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A One Health Approach to Marine Health

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Abstract

Background: Climate change, plastics, and overfishing are major threats to marine health. The scientific and public health communities will be front and center in dealing with these threats. A One Health approach, where the integration of various disciplines together promote the protection and preservation of people, animals, and the environment, represents a sound model to address marine health problems.

Purpose: The purpose of this paper is to show how a One Health approach can be applied to marine health in order to protect and preserve marine ecosystems. A literature review was conducted on Google Scholar using the keywords "climate change", "overfishing" and "plastics," with inclusion criteria of publication date as 2005-present.

Conclusions: A One Health model was formatted based on this review to target the marine threats of climate change, plastic pollution, and overfishing. This One Health model was found to benefit the health of marine individuals, populations, and ecosystems, as well as human health. Establishing One Health teams is an appropriate way to handle the addressed marine threats that require cross-disciplinary skills.

Recommendations: The complex threats marine ecosystems face demand international cooperation and cross-disciplinary knowledge. Based on the findings of this review, a One Health approach is strongly recommended to best promote the health of marine life.

Background

Humanity is at a critical turning point of redirecting global industrialization to favor the planet's health. Global industrialization has led to massive consequences that need to be acknowledged and accounted for. The most neglected, largest sink of pollution, and worldwide connector, is the planet's oceans. Earth's oceans have an estimated volume of 1.3324×10^9 km^3 and could hold up to 1 million more species than the 226,000 eukaryotic species currently described (Charette & Smith, 2010; Appeltans et al., 2012). Marine health is a broad term that covers everything from the health of fish and ocean mammals, tourism and fishing industries, water temperatures and rising sea levels, transportation and research, and human waste in every part of the blue planet. A major threat to marine health is climate change. The evidence of climate change affecting the global oceans is far too vast to list here, so the overall subject and its negative implications on marine health will be discussed here. One of the most obvious effects of warming global temperatures is the melting of ice. Lack of ice directly reduces wildlife habitat, which directly reduces traditional food available to indigenous peoples (Gadamus, 2013). Melting ice also decreases seawater salinity, which has been shown to negatively affect phytoplankton growth and subsequently disrupt the food chain (Mintenbeck, et al., 2012).

Ocean acidification, caused by the increase of CO_2 levels resulting in a lower pH, is another issue for marine health. The ocean absorbs about one third of atmospheric CO_2 emitted from human actions, and since carbon emissions have exponentially increased in the past century, the ocean's acidity has also increased (Mintenbeck, et al., 2012). Both temperature increase and ocean acidification are significant stressors of coral reefs, leading to bleaching and slowed growth (Hoegh-Guldberg, Poloczanska, Skirving, & Dove, 2017). Decreasing oceanic pH has

also been shown to decrease olfactory sense in fish larvae that allow them to find suitable habitat, which would reduce respective populations (Munday, et al., 2009).

Eutrophication is another problem for marine health, and has been documented as an environmental stressor, harming both animal and human populations. Eutrophication and climate change work in additive fashion to essentially make an aquatic habitat uninhabitable, whether by creating dead zones, increasing competition among microorganisms, or producing toxic phytoplankton (Suikkanen, et al., 2013). In addition to these concerns, climate change has also been shown to increase disease transmission between organisms, as higher temperatures allow for vector and parasitic range expansions (Ostfeld, 2009).

Plastic pollution is a major threat to marine health that plagues many spots in our ocean's geography. Plastics that consumers and industries use do not biodegrade, but form microplastics that congregate and mix in our oceans. When disposed, these plastics can end up in any of the five major oceanic gyres; two of which are located in the Pacific Ocean, one in the Indian Ocean, and two in the Atlantic Ocean. About 280 million tons of plastic is produced each year that ends up in one of these gyres (Sigler, 2014). In order to better understand the effects of plastics, it is critical to understand what constitutes these plastics, where how they end up in the ocean, how they affect marine health, and how they ultimately come back to affect human health.

Many additives are mixed in with natural polymers of plastic. Of concern are phthalates and bisphenol A (BPA). These chemicals can be toxic and have a negative effect on marine and human health. Phthalates are used in PVC (polyvinyl chloride) plastics while BPA is used as a monomer in production of polycarbonate plastics and PVC (Thompson, Moore, vom Saal & Swan, 2009). The main concern lies in the fact that phthalates are not chemically bound in plastics and can leach out of the material, which can negatively affect life in the ocean. BPA and

phthalates have been found to affect the life cycle and reproduction of many aquatic-inhabiting animals such as amphibians, crustaceans, and even insects. Another problem with plastics is that they attract harmful pollutants such as polychlorinated biphenyls (PCBs). PCBs have been found to cause cancers in marine animals and greatly affect the immune, nervous, endocrine, and reproductive systems. Through consumption and the nature of the ecosystem these harmful pollutants can end up back in humans and ultimately cause cancer or other harmful conditions within humans (Sigler, 2014).

Plastics can settle in the oceans in multiple different ways. Most oceanic plastics result from accumulation in landfills. There is also much accumulation of plastic that ends up on ocean shores. There have been reports of more than 100,000 items per square meter on some shorelines (Thompson, et al., 2009). Other avenues are through the contamination of sewage, fragments of plastic contaminating compost of municipal solid waste, and plastic traveling from streams, rivers, lakes and the sea ultimately ending up in the ocean (Thompson, et al., 2009). Once plastics reach the ocean, they can travel throughout its depths from the surface to the ocean floor, affecting all marine life in between. Plastics that have not degraded to microplastics pose a major threat of entanglement for marine animals such as cetaceans and sea turtles. Within the last decade, at least seven endangered humpback whales (*Megaptera novangliae*) have been spotted towing mass amounts of tangled nylon rope and items such as crayfish pots or buoys (Sigler, 2014).

Plastics can fragment due to UV, mechanical, and microbial degradation (Wright, Thompson, & Galloway, 2013). Once plastics become microplastics, they become difficult to distinguish between phytoplankton for fish and cetaceans and therefore, become consumed. Naturally these microplastics start to sink down to the ocean floor by biofouling which is the

accumulation of microorganisms, plants, and algae on surfaces and in this case microplastics. This causes the plastic to lose its buoyancy and chemical characteristics to where it no longer can stay on the surface of the water and sinks (Wright, et al., 2013). By this process, many new organisms are exposed and can accidently consume the plastic. These microplastics can then be brought back up to the ocean's surface by defouling, where animals feed on the biofilm accumulated on the plastics causing them to rise back up and affecting more animals on the way back up (Wright, et al., 2013). Once these microplastics are ingested, accumulation and blockage within the digestive tract can occur causing major blockages leading to death or affecting the health of the marine animals due to the chemical composition of these plastics. (Sigler, 2014).

Many additives are mixed in with natural polymers of plastic. Of concern are phthalates and bisphenol A (BPA). These chemicals can be toxic and have a negative effect on marine and human health. Phthalates are used in PVC (polyvinyl chloride) plastics while BPA is used as a monomer in production of polycarbonate plastics and PVC (Thompson, Moore, vom Saal & Swan, 2009). The main concern lies in the fact that phthalates are not chemically bound in plastics and can leach out of the material, which can negatively affect life in the ocean. BPA and phthalates have been found to affect the life cycle and reproduction of many aquatic-inhabiting animals such as amphibians, crustaceans, and even insects. Another problem with plastics is that they attract harmful pollutants such as polychlorinated biphenyls (PCBs). PCBs have been found to cause cancers in marine animals and greatly affect the immune, nervous, endocrine, and reproductive systems. Through consumption and the nature of the ecosystem, these harmful pollutants can end up back in humans and ultimately cause cancer or other harmful conditions within humans (Sigler, 2014).

Another major contributor to marine health is an unbalanced ecosystem of organisms. With a rise in global human population and thus demand of fish, a dramatic drop in fish numbers has been measured. Besides the obvious implications of reduced fish numbers including susceptibility to disease and extinction, the indirect effects promote even higher points of concern. In the Caribbean, overfishing of reef fish that consume sponges leads to coral reefs being overtaken by sponges (Loh, Mcmurray, Henkel, Vicente, & Pawlik, 2015). Such competition has the probability of driving off remaining fish, and more significantly, preventing the reestablishment of corals, which would further the chances of the ecosystem collapsing (Brandt, Olinger & Chaves-Fonnegra et al., 2019). Another effect of overfishing is the disruption of the food chain. Removing predatory fish populations has been shown to prevent the transfer of nutrients up the food chain, and has led to sustaining harmful algal blooms (Vasas, Lancelot, Rousseau, & Jordán, 2007). Overfishing also has drastic consequences for human health in the fishing industry. Because fish populations have declined, industrial fishing boats have resorted to fishing in more dangerous waters, and without the ability to increase fishermen wages, they lose employees. Boats are then forced to seek more dangerous waters, and cannot increase fishermen wages, so resort to recruiting workers coercively or by trafficking. It is estimated that over 100,000 are recruited by these means (Marschke & Vandergeest, 2016).

As public health addresses the important topic of marine health, it is also important that a good model be used in proposing solutions. One Health can provide such a model. One Health is the integration of human, animal, and environmental medicine and research, so that collective decisions of prevention and protection can be made from teams of all disciplines (Destoumieux-Garzón et al., 2018). One Health has been acknowledged for decades, but is only recently gaining traction in research and health practices. The benefits of One Health are numerous,

including but not limited to the promotion of global wellbeing through the interconnectedness of nations, the perspective shift of acknowledging that the health of the planet promotes the health of human and animal inhabitants, and the ever-increasing idea that interdisciplinary groups can advance problem solving far better than individual ones. The purpose of this paper is to apply a One Health approach to marine health in order to better protect and preserve the global marine ecosystems.

Methodology

This literature review was conducted using Google Scholar with inclusion criteria of journal articles from 2005-present and keywords of "climate change", "overfishing" or "plastics" within the title. This produced about 12,900 articles which demonstrated numerous approaches and recommendations for promoting marine wildlife, ecosystem, and human health. From this, articles were chosen that operationalized One Health in order to develop a framework (Figure 1), which required evaluating individual, population, and ecosystem health. For the purpose of this paper, these components were defined as a cycle induced by human action that subsequently affects marine health on the individual, population, and ecosystem levels. Such effects then come back to impact human health as demonstrated in the One Health Framework below (Figure 1).

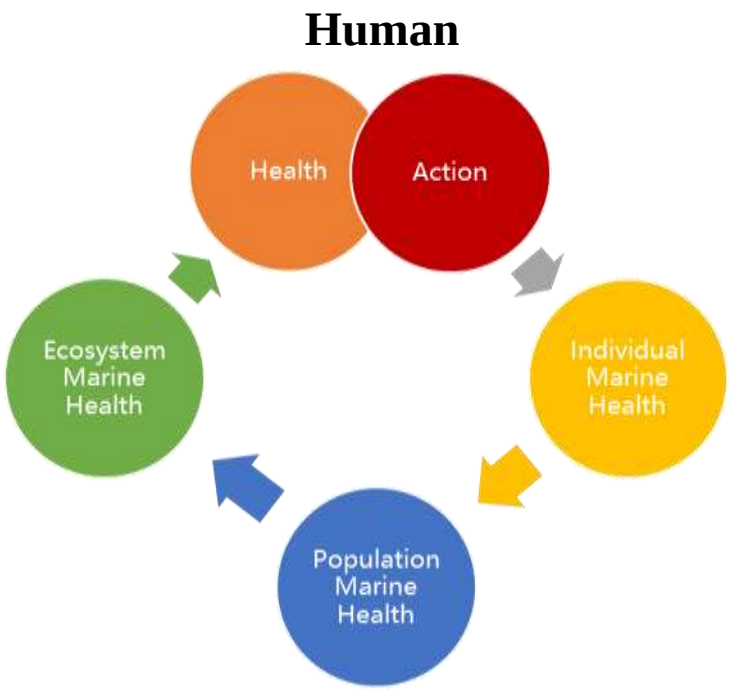

Figure 1.
The One Health Framework

Current Public Health Solutions

Melting ice has serious consequences for terrestrial and aquatic life as well as humans. It has been recommended that a Marine Mammal Health Map be incorporated into the Global Ocean Observing System, which would help link data on climate change while surveilling marine mammal health and indigenous people's needs (Moore & Gulland, 2014). A growing concern with melting ice is the interest industries have gained in opportunistic trade routes and drilling. It has been estimated that the Northern Sea Route would barely impact global trade, but drilling would be more beneficial, and therefore poses a greater risk (Bensassi, Stroeve, Martínez-Zarzoso, & Barrett, 2016). Russian drilling advances were stopped by the United States when Russia was sanctioned for its actions against Ukraine. This shows that political decisions have greater impacts than environmental concerns, and so it seems only necessary that a One Health Team for marine health include policy makers and governmental committee members

(Bensassi, Stroeve, Martínez-Zarzoso, & Barrett, 2016). Currently, combating plastic pollution involves tracking, collection and destruction strategies. Tracking trash uses radio frequency identification (RFID) tags and cellular transmitters (Sigler, 2014). This has allowed researchers to follow where trash has been, how long it has been moving before being deposited, and where the trash finally accumulates. This helps target where plastic pollution campaigns should be held, as well as target where more efforts should be put in plastic cleanup. Drones have been suggested in plastic collection as well as a major cleanup project called the Ocean Cleanup Array (Sigler, 2014). This project poses a solution by anchoring a platform to the ocean floor where plastics accumulate on top and marine life underneath remain unharmed. A projection of 7.25 million tons of plastic can be collected and removed in this way (Sigler, 2014). Finally, a destruction method called thermal degradation poses a solution to destroy plastics into liquid hydrocarbon fuel (Sigler, 2014). This way plastics no longer have to be accumulated through landfills and can have a direct route to be converted into fuel.An additive effect on top of these issues is overfishing. By further draining already stressed populations, humans are perfecting the stage for the possibility of even more extinctions. A study conducted by Herrera, Moeller, & Neubert, 2016) suggested that closing high seas to fishing will actually benefit self-interested states that are overexploiting fish resources. Creating a model that suggests convincing states to agree to such a closure was also found to be more attainable than one would think (Herrera et al, 2016). Marine reserves where fishing is not prohibited are economically beneficial even under non-cooperative systems (Herrera et al, 2016).

Conclusions

A One Health approach to marine health would benefit the environment, animals, and humans across the globe. The authors recommend that global surveillance be increased and

maintained, and stress that indigenous groups must be accounted for and listened to. A One Health team for marine health would be better able to implement policies to mitigate and manage the effects of climate change. The One Health team would also help to transition society towards a massive cultural shift in decreased waste production and sustainability, among other attributes.

A One Health approach would provide information on the overall health of the blue planet from perspectives of specialists in oceanography, wildlife medicine, ecology, public health, policy, and so many more. This disciplinary integration will better address and manage the effects humans have imposed on the natural world by increasing global surveillance of marine ecosystems. By utilizing the One Health approach, future generations will have data on the effects of climate change, plastic pollution, and overfishing on marine and human health and a comprehensive outlook on possible solutions.

Recommendations

The interconnectedness of the planet should be embraced and respected. Figure 2 shows an application of recently discussed issues and their consequences.

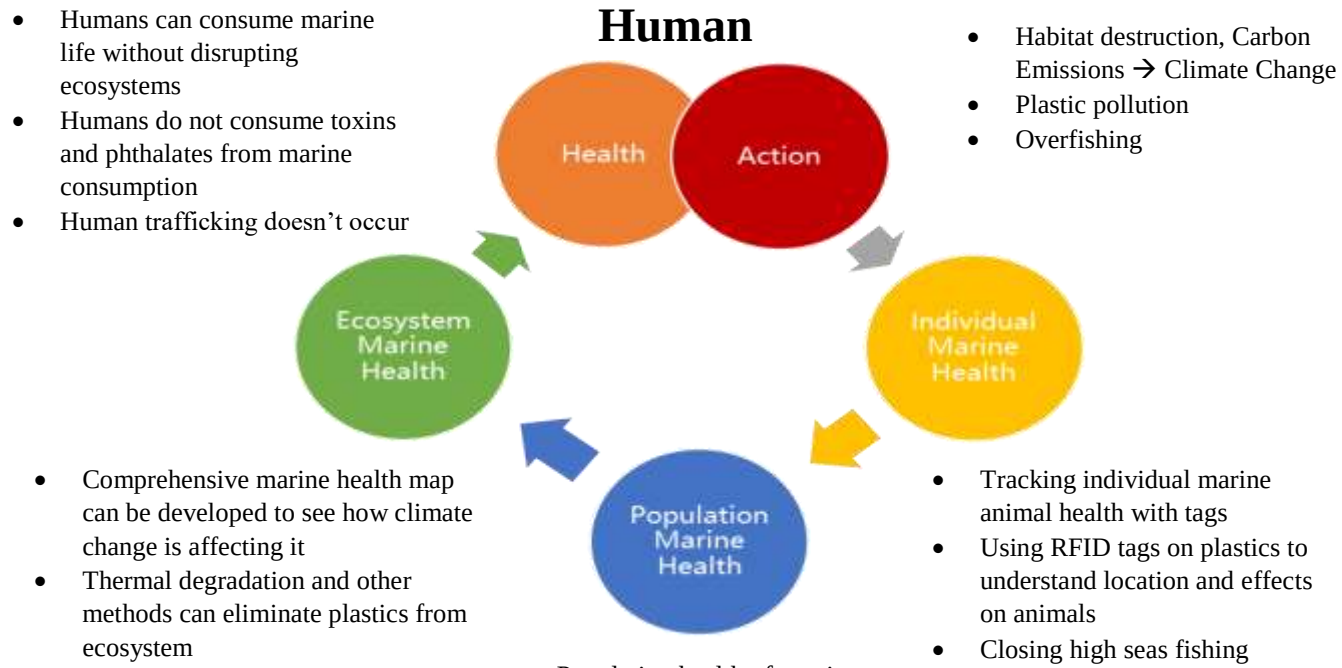

Figure 2.

In order to apply a One Health approach to marine health, teams can be formed to help shift society towards a more sustainable way of living. A One Health team addressing climate change would not only stress global surveillance and collaboration, but would also focus on applying scientific suggestions to public policies. There has been a disconnect between science and policy action, and having scientists and policy makers work together as a part of a One Health team would allow both parties to better understand each other's needs and how to enact solutions (Lemos & Rood, 2010). This communication will also benefit the prevention of disease transmission and outbreaks by increasing the preparedness of nations, overall global surveillance, and production of much needed vaccines and treatments.

