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ORAL HEALTH IN RELATION TO THE COVID-19 PANDEMIC

by

Anika Gram

A Thesis Submitted in Partial Fulfillment

Of the Requirements for the

University Honors Program

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Honors Department

The University of South Dakota

April 2023

The members of the Honors Thesis Committee appointed

to examine the thesis of Anika Gram

find it satisfactory and recommend that it be accepted.

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Ms. Carissa Regnerus  
Professor of Dental Hygiene  
Director of the Committee

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Ms. Jamie Turgeon Drake  
Professor of Health Sciences

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Ms. Katie Williams  
Professor of Dental Hygiene

## **ABSTRACT**

### Oral Health in Relation to the Covid-19 Pandemic

Anika Gram

Director: Ms. Carissa Regnerus

Oral health has seen significant changes through the Covid-19 pandemic. Many people experienced the lifestyle alteration of wearing a mask for a major portion of their day-to-day life, and some went to the dentist significantly less than they did pre-pandemic. The literature review explores dental practices during the Covid-19 pandemic. It also examines mask-wearing behaviors both before and during the pandemic and the research that has been conducted previously regarding the potential effects of mask-wearing. Despite the decrease in use of masks post-pandemic, many healthcare professionals continue to wear masks daily. Additionally, in the event of future disease outbreak, it is likely that masks will again be used to reduce transmission. Much is still unknown about the long-term effects of mask-use, but it was predicted that masks can cause harm in their disruption of the oral cavity's natural microbiome. A survey was distributed to investigate the possible impacts that the Covid-19 pandemic had on oral health. While the results varied, it was shown that the pandemic did have a multitude of effects on the health of a person's oral cavity, many connecting to mask-wear. This result can be used for future research regarding care for the oral cavity for healthcare workers and during pandemics.

Key Words: Oral health, Covid-19, Masks

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## **CHAPTER ONE**

### **Introduction**

The Covid-19 pandemic caused many significant changes throughout every part of society. Noticeable changes were seen in healthcare, as many branches remained open throughout the entire pandemic and had to maintain a safe environment for their patients. Although many remained open, dental offices saw a significantly lower number of patients during the pandemic. This could have had many causes including the cost of dental care and fears and attitudes towards leaving the home during and post-pandemic.

Prior to the Covid-19 pandemic, masks were commonly used as protection in the workplace for healthcare workers. They are considered personal protective equipment (PPE) and protect from biological hazards in the workplace (Ippolito et al., 2020). During the Covid-19 pandemic, masks served the same purpose for the general public. They were worn in public as PPE to protect people from the pathogens causing Covid-19. Masks come in many different models offering varying levels of protection and fit. The Centers for Disease Control and Protection provided guidelines for when these different levels were necessary.

Masks are important in their purpose of limiting the spread of disease within a healthcare setting and during time periods of disease spread. Despite this, there has been little research on the effects that both the short-term and the long-term wear of a mask can have on the user. The mask limits what can exit the mouth and respiratory system, meaning that those particles are then held behind the mask. Masks also change how a person breathes and the movements that they do with their mouth and jaw throughout their wear. Mask-use has become symbolic of the Covid-19 pandemic, but even with

restrictions being lowered and mask mandates being lifted, healthcare workers continue to wear masks for hours on end every day. Additionally, in the likely event of a future pandemic or disease outbreak, masks would be considered one of the primary containment methods. It is important that the possible long-term effects of wearing a mask are known to inform and protect society in these situations.

## CHAPTER TWO

### Dental Behaviors During the Covid-19 Pandemic

During the Covid-19 pandemic, much of the population had a deep-rooted fear of what they may face when leaving their home. This was in part a result of dubious information about the virus's transmission, incubation period, and mortality rate (Ornell et al. 2020). Many dental practices implemented new regulations to decrease the risk of disease spread including pre-appointment screenings, taking patients' temperatures, wearing additional PPE, and enhanced disinfectant procedures being some of the most common (Tranby et al., 2020). Although these procedures were necessary to maintain a safe environment and avoid disease spread, adding extra steps has the potential to lead people away from going to the dentist due to the increased responsibility and time commitment. Only 62.7% of adults visited the dentist in 2020, which was a direct decrease from the previous year's statistic of 65.5%. This decrease was prominent with both men and women and included all races and Hispanic-origin groups (Cha & Cohen, 2019).

Many factors could have contributed to the decrease in dental attendance. First, the fear of contracting Covid-19 upon leaving the house and entering a more populated space could have discouraged people from going to the dentist. Increased fear of Covid-19 moderately correlated with an increase in symptoms of agoraphobia (İnal et al., 2022). A person with agoraphobia often exhibits a fear of crowds, waiting in line, enclosed spaces, and public transportation (Mayo Clinic, 2023). The presence of these phobias and other pandemic-related fears could have contributed to a lesser inclination to attend a dental appointment.



This decrease in dental attendance also could be due to the cost of dental care in relation to the presence of downsizing and unemployment in many jobs during the pandemic. It is important to note that many people and families struggle to afford dental care. In a press release from the International Labour Organization in March 2020, it was estimated that the pandemic could raise unemployment rates by up to 25 million, leaving many more either underemployed or in working poverty (International Labour Organization, 2020). Many who could only afford dental care with their insurance were likely left uninsured and without enough income to pay out of pocket for dental care. In 2019, 68% of Americans had private healthcare coverage, 34.1% had government covered healthcare, and 8% were not covered by insurance. In a survey done on dentate adults with private health insurance, only 50.2% had dental coverage in 2019 (Blackwell, 2019). Out of the 34.1% of Americans with government covered healthcare, in 32 states, dental coverage is considered “limited”, “emergency”, or “no coverage” (Center for Health Care Strategies, 2019). With low insurance coverage for dental care and increased underemployment and unemployment, it is likely that many Americans did not go to the dentist because they could not afford it.

Lastly, many people likely became used to putting their responsibilities aside during the pandemic, with regular health check-ups and dental check-ups being included. The Mayo Clinic described how during the pandemic, information overload, rumors and misinformation can make life feel out of control and make it unclear what to do (Mayo Clinic, 2022a). This societal climate was likely a major contributing factor to the decreased attendance in the dental clinic.

An alternative to in-person dental check-ups that has seen an increase in popularity through the pandemic is “telehealth” check-ups. Telehealth is “the use of digital information and communication technologies to access health care services remotely” (Mayo Clinic, 2022b). Forty percent of dental offices either began using or plan to implement telehealth into their practices (Tranby et al., 2020). This made dental care more accessible and less expensive, making it a potential contributing factor to the decrease in dental visits during the pandemic. Although telehealth can allow for an increase in dental access during a pandemic, the dental care provided may not be fit for the long term. Telehealth would allow for routine dental check-ups, but making these check-ups remote could deplete many patients from yearly or biyearly fluoride treatments, necessary sealants, and other cavity preventing measures. This could lead to an increase in dental caries throughout the Covid-19 pandemic and thereafter.

