted using the databases - Web of Science, PubMed, and Scopus. A variety of mask-related scenarios, affected groups, and preventive measures were considered. The keywords used to search the databases were 'COVID-19- pandemic', 'the impacts of prolonged wearing of masks', 'impacts of wearing masks on – face, skin, eyes, voice, exercise', 'misuse of masks by perpetrator', 'face spoofing', 'forensic identification of mask-wearing people. The relevant search results were screened. The irrelevant results were filtered out of the study. The relevant papers were thoroughly studied and reviewed in the present paper. Various studies such as original research, case-control, cross-sectional, narrative reviews, systematic reviews, meta-analysis, surveys, and comparison studies were reviewed on the impact of the use of face masks for a longer duration.

Results

After going through the literature and reports on the prolonged wearing of masks, it was found that prolonged wearing of face masks leads to the development of several adverse effects in human beings. These effects of prolonged wearing of masks have been discussed in detail. Similarly, the forensic implications of this aspect have also been discussed.

Medical implications of prolonged wearing of face masks

Impact on Face:

Wearing masks for long hours leads to physiological and psychological stress. The usage of PPE and masks are associated with unpleasant effects such as headache [32], acne [33], and skin breakdown [34], obstructing vision and communication [35]. Wearing face masks has been shown to reduce the accuracy of facial identification in forensic examinations [36]. The face conveys a great deal of information, which is essential for human interaction. Face masks, on the other hand, can help to reduce viral transmission. Furthermore, face masks impair social interaction, individual identification, facial expressions, and emotions. Face masks have the disadvantage of making it difficult to remember someone's identity [37].

Impact on eyes and vision

Several studies have shown that wearing masks provides safety but can be harmful if worn for an extended period. Face shields have been proposed to protect the eyes from the viral transmission. Eye protection is underrated but still challenging. Eye protectors fog up, hinder vision, and are sometimes unbearable [38]. Ocular symptoms are common in COVID-19 infection [39]. Prevalent use of facemasks is associated with ocular dryness and irritation, increasing the risk of disease transmission and other eye health concerns [40]. However, there are solutions to overcome this problem. One of them is the use of hydrogel patches which are not easily affordable [41]. Other solutions which are quite simple and cost-effective are mentioned below:

1. Make a pointed tent-like fold on the nose clip (the metallic part on the upper border) of the mask to prevent fogging without touching the glasses [42-44].
2. Apply adhesive tape along the upper edge of the mask, over the skin beneath the eyes. The adhesive tape should be the same length as the inter-pupillary distance [42-44].
3. Place a piece of tissue paper on the nose bridge, underneath the mask, to absorb the moisture [42-44].
4. Cross-tying of the ear-loops will allow air to escape laterally and away from the eyeglasses [42-44].
5. Application of cleanser-based surfactant layering on glasses to reduce fogging [42-44].
6. Application of anti-fogging lenses, chemical layering, and polycarbonate-based lenses [42-44].
7. If none of these solutions work, another alternative is to wear contact lenses. Additionally, contact lenses offer better vision correction in some situations [42-44].

Changes in speech and voice

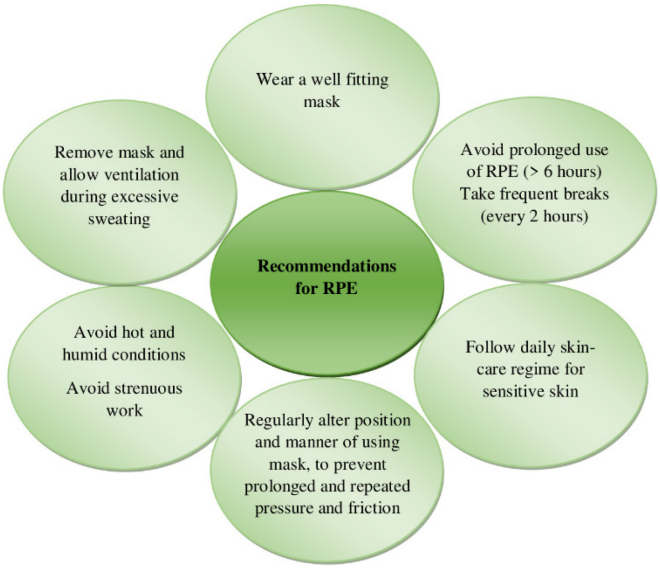
Voice assessment is a significant approach for evaluating the quality of voice. Voice assessment has been performed to assess the impact of face masks on voice. Wearing masks increased the sound pressure level, a significant fall-off in the F3-formant parameter, and lesser perturbation [45]. "A single frequency at which vocal tract transmission is more efficient than at neighboring frequencies" is defined as a formant. Moreover, the F3 formant parameter is a significant voice parameter for gender identification [46]. Wearing masks obstructs communication by acting as an acoustic filter [47]. The listener is unable to clearly understand the words spoken, particularly in noisy environments. Similarly, mask-wearing is a big

challenge for speakers in interpersonal communications [48]. During communication, the speaker has to put in more vocal effort. This may increase the discomfort in the vocal tract leading to cause difficulties during speech and breathing, an increase in vocal strength [49], spectral sound variations, etc. Comparative examinations, with the speaker communicating via transparent masks, convey visual information that assisted listeners to understand the sentences, even in noisy environments [50].

