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Alteration of Perceptions of Safety Before and After Fit Testing among College of Dentistry Students

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Environmental and Occupational Health

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Abstract

The COVID-19 pandemic has changed how hospitals and healthcare academic programs operate. This change has restricted services provided as well as educational opportunities for those training to be in healthcare. Further, personal protective equipment (PPE) has been required to help protect workers potentially having contact with patients who may have COVID-19. Dentistry workers are at particularly high risk due to repeated and continuous aerosol generating procedures. Healthcare students have traditionally been restricted to areas with minimal risk during clinical experiences; however, with the exposure occurring ubiquitously, avoiding the risk is nearly impossible. There is no uniform inclusion of students in respiratory protection programs within medical colleges currently; this limits knowledge surrounding perceptions of safety and application of safety behaviors by this population. To address this gap, we performed a cross-sectional study using a population of recently fit-tested dentistry students to gauge if safety perceptions change before and after being fit tested with N95 respirators. Sixty-five students completed pre- and post- fit testing for N95 personal respirators questionnaires. Over half of the participants (n=41) responded that their perception of safety changed from pre-fit testing to post-fit testing. All participants (n=65) responded that they knew how to wear an N95 respirator after fit testing. There was no significance found between pre-

and post- fit responses on additional paired questions (p=0.313 and p=0.131). This data supports that fit testing for N95 respirators alters safety perceptions in this population and demonstrates the need to educate students regarding exposures in their educational environment.

Introduction

As of April 21, 2021, over three million deaths globally had been attributed to the COVID-19 virus[1]. The pandemic changed how hospitals and academic programs operate; restrictions have been placed on services and access. Many of the restrictions center on non-mandatory services such as elective surgeries[2]. Common appointments have also been altered to protect healthcare and office staff. These changes have included installing partitions, decreasing the number of patients in waiting rooms, and performing temperature and symptom checks during check-in[3].

Because the COVID-19 virus is primarily spread through airborne transmission, it is present on aerosols created by infected individuals[4]. As a transmissible respiratory disease, protection against COVID19, therefore, merits emphasis on respiratory protections in addition to isolation, social distancing, and increased testing. It also infects without discrimination, affecting men and women of all ages and races[5]. An infected person can infect others up to 48 hours before they show symptoms or test positive. In addition to the potential to be completely asymptomatic, this infectious timeline creates the possibility for the virus to be spread without knowing[4,6].

Healthcare workers are at higher risk to contract COVID-19 due to their consistent and repeated exposure to patients[7]. The Morbidity and Mortality Weekly Report published by the Centers for Disease Control and Prevention (CDC) reported approximately 5.9% of COVID-19-associated hospitalizations between March and May 2020 were healthcare personnel[8]. Emergency procedures heighten the risk of possible transmission due to the inability to appropriately screen patients before procedures. Inability to assess patients before care may add risk of infection as well[9].

Dental procedures have a high risk of COVID-19 infection due to procedures revolving around patients being unmasked, close face-to-face communication and contact, and aerosol-generating procedures[10]. Additionally, clinical studies indicate that most dental procedures that utilize rotary handpieces generate considerable amounts of contaminated and potentially infectious aerosol and droplets[11] A systematic review regarding clinical procedures supported that over 75% of oral and dental procedures produce aerosols. Non-aerosol generating procedures did not specify the use of high-speed devices[12]. Sterilization of dental tools is also paramount to prevent any spread of infection to patients[13].

The National Institute for Occupational Safety and Health (NIOSH) has supported a hierarchy of controls that explain types of controls and their perceived effectiveness. The hierarchy lists the following controls from most effective to least effective: elimination, substitution, engineering controls, administrative controls, and personal protective equipment (PPE)[14]. COVID-19 as a workplace hazard evades the higher levels of elimination and substitution, therefore engineering controls, administrative controls, and PPE are relied upon to protect workers.