## **CHAPTER THREE**

### **Mask-Wearing Practices**

Prior to the Covid-19 pandemic, masks were used during other disease outbreaks. The introduction of face mask coverings for the mouth and nose can be traced back to the late 19th and early 20th century. In the 1930s, masks were first introduced via Martin Kirschner's publication of 'measures to combat infection' (Kirschner, M. & Schubert, A., 1927, p. 213-279) as a necessity in a surgical operating room. Still, however, in the 1990s, masks had not been completely accepted as common practice for medical personnel. It was not until recently that masks fully became an expected practice in medical work (Matuschek et al., 2020).

During the Covid-19 pandemic, mask usage differed depending on many factors including gender, age, and location (Haischer et al., 2020). Masks were considered one of the main public safety measures to allow people to leave their homes and enter a public area while keeping both the wearer and those around them protected in some way from viral transmission. Due to the lack of initial data about their effectiveness, when masks were made mandatory through public and private policies, it led many to protest (Haischer et al., 2020). In December of 2020, an observational study of customers in a sample of retail stores showed a 96% prevalence of mask-wearing, although only 86% wore the mask properly. This same study showed that people more commonly were unmasked or improperly masked in smaller public areas, such as a small grocery store. The unmasked or improperly masked people observed were significantly most commonly middle-aged males (Karimi et al., 2021). In a similar study in June of 2020, it was found that females wore masks 7.6% more often than males and that the lowest percentage of

mask-wearing was found in middle-aged people in rural areas (Haischer et al., 2020). Throughout the pandemic, the Centers for Disease Control and Prevention shaped the narrative of how important masks were. During most of the pandemic, there was a “high community level” (Centers for Disease Control and Prevention, 2022). This meant that it was recommended that all able people over the age of two wore masks in all public settings.

According to the Mayo Clinic (2022c), nonsurgical N95 masks give the most protection to the general public. Surgical N95 masks provide more protection, but it is recommended that these are withheld for medical professionals. The next level of protection is KN95s and medical/surgical masks. The lowest level of protection described is a cloth mask. Despite giving the weakest protection on the list, cloth masks still give adequate protection as long as they are well-fitted. The most effective cloth masks are made with multiple layers of tightly woven fabric (Mayo Clinic, 2022c). Special consideration is recommended when spending time around high-risk personnel such as the elderly or immunocompromised. In these situations, N95 masks are encouraged to reduce the risk of transmission (Centers for Disease Control and Prevention, 2022).

## CHAPTER FOUR

### Previous Research Regarding the Effects of Mask-Wearing

The use of a mask is known to cause resistance in a person's breathing (Lee & Wang, 2011). This is likely a contributing factor to the prevalence of "mouth breathing" when wearing a mask. When wearing a mask, most people overcome the resistance of the mask on their breathing by taking more forceful breaths, specifically through the mouth and often at a faster rate. Breathing through the mouth causes oral dehydration due to the increased evaporation of saliva in open air and a reduced salivary flow rate (Kisielinski et al., 2021). It has been found that the use of a mask is correlated to symptoms of xerostomia, or dry mouth (Liu et al., 2020), with the presence of mask coatings contributing to this result. Having a proper level of moisture in the mouth is vital to carrying out oral functions: neutralizing oral pH, removing food remnants, and remineralizing the enamel being some of the most important. Dental caries occurs at an increased rate with an altered oral pH and when there is a lesser ability to remove food and other bacteria from the teeth (Wyszynska et al., 2022). With the use of a mask, the mouth is likely more susceptible to dental caries as a result of the increased dryness within the oral cavity.

The wear-time of masks significantly contributes to perceived dry mouth. A longer wear-time caused the subject to feel that their dry mouth symptoms were more severe (Kanzow et al., 2021). The natural dynamic between the external air and the oral cavity is altered by the use of a mask. The mouth is generally a much more moist environment than the air that surrounds it, but the microclimate created by the use of a mask leads to increased moisture around the mouth and a dryer environment in the oral

cavity. A shift in the oral microbiome causes an imbalance of oral homeostasis and can cause dysbiosis, affecting the health of the whole body (Meenakshi et al., 2022). The temperature of the mouth and areas around the mouth is also affected by the use of a mask. Facial temperatures are increased 1.5-2.0 degrees Celsius by the prolonged use of a mask (Meenakshi et al., 2022). This warmer environment welcomes the presence of bacteria that can lead to gingivitis, cheilitis, or other bacteria-initiating oral diseases (Kisielinski et al., 2021).

The microbiome created by wearing a mask for a long period of time is both warm and moist, leading to the entrapment of bacteria or fungi in and around the mouth (Beri et al., 2022). The purpose of mask-wearing is to prevent respiratory droplets from traveling out of one person's mouth into the open air or to another person. This, in turn, traps much of the exhaled moisture and bacteria behind the mask where it can be in contact with the skin and lips. It has been found through multiple clinical trials that masks contributed to an increase in acne and other skin inflammations (Beri et al., 2022). This change was observed to become more prominent with a longer wear-time, changing aspects such as the pH and the hydration of the skin (Hua et al., 2020). Additionally, studies have shown evidence of inhaled mask polypropylene fibers entering the airways, causing a form of irritant rhinitis (Klimek et al., 2020). The long-term use of a mask introduces new substances to the skin and mouth that could have detrimental effects on the health of the user.

The presence of nitric oxide (NO) is often associated with illness or infection, taking part in the body's immune system responses (Wyszynska et al., 2022). There is a statistically significant difference in the amount of NO between an oral cavity before

wearing a mask and after an eight-hour wear (Wyszynska et al., 2022). It has been found that patients with chronic periodontitis have a significantly increased presence of NO in their saliva, while patients with no inflammation have little to no NO present (Reher et al., 2007). Throughout multitudes of studies, it has been found that the presence of NO in saliva correlates with oral health and cleanliness (Wyszynska et al., 2022). It is likely that one of the causes of the increase of NO in the mouth after wearing a mask for a prolonged period of time is the increased dryness of the mouth, impairing the mouth's natural cleaning processes.