Changes in skin characteristics

Since the beginning of the COVID-19 pandemic, several adverse skin reactions have been observed, associated with the prolonged wearing of PPE. The most prevalent adverse skin reactions were contact dermatitis [51], increased skin wrinkles and pore area [52], itch, urticaria, redness, rashes, and acne [53] indicating some allergic reactions. N95 masks were found to be associated with more unpleasant skin reactions as compared to surgical masks [54]. Healthcare professionals (HCPs) are vulnerable to injuries on the skin and mucous membrane, leading to dermatitis (acute and chronic), illness, and other skin diseases. The use of moisturizing products has been suggested for better skin protection [44,55]. The changes observed in the skin physiology included an increase in skin hydration, TEWL (trans-epidermal water loss) [56], erythema, sebum secretion, level of pH as well as skin temperature of HCPs using respiratory protective equipment (RPE) for 4-8 hours [57,58]. The studies were performed to examine the impact of masks on skin properties. Significant differences were seen in skin color, skin hydration, skin temperature, amount of skin keratin, skin redness, and skin elasticity between the mask-wearing and non-mask-wearing areas [53,59]. Szepietowski *et al.* [29] reported increased itching in individuals wearing face masks for a longer duration. This may lead to the inappropriate wearing of masks which ultimately poses people at risk. The novel findings of Choi *et al.* [60] reported two cases of facial reconstruction, which developed skin cancer following "sequelae of facial flap pressure" due to the use of face masks during the pandemic [60]. It has been suggested to develop strategies to diminish the heat burden caused by the prolonged use of masks. Recommendations for wearing respiratory protective equipment (surgical masks and respirators) [61] have been represented in Figure 3.

Figure 3. Recommendations for wearing respiratory protective equipment (RPE) (surgical masks and respirators).



Headache and Hypoxic conditions

Wearing face masks for long durations have been associated with an increased incidence of headaches in HCPs. A short duration of wearing face masks should be preferred to reduce the severity of headaches [62]. It is well-known that prolonged use of face masks leads to breathlessness and often leads to hypoxic symptoms [63]. During respiration, carbon dioxide exhaled gets trapped inside the face masks. In the next cycle of respiration, some fractions of carbon dioxide get inhaled back, leading to the development of chronic low-grade hypoxia, which is an emerging concern. Chronic hypoxia affects Red Blood Cell count and Hemoglobin concentration [64], although, hypoxemia and hypercapnia may also occur as a result of physical workouts and pre-existing respiratory problems [65]. Prolonged use of face masks (8-10 hours/day) continuously causes intermittent hypoxia which leads to a subsequent rise in hemoglobin levels [39]. Exercising with masks raises the risk of sudden cardiac death (SCD) along with the development of intermittent hypoxia and hypercapnia [66]. The increased CO_2 levels and decreased O_2 levels due to rebreathing of air under the mask lead to sympathetic stimulation and chemo-reflex hypoxia. This may further lead to hypertension and tachycardia [67]. Little information exists about the physical impact of face masks on children in the literature.

Impacts on sports, exercise, and walking

The COVID-19 pandemic has put numerous nations on lockdown and sports occasions have also been affected [68]. COVID-19 has affected workout routine

of people. There are various factors, such as temperature, moisture, type of mask, the capacity for exercise, ventilation [69], etc., that cause adverse effects while exercising with a mask [70]. No study has been conducted that evaluates the association between oxygen saturation and intensity of workouts with masks [71]. Wearing masks while exercising increase stress on the cardiovascular and metabolic systems. Exercise with masks is therefore advised at low-moderate intensity [72]. Wearing a mask during exercise has also been found to be associated with decreased cardiopulmonary capacity as well as discomfort [67,69]. Masks should be avoided during strenuous exercise and, if they must be worn, they should be worn at a low moderate rate to avoid the condition of lethal arrhythmias [67]. Further research is required to explore the physiologic reactions to chronic exercise with mask-wearing.

Forensic implications and facial identification

Biometric systems have become a fundamental part of human society with the increased demands for security at different levels. A security system verifies the identity of individuals to prevent unauthorized access. Common approaches for individual authentication mainly comprise password matching and identity card verification. Liveness recognition is an active approach among biometrics which includes the iris, fingerprint, gait, hand geometry detection, etc. [73,74].