Some levels within the hierarchy of controls are more expensive and more complex to implement rapidly; thus, PPE has been a significant focus in keeping healthcare workers safe. In addition to PPE recommendations by OSHA and the CDC, of such things as gowns, gloves, and face masks, personal respirators have been added to lower the risk of exposure to COVID-19. Specifically, N95 respirators have been pursued to provide respiratory protection. N95 respirators are more effective than standard surgical masks because they form a tight seal over the mouth and nose, where all respiration occurs through the filter.

N95 respirator filters are designed to filter out approximately 95% of ambient aerosols containing particulates that are at least 0.3 micrometers in diameter[15]. N95 respirators are certified by NIOSH. After initial certification, NIOSH can perform onsite and field audits

afterward for any manufacturer to ensure that masks continue to meet certification criteria. criteria[16].

With the demand for PPE increasing, the supply of N95 respirators has not been able to keep up with demand. Limited supply chains have added stress to healthcare systems to secure the proper and necessary PPE for their staff. Improper PPE has the potential of increased risk of exposure when working with infectious patients[6].

In the United States, nearly all healthcare workers are covered by the OSHA Respiratory Protection Standard (29 CFR 1910.134)[17]. This standard requires the employer to develop a written respiratory protection program for employees exposed to hazardous airborne pollutants that have a primary inhalation route of exposure. Policies surrounding the usage of personal respirators have also changed during the pandemic. Reusing personal respirators is not a new idea, with recommendations being made to allow for extended use and limited reuse during the 2004 SARS and 2009 H1N1 events[18]. These recommendations were largely based on the types of transmission of the pathogen and the types of infection control measures in use. NIOSH policies stated that limiting usage by considerations of hygiene, damage, and breathing resistance[19].

Healthcare students from medicine, dentistry, physician assistants, and allied health programs were not originally included in a Respiratory Protection Program. However, with the advent of COVID-19, many academic medical institutions are fit testing students who may encounter COVID-19 patients on rotations. With the risk of COVID virtually omnipresent, students must be educated about potential exposures and the use and maintenance of respirators. Therefore, academic medical institutions are grappling with the idea of enrolling these students in respiratory protection programs.

With the onset of COVID-19, our academic medical center included healthcare students for the first time in its respiratory protection program. This move was implemented by the academic. As a result, this research sought to gauge dental students' perception of safety and

knowledge related to the use of N95 respirators. In this pre/post-study, we hypothesized a change in safety perception among dental students after fit testing for N95 personal respirators.

Most of the safety perception research for students in medical and dental programs is focused on perceptions of safety for patients rather than the students themselves[20]. Many medical centers additionally gather information on safety perception from employed healthcare staff and faculty, but the focus still revolves around safety perceptions as it applies to the patients[21-23]. Brodani et al. (2020) further argue that the variance in dentistry practice protocols supports the need to develop evidence-based documents[24].

Materials & Methods

Study Design

In this cross-sectional study, we administered two questionnaires to dental and dental hygiene students before and after respirator fit testing. The questionnaires evaluated if safety perceptions and knowledge of respirator use changed after fit testing. We fit-tested participants with either 3M 8210 or 3M 1860S respirators (St. Paul, MN).

Study Participants

College of Dentistry students who were scheduled for a fit test on August 26, 2020, and who had not previously been fit tested participated in this quality improvement study.

Qualitative Fit Testing

Qualitative fit testing was performed as specified by the OSHA Respiratory Protection Standard 29 CFR 1910.134 using a saccharin solution, with the following exceptions: an automatic nebulizer - Mayluck handheld mesh atomizer nebulizer manufactured by the Gogguan Maijie Electronic Company (Bell Gardens, CA) was used in place of a manual medication nebulizer to reduce strain on testing personnel during qualitative fit testing and, the saccharin solution was diluted 1:3 with water from a concentrate of soluble saccharin (Louisburg, NC).

