Dental Hygiene Students Reported Physiological Symptoms Associated With Wearing an N95 Respirator Mask

Peyton Shea Butler
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DENTAL HYGIENE STUDENTS REPORTED PHYSIOLOGICAL SYMPTOMS
ASSOCIATED WITH WEARING AN N95 RESPIRATOR MASK

by

Peyton Shea Butler
B.S. June 2021, Old Dominion University

A Thesis Submitted to the Faculty of Old Dominion University in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE
DENTAL HYGIENE
OLD DOMINION UNIVERSITY
December 2023

Approved by:

Tara L. Newcomb (Director)
Ann Bruhn (Member)
Norou Diawara (Member)
Purpose: Physiological symptoms and comfort levels while wearing an N95 respiratory mask has not been examined with dental hygienists. The purpose of this study was to investigate dental hygiene students reported physiological symptoms and comfort perception while wearing an N95 respirator mask during patient care appointments. Methods: After IRB approval (IRB #1987754-2), a 16-item questionnaire was distributed through email to a convenience sample of 65 dental hygiene students. Questions assessed respiratory, dermatologic, cardiac, mask mouth and general physiological symptoms, as well as comfort levels. Additionally, participants were asked to respond to demographic questions and one open ended question inquiring about any additional physiological conditions not listed in the questionnaire. Descriptive statistics and a paired-sample t-test and an ANOVA test were used for data analysis. Results: An overall response rate of 95% was obtained (n=54). Between the two groups, senior students reported more physiological symptoms at a statistically significant rate when compared to junior students in sore throat ($P<0.0011$), hypoxia ($P<0.0476$), an increase in plaque retention ($P<0.0028$), bad breath ($P<0.0047$), facial bruising ($P<0.003$), facial indentations ($P<0.0102$), facial irritation ($P<0.0490$), physical fatigue ($P<0.0061$), headache ($P<0.0046$), myalgia ($P<0.0001$), anxiety ($P<0.0005$), trouble focusing ($P<0.0214$), jaw pain ($P<0.0001$), dizziness ($P<0.0086$), and lightheadedness ($P<0.0253$). In total, higher means and standard deviations were observed
in senior dental hygiene students. Most participants (81.48%) experienced some level of discomfort with no significant difference between senior and junior dental hygiene students level of comfort perception ($P<0.642$). Conclusion: Both junior and senior dental hygiene students reported physiological symptoms and discomfort related to prolonged N95 respirator mask use while providing patient care.
ACKNOWLEDGMENTS

I would like to thank the following people, without whom I would have not been able to successfully conduct and complete this research. Thank you to my committee members Professor Tara L. Newcomb, Professor Ann Bruhn, and Dr. Diawara for your time, dedication, patience, and help with this study. To my director, Professor Tara L. Newcomb I give my warmest thanks. Thank you, Professor Tara L. Newcomb for your huge contribution to this study, and for assisting and guiding me every step of the way. I have learned so much and am extremely proud of this original research study. Thank you Dr. Diawara for your helpful insight and direction regarding statistics and data analysis. Also, I would like to thank the junior and senior dental hygiene students at Old Dominion University who contributed data. Without their participation this study would not have been able to be conducted. To Professor Tara L. Newcomb, Professor Ann Bruhn, and Dr. Denise McKinney, thank you for your constant support throughout my undergraduate and graduate degree. You all have played a vital role in my academic success and professional and individual growth.

My biggest thanks goes to my family, Lance Butler (Dad), Christine Butler (Mom), Colton Butler (Brother), and Margaret Schillaci (Nanny Peggy-Grandmother), I am sincerely grateful and thankful for your endless love and support throughout my entire academic career. Lastly, thank you to my two cats Princess Keke Butler (Tuxedo short hair mix breed) and DaVinci Butler (Tuxedo Maine Coon), and two dogs Mr. Tux Walter Butler (Mini Goldendoodle) and Mr. Fredrick Oliver Butler (Mini Poodle), for always keeping me company while I worked on the computer for hours upon hours to complete this study.
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CHAPTER I
INTRODUCTION

The 2019 coronavirus 2 (SARS-CoV-2), as an emerging airborne infectious disease, initiated new guidelines for respiratory protection of dental and dental hygiene practitioners. In January 2020, the Centers for Disease Control and Prevention (CDC) reported the first case of the SARS-CoV-2 virus in the United States.\(^1\) By March 2020, the World Health Organization (WHO) declared COVID-19 a pandemic.\(^2\) The SARS-CoV-2 is a respiratory virus contracted through inhalation and mucous membrane penetration and is transmitted from animals to humans; however, the virus mutates when it is passed to humans.\(^3\)

SARS-CoV-2 can progress in stages of mild, moderate, to severe symptoms much like the coronavirus that caused the Severe Acute Respiratory Syndrome (SARS) of 2002 and Middle East Respiratory Syndrome (MERS) of 2012.\(^4\) SARS-CoV-2 symptoms can include fever or chills, muscle or body aches, loss of taste or smell, sore throat, congestion or runny nose, diarrhea, and nausea or vomiting.\(^4\) In advanced cases, patients may experience respiratory or cardiac distress which can result in long-term health issues or fatality.\(^3-4\) Individuals with the virus can present with symptoms or appear asymptomatic.\(^3-4\) Transmission is similar to other respiratory diseases as it can occur with droplet aerosols expelled during speaking, coughing, or sneezing and also through aerosols employed during clinical procedures.\(^5\) As a result of airborne transmission, asymptomatic carriers, waning vaccine efficacy, and frequent virus mutation of the SARS virus, COVID-19 remains contagious and has yet to be eradicated.\(^6\)

At the start of the pandemic, approximately 3 million U.S. healthcare workers were mandated to wear respiratory protection of some type.\(^1\) Certain occupations have been identified as being at a greater risk for exposure to SARS-CoV-2.\(^7\) Healthcare professions are at the highest
predicted risk for contracting the SARS-CoV-2 virus. Particularly, dental professionals including dental hygienists, oral and maxillofacial surgeons, dental assistants, and general dentists, are ranked as the top four individual occupations at highest risk of exposure. Dental professionals are at an increased risk for exposure to SARS-CoV-2 because of the unique nature of dentistry where aerosol producing equipment and procedures are common practice with close proximity of the provider to the patient’s mouth.

The CDC and National Institute for Occupational Safety and Health [NIOSH] approved general guidelines for N95 respirator masks for use in healthcare in 1998. The Occupational Safety and Health Administration (OSHA) classifies respiratory protection devices according to the air source, the type, and characteristics of the contaminants that it can block. The N95 respirator masks are also called filtering facepiece respirators (FFRs). Filtering facepiece respirators are the most used respiratory protection in healthcare. The FFRs are designed to fit around the user’s nose and mouth, creating an airtight seal with the face. Most N95 respirator masks are intended as disposable and single use because it is considered potentially biohazardous waste.

In general, the composition of most N95 respirator masks is limited to information listed in the package inserts, which list American Society for Testing and Materials (ASTM) levels, brand, approvals (NOISH/FDA), closure and filter type, color, disposability, and fluid resistance ratings. The N95 respirator mask is a disposable non-powered, particulate respirator that covers the nose and mouth of the wearer to reduce exposure of pathogenic biological airborne particulates. Tcharkhtchi et al found that an N95 respirator mask is made of polypropylene material that are synthetic plastic fibers derived from fossil fuels. The N95 respirator masks are comprised of four layers that include the inner layer (non-woven polypropylene), the support
layer (modacrylic), the filter layer (non-woven polypropylene melt-blown), and the outer layer (non-woven polypropylene). The three non-woven polypropylene layers of the N95 respirator mask trap bacteria and virus particles. The one modacrylic layer is electromagnetically charged and specifically attracts particles. Particle accumulation makes the N95 respirator mask more difficult to breathe through and decreases adequate oxygen flow. The CDC advises limited reuse (no more than five reuses), immediate disposal if breathing is restricted, and frequent removal between patients.

In the healthcare setting, N95 respirator masks provide adequate protection from most airborne pathogens, for example, influenza at 80 μm to 120 μm and tuberculosis at 5 μm. However, it provides no protection against fumes, oils, or vapors. In the United States, these filters bare the N95 respirator mask designation to indicate that it is not resistant to oil or solvents and intended to filtrate at least 95% of airborne particles that are >0.3 μm in size. The size of the SARS-CoV-2 ranges from 0.07 μm to 0.09 μm. The following calculations of the minimum sizes of particles containing SARS-CoV-2 assume a homogeneous distribution of viruses inside respiratory fluid particles, with a maximum size of 0.09 μm for SARS-CoV-2. Assuming that a respiratory particle can be completely 100% constituted of SARS-CoV-2, the theoretical minimum size of particles containing SARS-CoV-2 is calculated to be 0.09 μm corresponding to the size of a single virion. If 1% of the respiratory fluid particle is occupied by SARS-CoV-2, the minimum size of the respiratory particle that can contain SARS-CoV-2 is approximately 0.4 μm. Thus, the size of the SARS-CoV-2 particle can differ tremendously based on the strand and directly impacts the effectiveness of an N95 respirator mask.

The Food and Drug Administration (FDA) regulates N95 respirator masks for healthcare use as Class II devices, which are exempt from 510(k) premarket notification. Federal law
(Federal Food, Drug, and Cosmetic Act, section 513) established the risk-based device classification system for medical devices. Each device is assigned to one of three regulatory classes: Class I, Class II or Class III, based on the level of control necessary to provide reasonable assurance of its safety and effectiveness. As device class increases from Class I to Class III, regulatory controls increase. Class I devices are subject to the least regulatory control, and Class III devices are subject to the most stringent regulatory control. The regulatory controls for each device class include Class I (low to moderate risk): general controls, Class II (moderate to high risk): general controls and special controls, Class III (high risk): general controls and premarket approval (PMA).

The FDA has outlined precautions for healthcare workers who may be at higher risk of contracting SARS-CoV-2 and those who may be required to wear an N95 respirator mask while engaged in patient care. The CDC recommends healthcare workers who are over the age of 65, or that have underlying medical conditions or comorbidities to consult with their healthcare provider before wearing an N95 respirator mask. The CDC recommends healthcare workers that present with medical conditions and comorbidities such as obesity, diabetes, are immunocompromised, have high blood pressure or high cholesterol, sleep apnea, or respiratory or cardiac diseases and illnesses to consult with their health care provider before wearing an N95 respirator mask. As the N95 respirator mask restricts adequate airflow, it can make breathing more difficult, and can cause the wearer to experience adverse physiological symptoms.

Prior to wearing an N95 respirator mask, a medical evaluation and fit test must be completed. A medical evaluation determines an individual’s ability to wear an N95 respirator mask. The Occupational Safety and Health Administration (OSHA) standard (29 CFR 1910.134) requires a medical evaluation as an element of the written respiratory protection...
program. Yet, an additional medical evaluation may be required if an individual’s supervisor, or respiratory program administrator identifies signs or symptoms that may affect their ability to properly use an N95 respirator mask. Also, a licensed healthcare professional may deem that an individual could have a condition that causes one to need another medical evaluation.

