ASSESSMENT OF DENTAL STUDENTS' ATTITUDES AND AWARENESS OF CLIMATE CHANGE IN A MIDWESTERN DENTAL SCHOOL

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MASTER OF SCIENCE

by
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University of Missouri-Kansas City, 2023

ABSTRACT

The purpose of this project was to investigate the knowledge and attitudes of dental students toward climate change, and whether certain demographic characteristics were associated with high or low knowledge as well as attitude toward climate change. An IRB-approved 20-item survey was constructed and administered to 432 UMKC dental students spanning all four years to test if demographics including school year, gender, geographic region of upbringing, socioeconomic status during childhood, previous climate change-related education, and use of environmentally-friendly behaviors at home are associated with climate knowledge and attitude. The survey was introduced to students via an IRB-approved verbal script during a class, and the students anonymously completed the surveys. The survey questions were divided into 4 domains; demographic characteristics, knowledge of climate change, attitude toward climate change, and perceived barriers seen by the student which may prevent the use of environmentally-sustainable office practices. Student demographics were then used to evaluate whether there was an effect on students' climate change-related knowledge and attitude toward climate change. The survey results show a significant association between dental students' gender and previous climate change-related education and both their knowledge of and attitude toward climate change. However, utilization of

environmentally-friendly behaviors at home and year in dental school were significantly associated with attitude toward climate change only. There was no correlation found between overall knowledge of climate change and attitude.

APPROVAL PAGE

The faculty listed below, appointed by the Dean of the School of Dentistry, have examined a thesis titled "Assessment of Dental Students' Attitudes and Awareness of Climate Change in a Midwestern Dental School," presented by Sara Linstadt, candidate for the Master of Science Degree in Oral and Craniofacial Sciences, and hereby certify that in their opinion it is worthy of acceptance.

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CONTENTS

ILLUSTRATIONS

TABLES

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CHAPTER 1

INTRODUCTION

In recent years, it has become increasingly evident that the Earth's climate is undergoing temperature changes at an unprecedented and perhaps alarming rate, which has undoubtedly been augmented by human influence (Marcott et al. 2013). This global temperature increase is the result of inadvertent modification of the atmosphere, in which greenhouse gases and other airborne pollutants are emitted by human activity (Ramanathan and Feng 2009). Changes in global temperature have affected sea levels and weather patterns and increased the incidence of various human diseases and comorbidities (World Health Organization 2018). The role of healthcare in climate change is twofold, both protective and causative. It is in the hands of healthcare professionals to mitigate the health effects of climate change by treating its associated illnesses. However, the healthcare industry is also a major producer of pollution and greenhouse gases (GHGs), as well as a substantial consumer of fossil fuels (Chung and Meltzer 2009). Dentistry, too, contributes considerably to GHG emissions via patient and staff commuting, product procurement, office electricity and gas consumption, and production of clinical waste (Duane et al. 2017). Numerous studies have demonstrated the attitudes of healthcare professionals, medical students, and nursing students both in the United States (U.S.) and abroad regarding their role and contribution to climate change. Yet to be explored are the attitudes of dental students in the U.S., the factors that may affect the way that they perceive their profession's impact on our changing climate, and the barriers that may prevent them from operating an environmentally-sustainable dental practice after graduation.

A Global View on Climate Change

Natural variations in Earth's temperature have occurred over the last 65 million years due to geological processes, volcanic activity, ocean currents, and orbital changes. These processes have led to extended periods of global warming and cooling, as evidenced by data extracted from ice cores (Brook and Buizert 2018). However, the Earth's climate is now experiencing widespread changes in temperature, ice sheet mass loss, and weather patterns that are not explainable by natural fluctuations, with temperatures changing more rapidly than ever before (Briner et al. 2020).

Marcott et al. (2013) demonstrated that in the last 11,000 years, global temperatures have fluctuated up and down approximately 0.4 degrees Celsius from baseline, often taking thousands of years to change significantly. But since 1980, the average global temperature has already increased by 0.9 degrees Celsius. The authors assert that this sudden spike in global temperatures can be attributed to increased human fossil-fuel related activity (Marcott et al. 2013). As studied by Montzka et al. (2011), since the beginning of the Industrial Revolution in the early 1800s, and particularly in the last three decades, the combustion of fossil fuels for energy has increased, leading to an abundance of carbon-based gases within the atmosphere. These gases absorb infrared radiation and reflect it to the Earth's surface, and they may persist in the atmosphere for hundreds or thousands of years. The authors describe that these gases include carbon dioxide (CO_2), methane, nitrous oxide, and hydrofluorocarbons, and are collectively known as greenhouse gases (GHGs) (Montzka et al. 2011). These gases each have differing abilities to increase the infrared insulating capacity of the atmosphere, a phenomenon that is called "radiative forcing" (Myhre et al. 2013). Gases

with greater radiative forcing capacity have a greater potential to increase atmospheric temperature (Jain et al. 2000).

To provide a standard means of comparison between these gases, the global warming potential of non-CO_2 GHGs is mathematically converted and measured in CO_2 equivalents (CO_2-eq) (Montzka et al. 2011). In countries monitoring their carbon and GHG emissions, the CO_2-eq is generally measured in million metric tons, or megatons (Mt), which is equivalent to 1,000,000,000 kilograms (United States Environmental Protection Agency 2020). Worldwide data shows a dramatic spike in emissions over the past 30 years; in 1990, global CO_2 emissions were 22,273 $MtCO_2$-eq, increasing to 35,990 $MtCO_2$-eq by 2015 (World Resources Institute 2023). Carbon emissions in the U.S. have increased by 2.9% from 1990 to 2018, from 6,437 $MtCO_2$-eq to 6,677 $MtCO_2$-eq (United States Environmental Protection Agency 2020). The U.S. is the second-highest carbon-emitting country in the world (World Resources Institute 2023).

This increase in GHG emissions and the resulting increase in temperature has led to rising sea levels, melting glaciers, worsened air quality, and an increased incidence of extreme weather events (Hansen et al. 2016). Because increased temperature has produced a more arid climate, there have been more frequent and widespread wildfires, particularly in the western U.S. (Abatzoglou and Williams 2016). The oceans have been warmed by the action of radiative forcing, and the elevated concentration of atmospheric CO_2 has led to its absorption by the ocean, making it more acidic and affecting the ability of marine life to survive (Harrould-Kolieb and Herr 2012). As temperatures rise, plant and animal species requiring cool or temperate ecosystems will lose habitat, perhaps leading to increased rates of extinction (Pimm 2008). But climate change is not exclusively an environmental issue. It has

far-reaching effects, including the creation and perpetuation of an enormous global health problem.

Climate Change and Human Health

The changes in weather patterns, increases in sea level, and increases in global temperature and air pollutants can impact human health through multiple mechanisms (Costello et al. 2009). Aside from the mortality directly associated with more frequent and severe natural phenomena like wildfires and flooding, the displacement and resettlement of affected populations can lead to political conflict, undernourishment due to food instability, and increased spread of infectious disease due to overcrowding (McMichael et al. 2012). Additionally, elevated global temperature is expected to facilitate the expansion of the ecological niches occupied by certain pathogens; insects like mosquitos and ticks usually confined to particular geographic regions may flourish elsewhere, thereby increasing the incidence of vector-borne diseases like Lyme disease, West Nile virus, and malaria (Semenza and Suk 2017).

Climate change is also expected to affect the risk of non-communicable diseases (Kjellstrom et al. 2010). Increased temperature and air pollution have been linked to an increased risk of renal, cardiovascular, and respiratory diseases through a mechanism of dehydration, increased systemic inflammation and cytokine release, increased blood viscosity, and increased cardiac output in response to heat stress (Kenney et al. 2014; Franklin et al. 2015). Furthermore, the Intergovernmental Panel on Climate Change has suggested that because of the increased incidence of disease, food and water instability, and settlement uncertainty, the incidence of mental health and stress disorders is also expected to rise (Portier et al. 2010). As a result of the aforementioned factors, the World Health

Organization (WHO) estimates that climate change will directly contribute to an additional 250,000 deaths annually (World Health Organization 2018). These deaths are predicted to disproportionately affect vulnerable populations such as children, the elderly, those with lower socioeconomic status, and individuals with comorbidities or pre-existing health conditions (Balbus et al. 2016). The problem is so severe that the U.S. Department of Health and Human Services considers climate change to be one of the top public health challenges of our time and one of the largest obstacles facing the global community in the coming century (US Department of Health and Human Services 2014).

In addition to systemic effects, it has been postulated that climate change may have potential oral health associations. With poorer air quality, we may see increased rates of asthma and COPD, the treatments for which generally involve inhaled corticosteroids which can alter the oral microbiome and lead to increased rates of caries and oral fungal infections. Infection with vector-borne illnesses like Zika or Dengue Fever could result in oral ulcerations or hemorrhagic lesions. Moreover, food insecurity may lead to malnutrition, which could contribute to an increased incidence of necrotizing periodontal diseases. Similar results may be seen with elevated stress levels or mental health issues that could arise as a result of climate change (Hackley 2021).

It has been established that climate change is anthropogenic in nature, i.e. related to human activities, and the result of the radiative forcing capacity of various GHGs that are emitted into the atmosphere (Hansen et al. 2007). In the U.S., the largest sources of GHGs are the burning of fossil fuels for electricity, heat, and transportation, with industries including manufacturing, agriculture, aviation, and healthcare contributing the most to GHG emissions (United States Environmental Protection Agency 2018).

Healthcare's Impact on Climate Change

According to the WHO, healthcare professionals "study, advise on, or provide preventive, curative, rehabilitative, and promotional health services based on an extensive body of theoretical and factual knowledge in diagnosis and treatment of disease." Occupations considered to be healthcare professions include medical doctors, nursing professionals, pharmacists, optometrists, and dentists, among others (World Health Organization 2010). A study by Eckleman and Sherman (2016) determined that the U.S. healthcare industry produces 10% of the country's GHG emissions, for a total of 655 $MtCO_2$-eq annually. The authors report that this is a 30% increase over the past decade, and if it were a country, the U.S. healthcare sector would rank 13th in the world for GHG emissions (Eckelman and Sherman 2016). A small percentage of these GHG emissions are the direct result of the day-to-day energy expenditures and activities involved in running healthcare facilities, but the majority of emissions come from the suppliers of energy, goods, and services related to hospital care, physician and clinician services, and prescription drugs (Chung and Meltzer 2009).