Currently when combating plastic pollution, there are no talks on how to solve the issues of inadvertent marine consumption of plastics. Tracking, collection and destruction are all strategies being taken into account, which will eventually lead to less consumption; however, the flow of biofouling and defouling of microplastics and how it affects marine animals is not taken into account in collection strategies. Based on this, it is the researcher's suggestion to incorporate the expertise of ecologists and wildlife veterinarians to help reduce the number of marine life consuming plastics and detect those who have. In addition, medical doctors must understand how phthalates and toxins from consumed marine life affect human health. Therefore, a One Health team comprised of wildlife veterinarians, ecologists, doctors, marine scientists and public health officials needs to be formed when coming up with solutions to plastic pollution.

A humanitarian concern with overfishing is the 100,000 or more workers recruited coercively or by trafficking (Marschke & Vandergeest, 2016). In order to prevent such cases, global surveillance must be increased. This added surveillance will directly benefit human rights enforcers and illegal fishing prevention to establish a better understanding of fish populations

and their needs. A One Health approach would therefore benefit the health of marine populations as well as international human health. With the help of humanitarian and public health workers, a One Health team would utilize population health specialists to determine the health of marine systems and the least destructive areas and quotas for global fishing industries. This would prevent marine areas from being drained of resources and increase the resiliency of populations. Other parts of this team could include wildlife biologists and veterinarians to recognize and mitigate disease outbreaks that could further harm marine populations. Policy makers and economists would utilize their skills to advise trading and demand of resources in order to best determine trade effects and necessary laws (Zhou, Smith, & Knudsen, 2014). This integration of a One Health approach would be a catalyst in shifting societal attitudes and industry choices towards a more sustainable way of living, promoting the health of both marine ecosystems and human populations.

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Assessing Health Risks in Rural Communities Surrounding Zacapa, Guatemala

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Abstract

Purpose: To determine the prevalence of diabetes, obesity, and anemia among Guatemalan adults, as well as the rates of obesity among children in Zacapa, Guatemala. Location, gender, age, personal education level, household daily income, or employment status were examined to determine whether they influence rates of obesity and anemia among adults in Zacapa, Guatemala.

Methods: Community health assessments involved gathering height, weight, body mass index, blood glucose, hemoglobin, and blood pressure measurements from eligible participants. Microsoft Excel 2016 and IBM SPSS Version 23.0 were used to present descriptive statistics and analyze the data using binomial logistic regression tests.

Results/Findings: There were 130 child and 232 adult participants involved in this study. The majority of adult participants were female (84.05%) and between the ages of 15-39 (55.60%). 5.29% of adults suffered from diabetes, 32.47% from obesity, and 24.65% from anemia.

Conclusion: This study presented health information about childhood obesity; diabetes, obesity, anemia prevalence among adults, as well as various demographic, health-related behaviors, and socioeconomic factors. Out of the two separate logistic regression models, only the dependent variable of anemia was found to be statistically significant. Several limitations are mentioned.

Keywords: Zacapa, Guatemala, anemia, diabetes, obesity, children

Background:

Conducting community-based needs assessments and gathering culturally appropriate health data among diverse people groups around the world is currently a top priority for public health professionals. Gathering health-related data not only allows public health professionals to create health programs and initiatives that are specific to each community's needs but also allows them to create policies that will incite change on a larger level. Unfortunately, some developing countries are still unable to receive adequate aid due to limited availability of health data, which is evident in Zacapa, Guatemala. One report created by the government of Guatemala, estimates that 228,810 people lived in Zacapa in 2013 with a majority of residents being female (52.2%), living in rural communities (56.9%), and being of non-indigenous backgrounds (99.1%) (Caracterización Departamental Zacapa, 2013). Insufficient data was presented in this report that was reflective of health conditions within the community.

While limited health data exists in Zacapa, the country of Guatemala as a whole has recently been considered a strong economic force within Latin America. The World Bank reports that the country's gross domestic product (GDP) growth rate was 4.1% in 2015 with increasing rates of 2.8% in 2017 and 3.0% in 2018 (The World Bank in Guatemala, 2019). However, despite these economic strides, Guatemalan children and adults disproportionately suffer from malnutrition, food insecurity, stunting, iron deficiency anemia, diabetes, and obesity as compared to other Latin American countries. According to the United States Agency for International Development (USAID) (2018), the prevalence of stunting among children in Guatemala ranged from 47%-70% in 2014-2015, making it the sixth-highest country with chronic malnutrition rates across the globe. If left unaddressed, chronic malnutrition can lead to impaired muscle function, cardio-respiratory function, gastrointestinal function, immunity/wound healing, and increase in

psycho-social effects (e.g., apathy, depression, anxiety, self-neglect) (Saunders & Smith, 2010). Furthermore, indigenous Guatemalan children disproportionally suffer from malnutrition as compared to non-indigenous Guatemalan children (The World Bank in Guatamala, 2019; Lutter, 2009; Ramirez, 2014). Anemia is also common both among children less than five years old and pregnant women throughout Guatemala at approximately 40% and 22%, respectively (United States Department of Health and Human Services (UDHHS), 2017). Reasons for these high prevalence rates often include mother-child nutritional deficiencies during pregnancy, poor nutrition after birth, chronic parasitic infection, lead exposure, or other chronic diseases (UDHHS, 2017).

In 2013, a study focused on global health estimates of undiagnosed diabetes in adults reported that there were approximately 4.4-9.4% diagnosed cases of diabetes mellitus and 20.0-48.0% undiagnosed cases of diabetes mellitus in 2013 in Argentina, Bolivia, and Guatemala (Beagley, Guariguata, Weil, & Motala, 2014). Furthermore, the Central Intelligence Agency reported in 2018 that only 0.38 physicians were available per 1,000 people to provide medical treatments and care for residents of Guatemala (Central Intelligence Agency, 2019). This indicates that a common barrier to disease diagnosis/care within Guatemala is limited access to physicians and adequate health care systems. For this reason, many municipalities in Guatemala still lack health care data, such as Zacapa and other rural communities.

Purpose of Study

The aim of this study is to determine the prevalence of diabetes, obesity, and anemia among Guatemalan adults, as well as the rates of obesity among children in Zacapa, Guatemala. Additionally, data will be analyzed to determine if location, gender, age, personal education level, household daily income, or employment status may influence rates of obesity and anemia among

adult residents of Zacapa, Guatemala. Conducting this research is of importance because limited data currently exists regarding the health status of adults and children in the region of Zacapa, Guatemala. The information collected was inputted, interpreted, and used to assess and plan better strategies to help this community in the future.

Methods

Study Design and Data Collection

This primary research study was conducted from June 17 to June 24, 2019 in Zacapa, Guatemala using a cross-sectional study design in order to determine the prevalence of diabetes, obesity, hypertension, and anemia among adults and obesity rates among children living in Zacapa, Guatemala. The primary researcher, along with three other co-researchers, traveled to Zacapa, Guatemala during this study period and conducted community health assessments within five rural communities of Zacapa; Agua Caliente, Llano Verde, Santa Rosalia Marmol, Moran, and Nuevo Sunzapote. Community health assessments were conducted in collaboration with the local mission's coordinator at la Iglesia Primitiva and local municipality officials, within local primary (elementary) schools, and at a church setting between the hours of 7:30am-10pm on June 19th, 7:00am-4:00pm, on June 20th, 6:00am-3:30 on June 21st, and 6am-12pm on June 22nd. All necessary arrangements and purchases for the study were made six months prior to the study period.

Community health assessments involved gathering height, weight, body mass index (BMI), blood glucose, iron (anemia), and blood pressure measurements from eligible participants. Community members were eligible to receive blood glucose and anemia checks as part of the community health assessment if they were local residents of Zacapa, at least 15 years old, and if they completed an adult health questionnaire. Children were eligible to get their height and

weight checked if they were between the ages of 4 and 14 years old and if their parent completed a child health form. All qualifying individuals were eligible for participation regardless of gender, health status, occupation, or employment. In addition, eligible participants were able to review their results, receive health education, and express any health-related concerns with a doctor and the public health researchers at the end of their assessment.

Measures

Each adult health questionnaire consisted of 25 questions and was originally written in English. The final version of the adult health questionnaire was translated and printed in Spanish to maximize comprehensibility and communication efforts between the researchers and participants. Data collected on each adult health questionnaire pertained to gender, age, height, weight, blood glucose, BMI, body fat percentage, daily income, marital status, education level, number of children in the household, breastfeeding, oral hygiene, number and types of meals eaten, food access, and local water source. Data collected on each child health sheet included the date, age, birth date, height, weight, BMI, and body fat percentage. In total, there were 232 total adult participants and 130 child participants.

Health assessments pertaining to weight, height, and BMI/body fat percentage were gathered using a digital scale (kg), portable stadiometer, and Omron BMI Body Fat meter, respectively. All participants were instructed to remove their shoes and remain still for all three measurements. The Omron BMI Body Fat meter was chosen for this assessment because it uses bioelectrical impedance and is thought to produce more accurate results as compared to other BMI formulas/devices. Similar findings were reflected in a study by Rockamann, et. al., (2017) in which thumb-to-thumb bioelectric impedance analysis (BIA) devices were more accurate at estimating body fat percentage than dual energy X-ray absorptiometry devices. Blood glucose

levels were assessed using a drop of blood, blood glucose strips, and either a Contour Next or Walgreens True Metrix blood glucose meter. Blood glucose results were considered to be normal if they fell below 99 mg/dL (fasting) or 140 mg/dL (not-fasting) as indicated by the Centers for Disease Control and Prevention (CDC, 2019). Further, individuals were considered to be pre-diabetic if their blood sugar levels were between 100-125 mg/dL(fasting)/140-199 mg/dL (not-fasting), and diabetic at >126 mg/dL (fasting)/ >200mg/dL (not-fasting) (CDC, 2019). Hemoglobin levels were measured using a HemoCue201 device with the same available drop of blood in order to assess for anemia. Appropriate measures for operating this device were followed according to the HemoCue Hb 201+ Operating Manual (HemoCue, 2019). Multiple studies have found the accuracy of the HemoCue Hb 201 device to be comparable to the newest HemoCue Hb 301 device (Jain, Chowdhury, & Jain, 2018; Rappaport, Karakochuk, Whitfield, Kheang, & Green, 2016). Finally, blood pressure readings were acquired using Omron blood pressure devices and according to appropriate procedures (Omron Healthcare Co., 2010).

Funding for this study was sought and approved by the Center for Research & Scholarship at Liberty University. The awarded funds were used to cover travel costs (i.e., airline tickets, hotel accommodations, ground transportation, coordinator costs, food); materials and supplies (i.e., gloves, hand sanitizer, lancets, glucose meter strips, etc.) and equipment (i.e., blood glucose meters, HemoCue 201+meter, Omron body fat meters, digital scale, microcuvettes, etc.) throughout the duration of the study period.

Ethical Considerations

Appropriate ethical permissions were sought from the Institutional Review Board (IRB) of Liberty University with which the authors are affiliated, with the submission of the IRB application, adult and child questionnaire, recruitment letter, and consent form. Following review

of our application, the Liberty University IRB approved this study on November 29, 2018 under the expedited review category (45 CFR 46.110), which is applicable to specific, minimal risk studies. The consent form explained the purpose and procedures of the study, as well as data confidentiality. No names or identifying information were collected on the consent forms or questionnaires to protect participants' privacy and ensure anonymity. Furthermore, all data acquired through this study will be kept in a secure filing cabinet within the Department of Public and Community Health with only the practicum student and co-researchers being able to access the data. In addition, the data will be deleted and cross-shredded after 3 years. The verbal and written consent of respondents was sought before taking part in the community health assessment. Respondents were assured of their right to participate and withdraw from the study at will. There was no compensation for participating in this study.

Statistical Analysis

The data was entered into Microsoft Excel 2016 and analyzed using both Microsoft Excel 2016 and IBM SPSS Version 23.0. Descriptive statistics were presented regarding demographic and socioeconomic characteristics of adults, demographic characteristics of children, health related behaviors and concerns of adult participants, and distribution/prevalence of diseases among adult participants. The dependent variables in this study were diabetes, anemia, and obesity while the independent variables were location, gender, age, personal education level, household daily income, and employment status. Three separate binomial logistic regression tests was conducted using IBM SPSS Version 23.0 to determine whether any of the independent variables predicted an individual’s outcome of acquiring diabetes, anemia, or high BMI (obesity).

Results

Response Rates & Demographic Characteristics

There were 130 child and 232 adult participants involved in this study; however, varying numbers of adults responded to each question on the questionnaire and/or were able to complete all aspects of the community health assessments, as indicated in Tables 3-6. Table 1 presents demographic characteristics of children, the majority of whom were female between the ages of 8-11 years old (M=8.85) and were seen at the Nuevo Sanzapote location. The mean height and weight for the child participants was 128.06 cm (±17.15) and 29.16 kg (±11.77), respectively. In addition, most children were classified as having a healthy weight (75.19%); however, 24.81% of children were classified as being underweight, overweight, or obese (Table 2). Two children were removed from BMI categorizations due to errors when obtaining the necessary BMI percentages.

Table 1

Demographic Characteristics of Child Participants, Zacapa, Guatemala, June 2019

Characteristic	**Frequency**	**Percent**
Gender (*n=130*)		
Male	59	45.38
Female	71	54.62
Age *(n=130)*		
4-7 years	47	36.15
8-11 years	54	41.54
12-14 years	29	22.31
Location (*n=130*)		
Agua Caliente	31	23.85
Llano Verde	7	5.38

Santa Rosalia Marmol	28	21.54
Moran	28	21.54
Nuevo Sunzapote	36	27.69

Table 2:

BMI Categorizations of Child Participants, Zacapa, Guatemala, June 2019

Characteristic	**Location**					**Total**	**Frequency**
	Agua Caliente	Llano Verde	Santa Rosalia Marmol	Moran	Nuevo Sunzapote		
BMI % (*n=129*)							
Underweight	1	0	5	2	3	11	8.53%
Healthy	23	3	23	22	26	97	75.19%
Overweight	5	3	0	2	4	14	10.85%
Obese	2	1	0	2	2	7	5.43%

Table 3 displays various demographic and socioeconomic characteristics of all adult participants including gender, age, location of service, marital status, daily income, employment status, personal education level, education level of the head of household, personal transportation status, number of children under the age of 21 in the household, number of adults in the household, number of children, and status of giving birth within the past two years. Overall, the majority of adult participants were female (84.05%) between the ages of 15-39 (55.60%). This indicates that the proportion of female participants (84.05%) was more than five times that of male participants (15.95%). All adult participants were seen at five different locations throughout the study period, Agua Caliente, Llano Verde, Santa Rosalia Marmol, Moran, and Nuevo Sunzapote, with the most participants being seen at Nuevo Sunzapote (28.02%). Approximately

70% (70.43%) of adults identified as being married or living with a partner, 38.84% indicated a daily household income of 31-60 Quetzal per day ($4.05-$7.85 USD), and 77.16% reported being unemployed. More than half of adult participants documented that their highest level of education was primary school (elementary school) with slightly lower primary school attendance levels among the heads of the households (42.08%). Additionally, most adult participants indicated that they do not own their own vehicle for transportation (65.50%), have 1-3 children living in their household that are under the age of 21 (60.71%), have 1-3 adults living in their household (77.29%), have 1-3 children (60.71%), and have not given birth within the past two years (60.26%) (females only).

Table 3:

Demographic and Socioeconomic Characteristics of Adult Participants, Zacapa, Guatemala, June 2019

Characteristic	**Frequency**	**Percent**
Gender (*n=232*)		
Male	37	15.95
Female	195	84.05
Age *(n=232)*		
15-39 years	129	55.60
40-65 years	77	33.19
66-90 years	26	11.21
Location (*n=232*)		
Agua Caliente	48	20.69
Llano Verde	26	11.20
Santa Rosalia Marmol	38	16.38
Moran	55	23.71
Nuevo Sunzapote	65	28.02

Married or Live with a Partner (*n=230*)		
Yes	162	70.43
No	68	29.57
Household Total Daily Income (*n=224*)		
0-30 Quetzal	60	26.79
31-60 Quetzal	87	38.84
61-100 Quetzal	45	20.09
101+ Quetzal	32	14.29
Currently Employed (*n=232*)		
Yes	53	22.84
No	179	77.16
Personal Education Level (*n=230*)		
None	36	15.65
Primary	129	56.09
Secondary	35	15.22
Career	15	6.52
Bachelors	9	3.91
Masters	1	0.43
Other	5	2.17
Head of Household Education Level (*n=221*)		
None	54	24.43
Primary	93	42.08
Secondary	23	10.41
Career	16	7.24
Bachelors	4	1.81
Masters	1	0.45
Other	5	2.26
Don't Know	2	0.90

I Am the Head of the Household	23	10.41
Own a Vehicle for Transportation (*n=229*)		
Yes	78	34.06
No	150	65.50
Number of Children in Household <21 years (*n=224*)		
0	54	24.11
1-3	136	60.71
4-7	27	12.05
8-11	4	1.79
12+	3	1.34
Number of Adults in Household (*n=229*)		
1-3	177	77.29
4-7	48	20.96
8-11	2	0.87
12+	1	0.44
Number of Children (*n=231*)		
0	38	16.45
1-3	125	54.11
4-7	61	26.41
8-11	6	2.60
12+	1	0.43
Given birth in the past two years (females with children only) (*n=229*)		
Yes	32	13.97
No	138	60.26
Male or no children	59	25.76

Table 4 summarizes the health-related behaviors and concerns of the adult participants. As the results show, in general, the majority of adult participants reported visiting a doctor or

health care worker at least once per year (37.23%), having previously breastfed (69.16%), brushing their teeth eight or more times per week (52.16%), having stomach pains within the past two weeks (65.95%), and eating three meals per day (68.97%). While most adult participants reported "never" worrying about getting food (38.56%) and "no" to being unable to purchase food in the last year due to not having money (65.09%), more than half of participants reported "often" skipping meals so that other members of their family could eat (53.02%). Furthermore, 61.21% of adult participants reported "yes" to believing that they eat a balanced, nutritious diet regularly while 52.8% reported being typically hungry for 4-6 hours before eating their next meal. Common locations identified for purchasing food included "tiendas" (stores) and "despensas" (pantries), while common identified sources of drinking water included "agua potable" (drinking water), "del chorro" (water from the stream), "agua del rio" (water from the river), and "agua purificado" (purified water).