Fit test protocol is conducted to verify that an N95 respirator mask is both comfortable and provides the wearer with adequate protection. N95 respirator masks effectively provide adequate protection, as long as the seal between respirator and face remains tight. The Occupational Safety and Health Administration (OSHA) (29 CFR 1910.134) requires N95 respirator mask users to be fit tested. There are two types of fit tests that can be conducted and are equally effective, qualitative (QLFT) and quantitative (QNFT) tests.

A qualitative fit testing uses an aerosolized test agent, which relies on detection by the wearer’s sense of taste, smell, or cough. There are a total of four OSHA-accepted test agents. The isoamyl acetate test agent has a banana smell and is only for testing respirators with organic vapor cartridges. The saccharin test agent is a sweet taste and can test respirators with a particulate filter of any class. The bitrex® test agent is a bitter taste and can also test respirators with a particulate filter of any class. The irritant smoke test agent produces an involuntary cough reflex and is only for testing respirators with a level of 100 particulate filters.

A quantitative fit test (QNFT) involves using an instrument to measure leakage around the face seal and produces a numerical result called a “fit factor.” There are three OSHA-accepted QNFT test protocols. The generated aerosol uses a non-hazardous aerosol such as corn oil generated in a test chamber. The condensation nuclei counter (CNC) uses ambient aerosol and doesn’t require a test chamber. The controlled negative pressure (CNP) uses a test that creates a vacuum by temporarily cutting off air. N95 respirator mask wearers should be fit
tested once a year to ensure proper fit and function.\textsuperscript{20} In addition, N95 respirator masks can vary based on the brand, model, and size.\textsuperscript{9} Wearers should be fit tested when wearing a new model or size, with weight loss or gain, with facial or dental alterations, and with a change in medical history.\textsuperscript{9}

Transmission of the SARS-CoV-2 virus is possible in dental settings and greater during the delivery of aerosol-generating procedures.\textsuperscript{21} An aerosol-generating procedure (AGP) is defined as a medical or dental procedure that results in the production of respirable airborne particles.\textsuperscript{21} The AGPs are considered a significant risk for the transmission of respiratory viruses.\textsuperscript{12, 21} In addition, aerosols can contain a high number of pathogens with a high bio load of virus.\textsuperscript{12, 21} The AGPs specific to dentistry, such as those created when the “wet” oral environment is aerosolized by high-speed instrumentation, are termed aerosol-generating dental procedures (AGDPs).\textsuperscript{12, 21}

Non-aerosol generating procedures (non-AGP) produce a minimal number of airborne particles and are less likely to transmit SARS-CoV-2.\textsuperscript{21} Non-AGP procedures in dentistry include dental radiographs, hand scaling with high volume evacuation, or using a slow-speed instrument.\textsuperscript{22} Since the start of the pandemic, professionals within the field of dentistry have collaborated to develop and establish guidance for practices.\textsuperscript{22} Source control measures were recommended and implemented to help control the spread of SARS-CoV-2 and to ensure the health and safety of dental practitioners, staff members, and patients.\textsuperscript{23}

Estrich et al conducted a web-based survey comprised of common questions regarding COVID-19 and infection control procedures that had been implemented in dental practices across the U.S. during 2020.\textsuperscript{23} A total of 2,195 dentists participated in the web-based survey.\textsuperscript{23} Participants delivered care in a private practice or a public health facility.\textsuperscript{23} Survey results
showed 99.7% (n=2,024) of dentists had implemented enhanced infection prevention since the start of the SARS-CoV-2. In total, 72.8% (n=1,486) of dentists used personal protective equipment (PPE) in accordance with CDC interim guidance.

Results revealed that 99% (n=2,024) of dentists reported disinfecting all equipment, disinfecting commonly touched surfaces in patient waiting rooms, and disinfecting operatories multiple times a day. In addition, 98.4% (n=2,010) of participants reported that patients were required to complete a COVID-19 symptom screening questionnaire before their dental appointment. Results revealed 97.2% (n=1,985) of participants required patients to have their temperature taken before their dental appointment. Patients that failed the COVID-19 symptom questionnaire or presented with a low-grade (99 degrees F) or high-grade fever (100.4 degrees F) were rescheduled. Also, 94.4% (=n=1,927) of participants reported employees had to pass the COVID-19 symptom screening questionnaire and have their temperature taken before being permitted to work each day.

The survey revealed 99.1% (n=2,024) of staff members and 75.9% (n=1,550) of patients were required to wear a face mask of any type or shield. Social distancing and contract tracing was implemented to help reduce the spread of SARS-CoV-2 and reported by 98.9% (n=2,019) of participants. Physical protection such as equipment barriers, opening windows, or using air filters and scrubbers was reported by 85.2% (n=1,740) of participants. At the time the survey was conducted, CDC interim guidance recommended the use of surgical masks, basic clinical PPE, and eye protection during non-AGPs. Out of the 146 dentists that performed non-AGPs, 82.9% (n=121) reported that they always wore surgical masks, basic clinical PPE, and eye protection. When AGPs on non-infected or noncontagious patients was performed, 59.0% (n=1,117) of participants reported wearing a N95 respirator mask, basic clinical PPE, and eye protection.
A total of 61.6% (n=90) of participants reported wearing a N95 respirator mask, basic clinical PPE, and eye protection during non-AGPs.23

Currently, dental providers have been recommended to wear a surgical mask when providing aerosol producing procedures during patient care.24 Estrich et al conducted web-based surveys on COVID-19 related health, infection prevention and control, and PPE.25 The web-based surveys were administered each month to 6,976 US licensed dental hygienists between September 2020 to August 2021.25 Surveys revealed that 99.9% of dental hygienists reported implementation of specialized infection prevention and control standards at their dental practice since the start of COVID-19.25

Staff masking was reported by 99.1% of participants and 99.4% of participants reported more frequent operatory disinfection.25 Also, 97.4% of participants reported patients completed COVID-19 questionnaire screenings and had their temperatures taken prior to appointments.25 Patients were required to wear face masks and social distance.25 Additional air filtration systems and physical protection barriers were placed throughout dental practices to reduce the possible transmission of the SARS-CoV-2 virus.25 Estrich et al reported a decline in specific infection prevention and control standards at the start of 2021 and then continued to decline.25

Prolonged mask use is broadly defined within the literature. Rosner’s nursing publication defined prolonged mask use as wearing an N95 respirator mask for 3 or more consecutive hours and Singla et al defined prolonged use as wearing an N95 respirator mask for 6 consecutive hours.26,27 Research by Lim et al defined prolonged N95 respirator mask usage in healthcare workers as 4 or more consecutive hours, while Ipek et al defined prolonged mask use as wearing an N95 respirator for at least 1 consecutive hour and not to exceed 4 or more hours.18,28
However, wearing any type of mask (surgical or N95 respirator mask), for 4 or more consecutive hours is categorized as prolonged use by the CDC.\textsuperscript{29}

**Statement of the Problem**

Published literature on reported physiological symptoms with prolonged N95 respirator mask use within the healthcare professions is limited.\textsuperscript{17,18,19,26-28,30} More specifically, research on physiological symptoms reported by dental hygienists is scarce in the literature.\textsuperscript{17,18,19,26-28,30}

Prior to the pandemic, surgical masks were the recommended personal protective equipment (PPE) for covering the nose and mouth in dentistry and dental hygiene clinical practice.\textsuperscript{30} At the start of the pandemic, dental hygiene faculty and students mandatorily wore N95 respirator masks while completing clinical coursework related to direct patient care. This entailed wearing close-fitting N95 respirator masks for prolonged periods of time as defined in this paper as 3 or more consecutive hours. Studies indicated that N95 respirator masks have been associated with mild to moderate discomfort which has been associated with nonadherence.\textsuperscript{21,25,26,30,31}

Recommended changes in PPE from surgical masks to N95 respirator masks does require further research. A gap in the literature exists as there have been no studies evaluating the reported physiological effects of prolonged N95 respirator mask use among dental hygiene students. Further research on the physiological effects associated with prolonged N95 respirator mask use is necessary to ensure the health and safety of wearers.

The survey aimed to address the following research questions:

1) Are there differences or associations in student dental hygienists reported physiological symptoms based on junior (one semester of exposure) or senior standing (four semesters of exposure) in the dental hygiene program?
2) Is there a difference in student dental hygienists comfort perception reported between senior and junior dental hygiene students?

**Significance of the Problem**

Research evaluating the physiological impact and tolerance of prolonged N95 respirator mask use in healthcare is both sparse and conflicting.\(^{18,23,25,26,30,31}\) There is no published data on reported physiological effects of wearing an N95 respirator mask by dental hygienists or dental hygiene students.

Hussain et al study evaluated healthcare workers, specifically nurses, doctors, and hospital staff. Hussain et al found that prolonged N95 respirator mask use initiated a host of physiological burdens.\(^32\) Various literature supports that healthcare workers who experienced adverse physiological effects had decreased work efficiency and had a higher burn out rate.\(^{18,26,31-33}\) The passivity and tolerance of N95 respirator masks for prolonged periods of time have been associated with physiological symptoms and discomfort among healthcare providers.\(^{18,23,26,30,32-34}\) Hussain et al and Choudhury et al found that healthcare workers reported increased levels of exhaustion and fragility after wearing a N95 respirator mask for 4 or more consecutive hours.\(^{31,32}\) Also, in both studies healthcare workers reported extreme tiredness during shifts.\(^{31,32}\) In Locatelli et al study amongst healthcare workers, participants reported discomfort while wearing the N95 respirator mask and attributed discomfort to the physical mask features.\(^{35}\) Findings in various literature support the positive correlation between N95 respirator mask use and reported physiological symptoms in nurses and other healthcare workers.\(^{30-35}\) Garra et al found that prolonged N95 respirator mask use was associated with physiological effects such as headaches, lightheadedness, shortness of breath, facial bruising, facial irritation, mental fatigue,
and yawning. In addition, Garra et al found that N95 respirator masks are uncomfortable to wear and restrict adequate airflow.

Additionally, in a study conducted by Lim et al, healthcare workers in a hospital setting reported an increase in headaches after wearing the N95 respirator mask for a shift that exceeded four consecutive hours. Lim et al conveyed that an increase in headaches amongst participants was caused by hypoxemia, hypercapnia, and mechanical factors of the N95 respirator mask. Research by Rosner found that prolonged use of N95 respirator masks and surgical masks caused physical adverse effects such as headaches, impaired cognition, respiratory difficulty, dermatologic reactions, equilibrium difficulty, vision, and communication interference.

**Definition of Terms**

The following terms are defined to assist the reader in understanding the context of key terms in the study.

- **SARS-CoV-2 (coronavirus 2019):** is a virus named SARS-CoV-2 and was discovered in December 2019 in Wuhan, China. It is very contagious and has quickly spread around the world. COVID-19 most often causes respiratory symptoms that can feel much like a cold, flu, or pneumonia. COVID-19 may attack more than your lungs and respiratory system. Other parts of your body may also be affected by the disease.