While the healthcare industry significantly contributes to the GHG emissions responsible for climate change, it also bears the burden of care for the resulting health effects. It has been estimated that the U.S. healthcare sector will cause between 123,000 and 381,000 years of healthy life lost due to disability annually around the world, mostly attributable to malnutrition and expanding availability of disease vectors (Eckelman and Sherman 2018). Medicine, in particular, has recognized its impact and has taken steps to reduce emissions. In the U.S., organizations such as the American Medical Association have begun advocating that their members take initiative to reduce the carbon footprint of their

profession and encourage changes in environmental policy as it relates to healthcare (Schwartz et al. 2006). Additionally, the U.S. Department of Health and Human Services has put forth a series of guidelines on lessening the environmental impact of medical and hospital systems, including strategies for sustainable buildings, water use, and fleet management (2014). Many healthcare systems in the U.S. have joined the Health Care Climate Alliance and made commitments to reduce their GHG emissions by up to 50% before the year 2025 (Healthcare Without Harm 2023). And outside the U.S., measures to reduce healthcare-related GHG emissions are also being taken. In the United Kingdom (U.K.), where the National Health Service (NHS) serves as the main healthcare system, policies supporting sustainability in medicine have been implemented, and as of 2018, the NHS had decreased their emissions by 18.5% (Sustainable Development Unit 2018).

Dentistry's Impact on Climate Change

Reflecting the NHS system's interest in reducing emissions, the U.K. leads the world in research focused on dentistry's role in climate change. Dentistry, in addition to medicine, makes sizeable contributions to climate change via GHG emissions (Duane et al. 2012). It has been estimated that dentistry in the U.K. produces 0.675 $MtCO_2$-eq annually, making up around 3% of the 22.8 $MtCO_2$-eq produced by the NHS in total (Duane et al. 2017; NHS England 2018). A majority (61%) of the carbon emissions produced from dentistry in the U.K. come from the commuting of staff and patients to and from dental offices (Duane et al. 2019c). To reduce transportation-related GHG emissions, it has been recommended that transit be done more efficiently via carpooling or utilization of mass transit, and by implementing more digital technology and teledentistry to reduce patient appointments

(Mulimani 2017). The remainder of emissions come from item procurement, electricity and gas needed to power the office, and waste (Duane et al. 2019a).

In addition to direct emission of GHGs from vehicles and energy consumption, dental practices produce large amounts of solid and liquid wastes. The items frequently discarded include food, domestic and hygiene waste, infectious or biohazard waste, and hazardous chemicals contained in dental amalgam and x-ray fixer and developer (Duane et al. 2019b). These materials end up in the water, the air, or waste management facilities (Hiltz 2007). One report by Richardson et al. (2016), a waste audit of a dental practice in England, found that recyclable plastic and sterile wrapping were often incorrectly discarded as clinical waste, rather than recycled. Clinical waste is sent for incineration, a process that has been demonstrated to produce 1,833 kg CO_2-eq per ton of waste. This same report indicated that the GHG emissions created from the incineration of inappropriately discarded dental waste products result in an additional release of 476.58 kg CO_2-eq per dental office per year (Richardson et al. 2016).

The Eco-Dentistry Association, an international organization founded in 2008 to provide resources and information to dental professionals to facilitate the integration of environmentally-friendly office practices, has published a study with an estimate of waste products created by U.S. dental offices. After auditing five general dental practices for daily plastic and paper waste produced, disinfectants used, and electricity used, the authors extrapolated data to represent the U.S. as a whole. Their study asserts that annually, U.S. dental practices generate 1.7 billion sterilization pouches and 680 million chair barriers, light handle covers, and patient bibs, the majority of which are not recycled and instead end up in landfills or marked for incineration as biomedical waste (Eco Dentistry Association 2016).

When discarded as medical waste, these items are incinerated in a process that requires fossil fuels and produces GHGs such as CO_2, nitrous oxide, and ammonia (Windfeld and Brooks 2015).

While much of the research that has been done regarding dentistry's contribution to climate change has taken place in the U.K., emissions data in the U.S. has also been collected. In the U.S., dental services produce between 11 and 12 $MtCO_2$-eq annually, accounting for 2% of the total GHG emissions from the US healthcare industry (World Bank Group 2017). Dentistry-related CO_2-eq emissions are over 16 times greater in the U.S. than those produced in the U.K., despite having a population that is only five times larger (020; U.S. Census Bureau 2020). Considering this disproportionate difference in GHG emissions, it stands to reason that perhaps the dental profession's impact on climate change has not been addressed in the US to the extent that it has in the UK.

General Population Attitudes toward Climate Change

As the public has been increasingly exposed to the concept of climate change over the past two decades, efforts have been undertaken to evaluate the population's attitudes toward climate change. These attitudes can be influenced or shaped by many factors, which have been evaluated and described in several reports. Early reports reflected the effect of geographic location within the U.S. on a person's views of climate change. The findings of one such study demonstrated that those in the Northeast are more likely to be concerned about the changing climate, Southerners the least likely to be concerned, and Westerners and Midwesterners are more intermediate in their attitudes (Patchen 2006). A more recent study by Weber and Stern (2011) indicated that personal experience also affects attitudes toward climate change. Individuals who experience extreme weather events such as hurricanes,

wildfires, or severe droughts are more likely to be concerned about climate change. The same investigators also indicated that people with science-based educational backgrounds were nearly twice as likely to believe that climate change is human-caused; the authors attribute this difference to the difficulty of understanding what climate change is, as its causes are invisible and its environmental impacts are geographically distant for most individuals (Weber and Stern 2011).

A 2014 survey conducted by the Pew Research Center reached 2,002 members of the general population in the U.S. via telephone. Using weighting to correct statistical results for known demographic discrepancies, the results indicated that age, sex, political affiliation, and education level play a role in individuals' attitudes and views on climate change. This survey indicated that adults under age 50 are more likely to believe the Earth is warming because of human activity than their older counterparts. Additionally, 79% of women polled believe that there is solid evidence of climate change, compared to 63% of men. The survey also found that political ideology plays a role, with 72% of Democrats and 29% of Republicans reporting the belief that climate change is occurring as the result of human activities. Finally, those with college degrees, regardless of their field of study, are more likely to believe that there is evidence of climate change (2015). Another earlier survey reflected that the public in the U.S. is concerned about the environmental effects of climate change but has little to no awareness of the health effects (Lieserowitz 2005). Studies of healthcare providers' attitudes provide contrast in that they are more likely to demonstrate understanding and awareness of the impacts of climate change on human health.

Healthcare Providers' and Students' Attitudes toward Climate Change

Because the healthcare sector has been shown to play a large role in GHG emissions, the attitudes of healthcare professionals can be instrumental in shaping governmental policy on climate change. As such, the attitudes of healthcare professionals and students have been evaluated globally. In Sweden, a study was undertaken to evaluate nurses' perceptions of climate change (Anåker et al. 2015). The investigators found that the respondents felt sustainability in healthcare could be improved by decreasing product packaging waste and by streamlining the transportation of staff and patients to medical facilities. However, the same nurses also reported that in their daily work, their concern was on the immediate well-being of their patients, rather than climate change and its effects on health at a more global level. A different investigation of public health nurses in the U.S. revealed a high level of concern about the health-related impacts of climate change, although fewer than 40% of respondents felt that their cohort could decrease its effects on human health (Polivka et al. 2012). Another study of obstetricians and gynecologists in the U.S. found that 78% of those surveyed were aware of climate change and believed it to be a result of human activities. Among the respondents, a majority reported that waste reduction is an important aspect of improving their profession's environmental sustainability, and 66% expressed a preference for reusable, sterilizable instruments over their disposable counterparts (Thiel et al. 2017).

In addition to studies of the attitudes of graduated, practicing healthcare professionals, the attitudes of students in healthcare professions have also been examined. While healthcare provider surveys were completed between five and ten years ago, students in healthcare professions were surveyed more recently. The outcomes suggest that students may have a higher degree of awareness of climate change and its effects than professionals

who have completed their training. A report of medical, nursing, and physician assistant students at Yale University revealed that 94% of those surveyed reported awareness of the health effects of climate change and 77% agreed that they had concerns about healthcare's production of pollution and waste, although most underestimated the percentage of GHGs emitted by the U.S. healthcare industry. Nearly two-thirds of the surveyed students agreed that the relationship between climate change and human health should be part of their educational curriculum (Ryan et al. 2020). Another study of nursing students across four Arab countries indicated a similar result, with over 60% of respondents agreeing that a course on environmental sustainability should be included in the nursing school curriculum. Factors including residence in an urban area, country of residence, and previous educational exposure to the health effects of climate change all affected respondents' attitudes (Cruz et al. 2018). Based on the reported outcomes, it appears that health profession students are more likely to have concerns about the environmental and human impacts of climate change. However, these differences could be related to differences in survey timing, as climate change has become a more prominent issue in politics and the media in recent years (Patchen 2006). While many studies have been done to evaluate the attitudes of medical professionals and students toward climate change, relatively few investigations have been undertaken to understand the attitudes of dental professionals or dental students.

Dental Care Providers' and Students' Attitudes toward Climate Change

Much of the current research related to dentistry and climate change has been done in the U.K. and elsewhere in the world, while the U.S. has produced limited publications on the topic. Studies of dentists in Jordan and Saudi Arabia have shown that dental professionals tend to have a clear awareness of climate change and the impact their profession has on the

environment, but have taken few steps to implement more environmentally-friendly practices into their office protocols (Al Shatrat et al. 2013; Al-Qarni et al. 2016). Conversely, a survey of dental students in India showed that there are significant gaps in understanding biomedical waste management and effective recycling of dental materials (Ranjan et al. 2016). An investigation into the attitudes of dental professionals in England revealed mixed attitudes toward climate change and interest in sustainable office policies. Those who recycled and were environmentally aware at home were more likely to carry these practices into the office (Grose et al. 2016). More recently, the attitudes of dental professionals in Ireland have been examined (Diffley et al. 2019). The investigators found that although a majority of dentists and dental office team members were interested in environmental sustainability and believed that sustainable practices should be implemented, few prioritized environmentally-friendly product procurement or measured their carbon footprint This study further explored years since graduation as a variable and noted that more recent graduates had increased interest in climate change compared to individuals who completed dental school in the 1980s (Diffley et al. 2019).