Table 4:

Health-Related Behaviors and Reported Concerns of Adult Participants, Zacapa, Guatemala, June 2019

Characteristic	**Frequency**	**Percent**
Frequency visiting a doctor or healthcare worker (*n=231*)		
Never	26	11.26
At least once every five years	27	11.69
At least once every year	86	37.23
At least once at 6 months	54	23.38
At least once every month	38	16.45
Currently or previously breastfed (women with children only) (*n=227*)		
Yes	157	69.16
No	11	4.85

Male or no children	59	25.99
Frequency brushing teeth per week (*n=232*)		
0	4	1.72
1-2	20	8.62
3-4	71	30.60
5-7	16	6.90
8+	121	52.16
Stomach pain in the past two weeks (*n=232*)		
Yes	153	65.95
No	79	34.05
Meals eaten per day (n=232)		
0	0	0.00
1	2	0.86
2	39	16.81
3	160	68.97
4	16	6.90
5	14	6.03
6+	1	0.43
Ever worry about getting food to eat (n=227)		
Often	53	23.35
Sometimes	63	27.75
Rarely	28	12.33
Never	83	36.56
Frequency of skipping meals to feed other family members (n=232)		
Never	23	9.91
Rarely	60	25.86
Sometimes	26	11.21

Often	123	53.02
Unable to purchase food in the last year due to not having money (n=232)		
Yes	81	34.91
No	151	65.09
I believe that I eat a balanced, nutritious diet regularly (n=232)		
Yes	142	61.21
No	90	38.79
Length of time spent hungry before eating next meal (n=231)		
Never	36	15.58
1-3 hours	64	27.71
4-6 hours	122	52.81
7-9 hours	8	3.46
10 hours or more	1	0.43

Table 5 provides the means and standard deviations of quantitative health variables for all adult participants including age, height, weight, blood glucose, BMI, body fat percentage, hemoglobin, and systolic/diastolic blood pressure. As noted on Table 5, the average age of participants was approximately 40 years old with a height of 154.09 cm (60.66 in.) and weight of 65.24 kg (143.82 lbs.). A mean blood glucose reading of 121.85 indicated normal values for non-fasting individuals with additional widely distributed values (SD 51.99). The average BMI value for the population was calculated as 27.5, indicating that the general adult population seen at all five locations were generally overweight. Further, while variable depending on gender, a mean body fat percentage >30% also indicated that many adult participants were obese. The average hemoglobin level was 12.9 for both men and women, which was considered acceptable for females but low for males. Average systolic and diastolic blood pressure levels generally fell within normal limits as well (121.96/81.29).

Table 5:

Means and Standard Deviations of Quantitative Variables Among Adults, Zacapa, Guatemala, June 2019

Characteristic	N	Mean	Standard Deviation
Age	232	40.28	17.77
Height (cm)	231	154.09	7.99
Weight (kg)	231	65.24	15.42
Blood Glucose (mg/dL)	227	121.85	51.99
BMI	231	27.52	6.12
Body Fat %	200	34.08	10.00
Hemoglobin (mg/dL)	215	12.93	1.48
Systolic Blood Pressure (mmHg)	228	121.96	20.01
Diastolic Blood Pressure (mmHg)	228	81.29	11.61

Table 6 illustrates the prevalence and distribution of disease per location of service in Zacapa. Over two-thirds of adult participants had blood glucose levels that fell within normal ranges (<100 mg/dL fasting, <140 mg/dL non-fasting) with 20.71% of individuals displaying pre-diabetic (100-125 fasting mg/dL, 140-199 mg/dL non-fasting) or diabetic levels (>126 mg/dL fasting, >200 mg/dL non-fasting). The majority of participants from all locations were equally classified as being of normal weight (32.47%) or obese (32.47%). Approximately one-fourth of adults suffered from anemia and about half of adults had both systolic and diastolic blood pressure readings that fell within elevated to hypertensive levels. Llano Verde had the highest prevalence rate of diabetes (12%), obesity (44%), anemia (36.0%), high systolic blood pressure (hypertension stage 1&2, 48.0%), and high diastolic blood pressure (hypertension stage

1&2, 76.0%) as compared to the other communities. Moran was the only location in which adult participants displayed systolic and diastolic blood pressure within hypertensive crisis levels.

Table 6:

Distribution and Prevalence of Disease Among Adults per Location, Zacapa, Guatemala, June 2019

Characteristic	Location					Total	Percent
	Agua Caliente	Llano Verde	Santa Rosalia Marmol	Moran	Nuevo Sunzapote		
Blood Glucose							
Normal	35	18	34	40	53	180	79.30
Pre-diabetes	8	4	3	11	9	35	15.42
Diabetes (%)	1 (2.27)	3 (12)	4 (9.76)	3 (5.56)	3 (4.62)	12	5.29
Total	44	25	41	54	65	227	100.0
BMI							
Underweight	2	0	2	2	2	8	3.46
Normal	19	2	18	23	13	75	32.47
Overweight	13	12	9	17	22	73	31.60
Obese (%)	14 (29.17)	11 (44)	9 (23.68)	13 (23.64)	28 (40.08)	75	32.47
Total	48	25	38	55	65	231	100.0
Hemoglobin							
Normal	23	16	31	46	46	162	75.35
Anemic (%)	11 (32.35)	9 (36.0)	6 (16.22)	8 (14.81)	19 (29.23)	53	24.65
Total	34	25	37	54	65	215	100.0
Systolic Blood Pressure							
Normal	24	5	25	20	42	116	50.88
Elevated	8	8	4	11	12	43	18.86
Hypertension Stage 1 (%)	6 (13.04)	6 (24.0)	6 (15.79)	8 (14.81)	5 (7.69)	31	13.60

Hypertension Stage 2 (%)	8 (17.39)	6 (24.0)	3 (7.89)	12 (22.22)	6 (9.23)	35	15.35
Hypertensive Crisis (%)	0	0	0	3 (5.56)	0	3	1.31
Total	46	25	38	54	65	228	100.0
Diastolic Blood Pressure							
Normal	21 (45.65)	6 (24.0)	24 (63.16)	17 (31.48)	39 (60.0)	107	46.93
Hypertension Stage 1	14 (30.43)	10 (40.0)	8 (14.81)	20 (37.03)	22 (33.85)	74	32.46
Hypertension Stage 2	11 (23.91)	9 (36.0)	6 (11.11)	16 (29.63)	4 (6.15)	46	20.17
Hypertensive Crisis	0	0	0	1 (1.85)	0	1	0.44
Total	46	25	38	54	65	228	100.0

Analysis

Separate binomial logistic regressions were performed to determine the effects of location, gender, age, personal education level, household daily income, and employment status on the likelihood that participants were obese or have anemia. Before conducting the binomial logistic regression analyses, the researcher met/tested for the seven applicable assumptions concerning having a dichotomous dependent variable, having one or more continuous or nominal independent variables, demonstrating independence of observations, having mutually exclusive and exhaustive dependent and independent variables, having a minimum of 15 cases per independent variable, data not showing multicollinearity, and not having significant outliers.

Linearity of the continuous variables with respect to the logit of the obesity dependent variable was assessed via the Box-Tidwell (1962) procedure. A Bonferroni correction was applied using all 18 terms in the model resulting in statistical significance being accepted at $p < 0.0027$ (Tabachnick & Fidell, 2014). Based on this assessment, all continuous independent variables were found to be linearly related to the logit of the obesity dependent variable. No

outliers were identified. The logistic regression model was not statistically significant, χ^2 (6) = 11.632, *p*= 0.071 (Tables 7-8). The model explained 7.9% (Nagelkerke R^2) of the variance in obesity and correctly classified 65.8% of cases. Sensitivity was 13.6%, specificity was 91.7%, positive predictive value was 45.0% and negative predictive value was 68.1%. Of the six predictor variables, only two were statistically significant: sex and employment status as shown in Table 9. Females had 3.47 times higher odds of exhibiting obesity than males. Not being employed was associated with a reduction in the likelihood of exhibiting obesity.

Table 7:

Omnibus Tests of Model Coefficients for Obesity Dependent Variable, Zacapa, Guatemala, June 2019

		Chi-square	df	Sig.
Step 1	Step	11.632	6	.071
	Block	11.632	6	.071
	Model	11.632	6	.071

Table 8:

Model Summary for Obesity Dependent Variable, Zacapa, Guatemala, June 2019

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	241.236	.057	.079

Table 9:

Logistic Regression Predicting Likelihood of Obesity based on Location, Sex, Age, Personal Education, Household Daily Income, and Employment Status, Zacapa, Guatemala, June 2019

							95% CI for Odds Ratio	
	B	**S.E.**	**Wald**	**df**	**p**	**Odds ratio**	**Lower**	**Upper**
Location	0.150	0.116	1.686	1	0.194	1.162	0.926	1.459
Sex	1.244	0.543	5.252	1	0.022	3.470	1.197	10.054
Age	-0.005	0.010	0.255	1	0.614	0.995	0.975	1.015
Personal Education	0.038	0.145	0.067	1	0.795	1.038	0.781	1.380
Household Daily Income	0.137	0.170	0.655	1	0.418	1.147	0.823	1.600
Employment	-0.918	0.401	5.235	1	0.022	0.399	0.182	0.877
Constant	-0.882	1.123	0.617	1	0.432	0.414		

Linearity of all independent continuous variables with respect to the logit of the anemia dependent variable were found to be linearly related, $p < 0.05$; therefore, a Bonferroni correction was not needed for this dependent variable. There were six standardized residuals with value of 2.654, 3.067, 2.719, 2.827, 2.719, 2.540 standard deviations, which was kept in the analysis. The logistic regression model was significant, χ^2 (6) = 12.981, p= 0.043 (Tables 10-11). The model explained 94.0% (Nagelkerke R^2) of the variance in anemia and correctly classified 75.9% of cases. Sensitivity was 0.0%, specificity was 100.0%, positive predictive value was 0% and negative predictive value was 75.87%. Of the six predictor variables, age was the only variable that was statistically significant as shown in Table 12. Females were 1.037 times more likely than males to present with anemia.

Table 10:

Omnibus Tests of Model Coefficients for Anemia Dependent Variable, Zacapa, Guatemala, June 2019

		Chi-square	df	Sig.
Step 1	Step	12.981	6	.043
	Block	12.981	6	.043
	Model	12.981	6	.043

Table 11:

Model Summary for Anemia Dependent Variable, Zacapa, Guatemala, June 2019

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	206.900	.063	.094

Table 12:

Logistic Regression Predicting Likelihood of Anemia based on Location, Sex, Age, Personal Education, Household Daily Income, and Employment Status, Zacapa, Guatemala, June 2019

							95% CI for Odds Ratio	
	B	**S.E.**	**Wald**	**df**	**p**	**Odds ratio**	**Lower**	**Upper**
Location	-.106	.122	.758	1	.384	.899	.707	1.143
Sex	-.250	.492	.258	1	.611	.779	.297	2.043
Age	.036	.011	10.301	1	.001	1.037	1.014	1.060
Personal Education	.117	.165	.504	1	.478	1.124	.814	1.552
Household Daily Incor	.086	.187	.212	1	.645	1.090	.756	1.572

Employment	-.012	.445	.001	1	.978	.988	.413	2.364
Constant	-2.584	1.244	4.316	1	.038	.075		

Discussion

Diabetes, anemia, and obesity are health conditions that remain of eminent concern for health professionals around the world. According to the World Health Organization (WHO) (2018), the number of persons, living with diabetes, rose globally from 108 million in 1980 to 422 million in 2014. Likewise, the number of persons suffering from obesity has approximately tripled since the year 1975 (WHO, 2018). The WHO also reported that, globally, 496 million non-pregnant women and 273 million children suffered from anemia in 2011 (Stevens et al., 2013). The high prevalence of these diseases indicates that additional assessments and initiatives should be conducted to reduce the increasing global impact of diabetes, obesity, and anemia among people groups around the world. Therefore, this study sought to present the prevalence of diabetes, obesity, anemia, and other health conditions within adult populations living Zacapa, Guatemala, as well as obesity rates among children within Zacapa, Guatemala. The study also sought to determine if location, gender, age, personal education level, household daily income, or employment status could predict rates of diabetes, obesity, and anemia among these adult residents.

Information collected from child participants indicated that approximately one-fourth of all children were classified as being obese. Becoming obese during childhood is a cause for concern because children are at a five times greater risk of acquiring obesity into adulthood as compared to children who are not obese during childhood (Torres, Solberg, & Carlstrom, 2002). In order to address this problem, public health professionals within this area should begin creating more programs and regulations to address/prevent childhood obesity in Zacapa. In doing

so, children will maintain an appropriate weight for their age and height and will develop into healthy adults, which will ultimately reduce the disease burden on the population.

As previously indicated, the majority of participants were female. The reason for this unequal distribution of genders may be attributed to cultural habits and customs. More specifically, many male adults within the community health assessment areas were observed waiting outside for their significant others and children to complete the assessments as opposed to getting checked themselves. Reasons for these differences can often be associated with multifactorial causes related to machismo, as discussed in several other studies (Davis & Liang, 2015). Therefore, it is important to consider these gender specific differences when creating culturally appropriate programs that promote preventative care among all members of the household, not only women and children.

The results of this study also revealed that the majority of participants were married or living with a partner (70.43%). This distribution of responses is normal given the culture of marrying young and/or having children at younger ages. However, this distribution indicates that effective birth control and family planning education is necessary among younger age groups within Zacapa in order to maintain stable birth rates within Guatemala. One-fourth of participants indicated that they made between 0-30 quetzals in combined household income per day, which equates to a maximum of 840 quetzals per month. The Global Living Wage Coalition estimates that each household needs at least 900 quetzals per month to pay for housing expenses alone. Therefore, this indicates that at least 25% of adults within Zacapa do not make sufficient money to adequately cover their living expenses. This is evident due to a reported 77.16% rate of unemployment and 65.50% rate of people that do not own a vehicle. Not having sufficient sources of income ultimately increases a person's likelihood for disease, malnutrition, and

poverty, amongst other conditions. In turn, public health professionals should partner with appropriate government officials in order to increase available opportunities for employment within Zacapa and surrounding areas.

Most adults indicated they had received education from a primary school, with a limited number of persons receiving secondary education and above. Varying levels of education levels may be attributed to a variety of factors including having to work and provide for the family, having to stay home and take care of children, lower expectation for receiving formal education, amongst other reasons. Despite 77.06% of adult participants indicating that they visit a doctor or healthcare worker every month, one time per year, 5.29% of adult participants had blood glucose levels indicative of diabetes, 32.47% were obese, and 24.65% had anemia.

Conclusions

Overall, this study presented health information about childhood and adult obesity, diabetes, anemia prevalence among adults, as well as various demographic, health-related behaviors, and socioeconomic factors. Out of the three separate logistic regression models, only the dependent variable of anemia was found to be statistically significant. Age was the only variable that was shown to be statistically significant in predicting incidence of anemia among this population. This indicates that appropriate nutrition education should be provided to women starting at a young age in order to reduce their likelihood of becoming anemic as they get older. While binomial regression significance was not found with diabetes, increasing age showed a pattern of increased likelihood to acquire diabetes. Likewise, gender was associated with an increased likelihood of exhibiting obesity while unemployment status was associated with a reduction in the likelihood of exhibiting obesity. Reasons for these discoveries may be associated with gender roles in some way. For example, men are expected to go out and work to provide for

their family; therefore, they engage in more physical activity than women. Persons who are unemployed may also have more time to be at home and cook homemade meals as opposed to employed individuals who may eat out at restaurants or quick food marts more frequently.

Limitations for this study included having overheating problems with the HemoCue and blood glucose meter devices. Overheating technicalities reduced the number of individuals who were able to receive this assessment and may also have influenced accurate readings before or after the malfunctions. Likewise, if the HemoCue strips were not filled completely with blood, hemoglobin levels may have displayed inaccurate results. Data were also impacted by taking a lunch break during each community health assessment due to some participants that were waiting to receive assessments did not choose to return after the lunch break and therefore were unable to be seen. Finally, the results of the binomial logistic regression involving anemia may also have been skewed due to the inclusion of several outliers

Recommendations

Additional studies should be conducted to support the data presented within this study and provide more information regarding the health status of individuals within Zacapa, Guatemala. In doing so, more specific health interventions can be conducted within these adult and child populations to improve long-term health.

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Impact of Educational Intervention on Knowledge of Opioid Prescribing among Healthcare Providers: A Systematic Review

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Abstract

Purpose: To review educational interventions' impact on providers' knowledge regarding pain management and opioid painkillers.

Methodology: The literature search took place in January 2018 using three search engines of PubMed, Cochrane, and Psychinfo. The search included articles between the years 2008-February 2018. The keywords consisted of "prescription opioids," "pain," "education," and "practitioners (all fields such as physicians, nurse practitioners, e.g.). The inclusion criterion was conducting an educational intervention regarding pain management and opioids. The exclusion criteria were not having a target population of healthcare providers or had taken place outside the US. The articles Assessment tool was a modified version of the Critical Appraisal Skills Program (CASP) criteria for cohort studies.

Findings: After reviewing the title of possible publications, 505 prospective articles were found. After full review (title, abstract, and full text) of all articles, fifteen published articles were included. All studies reported improved the outcome of providers' knowledge.

Conclusions. Educational interventions for providers are helpful steps for prescribing opioids safely. The review demonstrates the positive impact of an educational intervention on the health professionals' knowledge and practice behavior regarding pain management and opioids and the need for similar opportunities.

Recommendations: Educating healthcare professionals about guidelines such as the CDC's could help to prevent opioid abuse.

Background

Prescription opioid misuse has been identified as a health crisis in the U.S. In 2018, more than thirteen thousand hospital visits were related to drug overdose, among which more than seven thousand were due to opioid overdose (Virginia Department of Health (VDH), 2018). The total "economic burden" of this problem in the US is $78.5 billion a year (Florence et al., 2016). According to the Centers for Disease Control and Prevention (CDC) (2019), about 11% of adults in the U.S. experience daily pain, and millions of them are treated with prescription opioids. About 21-29% of patients who receive prescription opioids to manage their chronic pain will misuse them (Vowles et al., 2015). Among the population who misuse their prescribed opioids, about 12% will struggle with an opioid use disorder (Muhuri, Gfroerer, & Davies, 2013).

Furthermore, prescribing opioid pain relievers to individuals diagnosed with opioid use disorders may increase the risk of relapse and overdose (Stein et al., 2017). The mortality rate due to drug overdose in all populations in the U.S. is rising. In 2016, about 66% of the drug overdose deaths were related to opioids. Among the opioids related deaths, about 40% of the mortalities were due to prescription opioid overdose (CDC, 2020).