Face spoofing

A facial spoofing attack is an interaction in which an assailant undermines a biometric recognition or authentication framework by presenting a forced facial video. Face detection plays a crucial role in surveillance and high-security systems. Facial spoofing attacks based on 3D photos have rendered the security systems for facial identification vulnerable. Taking off the mask for identification increases the risk of infection in crowded situations, such as airports and train stations [75]. Although wearing face masks to prevent transmission is a new norm in the COVID-19 pandemic, this also compromises the security and susceptibility of facial recognition frameworks. This point has so far been overlooked. Assailants can use presentation attacks to spoof the facial recognition frameworks by impersonating the identity of someone. Common practices of spoofing or presentation attacks include the use of 3D masks, printed photos, and recorded videos [76]. Face spoofing or presentation attack is an open security challenge in the biometric domain. The face is easy to imitate and access amid all biometric traits. Various studies have been performed based on deep learning techniques to investigate the performance of masked face recognition. The studies reported that the effect of wearing masks on the face is detectable in the systems investigated. The impact was most significant on the genuine scores conveyance, as opposed to the fraud scores distribution. The results of these studies indicate that the current facial identification approach was unreliable to match masked faces with unmasked faces and, in any event, requires reexamination. The studies highlighted the promising research directions and challenges for masked face recognition [77,78].

Status of face identification systems

COVID-19 has posed an unprecedented challenge for security establishments [79]. Numerous techniques using facial identification have been introduced in the last few years, including biometrics as well as upgraded temperature and access control systems. But the widespread use of masks has affected facial identification systems. Face masks usually cover several distinguishable features of the face which are used to identify an individual [80,81]. Many biometric systems identify individuals only if the entire face is visible. Due to the use of masks, a large portion of the face is hidden. Facial recognition methods are unable to recognize half-masked faces [82]. Even the facial recognition security system of mobile phones does not work if the person is wearing a mask. Current surveillance capabilities are insufficient to recognize partially covered faces. The absence of such capabilities has resulted in a greatly decreasing the identification of suspects using facial identification technology and can lead to an eventual rise in crime [83]. Facial identification of masked faces has become a significant challenge that received little to no attention before the pandemic. However, research in this field has been ongoing since the outbreak of COVID-19. Machine learning-based algorithms have been proposed for the identification of people with masked faces [84,85]. Along with this, another novel automatic detection approach is being researched, where image histograms of individuals with or without masks are analyzed using CNN (convolutional neural networks). This approach will have applications in biometrics, machine learning, and automatic face identification [86,87]. Nowadays, mobile phones are deployed with 'face recognition' features. Along with this, "MasterCard" is also testing a "selfie verification" feature for securing payment service through mobiles. Masked and spoofed faces

pose a serious challenge to facial recognition security systems and operations [88].In a study by Carragher and Hancock [89], human observers were found to have the worst performance for matching familiar and unfamiliar faces wearing masks. Legal enforcement agencies will also likely encounter cases where the perpetrator when committing a crime either partly covered with a mask or completely covered. There is a gap in research examining the performance of facial recognition techniques to identify individuals when the facial region below the eyes or lower half is covered [89,90].

Challenge in biometric identification of masked face

Since the outbreak of the COVID-19 pandemic, the security frameworks have been undermined due to the wearing of face masks, partially visible faces, or occluded faces. The COVID-19 pandemic caused the installment of contactless means of verification at highly sensitive places such as airports [91]. Fitousi *et al.* [92] reported that masks impede the speed and precision of extracting personality, expression, age, and gender. Existing challenges in biometric facial identification include face spoofing, morphing attacks, and other unusual attacks [36,93]. Currently, there is a lack of a publicly available database for masked face recognition. Recently, Mercaldo and Santone [94] developed an approach for automatic recognition of whether an individual is wearing a face mask or not. The proposed approach still needs to be tested for real-world applicability [94]. Another technique for mask detection is based on a machine learning algorithm connected to CCTV authenticating the entry of masked people [83].

Discussion

The COVID-19 pandemic compelled the worldwide population to embrace the new restrictions in their everyday routine, including mandating the wearing of face masks. Wearing face masks is necessary to protect ourselves from airborne diseases such as COVID-19. Various studies have elucidated the side effects and serious consequences of prolonged use of face masks, especially amongst HCPs and other front-line workers. The most common adverse effects observed in the skin of HCPs due to prolonged wearing of surgical or N95 masks were increased incidents of acne. Along with this, other facial dermatoses have also been observed, including rosacea, seborrheic dermatitis, and irritant contact dermatitis. Dermatologists need to properly assess the mechanisms of adverse skin reactions due to the prolonged use of respiratory protective equipment. Daily prolonged wearing of the mask can change skin characteristics. The most prevalent symptoms reported, indicating allergic skin reactions, were itching, rashes, redness as well as increased skin wrinkles and pores. Therefore, special care is required for the skin underlying masks. There is a necessity of devising proper safety and preventive measures. Personal protective equipment has been reported to hamper communication in the operation theatre. More research is required to find an alternative method for communication in operation theatres. Most studies to date have been conducted on investigating the adverse effects on frontline workers or health care professionals. In addition, studies should also be conducted to explore the impact of prolonged wearing of face masks in the general population. People should be made aware of the adverse effects caused by wearing masks for long durations. Additionally, advocacy programs should also be conducted, demonstrating the appropriate way of wearing facial masks.