It is significantly more difficult to take a fresh breath of air while wearing a mask. Wearing a mask increases the natural dead space in the respiratory system (nose, throat, trachea, bronchi) into the space that the mask occupies (Kisielinski et al., 2021). When the dead space is increased, it has been experimentally found that there is an increase of carbon dioxide (CO<sub>2</sub>) retention at rest in addition to an increase in the carbon dioxide partial pressure (pCO<sub>2</sub>) in the blood (Zatoń et al., 2020). The dead space induced by the mask reduces the gas exchange volume available to the lungs by 37% (Lee & Wang, 2011), which leads to a lesser ability to exhale excess CO<sub>2</sub>. In a study on neurosurgeons, it was found that there was a decrease in oxygen saturation in the first hour of wearing a mask with the saturation decreasing further after a second hour (Beder et al., 2008). The lack of oxygen saturation after hours wearing a surgical mask additionally shows that there is an increase in CO<sub>2</sub> present under the mask, leading to additional rebreathing. A higher blood pCO<sub>2</sub> pushes the body towards acidosis, giving the blood a lower pH and causing damage to the entire body over a long period of time.

It has been observed that the pH of saliva is related to the pH of blood, with acidic saliva often signifying acidosis of the blood (Baliga et al., 2013). Since the use of a mask can alter the blood pH towards acidosis (Kisielinski et al., 2021), it is reasonable to assume an alteration in saliva pH. Although this does not have an immediate effect on oral health, someone who wears a mask for prolonged periods of time each day may experience negative effects with a small change in pH. This can cause dysbiosis, leading to other medical problems as well as leaving the teeth more susceptible to dental caries.

Despite the known differences in face shapes and sizes among people, masks are created to be relatively uniform. Historically, PPE has been created to fit the average European or American white male (Janson et al., 2020). Those who do not fit into this category may find difficulty obtaining a mask that is not ill-fitting. Many are able to find a mask that technically fits, but is not comfortable in wearing for an extended period during a work shift. Only 6% of healthcare workers reported feeling capable of wearing an N95 mask for an 8-hour shift without discomfort (Baig et al., 2010). In a study including 158 healthcare workers, 81% of participants developed *de novo* headache symptoms from their PPE. In addition, 91.3% of those with preexisting headache diagnoses “agreed” or “strongly agreed” that the use of PPE affected the control of their background headaches (Ong et al., 2020). The prominence of this issue questions not only the comfort and satisfaction of healthcare workers but also their productivity and ability to help patients while wearing an ill-fitting mask. Much of the discomfort associated with mask-wear is a result of them being ill-fitting, leading to the tightening of straps or the movement of the jaw into an uncomfortable position to hold the mask up.



When a person wears a mask, it is common for them to push their jaw forward and downward (Zuhour et al., 2022), whether to adjust its position or to hold it into place. This is especially prominent in cases where a mask is ill-fitting and where a person is in a setting not appropriate to touch their face with their hands. Temporomandibular disorders (TMD) involve the articular joints and masticatory muscles of the head and neck region. It can be diagnosed by observing disc flattening, irregular, and rounded morphologic features (Zuhour et al., 2022) as well as by reports of jaw pain or restriction. Although these disorders are common, it has been found that many do not seek diagnosis or treatment for the disorder (Choi et al., 2002). Through a study on both patients with TMD and without, it was found that the prolonged use of a mask increased jaw pain. In subjects who had previously been diagnosed with TMD, their regular symptoms increased, while patients not previously diagnosed with TMD experienced high levels of osteoarthritis (Zuhour et al., 2022).

## **CHAPTER FIVE**

### **Rationale**

The previous chapters reflect the research that has been done thus far on dental behaviors during the Covid-19 pandemic and previous studies on mask-wearing. These chapters served the purpose of connecting dental behaviors and mask-wearing during the Covid-19 pandemic to public dental health. Therefore, a survey was distributed to investigate this relationship.

The survey was designed to understand the mask-wearing behaviors of the general public before and during the pandemic. It also intended to examine the presence of dental caries and if this increased during or after this period. It explored topics such as dry mouth and acne and their relationship with mask-wearing. This was followed with a section regarding situations in which subjects were commonly required to wear masks and which types of masks they wore to cross-examine if certain masks in certain situations caused more noticeable symptoms. Lastly, the survey was designed to assess the connection between jaw pain and mask-wearing, specifically with symptoms of temporomandibular joint disorder both in participants who had this disease pathology prior to the pandemic and those who did not.

Through this survey, it was expected that there would be varying responses regarding the presence of the researched effects that the pandemic had on oral health. This was predicted due to the difference in mask-wearing hours between different in-person and at-home professions and between healthcare and non-healthcare workers. By researching the negative effects that prolonged mask-wearing can have on a person, it is to be hoped that healthcare workers will be made aware of these risks and provided

solutions for when they are having a physical reaction to prolonged mask-wearing. Additionally, this research aims to better prepare the general public for situations where masks become necessary so that they can also avoid unpleasant symptoms associated with an extended period of mask wear.

## CHAPTER SIX

### Methods

A survey was created by the author and administered online via Google Forms. It was approved by the Institutional Review Board (IRB) and the University of South Dakota (USD). The IRB approval can be found in Appendix A. The survey consisted of 10 questions, all answered in a free response format. They each prompted a question with one to three parts, containing a blank space for the participants to type their answers.

The first section of the survey addressed mask usage before and during the pandemic. These answers were used as a baseline for the rest of the survey to gauge if there was a significant difference between people who wore masks in their lives and those who had never worn a mask before the pandemic. Participants were asked about the number of hours in a day they wore a mask during the pandemic as well as the type of mask worn if they used one prior to the pandemic.

1. Approximately how many hours during the day did you wear a mask during the Covid-19 pandemic?
2. Did you wear a mask before the Covid-19 pandemic?  
If so, what kind of mask? (Examples: cloth mask, surgical mask, N95).

The second section of the survey focused on the participant's dental history. The patient was asked how often they went to the dentist prior to the pandemic and if this changed during the pandemic. Additionally, they were asked about how many cavities they had per check-up and if this changed during the pandemic. Both questions serve the purpose to analyze the changes that were seen in the patient's dental habits and health throughout the Covid-19 pandemic.

3. How many visits to the dentist did you have per year prior to the pandemic?  
Did this increase or decrease during the pandemic?

4. Approximately how many cavities did you have at each check-up?  
Did this number increase during or after the pandemic?

The third section addressed the predicted side effects of wearing a mask for a prolonged period. The participant was asked if they had experienced dry mouth when they wore a mask. Those with positive responses were then asked if this increased in severity with a longer wear-time. This serves the purpose of discovering if there is a potential connection between xerostomia symptoms and wearing a mask. Additionally, in this section, the participant was asked if they experienced an increased amount of acne when they wore a mask often. This served the purpose of discovering if there is a similar potential connection between acne and wearing a mask.