- **Personal Protective Equipment (PPE):** Equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal protective equipment may include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, coveralls, vests, and full-body suits.
- **N95 Respirator Mask**: A respiratory protective device designed to achieve a very close facial fit and very efficient filtration of airborne particles. Note that the edges of the respirator are designed to form a seal around the nose and mouth. Surgical N95 Respirators are commonly used in healthcare settings and are a subset of N95 Filtering Facepiece Respirators (FFRs), often referred to as N95s.\(^{38}\)

- **Physiological Symptoms**: Physiological symptoms are the physical symptoms that occur when you feel anxious or under display. These are bodily reactions and may be apparent to other people.\(^{34}\) In this study, physiological symptom categories examined included respiratory symptoms, mask mouth symptoms, dermatologic symptoms, cardiac symptoms, and general symptoms.

- **Centers for Disease Control (CDC)**: CDC is the United State of America’s leading science-based, data-driven, service organization that protects the public’s health.\(^{39}\)

- **Occupational Safety and Health Administration (OSHA)**: The Occupational Safety and Health Administration works to ensure safe and healthful working conditions for workers by setting and enforcing standards and by providing training, outreach, education, and assistance.\(^{40}\)

- **Dental Hygiene Students**: Junior and senior students enrolled in Old Dominion University’s School of Dental Hygiene program who provide clinical care to patients in the dental hygiene care facility.
Research Question and Hypotheses

This study intended to answer the following question:

1. What are the physiological symptoms and perceived comfort levels reported by junior and senior dental hygiene students who wear N95 respirator masks for prolonged periods of time during patient care appointments.

Hypotheses

The following null hypotheses were tested at the 0.05 level of significance:

1) There will be no statistically significant difference in the number of reported physiological symptoms based on junior (one semester of exposure) or senior standing (four semesters of exposure) while wearing an N95 respirator mask for prolonged periods of time in clinical care.

2) There will be no statistically significant difference in comfort perception reported between junior and senior students who wore N95 respirator masks for prolonged periods of time while providing clinical care.
Limitations

Limitations of this study include:

- Small sample size of participants due to convenience sampling.
- Recall bias.
- Selection bias due to convenience sampling.
- Voluntary participation.
- Research conducted in a short amount of time.
- Lack of previous research studies on this topic.

Assumptions

Assumptions of this study include:

- All participants answered the survey truthfully and completely.
- The survey was administered properly, and participants did not encounter technical difficulties.
- The standardization of methods and measures for researchers was thoroughly discussed prior to the start of the study. The validity of the survey is intended to measure what it is claiming to measure, in this study, the side effects of prolonged usage of the N95 respirator mask amongst junior and senior dental hygiene students at Old Dominion University and their comfort perception.
CHAPTER II

REVIEW OF LITERATURE

To present a foundational review for this study, the most current evidence-based literature is included and relates to the side effects of prolonged usage of the N95 respirator mask and comfort perceptions in healthcare workers.

Respiratory Protection Prior to and During the COVID-19 Pandemic

Prior to the COVID-19 pandemic, healthcare workers wore various levels of surgical masks.\textsuperscript{11} Surgical masks are tested and approved by the U.S. Food and Drug Administration.\textsuperscript{11} Surgical masks are fluid-resistant and provide the wearer protection against large droplets, splashes, or sprays of bodily or other hazardous fluids and patient’s respiratory emissions.\textsuperscript{11} In addition, surgical masks are for single use (one mask per patient), not seal checked, and are more loose fitting than an N95 respirator mask (RM).\textsuperscript{11} From the beginning of the COVID-19 pandemic, dental hygiene students and other healthcare workers have mandatorily worn advanced respirator protection. Advanced respirator protection such as the N95 respirator mask was implemented to maintain proper infection control and decrease the spread of SARS-CoV-2.\textsuperscript{35} Due to the shortage of PPE, N95 respirator masks were often worn for a prolonged amount of time.\textsuperscript{35}

Characteristics of the N95 Respirator Mask

The N95 respirator mask is FDA approved by The National Institute for Occupational Safety and Health of the United States (NIOSH) and indicates the filtering efficiency of particles.\textsuperscript{24} An N95 respirator mask is 95% effective at filtering large and small airborne particles.\textsuperscript{29} N95 respirator masks are rated by an alphabetical number, such as “N-not resistant to oil, R-somewhat resistant to oil, and P-strongly resistant to oil (oil-proof). Levels of filter
efficiencies 95% (N95), 99% (N99), and 99.97% (N100 or HEPA filter) tested against aerosol (fine mist) droplets 0.3 mm in diameter”.

N95 respirator masks are effective when used correctly and fitted tightly to the wearer’s face. Individuals must consult with their primary physician prior to wearing an N95 respirator mask, as the respirator can make it more difficult for the wearer to breathe and there may be health contraindications to wearing it. Hours of usage, type of respirator, and frequency of use should ultimately be determined by the wearer and wearer’s physician. One’s level of respiratory protection when wearing an N95 respirator mask relies on proper fit-testing and appropriate care of the respirator. The CDC emphasizes the only way to prevent transmission of microorganisms like the SARS-CoV-2 virus is through a combination of interventions from across the hierarchy of controls, not just PPE alone.

**Physiological Symptoms Associated with N95 Respirator Masks in Healthcare**

Several studies have reported physiological effects and symptoms associated with N95 respirator masks in healthcare workers and when worn for prolonged periods of time. Garra et al conducted a nonrandomized cohort study, amongst hospital-based healthcare workers who wore a surgical mask and/or an N95 respirator mask during a routine clinical activity. The goal of the study was to distinguish and compare the physiological symptoms of surgical masks and N95 respirator masks when worn for two or more consecutive hours. The study participants were comprised of 72 surgical mask wearers and 72 N95 respirator masks wearers. Researchers found that 77% of participants reported experiencing physiological symptoms when wearing either a surgical mask or an N95 respirator mask. Forty-four percent of participants (n=32) reported experiencing frequent new headaches while wearing a surgical
mask, while a higher percentage 56% (n=40) of participants experienced frequent new headaches while wearing an N95 respirator mask.\textsuperscript{34}

Garra et al research findings were consistent with the findings by Ong et al. (2020), which reported that 81% of healthcare workers reported new headaches when wearing a N95 respirator masks during the SARS-CoV-2 (COVID-19) pandemic.\textsuperscript{34,43} Lightheadedness was reported in 36% (n=26) of surgical mask wearers and 47% (n=34) of N95 respirator mask wearers.\textsuperscript{34} Shortness of breath was reported in 40% (n=29) of participants wearing a surgical mask and 54% (n=39) of participants wearing an N95 respirator mask.\textsuperscript{34} Regarding dermatologic symptoms, facial irritation was reported in both groups, 56% (n=40) amongst participants wearing a surgical mask and 75% (n=54) among participants wearing an N95 respirator mask.\textsuperscript{34} Facial bruising was reported in 29% (n=21) of surgical mask wearers and 53% (n=38) of N95 respirator mask wearers.\textsuperscript{34} Also, physical fatigue was reported in 36% (n=26) wearing a surgical mask and 56% (n=40) wearing an N95 respirator mask.\textsuperscript{34} Garra et al concluded that surgical masks and N95 respirator masks are both difficult to tolerate for a prolonged period of time.\textsuperscript{34} Results revealed that N95 respirator mask wearers experienced more physiological symptoms than participants wearing a surgical mask.\textsuperscript{34} Thus, frequent breaks to doff (take off) masks are necessary throughout a clinical shift, to ensure the health and safety of healthcare workers.\textsuperscript{34}

A study conducted by Lim et al surveyed healthcare workers during the 2003 respiratory severe acute distress syndrome epidemic.\textsuperscript{18} During the epidemic, healthcare workers mandatorily wore N95 respirator masks in high-risk areas of the hospital and for a prolonged period; defined as exceeding 4 hours.\textsuperscript{18} In this survey study, healthcare workers were gathered from intensive care units, emergency rooms, isolation wards, general medical wards, and operating rooms.\textsuperscript{18} A total of 212 healthcare workers consented and completed a self-administered questionnaire that
asked about their demographics, pre-existing health conditions (headaches and migraines), and new side effects of prolonged mask usage. The goal of the study was to determine the prevalence of headaches from prolonged use of the N95 respirator mask amongst healthcare workers.

Out of the participants, 79 reported experiencing headaches when wearing the N95 respirator mask. Of the 79 participants, 37.3% reported having pre-existing headaches and 62.7% reported experiencing new headaches. Following, 32.9% experienced more than 6 headaches in a month, 7.6% had taken sick leave due to having a headache, and 59.5% experienced headaches that had to be managed with abortive analgesics (over the counter pain medication). Lim et al results attested to the phenomenon of wearers increased headaches possibly being linked to using the N95 respirator mask for prolonged periods of time.

Rosner conducted a cross-sectional study amongst 343 hospital workers who wore surgical masks and N95 respirator masks for 1-3 hours during the COVID-19 pandemic. The study aimed to investigate healthcare professionals reported adverse effects of prolonged use of surgical masks and N95 respirator masks. Out of the 343 participants, 59.2% (n = 203) were N95 respirator mask wearers and 40.8% were surgical mask wearers. Reported adverse effects among both groups included headache, acne, skin breakdown, and impaired cognition. Results revealed that 91.5% of participants reported experiencing one or more adverse effects. The greatest adverse effect was headache reported by 71.4% of participants. However, 15.2% of participants stated their headaches occurred within 1 hour of wearing the mask, 30.6% after 1 hour of wearing the mask, and 29.7% after 3 hours or more of wearing the mask.

Repetitive surgical mask and N95 respirator mask use can have a negative impact on the integrity of the skin. Repetitive wear can cause shearing and breakdown of the wearers skin.
Dermatological findings of the study included that within 1-3 hours of mask usage (18.1 percent, n=62) of participants reported skin breakdown and after 3 or more hours of mask usage (44 percent, n=151) of participants reported skin breakdown. Participants reported the most common affected areas were the bridge of the nose (42.9 percent, n=147) and cheek bones (28.6 percent, n=98). Additional affected areas included skin breakdown of the chin (14.3 percent, n=49) and skin breakdown behind the ears (32.1 percent, n=110). A history of acne was reported in (35.3 percent, n=121) of participants. Participants reported acne within 1-3 hours of wearing a mask (11.1 percent, n=38) and after 3 hours (47.8 percent, n=164). Overall, most participants reported acne as an adverse effect (53.1 percent, n=182).

Components of N95 respirator masks have been found to cause dermatological changes. Contact dermatitis and urticaria (hives) are common adverse dermatological symptoms reported by N95 respirator mask wearers. The N95 respirator mask material contains the harsh chemical formaldehyde. Many individuals are extremely sensitive and are allergic to formaldehyde.