In the U.S., the attitudes of dental professionals toward climate change have been largely unexplored. At the University of Michigan, as reported in a Dow Sustainability Fellows Program report, dental students were surveyed to measure their attitudes toward sustainability and materials usage before a 15-minute educational session aimed at discussing the use of environmentally-friendly dental practices (Goddard et al. 2016). Two weeks later, the students were re-surveyed, and the results indicated that more students reported that environmental sustainability was important to them. A waste audit revealed there were also noticeable decreases in the use of gloves, masks, and barriers in the clinic. This educational

intervention, among other factors previously discussed, may be responsible for the dental students' attitudes toward more environmentally-sustainable dentistry. Additionally, a recent poster presentation from Harvard School of Dental Medicine and Queen Mary University in London established that while dental students and faculty report a low level of familiarity with environmental sustainability in dentistry, the majority show a high degree of interest in learning more about the topic and incorporating environmentally-sustainable dentistry (ESD) into the formal curriculum (Lee and Parchure 2021). Similar findings were reported by an even more recent paper, indicating that a majority of dental students surveyed across the U.S. believe that it is important to learn ESD principles while in dental school (Gershberg et al. 2022).

Problem Statement

Despite the dental clinic sustainability project in Michigan and the recent works evaluating dental students' interest in learning more about ESD, there have been no peer-reviewed publications to date reporting on U.S. dental students' attitudes toward climate change, the factors that may affect those attitudes, and the barriers that they see that could prevent them from implementing climate-friendly policies in their future offices. More specifically, no research has investigated the role of individual demographic characteristics including geographic or regional upbringing, socioeconomic status during childhood, or prior climate-related education in affecting dental students' attitudes toward climate change. Additionally, no investigation has been done to evaluate the differences in attitude between students in different years of dental education. This study aims to assess the level of understanding of climate change among dental students as well as the varying geographic, socioeconomic, and educational factors that may influence these attitudes.

Hypotheses

1. There will be a difference in the knowledge of climate change between dental students based on their individual demographic factors including home location, socioeconomic status, year in dental school, and previous education.
2. There will be a difference in attitude toward climate change between dental students based on their individual demographic factors including home location, socioeconomic status, year in dental school, and previous education.
3. A lack of knowledge of environmentally-sustainable dentistry will be the most commonly-cited perceived barrier that dental students see that may prevent them from implementing environmentally-sustainable practices and policies in their future offices.

CHAPTER 2

MATERIALS AND METHODS

Survey Development and Description

To investigate the knowledge and attitudes of dental students with respect to climate change and dentistry's impact, a twenty-item survey was constructed. The survey included questions aimed at acquiring information on students' demographics, their knowledge of and attitudes toward climate change, their level of interest in using ESD in dental school and their future practices, and the barriers they see that may prevent them from implementing climate-friendly practices in their future offices.

The twenty-item survey was divided into four domains. The first domain, student demographics, collected information about the students' demographic characteristics, including their anticipated year of graduation, their gender, their geographic region of upbringing, their socioeconomic status during childhood, and the frequency with which they use environmentally-friendly behaviors in their home life. Socioeconomic status was determined using the Socioeconomic Status and Education/Occupation Indicator provided by the American Dental Education Association's (ADEA) Associated American Dental Schools Application Service (American Dental Education Association 2016). This tool utilizes four education levels and two aggregate groups of occupations to determine the Education/Occupation indicator for each student. According to the criteria presented by ADEA, a student whose parents have less than a bachelor's degree and work in the service/clerical/labor industry is considered to be from a socioeconomically disadvantaged background. This survey slightly modified the ADEA model, in that the ADEA model requires information about both parents. In this survey, the student answered based only on

their most educated parent. An additional item in the first domain elicited the students' prior classroom-based educational exposure to climate change. The final question in the first domain prompted information regarding the frequency with which students use environmentally-friendly behaviors at home.

The second domain, student knowledge of climate change, aimed at evaluating the degree to which the students knew about climate change. The three items in this domain were constructed based on several climate change-related studies that were previously cited. The information gathered in this domain allowed for testing of the first hypothesis by correlating student demographic characteristics to their responses in the second domain, which evaluated their knowledge of climate change.

The third domain, student attitudes toward climate change, was comprised of nine items that elicited information regarding student attitudes toward climate change, including their current and planned future behaviors concerning ESD. The information gathered in this domain allowed for the testing of the second hypothesis by correlating their demographic characteristics to their responses in this third domain regarding attitude toward climate change.

The fourth and final domain, barriers, consisted of a single item. This item was aimed at collecting information about the barriers perceived by students that may prevent the implementation of environmentally-sustainable policies in their future offices. This item was constructed to answer the third hypothesis by obtaining information from dental students about these perceived barriers if any.

During survey development, the Committee provided feedback regarding question clarity and necessity. This feedback was used to revise the survey. A focus group of

Advanced Periodontics residents then reviewed the survey and discussed any previously unforeseen problems with the questions. After making updates to the survey based on the focus group's feedback, the survey was given to three faculty in the Department of Public Health. The questions were again updated to reflect their feedback and suggestions for questions.

After updates were made to the survey based on faculty members' feedback, the survey was given to a group of current D4 Summer Scholars to review and provide feedback. These Summer Scholars, graduating in May of 2021, were no longer students at the dental school at the time of survey distribution. Modifications were made according to their responses and the survey was finalized.

The final version of the survey was developed in REDCap (Research Electronic Data Capture) for distribution. Study data were collected and managed using REDCap electronic data capture tools hosted at UMKC. REDCap is a secure, web-based software platform designed to support data capture for research studies, providing 1) an intuitive interface for validated data capture; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for data integration and interoperability with external sources (Harris et al. 2009; Harris et al. 2019). The final version of the survey is included in Appendix 1.

Survey Distribution and Data Collection

Following review and approval of the classroom script and the survey by the University of Missouri – Kansas City (UMKC) Institutional Review Board (IRB), the survey was distributed to UMKC dental students (Classes of 2022, 2023, 2024, and 2025). The approval letter from the IRB is included in Appendix 2.

All members of the D1 class (109), D2 class (109), D3 class (105), and D4 class (109) were potential participants. The survey was administered via REDCap to each dental school class during designated class time in the first half of the Fall semester. For the D1 class, this occurred during the Dental Ethics course, for the D2 class, during the Patient Care III course, for the D3 class, during the Behavioral Science course, and for the D4 class, during the Special Needs course. The course director of each of the aforementioned courses approved the use of class time for survey participation. The Committee Chair introduced and explained the survey to each respective class using the Verbal Classroom script, which is included in Appendix 3. A link and/or QR code to the REDCap survey was available on each respective course's Canvas site. Students were given approximately 10 minutes in class to complete the survey.

Experimental Design

This cross-sectional study utilized a non-experimental design. The dependent variables to be assessed were (1) Student knowledge of climate change, (2) Student attitude toward climate change, and (3) Potential barriers seen by the student which may prevent the use of environmentally-sustainable office practices. Student demographics were the independent variable, with six specific demographic features. Table 1 outlines the experimental design with specifics regarding the dependent and independent variables. The sample size was a convenience sample based on the number of respondents from the potential maximums of 109 D1 students, 109 D2 students, 105 D3 students, and 109 D4 students.

TABLE 1

EXPERIMENTAL DESIGN: INDEPENDENT AND DEPENDENT VARIABLE SPECIFICS

Independent variables	Specific details of Student demographics	Dependent variables
Student demographics	Dental school year (Q1)	1.) Student knowledge of climate change (composite score of Q8-10) 2.) Student attitude toward climate change (Q11-19) 3.) Barriers seen by student regarding environmentally-sustainable office practices (Q20)
	Gender (Q2)	
	Region of upbringing (Q3)	
	Socioeconomic status during upbringing (Q4/5)	
	Prior climate change-related educational experience (Q6)	
	Environmentally-friendly habits at home (Q7)	

Sample size (n) = number of respondents out of 432 UMKC dental students

Data Analysis

Data collected from the items in the survey were entered into a statistics software program[1]. Descriptive statistics (counts and percentages) were calculated for all variables within each domain from the survey data. Demographic information regarding gender was recategorized into two variables, “Male” and “Female.” Additionally, region of upbringing was recategorized into two variables, “Midwest” and “Outside Midwest.” The Socioeconomic Status variable was recategorized as “Low” and “Not Low” determined using the previously-discussed ADEA EO/IO indicator tool. Per this indicator tool, students who selected both that their most educated parent had obtained less than a bachelor’s degree and

[1] SPSS Statistics for Windows, Version 26.0, IBM Corp. Armonk, NY 10504

work in the service, clerical, or labor industry were considered “Low” socioeconomic status. Student use of environmentally-friendly home behaviors was recategorized into two variables, “Often” and “Not often.” Students who responded either “Always” and “Almost always” in response to the question “How often do you prioritize environmentally-friendly actions in your home life?” were considered to “Often” use these behaviors.

In addition, for the second domain, student knowledge of climate change, a composite score was generated. This allowed the same types of questions to be compared as a group instead of comparing individual questions. Items 8-10 on the survey had a minimum possible score of 0 and a maximum possible score of 3. Higher scores of 2 to 3 correct answers indicated that the student had a higher level of objective knowledge about climate change and its relationship with the healthcare industry as well as dentistry, while lower scores of 0 to 1 correct answers indicated that the student had a lower level of objective knowledge about climate change. The third domain, attitude toward climate change, was not converted to a composite score. This allowed for each item to be addressed individually rather than as a group.

Chi-squared and Fisher’s exact tests were used to evaluate the associations between student demographics on student knowledge of and student attitude toward climate change. Significance for all testing was set at ($\alpha = 0.05$).

CHAPTER 3

RESULTS

Demographics

The survey was distributed to 432 UMKC dental students, of which 95 initiated and completed the survey, with an overall response rate of 22%. Table 2 summarizes the student demographic information. The greatest response rate came from dental students in their fourth year of dental school (34%), and a slight majority of respondents identified as female (51%). A majority of respondents lived for most of their childhood in the Midwest (82%). Twelve respondents (13%) were of low socioeconomic status, as defined by an Education/Occupation Indicator score of EO-1. A majority of respondents had learned about climate change in high school classes (74%), college classes (63%), or on their own, outside of class (63%), while 3% of respondents reported having no experience with climate change-related education. Additionally, 73% of students reported often prioritizing environmentally-friendly actions in their home life.