5. Did you notice yourself having a drier mouth when you wore a mask?  
If so, did this become better or worse when you wore the mask for a long period of time?
6. Did you notice yourself having an increase in acne when wearing a mask often?

The fourth section addressed the different settings in which participants had to wear a mask. The participant was asked if they wore a mask for work, how many hours per week they worked, and which type of mask they wore when working. Additionally, they were asked if they wore a mask while exercising, with the same follow-up questions- how many hours per week they exercised, and what type of mask they wore. These both served the purpose of understanding the setting in which participants most often wore masks.

7. Did you have to wear a mask for work?  
If so, how many hours per week did you work?  
If so, what kind of mask did you wear? (Examples: cloth mask, surgical mask, N95).

8. Did you wear a mask to exercise?  
If so, how often?  
If so, what kind of mask did you wear? (Examples: cloth mask, surgical mask, N95).

The fifth section addressed an additional theory regarding mask usage and left a space for additional comments. The participant was asked if they have a temporomandibular joint disorder (TMD) and if their symptoms were more prominent when they wore a mask for an elongated time. If they do not have TMD, participants were asked if they felt unusual jaw pain while wearing a mask. This served a purpose of analyzing the relationship between mask wearing and jaw pain whether or not the participant has a history of TMD. The last question allowed for information not covered in the survey to be addressed by the participant. This question was not required in the completion of the survey. This gave participants an open response space with the intention of obtaining information not considered by the research team.

9. If you had TMJ (Temporomandibular Joint Disorder), did you notice your symptoms increasing or decreasing with mask use?  
If not, did you feel unusual jaw pain with mask usage?
10. Do you have any other comments that you would like to provide?

## CHAPTER SEVEN

### Survey Results

#### Participants

Participants were 172 subjects who were over the age of 18 and volunteered to complete the survey online. The survey was completely voluntary, but once the participant began the survey, each question was required for completion. Despite this, many responses were submitted incomplete due to participants not answering the full given question. Data was not collected for demographics, although it was found that 18% of participants wore a mask prior to the pandemic, either for their profession or for their safety (n=31). Additionally, participants were asked for an estimate of how many hours they wore a mask during the Covid-19 pandemic. On average, participants wore a mask for 6.14 hours per day during the pandemic with a standard deviation of 3.20. The survey also found that 40.1% of subjects wore a mask for 8 or more hours a day (n=69). Many participants expressed that their hours varied depending on how many hours they worked in the week. Their masked hours were calculated as an average of the range given (n=27).

#### Survey Data

This section will analyze the received responses for each section of the survey. These results will then be compared using a mixed methods approach to assess the effects that the Covid-19 pandemic had on oral health.

When asked how many visits participants had per year to the dentist prior to the Covid-19 pandemic, an average of 1.78 visits per year was recorded. Within this calculation, 6 participants answered with 0 dental visits per year. The participants were

also asked if this number increased or decreased during the pandemic, in which 34.3% said that their dental attendance decreased (n=59), 43.0% (n=74) said this remained the same, while for 22.7% (n=39), this remained unclear. 16.3% (n=28) of respondents noted that they usually had one or more cavities with each dental visit, while 83.7% (n=144) responded that they regularly did not have cavities at their dental office visits. 10.5% (n=18) of respondents observed an increase in the number of cavities they had during or after the pandemic while 54.7% (n=94) saw no change. 3.5% (n=6) of subjects mentioned that they had no way of knowing if they had an increased number of cavities because they had not returned to the dentist since before the pandemic.

When asked if they noticed themselves experiencing symptoms of dry mouth with mask wear, 48.3% (n=83) of subjects answered that they did have apparent symptoms. Of these 83 subjects, 80.1% (n=67) included that they noticed their dry mouth symptoms becoming more severe with longer mask wear time. 39.0% (n=67) of participants indicated that they did not notice symptoms of dry mouth with their mask wear. For 12.8% (n=22) of subjects, this was inconclusive. When questioned if their acne increased with mask wear, 67.4% (n=116) of participants answered that they did notice more prominent acne associated with their mask wear. 32.0% (n=55) of participants noted that they did not notice their acne becoming worse, but 3.6% (n=2) of those who said no mentioned that they noticed an increase in others but were not susceptible to acne themselves. 1.8% (n=1) of subjects who answered in the negative mentioned that they did not mask so any change in their acne would not have been a result of mask wear.

Participants were asked if they wore a mask when they were working. 75% (n=129) of subjects were required to wear a mask at work. Of those who responded that



they regularly wore masks at work, many responded that they wore multiple different types of masks depending on their day-to-day work situation. 41.1% (n=53) wore cloth masks, 54.3% (n=70) wore surgical masks, 28.7% (n=37) wore N95 masks, and 1.6% (n=2) wore powered air purifying (PAP) masks. On average, respondents who were required to wear a mask worked 29.3 hours per week. 18.6% (n=32) were not required to wear a mask, and 6.4% (n=11) did not work during the pandemic. When asked if they wore a mask while exercising, 26.7% (n=46) responded that they did, while 73.3% did not. It can be assumed that many of the respondents that did not wear a mask while exercising either did not exercise or exercised at home or outdoors where masks were not required. Of those who wore a mask while exercising, 65.2% (n=30) wore cloth masks, 32.6% (n=15) wore surgical masks, and 2% (n=1) wore an N95 mask.

The subjects were then asked if they had been diagnosed with temporomandibular disorder. Most participants answered that they had not been diagnosed, with 86.6% answering no (n=149). Of those who had not been diagnosed, 10% (n=15) reported that they felt unusual jaw pain with mask-use. 5% (n=8) of participants had been diagnosed with TMD before and 75% (n=6) mentioned that they felt more noticeable pain with mask-wear.

The last question left an open response area for participants to leave any additional comments that they had regarding the survey. Some of the most interesting responses included two participants stating that they developed TMD during the pandemic and attribute some of the reasoning for this to mask-wear. One subject stated that the N95 mask caused more jaw pain than the surgical mask and another stated that their teeth felt more sensitive, possibly due to jaw clenching. Two subjects also

mentioned that they had noticeably bad breath after wearing a mask, with one mentioning this could be partially attributed to the lesser amount of water they were drinking. Two participants commented on the effects masks had on their eyes, one stating that their glasses often fogged and another saying mask-wear made their eyes so dry that they could not wear contact lenses. Lastly, one participant mentioned that throughout the pandemic, they felt that their skin and mouth adapted to mask wear and it became less bothersome as time went on.