To prevent drug misuse and overdose, the CDC has suggested a guideline that helps the healthcare providers take the necessary measures for patient's safety when treating pain by prescribing opioids. A state-based database called the Prescription Drug Monitoring Program (PDMP) stores patients' prescribed medication information. Utilizing this data could help practitioners and pharmacists to avoid multiple opioid prescriptions or possible dangerous drug interactions such as overdose due to concurrent benzodiazepines and opioids. Some studies have noted that adopting the recommended guidelines could reduce the average opioid dosage prescribed for patients, but providers' knowledge of the guidelines can vary. For instance, opioid

prescribing providers in Washington State, who did not adhere to any guideline, felt concerned regarding opioid use for pain; however, those affiliated with opioid prescribing guidelines felt more confident about their practice and prescription opioids (Franklin et al., 2013). Chen et al. (2016) noted that, although there is pressure to familiarize the providers with opioid prescribing guidelines for pain management, evidence shows that only knowledge about the guidelines does not always produce a positive impact on providers' practice behavior.

Primary care providers (PCPs) prescribe most of the opioid painkillers dispensed for non-cancer chronic pain, but only a few primary care practitioners follow the suggested guidelines (Lasser et al., 2015). Chronic pain management training only exists in about half of family medicine programs (Schiel, Zoberi, Everard, & Antoun, 2016), and while providers believe that treatment of pain by using opioids is challenging, they feel the need for more training (Porucznik, Johnson, Rolfs, & Sauer, 2013). There are some online educational programs for pain management with opioids available to healthcare providers to enroll in as part of their continuing medical education (SAMHSA, n.d.). There is a growing focus on medical students and residents training for more comprehensive education regarding pain management; however, educational interventions remain considerably variable (Barth, Guille, McCauley, & Brady, 2017). Medical schools, residency programs, and others have different approaches to training their students about pain management and opioid use, highlighting the need for additional education for healthcare providers. Comprehensive education on opioid painkillers' topic might improve providers' practice behavior and the patient's outcome.

This systematic review will assess whether an educational intervention has any impact on the healthcare provider's knowledge and attitudes towards pain management using prescription

opioids. Enhancement of providers' knowledge and practice behavior due to a comprehensive education program could indicate the need for global education for all healthcare workers.

Methodology

The literature search, which was started in January 2018 and completed in March 2018, included papers between the years 2008-2018, and used the search engines of PubMed, Cochrane, and Psychinfo. The keywords consisted of "prescription opioids," "pain," "education," and "healthcare professionals delineated as healthcare providers, practitioners, doctors, nurses, physician, physician assistant, dentist, or pharmacist." The primary selection was based on the title and abstract relevance to the topic. Using the Endnote reference manager, the duplicated articles were removed. Conducting an educational intervention (e.g. lectures, workshops) for healthcare providers in the U.S., which covers prescribing opioid painkillers usage in pain management, was the inclusion criterion. The exclusion criteria were not having a study population of healthcare providers, and the study had taken place outside the U.S. The secondary selection was conducted by reviewing the contents of full text, considering the exclusion criteria, and the relevance to the topic and inclusion criteria. All other studies were excluded.

The first author made the articles' search and selection, and quality assessment was done by both authors independently. The Assessment tool was a modified version of the Critical Appraisal Skills Program Checklist (CASP) criteria for cohort studies (Critical Appraisal Skills Programme, n.d.). The modification point was to simplify the scoring process and fit the studies included in this review, and the answers to the questions were chosen as "yes" or "no." Table 1 shows the modified assessment questions. The maximum possible assessment score was 12 and the assessment scores by the two authors were quite similar. The summary of the process is demonstrated in Figure 1, which exhibits the Prisma flow chart (Moher et al., 2009)

Table 1

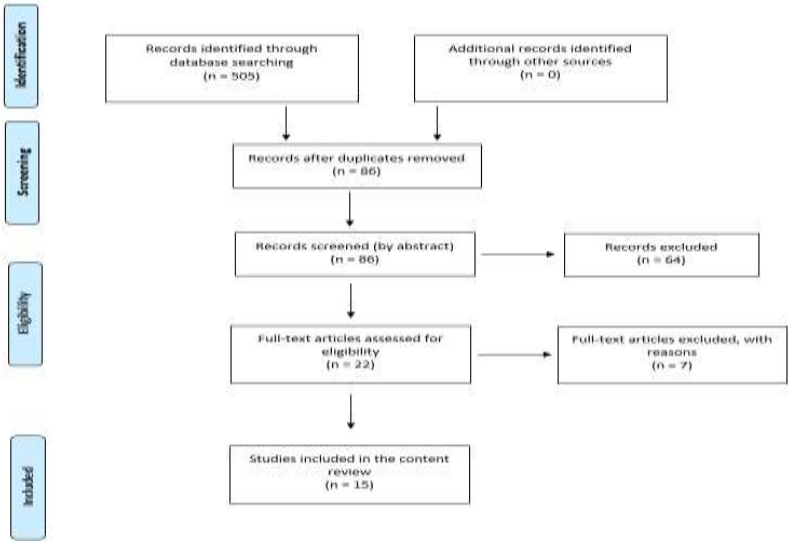
Articles assessment questions for the scoring

Question	**Yes**	**No**
1. Did the study address a clearly focused issue?		
2. Was the cohort recruited in an acceptable way?		
3. Was the exposure accurately measured to minimize bias?		
4. Was the outcome accurately measured to minimize bias?		
5. Have they taken account of the confounding factors in the design and/or analysis?		
6. Was the follow up of subjects complete enough?		
7. Was the follow up of subjects long enough?		
8. Are the results precise?		
9. Do you believe the results?		
10. Can the results be applied to the local population?		
11. Do the results of this study fit with other available evidence?		
12. Are the implications of this study clear for practice?		

*Maximum possible score = 12

Figure 1.

Summary of the article selection process



Findings

During the first review, 505 articles were found through different combinations of the keywords. Through reading the titles or abstracts among the articles, 64 articles that did not have the study population of healthcare providers or did not meet the inclusion criteria were excluded (Figure 1). Since the study aimed to evaluate the impact of further education on American healthcare providers' knowledge of the available guidelines to manage pain using opioids, seven articles conducted outside the US were excluded through reviewing the full text. In the end, fifteen articles were used in this review. The range of assessment scores was 9-12, with an average of 10.

Most of the studies implemented a combination of live interactive workshops or lectures while offering extra resources to the participants. A few studies had the option of participating in an online module or a live session. The mode of the intervention is categorized in Table 2.

Table 2.

Type of Educational Interventions Methods on Prescribing Opioid

Educational Intervention Category	Number of Articles
Lecture/Workshop	5
Books/Online Resources	2
Combination of Lecture/Workshop & Online Resources	8
Total	15

Data extraction was completed for each selected paper, and the following variables were recorded, including the study population, type of intervention, and the main result. The summary of the results is presented in Table 3.

Table 3

Summary of the data extraction

Type of intervention(s)	Author, Year	Study population	Results
Educational presentations	Cochella & Bateman, 2011	Primary care physicians and health care providers	Death rate due to accidental opioid overdose dropped. Providers' prescription behavior changed regarding following recommendations
Book (physicians' guide)	Young et al., 2012	Physicians	Most physicians, especially primary care practitioners were likely to follow the pain management guidebook
Interactive didactic lectures	Brown et al., 2013	Internal medicine and transitional year residents and medical students enrolled in internal medicine	Improved knowledge of addiction and pain management using opioids
A combination of lectures, case reports, journal clubs, and decision support tool for electronic health record	Guglemann et al., 2013	Physicians, residents, nurse practitioners, and nurses	A drop in the prescription opioids' rate especially for patients with a history of dependency
Training and providing protocols (electronic medical record-based) and instructions	Canada et al., 2014	Internal medicine interns, Primary care residents, attending physicians, nurse practitioners	Providers adherence to the guidelines improved, providers' knowledge and attitude improved, decreased number of opioid prescriptions
Live and online educational program	Alford et al., 2016	Clinicians who manage chronic pain	Improvement in clinicians' knowledge, confidence, attitude, and practice
Guidelines distributed through emails or at mandatory meetings presentation, and social marketing	Chen et al., 2016	Internal medicine residents and faculties, family medicine faculties	Decreased opioid prescription rate for non-cancer chronic pain, increase in using urine drug screening test

Type of intervention(s)	Author, Year	Study Population	Results
Interactive lecture and pictorial demonstration	Dion, 2016	Nursing students	Improvement in knowledge of opiate overdose signs and administration of intranasal naloxone
One-on-one educational visits, provided additional resources	Kattan et al., 2016	Physicians, nurse practitioners, physician assistants	Decreased in prescription rate of high-dose opioids, improved providers' knowledge
Interactive didactics	Regunath et al., 2016	Internal medicine residents	Improve knowledge and confidence regarding prescribing opioids
Multidisciplinary educational grand rounds, CME modules, lectures, interactive workshops, framework for prescribing opioids, and assessment tools	Lester et al., 2017	Physicians, pharmacists, nurses, physician assistants, nurse practitioners	Reduction in prescription opioids, improved practice and knowledge, higher patient satisfaction rate
Meetings or online education, workshop	Zisblatt et al., 2017	Physicians, pharmacists, nurse practitioners, physician assistants	Improvement in knowledge, confidence, attitude and self-reported practices
Case-based experimental or text-based online continuing education program	Trudeau et al., 2017	Primary care providers (MDs, DOs, residents, fellows, NPs, Pas)	Improved knowledge, attitude, pain practice behavior; the experimental program group were less likely to prescribe tamper-resistant opioids compared to text-based group
Lectures, discussions, and workshop	Ruff et al., 2017	Internal medicine residents (second- and third-year)	Improved knowledge and confidence in pain management and opioid use

Results

Lectures/Workshops

Cochella and Bateman (2011) conducted a series of educational presentations in Utah, teaching providers and incentivizing them with continuing medical education credits. After the presentations, which included information regarding opioid painkillers, the rate of prescribed opioids dropped, and providers reported improved prescribing behaviors. Brown et al. (2013) offered a series of interactive lectures covering addiction, pain management, and use of opioids to a group of medical students, and transitional-year and internal medicine residents. After the intervention, the survey showed that the participants' knowledge of addiction and the use of opioids improved compared to the baseline. Dion et al. (2016) conducted an interactive lecture and pictorial demonstration for nursing students to teach the symptoms and signs of opioid overdose and intranasal Naloxone administration for the patients in need. The study found an improvement in nursing students' knowledge about the diagnosis of opiate overdose and Naloxone's use. Regunath et al. (2016) conducted a module informing internal medicine residents about chronic non-cancer pain management and opioid use. The participants' knowledge and confidence level in prescribing opioids improved as the result of the intervention. Ruff et al. (2017) implemented a set of lectures, a workshop, and discussions targeting second- and third-year internal medicine residents regarding chronic pain management and opioid misuse disorder. The intervention had a positive effect on the residents' confidence level and perceived skills for managing patients.

Online Resources

A physician guidebook on prescribing opioids for pain was distributed among physicians in Georgia (Young et al., 2011). Young and his co-investigators conducted a survey study to evaluate the impact of the book. The most significant effect was noted among the primary care physicians who were more likely to change their practice patterns regarding opioid use. Trudeau et al. (2017)

conducted a study that assigned participants to either a case-based experimental module or a text-based routine online continuing medical education module. The participants were primary care providers, including medical doctors, doctors of osteopathic medicine, residents, fellows, nurse practitioners, and physician assistants. Both groups showed an improvement in knowledge, attitude, and practice behavior. The experimental group who learned the information by the help of simulated patient cases had a more significant improvement regarding the use of tamper-resistant opioids.

Combination of Lecture/Workshop & Online Resources

A combination of interventions, which included case discussions, journal clubs, lectures, and support tools for using electronic health records, and targeted a group of providers was implemented by Gugelmann et al. (2013). The providers included physicians, residents, nurse practitioners, and nurses at two urban emergency departments. After the educational interventions, a drop in the rate of prescribing opioids was noted, especially in patients with a history of substance dependency. Canada et al. (2014) conducted a study that offered providers an electronic medical record-based protocol, management, and data sortation instructions for patients with chronic pain who use opioids. The providers included were primary care residents, internal medicine interns, attending physicians, and nurse practitioners. They also offered monetary compensation for attending physicians. The results of their study showed an improvement in the providers' adherence to the protocols. Canada et al. (2014) also noticed that the health caregivers' practice behavior (such as the use of urine drug screening and documentation of the diagnosed chronic pain), attitude, and knowledge improved, and the number of opioid prescriptions reduced. Another series of online or live educational programs were held in sixteen U.S. states that targeted clinicians who manage chronic pain (Alford et al., 2015). An immediate and a two-month post-program assessment of the clinicians' knowledge, confidence, attitude, and practice regarding pain management showed improvement. Chen et al. (2016) distributed

guidelines for prescribing opioids for chronic pain through emails or during mandatory meetings through presentations. They also implemented social marketing by using posters to raise awareness about the guidelines. The recipients of the guidelines were Stanford's internal medicine residents and faculty, as well as family medicine faculty. They compared pre- and post-intervention medical records to evaluate the practice behavior changes due to the intervention. The results suggested a decrease in the opioid prescription rate for non-cancer chronic pain and increased urine drug screening tests. Kattan et al. (2016) implemented a public health detailing campaign by conducting one-on-one educational visits and handing out "action kits" that included additional resources. The data analysis showed improved providers' knowledge of opioids and a drop in high-dose opioid painkillers' prescription rates.

At the Oregon Health and Science University, the general internal medicine clinic implemented an educational intervention and introduced an opioid prescribing policy that limited the dosage of opioids for the patients (Weimer et al., 2016). The target of that intervention was all primary care providers, including residents, faculty, and mid-level providers. After the intervention, the overall rate of opioid dose prescribed for patients reduced. They also found that younger physicians tend to prescribe less high-dose opioids than providers with more years of practice. In another study, a series of multidisciplinary educational grand rounds, continuing medical education modules, lectures, and interactive workshops were implemented, providing a framework for prescribing opioids, and assessment tools for the prescribers (Lester et al., 2017). The interventions' target population was a group of physicians, pharmacists, nurses, physician assistants, and nurse practitioners. The focus of these rounds and workshops was on pain management and selection of painkillers, including opioids.

A reduction in the number of prescription opioids, an improvement in practice and knowledge, and a higher patient satisfaction rate of their treatment were the results of a study by Lester et al.

(2017). Through a three-hour educational meeting or an online module, and a series of two-hour workshops, information was disseminated about long-acting and immediate-release opioids, and risk evaluation and mitigation strategy when prescribing opioids (Zisblatt et al., 2017). The participants were the providers, including physicians, pharmacists, nurse practitioners, and physician assistants. The survey results showed that the providers' confidence level, attitude, knowledge, and self-reported practices improved after receiving the information.

Summary

According to the literature, the healthcare providers' knowledge of prescription opioids is inconsistent (Rasulnia, Burton, & Patel, 2019). This systematic review found that educational interventions regarding pain management, addiction, and opioid use positively impact healthcare providers' knowledge and practice behavior. Due to the interventions, providers' knowledge level of safe practice when prescribing opioid painkillers (e.g. choosing dosage, monitoring patients on chronic opioid therapy, avoiding multiple prescriptions) improved. In addition, practice behavior, confidence level, and attitudes of the prescribers were enhanced. In some studies that measured the rate of prescribed opioids for patients, a decline in the number of opioids prescriptions was noted.

The limitation of the studies included in the review was that the interventions' long-term impact on knowledge, attitudes, and behavior of the providers was not measured. Despite this limitation, all studies were adequately significant to suggest that comprehensive education on pain management and opioid painkillers targeting healthcare professionals is effective. This review could also not categorize the intervention methods based on their effectiveness. Whether one educational method works better than the other is not clear. Another limitation was that the studies chose different materials to inform their participants and, although all materials were related to opioids somehow, no

interventions were quite similar. Hence, there is a possibility of bias when comparing the impact of different educational materials.

Conclusion

This study showed that health care providers are mostly concerned about pain management and prescribing opioids and would prefer more education (Franklin et al., 2013). The literature review also showed the effectiveness of focused training regarding the use of opioid painkillers, made available to healthcare providers (Aronowitz, Compton, & Schmidt, 2020). The positive impact of additional education for health care providers on pain management and prescribing opioids is evident. Additional education in the healthcare professions' curricula could clarify misunderstood points or any confusions about prescription opioids (Busse, Douglas, Chauhan, Kobeissi, & Blackmer, 2020). Whether some intervention method is more effective than the others, and which one is preferable to the providers are two critical points that are unclear. More research focusing on the method, material, and length of effective educational interventions is needed. There is also a need to study the long-term effect of the educational interventions, aiming at the providers' practice behavior and opioid prescription rates.

Recommendations

This review underscores the need for more comprehensive education regarding using opioid painkillers for pain management to inform healthcare providers. As suggested in the literature, adherence to practice guidelines could result in evidence-based practice pattern among healthcare providers (Busse et al., 2020). The available guidelines, including the CDC's Guideline for Prescribing Opioids for Non-Cancer Chronic Pain, could be an appropriate resource to educate the providers. Detailed information on the CDC's guideline recommendations could be the common ground of the educational material shared with all healthcare professionals to enhance their knowledge.

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Prevalence of Musculoskeletal disorders (MSDs) Among Dental Health Professionals: A Review of the Literature

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Abstract

Background:

Musculoskeletal Disorders (MSDs) are common problems among dentists, dental hygienists, and dental students due to their static working positions. This review article discusses the prevalence of work-related MSDs among dental health professionals based on peer-reviewed research studies which have reported about MSDs among dental health professionals.

Methodology:

For this review, papers that studied and researched the prevalence of MSDs and their risk factors were considered. Articles were reviewed from relevant articles, which were searched online from January to April 2020. Case studies and literature reviews published within the last 10 years in peer-reviewed journals were included. Studies conducted among participants other than dental hygienists, dentists or dental students were excluded without any restrictions based on age, sex, race, or socioeconomic status.

Results:

The prevalence of musculoskeletal disorder-related pain ranges from 39% to 95% among dental health professionals. Dentists, dental hygienists, and dental students have reported experiencing most frequent pain in cervical (88.3%), lower back (15.7%-86%), upper back (17%-55%), shoulder (12.7%-92.7%), neck (15.7%-85%) regions. Hand/wrist pain ranged from 22%-54.8% and lower extremities pain reported was pain at ankles/feet (19%), hip/thigh (15%), and knees (9%). There is no large difference between work-related musculoskeletal pain rates at different body parts among dentists and dental hygienists.