Quantitative Fit Testing

Quantitative fit testing was performed as directed by OSHA Standard 1910.134 App A using an Accufit 9000 (Tulsa, Oklahoma) utilizing the ambient aerosol method. Aerosols were generated using a humidifier. Quantitative fit testing was only performed to ease workflow and if participants could not taste the saccharin aerosol during the sensitivity phase of the qualitative fit test.

Questionnaires

Participants completed questionnaires immediately before and immediately after fit testing, with both questionnaires labeled with identification stickers to match single participant pre and post responses. The purpose of the pre-questionnaire was to gauge the initial perception of safety against COVID-19 in clinical settings with questions such as "Do you feel that getting fit tested for an N95 respirator will increase your safety?" Post fit testing questionnaire questions were used to analyze any changes in perceived safety regarding using N95 respirators in clinical settings after completing fit testing. The pre-fit test questionnaire is provided in Appendix A. The post-fit test questionnaire is provided in Appendix B.

Statistical Analysis

Data analysis was performed using SPSS software version 27 (Armonk, NY), and an alpha value of 0.05 was considered significant (two-sided). Descriptive statistics, including frequencies, percentages, and averages, were used to report participants' demographic information and post fit questionnaire responses. Pre- and post-fit testing safety perception statements were compared using a Wilcoxon signed-rank test. A Chi-square was used to evaluate the association of gender and school program with non-paired pre-fit testing and post-fit testing questions.

Results

A total of 65 dental and dental hygiene students participated, all of whom completed the pre- and post-fit test questionnaires. There were 20 (30.8%) females and 45 (69.2%) males. Most participants were between 19 - <30 years (n=63, 96.9%). Most participants were enrolled

in the DDS program (n=44, 67.7%). Table 1 shows the demographic characteristics of the participants.

Table 1. Demographic characteristics of fit-tested participants (N=65)

	Response	Frequency	%
Age Category	19 - <30 30 - <40	63 2	96.9 3.1
Gender	Male Female	20 45	30.8 69.2
Program	DDS[a] Dental Hygiene[b]	44 21	67.7 32.3

[a]Includes data marked as DDS, Dental, and Dentistry
[b]Includes data marked as Dental Hygiene and DH

When asked about participants' experience and interpretations of safety regarding N95s and education, approximately 48% of participants responded that they needed N95 respirators when seeing patients. Most of the participants (95.4%) had never worn an N95 respirator prior to fit testing. Thirty-seven participants (n=37) also responded that they feel they have been provided the knowledge on respirator fit and use to conduct work related to COVID-19. Over half of participants responded that their overall perception of safety changed after fit testing (Chart 1). There was no significant association between the gender of participants or type of program regarding their responses to if the fit test changed their overall perception of safety (p=0.646 and p=0.415, respectively).