TABLE 2

RELATIONSHIP BETWEEN DEMOGRAPHIC CHARACTERISTICS AND LEVEL OF KNOWLEDGE OF CLIMATE CHANGE

		Knowledge Level		
	Overall N = 95 N (%)	Low N = 42 N (%)	High N = 53 N (%)	P-value[†]
Dental school year				0.263
1st	13 (14%)	7 (54%)	6 (46%)	
2nd	20 (21%)	9 (45%)	11 (55%)	
3rd	30 (32%)	9 (30%)	21 (70%)	
4th	32 (34%)	17 (53%)	15 (47%)	
Gender				0.049
Female	48 (51%)	25 (52%)	23 (48%)	
Male	44 (46%)	14 (32%)	30 (68%)	
Region of Upbringing				0.794
Midwest	78 (82%)	34 (44%)	44 (56%)	
Outside Midwest	17 (18%)	8 (47%)	9 (53%)	
Prior climate change related education				0.582[‡]
No	3 (3%)	2 (67%)	1 (33%)	
Yes	92 (97%)	40 (44%)	52 (56%)	
Prior climate change-related education in				
High school class				0.020
No	25 (26%)	16 (64%)	9 (36%)	
Yes	70 (74%)	26 (37%)	44 (63%)	
College class				0.053
No	35 (37%)	20 (57%)	15 (43%)	
Yes	60 (63%)	22 (37%)	38 (63%)	
Outside of class				0.279
No	35 (37%)	18 (51%)	17 (49%)	
Yes	60 (63%)	24 (40%)	36 (60%)	
Socioeconomic Status				0.417
Low	12 (13%)	4 (33%)	8 (67%)	
Not low	83 (87%)	38 (46%)	45 (54%)	
Environmentally-friendly home behaviors				0.104
Often	69 (73%)	27 (39%)	42 (61%)	
Not often	26 (27%)	15 (58%)	11 (42%)	

[†]Calculated using a Chi-square or [‡]Fisher's Exact Test

Climate Knowledge

As can be noted in Figure 1, respondents' knowledge about climate change was mixed. Overall climate knowledge was found to be high in 56% of respondents and low in 44% of respondents. The majority of respondents (77%) were able to correctly identify that the general trend in global temperature has increased over the last century. Nearly three-quarters of participants (73%) identified the correct percentage range of GHG emissions produced by the U.S. healthcare sector. However, only 1% of students correctly selected that the majority of dentistry-related GHG emissions are produced by the commuting of staff and patients.

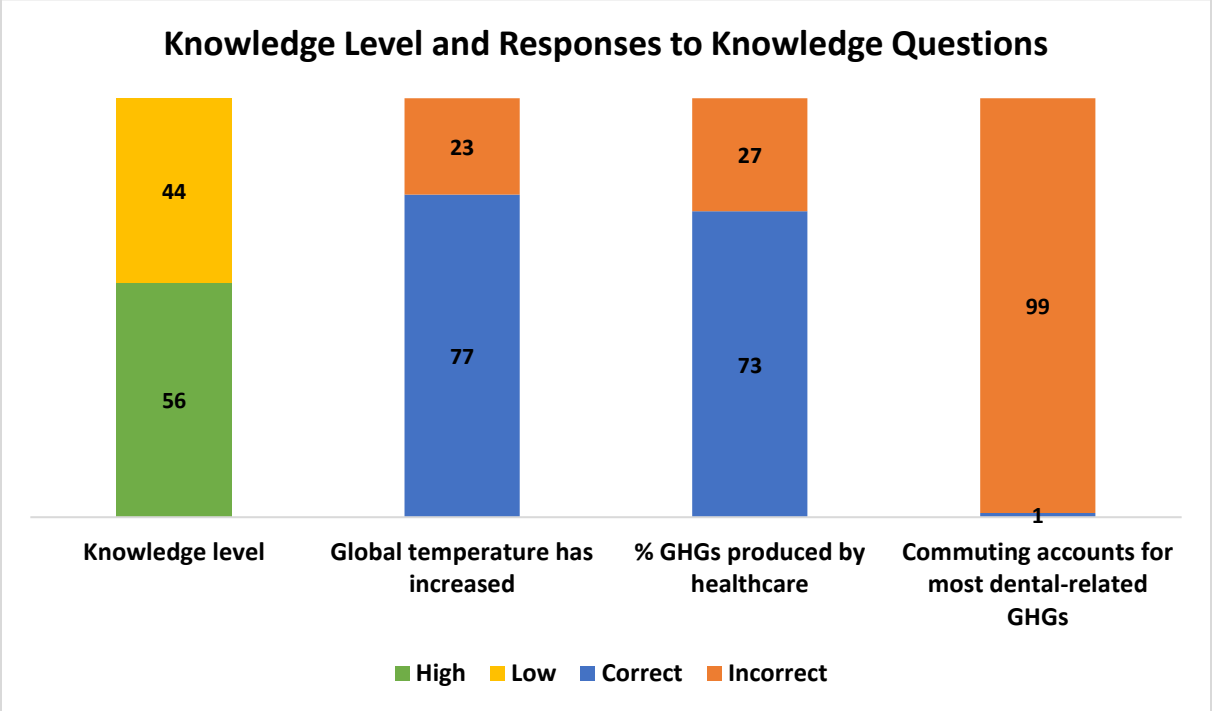

Figure 1. Overall percentages of respondents' high and low levels of climate change-related knowledge and percentages of correct and incorrect responses to climate knowledge-based questions.

Table 2 also shows the relationship between student demographics and knowledge of climate change. There was a significant association between climate knowledge and gender

along with prior climate-related education during high school. Male respondents were more likely to have a higher level of climate knowledge than females (68% vs 48%, p = 0.049). Students who reported having been exposed to climate change-related education in high school were also more likely to have a high level of climate knowledge than those who were not (63% vs 36%, p = 0.020). This association did not exist for students reporting climate-related education in college, outside of class, or no educational experience, though college class experience nearly reached significance (p = 0.053). Year in dental school, childhood location, SES, and use of environmentally friendly home behaviors were not significantly associated with climate change knowledge.

Attitudes Toward Climate Change

Figure 2 illustrates the percentage of respondents who reported agreement with various statements about climate change and dentistry. The majority of students (75%) selected that climate change is occurring primarily as a result of human activities.

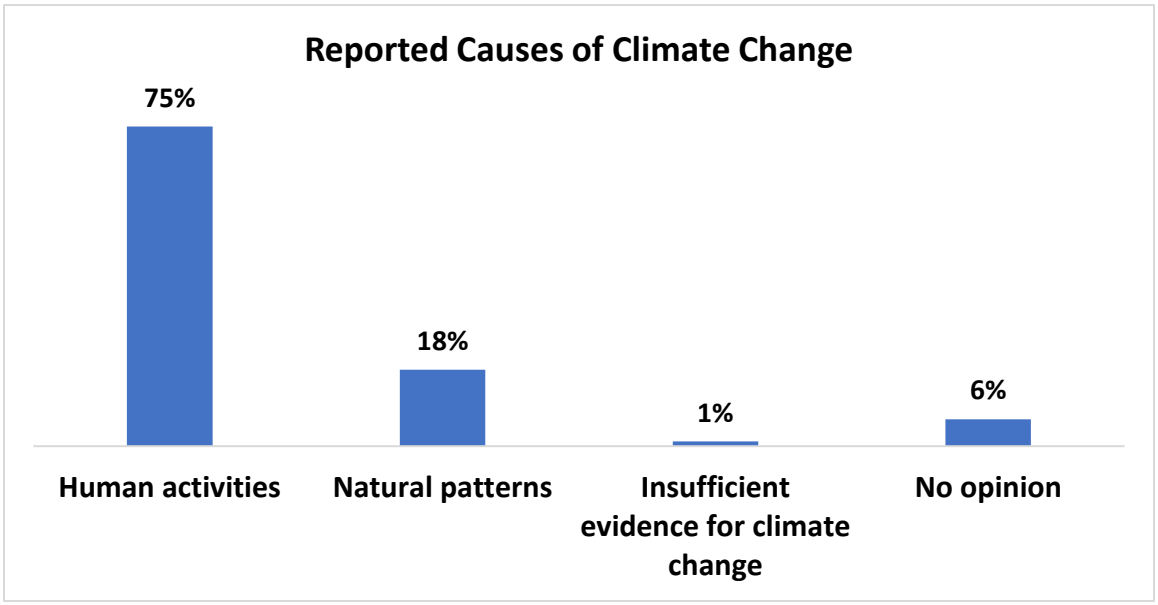

Figure 2. Reported attitude toward the cause of climate change.

Figure 3 summarizes the respondents' attitudes toward climate change. The majority strongly agreed/agreed with all opinions except "currently prioritize sustainability in product use" (40%). The most positive responses were for "Dental professionals have a responsibility to conserve resources (90%). Fewer students reported current use of ESD principles in product use (40%) and waste disposal (66%) than plan to do so in the future (68% and 87%, respectively). A majority of students (72%) reported an interest in learning more about ESD.

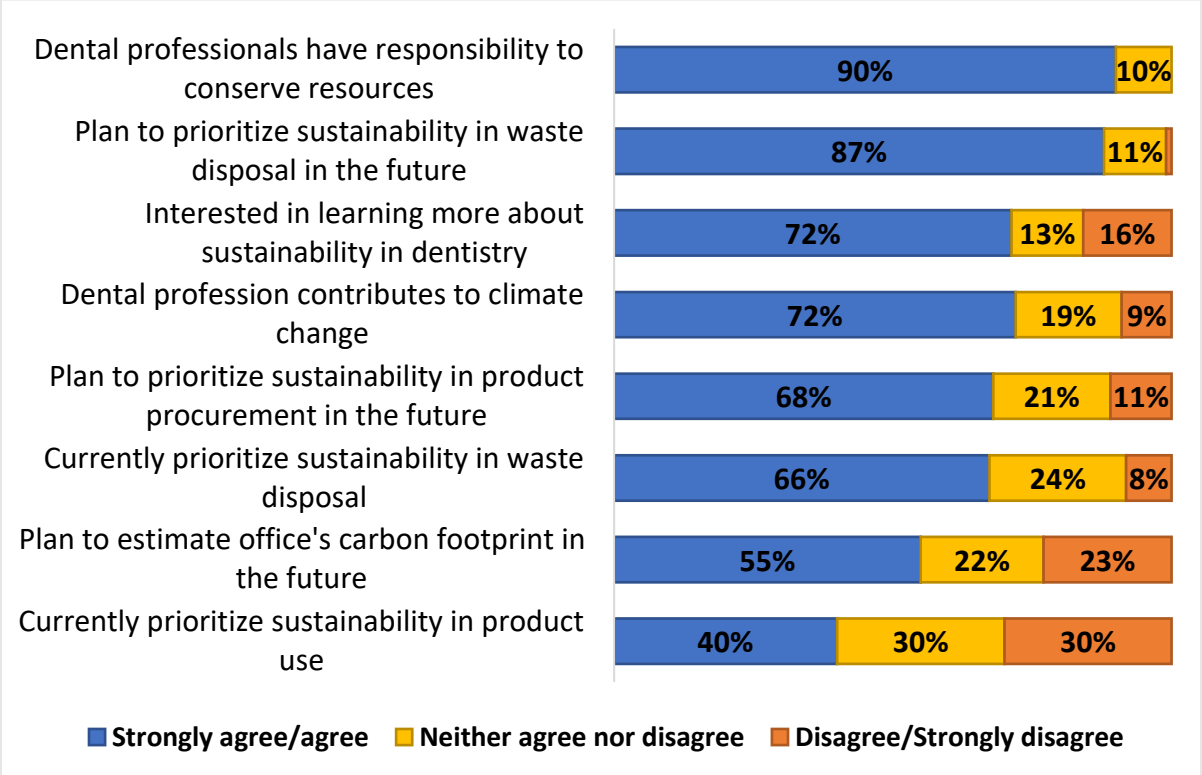

Figure 3. Summary of respondents' attitudes toward climate change.