Conclusions:

This review indicates the importance of considering ergonomics and preventive measures in sustaining the highest quality of dental care to the public and suggests that musculoskeletal disorder-related pain affects physical and mental health along with the overall well-being of a dental professional. This review shows the prevalence of musculoskeletal pain among dental healthcare professionals providing dental care to the public around the world which indicates more scientific research and regular musculoskeletal pain assessment are needed to address this issue for early detection, effective prevention and management of underlying causes of musculoskeletal disorders.

Introduction

Work-related Musculoskeletal Disorders (MSDs) result from overuse of soft tissue causing discomfort or injury in the muscular system, skeletal system, or structure that joins muscle and bone together while performing their work (Roquelaure, Bodin, Descatha, & Petit, 2018). Work-related MSDs among healthcare professionals can have an impact on their physical and mental health, stamina, patient & healthcare provider relationship, and concentration in their job performance which has the potential to shorten their career (Howarth, Hallbeck, Lemaine, Singh, & Noland, 2019). MSDs are one of the leading factors among healthcare workers resulting in lower life satisfaction, disability, depression, anxiety and mood disorders as chronic pain has been reported as a predictor of major depression (Currie & Wang, 2004; Heikkinen et al., 2019; Mock & Cherian, 2008). Chronic pain is responsible for high financial and social burdens along with disability affecting the quality of life (Mutubuki, Beljon, et al., 2019; Mutubuki et al., 2020; Mutubuki, Luitjens, et al., 2019; Vargas et al., 2018). Musculoskeletal pain and complications hurt healthy aging thus affecting an individual's ability to engage in physical activity, exercises, loss of independence, and overall well-being (Briggs et al., 2016).

A study conducted in a dental workstation, which examined the patterns of movements performed daily and work posture, showed that dentists were performing most of their work in an awkward position which is considered one of the factors for MSDs (Ohlendorf et al., 2017; Taylor, Strauss, & Best, 2018). MSDs of the neck and back have been reported to have an impact on the dental health professional's normal activities and may prevent them from performing their job responsibilities comfortably (Taib, Bahn, Yun, & Taib, 2017). In another study, the 12-month prevalence of musculoskeletal disorders among dentists was found to be 91.9%, with a higher prevalence found among female dentists (Hosseini et al., 2019). Exercise of less than 3 hours per week

was also found to play a significant role in the occurrence of MSDs among the study population (n=136).

The major risk factors for musculoskeletal disorders among dental professionals were reported as awkward posture, the number of patients treated every day, administrative work, vibration, and repetitive tasks (Lietz, Kozak, & Nienhaus, 2018). The main affected parts of the body among dental professionals with MSDs were found to be the neck, lower back, shoulders and upper back (Lietz et al., 2018). In a recent study by Partido, Henderson, & Kennedy (2020), which showed improvement in dental educators ergonomics scores from week one to week four among participants in the training group, dental educators strongly agreed that ergonomics training is required for both dental students and dentists to understand, apply and have accurate ergonomics self-assessment skills in clinical practice. A study conducted by Rambabu, et al. (2014) which included 300 surgeons, 100 from each field, reported a higher prevalence of MSDs among dental surgeons, which was almost double than physicians and more than three times higher than other surgeons. The main aim of this review is to analyze the available literature and to report the prevalence of work-related musculoskeletal disorder and its underlying factors among dentists, dental hygienists, and dental students.

Methods

For this review, papers that studied and researched the prevalence of MSDs and their risk factors were considered. Articles were reviewed from relevant articles, which were searched online from January to April 2020. Articles were searched primarily in PubMed, CINAHL and Cochrane with the following terms as keywords: Musculoskeletal diseases/disorders, Dentists, Dental hygienists, and Dental students. Case studies and literature reviews published within the last 10 years in peer-reviewed journals were included. Studies conducted among participants other than dental hygienists,

dentists or dental students were excluded without any restrictions based on age, sex, race, or socioeconomic status.

Articles containing the keywords within the abstract or title were identified. Those articles which had conducted studies among dental health professionals were considered relevant. Forty articles were identified by title. Five other relevant articles, which were found in the reference list of the included articles, were also reviewed. Articles that then met all the inclusion criteria were finally considered for this review. Twenty-nine articles were excluded from the review as they did not meet the inclusion criteria, and ten articles, which had conducted a survey or study on the prevalence of musculoskeletal disorders among dental health professionals, were included for the final review.

Results

All of the articles presented in Table 1 utilized the Nordic standard questionnaire except one (Kapitan et al., 2018) which used an author developed questionnaire similar to the Nordic-standard questionnaire. A cross-sectional study design among dentists, dental hygienists, or dental hygiene students was used in which self-reporting questionnaires were provided to the target population through email or mail which were completed and returned by the participants. Researchers determined the total musculoskeletal disorder prevalence rate, and affected body part based on the responses provided by the total participants. The musculoskeletal disorder prevalence rate (at certain body parts) was determined as a percentage of MSD occurrence in the target population taking into account the total response or total number of participants (n) (Table 1). Prevalence rates were based on total population and were not stratified between genders.

Table 1

Musculoskeletal disorder prevalence rates by body part, study population and country of study

Body part	Reference	MSD Prevalence rate (%)	Study population (# participants (n))	Country
Any	Al-Mohrej, AlShaalan, Al-Bani, Masuadi, & Almodaimegh, (2016)	90.2 (Higher prevalence in females)	Dentists (n=204) 101 Females, 103 Males	Saudi Arabia
	Bruers, Trommelen, Hawi, & Brand, (2017)	80 Dentists 95 Dental students	Dentists (n=196) Dental students (n=359)	Netherlands
	Kapitan,Pilbauerova, Vavrickova, Sustova, & Machac, (2018)	39	Dental students (n=182)	Czech Republic
	Batham & Yasobant, 2016	>92	Dentists (n=93)	India
	de Jesus Junior et al., 2018	63.6	Dentists (n=286)	Brazil
	Isper Garbin, Barreto Soares, Moreira Arcieri, Adas Saliba Garbin, & Siqueira, 2017	81.4	Dentists (n=204)	Brazil
Back	Hayes, Smith, & Taylor, 2013	68 Lower-back 55 Upper-back	Dental Hygienists (n=624)	Australia
	Al-Mohrej et al., 2016	68.1 Lower-back	Dentists	Saudi Arabia

	Botha, Chikte, Barrie, & Esterhuizen, 2014	69.8 Lower-back	Dentists	South Africa
	Tirgar, Javanshir, Talebian, Amini, & Parhiz, 2015	56.7 back	Dentists (n=60)	Iran
	Batham & Yasobant, 2016	86 Lower-back 17 Upper-back	Dentists (n=93)	India
	Isper Garbin et al., 2017	15.7 Lower-back	Dentists (n=204)	Brazil
Hand/wrist	Hayes, Smith, & Taylor, 2013	53	Dental Hygienists (n=624)	Australia
	Al-Mohrej et al., 2016	22	Dentists	Saudi Arabia
	Batham & Yasobant, 2016	54.8 Hand-wrist	Dentists	India
Neck	Hayes, Smith, & Taylor, 2013	85 Neck	Dental Hygienists (n=624)	Australia
	Al-Mohrej et al., 2016	34.3	Dentists	Saudi Arabia
	Botha et al., 2014	77.9 Neck pain	Dentists (n=93)	India
	Isper Garbin et al., 2017	15.7	Dentists (n=204)	Brazil
Shoulder	Hayes, Smith, & Taylor, 2013	70 Shoulder	Dental Hygienists (n=624)	Australia
	Al-Mohrej et al., 2016	33.3	Dentists	Saudi Arabia
	Botha et al., 2014	72.4	Dentists	South Africa

	Tirgar et al., 2015	41	Dentists	Iran
	Batham & Yasobant, 2016	34.4 Shoulder	Dentists (n=93)	India
	Taib, Bahn, Yun, & Taib, 2017	92.7	Dentists (n=85)	Malaysia
	Isper Garbin et al., 2017	12.7	Dentists (n=204)	Brazil
Lower Extremities	Hayes, Smith, & Taylor, 2013	15 Hips/Thigh, 9 Knees	Dental Hygienists (n=624)	Australia
	Batham & Yasobant, 2016	19.3 Ankles/Feet	Dentists (n=93)	India
Other	Tirgar et al., 2015	88.3 Cervical	Dentists (n=60)	Iran

As Table 1 shows, most of the studies reported a higher prevalence of musculoskeletal disorder related symptoms among dental health professionals. More than 92% of dentists in India reported to have experienced pain related to MSDs. In contrast, only 39 % of dental students and faculty in the Czech Republic reported to have experienced musculoskeletal pain. Similarly, 95% of dental students from Netherlands reported muscular and joint pain over the previous 12 months. There was also variance in the site of musculoskeletal pain among the different studies. Among the dentists who participated in the studies across India, there was a higher prevalence of lower back pain (86%), hand/wrist pain (54.8%), neck pain (77.9%), and comparatively, a lower prevalence of shoulder pain (34.4%) and lower extremities pain (19.3%). More than half of the dental hygienists from Australia reported to have experienced upper-back pain. Eighty-five percent of Australian dental hygienists experienced neck pain and 70% reported shoulder pain. A study of dentists in Iran found that 88.3% of them had experienced cervical pain. Studies among dental hygienists from Australia and dentists from India reported that almost one-fifth had lower extremities pain. There was also variance in the

prevalence of MSDs based on gender. A study conducted among 136 dentists found the prevalence of MSDs among female dentists was higher in comparison to male dentists (Hosseinini et al., 2019). A similar study conducted among 85 dentists found no significant difference in the prevalence of MSD symptoms based on gender, age, body mass index, years in practice, number of patients and frequency of breaks (Taib, et al., 2017).

Discussion:

All of the articles analyzed responses from more than 60 participants; however, the articles did not discuss confounding factors for pain, such as off-work responsibilities, adequate sleep, exercise routine, use of medications, or participant's health history, that may be contributing to a higher risk of pain among dentists. One limitation of the study was the results were analyzed from self-reported standard Nordic questionnaires which may have been impacted by the participants' reporting bias. Another limitation involved the study design as the studies used a cross-sectional study design and may have missed the health history, occupational history, and workload of the participants. In addition, some of the articles utilized convenience sampling with dental students whose results may not be generalizable to the larger population. Dental health professionals may also have changed professions or taken an early retirement due to severe pain and those who participated in the survey may be experiencing the pain. The mount of pain, pain tolerance of a person and duration of experiencing pain may impact responses (Michaelides, 2019). The results from the studies also showed variance in MSD pain at different body sites on different studies.

Management:

Magnifying loupes and indirect vision techniques are well-known to have a significant impact on the reduction of musculoskeletal disorder-related symptoms in dentistry whereas ergonomics interventions and their impact on preventing MSDs still lack enough evidence (Mulimani et al., 2018;

Roll et al., 2019; Tirgar et al., 2015). The use of loupes has been reported to have both positive and negative effects on musculoskeletal pain (Hayes, Osmotherly, Taylor, Smith, & Ho, 2014, 2016). A study conducted by Ludwig, McCombs, Tolle, & Russell (2017) reported that the use of loupes helped improve work posture. Hhowever, participants from a comparatively smaller survey study mentioned some difficulties participants faced while using loupes such as a longer adjustment period, limited depth of vision, headache and vertigo (Hayes, Taylor, & Smith 2016). Participants in this study had worn the loupe for only six months so their difficulties may fade away once they have adapted to wearing the loupes (Hayes, et al., 2016). Dental students were also found to be working in prolonged static postures which needs to be addressed with ergonomics training and application of ergonomics principle to clinical practice (Movahhed, Dehghani, Arghami, & Arghami, 2016). Few studies supported the effectiveness of using saddle seats in reducing musculoskeletal pain and improving work posture (Plessas & Bernardes Delgado, 2018). Pain assessment should be done to improve the ability to target the right treatment and improved outcomes as longer job history and age has been related to greater knee pain (Hawker, 2017; Tirgar et al., 2015).

Conclusion:

Dental health professionals were reported to have a higher risk of pain in the neck, shoulder, and hands. Prevalence of musculoskeletal disorder symptoms experienced by dental health professionals on at least one body part ranged from 39% to 95%. This rate shows that the importance of ergonomics training and its application to clinical practice at every dental setting to prevent musculoskeletal injuries and its impact on the physical and mental health of practitioners along with the psychological and economic effects to society. There is a need for more scientific studies to determine the etiology of the MSDs which involve effective ergonomic interventions and their clinical applications. Self-awareness may help to improve work posture so that periodic evaluations should be

conducted to prevent musculoskeletal injuries and control for the possible chronic pain, disability, and early retirement of dental health professionals that may result from these injuries.

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2003 Severe Acute Respiratory Syndrome (SARS) Epidemic: A One Health Perspective

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Abstract

Background: The 2003 Severe Acute Respiratory Syndrome (SARS) outbreak was a global epidemic that affected 8,098 individuals and resulted in 774 deaths by March 2003. Originating in Guangdong, China in late November 2002, this virus quickly crossed international borders to nearby countries like Hong Kong and Singapore and traveled as far as the United States. Patients infected with SARS suffered from severe respiratory symptoms that ranged from dry coughs to severe forms of pneumonia. Initial medical teams and community members in Guangdong had little to no information on the new strain of coronavirus. This gap in information and lack of medical resources combined with slips in surveillance from the Chinese federal government and public health officials facilitated the rapid spread of SARS that led to detrimental repercussions.

A One Health approach that utilizes human, animal, and environmental disciplines may have improved the surveillance and treatment of SARS. With this interdisciplinary approach, public health officials could have better educated and trained medical communities and the general public to ensure that these infectious diseases do not emerge while humans and animals increasingly interact with the environment.

Purpose: The purpose of this paper is to (1) present the epidemiology of the 2003 SARS outbreak (2) identify lessons learned from the 2003 SARS outbreak, and (3) explore the role of One Health in addressing the SARS outbreak.

Introduction

The coronavirus refers to a single-stranded RNA virus covered in glycoprotein spikes that can mutate in around 40 different forms (Aronson, 2020). Known for infecting both humans and non-humans, coronaviruses can easily spread from animal to human. There are seven types of human coronaviruses to date that all vary in severity from the common cold to severe respiratory infections (Virginia Department of Health, 2020). Scientists and the rest of the world witnessed the severity of coronavirus in humans during the 2003 Severe Acute Respiratory Syndrome (SARS) Epidemic. This is comparable to the more novel, deadly strain of coronavirus, COVID-19, in the ongoing global pandemic that currently has 40 million worldwide cases as of October 20, 2020 after the initial outbreak in Wuhan, China in late 2019 (Johns Hopkins University, 2020)**.** Both SARS and COVID-19 have witnessed rapid transmission rates via respiratory droplets and severe respiratory infections but SARS had a much higher case fatality ratio (Khafaie & Rahim 2020). This manuscript highlights how the 2003 SARS Epidemic occurred on a smaller scale than COVID-19 but had far reaching effects.

Severe Acute Respiratory Syndrome (SARS)

The 2003 outbreak of Severe Acute Respiratory Syndrome was an international epidemic that affected over 8,098 individuals among which 774 died (Centers for Disease Control and Prevention, 2017). In other words, this deadly acute respiratory disease killed 1 in 10 people infected from November 2002 to July 2003 (National Health Services, 2019). SARS is caused by the SARS coronavirus (SARS-CoV) that contributed to the wide range of symptoms patients experience 2-10 days within exposure. Infected individuals began with a high fever over 100.4^0F before experiencing headaches, body aches, diarrhea, dry coughs, and the eventual development of pneumonia (Mayo Clinic, 2019). The route of transmission includes person-to-person contact through respiratory droplets,

contaminated surfaces, and airborne spread that allows SARS to spread rapidly from an infected individual to the surrounding environment.

As SARS began to gain international attention by early 2003, travel bans, and isolation protocols were quickly put into place in Asian and American countries by the government and by health institutions such as the World Health Organization (WHO) and Centers for Disease and Control and Prevention (CDC). During this time, health professionals reported the elderly population were at a higher risk for the airborne disease due to weaker or compromised immune systems. By the end of the epidemic, more than half of the infected individuals who were 65 years or older had succumbed to SARS (National Health Services, 2019). Since the 2003 outbreak, there has been no reported cases of SARS and while there was no official treatment developed, ongoing research continues. The aftermath of SARS gave an urgency to public health institutions to strengthen their response systems for similar outbreaks (Hung, 2003). This paper serves to (1) present the epidemiology of the 2003 SARS outbreak (2) identify lessons learned from the 2003 SARS outbreak, and (3) explore the role of One Health in addressing the SARS outbreak.

2003 SARS Epidemic

The SARS outbreak began in mainland China, specifically Guangdong, before spreading to other parts of the world including Hong Kong, United States, and Canada (Centers for Disease Control and Prevention, 2013). Guangdong is the southernmost mainland portion of China surrounded by the South China Sea and connected to Hong Kong and Macau (Yeung & Chang, 2016). Historically, Guangdong has had a unique physical and cultural environment that separates itself from the rest of China. This may have contributed to the quick, yet hidden, spread of SARS. Early reports during the start of this worldwide epidemic came from cities in Guangdong like Foshan, Heyuan, and Zhongshan as physicians, in mid-November 2002, noticed abnormal patient cases of atypical pneumonia (Huang,

2004). Yet, Chinese health officials did not receive reports of these patients until a month later when health experts were sent to local hospitals. These patients were then diagnosed with an "infection-based disease" and this information began to slowly move through the chain of command from the local Guangdong hospitals to the Ministry of Health in Beijing (Huang, 2004). By January 2003, the virus was spreading among the public without their knowledge as health officials withheld information from the public and medical community (Huang, 2004).