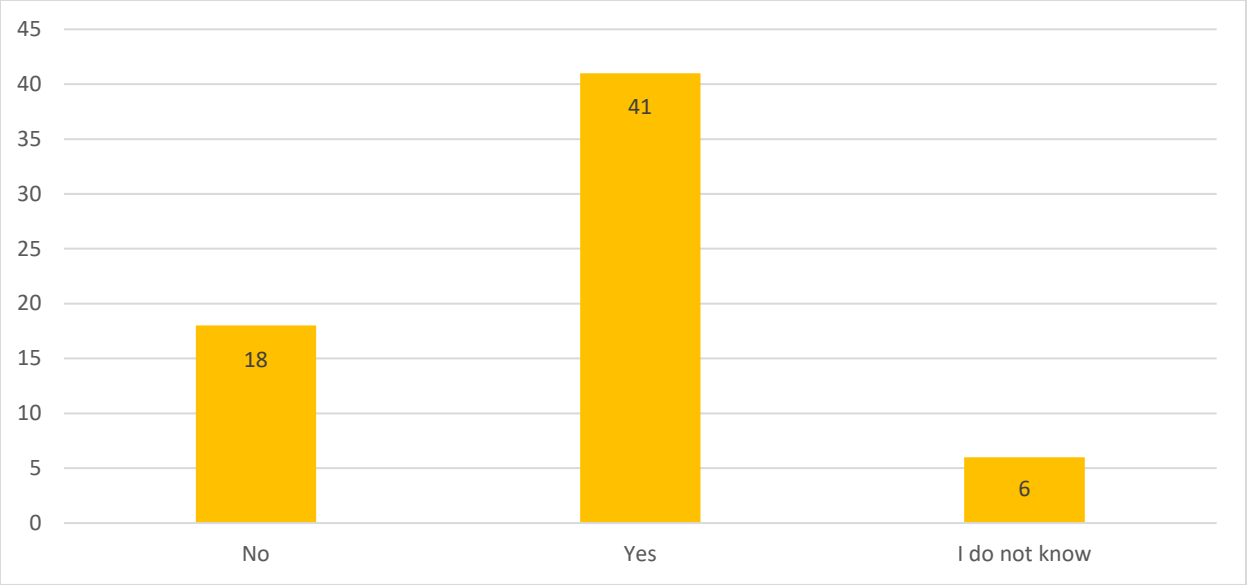

Chart 1. 'Did the fit test change your overall perception of safety' Post fit testing response frequency.

Thirteen (20%) of participants responded that they knew how to wear an N95 respirator before fit testing. All 65 (100%) participants responded that they knew how to wear an N95 respirator after fit testing. Less than half (n=28, 43.1%) of participants responded that they agreed or strongly agreed that it would be difficult to wear an N95 during clinical work. After fit testing, over half (n=36, 65.4%) agreed or strongly agreed. Overall, the distribution of responses did not differ from pre-fit testing and post-fit testing for difficulty of wearing N95 respirators during clinical work and fit testing for N95 respirators, increasing safety (p=0.313 and p=0.131). There was a shift in responses from disagree and strongly disagree to neutral, agree, and strongly agree responses for all questions (Table 2). No significant differences in distribution were noticed when comparing post- fit testing questionnaires by gender or educational program by Chi-square test.

Table 2. Frequency of fit testing responses before and after fit testing						
Question	**Response**	**Responses Before fit testing (N=65)**		**Responses After fit testing (N=65)**		
		N	**%**	**N**	**%**	**P**
Do you know how to wear an N95 respirator?	No	48	73.8	0	0	N/A
	Yes	13	20	65	100	
	I do not know	4	6.2	0	0	
It would be difficult to always wear an N95 respirator during clinical work.	Strongly Disagree	1	1.5	0	0	0.313[a]
	Disagree	11	16.9	13	20	
	Neutral	25	38.5	16	24.6	
	Agree	17	26.2	26	40	
	Strongly Agree	11	16.9	10	15.4	
Do you feel that getting fit tested for an N95 respirator will increase your safety?	Strongly Disagree	0	0	0	0	0.131[a]
	Disagree	2	3.1	2	3.1	
	Neutral	10	15.4	6	9.2	
	Agree	25	38.5	25	38.5	
	Strongly Agree	28	43.1	32	49.2	

[a]p-value was determined by Wilcoxon signed rank test.

Discussion

This study showed that 63% (n = 41) of participants responded that their perception of safety changed after fit testing. Of a total of 65 participants, 57 participants (87%) either agreed or strongly agreed that getting fit tested would increase their safety. Additionally, 100% (n=65) of participants responded that they knew how to wear an N95 respirator after fit training. These positive trends toward safety perception regarding fit testing demonstrate that targeted and thorough education is needed to create personal awareness of protective equipment and what it can do. Roughly 54% (n=35) of participants also were able to taste saccharin after fit testing. It was an additional assurance that an N95 respirator protected them from the testing agent for these participants. A limitation of this study is that we did not include an option for participants to respond if their perceptions of safety increased or decreased.

Of the 24 participants who responded ‘No’ or ‘I do not know’ to whether the fit test changed their overall perception, 19 participants still agreed or strongly agreed that getting tested would increase their safety. These participants may already have a high safety

perception, and fit testing did not change their knowledge of clinical risks. Of the remaining five participants, two responded that they disagreed that fit testing would increase their safety, while the last three responded that they felt neutral.