Prolonged wearing of masks also has an impact on the eyes, causing ocular irritation and dryness. The prevalence of masks in the present context can lead to ocular irritation and dryness becoming a common issue for a majority of the population. There is a need of spreading awareness among people about eye care and safety. Advocacy programs should also provide information on alleviating the major issues faced by a majority of individuals with eyeglasses, as shown in Figure 3. Frequent breaks that allow the removal of masks as well as judicious use of ocular lubricants should be advocated to prevent and cure dryness and irritation symptoms. Further research is suggested on the association of prolonged mask use in the general population with increased incidences of ocular symptoms as well as associated occupational safety measures should also be explored.

In addition to the adverse effects stated above, a significant increase in vocal intensity when using masks has been reported. The changes in speech parameters lead to impaired communication. The speaker is required to put more effort to fine-tune his phonation characteristics to make his sound clear. This particular situation leads to the development of vocal misbehavior and voice disorders. The adverse and persistent consequences on voice aerodynamics and pathology caused by prolonged use of face masks should be analyzed to discover preventive measures.

Extensive use of face masks while exercising has also been associated with a pathophysiological risk to the cardiovascular and metabolic systems.

Additionally, intensive strenuous exercises are not recommended while wearing masks. Therefore, under the current scenario, exercise is best undertaken at home, individually or under supervision, if required. When required to exercise in a group, recommendations include the use of low-moderate intensity exercises, frequent breaks with the removal of masks, etc. [63,66]. On the other hand, wearing masks during exercise has been found to have no association with pulse rate or blood pressure.

The prevalent use of masks in public and social life has also led to numerous difficulties being faced by facial recognition technologies. Future research should focus on alleviating these difficulties, and can include studies on using biometric data from the upper half of the face, including the eyes, eyebrows, forehead, etc., to further enhance the recognition capabilities of these facial recognition techniques.

With the continued emergence of mutations of SARS-CoV-2, the general public's use of masks appears to continue in the future. In this regard, most studies found during the literature search were conducted on the effects of wearing masks in HCPs. The increased prevalence of wearing masks among the general public should be investigated to identify the adverse effects that may vary from the findings of past studies. Preventive and curative measures for these adverse effects can only be developed after a complete evaluation of the pathophysiology of the adverse effects of wearing masks in HCPs as well as in the general population. In addition, research needs to focus on developing better designs for masks to allow for prolonged use, with less discomfort to increase the adoption of wearing masks universally. These are some of the issues that should be considered while developing policies on mandating mask use along with the focus on control and abolition of COVID-19.

This communication in no way intends to advocate the discontinuation of wearing masks, on the contrary, the primary goal of this article is to spread awareness about the adverse effects associated with prolonged use of facial masks (N95, KF94, or surgical). This will help in increasing compliance with mask mandates by helping to develop preventive solutions to the problems that tend to deter the general public.

Conclusions

The authors would like to communicate that the prolonged wearing of masks may cause physiologic and psychological stress, leading to declined working efficiency. Wearing masks may also be associated with headaches, dryness, hypoxia, and skin allergic reactions such as redness, rashes, wrinkles, acne, and itching. Further research is required for preventing the discomfort associated with the prolonged wearing of facial masks. Additional advocacy is needed to impart knowledge on the proper methods of the use of facial masks, as well as the need for taking special care of the skin underlying masks. In addition, the widespread use of facial masks is set to continue, with newer variants still causing sharp increases in the number of infections. This is bound to hinder facial recognition technology that is widely used in our everyday life, including verification for payment gateways, attendance and time stamping at workplaces, and far more importantly, for public surveillance and security. The use of masks has also been reported to hinder facial recognition in mobile phones [95]. This can be solved by using biometrics of partial facial images, which have not been studied in detail as yet. This was an issue even before surveillance, of trying to detect masked men involved in robberies, kidnappings, etc. However, resources were not adequate for developing these technologies that catered only to a niche market. The development of this technique, of using biometrics of partial facial images, can now get a boost with the increase in its applicability for the general public. Additionally, biometrics could also be used to help in the identification of masked perpetrators, including the ear(s), eyes, hands, etc. Corroborative use of all these biometrics can perhaps provide a suitable solution. Once again, further research on this is urgently required.

Finally, the authors found that a majority of studies examined the effects of prolonged facial mask use on HCPs. The COVID-19 pandemic has ensured that prolonged facial mask use is now more widespread. As a result, the effects on the general public need to be assessed as these could vary from the effects seen in highly educated, skilled, and trained HCPs. Additionally, awareness and advocacy programs need to cater to imparting knowledge on the proper use of facial masks and the remedies to the common issues faced. This also needs to further examine the effects on the general population, before the problems are identified and their solutions developed. Ensuring adequate education of the general public on the benefits of wearing masks, their proper usage, and common adverse effects associated with prolonged use along with the remedies, is the only way to ensure compliance and thereby strengthen the public health measures against SARS-CoV-2.