Additionally, Clawson and Pariser’s study specifically focused on the formaldehyde chemical in N95 respirator masks. Formaldehyde is an identified mucous membrane and skin irritant, which is known to cause facial dermatitis, other adverse skin reactions, and in severe cases an immediate anaphylactic reaction. Also, the inhalation of formaldehyde has been linked to asthma. Clawson and Pariser’s study found an increase in facial inflammatory dermatoses, facial acne, allergic contact dermatitis, and irritant contact dermatitis amongst healthcare workers who wore a N95 respirator mask 6 or more hours a day.

The study conducted by Ipek et al surveyed 34 healthcare professionals who wore an N95 respirator mask or surgical mask for 1-4 consecutive hours while providing patient care in non-
COVID wards. Results revealed a significant difference \( (P=0.001) \) in N95 respirator mask use and increased physiological symptoms reported such as headaches, respiratory distress, dizziness, and fatigue. Headache was reported in 59% of N95 respirator mask wearers and 15% of surgical mask wearers. Respiratory distress was reported in 80% of N95 respirator mask wearers and 24% of surgical mask wearers. Dizziness was observed in 47% of N95 respirator mask wearers and 6% of surgical mask wearers and fatigue was reported in 62% of N95 respirator mask wearers and 15% of surgical mask wearers. N95 respirator mask wearers reported they experienced a greater amount of difficulty concentrating and attention deficit versus those who wore a surgical mask. Difficulty concentrating was observed in 62% of N95 respirator mask wearers and in 18% of surgical mask wearers. Attention deficit was reported in 50% of N95 respirator mask wearers and in 15% of surgical mask wearers. Ipek et al concluded that mask-free rest times should be created and implemented in intervals to ensure healthcare providers safety, comfort, and decrease of physiological symptoms.

Kisielinski et al conducted a systematic review of 2,168 studies on adverse medical mask effects (surgical mask and N95 respirator mask). Researchers found a significant number of adverse effects associated with both surgical masks and N95 respirator masks. Headaches were prevalent amongst 62% of surgical mask wearers and 75% of N95 respirator mask wearers. Facial irritation, such as itching was reported in 26% of surgical mask wearers and 51% of N95 respirator mask wearers respectively. In the review, the N95 respirator mask produced a greater number of adverse effects. The review revealed the N95 respirator mask decreased blood oxygenation. Surgical masks are larger and more loosely fitted when compared to N95 respirator masks, which are more restrictive and tightly fitted to the wearers face. As a result of the tightly fitted seal, wearers of the N95 respirator mask may have restricted oxygen intake or
compromised breathing. Hypoxemia (low levels of oxygen in the blood) can cause detrimental health effects, such as increased heart rate and systolic blood pressure.

Roberge et al conducted a human study, which gathered baseline data on the physiological impact of N95 respirator mask usage amongst healthcare workers. Ten healthcare workers were recruited and assessed. Participants wore an N95 respirator mask while walking on a treadmill for one hour. All participants had adequate experience of wearing an N95 respirator mask and were deemed healthy. The incorporation of a treadmill was used to simulate the normal amount of physical activity (such as walking) that occurs daily in participants work environment. Participants heart rate, respiratory rate, and blood oxygen levels and saturation were monitored by researchers. Researchers found that healthcare workers that wore an N95 respirator mask for 1 hour, during low exertion activity, experienced mild physiological effects. Participants heart rate and respiratory rate slightly increased but were not classified as out of the ordinary with the level of exercise. Blood oxygen levels and saturation were not significantly impacted. Roberge et al concluded that further research is necessary to evaluate the physiological impact of the N95 respirator masks and to address the possibility of CO2 retention amongst individuals with underlying health conditions.

Manerkar et al conducted a repeated measure observational study that aimed to assess oxygen saturation amongst participants that wore N95 respirator mask and 3 ply surgical masks. Also, Manerkar et al aimed to determine the presence of subjective discomfort amongst participants such as headaches, giddiness, and mental confusion. Study participants were comprised of 60 frontline dental healthcare workers (DHCWs) that wore N95 respirator masks (Group A) and 60 DHCWs that worked in a non-clinical setting and wore surgical masks (Group B). To factor out the effect of dehydration, all participants were permitted to drink water after
60 minutes. Participants completed a self-administered questionnaire, which was comprised of demographic variables and existing health conditions (cardiac, respiratory). Participants oxygen saturation and pulse rate was monitored at baseline, at 60 minutes, and at 120 minutes by using pulse oximetry. Oxygen saturation was compared between the two groups and statistically significant at $P<0.05$.

Results of the study revealed a significant drop in oxygen saturation amongst N95 respirator mask wearers after one hour, and further dropped by hour two. The mean oxygen saturation at baseline reported was 98.3 ± 0.97 and 98.29 ± 1.36 in Group A and Group B, respectively. The oxygen saturation dropped to 96.13 ± 2.84 after 60 minutes and to 97.61 ± 1.99 after 120 minutes in Group A, which was statistically significant. Group B did not exhibit a similar pattern, with reported oxygen levels of 98.14 ± 1.16 and 98.17 ± 1.04 at the two-time intervals. Overall, oxygen saturation drop was statistically significant between the two groups.

The most common physiological symptom reported amongst participants was headache (64.8%). Also, participants reported fatigue (20.3%), giddiness (5.4%), and confusion (4%). N95 respirator mask wearers in Group A were 6.8 times more inclined to experience headaches than surgical mask wearers in Group B. Subjects with pre-existing headache disorders were 1.9 more likely to develop headache after wearing an N95 respirator mask. The odds of experiencing headache were 7.9 times more after 120 minutes of donning the mask as compared to 60 minutes. Overall, findings by Manerkar et al concluded that prolonged use of N95 respirator masks contributed to the increased reported physiological symptoms of participants. Manerkar et al suggested further research must be conducted to address the reported increased physiological symptoms in DHCWs that wore N95 respirator masks.
Wearing a N95 respirator mask for prolonged periods of time have been associated with discomfort and level of exertion for wearers, which is still not well understood.\textsuperscript{47} Comfort is an important factor of wearer compliance when wearing N95 respirator mask.\textsuperscript{46} Nwosu et al conducted a cross-sectional study that evaluated the impact of wearing surgical masks and N95 respirator masks, over various periods of time.\textsuperscript{48} The study aimed to assess the comfort level and arterial oxygen saturation of healthcare workers.\textsuperscript{48} A total of 76 healthcare workers participated in the study engaged in clinical duties while wearing both types of masks for periods between 68-480 minutes participated in the study.\textsuperscript{48} Participants consisted of anesthetists, surgeons, perioperative nurses, anesthetic nurses, and operating department assistants (ODAs).\textsuperscript{48} Subjective self-assessment of discomfort was scored by a 11-point numerical scale from 0 (no discomfort) to 10 (worst discomfort imaginable).\textsuperscript{48} Participants perceived elements of discomfort were also assessed via free response.\textsuperscript{48} Clinical data collected by researchers was the type of mask, duration of mask usage, level of mask discomfort and SpO\textsubscript{2} (before and after mask usage).\textsuperscript{48} The level of statistical significance was determined by the p-value of $<0.05$.\textsuperscript{48} Results revealed the perceived discomfort participants experienced the use of the N95 respirator mask, was significantly greater than the surgical mask ($4.3\pm 2.0$ vs. $2.7\pm 1.8$ SD, $P<0.001$).\textsuperscript{48}

In Locatelli et al, healthcare providers reported that the N95 respirator masks tight fitting seal, thick material, and restrictive straps contributed to non-compliance.\textsuperscript{35} Manerkar et al uttered that efforts must be taken to address the level of discomfort associated with wearing an N95 respirator mask.\textsuperscript{33} Further research should be conducted on the physics and engineering of the N95 respirator mask.\textsuperscript{33} Redesign of the N95 respirator mask will lead to increased comfort and wearer compliance.\textsuperscript{33}
Choudhury et al and Bhattacharya support that prolonged N95 respirator mask wearers have reported experiencing an increase in bad breath, severe dry mouth, and tooth decay (cavities).\textsuperscript{31,49} The oral problems have been termed collectively as “Mask Mouth Syndrome”.\textsuperscript{49} Mask mouth is often triggered by mouth breathing and wearing a mask for prolonged periods of time.\textsuperscript{49} Mouth breathing causes the oral cavity to dry out and increases the risk of wearers developing tooth decay, gum disease, enamel erosion, tooth stain, or fungal infections.\textsuperscript{49}

Summary

To reiterate, healthcare providers have experienced an array of physical and psychological symptoms, as a result of wearing an N95 respirator mask for prolong periods of time, in excess of 2 or more hours consecutively.\textsuperscript{19} When compared to surgical masks, N95 respirators are more difficult to tolerate, are restrictive and uncomfortable. To the researcher’s observation, the available literature on this topic in the United States is only regarding medical professionals that work in hospitals. There is no research on this topic among dental professionals in the United States. Thus, further research on this topic within the dental field is essential to ensure the health, safety, and comfort of dental professionals.
CHAPTER III

METHODOLOGY

The current modified descriptive survey was adapted and adopted from Rosner’s 2020 survey titled “Adverse Effects of Prolonged Mask Use among Healthcare Professionals During COVID-19,” which was given amongst nursing professionals. In the current study, a convivence sample of dental hygiene students was utilized, as in Rosner’s and in Lim et al. All junior and senior dental hygiene students were invited to participate in the research study. The survey consisted of a total of 16 questions regarding demographics, physiological symptoms reported with prolonged use of the N95 respirator masks (3-4 hours per clinic session and per week), and comfort perception. An open-ended question was also included to inquire about any other symptoms experienced that were not listed in the survey. All survey responses were collected anonymously. This study received exempt status by Old Dominion University’s College of Health Sciences Institutional Review Board (IRB#1987754-2) (Appendix A).

Data Collection Tool

The survey was deployed using the 2022 version of Qualtrics® software (Qualtrics eXperience Management, (XM)). Survey questions were originally created and specifically tailored toward dental hygiene students. Participants answered demographic questions such as race, ethnicity, age, and current class standing. Also, N95 respirator mask frequency and time usage was assessed. Participants were asked the total hours per week they wore a N95 respirator mask while providing care. Participants recorded how many total consecutive hours per clinic session they spent wearing an N95 respirator mask. Physiological symptoms were assessed and recorded using a 3-point Likert scale of Never-0, Sometimes-3, and Always-5.
Participants were questioned if they had experienced any of the following respiratory symptoms when wearing an N95 respirator mask while providing clinical care such as asthma, shortness of breath, nasal congestion, wet or dry cough, tachypnea (abnormal rapid breathing), shallow breathing, sore throat, runny nose, postnasal drip, nosebleed, hypoxia, and other symptoms not listed in this section of the survey. Participants were also asked if they had experienced any of the following mask mouth symptoms when wearing an N95 respirator mask while providing clinical care such as dry mouth, dry lips, increased plaque retention (generalized or localized), increased calculus formation (on facials of anterior teeth), bad breath, bleeding gums, and other symptoms not listed in this section of the survey.