## CHAPTER EIGHT

### Discussion

There are many contributing factors to oral health. During the Covid-19 pandemic, many people experienced significant changes to their lifestyles. In particular, the necessity to wear a mask while in public places was a change experienced by many. Question two revealed that 18% of participants had ever worn a face mask prior to the pandemic. This population may be overrepresented in this sample due to the presence of students and faculty in the health field that were given the opportunity to complete the survey. Regardless, this shows that a significant number of subjects had never worn a mask prior to the Covid-19 pandemic. With an average of 6.14 hours of mask-use per day during the pandemic (Q1), many subjects' lifestyles changed from almost never having their mouth covered to having it covered for a significant portion of their day. Only one participant mentioned that they rarely wore a mask in public, which was consistent with the literature review where a 96% prevalence of mask-wearing was noted (Karimi et al., 2021). A similar study mentioned that the lowest percentage of mask-wearers were middle-aged people in rural areas (Haischer et al., 2020). The main population pool for this survey was likely students at a rural university. Despite this, the percentage of subjects who wore a mask in public during the Covid-19 pandemic was 99%.

When at work or exercising, the survey found that subjects most commonly wore surgical masks at work, and cloth masks when exercising. There was a significantly higher proportion of participants who answered positively that they wore masks at work than those who wore masks exercising. This is likely due to the ability to exercise outdoors or in the home. Although the number of subjects who responded that they

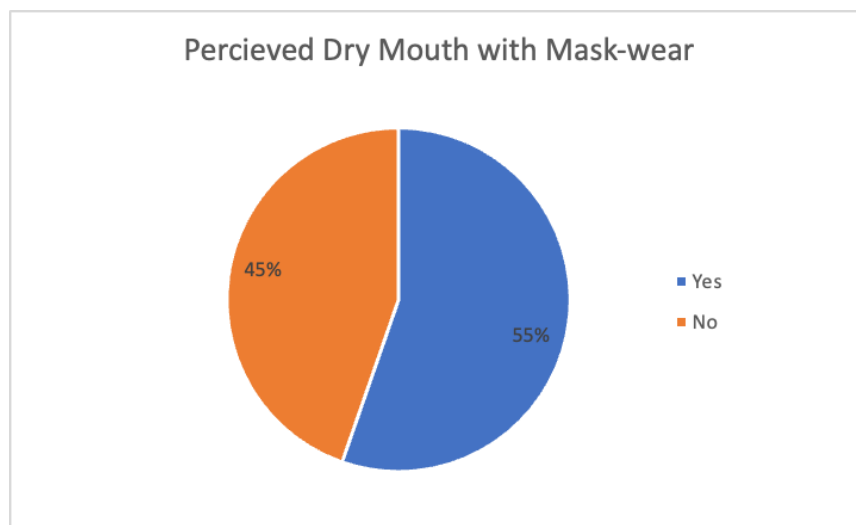
worked from home was low, the ability to do remote work is often seen in higher-paying professions. This disproportionately affects lower-class individuals, as the harms that can be seen from long-term masking can be significant to one's oral health. Additionally, many of the respondents to the survey mentioned that the N95 mask is the most uncomfortable to wear for long periods of time. Healthcare workers often wear this model of mask in order to protect themselves as well as their patients from exposure to any illness, and this continues post Covid-19 pandemic. The possible harms that mask-wear can cause to these populations should be further researched so that proper measures can be taken to limit these effects as well as so mask technology can be improved.

Many portions of the survey data collected were consistent with the literature review. In particular, responses to question three regarding dentist office visits gave an expected result. Many subjects answered that they had a decrease in dental visits during the pandemic, consistent with the decrease found by the National Center for Health Statistics in both men and women and all races and Hispanic-origin groups (Cha & Cohen, 2019). There are many possible reasons for this, including an overwhelming social climate (Mayo Clinic, 2022a), the increase in fear of leaving home being correlated to the public's fear of Covid-19 (İnal et al., 2022), an increase in unemployment or underemployment and lack of dental insurance coverage (International Labour Organization, 2020; Blackwell, 2019; Center for Health Care Strategies, 2019). Dental care was likely holding lesser importance in comparison to food, shelter, or emergency medical care for most people.

The presence of dry mouth in correlation to mask-wear also held similarities to results found in the literature review. Approximately half of the respondents reported

feeling symptoms of dry mouth when they wore a mask. Mask-wear promotes mouth breathing to overcome breathing resistance along with a faster breathing rate, increasing oral evaporation (Kisielinski et al., 2021). Additionally, the longevity of mask-use has been shown to increase perceived dry mouth significantly (Kanzow et al., 2021). Respondents who reported feeling dry mouth symptoms when wearing a mask also reported this increasing with wear time in 80.7% of responses.

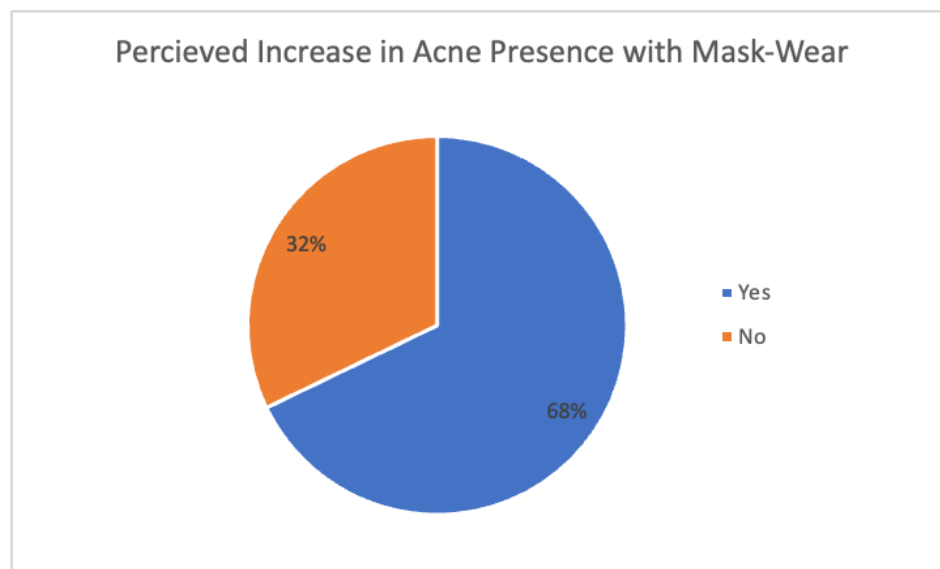
Figure 1. Statistical pie chart displaying the percentage of respondents who responded “yes” or “no” when asked if they felt dry mouth symptoms with mask-wear.