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References

1. Xi J, Si XA, Nagarajan R (2020) Effects of mask-wearing on the inhalability and deposition of airborne SARS-CoV-2 aerosols in human upper airway. Phys Fluids 32: 123312.
2. Akin L, Gözel MG (2020) Understanding dynamics of pandemics. Turk J Med Sci 50: 515-519.
3. Lone SA, Ahmad A (2020) COVID-19 pandemic–An African perspective. Emerg Microbes Infect 9: 1300-1308.
4. Payne S (2017) Viruses-from understanding to investigation. United States: Academic Press149-158 p.
5. Behera BC, Mishra RR, Thatoi H (2021) Recent biotechnological tools for diagnosis of coronavirus disease: A review. Biotechnol Prog 37: e3078.
6. Gonzalez JM, Gomez-Puertas P, Cavanagh D, Gorbalenya AE, Enjuanes L (2003) A comparative sequence analysis to revise the current taxonomy of the family *Coronaviridae*. Arch Virol 148: 2207-2235.
7. Yang YT, Xing X, Sreekissoon S, Li Z (2021) Impact of transmission control measures on the epidemiology of maxillofacial injuries in Wuhan city during the COVID-19 epidemic. J Craniofac Surg 32: 1381-1384.
8. Abu-Hammad O, Dar-Odeh N, Abu-Hammad A, Althagafi N, Eshky R, Abu-Hammad S (2021) Long-term complications of coronavirus disease 2019 what the oral surgeon needs to know. J Craniofac Surg 32: e652-e655.
9. Patil PV, Sarode SC, Sarode GS, Sengupta N, Ghone U, Patil S (2021) Prolonged use of face mask and future concerns. World J Dent 12: 433-434.
10. Zhang X, Ji Z, Yue Y, Liu H, Wang J (2020) Infection risk assessment of COVID-19 through aerosol transmission: A case study of South China seafood market. Environ Sci Technol 55: 4123-4133.
11. Vellone V, Marianetti TM, Di Renzo L, Ricci A, Bocciolesi F, Ramieri V (2020) How to produce cheap and easy custom-made sterilizable filtering facepiece /3 masks for healthcare providers during pandemic covid-19 emergency. J Craniofac Surg 31: e640-e642.
12. World Health Organization (2022) Coronavirus (COVID-19) dashboard. Available: https://covid19.who.int/. Accessed 19 February 2022.
13. World Health Organization (2021) The impact of COVID-19 on health and care workers: A closer look at deaths. Available: https://www.who.int/publications/i/item/WHO-HWF-WorkingPaper-2021.1. Accessed 4 February 2022.
14. Cetinkaya EA (2020) COVID-19 pandemic and otologic surgery. J Craniofac Surg 31: e651-e652.
15. Andrews BT, Garg R, Przylecki W, Habal M (2020) COVID-19 pandemic and its impact on craniofacial surgery. J Craniofac Surg 31: e620-e622.
16. Figueiredo LB, Araújo SC, Martins GH, Costa SM, Amaral MB, Silveira RL (2021) Does the lockdown influence the oral and maxillofacial surgery service in a level 1 trauma hospital during the COVID-19 pandemic. J Craniofac Surg 32: 1002-1005.
17. Lotfi M, Hamblin MR, Rezaei N (2020) COVID-19: Transmission, prevention, and potential therapeutic opportunities. Clin Chim Acta 508: 254-266.
18. Shubhanshu K, Singh A (2021) Prolonged use of N95 mask a boon or bane to healthcare workers during COVID–19 pandemic. Indian J Otolaryngol Head Neck Surg 1-4.
19. Rosner E (2020) Adverse effects of prolonged mask use among healthcare professionals during COVID-19. J Infect Dis Epidemiol 6: 130.
20. Palmieri V, De Maio F, De Spirito M, Papi M (2021) Face masks and nanotechnology: Keep the blue side up. Nano Today 37: 101077.
21. Wei-Haas M (2021) The coronavirus is mutating—but what determines how quickly. National Grographic. Available: https://www.nationalgeographic.com/science/article/the-coronavirus-is-mutating-but-what-determines-how-quickly. Accessed: 5 February 2022.
22. Dubey A, Choudhary S, Kumar P, Tomar S (2022) Emerging SARS-CoV-2 variants: Genetic variability and clinical implications. Curr Microbiol 79: 1-8.
23. Le Page M (2021) What are the new coronavirus variants. New Sci 249: 9.
24. da Silva SJ, Pena L (2021) Collapse of the public health system and the emergence of new variants during the second wave of the COVID-19 pandemic in Brazil. One Health 13: 100287.
25. World Health Organization (2021) Classification of omicron (B.1.1.529): SARS-CoV-2 variant of concern. Available: https://www.who.int/news/item/26-11-2021-classification-of-omicron (b.1.1.529)-sars-cov-2-variant-of-concern. Accessed: 22 June 2022.
26. Dhawan M, Priyanka, Choudhary OP (2022) Omicron SARS-CoV-2 variant: Reasons of emergence and lessons learnt. Int J Surg 97: 106198.
27. Lari A, Alherz M, Nouri A, Botras L, Taqi S (2020) Caution against precaution: A case report on silent hypoxia in COVID-19. Ann Med Surg 60: 301-303.
28. Tian Z, Kim BY, Bae MJ (2020) A study on the effect of wearing masks on stress response. Memory 8: 12.
29. Szepietowski JC, Matusiak Ł, Szepietowska M, Krajewski PK, Białynicki-Birula R (2020) Face mask-induced itch: a self-questionnaire study of 2,315 responders during the COVID-19 pandemic. Acta Derm Venereol 100: 1-5.
30. Platto S, Xue T, Carafoli E (2020) COVID19: An announced pandemic. Cell Death Dis 11: 1-3.
31. Atzori L, Ferreli C, Atzori MG, Rongioletti F (2020) COVID-19 and impact of personal protective equipment use: from occupational to generalized skin care need. Dermatol Ther 33: e13598.
32. Zaheer R, Khan M, Tanveer A, Farooq A, Khurshid Z (2020) Association of personal protective equipment with de novo headaches in frontline healthcare workers during COVID-19 pandemic: a cross-sectional study. Eur J Dent 14 Suppl 01: 79-85.
33. Kim J, Yoo S, Kwon OS, Jeong ET, Lim JM, Park SG (2021) Influence of quarantine mask use on skin characteristics: One of the changes in our life caused by the COVID-19 pandemic. Skin Res Technol 27: 599-606.
34. Trehan RS, McDonnell EP, McCoy JV, Ohman-Strickland PA, Donovan C, Quinoa TR, Morrison DS (2021) Comparing the quantitative fit-testing results of half-mask respirators with