Year in Dental School

Table 3 demonstrates the relationships between year in dental school and attitude toward climate change. Class year was significantly associated with several components of attitude, though no fully consistent pattern was noted across years. First- and fourth-year students were more likely to disagree that they plan to prioritize ESD in waste disposal

compared to other classes (23% and 22%, respectively, vs 0% of 2nd years and 9% of 3rd years, respectively, $p = 0.016$). Second- and fourth-year students were more likely to disagree that they plan to monitor their offices' carbon footprints (60% and 59%, respectively, vs 31% of 1st years and 27% of 3rd years, $p = 0.022$). And while a majority of respondents from each year did report an interest in learning more about ESD principles, second- and fourth-year students were again more likely to disagree than other classes (40% and 37%, respectively, vs 31% of 1st years and 10% of 3rd years, $p = 0.037$).

TABLE 3

RELATIONSHIP BETWEEN YEAR IN DENTAL SCHOOL AND ATTITUDE TOWARD CLIMATE CHANGE

	Overall N = 95	Dental school year				
	N (%)	1st	2nd	3rd	4th	P-value[†]
Climate change as the result of human activities						0.304[‡]
Agree	71 (74%)	9 (69%)	14 (70%)	26 (87%)	22 (69%)	
Do not agree	24 (26%)	4 (31%)	6 (30%)	4 (13%)	10 (31%)	
Dental profession contributes to climate change						0.675[‡]
Agree	68 (72%)	11 (85%)	13 (65%)	22 (73%)	22 (69%)	
Do not agree	27 (28%)	2 (15%)	7 (35%)	8 (27%)	10 (31%)	
Dental professionals have responsibility to conserve resources						0.619[‡]
Agree	85 (90%)	11 (85%)	17 (85%)	27 (90%)	30 (94%)	
Do not agree	10 (10%)	2 (15%)	3 (15%)	3 (10%)	2 (6%)	
Currently prioritize sustainability in product use						0.292
Agree	38 (40%)	8 (62%)	6 (30%)	13 (43%)	11 (35%)	
Do not agree	56 (59%)	5 (38%)	14 (70%)	17 (57%)	20 (65%)	
Currently prioritize sustainability in waste disposal						0.788[‡]
Agree	63 (66%)	9 (69%)	13 (65%)	22 (73%)	19 (61%)	
Do not agree	31 (33%)	4 (31%)	7 (35%)	8 (27%)	12 (39%)	
Future plans to prioritize sustainability in product procurement						0.158[‡]
Agree	65 (68%)	10 (77%)	16 (80%)	22 (73%)	17 (53%)	
Do not agree	30 (32%)	3 (23%)	4 (20%)	8 (27%)	15 (47%)	
Future plans to prioritize sustainability in waste disposal						0.016[‡]
Agree	83 (87%)	10 (77%)	20 (100%)	28 (97%)	25 (78%)	
Do not agree	11 (12%)	3 (23%)	0 (0%)	1 (3%)	7 (22%)	
Future plans to estimate office's carbon footprint						0.022
Agree	52 (55%)	9 (69%)	8 (40%)	22 (73%)	13 (41%)	
Do not agree	43 (45%)	4 (31%)	12 (60%)	8 (27%)	19 (59%)	
Interest in learning more about sustainability in dentistry						0.037[‡]
Agree	68 (72%)	9 (69%)	12 (60%)	27 (73%)	20 (63%)	
Do not agree	27 (28%)	4 (31%)	8 (40%)	3 (27%)	12 (37%)	

[†]Calculated using a Chi-square or [‡]Fisher's Exact Test

Gender and Environmentally-Friendly Home Behaviors

Table 4 illustrates the relationships between student gender and environmentally-friendly home behaviors with attitude toward climate change. Student gender was significantly associated with two components of attitude toward climate change, future plans to prioritize sustainability in product placement and in waste disposal. Female students were more likely to agree with the statement that they planned to prioritize ESD in product procurement (79% vs 59%) and waste disposal (96% vs 76%) compared to males ($p = 0.037$ and $p = 0.018$, respectively). However, there was no significant relationship between gender and current use of ESD principles.

The demographic variable with the most consistent significant association with attitude toward climate change was the use of environmentally-friendly home behaviors. Students who reported often utilizing sustainable practices in their home life were more likely to agree that climate change is occurring primarily as the result of human activities (81% vs 58%, $p = 0.019$), that the dental profession contributes to climate change (78% vs 54%, $p = 0.019$), and that dental professionals have an ethical obligation to conserve resources (94% vs 77%, $p =0.023$) than those who use sustainable practices at home less often. Additionally, students who reported using environmentally-friendly behaviors in their home life were significantly more likely to prioritize sustainability in their use of products in dental labs and clinics (51% vs 12%, $p < 0.001$) and have more interest in learning more about ESD (81% vs 46%, $p < 0.001$) than those who use sustainable practices at home less often.

TABLE 4

RELATIONSHIP BETWEEN GENDER AND FREQUENCY OF USING ENVIRONMENTALLY-FRIENDLY BEHAVIOR AT HOME AND ATTITUDE TOWARD CLIMATE CHANGE

	Gender		Using environmentally-friendly behavior at home	
	Female	Male	Often	Not often
Climate change is primarily the result of human activities				
Agree	35 (73%)	34 (77%)	56 (81%)	15 (58%)
Do not agree	13 (27%)	10 (23%)	13 (19%)	11 (42%)
P-value†	0.630		0.019	
Dental profession contributes to climate change				
Agree	39 (81%)	28 (64%)	54 (78%)	14 (54%)
Do not agree	9 (19%)	16 (36%)	15 (22%)	12 (46%)
P-value†	0.058		0.019	
Dental professionals have responsibility to conserve resources				
Agree	43 (90%)	39 (89%)	65 (94%)	20 (77%)
Do not agree	5 (10%)	5 (11%)	4 (6%)	6 (23%)
P-value†	0.884‡		0.023‡	
Currently prioritize sustainability in product use				
Agree	20 (43%)	17 (39%)	35 (51%)	3 (12%)
Do not agree	27 (57%)	27 (61%)	34 (49%)	22 (88%)
P-value†	0.704		<0.001	
Currently prioritize sustainability in waste disposal				
Agree	34 (72%)	27 (61%)	50 (73%)	13 (52%)
Do not agree	13 (28%)	17 (39%)	19 (28%)	12 (48%)
P-value†	0.266		0.062	
Future plans to prioritize sustainability in product procurement				
Agree	38 (79%)	26 (59%)	51 (74%)	14 (54%)
Do not agree	10 (21%)	18 (41%)	18 (26%)	12 (46%)
P-value†	0.037		0.061	
Future plans to prioritize sustainability in waste disposal				
Agree	45 (96%)	35 (79%)	62 (91%)	21 (81%)
Do not agree	2 (4%)	9 (21%)	6 (9%)	5 (19%)
P-value†	0.018‡		0.170‡	
Future plans to estimate office's carbon footprint				
Agree	30 (63%)	21 (48%)	41 (81%)	11 (42%)
Do not agree	18 (37%)	23 (52%)	28 (19%)	15 (58%)
P-value†	0.154		0.135	
Interest in learning more about sustainability in dentistry				
Agree	38 (79%)	29 (66%)	56 (81%)	12 (46%)
Do not agree	10 (21%)	15 (34%)	13 (19%)	14 (54%)
P-value†	0.153		<0.001	

†Calculated using a Chi-square or ‡Fisher's Exact Test

Prior Climate Change-Related Education

Table 5 provides data regarding the associations between prior climate change-related education and attitude toward the subject. Students who had educational exposure on their own, outside of class were significantly more likely to agree than disagree that climate change is occurring primarily due to human influence (69% vs 46%, $p = 0.042$) and that the dental profession contributes to climate change (71% vs 44%, $p = 0.017$). Students reporting exposure to climate change-related education during college were more likely to agree than disagree that the dental profession should conserve resources (68% vs 20%, $p = 0.005$) and that they currently prioritized environmental sustainability in their product use (82% vs 50%, $p = 0.002$).

Students who reported having no educational experience related to climate change were significantly more likely to disagree than agree with the statement that they plan to prioritize ESD in considering product procurement (10% vs 0%, $p = 0.029$) or in waste disposal (18% vs 1%, $p = 0.035$). These respondents were also more likely to disagree than agree that they are interested in learning more about ESD (11% vs 0%, $p = 0.021$).

Region of upbringing, socioeconomic status during upbringing, and level of climate knowledge demonstrated no significant association with any component of attitude toward climate change (data not shown).