Fit testing also demonstrated to participants how arduous an N95 respirator could be to wear for prolonged periods; most participants responded that they felt that wearing an N95 would be difficult in the clinic compared to before. The fit testing process lasts only approximately seven minutes, and any difficulty would need to reflect a full day of respirator usage.

The sampled population included both dental hygiene and doctor of dentistry students. Both programs are at high risk for aerosol exposure due to the nature of their profession and aerosol generating procedures[25].In addition to clinical risks, there can be educational differences if a student is unable to wear N95 respirators due to failing fit-testing. Restrictions from attending or participating in procedures and opportunities that require N95 respirators could limit the educational and clinical practice experiences of dental hygiene and DDS students. The option of pursuing a powered air purifying respirator (PAPR) may be pursued in cases where N95s are not available or fit testing has failed. Unlike disposable N95 respirators, a PAPR may be used multiple times and does not require fit testing, however still requires appropriate training for usage. Most older models of PAPRs are too cumbersome for the practice of dentistry as well. PAPRs can cost over 200 times more than an N95 respirator which limit the purchaser's availability to supply this type of respirator for an entire workforce[26].

The American Dental Association (ADA) interim guidance states that dental staff should use N95 respirators during aerosol generating procedures[27]. This guidance is to supplement comprehensive respiratory protection programs within the workplace. There is currently no timeline published by the ADA regarding when the recommendation of N95 respirators should be discontinued.

OSHA requires employees in environments that have hazardous respiratory exposures to implement a respiratory protection program. With the COVID-19 pandemic, the advent of explicitly including affected healthcare students in these programs is new to our institution and can introduce additional burden to train and document participants. We reviewed seven medical colleges' respiratory protection programs in the Midwest; three did not mention students within their respiratory protection programs. The addition of this healthcare students into respiratory protection programs has the potential of adding costs to the institution. These costs may come in the form of PPE, staff maintenance of the respiratory protection program, and pursuing additional control measures to limit or eliminate the hazard.

Our study had several strengths. First, this is research looked at performing evaluations of safety perceptions in a population that has not been well studied before. Second, the study evaluated alteration of perceptions immediately after fit testing. Third, we had 100% participation fill out both the pre- and post-fit testing questionnaires.

Limitations

We were not able to determine the direction of change of perceptions. The post-test questionnaire was administered in the presence of the tester. Therefore, we thought the study subject may feel pressured to say their safety perception increased because of the fit test. However, when taken in tandem with other responses, it appears that the change was in the positive direction, i.e., their safety perception increased after the fit test. Our study was performed over the period of a single day with no intention of extending further. This timeline did not allow us more than the 65 participants.

Conclusion

This study supported our hypothesis that perceptions of safety were altered in DDS and dental hygiene students after fit testing. This study highlights the need to continue respirator fit testing for persons required to wear N95 respirators due to a respiratory hazard. It is imperative to fit test students to lower their risk of exposure to respiratory hazards. Fit testing is also an

opportunity to engage students regarding the potential hazards they may find within their workplace.

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Disclosure

The authors declare that there is no conflict of interest.

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Appendix A. Pre-Fit Testing Questionnaire

N95 Respirator Fit Test—Quality Improvement Project (Pre)

This questionnaire will be used for academic purposes to evaluate the fit test program

Please select one answer for each question

1. Which category below includes your age?
   a) 19 - <30
   b) 30 - <40
   c) 40 - <50
   d) 50 - <60
   e) 60 and over

2. What is your gender?
   a) Female
   b) Male
   c) Other
   (specify):_____

3. What is your role at the College of Dentistry?
   a) Faculty
   b) Staff
   c) Student (please answer 3a and 3b)

   3a. What is your program?_____

   3b. What year are you in?_____

4. Have you ever worn an N95 respirator before? If you answer yes to this question, please answer question 4a.
   a) Yes
   b) No
   c) I don't know