Following, participants were asked to record if they had experienced any of the following dermatologic symptoms when wearing an N95 respirator mask while providing clinical care such as acne, contact dermatitis, facial redness, facial bruising, facial indentations, facial irritation, hives, itchiness, dry skin, nasal bridge scarring, and other symptoms not listed in this section of the survey. Participants were asked if they had experienced any of the following cardiac symptoms when wearing an N95 respirator mask while providing clinical care such as: tachycardia (rapid heartbeat), arrhythmia (irregular heart rhythm), angina (chest pain), and other symptoms not listed in this section of the survey. Additionally, participants recorded if they had experienced any of the following general symptoms when wearing an N95 respirator mask while providing clinical care such as physical fatigue, headache, myalgia (muscle aches and pain), anxiety, trouble focusing, decreased work efficacy, ear pain, jaw pain, sweating, dizziness, equilibrium issues, lightheadedness, dehydration, nausea, dry eye, yawning, and other symptoms not listed in this section of the survey (Appendix C).
**Comfort Perception**

In the survey, participants were asked how they would rate the N95 respirator masks level of comfort. An ANOVA test was used to individually compare data between junior and senior dental hygiene students. Anderson’s 9-point Modified Comfort Perception Scale was used to collectively obtain wearer comfort and included the following ranges: extremely uncomfortable (1), very uncomfortable (2), uncomfortable (3), slightly uncomfortable (4), neutral (5), slightly comfortable (6), comfortable (7), very comfortable (8), and extremely comfortable (9).50.

**Participants**

Informed consent was required, and only participants who voluntarily consented were able to complete the survey. Participants had the opportunity to withdraw from the survey at any point in time. In the survey, settings were applied that restricted participants to go back to previous questions. Thus, the survey could only be taken once and had to be completed in one sitting. The inclusion criteria for the study participants were junior and senior dental hygiene students at Old Dominion University enrolled in the School of Dental Hygiene (SODH) and were 18 years or older. The exclusionary criteria included junior and senior students not enrolled in Old Dominion University’s School of Dental Hygiene and those under the age of 18.

**Statistical Analysis**

The dependent variables described previously and determined from individual surveys were analyzed using fixed-effect measures under the paired t-test design technique. Physiological symptoms were used as response variables across a 3-point Likert scale approach to achieve a better understanding of the side effects of the N95 respirator mask between junior and senior dental hygiene students. An ANOVA test was used to analyze N95 respirator mask comfort
perception between junior and senior students. All analyses were performed using statistical software SAS® 9.4 statistical software (SAS Institute, Inc.), with the risk of Type I error set at 0.05 or lower.

**Sample Size Justification and Power Calculations**

In this study, a convivence sample of junior and senior dental hygiene students was used. The sample size in the current study (n=54) was larger than Roberge et al (n=10), yet smaller than Lim et al (n=212) and Rosner (n=343).\(^{18,26,46}\) Due to a large number of potential variables, statistical tests were performed to find the variables that were the most influential. The benefits of this study provide new research regarding the reported physiological symptoms and comfort perception associated with prolonged, continuous usage of the N95 respirator mask among dental hygiene students. In addition, this study will aid in future research that investigates reported symptoms associated with prolonged, continuous usage of the N95 respirator mask among dental hygiene practitioners. These variables became the primary endpoints for our analyses. Each variable was used to estimate the sample size needed (n=54), maintaining at least a 95% statistical power at a 5% level of significance.

**Statistical Models**

The independent variables collected in this study were the participants race/ethnicity, age, current class standing, total hours per week spent wearing a N95 respirator mask, and total consecutive hours per clinic session wearing a N95 respirator mask. The dependent variables recorded in this study were participants reported respiratory symptoms, mask mouth symptoms, dermatologic symptoms, cardiac symptoms, general symptoms, and comfort perception. For this study, a parametric, paired t-test was utilized for statistical analysis. Primary analyses involved the use of fixed effects to measure the significant difference between junior and senior dental
hygiene students and the reported physiological symptoms and comfort perception while wearing a N95 respirator mask for a prolonged period of time.

Data Analysis

Descriptive statistics such as means, standard deviations, counts, percentages, and p-values were based on the level of measurement for each variable. The normality of data sets was thoroughly analyzed, and transformations were applied to normalize the outcome variables when deemed necessary. Since some variables are discrete, all quantitative data were analyzed by the SAS® 9.4 statistical software (SAS Institute, Inc.). With the risk of Type I error set at 0.05 or lower. Collected demographic information, reported mask use (total hour per week and total consecutive hours), reported breaks between clinic sessions and mask wearing, and perceived comfort perception levels were represented as numbers and percentages. Categories of physiological symptoms are reported as mean ± standard deviation (SD). A p-value less than 0.05 ($P<0.05$), is considered statistically significant.

The survey results exhibit a high statistical significance between the dependent and independent variables. Finally, a 95% confidence interval for reported physiological symptoms was built using means and standard deviations. A statistician computed, examined, and reviewed the final data tables and charts to authenticate and provide dependability.
CHAPTER IV

RESULTS

A total of 57 junior and senior dental hygiene students were invited to participate in the research study. One participant was omitted due to not consenting, and two were omitted due to non-completion and non-response. In the study 54 participants were retained and generated a completion rate of 100%. The sample included 30 junior students (55.5%) and 24 senior students (44.4%). Junior participants identified as Black or African American 10.00% (n=3), White/Caucasian 53.3% (n=16), Asian 20.0% (n=6), and Hispanic or Latino 16.67% (n=5). Senior participants identified as Black or African American 12.5% (n=3), White/Caucasian 66.7% (n=16), Asian 4.1% (n=1), and Hispanic or Latino 16.6% (n=4). The average age of junior student participants included 90.0% between the age range of 18-30 and 10.0% in the age range of 31-40 years old. Similarly, 91.6% senior dental hygiene students were between the ages of 18-30 and 4.17% (n=1) were between the ages of 31-40 (Table I).

Reported N95 Respirator Mask Continuous Use

All junior participants 100% (n=30) reported wearing a N95 respirator mask for 3-4 total consecutive hours per clinic session and 100% (n=30) for a total of 6-8 hours per week. The majority of seniors, 79.1% (n=19), reported wearing a N95 respirator mask for 3-4 total consecutive hours per clinic session. A smaller percentage of senior dental hygiene students reported wearing a N95 respirator mask for 5-6 consecutive hours; 8.3% (n=2) of seniors reported wearing an N95 respirator mask for 5-6 consecutive hours; 8.3% (n=2) of seniors reported 7-8 consecutive hours per clinic session, and 4.2% of (n=1) seniors reported wearing an N95 respirator mask for more than 9 consecutive hours per clinic session. Regarding total hours per week wearing an N95 respirator mask while rendering patient care, 8.3% (n=2) of seniors
reported 6-8 hours, 33.3% (n=8) of seniors reported they wore the N95 respirator mask for 9-11 hours, and 58.3% of (n=14) seniors reported wearing for more than 12 hours a week (Table I).

Table I. Demographics and Clinical Hours Reported by Dental Hygiene Students.

<table>
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<tr>
<th>Demographics</th>
<th>Junior Students</th>
<th>Senior Students</th>
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<tr>
<td>Student Class Standing</td>
<td>n=30</td>
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<td>Total hours per week wearing an N95 respirator</td>
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Physiological Symptoms

A validated three-point Likert scale ranging from never (0), to sometimes (3), to always (5), was used to assess the occurrence and frequency of various physiological symptoms associated with prolonged N95 respirator usage. In total, higher means and standard deviations
were observed in senior dental hygiene students when compared to junior dental hygiene students when reporting symptoms and these differences were significant. Higher means and standard deviations among senior students can be attributed to spending more than four consecutive hours wearing an N95 respirator mask per clinic session and total hours per week versus junior students.

**Respiratory Symptoms**

Two respiratory symptoms were found to be statistically significant among junior and senior dental hygiene students. Sore throat was found statistically significant between the two groups and reported as \((0.00 \pm 0.00 \text{ vs. } 0.87 \pm 1.39, P<0.0011)\). Hypoxia was found statistically significant between the two groups and reported as \((0.56 \pm 1.33 \text{ vs. } 0.00 \pm 0.00, P<0.0476)\).

Asthma, shortness of breath, nasal congestion, wet or dry cough, tachypnea (abnormal rapid breathing), shallow breathing (slow breathing), runny nose, postnasal drip, and nose bleeds were not found to be statistically significant between the two groups. Junior and senior students did not report experiencing other respiratory symptoms. The mean and standard deviation in the majority of respiratory categories were higher in senior dental hygiene students when compared to junior dental hygiene students. Higher means and standard deviations amongst senior dental hygiene students can be attributed to more consecutive hours and total hours per week spent wearing an N95 respirator mask (Table II).
Table II. Reported Respiratory Symptoms.

<table>
<thead>
<tr>
<th>Respiratory</th>
<th>Junior Students (n=30)</th>
<th>Senior Students (n=24)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Asthma</td>
<td>0.10</td>
<td>0.54</td>
<td>0.12</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>2.16</td>
<td>1.80</td>
<td>2.0</td>
</tr>
<tr>
<td>Nasal Congestion</td>
<td>1.93</td>
<td>1.96</td>
<td>1.58</td>
</tr>
<tr>
<td>Wet or dry cough</td>
<td>0.16</td>
<td>0.91</td>
<td>0.70</td>
</tr>
<tr>
<td>Tachypnea (abnormal rapid breathing)</td>
<td>0.60</td>
<td>1.22</td>
<td>0.33</td>
</tr>
<tr>
<td>Shallow breathing</td>
<td>1.56</td>
<td>1.92</td>
<td>1.91</td>
</tr>
<tr>
<td>Sore throat</td>
<td>0.00</td>
<td>0.00</td>
<td>0.87</td>
</tr>
<tr>
<td>Runny nose</td>
<td>2.06</td>
<td>2.09</td>
<td>2.12</td>
</tr>
<tr>
<td>Postnasal drip</td>
<td>0.73</td>
<td>1.55</td>
<td>1.16</td>
</tr>
<tr>
<td>Nose bleeds</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Hypoxia (lack of oxygen)</td>
<td>0.56</td>
<td>1.33</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Mask Mouth Symptoms

Two mask mouth symptoms were found to be statistically significant among junior and senior dental hygiene students. An increase in plaque retention (generalized or localized) was found statistically significant between the two groups and reported as (0.1 ± 0.54 vs. 1.16 ± 1.76, $P<0.0028$). Bad breath was also found to be statistically significant between the two groups and reported as (1.26 ± 1.61 vs. 2.70 ± 1.96, $P<0.0047$). Dry mouth, dry lips, increase in calculus formation on the facial of anterior teeth, and bleeding gums were not found to be statistically significant between the two groups. Junior and senior students did not report experiencing other mask mouth symptoms. The mean and standard deviation in all mask mouth categories were higher in senior dental hygiene students when compared to junior dental hygiene students. Higher means and standard deviations amongst senior dental hygiene students can be attributed
to more consecutive hours and total hours per week spent wearing an N95 respirator mask (Table III).

Table III. Reported Mask Mouth Symptoms.