This aligns with the theory that mask-wear contributes to dry mouth and suggests that the oral cavity is not able to adjust quickly enough to the change in breathing patterns to combat this over time. Respondents who reported having worn a mask before the pandemic later answered that they felt dry mouth symptoms with mask wear in 67.7% of responses, being a higher percentage than the overall sample. Many of these subjects were likely healthcare professionals, so this result shows that having experience wearing masks does not significantly affect the body’s ability to accommodate for the water loss.

One of this study's most significant results was the number of respondents who saw an increase in acne with mask use. Through multiple clinical trials, it has been found that masks contribute to an increase in acne and other skin irritations in areas where the mask lies (Beri et al., 2022). The survey pool could have skewed this result, as acne is more prevalent in young people, and this survey was sent to many college students. Regardless, subjects responded positively 67% of the time when asked if they noticed an increase in acne with mask use.

Figure 2. Statistical pie chart displaying the percentage of respondents who responded “yes” or “no” when asked if they saw an increase in acne with mask-wear.

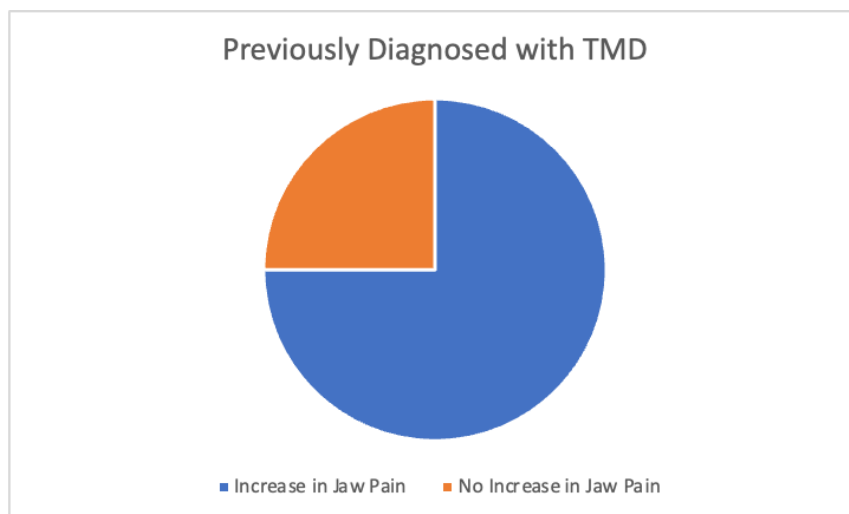


According to the American Academy of Dermatology, acne is multifactorial. Some of the common causes for an increase in acne include diet, lack of sleep, stress, and the presence of oil on the skin (American Academy of Dermatology, 2023). These are all possible contributing factors to the increase of acne seen during the pandemic along with the irritation caused by mask wear. Additionally, it is likely that many did not change

their masks when wearing them for a long period or wash reusable masks after each wear. This allows for excess oil and bacteria to accumulate on the mask and be deposited back onto the skin, leading to skin irritation and acne. Subjects who reported having worn masks prior to the pandemic answered that they saw an increase in acne with mask wear in 87.1% of responses. This shows that their skin had not acclimated to mask wear over the time that they had worn a mask prior to the pandemic, again suggesting that the effects of mask wear are not minimized when they are used over multiple years.

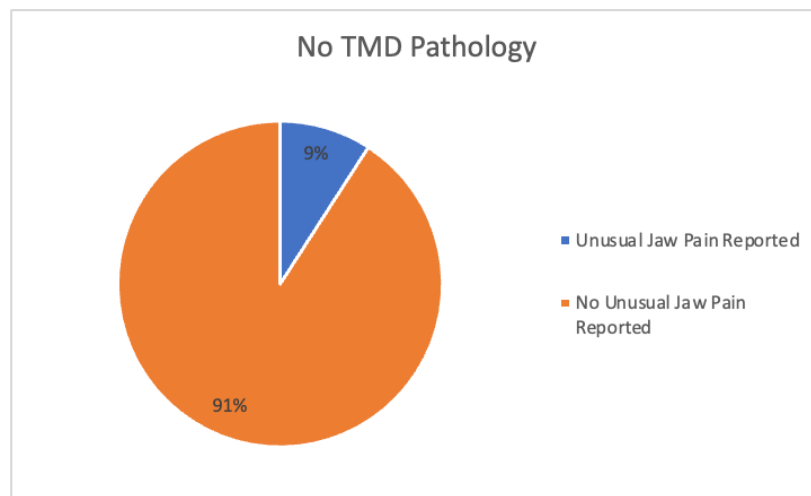
The National Institute of Health reports that TMD is found in five to twelve percent of people (U.S. Department of Health and Human Services, 2018). This study found that 4.7% of subjects had been diagnosed with TMD- slightly below the population average. Of those with TMD, 75% responded positively, that they did feel an increase in their symptoms with the use of a mask.

Figure 3. Statistical pie chart displaying the responses of subjects who had been previously diagnosed with TMD when asked if they felt an increase in their symptoms with mask-use.



This is likely caused by the need to push the jaw forward and downward to hold a mask into place (Zuhour et al., 2022). Additionally, it is possible that subjects repeated this motion and other jaw movements to adjust an ill-fitting mask. Subjects with TMD mentioned having to purchase a nightguard and visit a massage therapist specializing in TMJ pain to alleviate their discomfort from mask-wear. Additionally, 8.7% of subjects who had not been diagnosed with TMD responded that they did have unusual jaw pain when they wore a mask.

Figure 4. Statistical pie chart displaying the responses of subjects who previously had no disease pathology of TMD when asked if they felt irregular jaw pain with mask-use.



This corresponds with the results found in the literature review that revealed that patients who had not previously been diagnosed with TMD experienced high levels of osteoarthritis during and post mask-wear (Zuhour et al., 2022). One subject mentioned that even after not wearing a mask for months post-pandemic, their jaw pain still has not resolved. The jaw pain caused by masks is likely not caused by the mask itself, but by the



uniformity in mask sizing. Different sized masks have been created but are rarely found in a healthcare setting as only 6% of healthcare workers report feeling capable of wearing an N95 for their 8-hour shift without discomfort (Baig et al., 2010). Having comfortably fitting masks available in the workplace would likely alleviate the jaw discomfort of those with and without TMD.