   4a. Were you fit tested for an N95 respirator?
   a) Yes
   b) No

5. To protect yourself from COVID-19, do you feel that you need to wear an N95 respirator when seeing patients?
   a) Yes
   b) No
   c) I do not know

6. Do you know how to wear an N95 respirator?
   a) Yes
   b) No
   c) I do not know

7. Do you feel that getting fit tested for an N95 respirator will increase your safety?
   a) Strongly agree
   b) Agree
   c) Neutral
   d) Disagree
   e) Strongly Disagree

8. Do you feel that you have been provided the knowledge on respirator fit and use to conduct work related to COVID-19?
   a) Strongly agree
   b) Agree
   c) Neutral
   d) Disagree
   e) Strongly disagree

9. It would be difficult to always wear an N95 respirator during clinical work.
   a) Strongly agree
   b) Agree
   c) Neutral
   d) Disagree
   e) Strongly disagree

Thank you for participating

Nebraska Medical Center

Appendix B. Post-Fit Testing Questionnaire

N95 Respirator Fit Test—Quality Improvement Project (Post)

This questionnaire will be used for academic purposes to evaluate the fit test program

Please select one answer for each multiple-choice question

1. Did the fit test change your overall perception of safety?
   a) Yes
   b) No
   c) I do not know

2. After the fit test, do you know how to wear an N95 respirator?
   a) Yes
   b) No
   c) I do not know

3. After the fit test, do you feel that getting fit tested for an N95 respirator will increase your safety?
   a) Strongly agree
   b) Agree
   c) Neutral
   d) Disagree
   e) strongly Disagree

4. It would be difficult to always wear an N95 respirator during clinical work.
   a) Strongly agree
   b) Agree
   c) Neutral
   d) Disagree
   e) Strongly disagree

5. Would you like to share any comments related to fit test or risk of COVID-19?

Thank you for participating

To be completed by tester: Did the participant taste saccharin or bitrex post fit?
1. Yes
2. No.
3. Not applicable

Appendix C: Demonstrated Competencies

MPHF3: Analyze quantitative and qualitative data using biostatistics, informatics, computer-based programming and software, as appropriate.

EOHMPH2: Examine exposures and pathways for environmental and occupational agents associated with human injuries and diseases.

EOHMPH7: Employ measures to control workplace injury and illness including engineering, education, regulations, incentives, and best practices.

Appendix D: Biography & Resume

Tanner Clark is a Master of Public Health student at the University of Nebraska Medical Center College of Public Health. His studies have concentrated on environmental and occupational health and safety. His early work experience focused on genetics, specifically hereditary cancer. In the summer of 2020, he joined the Nebraska Department of Health and Human services as a Disease investigator to aid in contact tracing and epidemiological studies for Sars-CoV-2 (COVID-19). He then took a position as an Environmental Health Specialist in early 2021 to aid in providing environmental policy recommendations to aid in the prevention of infectious diseases for Nebraska businesses. His work has provided him with multiple avenues of experience: lab work and maintenance, development of interpersonal relationships, policy review and implementation, and much more. Tanner Clark has a Bachelor of Science degree from Doane University.

Tanner Clark

Ambitious graduate student pursuing a career in public health with experience in occupational and environmental health and safety.

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Work Experience

Nebraska State Department of Health and Human Services, Lincoln, NE

- *Environmental Health Specialist* (January 2021 - Present)

  Acted as part of a multi-disciplinary team to provide infection prevention recommendations to the Nebraska public. Performed site visits to evaluate needs of clients and better form policy and educational recommendations. Prepared and presented written reports and presentations to clients. Created and implemented standard operating procedures for the Nebraska Community Strike Team. Collaborated with the Nebraska Department of Health and Human Services, the University of Nebraska Medical Center, and Nebraska Local Health Departments to monitor and evaluate and respond to potential outbreaks.
- *Disease Investigator* (July 2020 – January 2021)
  Assessed the requirements of Nebraska health departments in consultation with local staff to educate and recommend control measures regarding the COVID-19 outbreak. Consulted with residents of Nebraska to provide information and resources regarding confirmed diagnosis of COVID-19 or risk of contact with a positive case. Participated in multiple training courses through educational organizations to gain requisite knowledge and experience to work in public health during a pandemic. Voluntarily conducted additional projects within other divisions of public health to aid established teams in completing or developing health measures, databases, and policies for the state of Nebraska.