various skin barriers in a crossover study design: a pilot study. J Hosp Infect 111: 125-131.
35. Shekaraiah S, Suresh K (2021) Effect of face mask on voice production during COVID-19 pandemic: A systematic review. J Voice S0892-1997(21)00327-1.
36. Freud E, Stajduhar A, Rosenbaum RS, Avidan G, Ganel T (2020) The COVID-19 pandemic masks the way people perceive faces. Sci Rep 10: 1-8.
37. Ferrari C, Vecchi T, Sciamanna G, Blandini F, Pisani A, Natoli S (2021) Facemasks and face recognition: Potential impact on synaptic plasticity. Neurobiol Dis 153: 105319.
38. Coroneo MT, Collignon PJ (2021) SARS-CoV-2: Eye protection might be the missing key. Lancet Microbe 2: 173-174.
39. Cheong KX (2020) Systematic review of ocular involvement of SARS-CoV-2 in coronavirus disease 2019. Curr Ophthalmol Rep 8: 185-194.
40. Moshirfar M, West WB, Marx DP (2020) Face mask-associated ocular irritation and dryness. Ophthalmol Ther 9: 397-400.
41. Bhardwaj A, Sharma C, Bandhala RM (2021) Simple solutions for the fogging of spectacles when wearing surgical masks. J Am Acad Dermatol 85: e237–e238.
42. Agarwal P, Sharma D (2021) How to prevent fogging of spectacle glasses when wearing a face mask. Indian J Surg 83: 1609-1610.
43. Maldonado-Codina C, Navascues-Cornago M, Plowright AJ, Mirza A, Smith S, Read ML, Vega J, Orsborn GN, Morgan PB (2021) Using face masks with spectacles versus contact lenses. Cont Lens Anterior Eye 45: 101516.
44. Yan Y, Chen H, Chen L, Cheng B, Diao P, Dong L, Gao X, Gu H, He L, Ji C, Jin H (2020) Consensus of Chinese experts on protection of skin and mucous membrane barrier for health-care workers fighting against coronavirus disease 2019. Dermatol Ther 33: e13310.
45. Lin Y, Cheng L, Wang Q, Xu W (2021) Effects of medical masks on voice assessment during the COVID-19 pandemic. J Voice S0892-1997(21)00163-6.
46. Hampton T, Crunkhorn R, Lowe N, Bhat J, Hogg E, Afifi W, De S, Street I, Sharma R, Krishnan M, Clarke R (2020) The negative impact of wearing personal protective equipment on communication during coronavirus disease 2019. J Laryngol Otol 134: 577-581.
47. Goldin A, Weinstein B, Shiman N (2020) How do medical masks degrade speech perception. Volta Rev 27: 8-9.
48. Molnar-Szakacs I, Uddin LQ, Heffernan MB (2021) The face behind the mask: the future of interpersonal interaction. Neuron 109: 1918-1920.
49. Joshi A, Procter T, Kulesz PA (2021) COVID-19: Acoustic measures of voice in individuals wearing different facemasks. J Voice S0892-1997(21)00201-0.
50. Yi H, Pingsterhaus A, Song W (2021) Effects of wearing face masks while using different speaking styles in noise on speech intelligibility during the COVID-19 pandemic. Front Psychol 12: 682677.
51. Zuo Y, Hua W, Luo Y, Li L (2020) Skin reactions of N95 masks and medial masks among health care personnel: a self-report questionnaire survey in China. Contact Dermatitis 83: 145–147.
52. Bhoyrul B, Lecamwasam K, Wilkinson M, Latheef F, Stocks SJ, Agius R, Carder M (2019) A review of non-glove personal protective equipment-related occupational dermatoses reported to EPIDERM between 1993 and 2013. Contact dermatitis 80: 217-221.