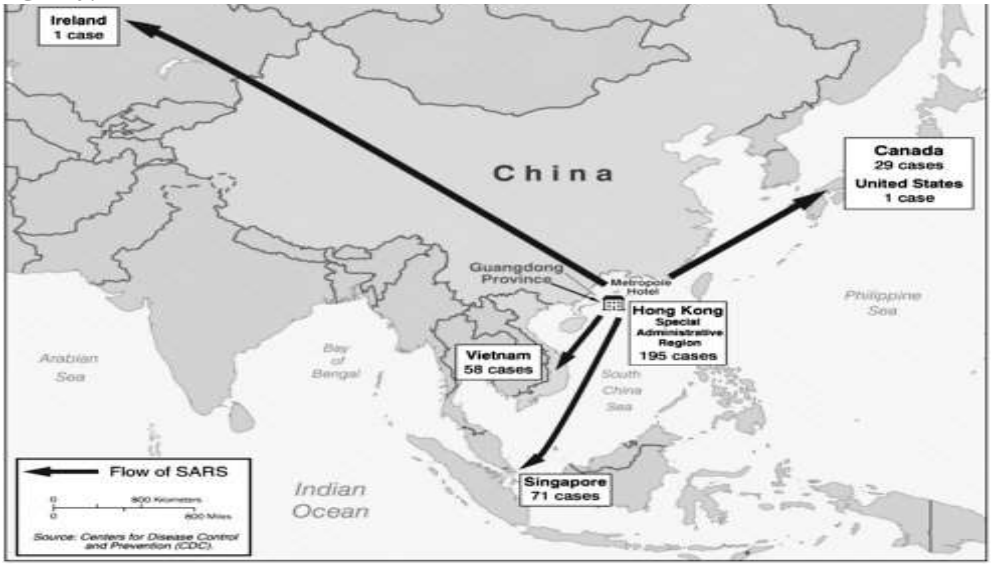
The rapid spread of SARS can be traced to the initial phase of the outbreak. With a lack of public information, doctors and nurses continued to treat patients with the reported "infectious disease" (Huang, 2004). Health care workers were the first to get infected which allowed the virus to be easily transmitted among other health care staff and inevitably, the larger community (Thompson et al., 2003). This pattern of transmission was observed in several regions of southern China as abnormal cases began to rapidly appear in the surrounding provinces. No travel bans were issued at this point which meant infected individuals were unknowingly traveling to outside countries and transmitting the disease across borders all over the world.

In mid-February 2003, the WHO was finally informed of the rising numbers of patients with atypical pneumonia (Gittings & Meikle, 2003). In China alone, there was approximately 305 infected cases and 5 deaths while other countries, such as Singapore, Canada, and the U.S., began to report initial cases of patients with atypical pneumonia (Gittings & Meikle, 2003; World Health Organization, 2015). WHO officials instantly issued a travel advisory for all individuals to infected regions to prevent the further spread of the virus and remain cautious for possible symptoms that could develop during the incubation period (World Health Organization, 2003). Panic was rapidly escalating on the international front from health institutions and governments as the Chinese government faced increased scrutiny for their attempt to cover the scale of the outbreak (Gittings & Meikle, 2003).

By March 21, 2003, the CDC released the first preliminary clinical description of SARS describing the typical symptoms and characteristics of affected SARS patients. At the same time, health officials acknowledged that the severity of SARS and etiology of the disease remained unknown (WHO, 2003). This increased the emphasis on utilizing the international travel ban as a form of a global surveillance system. This was conducted through heightened screening of passengers traveling to and from infected areas and increased sanitization of aircrafts to prevent the international spread (Hoffmann, 2006). Meanwhile, entire teams of WHO health officials were traveling through the hospitals of Guangdong provinces to collect information on the patient population affected by SARS (World Health Organization, 2015). As shown in Figure 1, cases spread from the epicenter in Guangdong, China to countries from Hong Kong to Canada. By the end of April, the number of infected individuals from all 7 affected countries reached 3800 cases of which 200 were reported as deaths (WHO, 2015).

Figure 1.

Spread of SARS Cases by March 28, 2003 From the Epicenter in Guangdong, China.

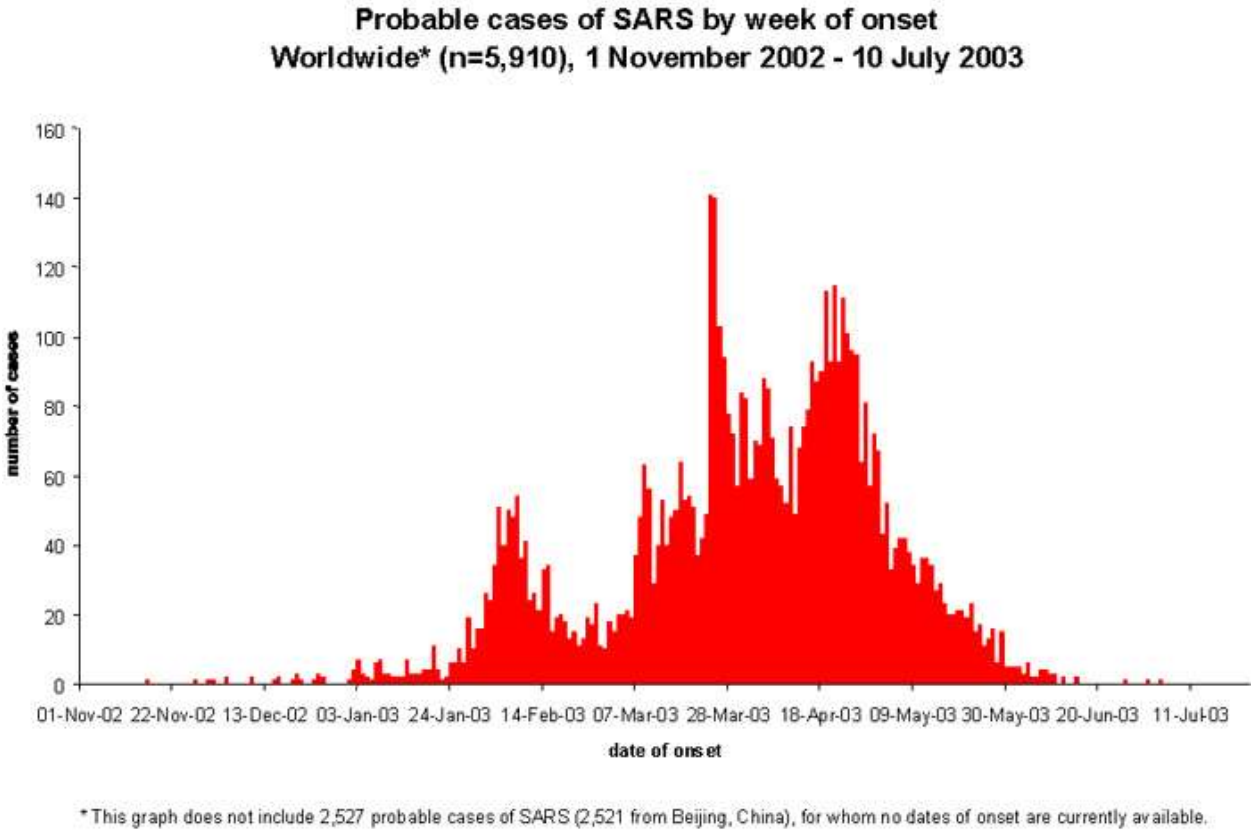


With the highest concentration of SARS patients being in China, which had a record high of 3000 cases, the government quickly imposed a set of precautions to begin to contain the epidemic. They shut down schools, public events, and other recreational events and issued a quarantine order for citizens (Hoffmann, 2006). Health officials were increasingly worried about the availability and capacity of medical resources in more rural parts of China as there were no real public health infrastructures in place to distribute medical resources and individuals.

The WHO began to lift travel restrictions in early July with Taiwan becoming the last country to be removed from the international list of possible local SARS transmission (World Health Organization, 2003). By late July 2003, the SARS outbreak was declared officially contained as the number of new cases reached zero, as shown in Figure 2 (Centers for Disease Control and Prevention, 2017). By the end of the SARS outbreak, the WHO had reported 8096 probable cases and 774 deaths (CDC, 2013). Epidemiological reviews concluded that the SARS epidemic could have been contained earlier if the proper public health measures had been put into place (Hoffmann, 2006). It was clear that all affected countries, especially China, should remain in continued vigilance and surveillance as the world was not completely SARS free (Thompson et al., 2003).

Figure 2.

Total Number of SARS Cases Reported Globally from November 1, 2002 to July 10, 2003.



China's Handling of SARS

From the beginning, the outbreak had slips in the surveillance net that gave SARS an easier route of transmission. This had severe health, political, and social repercussions not only in China but also on the international front. Local hospitals in the southern province of China had a weak chain of accountability and a lack of public health infrastructure in place to respond to a disease on the scale of SARS (Huang, 2004). The downplaying of the severity of SARS by Chinese physicians and government officials had severe impacts on the public.

The cracks in the political system were instantly noticeable as the old Chinese health minister and Beijing mayor were removed for failing to report the correct number of cases and claiming that the "crisis was under control" (Gittings & Meikle, 2003). The new health minister, Gao Quiang, gave a rare nationally televised public conference acknowledging the mishandling of the Chinese government through a weak epidemic control system (Gittings & Meikle, 2003). Mr. Gao stated that more than 200

SARS patients in military hospitals were undisclosed in the beginning and blamed the rapid spread and lack of preparedness in the Chinese public health system (Eckholm, 2003). Military hospitals failed to report the number of affected civilian patients that led to numerous errors and intentional deception (Eckholm, 2003). Domestic scrutiny increased as the public's faith in China reached an all-time low that many experts cite was comparable to the 1989 Tiananmen Square massacres (Eckholm, 2003). International scrutiny came from institutions like the WHO and CDC which questioned the balance between Chinese medical whistle-blowers and local individuals (Eckholm, 2003). While China was quick to correct its mistakes, the initial fragmented system only quickened the spread of SARS that could have been contained much earlier. This highlights the important relationship necessary between a proper epidemic response system and a chain of command with accountability.

Lessons Learned

The world learned several lessons after SARS that completely altered the field of global surveillance. It encouraged international public health institutions to establish early diagnostic tests, identify animal reservoirs, and create a global health database (Thompson et al., 2003). These three components would allow health officials to identify a virus much earlier and separate it from other similar cases. Additionally, identifying the origin increases the understanding of transmission methods that international scientific communities can use to prevent, diagnose, and treat affected patients.

It is important to keep in mind that no matter how robust a response system is, there is always a chance an entire country can succumb to a disease, as seen during the 2003 SARS epidemic. An explosive spread combined with no coordination among authorities or protocols for isolation methods between hospitals led to a disparity in infected patients and repercussions on a much bigger scale (Thompson et al., 2003). This distinct aspect of SARS separates it from its predecessors. An increase in governmental investment in infection control training for health and epidemiological specialists

could increase the awareness of not only the patients affected but also the physicians and nurses who are the ones responding first. These changes could have improved the flow of information between mainland China and the international community that would have been critical to controlling the spread of SARS.

One Health Approach

A One Health approach involves the use of human, animal, and environmental factors to approach a health issue (Stadtländer, 2015). This three-pronged, interdisciplinary approach allows for increased education between scientific communities, medical professionals, and the general public and could have been applied during the 2003 SARS outbreak as part of their epidemic response. A mutated virus at the center of any outbreak emerges not from a single factor but a combination of three factors, humans, animals, and the environment (Stadtländer, 2015). Identifying the source of the virus, or animal vector, in the triangle of One Health lends health experts a surplus of information as there is a small line between veterinary and human health (Stadtländer, 2015; Knobler, 2014). In the SARS epidemic, a civet was identified as the possible animal vector; however, a ban on exports was only enforced in January 2004, a year after the outbreak (Centers for Disease Control and Prevention, 2013). In addition, many small towns in southern China specialize in selling exotic animals for consumption as noted in the Karl Taro Greenfield's *China Syndrome.*

This aspect of the SARS disease has direct links to the human and environmental factors involved in the epidemic. Human health was instantly compromised as SARS began to spread in November 2002 (Centers for Disease Control and Prevention, 2013). Many infected patients were kept in close quarters with other patients experiencing similar respiratory illnesses that, when combined with the poor hospital infrastructure, led to dire mortality rates (Hung, 2003). Quarantine protocols were not in place which encouraged a lack of information and led to an explosive jump in the number

of infected individuals. Environmental factors involved poor sanitation that spread through fecal matter as SARS was known by spreading through any type of body liquid or air droplets that contained high concentrations of the virus (Hung, 2003). Housing estates, such as Amoy Gardens, were common in certain regions of China and allowed individuals to live in close proximity to each other (Hung, 2003). An infected individual experiencing diarrhea as a symptom of SARS could easily spread the disease through U-traps, the communal plumbing system found in these estates (Hung, 2003). This highlights how the interdisciplinary approach of One Health could have been targeted at any one of these situations.

Using a One Health approach definitely brings some barriers as it requires education, funding, and advanced diagnostics. The lack of these components in the Chinese public health infrastructure contributed to the rapid spread of the global epidemic (Stadtländer, 2015). Health professionals in medicine are trained to focus purely on human health without considering environmental or animal factors that can lead to overlooking certain aspects of disease treatment (Stadtländer, 2015). However, to better address health issues and more importantly, prepare us for the next epidemic similar to SARS, the disease must be viewed through an interdisciplinary lens between the human population, zoology, and the environment. One Health gives promise to developing new tools that better allow us to better predict and prevent a disease at the start of the outbreak rather than after.

Summary and Recommendations

The 2003 SARS epidemic affected approximately 8098 individuals, among which 774 died from November 2002 to March 2003. Through the combination of respiratory droplets and international travel, the virus quickly spread from Guangdong, China to as far as the United States. More importantly, the spread of SARS was facilitated by the gap in knowledge between the public, medical community, and public health officials in the Chinese government. This may have slowed the

dispersion of information to the international community but sped up the consequences of SARS on a health, political, and economic level. This epidemic has shed light on the importance of maintaining robust public health infrastructures that can respond quickly and effectively to outbreaks. Establishing a clear line of communication between physicians and nurses on the frontlines to the government and public health officials can help communities better follow proper health measures to mitigate the spread of a novel virus. Utilizing a One Health approach for the SARS outbreak could have provided a multidisciplinary approach to address the interactions between humans, animals, and the environment that are at the core of any outbreak. Utilizing this interdisciplinary lens not only allows public health officials to strengthen their response during an ongoing epidemic but also allows for the establishment of a strong framework to prevent the next epidemic.

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Social and Behavioral Risk Factors of Sexually Transmitted Infections in Community College and University Female Students

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Abstract

Purpose: To compare female students' engagement in behavioral risk factors for Sexually Transmitted Infections (STIs) between a 4-year university and a 2-year community college and determine the impact of institutional setting on risky sexual behavior.

Methods: Participants aged 18-24 years were recruited from a local community college or university and 143 female students were included in the study. Paper questionnaires were distributed to all participants to identify various socioeconomic and behavioral risk factors known to be associated with a high incidence of STIs among college-aged students.

Results: Between the two institutional types, females from the community college were more likely to have parents with less educational attainment and a lower family income ($p<0.001$). In fact, students whose parents' highest level of education was a high school diploma were more likely to report not always using condoms during vaginal intercourse in comparison to students whose parents had a post graduate degree (OR: 8.62; 95% CI: 2.67-27.89, $p<0.001$).

Findings: Students within the community college reported lower parental income and education attainment in addition to more sexual partners and alcohol consumption in the past week.

Conclusion: The findings suggest a potential correlation between low socioeconomic status and STI contraction.

Purpose

The United States of America, like other countries, has been plagued with a rise in sexually transmitted infections (STIs), especially among college-aged young adults. According to Scholl, Katz, Cole & Heck (2010), more undergraduate college students are engaging in sexual activity and sexual experimentation, without taking preventative measures for disease transmission such as condom usage. Each year, roughly 19 million people are diagnosed with an STI, with half of those occurring among young people aged 15-24 years (Centers for Disease Control and Prevention (CDC), 2019; Collado, Johnson, Loya, Johnson, & Yi, 2017). Even though this age group accounts for only 27% of the population that is sexually active, they are disproportionately affected by STIs in comparison to other age groups (Collado et al., 2017; Subbarao & Akhilesh, 2017). The college years account for the majority of this time frame and, for many biological, behavioral, and cultural reasons, this age group is at a much higher risk of STI infection. For these reasons, STI research among college-aged students is essential.

Past research has assessed university **students'** knowledge on sexuality topics, including contraception and STIs and the *results* indicated a lack of knowledge surrounding these topics. The researchers found that it was imperative to provide sexual counseling and education to university students **(**Allen, Sherrod, & Williams, 2017; Fehr, Vidourek, & King, 2015; Karaoglu, Onal, Ozgul, & Karaoglu, 2009; Lally et al., 2015; Subbarao & Akhilesh, 2017). Further studies have shown an increase in STIs among university students across genders, particularly among females (Bontempi, Mugno, Bulme, Danvers, Vancour, 2009). Female college students may be disproportionately affected by STIs due to a lack of prevention and intervention methods to decrease these rates (Lewis, Melton, Succop, & Rosenthal, 2000; Lindley, Barnett, Brandt, Hardin & Burcin, 2008) Another study found that female students were unprepared to have sexual intimacy, faced pressure from males, and were

often prone to regret their decisions (Naghavi, Rotonda, Stewart, Tattersall, Winkler, 2012). Among female African American college students, Vasilenko, Lefkowitz, Maggs (2012) noted that, although the participants displayed a knowledgeable awareness about STIs and their consequences, they still engaged in risky sexual behaviors and were more likely to contract an STI. College environments foster behaviors favorable for STI contraction, but limited research compares risky sexual behaviors between institutional type. For these reasons, this study will compare female students' engagement in behavioral risk factors for STIs between a 4-year university and a 2-year community college to determine the impact of institutional setting on risky sexual behavior.

Methods

All participants were female college students aged 18-24 that were recruited from a local community college or university. To ensure college enrollment, all identities from students were confirmed by their institutional student ID. A total of 278 participants, 139 from each institution, were recruited for the study. Of the 278 participants, 68 females responded from the 2-year community college and 75 females from the 4-year university. The remaining 135 participants were male students that were not included in the final analyses. A self-developed questionnaire that was previously validated by a prior study was distributed to participants in sealed envelopes through a cross sectional study design (Attin, 2012; McMillan, 2000). Questions within the survey focused on identifying socioeconomic and behavioral risk factors known to be associated with a high incidence of STIs among college-aged students. Once the data were collected, the Statistical Product and Service Production (SPSS) software 20.0 was used to analyze the results. Both chi square and multiple regression analyses were conducted utilizing income of birth family and education level of parents as the independent variables and condom use, number of sexual partners, type of sex, and drinking habits as the dependent variables. Linear regression analysis was also conducted utilizing institution type as

the independent variable and number of lifetime partners and number of drinks as the dependent variables.