University of Nebraska Medical Center, Omaha, NE

- *Genetic Counseling Associate* (November 2018 – July 2020)

  Collaborated with genetic counselors and medical geneticists to daily assess patients' needs and department requirements. Conducted case preparation, clinic coordination and scheduling, and patient documentation focusing on family history in conjunction with senior staff and medical providers. Took on additional responsibilities outside of required job functions surrounding patient screening, clinic analytics, and result dissemination. Participated in multidisciplinary tumor boards focusing on oncology testing and treatment. Awarded UNMC Munroe-Meyer Standout September 2019.
- *Cytogenetic Technologist I, Tissue Culture Technician* (May 2015 – November 2018)
  Assembled and conducted karyotype and genetic profile analysis to aid in diagnosis of diseases. Trained cytogenetic technologists in live culture rooms and microarray. Adhered and adapted to evolving CAP and OSHA standards. Gained competency in live tissue culture as well as microarray bench processing and DNA extractions. Drafted, edited, and updated lab Standard Operating Protocols (SOPs).

Boys Town Behavioral Center, Boys Town, NE

- *Behavioral Interventionalist* (August 2017 – March 2018)

Doane University, Crete, NE

- *Research Assistant* (May 2014 – May 2015)
- *Admissions Assistant* (May 2014 – May 2015)

Education

University of Nebraska Medical Center – College of Public Health
Omaha, NE – *Master of Public Health*
August 2016 – May 2021
UNMC Student Senator 2017-2018. COPH Student Association Member 2017-2018.

Doane University
Crete, NE – Bachelor of Science
August 2011 – May 2015
Alpha Pi Epsilon Fraternity 2012-2015, Student Judicial Board Member 2012-2014

Advocacy and Volunteer Experience

Student Alliance for People of All Abilities (SAPA) - Board Member, Secretary (2018-2021)
Worked with students across all University of Nebraska Medical Center colleges to promote and create educational events surrounding understanding and advocacy for persons who have a disability.

Court Appointed Special Advocate (CASA) of Douglas County - Volunteer (2018-Present)
Established rapport with foster child and families as well as involved parties in order to advocate for needs and desires of child. Presented information via written court report to Douglas County Court judges and provided input on record.

Metro Omaha Tobacco Action Coalition (MOTAC) - Volunteer (2018-2020)
Participated in general board meetings and volunteered at organizational fairs to promote education surrounding tobacco and e-cigarette usage and health hazards. Awarded 'Volunteer of the Year' award in 2019.

Village Green Townhomes - Board Member (2019-2020)

Munroe-Meyer Institute Recreational Therapy Programs - Volunteer (2015-2018)

Presentations

Clark T, Morgan C, (2015) *Effects of Aged Garlic Extract on Cell Growth, Quorum Sensing, and Gene Transcription in Pseudomonas aeruginosa* [Poster]. Exhibited at The American Society for Microbiology. New Orleans, May 30, 2015 through June 02, 2015.

Publications

Sanmann JN, Casas KA, Bevilacqua J, Bishay DL, **Clark T**, Van Dyke AZ, Leiferman PC, Reddi HV, Starr LJ. The first patient with tandem duplication of 6q14q16: Molecular and phenotypic characterization. Am J Med Genet A. 2016 Sep;170(9):2416-20. doi: 10.1002/ajmg.a.37797. Epub 2016 Jun 23. PMID: 27338032.