53. Park SR, Han J, Yeon YM, Kang NY, Kim E, SUH BF (2022) Long-term effects of face masks on skin characteristics during the COVID-19 pandemic. Skin Res Technol 28: 153–161.
54. Darlenski R, Tsankov N (2020) COVID-19 pandemic and the skin: what should dermatologist know. Clin Dermatol 38: 785-787.
55. Masood S, Tabassum S, Naveed S, Jalil P (2020) COVID-19 pandemic & skin care guidelines for health care professionals. Pak J Med Sci 36 COVID-19 Suppl 04: 115-117.
56. Voegeli R, Gierschendorf J, Summers B, Rawlings AV (2019) Facial skin mapping: from single point bio-instrumental evaluation to continuous visualization of skin hydration, barrier function, skin surface pH, and sebum in different ethnic skin types. Int J Cosmet Sci 41: 411-424.
57. Grice K, Sattar H, Sharratt M, Baker H (1971) Skin temperature and transepidermal water loss. J Investig Dermatol 57: 108-110.
58. Kezic S, Nielsen JB (2009) Absorption of chemicals through compromised skin. Int Arch Occup Environ Health 82: 677-688.
59. Kim J, Yoo S, Kwon OS, Jeong ET, Lim JM, Park SG (2021) Influence of quarantine mask use on skin characteristics: One of the changes in our life caused by the COVID-19 pandemic. Skin Res Technol 27: 599-606.
60. Choi M, Wo L, Joshi P, Nugent A, Thaller SR (2022) Facial flap necrosis from COVID-19 face mask precautions. J Craniofac Surg 33: 1840-1842.
61. Han HS, Shin SH, Park JW, Li K, Kim BJ, Yoo KH (2021) Changes in skin characteristics after using respiratory protective equipment (medical masks and respirators) in the COVID-19 pandemic among healthcare workers. Contact Dermatitis 85: 225-232.
62. Lim EC, Seet RC, Lee KH, Wilder-Smith EP, Chuah BY, Ong BK (2006) Headaches and the N95 face-mask amongst healthcare providers. Acta Neurol Scand 113: 199-202.
63. Beder A, Büyükkoçak Ü, Sabuncuoğlu H, Keskil ZA, Keskil S (2008) Preliminary report on surgical mask induced deoxygenation during major surgery. Neurocirugia (Astur) 19: 121-126.
64. Purushothaman PK, Priyangha E, Vaidhyswaran R (2021) Effects of prolonged use of facemask on healthcare workers in tertiary care hospital during COVID-19 pandemic. Indian J Otolaryngol Head Neck Surg 73: 59-65.
65. Chandrasekaran B, Fernandes S (2020) "Exercise with facemask; are we handling a devil's sword?"–A physiological hypothesis. Med Hypotheses 144: 110002.
66. Atangana E, Atangana A (2020) Facemasks simple but powerful weapons to protect against COVID-19 spread: Can they have side effects. Results Phys 19: 103425.
67. Lee S, Li G, Liu T, Tse G (2020) COVID-19: Electrophysiological mechanisms underlying sudden cardiac death during exercise with facemasks. Med Hypotheses 144: 110177.
68. Pifarré F, Zabala DD, Grazioli G, Maura IDYI (2020) COVID-19 and mask in sports. Apunts Sports Medicine 55: 143-145.
69. Fikenzer S, Uhe T, Lavall D, Rudolph U, Falz R, Busse M, Hepp P, Laufs U (2020) Effects of surgical and FFP2/N95 face masks on cardiopulmonary exercise capacity. Clin Res Cardiol 109: 1522-1530.