<table>
<thead>
<tr>
<th>Mask Mouth</th>
<th>Junior Students (n=30)</th>
<th>Senior Students (n=24)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean  SD</td>
<td>Mean  SD</td>
<td></td>
</tr>
<tr>
<td>Dry Mouth</td>
<td>1.83  1.98</td>
<td>2.41  2.22</td>
<td>0.3138</td>
</tr>
<tr>
<td>Dry Lips</td>
<td>2.36  1.99</td>
<td>3.41  1.81</td>
<td>0.0506</td>
</tr>
<tr>
<td>Increase Plaque Accumulation</td>
<td>0.1    0.54</td>
<td>1.16  1.76</td>
<td>0.0028</td>
</tr>
<tr>
<td>Increase Calculus Accumulation</td>
<td>0.1    0.54</td>
<td>0.45  1.28</td>
<td>0.1731</td>
</tr>
<tr>
<td>Bad Breath</td>
<td>1.26  1.61</td>
<td>2.70  1.96</td>
<td>0.0047</td>
</tr>
<tr>
<td>Bleeding Gums</td>
<td>0.1    0.54</td>
<td>0.20  1.02</td>
<td>0.6198</td>
</tr>
</tbody>
</table>

Dermatologic Symptoms

Three dermatologic symptoms were found to be statistically significant among junior and senior dental hygiene students. Facial bruising was found statically significant between the two groups and reported as (0.56 ± 1.33 vs 2.5 ± 2.28, P<0.003). Facial indentations were found statistically significant between the two groups and reported as (3.33 ± 2.17 vs 4.58 ± 0.82, P<0.0102). Facial irritation was found statistically significant between the two groups and reported as (3.03 ± 1.92 vs 3.95 ± 1.30, P<0.0490). Acne, contact dermatitis, facial redness, hives, itchiness, dry skin, and nasal bridge scarring were not found to be statistically significant between the two groups. Junior and senior students did not report experiencing other dermatologic symptoms. The mean and standard deviation in all dermatologic categories were
higher in senior dental hygiene students when compared to junior dental hygiene students.

Higher means and standard deviations among senior dental hygiene students can be attributed to more consecutive hours and total hours per week spent wearing an N95 respirator mask (Table IV).

**Table IV.** Reported Dermatologic Symptoms.

<table>
<thead>
<tr>
<th>Dermatologic</th>
<th>Junior Students (n=30)</th>
<th>Senior Students (n=24)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Acne</td>
<td>2.8</td>
<td>1.62</td>
<td>3.70</td>
</tr>
<tr>
<td>Contact dermatitis</td>
<td>0.63</td>
<td>1.49</td>
<td>1.5</td>
</tr>
<tr>
<td>Facial redness</td>
<td>3.43</td>
<td>1.5</td>
<td>4.08</td>
</tr>
<tr>
<td>Facial bruising</td>
<td>0.56</td>
<td>1.33</td>
<td>2.5</td>
</tr>
<tr>
<td>Facial indentations</td>
<td>3.33</td>
<td>2.17</td>
<td>4.58</td>
</tr>
<tr>
<td>Facial irritation</td>
<td>3.03</td>
<td>1.92</td>
<td>3.95</td>
</tr>
<tr>
<td>Hives</td>
<td>0.16</td>
<td>0.91</td>
<td>0.45</td>
</tr>
<tr>
<td>Itchiness</td>
<td>2.53</td>
<td>1.99</td>
<td>3.04</td>
</tr>
<tr>
<td>Dry skin</td>
<td>2.1</td>
<td>2.00</td>
<td>2.54</td>
</tr>
<tr>
<td>Nasal bridge scarring</td>
<td>1.23</td>
<td>1.99</td>
<td>2.25</td>
</tr>
</tbody>
</table>

**Cardiac Symptoms**

No cardiac symptoms were found to be statistically significant amongst junior and senior dental hygiene students. Tachycardia (rapid heartbeat), arrhythmia (irregular heart rhythm), and angina (chest pain) were not found to be statistically significant between the two groups. Junior and senior students did not report experiencing other cardiac symptoms. The mean and standard deviation in all cardiac categories were higher in senior dental hygiene students when compared to junior dental hygiene students. Higher means and standard deviations among senior dental
hygiene students can be attributed to more consecutive hours and total hours per week spent wearing an N95 respirator mask (Table V).

**Table V. Reported Cardiac Symptoms.**

<table>
<thead>
<tr>
<th>Cardiac</th>
<th>Junior Students (n=30)</th>
<th>Senior Students (n=24)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Tachycardia (rapid heartbeat)</td>
<td>0.30</td>
<td>0.91</td>
<td>0.45</td>
</tr>
<tr>
<td>Arrhythmia (irregular heart rhythm)</td>
<td>0.20</td>
<td>0.76</td>
<td>0.25</td>
</tr>
<tr>
<td>Angina (chest pain)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.20</td>
</tr>
</tbody>
</table>

**General Symptoms**

Eight general symptoms were found to be statistically significant among junior and senior dental hygiene students. Physical fatigue was found statistically significant between the two groups and reported as (1.16± 1.59 vs. 2.58 ± 2.04, P<0.0061). Headache was found statistically significant between the two groups and reported as (1.53± 1.73 vs. 2.95 ± 1.78, P<0.0046). Myalgia (muscle aches and pain) was found statistically significant between the two groups and reported as (0.00± 0.00 vs. 1.70 ± 2.01, P<0.0001). Anxiety was found statistically significant between the two groups and reported as (0.7± 1.29 vs. 2.25± 1.75, P<0.0005). Trouble focusing was found statistically significant between the two groups and reported as (1.16± 1.59 vs. 2.25 ± 1.75, P<0.0214). Jaw pain was found statistically significant between the two groups and reported as (0.00± 0.00 vs. 1.62 ± 1.90, P<0.0001). Dizziness was found statistically significant
between the two groups and reported as (0.93± 1.63 vs. 2.16 ± 1.65, \( P < 0.0086 \)). Lightheadedness was found statistically significant between the two groups and reported as (1.06± 1.57 vs. 2.12 ± 1.80, \( P < 0.0253 \)). Decreased work efficacy, ear pain, sweating, equilibrium issues, dehydration, nausea, dry eye, and yawning were not found to be statistically significant between the two groups. The mean and standard deviation in all general categories were higher in senior dental hygiene students when compared to junior dental hygiene students. Higher means and standard deviations amongst senior dental hygiene students can be attributed to more consecutive hours and total hours per week spent wearing an N95 respirator mask (Table VI).

<table>
<thead>
<tr>
<th>General</th>
<th>Junior Students (n=30)</th>
<th>Senior Students (n=24)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Physical Fatigue</td>
<td>1.16</td>
<td>1.59</td>
<td>2.58</td>
</tr>
<tr>
<td>Headaches</td>
<td>1.53</td>
<td>1.73</td>
<td>2.95</td>
</tr>
<tr>
<td>Myalgia (muscle aches and pains)</td>
<td>0.00</td>
<td>0.00</td>
<td>1.70</td>
</tr>
<tr>
<td>Anxiety</td>
<td>0.7</td>
<td>1.29</td>
<td>2.25</td>
</tr>
<tr>
<td>Trouble focusing</td>
<td>1.16</td>
<td>1.59</td>
<td>2.25</td>
</tr>
<tr>
<td>Decrease work efficacy</td>
<td>1.56</td>
<td>1.63</td>
<td>2.16</td>
</tr>
<tr>
<td>Ear pain</td>
<td>2.43</td>
<td>2.04</td>
<td>3.20</td>
</tr>
<tr>
<td>Jaw pain</td>
<td>0.00</td>
<td>0.00</td>
<td>1.62</td>
</tr>
<tr>
<td>Sweating</td>
<td>2.66</td>
<td>1.82</td>
<td>3.58</td>
</tr>
<tr>
<td>Dizziness</td>
<td>0.93</td>
<td>1.63</td>
<td>2.16</td>
</tr>
<tr>
<td>Equilibrium issues</td>
<td>0.00</td>
<td>0.00</td>
<td>0.20</td>
</tr>
<tr>
<td>Lightheadedness</td>
<td>1.06</td>
<td>1.57</td>
<td>2.12</td>
</tr>
<tr>
<td>Dehydration</td>
<td>1.9</td>
<td>2.05</td>
<td>2.83</td>
</tr>
<tr>
<td>Nausea</td>
<td>0.00</td>
<td>0.00</td>
<td>0.20</td>
</tr>
<tr>
<td>Dry eye</td>
<td>0.3</td>
<td>0.91</td>
<td>0.45</td>
</tr>
<tr>
<td>Yawning</td>
<td>1.4</td>
<td>1.83</td>
<td>2.04</td>
</tr>
</tbody>
</table>

Table VI. Reported General Symptoms.
The survey included one free response question that asked participants “Since wearing an N95 respirator mask while providing clinical care have you experienced any other side effect that was not mentioned?” Junior participants did not report experiencing any additional symptoms. Three senior participants individually reported: feeling hot and dizzy, clenching their teeth, and irritability.

**Dental Hygiene Students’ Perceived Comfort Levels**

N95 respirator mask comfort was assessed by Anderson’s 9-point Modified Perceived Comfort Scale. All junior dental hygiene students and senior dental hygiene students were evaluated collectively (Table VII, Figure 1). An ANOVA test revealed no statistically significant difference between junior and senior dental hygiene students perceived comfort level (Table VIII, Figure 2). However, results revealed that junior students were slightly more uncomfortable wearing an N95 respirator mask when compared to senior students (3.2± 1.44 vs. 3.00 ± 1.69, \( P>0.642 \)) (Table VIII). Most students (81.48%) reported that wearing an N95 respirator mask was uncomfortable. No student reported feeling comfortable when wearing an N95 respirator mask. In total, participants reported perceived comfort while wearing the N95 respirator mask as the following: extremely uncomfortable (19.0%), very uncomfortable (24.0%), uncomfortable (11.0%), slightly uncomfortable (28.0%), neutral (11.0%), and slightly comfortable (7.0%).
### Table VII. Reported Comfort Perception.