TABLE 5

RELATIONSHIP BETWEEN PRIOR EXPOSURE TO CLIMATE CHANGE-RELATED EDUCATION AND ATTITUDE TOWARD CLIMATE CHANGE

	High school class	College class	Outside of class	No education
	N = 70	N = 60	N = 60	N = 3
	N (%)	N (%)	N (%)	N (%)
Climate change is primarily the result of human activities				
Agree	52 (73%)	46 (65%)	49 (69%)	1 (1%)
Do not agree	18 (75%)	14 (58%)	11 (46%)	2 (8%)
P-value†	0.866	0.571	0.042	0.094
Dental profession contributes to climate change				
Agree	51 (75%)	46 (68%)	48 (71%)	1 (1%)
Do not agree	19 (70%)	14 (52%)	12 (44%)	2 (7%)
P-value†	0.644	0.150	0.017	0.194‡
Dental professionals have responsibility to conserve resources				
Agree	64 (75%)	58 (68%)	56 (66%)	2 (2%)
Do not agree	6 (60%)	2 (20%)	4 (40%)	1 (10%)
P-value†	0.447‡	0.005‡	0.164‡	0.286‡
Currently prioritize sustainability in product use				
Agree	31 (82%)	31 (82%)	27 (72%)	0 (0%)
Do not agree	38 (68%)	28 (50%)	33 (59%)	3 (5%)
P-value†	0.140	0.002	0.230	0.270
Currently prioritize sustainability in waste disposal				
Agree	47 (75%)	42 (67%)	42 (67%)	1 (2%)
Do not agree	22 (71%)	17 (55%)	18 (58%)	2 (7%)
P-value†	0.708	0.265	0.414	0.252‡
Future plans to prioritize sustainability in product procurement				
Agree	46 (71%)	44 (68%)	41 (63%)	0 (0%)
Do not agree	24 (80%)	16 (53%)	19 (63%)	3 (10%)
P-value†	0.342	0.177	0.981‡	0.029‡
Future plans to prioritize sustainability in waste disposal				
Agree	60 (72%)	52 (63%)	53 (64%)	1 (1%)
Do not agree	9 (82%)	7 (64%)	6 (55%)	2 (18%)
P-value†	0.721‡	1.000‡	0.741‡	0.035‡
Future plans to estimate office's carbon footprint				
Agree	38 (73%)	37 (71%)	34 (65%)	0 (0%)
Do not agree	32 (74%)	23 (54%)	26 (61%)	3 (7%)
P-value†	0.882	0.076	0.621	0.089‡
Interest in learning more about sustainability in dentistry				
Agree	50 (74%)	44 (65%)	46 (68%)	0 (0%)
Do not agree	20 (74%)	16 (59%)	14 (52%)	3 (11%)
P-value†	0.957	0.620	0.150	0.021‡

†Calculated using a Chi-square or ‡Fisher's Exact Test

Barriers

Figure 4 shows some of the responses to the survey question regarding perceived barriers that may prevent students from using environmentally-sustainable practices and policies in their future offices. A majority of respondents (92%) selected that they perceived that environmentally-sustainable policies may cost more. Only 47% of respondents selected a lack of knowledge about ESD as a barrier to their implementation. In the write-in responses, half of the students reflected that infection control policies seem to necessitate the use of disposable or single-use items to maintain adequate sanitation. Themes including a lack of infrastructure and effectiveness for environmentally-sustainable practices were also written in as perceived barriers in three out of the eight write-in responses.

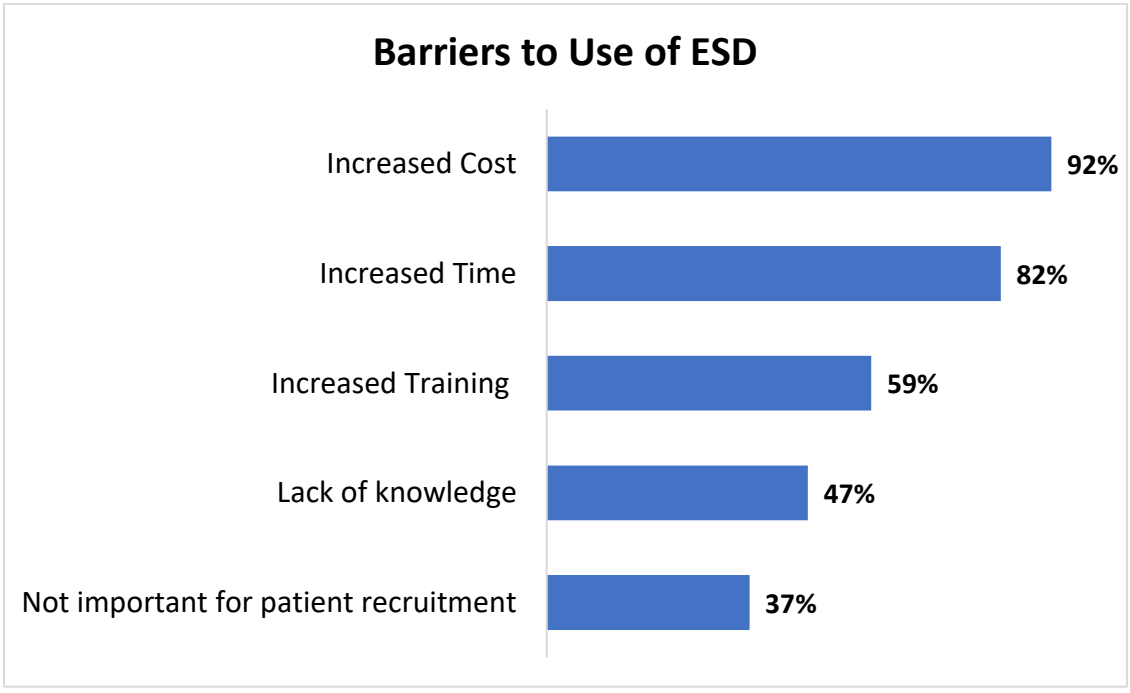

Figure 4. Perceived barriers that may prevent the use of environmentally-sustainable office policies and practices. No students selected the option for "no barriers exist." Students could select more than one option; will not sum to 100%.

CHAPTER 4

DISCUSSION

This study evaluated dental students' knowledge of and attitude toward climate change in a Midwestern dental school. Previous studies have evaluated medical students' awareness and attitudes toward climate change, but none have yet been used to evaluate the overall knowledge or attitudes of dental students in the U.S. Similar to the current study's findings, several previous studies on dentists or dental students found high levels of interest in learning about ESD (Diffley et al. 2019; Lee and Parchure 2021; Gershberg et al. 2022). However, while the aforementioned studies and this project both evaluated the degree of student interest in learning more about ESD, no other published works examined demographic characteristics associated with either knowledge of or attitude toward climate change.

Significant Demographic Factors

The survey results show that both gender and previous climate change-related education are significantly associated with dental students' knowledge of and attitude toward climate change. However, utilization of environmentally-friendly behaviors at home and student year in dental school year are significantly associated with attitude toward climate change only. Surprisingly, there is no correlation between overall knowledge of climate change and attitude.

Knowledge of Climate Change

Over 70% of respondents in this survey correctly identified that the general trend in global temperature has increased over the last century, and that the U.S. healthcare sector produces between 1-25% of the country's GHG emissions. The results differ from a recent

study of medical, physician assistant, and nursing students, which found only 38% of students could accurately identify that the U.S. healthcare sector produces 10% of the nation's GHG emissions (Ryan et al. 2020). This may indicate that dental students at UMKC have a greater knowledge of climate change than the group surveyed by the other study. More likely, the difference found here may be that the previous study had a narrower range of percentages to choose from for a response; if this study had presented smaller ranges of options to choose from, the results may have been similar to those of Ryan et al. (2020).

Interestingly, most respondents selected either waste production and processing or product procurement as the primary causes of dentistry-related GHG emissions, and only 1% of students correctly identified that the majority of these emissions are the result of patient and staff commuting. However, it has been demonstrated that waste management and product procurement account for only 0.2% and 19.0% of dentistry's carbon footprint, respectively (Duane et al. 2017). This gap in knowledge and the respondents' limited focus on dentistry's waste production leaves an opportunity for education. Many students may not recognize that limiting staff and patient commuting can reduce GHG emissions. By informing students of their profession's impact on the environment, and perhaps incorporating more aspects of teledentistry into the dental school curriculum, students may become more aware of both their impact on the environment and ways to minimize said impact.

This study found that the male gender was associated with a higher level of climate-related knowledge, opposing the findings of other works which suggest that either women are more likely to have a higher awareness or that no significance exists between genders (McCright 2010; Felicilda-Reynaldo et al. 2018). The difference could be related to either the

sample size or the population; the sample available at the UMKC dental school is likely not representative of the entire population of the U.S. as surveyed by McCright (2010).

Exposure to climate change-related education during high school was also significantly associated with a high level of climate knowledge, while exposure in college class neared significance with a p-value of 0.053. If the sample size was larger, a significant relationship may have been seen between college education and a high level of knowledge. Learning about climate change on one's own, outside of class had no association with knowledge level. This suggests that formal education is necessary to instill a sufficient level of climate change-related knowledge. Considering that in this study, only 56% of students had an overall high level of climate knowledge, the data also suggests that there may be a benefit to including climate-related education in the dental school curriculum.

Of note is that there was no significant relationship between knowledge of climate change and attitude toward climate change. This contrasts with the findings of other studies, in which healthcare professional students who disagreed that they were concerned about pollution from healthcare were significantly more likely to have low knowledge of the carbon footprint of the U.S. healthcare sector (Ryan et al. 2020). One possible reason for this discrepancy is, again, the lack of education about ESD. Students may have a high knowledge level of climate change but may be unaware of the role that dental professionals play in producing GHGs. They may also have limited knowledge of how to reduce their impact. This is supported by the data collected in the present report, which showed that only a single student was able to correctly identify commuting as the main source of dentistry-related GHG emissions. If students do not truly understand the mechanisms by which they produce GHGs and contribute to climate change, they are unable to modify these behaviors and act

more sustainably. If students are provided with more education in this area, the results may be different.

Attitude toward Climate Change

As with awareness of climate change, gender presented a significant association with attitude. Female students were more likely than males to agree that they planned to prioritize environmental sustainability in future practices regarding either product procurement or waste disposal. These findings are similar to those from Ryan et al. (2020).

The data collected in this study demonstrated that students with educational exposure to climate change in college classes were significantly more likely to prioritize sustainability in their product use. Moreover, students who reported no education related to climate change were significantly more likely to disagree that they planned to prioritize ESD in the future, either for product procurement or waste disposal, and to disagree that they were interested in learning more about sustainability in dentistry. This low interest may be due to a lack of exposure to the subject. If students are exposed to climate-related educational experiences within the dental school curriculum, more students may plan to use more environmentally-sustainable policies in their future offices.