Results

Descriptive Statistics

A frequency analysis of sexual behavior risk factors showed that 35% (n = 19) of females in the 4-year university used condoms compared to 41% (n = 29) of females in a 2-year community college (p = 0.479) (Table 1). During vaginal intercourse, more females from the 4-year university used condoms (57%, n = 30) compared to those attending a 2-year community college (30%, n = 21; $p < 0.003$). Furthermore, the results showed that fewer 2-year female community college students (n = 48) had more than one partner in the past year as compared to their counterparts (n = 22). The results also indicated that 4-year university females engaged in more unwanted sex (n = 6) compared to community college students (n = 1; p = 0.038). However, findings suggested that there was no significance difference when examining students' engagement in intercourse under the influence of drugs or alcohol (p = 0.208).

Table 1

Frequencies of STI Sexual Risky Behaviors among Females By Institution Type[a]

	Four Year University (n=68)	**Community College (n=75)**	**X^2**	**p-value**
Condom used with oral contraception				
Yes	19 (35)	29 (41)	0.50	0.479
No	35 (65)	41 (59)		
Condom used during vaginal intercourse				
Always	30 (57)	21 (30)	8.80	**0.003**
Not always	23 (43)	49 (70)		
Condom used during anal intercourse				
Always	6 (67)	5 (100)	2.12	0.145
Not always	3 (33)	0 (0)		
More than one sexual partner in the past year				
1 partner	32 (59)	22 (31)	9.60	**0.002**
More than 1 partner	22 (41)	48 (67)		
Engaging in intercourse under the influence				
No	17 (25)	49 (65)	1.58	0.208
Yes	17 (25)	26 (35)		
Engaging in unwanted sex				
No	62 (91)	74 (99)	4.30	**0.038**
Yes	6 (9)	1 (1)		

[a] 0 = 4-year college, 1 = community college

A logistic regression analysis was performed to examine the association between institution type and risky behaviors (Table 2). Females enrolled in a community college were three times more likely to report not always using a condom during vaginal intercourse (OR: 3.04; 95% CI: 1.44-6.43; $p<0.01$) than those enrolled in a 4-year university. Furthermore,

females enrolled in a community college were also three times more likely to have more than one sexual partner within the last year (OR: 3.17, 95% CI: 1.51-6.66, p<0.01) and reported an average of three more lifetime partners than those enrolled in a 4-year university (OR: 0.30; 95% CI: -0.03-0.57; p<0.05). No significant differences were observed between university types for condom\oral contraception use or for engaging in intercourse under the influence. The linear regression analysis showed that institution type played a significant role in student's number of lifetime partners and drinking habits (P<0.05).

Table 2

Regression Analysis Examining the Association Between Institution Type[a] and STI Behavioral Risk Factors Among Females.

	Odds ratio	*SE*	95% CI
Logistic Regression Analysis			
Condom\condom with oral contraception used[b]			
Institution type[a]	0.77	0.37	0.37 – 1.60
Condom used during vaginal intercourse[c]			
Institution type[a]	3.04**	0.38	1.44 – 6.42
Condom used during anal intercourse[c]			
Institution type[a]	Cannot be computed due to limited sample size		
More than one sexual partner in the past year[d]			
Institution type[a]	3.17**	0.38	1.51-6.66
Engaging in intercourse under the influence[e]			
Institution type[a]	1.59	0.37	0.78-3.29
Engaging in unwanted sex[e]			
Institution type[a]	0.14	1.09	0.02-1.19
Linear Regression Analysis	B	*SE*	95% CI
Number of lifetime partners			
Institution type[a]	0.30*	0.14	0.03-0.57
Number of drinks			
Institution type[a]	0.05	0.13	-0.22 – 0.31

[a] 0 = 4 year college, 1= community college; [b] 0 = yes, 1 = no; [c]0 = always, 1 = not always; [d]0 = 1 partner or less , 1 = more than one partner; [e] 0 = no, 1= yes; *p < .05; **p < .01;***p < .001.

As shown in Table 3, after controlling for socioeconomic status, no significant differences were observed between females attending community college and those attending 4-year universities for reported condom use. However, parental educational attainment was found to be a significant predictor of condom use during vaginal intercourse. In fact, students whose parents highest level of education was a high school diploma were more than 8.5 times as likely to report not always using condoms during vaginal intercourse in comparison to students whose parents had a post graduate degree (OR: 8.62; 95% CI: 2.67-27.89, $p<0.001$). Similarly, students whose parents were college graduates were 4.6 times more likely to not always use condoms during vaginal intercourse in comparison to the same group with a post graduate degree (OR: 4.6, 95% CI: 1.55-13.69, $p<0.01$).

Table 3

Logistic Regression Analysis Eamining the Associations Between Institution Type[a], Parental Income & Education & Risky Behaviors Adjusted for Demographics (Females Only)

	Odds ratio	*SE*	95% CI
Condom used with oral contraception[b]			
Parental Education[c]			
High school graduate	0.89	0.54	0.31 – 2.60
College graduate	2.03	0.54	0.71 – 5.83
Income[d]			
Less than 19,999	1.41	0.64	0.40-4.95
20,000–49,999	0.55	0.61	0.17 – 1.81
Institution type[a]	0.70	0.44	0.30 – 1.64
Condom used during vaginal intercourse[e]			
Parental Education[c]			
High school graduate	8.62***	0.60	2.67-27.89
College graduate	4.6**	0.56	1.55 – 13.69
Income[d]			
Less than 19,999	0.96	0.65	0.27 – 3.43
20,000–49,999	1.13	0.63	0.33 – 3.90
Institution type[a]	1.89	0.46	0.77 – 4.62
Condom used during anal intercourse[e]	Cannot be computed due to limited sample size		

[a] 0 = 4 year college, 1= community college; [b] 0 = yes, 1 = no; [c] post graduate degree is the reference category; [d] 50,000 or more per year is the reference category; [e]0 = always, 1 = not always; *$p < .05$; **$p < .01$;***$p < .001$.

After controlling for parental socioeconomic status, females enrolled in a community college were nearly six times more likely to report more than one sexual partner within the past year (OR: 5.89; 95% CI: 2.15-16.14, p<0.01) (Table 4). Neither parent's educational attainment nor income status was a significant risk factor for number of sexual partners in the past year. However, when looking at engagement in sexual intercourse under the influence, parental educational attainment was found to be a significant predictor. Compared to females whose parents achieved a post graduate degree, those whose parents had a high school diploma were nearly four times more likely to engage in intercourse under the influence (OR: 3.92, 95% CI:

1.14 – 13.54, p<0.05) while those whose parents had a college degree were 4.5 times more likely (OR: 4.71, 95% CI: 1.44 – 15.35, p<0.05). Neither parental educational attainment nor income was a significant predictor for engaging in unwanted sex. As Table 5 shows, after controlling for parental education and income, there were no significant differences between females enrolled in community colleges and those enrolled in 4-year universities for the number of lifetime partners or the number of reported drinks within the past week. Compared to females whose parents had a post graduate degree, females whose parents had a high school diploma reported, on average, nearly 1.5 more drinks within the past week (OR: 0.76; 95% CI: 0.41-1.10, p<0.001).

Table 4

Logistic Regression Analysis Examining the Associations Between Institution Type[a], Parental Income & Education & Risky Behaviors, Adjusted for Demographics (Females Only) (continued)

	Odds ratio	*SE*	95% CI
More than one sexual partner in the past year[b]			
Parental Education[c]			
High school graduate	0.48	0.58	0.15 – 1.50
College graduate	1.00	0.56	0.34 – 3.03
Income[d]			
Less than 19,999	0.76	0.65	0.21 – 2.69
20,000- 49,999	3.09	0.63	0.91 – 10.54

Institution type[a]	5.89**	0.52	2.15 – 16.14
Engaging in intercourse under the influence[e]			
Parental Education[c]			
High school graduate	3.92*	0.63	1.14 – 13.54
College graduate	4.71*	1.55	1.44 – 15.35
Income[d]			
Less than 19,999	0.55	0.62	0.16 – 1.86
20,000–49,999	0.39	0.61	012 – 1.30
Institution type[a]	1.42	0.43	0.62 – 3.27
Engaging in unwanted sex[e]			
Parental Education[c]			
High school graduate	2.40	1.31	0.18- 31.34
College graduate	4.80	1.57	0.49 – 47.04
Income[d]			
Less than 19,999	2.37	1.26	0.20 – 27.80
20,000–49,999	2.17	1.21	0.20 – 23.48
Institution type[a]	0.10	1.14	0.01 – 1.00

[a] 0 = 4 year college, 1= community college; [b]0 = 1 partner or less , 1 = more than one partner; [c] post graduate degree is the reference category; [d] 50,000 or more per year is the reference category; [e] 0 = no, 1= yes; *$p < .05$; **$p < .01$;***$p < .001$.

Table 5

Linear Regression Analysis Examining the Associations Between Institution Type and Risky Behaviors, Adjusted for Demographics (Females Only)

	B	*SE*	95% confidence interval
Number of lifetime sexual partners			
Parental Education[b]			
High school graduate	0.16	0.19	-0.22 – 0.54
College graduate	-0.07	0.18	-0.43 – 0.29
Income[c]			
Less than 19,999	0.26	0.22	-0.17 – 0.69
20,000- 49,999	0.08	0.20	-0.33 – 0.48

Institution type[a]	0.16	0.15	-0.13 – 0.46
Number of drinks in the past week			
Parental Education[b]			
High school graduate	0.76***	0.18	0.41 – 1.10
College graduate	0.17	0.17	-0.16 – 0.50
Income[c]			
Less than 19,999	-0.06	0.20	-0.45 – 0.33
20,000–49,999	-0.13	0.19	-0.50 – 0.24
Institution type[a]	-0.17	0.14	-0.44 – 0.10

[a] 0 = 4 year college, 1= community college; [b] post graduate degree is the reference category; [c] 50,000 or more per year is the reference category; [e] 0 = no, 1= yes; **p* < .05; ***p* < .01;****p* < .001.

As shown in Table 6, the results of the chi-square analysis indicated that females 18-to-24 years of age enrolled in a 2-year community college were more likely to have parents with lower income and lower educational attainment than those enrolled in a 4-year university. Specifically, 65% of females from the 2-year community college had parents that were more likely to have lower income (e.g. less than $19,999) than parents of students from a 4-year university. Similarly, 75% of females in the 4-year university reported parents having a higher education at the graduate/post graduate level as compared to only 44% of 2-year community college students (p<0.001).

Table 6

Chi-square Analysis Examining Demographic Differences by Institution Type

	Four Year University (n=68)	**Community College (n=75)**	**X^2**	**p-value**
Income (n (%))				
Less than 19,999	20(29)	49(65)	20.31	**<0.001**
20,000-49,9999	29(43)	20(27)		
50,000 or more	19(28)	6(8)		
Parental Education (n(%))				

High school graduate	17(25)	42(56)	16.26	**<0.001**
College graduate	24(35)	21(28)		
Post college graduate	27(40)	12(16)		

Summary

The results showed that female students from both institutions, whether 2-year community college or 4-year university, displayed sexual risk behaviors that increasd the probability of contracting STIs. Additionally, female community college students had a lower SES and parents with a lower degree of education in comparison to the 4-year university females. Among students whose parents had a low educational attainment (i.e. high school diploma), the results indicated that condoms were not always used during vaginal intercourse, which demonstrates the effect of socioeconomic status on STI contraction. Several studies also highlight a lack of consistent condom usage among college students and potential association with low income (Fehr, Vidourek, King, & Nabors, 2017, 2018; Harling, Subramanian, Barnighausen, & Kawachi, 2013). When comparing female students between each institutional type, those in the community college reported having more sexual partners than their 4-year university counterparts.

Conclusion and Recommendations

This research compared female students in two educational settings, a 2-year community college and a 4-year university. Results from the study indicated that, depending on institutional setting, female college students exhibited different behavioral risk factors for STI contraction. Based on the results, interventions to reduce the number of sexual partners among 2-year community college students and to increase condom usage among 4-year university students are needed (Fehr, Vidourek, King, & Nabors, 2018). Such programs to increase students' awareness

of STIs are essential in college institutions to tackle the STI problem among young adults (Collado, Johnson, Loya, Johnson, & Yi, 2017; Fehr, Vidourek, King, & Nabors, 2017, 2018; Miller, 2018). Future studies could be performed to determine differences by age group, class (i.e. freshmen, sophomores, juniors, and seniors), or ethnic group. More in-depth studies could also identify specific risk factors of each institution such as low condom use, multiple sexual partners, and poor drinking habits. STIs have proven to be costly and devastating in the long run, and may cause irreversible damage. For these reasons, there is a need for primary, secondary, and tertiary prevention methods to tackle this ever-increasing burden. Increasing STI awareness on college campuses is critical, and public health officials must emphasize the importance of safe sexual behaviors.

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Using Age-Adjusted and Crude Rates for Assessing COVID-19 Cases

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Abstract

Purpose: To assess the difference in crude rates and age-adjusted rates in COVID-19 cases.

Methods: COVID-19 cases in Virginia were obtained from the publicly available dataset as of June 21, 2020. Crude rates of COVID -19 cases were calculated and estimates for the total population of Virginia were age-adjusted to the U.S. Census 2000 population using the direct method.

Results: There was a wide difference between the crude rate and the age-adjusted rate in the different age-groups. The crude rate was highest for the over 80 age group, 1063.93 per 100,000 population. However, the age-adjusted rate was highest in the 40-49 years age group, 147.72 per 100,000 followed by the 30-39 group and 20-29 group.

Conclusion: Comparing the crude rates and age-adjusted rates of COVID-19 cases takes into account the confounding effect of age due to differences in the distribution of a population. Given the risk and higher COVID-19 cases among certain age-groups, knowing the crude rates and the age-adjusted rates may help in population-based prevention and interventions and can be used for planning capabilities and targeted measures.

Key Words: Age-adjusted rate, COVID-19, Crude rate

Background

The World Health Organization (WHO) declared the novel Coronavirus (COVID-19) as a pandemic on March 11, 2020 (WHO, 2020). Many earlier estimates across different states in the United States have reported on cases and mortality rates, across different races and ethnicity (Centers for Disease Control (CDC), 2020). Co-morbidities of Covid-19 (e.g. diabetes, cardiovascular disease) increase with age, and underlying health conditions (Dowd et al., 2020; Shahid et al., 2020). The contribution of age distribution, when comparing cases across variables such as race, is relevant and will help in presenting a clearer picture of the spread of the coronavirus. This is especially relevant since for diseases in general and for COVID-19, a number of factors may have an impact, especially age as a confounding factor.

Generally, crude rates of cases or incidence of COVID-19 has been reported with a few exceptions, where age-adjusted rates have been described (CDC, 2020). Crude rates are useful when comparing different populations of varying sizes, such as comparing death rates for all causes over a particular time period (CDC, 2020). However, crude rates do not take into consideration the demographic makeup of a population. The reported crude rates of cases varies widely between different populations and the limitations of using crude rates has been addressed in other diseases like HIV and hypertension (Cosby et al., 2019; Hoyert et al., 2001; Ostchega et al., 2020; Zaba et al., 2007). Crude rates control for the population size, but assumes that all of the population are equally at risk, irrespective of the socioeconomic and demographic factors, like a younger population, and variation in age-structure (Klein & Schoenborn, 2001). Given the difference in health risks and outcomes across different age groups and races, understanding the effect of the age distribution of a population is essential. Information on age-adjusted rates while

reporting cases serves as a measure of the demographic impact of the pandemic (Cosby et al., 2019; Hoyert et al., 2001; Ostchega et al., 2020; Zaba et al., 2007).

Using age-adjusted rates controls for age when comparing different populations with varying age-distributions (Curtin & Klein, 1995). In this manuscript, the extent to which age distribution of COVID-19 cases varies across different age groups and races within the Commonwealth of Virginia will be examined by comparing the crude rates with the age-adjusted rates at different locations across Virginia. There is a marked difference between the age-adjusted rates and crude rates for some population groups, which may be due to the difference in the population distribution of that particular group. For example, the Hispanic population has a much younger age distribution in the United States (U.S. Census Bureau, 2018). Thus, age standardization is necessary to prevent potential bias across different age groups (Curtin & Klein, 1995; Klein & Schoenborn, 2001).

Methods

Secondary datasets of COVID-19 cases containing age groups and races across the Commonwealth of Virginia were obtained from the publicly available database on June 21, 2020 (VDH, 2020). The population of Virginia was downloaded from the United States census website (U.S. Census Bureau, 2018). The total population in Virginia was 8,517,685 (US Census bureau, 2018). Twenty-five percent of the population was in the 0-19 years age-group, 13.7% in both 20-29 and 30-39 age-groups, 12.8% in the 40-49 age-group, 13.3% in the 50-59 age-group, 11.4% in the 60-69 years age-group, 6.7% in the 70-79 years age-group and 3.6% in the over 80 age-group (US Census bureau, 2018). The age groups for the study were extracted based on those reported in the publicly available dataset. Crude rates of COVID -19 cases were calculated

and estimates for the total population of Virginia were age-adjusted to the U.S. Census 2000 population using the direct method and age-groups 0-9, 20-29, 30-39,40-49, 50-59, 60-69, 70-79 and over 80 years (Curtin & Klein, 1995). The direct standardization method for age-adjustment, used by the CDC's National center for Health Statistics (NCHS), is the application of observed age-specific rate to a standard age distribution that would eliminate the differences in crude rate, resulting from differences in the population age distribution (Hoyert et al., 2001; Klein & Schoenborn, 2001). Age-adjustment was done by multiplying the crude rates with the age-adjusted specific weights for each age group (Curtin & Klein, 1995). For example, for the age group 0-9 years, the crude rate of COVID-19 was 182.81 per 100,000. Multiplying the crude rate by the age group specific weight resulted in an age-adjusted rate, based on the U.S. Census 2000 population, of 0.141666. The direct method is particularly relevant in the United States as the White and Hispanic populations vary greatly in age-structure, and thus, using this method would then eliminate the difference due to one population being older than the other (Hoyert et al., 2001; US Census Bureau, 2018).

Results

As of June 21, 2020, Virginia had recorded 57,994 cases of COVID-19 of which 4,195 (7.3%) were missing ages and therefore were excluded from the analysis. Among the 53,799 cases with known age, the age group distribution of cases included 3.4% of cases between 0-9 years, 17.7% between 20-29 years, 20% between 30-39 years, 19.5% between 40-49 years, 16.7% between 50-59 years, 11% between 60-69 years, 5.7% between 70-79 years and 6% over 80 years of age (Table 1). Table 1 also displays the crude rates and age-adjusted rates of COVID-19 for each age group. As seen, there was a wide difference between the crude rate and the age-

adjusted rate in the different age groups. The crude rate was highest for the over 80 age group at 1063.93 per 100,000 population, followed by the 40-49 age group, and 50-59 age group, with crude rates of 959.41 and 792.65 per 100,000 population respectively. However, the age-adjusted rate of cases was highest in the 40-49 years age group at 147.72 per 100,000 followed by the 30-39 group and 20-29 group at 140.81 and 106.29 per 100,000, respectively. The age-adjusted rate for the over 80-age group was 35.48 per 100,000 population.