<table>
<thead>
<tr>
<th>Comfort Perception</th>
<th>Junior and Senior Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number (n=54)</td>
</tr>
<tr>
<td>Extremely uncomfortable</td>
<td>10</td>
</tr>
<tr>
<td>Very uncomfortable</td>
<td>13</td>
</tr>
<tr>
<td>Uncomfortable</td>
<td>6</td>
</tr>
<tr>
<td>Slightly uncomfortable</td>
<td>15</td>
</tr>
<tr>
<td>Neutral</td>
<td>6</td>
</tr>
<tr>
<td>Slightly comfortable</td>
<td>4</td>
</tr>
<tr>
<td>Comfortable</td>
<td>0</td>
</tr>
<tr>
<td>Very comfortable</td>
<td>0</td>
</tr>
<tr>
<td>Extremely comfortable</td>
<td>0</td>
</tr>
</tbody>
</table>

### Figure 1. N95 Reported Comfort Perception Amongst Dental Hygiene Students Pie Chart.
Table VIII. Comparison of the Average N95 Comfort Perceptions between Junior and Senior Dental Hygiene Students.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std</th>
<th>Mean</th>
<th>Std</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junior</td>
<td>3.2</td>
<td>1.448</td>
<td>Senior</td>
<td>3.0</td>
<td>1.694</td>
</tr>
</tbody>
</table>

Figure 2. Average N95 Comfort Perception between Junior and Senior Dental Hygiene Students Box Plot.
CHAPTER V
DISCUSSION

Since the start of the COVID-19 pandemic, healthcare providers have been mandated through policy and institutional recommendations to wear advanced respiratory protection to limit exposure and reduce transmission of SARS-CoV-2.\textsuperscript{18,19,23,25,26,27,32,34,43} Prior to the COVID-19 pandemic, medical and dental providers wore surgical masks while providing patient care.\textsuperscript{34} Healthcare providers have reported N95 respirator masks are more difficult to tolerate, restrictive, and are uncomfortable in comparison to surgical masks.\textsuperscript{18,19,26,28,34,43} Recent studies revealed a multitude of adverse psychological effects associated with prolonged N95 respirator mask usage.\textsuperscript{18,19,23,25,26,33,34,46} The various adverse effects reported with prolonged N95 respirator mask usage have been associated with both short and long term negative impacts on the health and well-being of wearers.\textsuperscript{18,19,25-27,30-35,43-49}

The present study results indicate an association between prolonged N95 respirator usage and an increase in negative physiological effects, and level of perceived comfort. There were statistically significant differences in most physiological symptom categories and level of perceived comfort among junior and senior dental hygiene students. The present study evaluates junior and senior dental hygiene students reported physiological symptoms associated with wearing an N95 respirator mask and comfort perception. Students engaged in wearing an N95 respirator mask for prolonged periods of time while providing clinical patient care at Old Dominion University’s School of Dental Hygiene Care Facility. The present study indicated that wearing advanced respiratory protection can impact physiological symptoms of wearers and can cause generalized discomfort.
Results revealed a statistically significant difference in various physiological symptom categories between both junior and senior dental hygiene students. Higher means and standard deviations among senior dental hygiene students can be attributed to longer hours spent wearing the N95 respirator mask, in turn, increasing the occurrence of adverse physiological and psychological effects and decreasing comfort.

**Dental Hygiene Students’ Demographics and Class Standing**

In this study, demographic variables such as race and age had no statistically significant impact between junior and senior dental hygiene students. However, participants class standing, total consecutive hours per clinic session wearing a N95 respirator mask, and total hours per week wearing a N95 respirator mask was found to be statistically significant between the two groups. The mean and standard deviation in the physiological categories were higher in senior dental hygiene students when compared to junior dental hygiene students. Higher means and standard deviations amongst senior dental hygiene students can be attributed to more consecutive hours and total hours per week spent wearing an N95 respirator mask. These finding are also similar to research conducted by Lim et al, Rosner et al, Garra et al, and Manerkar et al who found that increased wear equated to increased reported physiological symptoms.\(^{18,26,33,34}\)

Authors recommend that N95 respirator mask wearers should take frequent mask breaks to regulate oxygen flow and normal bodily function.\(^{18,19,26,27,30-35,43-49}\)

**Respiratory Symptoms**

Findings from the present study indicated sore throat and hypoxia (low blood oxygen levels) were respiratory symptoms reported by junior and senior dental hygiene students. Purushothaman et al study also found that 25% of N95 respirator mask participants experienced a sore throat.\(^{51}\) Participants attributed their sore throat to inadequate consumption of water or
other hydrating fluids during prolonged N95 respirator mask usage.\(^{51}\) Thus, N95 respirator mask wearers should take frequent sips of water when permitted and rehydrate during mask breaks.\(^{49,51}\) Previous literature has uttered that the dead space and material of a N95 respirator mask is the cause of increased CO2 levels.\(^{52}\) N95 respirator mask wearers experience hypoxia as a result of the increased CO2 levels.\(^{52}\) Manerkar et al highlighted that participants experienced a drop in oxygen saturation after wearing an N95 respirator for one hour and significant decreased after two hours.\(^{33}\) Overall, N95 respirator wearers must limit consecutive hours spent in the mask.\(^{46}\)

**Dermatologic Symptoms**

Dermatologic symptoms such as facial bruising and facial indentations were found to be statistically significant between junior and senior dental hygiene students. Garra et al found that facial bruising was reported in 53% of N95 respirator mask wearers.\(^{34}\) Rosner uttered that the use of tegaderm, tape, or a dressing while wearing an N95 respirator can reduce facial bruising and facial indentations.\(^{26}\)

Rosner noted that the N95 respirator mask has a negative impact on wearers skin barrier when worn repetitively and for prolonged periods of time.\(^{26}\) Rosner stated N95 respirator mask wearers should take preventative measures, such as apply facial moisturizers and apply barrier creams.\(^{26}\) These preventative measures will help prevent skin breakdown and make lines less visible.\(^{26}\) Yet, facial moistures and barrier creams should be used with caution and not to interfere with the N95 respirator mask seal.\(^{26}\) Overall, Lim et al noted that shorter duration of N95 respirator mask wear reduces the frequency and severity of facial bruising and indentations.\(^{18}\)
Cardiac Symptoms

No statistical significance was found in this study for cardiac symptoms, specifically, tachycardia (rapid heartbeat), arrhythmia (irregular heart rhythm), and angina (chest pain). This differs from the systematic review by Kisielinski et al which found that N95 respirator mask wearers reported increased heart rate and systolic blood pressure. Roberge et al concluded that differences exist between healthcare workers who may be more sedentary while providing clinical care. Age could also be a factor as participants in this study were primarily under the age of 30.

General Symptoms

Previous literature findings were consistent with the findings in this study. Garra et al results showed that physical fatigue was reported in 56% of participants wearing an N95 respirator mask. Rosner’s study revealed the greatest adverse effect reported among participants was headache. Manerkar et al results revealed that 20.3% of participants experienced fatigue, 5.4% of participants experienced giddiness, and 4.0% of participants experienced headaches when wearing an N95 respirator mask. Previous literature supports prolonged N95 respirator mask usage contributed to wearers perception of discomfort, over exertion, and physiological and psychological burdens.

Ipek et al study found that healthcare professional that wore a N95 respirator mask for 1-4 consecutive hours experienced increased physiological symptoms. Ipek et al results showed that dizziness was reported in 47% of N95 respirator mask wearers, headache in 59% of N95 respirator mask wearers, and difficulty concentrating in 62% of N95 respirator mask wearers. Garra et al study found that lightheadedness was reported by 47% of participants wearing an N95 respirator mask. Ipek et al recommended implementation of N95 respirator mask-free breaks.
Findings from this study and previous literature support that mask-free breaks will help ensure the safety of wearers and decrease adverse physical and psychological symptoms experienced when wearing an N95 respirator mask.\textsuperscript{19,26,28,33} In effort to decrease headache and impaired cognition, Rosner recommended alternating between a surgical mask and N95 respirator mask while providing care and increasing food and water intake prior to a shift.\textsuperscript{26} Further research should be conducted to assess the prevalence of myalgia, jaw pain, and anxiety among N95 respirator mask wearers. Overall, shorter duration of wearing an N95 respirator mask will aid in reduction of the frequency and severity of physiological adverse effects.\textsuperscript{19,26,28,33}

**Mask Mouth Symptoms**

In the present study, an increase in plaque retention (generalized or localized) and bad breath, which are mask mouth findings, were statistically significant between junior and senior dental hygiene students. Bhattacharya pointed out that N95 respirator mask wearers should take preventative measures and engage in proper mask etiquette to decrease mask mouth symptoms.\textsuperscript{49} Specifically, N95 respirator mask wearers should change out masks regularly (after 4 hours of use) and ensure to wear a clean mask.\textsuperscript{49} In addition, they found that the cause of bad breath in mask mouth patients was due to bacteria.\textsuperscript{49} Regular mask replacement has been shown to decrease bacterial growth and recirculation.\textsuperscript{53} By decreasing the bacterial load that circulates throughout an N95 respirator mask, wearers should experience a reduction of bad breath.\textsuperscript{49} Additionally, Bhattacharya recommended the use of salivary replacements to decrease xerostomia and plaque retention.\textsuperscript{49} Bhattacharya noted that N95 respirator mask wearers can use a chlorhexidine mouth wash at least once a day to decrease plaque retention.\textsuperscript{49} Overall, reduction of prolonged N95 respirator mask usage will decrease mask mouth symptoms.\textsuperscript{49} Lastly, in an effort to decrease mask mouth syndrome, Bhattacharya and Illinois Department of Public Health
recommended N95 respirator mask and surgical mask wearers to take frequent mask breaks and to reduce prolonged time spent in a mask.\textsuperscript{49,53}

**Dental Hygiene Students’ Comfort Perception**

In the present study, Anderson’s Modified Perceived Comfort Scale was utilized to assess N95 respirator mask comfort between junior and senior dental hygiene students.\textsuperscript{50} A valuable finding in this study was that no participants reported that the N95 respirator mask was comfortable, very comfortable, or extremely comfortable to wear. The majority of participants reported wearing an N95 respirator mask was uncomfortable. Results revealed junior students were slightly more uncomfortable while wearing the N95 respirator mask when compared to senior students. At the time the survey was deployed, junior students had only worn the N95 respirator mask for one semester. Thus, Junior students may have been merely adjusting to wearing an N95 respirator mask, which could be the sole factor of junior students reporting more uncomfortability. Senior students had worn an N95 respirator mask for three semesters and are more accustomed to wearing the mask. The findings in the present study are parallel to those found in research conducted by Roberge et al.\textsuperscript{46} Roberge et al examined N95 respirator mask wearer comfort by using Anderson’s Modified Perceived Comfort Scale.\textsuperscript{46,50} Results revealed that perceived comfort was low and had a negative impact on N95 respirator mask wearer compliance.\textsuperscript{46} Previous study findings correlate with the present study findings regarding the association between N95 respirator mask wearers and low perceived comfort.\textsuperscript{18,21,26,31} Rosner et al noted N95 respirator masks have been associated with mild to moderate discomfort after prolonged use by healthcare workers.\textsuperscript{26}

Lim et al uttered that N95 respirator mask comfort is low because of the restrictive straps that put pressure on the face, neck, head, ears, and various superficial nerves of wearers.\textsuperscript{18}
Comfort is a significant determinant of compliance and tolerability amongst N95 respirator mask wearers.\textsuperscript{18,33,46} This study results and previous literature supports that comfort must be considered in the design and material components of the N95 respirator mask.\textsuperscript{35,46} Redesigning of the N95 respirator mask material and elasticity of the straps could improve wearer comfort and extend tolerability.\textsuperscript{35} Overall, results of this study correlate with past literature in that the perceived comfort level reported by N95 respirator mask wearers is low.\textsuperscript{18,26,30,33,35,46,47,52} Further research must be conducted to address and resolve discomfort associated with the N95 respirator mask.