While not significant, it is of note that fewer students reported currently prioritizing environmentally-sustainable practices for product use and waste disposal than reported planning to do so in the future. This disconnect may result from several factors. For example, students working in labs or clinics may not be able to fully control the extent of their product use. Infection control policies within the dental school clinics require the application of disposable barriers to wipeable surfaces which do not necessitate barrier application. Thus, students are currently obligated to use more products than may be truly needed. Further, there

are currently no options for recycling within the clinics, and all waste is divided into either biohazard or nonclinical waste bins. As a result, students are improperly disposing of otherwise recyclable items. The responding students may recognize these barriers preventing the current use of environmentally-sustainable practices and plan to act differently in the future.

Dental school year was also a significant predictor of attitude toward climate change. Overall, a majority of students agreed that they plan to prioritize ESD in waste disposal, though first- and fourth-year students were significantly more likely than other classes to disagree with this statement. Additionally, second- and fourth-year students were significantly more likely to disagree that they planned to monitor their offices' carbon footprints and were significantly more likely to disagree with an interest in learning more about ESD.

The findings here contrast with a study of nursing students' attitudes toward climate change and sustainability, in which year of training had no significant relationship with attitude (Cruz et al. 2018). However, the previously-mentioned study only evaluated sophomores and juniors, with seniors excluded. If seniors had been included, a different result may have been noted. In the present study, the year of training may play a role because of the structure of the academic and didactic experience within the UMKC dental school. First-year students may be less concerned with waste production because they have not been exposed to product use in the clinics and may be unaware of the volume of waste produced in the course of patient care. Second-year students at UMKC also have a very heavy didactic load and may be unwilling to add any further educational burden associated with didactic exposure to ESD. Fourth-year students may also be more concerned about the costs of

running a future practice. From data collected in the Barriers domain of the survey, 92% of students perceived that there may be increased costs associated with environmentally-sustainable dentistry. As they near graduation, students may have a heightened awareness of the financial considerations involved in running a dental office, as well as the repayment of student debt. Assuming that environmentally-friendly dentistry has increased costs, they may be less likely to plan to use such practices.

Lastly, the frequency of using environmentally-friendly policies at home had a significant relationship with attitude toward climate change. In alignment with other research, those who often prioritized sustainability in their home life were more likely to believe that climate change is occurring primarily due to human causes, to agree that the dental profession contributes to climate change, and to agree that dental professionals must conserve resources (Grose et al. 2016). Interestingly, there was no relationship between sustainability at home and plans for using sustainable policies in their future offices. This may be due to various perceived barriers including increased cost, time, and staff training. Students may be more comfortable using environmentally-friendly behaviors at home, where these complicating factors do not come into play. While the primary goal of dentistry is to provide care for patients, operating a dental office is also a business, and finances play an issue in decision-making. If students perceive that increased costs are involved with sustainable dentistry, they may be less likely to plan to adopt those policies in the future. In order to inform students about the importance of the environmental impact of clinical dentistry, it could therefore be beneficial to introduce more climate change-related education into the dental school curriculum.

Barriers

The purpose of this domain was to perform a quantitative assessment of which barriers to ESD use were most commonly selected, therefore in-depth analyses of the write-in responses were not conducted. However, notable themes that arose from the data collected included concerns about cost, time, training, and lack of knowledge as barriers to the future use of ESD. These findings are consistent with other recent studies of dental professionals. One such review found that time was considered to be the most important barrier, though infrastructural barriers such as costs and the difficulty of ensuring that suppliers and manufacturers of dental products are acting sustainably were also commonly-cited concerns (de Leon 2020).

Additional comments from respondents tended to reinforce the presence of infrastructural barriers to the use of ESD. Several students replied that current infection control measures seem to necessitate the use of disposable items. They suggested that there may be no alternative options to single-use items, and that waste production seems unavoidable. These comments again have a narrow range of focus on the production of waste in dentistry, which has a relatively minor contribution to dentistry's carbon footprint. That students are heavily focused on waste production rather than the GHGs produced by staff and patient commuting, or those related to product procurement implies a lack of knowledge and education on the topic. This underscores the importance of incorporating ESD into predoctoral dental curricula.

Most students (92%) selected cost as the primary barrier which would prevent the use of ESD in practice. However, utilization of ESD principles is not always less cost-effective than running a practice without consideration of sustainability. It has been proposed that

properly recycling items rather than disposing of sterile wrappings and barriers as clinical waste not only lowers dental GHG emissions but may also be more profitable for the dental practice (Richardson et al. 2016). Purchasing products that are sterilizable and reusable rather than disposable may reduce costs in the long run, and ensuring that an office is operating in an energy-efficient manner by turning off lights and computer monitors while not in use can also save on utility bills (Duane et al. 2019b). Based on the results of this study, it is unlikely that the dental students surveyed are aware that ESD policies are not necessarily expensive. By implementing ESD-focused education within the dental school curriculum, dental students may be less likely to find cost as a major barrier that would prevent them from using ESD principles in practice.

In this study, 47% of students reported a lack of knowledge of ESD as a barrier to its use. However, 72% of respondents indicated that they were interested in learning more about the topic. The results here are consistent with other published data suggesting that dental students believe learning about ESD in dental school was important (Gershberg et al. 2022). While there appears to be a current absence of environmentally-sustainable education in dental school, there is certainly interest in the topic. Incorporating ESD into the dental school curriculum may lead to a reduction in the number of students who perceive a lack of knowledge on the topic as a barrier to its future implementation. This could be done in a clinical or didactic setting at several different time points during the dental school experience. In first or second-year didactic courses, the effects of climate change on systemic and oral health could be taught in courses related to epidemiology. When students start in clinic, infection control or patient care-related classes could place an emphasis on appropriate waste disposal methods. Additionally, content related to reducing office-produced GHGs or

ways to implement environmentally-sustainable products could be delivered in practice management courses. Because fourth-year students were among the least likely to report prioritizing ESD either in current or future practice, it may be beneficial to provide ESD-related education during the final year of school.

Clinical Implications

The responses to this survey as well as prior studies show that dental students are interested in learning more information about ESD (Lee and Parchure 2021, Gershberg et al. 2022). This interest should drive educators to include ESD-related education into the dental school curriculum. In teaching students about prioritizing sustainability in dentistry, the schools themselves may be more likely to adopt environmentally-friendly policies and practices. For example, there may be the inclusion of recycling bins in clinics here at UMKC. When students are exposed to ESD in the school environment, they may be more likely to recognize their profession's impact on climate change and implement ESD policies in their future practices. Educated students may drive demand for more environmentally-sustainable dental products. Perhaps increased pressure from professionals and customers will inspire dental supply companies to more responsibly manufacture, package, and ship their products to reduce their GHG production. Moreover, more ESD-related education may lead to increased interest in practice alternatives like teledentistry. While that field is still developing, it holds promise for reducing the dental profession's impact on climate change, as teledentistry-based practice will likely require less patient and staff commuting than a traditional practice model.

Study Limitations

The main limitation of this study is the small sample size of 95 dental students out of a possible 432, yielding a response rate of 22%. This low response rate was obtained despite class time being carved out for these students to participate in the survey. The response rate may have been greater if the survey had also been distributed as a link via email to allow students to respond outside of class. However, another recent survey of UMKC dental students distributed similarly had a response rate of 76.9% (Shaw 2016). The title or content of the survey may have influenced the overall number of respondents, as the survey distributed for this study was titled "Climate Change Survey." This may have led to an overrepresentation of those who are interested in climate change, or it may have discouraged those with no interest in climate change from taking the survey. To limit this possibility, the survey could have been titled in a more neutral manner, such as "Survey of Dental Students."

Additionally, the students surveyed were all from within the same Midwestern dental school. This population of students was not highly diverse in geographic background, with over 81% of those surveyed responding that they spent most of their childhood in the Midwest. If more dental schools from more regions of the country were included, the results may be more generalizable to represent dental students as a whole, and not only UMKC dental students.

Future Directions

A reasonable next step for this study would be expanding the population of students to which the survey is distributed. It would be interesting to see if the climate change-related knowledge and attitudes of the dental students at UMKC are representative of the knowledge and attitudes of dental students across the country. Also of interest would be surveying the

students before and after a climate change-related educational intervention, as in the Dow Sustainability Fellows Program report out of the University of Michigan. While that project demonstrated an objective reduction in waste and an increased level of knowledge, students' attitudes were not evaluated. We may see changes in attitude after dispensing information about climate change.

In this study, no relationship was seen between knowledge of climate change and attitude. However, the knowledge tested here was more general, rather than specifically targeted toward dentistry's impact on climate change. It would be interesting to evaluate student knowledge when limited to a narrower range of focus. A future investigation could test knowledge specifically related to dentistry's impact on climate change to determine if there was any association with attitude.

Additionally, a similar survey could be used to evaluate the knowledge and opinions of practicing dentists about climate change. The data collected in this study indicate that, while the year of training did demonstrate significant differences in relation to attitude, it did not follow a distinct pattern. No single class was significantly more or less interested in the topic across the board. It would be interesting to see if this holds true with dentists in practice and to see if the duration of time in practice influences their attitude toward dentistry's role in climate change.

CHAPTER 5

CONCLUSIONS

1. Certain student demographics affect student knowledge of climate change.
    a. Males were significantly more likely to have a high level of knowledge than females.
    b. Students with prior climate change-related education were significantly more likely to have a high level of knowledge of climate change.
2. Certain student demographics affect student attitude toward climate change.
    a. Females were significantly more likely than males to plan to implement ESD policies in their future offices.
    b. Students who had prior climate change-related education were significantly more likely to prioritize ESD in product use and agree that dental professionals should conserve resources than those who did not.
    c. Second- and fourth-year students were significantly more likely to disagree with interest in using ESD principles in their future practices than other classes.
    d. Students who reported often using environmentally-friendly behaviors at home were significantly more likely to believe that dentistry plays a role in climate change and have a greater interest in learning more about ESD than those who did not report using those behaviors often.
3. Cost was the most commonly-cited perceived barrier that dental students see that may prevent them from implementing environmentally-sustainable practices and policies in their future offices.