There was inconsistent research regarding the average number of cavities per visit patients had, excluding that statistic from the literature review. Despite this, the National Institute of Dental and Craniofacial Research reported that the percentage of adults ages 20 to 64 with tooth decay has remained relatively constant in the last two National Health and Nutrition Examination Surveys (U.S. Department of Health and Human Services, 2022). This study reveals, however, that 10.5% (n=18) of subjects reported an increase in the number of cavities they have had after the pandemic. This increase could be attributed to many factors including stress, different eating habits, lifestyle changes, decreased visits to the dentist during the pandemic, and mask-use. Dental caries is more prominent when the oral cavity is more dehydrated, making it incapable to remove food remnants and bacteria as well as having an increased pH (Wyszynska et al., 2022). Additionally, the concept of rebreathing, or breathing air that has a higher CO<sub>2</sub> content, could have influenced the increase in cavities seen during the pandemic. In both the first and second hours of mask-wear, a person experiences a decrease in oxygen saturation (Beder et al., 2008). This could lead to an increase in blood pCO<sub>2</sub> and an increase in blood acidity. Since blood acidity and saliva acidity are correlated (Baliga et al., 2013), this can additionally affect the pH in the oral cavity, increasing the likelihood of developing dental caries. The sudden change from no mask-wear to hours of mask-wear could have

changed the microclimate of the mouth in enough ways to produce this irregular increase in cavities.

### Limitations

The data collected in this study includes limitations within the subject pool as well as within the data collected. First, most participants are likely students in college. This is due to the survey being sent to university newsletters and academic groups. Additionally, the university this survey originated from is considered a rural university in a state that never had a mask mandate, meaning many of the subjects may not have been required to wear a mask as often as those who live in other states. Many of the newsletters and academic groups this survey was sent to were health and science centered programs, making it possible that much of the mask-wear noted was in a clinical setting where strict PPE guidelines are often in place. The questions in this study were subjective, causing there to be possible errors in the responses and interpretations of the responses. Lastly, due to the timeline of this study, many subjects may have misremembered details from during the pandemic. In the future, a study similar to this one could be done on a much larger scale, taking a random sample from more demographic areas. Additionally, a demographics section could be included in order to assess any correlations between factors such as age or sex on the effects that the pandemic had on oral health.

## CHAPTER NINE

### Conclusion

It is known that the Covid-19 pandemic brought about new experiences for most people. Among these are changes that were seen in the oral health of individuals, from the effects of continuous mask-wear to the decrease in dental attendance. A survey was administered in order to investigate the possibility that the Covid-19 pandemic negatively impacted oral health, with one of the main variables being mask-wear.

Based on the data and analysis given above, there are a few important results that should be noted. The survey found that:

- 55% of subjects reported perceived dry mouth with mask-use, 80.7% noting this increasing with wear time.
- 67% of subjects reported noticing an increase in acne with mask-use.
- 75% of subjects with TMD pathology reported an increase in symptoms, while 9% of those without TMD pathology reported unusual jaw pain.
- 11% of subjects reported an increase in their number of cavities post-pandemic.

It is possible that some of these results are due to other factors. Covid-19 brought about a multitude of lifestyle changes that could have influenced oral health- a lesser desire for hygiene while staying home, changed eating habits, and increased stress to name a few. Despite this, the literature review suggests that the use of masks could have had a significant impact on a person's oral cavity.

The fact that the long-term use of masks may be harmful to the oral cavity is an idea that should bring about further research. If masks can cause harm, those who are wearing them for hours each day for their profession should be informed about the risks. There

should also be measures in place to limit the effects that mask-wear can have on the oral cavity in terms of jaw pain, dry mouth, acne, tooth decay, and other issues that have not yet been investigated. Lastly, masks should continue to be remodeled to improve in technology and fit. In the case of a future pandemic, it is likely that masks will be popularized for the general public again. Although the negative effects of masks may still be present, with improved technology and information sources regarding how to limit these effects, their impacts will be less severe.

## **APPENDICES**

### **Appendix A**

#### **Final IRB Approval**

3/29/23, 4:36 PM

Mail - Gram, Anika Lauren - Outlook

IRB-22-264 - Modification: Amendment Approval

do-not-reply@cayuse.com <do-not-reply@cayuse.com>

Fri 3/3/2023 8:04 AM

To: Gram, Anika Lauren <Anika.Gram@coyotes.usd.edu>; Regnerus, Carissa <Carissa.Regnerus@usd.edu>; Turgeon-Drake, Jamie <Jamie.Turgeon-Drake@usd.edu>



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Date: March 3, 2023

The University of South Dakota  
414 E. Clark Street  
Vermillion, SD 57069

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PI: Carissa Regnerus Jamie Turgeon-Drake, Timothy Ricker  
Student PI: Anika Gram  
Re: Modification - IRB-22-264, *Dental Health in Relation to Covid-19*

The University of South Dakota Institutional Review Board has rendered the decision below for this project. The approval is effective starting March 3, 2023 and will expire on --. Veterans Administration (VA) research may not begin until R&D Committee approval is obtained.

Decision: Approved  
Category: Exempt  
Approved Revision: Remove Personnel-Timothy Ricker

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The University of South Dakota Institutional Review Board (IRB) has received and reviewed your amendment. The University of South Dakota IRB has approved the amendment and the information has been added to the file. Thank you for keeping the IRB informed of the project changes.

If there are any additional project updates or changes you plan to make in the future (e.g., protocol amendments, revised informed consents, changes to study procedure, adding or removing investigators, etc.) in this or other IRB-approved human subjects research, please make sure your amendment reflecting those changes has been filed and approved before implementing any changes in your study.

Please keep in mind that any research-related injuries (physical or psychological), adverse side effects or other unexpected problems that occur during the conduct of this study need to be reported to the IRB within 5 days of notification of the occurrence.

If you have any questions, please contact [irb@usd.edu](mailto:irb@usd.edu) or (605) 658-3743.

Sincerely,

A handwritten signature in black ink, appearing to read 'Linda Rupp'.