After analyzing the results of this survey, the use of N95 respirator masks during procedures that generate aerosols in combination with surgical masks worn during pre-procedure non-aerosol producing procedures could be considered to reduce physiological symptoms and improve comfort. The only previous research conducted on this topic, was within the medical profession (nurses, doctors, hospital staff).\textsuperscript{17} Regardless of the limitations, an equitable and high participation percentage was attained for the survey. Future research studies should aim to increase the sample size and utilize non-purposeful sampling by surveying dental hygiene students across the nation. Yet, further studies should be conducted to generate greater data on this topic and to ensure the health and safety of N95 respirator mask wearers. Additional studies in dental hygiene should aim to compare physiological symptoms and comfort level associated between surgical and N95 respirator masks.

**Limitations**

Although the results of this study contribute to the literature, various limitations exist. First, the use of convenience sampling resulted in a small sample size of dental hygiene students. Second, recall bias could exist as participation relied on self-selection and self-reported data. In
addition, social desirability could have occurred, and participants may have answered the survey questions in a manner that could be recognized as more favorable. Limited data collection on pre-existing health conditions among participants, could have impacted result findings. Measurements on pre and post vital signs of participant to confirm cardiac (blood pressure, pulse) and respirations could have confirmed reported physiological symptoms. Lastly, there was a lack of prior research studies within the dental field on this topic.

Despite these limitations, this study is the first to assess physiological symptoms and comfort perceptions among dental hygiene students. This survey was useful in identifying the impact of prolonged N95 respirator mask usage and ways to mitigate the effects through mask breaks, hydration, use of salivary substitute products, and alternating between surgical masks and N95 respirator masks. This validated modified survey could be used to understand or compare findings of practicing dental hygienists, dentists, and other allied dental professionals. Future research with a larger sample size, assessment of vital sign changes, and consideration of pre-existing conditions could provide more insight into physiological symptoms reported by healthcare professionals while wearing an N95 respirator mask for prolonged periods of time.
CHAPTER VI
CONCLUSION

Healthcare workers have experienced physiological symptoms and discomfort while wearing N95 respirator masks. As additional information on guidelines for respiratory protection evolve, new research assessing the impact of changes will assist in developing safe and effective measures to protect clinicians to include their physiological health. Dental hygiene participants in this study reported physiological symptoms and varying levels of discomfort while wearing an N95 respirator mask for over 3 hours of consecutive wear. These findings may prompt innovation in N95 respirator masks that both protect and minimize physiological symptoms and discomfort. New designs of the N95 respirator mask and use of biocompatible materials should be considered to increase wearer compliance and comfort. Results from this study contributed to the literature and provided new findings associated with prolonged usage of a N95 respirator masks among dental hygiene students.
REFERENCES


APPENDIX A

IRB APPROVAL LETTER

OFFICE OF THE VICE PRESIDENT FOR RESEARCH

Physical Address
4111 Monarch Way, Suite 203
Norfolk, Virginia 23508

Mailing Address
Office of Research
1 Old Dominion University
Norfolk, Virginia 23529
Phone: (757) 683-3460
Fax: (757) 683-5902

DATE: November 18, 2022

TO: Tara Newcomb, M.S.
FROM: Old Dominion University Health Sciences Human Subjects Review Committee

PROJECT TITLE: [1987754-2] Dental Hygiene Students Reported Physiological Symptoms Associated with Wearing a N95 Respirator Mask

REFERENCE #: Amendment/Modification

ACTION: DETERMINATION OF EXEMPT STATUS

DECISION DATE: 

REVIEW CATEGORY: Exemption category # 2

Thank you for your submission of Amendment/Modification materials for this project. The Old Dominion University Health Sciences Human Subjects Review Committee has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact Harry Zhang at (757)-683-6870 or qzhang@odu.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Old Dominion University Health Sciences Human Subjects Review Committee's records.
INVITATION LETTER TO DENTAL HYGIENE STUDENTS

Dear Junior and Senior Old Dominion University School of Dental Hygiene Students,

I am conducting a research study as part of my graduate degree requirements titled “Dental Hygiene Students Reported Physiological Symptoms Associated with Wearing a N95 Respirator Mask”. This is a letter of invitation for junior and senior students attending Old Dominion University’s School of Dental Hygiene Program to participate in this research study. The study will be conducted via an anonymous, electronic survey.

The purpose of this study is to evaluate reported side effects of prolonged use of an N95 respirator amongst dental hygiene students at Old Dominion University, School of Dental Hygiene. This study will provide new research regarding the reported physiological symptoms of prolonged, continuous usage of the N95 respirator amongst dental hygiene students.

By agreeing to participate in the study, you will be giving your consent for the researchers to include your anonymous survey responses in a group data analysis. Your participation in this research study is strictly voluntary, and you may choose not to participate without fear of penalty or any negative consequences. You will be able to withdraw from the survey at any time.

An informed consent agreement will appear on the first screen page of the survey. There will be no individually identifiable information, remarks, comments, or other identification of you as an individual participant. All results will be presented as aggregate, summary data. If you wish, you may request a copy of the results of this research study by writing to the researcher at tgarlow@odu.edu.

The survey will last no more than 15-20 minutes. Your participation will contribute to the current research literature on reported physiological symptoms of prolonged, continuous N95 respirator masks usage in clinical practice. No compensation will be offered for your participation.

If you decide to participate after reading this letter, you can access the survey from the link below:

survey link will be attached here after IRB exemption

If you have any questions, please contact me at pbutt001@odu.edu or my faculty advisor, Tara L Newcomb at tgarlow@odu.edu. This study has been reviewed and approved by the College of Health Science Institutional Review Board who can be reached at (757) 683-6870.

Thank you for your consideration,

Tara L. Newcomb BSDH, MS
Associate Professor
Chief Departmental Advisor
Q1 Voluntary Consent:

Taking part in this study is voluntary. This study should take participants about 15-20 minutes to complete. By selecting "Yes" below, you are stating that you understand the study and the information stated: furthermore, by checking the box below, you are voluntarily agreeing to participate in this research study. Please click one of the following:

○ Yes, I voluntarily agree to participate in this study. (1)
○ No, I do not wish to participate in this study. (2)

Q2 What is your race/ethnicity?

○ Black or African American (1)
○ White (2)
○ American Indian or Alaska Native (3)
○ Asian (4)
○ Native Hawaiian or Other Pacific Islander (5)
○ Hispanic or Latino (6)
○ Two or more races (7)
Q3 What is your age range?

- 18-30 (1)
- 31-40 (2)
- 41-50 (3)
- 51 or older (4)

Q4 What is your current class standing?

- Junior Dental Hygiene Student (1)
- Senior Dental Hygiene Student (2)

Q6 How many total hours per week do you wear an N95 respirator while rendering clinical care in the School of Dental Hygiene Care Facility?

- 6-8 hours (1)
- 9-11 hours (2)
- More than 12 hours a week (3)

Q7 How many total consecutive hours per clinic session do you wear an N95 respirator while rendering clinical care in the School of Dental Hygiene Care Facility?

- 3-4 hours (1)
- 5-6 hours (2)
- 7-8 hours (3)
- More than 9 hours (4)
Q8 How many minutes between clinic sessions do you not wear an N95 respirator?

- Less than 30 minutes (1)
- More than 31 minutes (2)
- No break (3)
- Other (4)

Q9 While wearing an N95 respirator in providing clinical care have you experienced any of the following respiratory symptoms?

- Asthma (1)
- Shortness of breath (2)
- Nasal congestion (3)
- Wet or dry cough (4)
- Tachypnea (abnormal rapid breathing) (5)
- Shallow breathing (12)
- Sore throat (6)
- Runny nose (7)
- Post nasal drip (8)
- Nose bleeds (9)
- Hypoxia (11)
- Other (10)
Q10 While wearing an N95 respirator in providing clinical care have you experienced any of the following mask mouth symptoms?

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Sometimes (1)</th>
<th>Always (2)</th>
<th>Never (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry mouth (1)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Dry lips (5)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Increased plaque retention</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Increase calculus formation</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Bad breath (2)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Bleeding gums (3)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Other (4)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Q11 While wearing an N95 respirator in providing clinical care have you experienced any of the following dermatologic symptoms?

<table>
<thead>
<tr>
<th></th>
<th>Sometimes (1)</th>
<th>Always (2)</th>
<th>Never (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acne (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact dermatitis (2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facial redness (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facial bruising (4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facial indentations (5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Facial irritation (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hives (6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Itchiness (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry skin (8)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Nasal bridge scarring (9)</td>
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<td></td>
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<tr>
<td>Other (10)</td>
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<td></td>
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</tbody>
</table>
Q12 While wearing an N95 respirator in providing clinical care have you experienced any of the following cardiac symptoms?

<table>
<thead>
<tr>
<th></th>
<th>Sometimes (1)</th>
<th>Always (2)</th>
<th>Never (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tachycardia (rapid heart beat) (5)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Arrhythmia (irregular heart rhythm) (6)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Angina (chest pain) (3)</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Other (7)</td>
<td>○</td>
<td>○</td>
<td>○</td>
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</tbody>
</table>
Q13 While wearing an N95 respirator in providing clinical care have you experienced any of the following general symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Sometimes (1)</th>
<th>Always (2)</th>
<th>Never (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical fatigue (1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headache (2)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Myalgia (muscle aches and pain) (15)</td>
<td></td>
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<tr>
<td>Anxiety (3)</td>
<td></td>
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<tr>
<td>Trouble focusing (4)</td>
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<tr>
<td>Decreased work efficacy (5)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ear pain (6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jaw pain (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweating (8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dizziness (9)</td>
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<td></td>
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<tr>
<td>Equilibrium issues (10)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lightheadedness (16)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dehydration (11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nausea (12)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry eye (17)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yawning (14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (13)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q14 How would you rate your N95 respirator comfort perception?

- Extremely uncomfortable (1)
- Very uncomfortable (2)
- Uncomfortable (3)
- Slightly uncomfortable (4)
- Neutral (5)
- Slightly comfortable (6)
- Comfortable (7)
- Very comfortable (8)
- Extremely comfortable (9)

Q15 Since wearing an N95 respirator while providing clinical care have you experienced any of the following impairments?

- Vision (1)
- Communication (2)
- Cognitive (3)
- Olfactory (smell) (4)
- None (5)
- Other (6)
Q16 Since wearing an N95 respirator while providing clinical care have you experienced any other side effect that was not mentioned?

________________________________________________________________

End of Block: Default Question Block
NAME: Peyton Shea Butler, RDH
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Norfolk, VA 23529

EDUCATION:
In Progress Old Dominion University
Norfolk, VA
Master of Science, Dental Hygiene
2021 Old Dominion University
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Bachelor of Science, Dental Hygiene

PROFESSIONAL EXPERIENCE:
Present Registered Dental Hygienist, Independent Contractor,
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Present Medical Sales Representative-Specializing in Biologics,
Monarch Medical, Virginia Beach, VA
2020-2021 Graduate Teaching Assistant, Department of Dental Hygiene,