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APPENDIX A

SURVEY

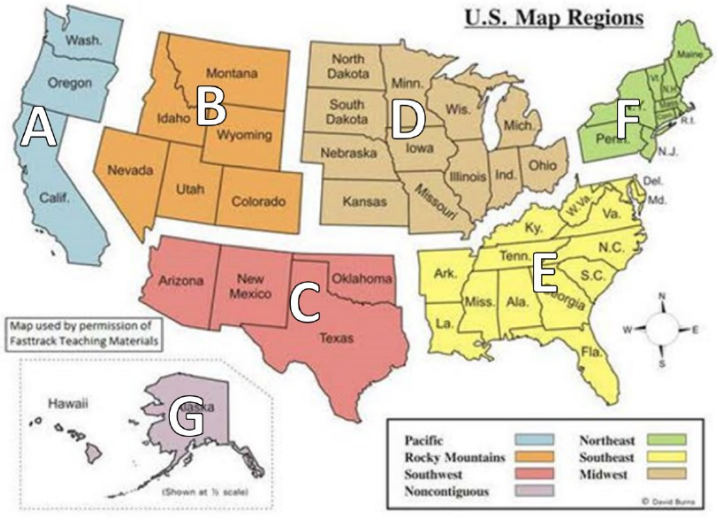
Thank you for your participation in this survey. The following questions are meant to gauge your knowledge of and beliefs about climate change and its relationship to dentistry. Information will also be gathered regarding your interest in implementing environmentally-friendly policies in your current and future dental practice.

1. What year in dental school are you currently enrolled in?
    A. First year (Class of 2025)
    B. Second year (Class of 2024)
    C. Third year (Class of 2023)
    D. Fourth year (Class of 2022)

2. What is your gender?
    A. Female
    B. Male
    C. Other/Prefer to self-describe
    D. Do not wish to answer
        If C is selected: You selected Other/Prefer to self-describe for gender. Please write in your preference.

3. In which region of the map below did you live for most of your life before attending college or university?

    A. Pacific
    B. Rocky Mountains
    C. Southwest
    D. Midwest
    E. Southeast
    F. Northeast
    G. Noncontiguous
    H. I grew up outside of the United States



4. Consider which of your parents holds the most advanced degree. What is the highest level of schooling this parent has completed?
    A. Less than bachelor's degree
    B. Bachelor's degree
    C. Master's degree
    D. Doctorate or professional degree

5. Consider the same parent as the previous question. Which of the following careers most closely approximates that of your parent for the majority of your childhood?

    A. Service industry – retail, waitstaff, hair stylist, call center, etc.
    B. Clerical – administrative assistant, receptionist, etc.
    C. Unskilled labor – janitor, cashier, housekeeper, etc.
    D. Skilled labor – electrician, plumber, welder, mechanic, etc.
    E. Managerial – human resources, information technology, marketing, sales, etc.
    F. Professional – physician, engineer, lawyer, accountant, etc.

6. In which context(s) have you previously learned about climate change? Please select all that apply.
    A. High School class
    B. College class
    C. On my own, outside of class
    D. I have not learned about climate change

7. How often do you prioritize environmentally-friendly actions in your home life? This includes minimizing energy usage, recycling, and limiting fossil fuel consumption.
    A. Almost always
    B. Sometimes
    C. Occasionally
    D. Rarely
    E. Never

8. In your estimation, what has been the general trend in global temperature over the last century?
    A. Global temperature has decreased by several degrees Fahrenheit
    B. Global temperature has not changed in this time
    C. Global temperature has increased by several degrees Fahrenheit
    D. I do not know

9. ‘Greenhouse gas’ is a common term for gases that both absorb and emit thermal energy. These include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), among others. Of all United States greenhouse gas emissions, what percentage do you think is emitted by the healthcare sector?

    A. 0%
    B. Between 1% and 25%
    C. Between 25% and 50%
    D. Greater than 50%

10. From which of the following categories do you think the majority of dentistry-related greenhouse gas emissions are produced?
    A. Waste production and waste processing
    B. Manufacturing and shipping of office and dental supplies
    C. Electricity and gas for office operation
    D. Commuting of patients and staff

Please keep in mind that for the remainder of the questions, we would like your honest opinion. There is no one correct answer.

Consider the following definition of climate change: A long-term shift in temperature and typical weather patterns on a local, regional, and/or global scale.

11. Which of the following statements about climate change comes closest to your view?
    A. Climate change is occurring mostly because of human activities such as the burning of fossil fuels.
    B. Climate change is occurring mostly because of natural patterns in Earth’s environment.
    C. There is not enough evidence that climate change is occurring.
    D. I do not have an opinion on climate change.

12. I believe that the dental profession contributes to climate change by various mechanisms, for example, by producing waste and using fossil fuels.
    A. Strongly agree
    B. Somewhat agree
    C. Neither agree nor disagree
    D. Somewhat disagree
    E. Strongly disagree

13. I believe that within their practice, dental professionals have a responsibility to conserve resources and prevent pollution.
    A. Strongly agree
    B. Somewhat agree
    C. Neither agree nor disagree
    D. Somewhat disagree
    E. Strongly disagree

Consider the following definition of environmental sustainability: The avoidance of the depletion of natural resources (water, land, air, minerals, and energy sources) in order to maintain an ecological balance for current generations and for those to come.

14. I currently prioritize environmental sustainability in my use of products and materials in clinic and pre-clinical labs.
    A. Strongly agree
    B. Somewhat agree
    C. Neither agree nor disagree
    D. Somewhat disagree
    E. Strongly disagree

15. I currently prioritize environmental sustainability in my disposal of biohazard versus general waste in clinic and pre-clinical labs.

    A. Strongly agree
    B. Somewhat agree
    C. Neither agree nor disagree
    D. Somewhat disagree
    E. Strongly disagree

Your role in your future dental practice may vary, and we understand that as an associate, a resident, an academic, etc., you may not be in a position to implement environmentally-friendly protocols in your office. Please answer the following three questions as though you were a private practice owner and able to make these decisions for your practice.

16. In my future practice, I plan to prioritize environmental sustainability in dental and office supply acquisition, for example, by choosing local sources to minimize emissions from shipping, or by purchasing from companies that use environmentally-friendly practices in their manufacturing.
    A. Strongly agree
    B. Somewhat agree
    C. Neither agree nor disagree
    D. Somewhat disagree
    E. Strongly disagree

17. In my future practice, I plan to prioritize environmental sustainability in waste disposal, for example, by doing any of the following: recycling, separating clinical or biohazard waste from general waste, and/or using reusable or sterilizable instruments.

    A. Strongly agree
    B. Somewhat agree
    C. Neither agree nor disagree
    D. Somewhat disagree
    E. Strongly disagree

18. In my future practice, I plan to estimate my office's carbon footprint. This includes doing any or all of the following: monitoring the office's energy use, water use, waste production, and approximating the emissions produced by staff and patient travel.
    A. Strongly agree
    B. Somewhat agree
    C. Neither agree nor disagree
    D. Somewhat disagree
    E. Strongly disagree

19. I am interested in learning more about environmental sustainability in dentistry for my future practice.
    A. Strongly agree
    B. Somewhat agree
    C. Neither agree nor disagree
    D. Somewhat disagree
    E. Strongly disagree

20. What do you consider to be potential barriers to implementing environmentally sustainable policies and procedures in your future dental practice? Please select all that apply.
    Environmentally-sustainable policies:
    a. may cost more
    b. may be more time consuming
    c. will not lead to increased patient recruitment or improve the patient experience in the office
    d. may require additional staff training
    e. are something I do not know enough about to implement in my future practice
    f. I do not see any barriers
    g. Other potential barriers not listed (please explain below)

    If you would like to elaborate on your answer, please do so here:

APPENDIX B

IRB APPROVAL LETTER

UMKC Institutional Review Board
University of Missouri-Kansas City

5319 Rockhill Road
Kansas City, MO 64110
816-235-5927
umkcirb@umkc.edu

July 26, 2021

Principal Investigator: Melanie Lea Simmer-Beck
Department: Dent Public Health & Behav Sci

Your IRB Application to project entitled "ASSESSMENT OF DENTAL STUDENTS' ATTITUDES AND AWARENESS OF CLIMATE CHANGE IN A MIDWESTERN DENTAL SCHOOL -- OCS Linstadt/Simmer-Beck" was reviewed and determined to qualify for IRB exemption according to the terms and conditions described below:

IRB Project Number	2065567
IRB Review Number	329649
Initial Application Approval Date	July 26, 2021
IRB Expiration Date	n/a
Level of Review	Exempt
Project Status	Active - Exempt
Exempt Categories	45 CFR 46.104(d)(2)
Risk Level	Minimal Risk

Approved Documents
- linstadt_research_proposal_to_committee_with_edits_v.2_sl.docx
- linstadt_survey_v11_sl.docx
- linstadt_verbal_script_v1_sl.docx

The principal investigator (PI) is responsible for all aspects and conduct of this study. The PI must comply with the following conditions of the determination:

1. No subjects may be involved in any study procedure prior to the determination date.
2. Changes that may affect the exempt determination must be submitted for confirmation prior to implementation utilizing the Exempt Amendment Form.
3. The Annual Exempt Form must be submitted 30 days prior to the determination anniversary date to keep the study active or to close it.
4. Maintain all research records for a period of seven years from the project completion date.

If you are offering subject payments and would like more information about research participant payments, please click here to view the UM system Policy on Research Subject Payments: https://www.umsystem.edu/oei/sharedservices/apss/nonpo_vouchers/research_subject_payments

If you have any questions, please contact the IRB at 816-235-5927 or umkcirb@umkc.edu.

Thank you,
UMKC Institutional Review Board

APPENDIX C

VERBAL CLASSROOM SCRIPT

Verbal script for survey instructions

The purpose of this research study is to evaluate how dental students perceive climate change and its relationship to dentistry.

We are asking dental students from the Classes of 2022, 2023, 2024, and 2025 to volunteer to complete a short survey regarding their knowledge of and attitude toward climate change, as well as any barriers you see that may prevent you from implementing environmentally-friendly policies in your future offices.

This survey will take approximately 10 minutes or less. All responses will be completely anonymous and unidentifiable. The surveys will not have any identifiers to link your responses back to you or any other participants. We are only interested in evaluating the data for the entire group.

There are neither risks nor benefits to participating in this research study. Your decision to participate or not participate will not have any influence on your grade in any class or on your rights as a student. Your participation in this research study is optional.

All surveys will be collected via REDCap. You may access the survey by clicking the link on this course's Canvas site or by scanning the QR code projected here on the screen. Your assistance is greatly appreciated.

If you have any question regarding the research, please contact Dr. Melanie Simmer-Beck at 816-235-2083.

If you have any questions regarding your rights as a research participant, please contact the IRB Administrator of UMKC's Institutional Review Board at 816-235-5927.

VITA

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6/2013	D.D.S.	University of the Pacific Arthur A. Dugoni School of Dentistry San Francisco, CA
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5/2023 In Process	M.S. Oral & Craniofacial Sciences	University of Missouri-Kansas City School of Dentistry Kansas City, MO
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