70. Roberge RJ, Coca A, Williams WJ, Powell JB, Palmiero AJ (2010) Physiological impact of the N95 filtering facepiece respirator on healthcare workers. Respir Care 55: 569-577.
71. Scheid JL, Lupien SP, Ford GS, West SL (2020) Commentary: physiological and psychological impact of face mask usage during the COVID-19 pandemic. Int J Environ Res Public Health 17: 6655.
72. Walsh NP, Oliver SJ (2016) Exercise, immune function and respiratory infection: An update on the influence of training and environmental stress. Immunol Cell Biol 94: 132-139.
73. Karmakar D, Mukherjee P, Datta M (2021) Spoofed facial presentation attack detection by multivariate gradient descriptor in micro-expression region. Pattern Recognit Image Anal 31: 285-294.
74. Maltoni D, Maio D, Jain AK, Prabhakar S (2009) Handbook of fingerprint recognition, 2nd Edition. Italy: Springer Science & Business Media 271-302 p.
75. Ahmadian M, Ghasemi M, NasrollahiBorujeni N, Afshan S, Fallah M, Ayaseh H, Pahlavan M, Nabavi Chashmi SM, Haeri T, Imani F, Zahedmanesh F (2022) Does wearing a mask while exercising amid COVID-19 pandemic affect hemodynamic and hematologic function among healthy individuals? Implications of mask modality, sex, and exercise intensity. Phys Sports Med 50: 257-268.
76. Fang M, Damer N, Kirchbuchner F, Kuijper A (2022) Real masks and spoof faces: On the masked face presentation attack detection. Pattern Recognit 123: 108398.
77. Alzu'bi A, Albalas F, Al-Hadhrami T, Younis LB, Bashayreh A (2021) Masked face recognition using deep learning: A review. Electronics 10: 2666.
78. Damer N, Grebe JH, Chen C, Boutros F, Kirchbuchner F, Kuijper A (2020) The effect of wearing a mask on face recognition performance: an exploratory study. International Conference of the Biometrics Special Interest Group (BIOSIG*)*. Available: https://ieeexplore.ieee.org/abstract/document/9210999. Accessed 6 March 2022.
79. Das A, Ansari MW, Basak R. Covid-19 face mask detection using TensorFlow, Keras and OpenCV (2020) 2020 IEEE 17th India Council International Conference (INDICON). Available: https://ieeexplore.ieee.org/abstract/document/9342585. Accessed 6 March 2022.
80. Erdogmus N, Marcel S (2014) Spoofing face recognition with 3D masks. IEEE transactions on information forensics and security 9: 1084-1097.
81. Calbi M, Langiulli N, Ferroni F, Montalti M, Kolesnikov A, Gallese V, Umiltà MA (2021) The consequences of COVID-19 on social interactions: an online study on face covering. Sci Rep 11: 1-10.
82. Gupta S, Sreenivasu SV, Chouhan K, Shrivastava A, Sahu B, Potdar RM (2021) Novel face mask detection technique using machine learning to control covid'19 pandemic. Mater Today Proc. In press.
83. Chingovska I, Erdogmus N, Anjos A, Marcel S (2016). In Bourlai T (ed.) Face recognition across the imaging spectrum. Cham: Springer International Publishing. 165-194.
84. Singh S, Ahuja U, Kumar M, Kumar K, Sachdeva M (2021) Face mask detection using YOLOv3 and faster R-CNN models: COVID-19 environment. Multimed Tools Appl 80: 19753-19768.
85. Loey M, Manogaran G, Taha MH, Khalifa NE (2021) Fighting against COVID-19: A novel deep learning model based on YOLO-v2 with ResNet-50 for medical face mask detection. Sustain Cities Soc 65: 102600.
86. Yao G, Lei T, Zhong J (2019) A review of convolutional-neural-network-based action recognition. Pattern Recognit Lett 118: 14-22.
87. Wang M, Deng W (2021) Deep face recognition: A survey. Neurocomputing 429: 215-244.
88. Jia S, Hu C, Li X, Xu Z (2021) Face spoofing detection under super-realistic 3D wax face attacks. Pattern Recognit Lett 145: 103-109.
89. Carragher DJ, Hancock PJ (2020) Surgical face masks impair human face matching performance for familiar and unfamiliar faces. Cogn Research 5: 1-5.
90. Fisher GH, Cox RL (1975) Recognizing human faces. Appl Ergon 6: 104-109.
91. Manimuthu A, Dharshini V, Zografopoulos I, Priyan MK, Konstantinou C (2021) Contactless technologies for smart cities: big data, IoT, and cloud infrastructures. SN Comput Sci 2: 1-24.
92. Fitousi D, Rotschild N, Pnini C, Azizi O (2021) Understanding the impact of face masks on the processing of facial identity, emotion, age, and gender. Front Psychol 12: 4668.
93. Venkatesh S, Ramachandra R, Raja K, Busch C (2021) Face morphing attack generation & detection: A comprehensive survey. IEEE Technol Soc Mag 2021 2: 128-145.
94. Mercaldo F, Santone A (2021) Transfer learning for mobile real-time face mask detection and localization. J Am Med Inform Assoc 28: 1548-1554.
95. Libby C, Ehrenfeld J (2021) Facial recognition technology in 2021: masks, bias, and the future of healthcare. J Med Syst 45: 1-3.

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