Linda Rupp  
Research Compliance Coordinator  
University of South Dakota  
(605) 658-3743

<https://outlook.office.com/mail/inbox/id/AAQkADgwNGM3Y2JkLTc0MTMtNDNiYi1hYzJmLTA4NWE1ZGIyNWQyMgAAQAH6Tfkfxt5JgZm83sK9zq8%3D>

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## Appendix B

### Survey Participant Informed Consent

**UNIVERSITY OF SOUTH DAKOTA  
Institutional Review Board  
Informed Consent Statement**

Title of Project: Dental Health in Relation to Covid-19

Principle Investigator: Carissa Regnerus, Health Sciences Building 38D,  
Vermillion, SD 57069  
(605) 658-5962 [carissa.regnerus@usd.edu](mailto:carissa.regnerus@usd.edu)

Other Investigators: Timothy Ricker, 17 Dakota Hall Vermillion, SD 57069  
(605) 658-5966 [timothy.ricker@usd.edu](mailto:timothy.ricker@usd.edu)

Jamie Turgeon, Health Sciences Building 228, Vermillion,  
SD 57069  
(605) 677-3902 [jamie.turgeon@usd.edu](mailto:jamie.turgeon@usd.edu)

Carissa Regnerus, Health Sciences Building 38D,  
Vermillion, SD 57069  
(605) 658-5962 [carissa.regnerus@usd.edu](mailto:carissa.regnerus@usd.edu)

Anika Gram, 120 Old Main, Vermillion, SD, 57069

The purpose of this research study is to understand the correlation between oral health before wearing masks and after wearing masks to increase awareness of the effects mask-wearing has on oral health. You must be 18 years of age older to be eligible to participate.

You are asked to answer a short survey, that will take about 10 minutes to complete. The questions are in short answer format with a space to record your answer. You will not receive compensation for your participation

There are no risks in participating in this research beyond those experienced in everyday life and you may not benefit personally from participating in this research project.

The survey does not ask for any information that would identify who the responses belong to. Therefore, your responses are recorded anonymously. If this research is published, no information that would identify you will be included since your name is in no way linked to your responses.

The researchers conducting this study are Jamie Turgeon, Timothy Ricker, Carissa Regnerus, and Anika Gram. If you have questions, concerns, or complaints about the research please contact Jamie Turgeon-Drake at (605) 658-5955 during the day.

If you have questions regarding your rights as a research subject, you may contact The University of South Dakota- Office of Human Subjects Protection at (605) 677-6184 or [irb@usd.edu](mailto:irb@usd.edu). You may also contact this office with problems, complaints, or concerns about the research. Please contact this office if you cannot reach research staff, or you wish to talk with someone who is an informed individual who is independent of the research team.

You do not have to participate in this research. You can stop your participation at any time. You may refuse to participate or choose to discontinue participation at any time without losing any benefits to which you are otherwise entitled. You do not have to answer any questions you do not want to answer.

Completion and return of the survey implies that you have read the information in this form and consent to participate in the research.

Please keep this form for your records or future reference.

[https://docs.google.com/forms/d/e/1FAIpQLSf6Aqb-XHHv3oCySQXSEYez1sMhHm2lluLv2YTRu9113f2r1w/viewform?usp=sf\\_link](https://docs.google.com/forms/d/e/1FAIpQLSf6Aqb-XHHv3oCySQXSEYez1sMhHm2lluLv2YTRu9113f2r1w/viewform?usp=sf_link)



## Appendix C

### Survey

# Dental Health During Covid-19 Questionnaire ✕ ⋮

To be used in an undergraduate thesis research project.

Consent

**UNIVERSITY OF SOUTH DAKOTA**

**Institutional Review Board**

**Informed Consent Statement**

Title of Project: Dental Health in Relation to Covid-19

Principle Investigator: Carissa Regnerus, Health Sciences Building 38D, Vermillion, SD 57069  
(605) 658-5962 [carissa.regnerus@usd.edu](mailto:carissa.regnerus@usd.edu)

Other Investigators: Katie Williams, Health Sciences Building 320, SD 57069  
(605) 658-5968 [katie.williams@usd.edu](mailto:katie.williams@usd.edu)

Jamie Turgeon, Health Sciences Building 228, Vermillion, SD 57069  
(605) 677-3902 [jamie.turgeon@usd.edu](mailto:jamie.turgeon@usd.edu)

Anika Gram, 120 Old Main, Vermillion, SD, 57069

The purpose of this research study is to understand the correlation between oral health before wearing masks and after wearing masks to increase awareness of the effects mask-wearing has on oral health. You must be 18 years of age or older to be eligible to participate.

You are asked to answer a short survey, that will take about 10 minutes to complete. The questions are in short answer format with a space to record your answer. You will not receive compensation for your participation.

There are not risks in participating in this research beyond those experienced in everyday life and you may not benefit personally from participating in this research project.

The survey does not ask for any information that would identify who the responses belong to. Therefore, your responses are recorded anonymously. If this research is published, no information that would identify you will be included since your name is in no way linked to your responses.

The researchers conducting this study are Jamie Turgeon, Katie Williams, Carissa Regnerus, and Anika Gram. If you have questions, concerns, or complaints about the research please contact Carissa Regnerus at (605) 658-5962 during the day.

If you have questions regarding your rights as a research subject, you may contact The University of South Dakota- Office of Human Subjects Protection at (605) 677-6184 or irb@usd.edu. You may also contact with office problems, complaints, or concerns about the research. Please contact this office if you cannot reach research staff, or you wish to talk with someone who is an informed individual who is independent of the research team.

You do not have to participate in this research. You can stop your participation at any time. You may refuse to participate or choose to discontinue participation at any time without losing any benefits to which you are otherwise entitled. You do not have to answer any questions you do not want to answer.

Completion and return of the survey implies that you have read the information in this form and consent to participate in the research.

Please keep this form for your records or future reference.

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Do you consent to this survey? \*

- Yes. I consent to the completion of this survey.
- No. I do not consent to this survey.

Approximately how many hours during the day did you wear a mask during the Covid-19 pandemic? \*

Short answer text

Did you wear a mask before the Covid-19 pandemic? \*

If so, what kind of mask? (Examples: cloth mask, surgical mask, N95).

Short answer text

How many visits to the dentist did you have per year prior the pandemic? \*

Did this increase or decrease during the pandemic?

Short answer text

Approximately how many cavities did you have at each check-up? \*

Did this number increase during or after the pandemic?

Short answer text

Did you notice yourself having a drier mouth when you wore a mask? \*

If so, did this become better or worse when you wore the mask for a long period of time?

Short answer text

Did you notice yourself having an increase in acne when wearing a mask often? \*

Short answer text

Did you have to wear a mask for work?

If so, how many hours per week did you work?

If so, what kind of mask did you wear? (Examples: cloth mask, surgical mask, N95).

Short answer text

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\*

Did you wear a mask to exercise?

If so, how often?

If so, what kind of mask did you wear? (Examples: cloth mask, surgical mask, N95).

Long answer text

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If you had TMJ (Temporomandibular Joint Disorder), did you notice your symptoms increasing or decreasing with mask use? \*

If not, did you feel unusual jaw pain with mask usage?

Short answer text

---

⋮

Do you have any other comments that you would like to provide?

Long answer text

---

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