Table 1

Age-adjusted Rates of COVID-19 Cases in Virginia (Data as of June 21, 2020)

Age Groups	**Total COVID-19 (Age-reported) Cases in Virginia as of June 21, 2020* *N* (%)**	**Crude Rate Per 100,000**	**Age-Adjusted Rate Per 100,000**
0-9	1859 (3.4)	182.81	25.90
20-29	9519(17.7)	816.35	106.95
30-39	10785(20)	927.57	140.81
40-49	10476(19.5)	959.41	147.72
50-59	8987(16.7)	792.65	88.12
60-69	5908(11)	606.46	44.31
70-79	3044(5.7)	533.72	31.37
80+	3221(6)	1063.93	35.48
Total	53,799		

*Total cases *N*= 57,994, Age missing = 4,195 cases (7.25%)

Discussion

At first glance, the crude rate data indicates that in Virginia, the age group of over 80 years had a higher prevalence of COVID-19, relative to other age groups. However, the age-

adjusted variation of cases demonstrated that the 40-49 and 30-39 age groups had the highest rates of COVID-19 cases. The study data shows that the disparities in the unadjusted crude rates of cases are confounded by differences in the age structure of the population (Curtin & Klein, 1995; Hoyert et al., 2001; VDH, 2020). The results of this study is consistent with the literature which has shown if age is a confounding factor, it can be identified by comparing crude and age-adjusted case rates (Shahid et al., 2020).

In Virginia, the age distribution in each population group varied, as the over 80 age-group represented about 4% of the total population, while the age-groups 20-29, and 30-39 represented 14% of population each, and those in the age groups 40-49 years and 50-59 years contributed 13% each (US Census Bureau, 2018). Thus, it was found that COVID-19 cases were higher among the age group between 30-49 compared to those 80 years and above when age was adjusted. These results demonstrate the pitfalls of comparing crude rates, which resonates with what has been documented in the extant literature, and the value added by age-adjusting when studying diseases related to age-groups or geography (Cosby et al., 2019; Dowd et al., 2020; Ostchega et al., 2020). Standardization removes the effect of age as a confounder given the effect of age and comorbidities on COVID-19 (Shahid et al., 2020).

Public Health Implications and Conclusion

Using age-adjusted rates reduces the probability of bias when comparing unadjusted rates of cases across age groups, as the confounding effect of age will be taken into account. Results from this study can be used for planning capabilities and targeted measures to raise awareness of COVID-19, given the risk and higher cases among certain age groups. Knowing the crude rates and the age-adjusted COVID-19 case rates can help in population-based prevention and interventions by assisting in identifying vulnerable populations for testing and providing

education on public health measures, such as social distancing, that help to suppress the spread of COVID-19. Comparing the crude and age-adjusted rates of COVID-19 cases takes into account the confounding effect of age due to differences in the age distribution of a population. The prevalence of COVID-19 cases in the younger age groups may highlight the intersection of social determinants of health, such as access to healthcare (testing) as a contributing factor to the spread of COVID-19.

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Well Water Screening in Suffolk, VA, for Contaminants Affecting Human Health

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Abstract

Purpose: Despite regulations, one area that remains outside the scope of the clean water policies is well water. With the lack of oversight, the millions of home that rely on well water remain susceptible to numerous pollutants and contaminants. To ensure the safety of well water, development of screening and testing protocols is imperative. Many households in Suffolk, VA still use well water making it an apt location to conduct a preliminary study screening for potential water contaminants.

Methods: Water samples from kitchen and garden sources were collected from households in Suffolk, VA. These samples assessed for TDS via Milwaukee EC59 pen, pH via Sper Scientific test tube pen, arsenic via Quick Rapid Arsenic Test Kit, *E. coli* and coliform, and lead via Simpletek Micro Tester Pro self-filling test ampoules.

Findings: Four of the thirty kitchen-sourced samples tested positive for coliform contamination. The positive findings may represent hazards for health thus warranting further investigation.

Conclusion: Many Suffolk homes rely on well water but lack of regulations can bring risk for contamination. This study indicated a potential coliform problem in Suffolk and more work must be done to evaluate for coliform contamination and its resultant health consequences.

Background

The Clean Water Act of 1972 established safety requirements for water sources such as lakes, rivers, and other surface water; this was accomplished in part by regulating pollution into surface water as well as funding sewage facilities and water treatment plants for municipal water. However, many contaminants can still seep into groundwater from sources such as septic tanks, septic drain fields, urban runoff, fertilizers and pesticides, and underground fuel tanks. Common contaminants that may affect water quality include total dissolved solids (TDS), pH, lead, arsenic, *Escherichia coli* (*E. coli*), and coliform bacteria. TDS is associated with hardness, and in conjunction with acidic pH, can predispose pipes to corrosion (Isaac et al., 1997). Corroded pipes may then leach heavy metals into drinking water which was the case in Flint, Michigan. Lead levels in Flint water samples in 20-32% of 6 city wards exceeded the Lead and Copper Rule's threshold for remedial action. Some water samples even had lead concentrations greater than 1000 µg/L (Bellinger, 2016). Lead, even at low levels, has been associated with hypertension, growth retardation, neurological and cognitive deficits, immunosuppression, hepatotoxicity, cardiotoxicity, and congenital defects (Goyer, 1990; Mudipalli, 2007; Needleman & Bellinger, 1991).

Arsenic, another natural contaminant, is most often sourced from water (Kapaj et al., 2006). Arsenic may build up in tissues such nails, hair, and skin and is associated with cardiotoxicity, diabetes, peripheral neuropathy, and various types of cancer (Abernathy et al., 1999). Coliforms encompass a range of gram-negative, rod-shaped, lactose-fermenting bacterial species that reside in the intestinal tracts of organisms that can potentially cause a variety of different clinical presentations if infection occurs. Well-known species include *Escherichia*, *Klebsiella*, *Citrobacter*, *Serratia*, *Proteus*, and *Enterobacter* (Guentzel, 1996).

According to the Environmental Protection Agency (EPA) and the 2017 U.S. Census American Housing Survey, approximately 13 million homes in the U.S. use private wells supplied by groundwater sources for their drinking water (EPA, 2019a). The EPA does not regulate the safety of private wells, and it is up to homeowners to test the water frequently for safety. This creates the opportunity for wells to be a significant source of contamination since runoff from nearby industrial plants or farms can go unnoticed until health consequences arise. Broader water quality testing in rural drinking water wells found a greater prevalence of bacterial contamination compared to public wells (Invik et al., 2017).

In sixty of Virginia's ninety-five counties, a majority of households rely on private well water. Suffolk County, VA is one such county (US Census Bureau, n.d.; Virginia Department of Health (VDH), n.d.). As a mostly rural area, many residents source their water from private wells like the regions described in the previous studies. This makes the region a good candidate for further water quality screenings and a good representation for other Virginian counties.

Methods

To choose our sample population, a map from the City of Suffolk website was obtained and confirmed with the Suffolk Health Department that the city supplied water to homes within a five mile radius of the city center. An area outside of the five mile radius was selected and Google Earth was used to confirm that physical homes were associated with addresses. Zip codes which contained houses were designated as clusters. Three zip codes were selected to obtain samples, and 100 homes were supplied with water sample selection kits. We hand delivered sample kits consisting of two 500mL glass bottles, a survey to collect information about the well, and a letter detailing an explanation of the study and instructions for collection. The survey asked for the depth of the well, how it was built, the distance between the well and septic tank, and the

distance between the well and septic drain field. The residents were instructed to fill one bottle from the kitchen tap and the other from the garden tap. The kits were delivered on the weekend and were picked up the following weekend.

All tests, except TDS and pH, were done with colorimetric screening kits. We evaluated the water for the presence of *E. coli*, coliform, and lead using Simpletek Micro Tester Pro self-filling test ampoules. To test for *E. coli* and coliform, water was drawn up into the ampoules and inverted several times to ensure sufficient growth medium dissolution, placed into a desktop incubator at 35°C, and checked for the presence of color change at 4, 12, and 24 hours. In evaluating for coliforms, the color of the sample was observed to change from a pale yellow, indicating negative, to a vivid yellow, indicating a positive result. To determine the presence of *E. coli*, the samples needed to be viewed under ultraviolet light observing for a blue color to indicate a positive result. Testing for lead, water was drawn up into the ampoules and inverted several times for the reagent to mix, with the results read immediately. The presence of lead could be observed as yellow for negative, orange for low presence, or dark orange for high presence.

Arsenic was tested using the Quick Rapid Arsenic Test Kit for arsenic 3 and 5. For each sample, 100mL was mixed with three reagents in a reaction bottle from the kit, a test strip was placed in the cap of the bottle and the reaction was allowed to run for ten minutes, after which we observed for the presence of a color change to be matched against the color chart provided. TDS was measured with the Milwaukee EC59 pen and pH with the Sper Scientific test tube pen. Any locations that tested positive for contamination had the distance measured from the nearest body of water using Google Maps. Due to the fact that we tested by screening method, there

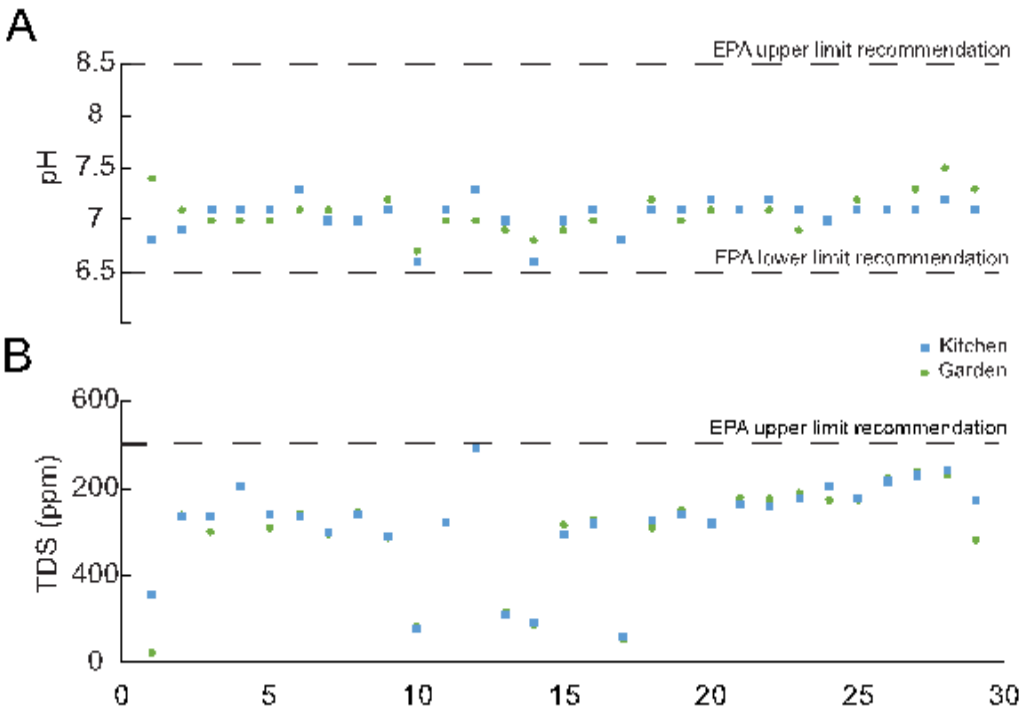
were no quantitative numbers to run any statistical analysis; however, we did a comparison of the TDS, pH, and well information gathered from the survey.

Results

Out of the 100 kits, 30 were returned for a total of 60 samples tested. The results of the calorimetric screening kits showed that for all locations, both kitchen and garden water sources were negative for lead, arsenic, and *E. coli*. The EPA water pH ranges for all the homes was between 6.5 to 8.5 which falls within the EPA standards (EPA, 2019b). As shown in Figure 1a, all of the samples from both sources fall within this range. TDS findings were also non-significant. The recommendation for TDS is below 500 mg/L and all samples fell below that limit (Figure 2b).

Figure 1

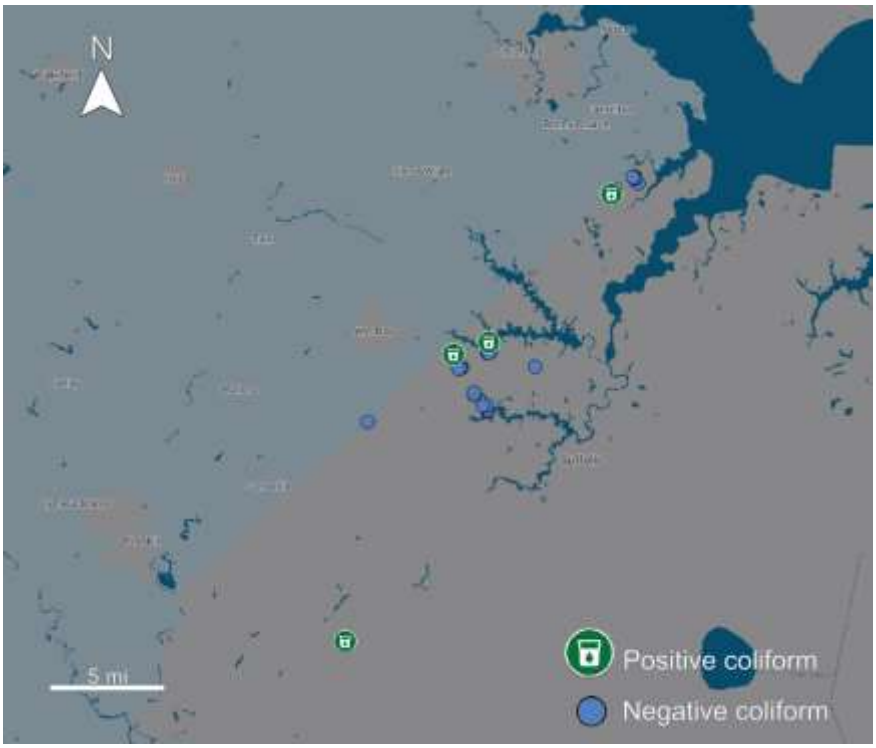
Scatterplot Showcasing Individual pH and TDS Values Obtained from Each Home



There were positive coliform findings in four locations, all of which were seen from kitchen water sources while the garden water samples were negative. The geographical locations of the results are shown in Figure 2. The map depicts the greater Suffolk area from which samples were collected. Homes which provided negative samples are represented with a blue circle while homes with positive samples are represented by a green icon. Three samples were found in homes within 1.50km of a river; however, the fourth sample was located more than 27.00km away from any large water source. Most homeowners omitted well to drainage field and well to septic tank distances on surveys. As such, no conclusions were able to be made from these metrics and this data was excluded from analysis.

Figure 2

Geographical Depiction of the Location the Samples Originated From



Discussion

Groundwater used in private well water systems is susceptible to contamination by run off. This has been a growing concern over the past few decades as there has been an increase in waterborne disease outbreaks involving private water systems with the majority of these cases being linked to groundwater contamination (Craun et al., 2010). Compounded with the lack of EPA oversight, this issue remains unaddressed and unrecognized for many populations. However, screening well water can potentially catch and even prevent health conditions like lead poisoning and gastroenteritis.

Although our sample population was largely free of lead, arsenic, and *E. coli*, four homes with coliforms found in kitchen water samples were detected. At the time of the study, the species of the found coliform samples were not identified. Even if the coliforms present in a household's water supply are not pathogenic, the result is still concerning because their presence suggests structural compromises within the household's well system, increasing the likelihood of later water-borne illnesses (New York State Department of Health, 2017).

Due to the health consequences of water contamination, it is important to identify factors and patterns leading to contamination. Examining the geographic relationships between homes with positive coliforms, no apparent patterns were found. The four homes were not clustered together. Three of the four positive homes were near bodies of water, but other homes on the same street did not test positive. Also, the fourth positive home was not close to any potential contaminating water source. These findings suggest that the positive coliform homes likely had vulnerabilities within their individual well systems leading to contamination.

Due to the nature of the study and institutional policies, there are inherent limitations to the study. First, the researchers were not permitted to enter residents' homes and residents were

required to collect the samples themselves. This could have introduced contaminants foreign to the water supply, failure to properly gather the sample, mislabeling, or other confounders. Additionally, the study was based on voluntary participation and thus some data was lost to follow up.

Conclusion

Ultimately, our water screening revealed that residential well water within Suffolk, VA is largely free of contamination; however, the positive findings indicate some homes would benefit from further well system assessment. As the present study was only a screening, it only provides preliminary data indicating that among populations that rely on well water, there is a plausible risk of contamination. Suffolk is a paradigm for most other counties in Virginia and this study may represent a larger scale problem. Moving forward, we aim to investigate the coliform burden in other Virginia counties and identify the potential health consequences of such contamination.

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Virginia Journal of Public Health Submission Guidelines

The Virginia Journal of Public Health (VJPH) is published twice yearly, fall and spring by the Virginia Public Health Association. The VJPH welcomes research articles, professional articles and literature reviews for consideration for publication (Please see the specific formats for each type of manuscript listed below).

Deadline for Manuscript Submissions:

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Journal manuscripts should be sent to Dr. Kim Baskette, Editor (kbaskett@vtc.vt.edu) as a WORD document, email attachment. In the cover letter or email, the corresponding author needs to affirm that the article has not been published elsewhere.

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1. Follow the form of the Publication Manual of the American Psychological Association (APA), 7th edition (http://www.apastyle.org).
2. Typed and submitted as a Word document; **double spaced, 12 pt. font (font style should be in alignment with new APA guidelines in 7th ed), 1" margins.**
3. Include a title page with the names and addresses of each author to include professional affiliation.
4. Include a title page without author identification (will be used for blind review).
5. Include a pdf copy of the Institutional Review Board approval if appropriate.
6. Include references at the end of the manuscript in **APA format.**
7. Have any figures or tables embedded in the manuscript; do not include at the end of the manuscript. Tables and figures should be **formatted in APA format only.**
8. Include an abstract containing 200 words or less with appropriate delineated sections.

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Questions: Contact Dr. Kim Baskette at kbaskett@vtc.vt.edu