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EXPLORATORY STUDY OF SEASONAL INDOOR BIOAEROSOLS AND THE ASSOCIATED HEALTH OUTCOMES IN LOW-INCOME COMMUNITIES IN EL PASO, TEXAS, 2014

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by

ERIC MARTINEZ, B.S.

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ABSTRACT

Introduction: Structural degradation, moisture levels, and building failures can influence poor indoor air quality and create a good environment for bioaerosols. People spend much of their time indoors and can potentially be exposed to these bioaerosols. Several studies have correlated exposures to high concentrations of bioaerosols to various health problems, severe allergies, asthma, or other respiratory illness. **Objectives:** The objectives of this study are to describe bioaerosol concentrations, meteorological factors, and health outcomes during the summer and fall seasons; characterize bioaerosols (bacteria and fungi) collected in low-income communities; compare bioaerosol concentrations by season; compare meteorological factors to bioaerosol concentrations by season; and compare health outcomes associated with bioaerosols by season. **Methods:** Indoor air quality measurements for bioaerosols were conducted in the morning for two seasons using an Andersen 2-stage cascade impactor. A health quality questionnaire was given to assess reported health outcomes of low-income residents as well as a technical survey administered to check house conditions, which may be potential factors for bioaerosols. Bacterial and fungal colonies were counted and identified in the laboratory. **Findings**: Overall, 45 houses were sampled for the summer and fall season. Majority of the bacteria found was non-pathogenic or opportunistic to those who are immunocompromised. Some important pathogens to consider were *streptococcus pneumoniae* and methicillin resistant *S.haemolyticus* and *S. auricularis*. The identified fungi are considered to be aeroallergens with the capacity to release spores and cause allergic reactions. Concentrations for bacteria were highest for fine bacteria (134 CFU/m^3) during the fall, while fungi concentrations were highest for fine fungi (438 CFU/m^3) during the summer. A Wilcoxon signed-rank test showed that both fine and coarse bioaerosol concentrations did elicit a statistically significant change between summer and fall ($p < 0.001$).

When reporting meteorological factors, low-income communities had a higher mean temperature (27.58°C) and relative humidity (56.97%) in the summer than in the fall. During the summer, participant's highest reported health outcomes were allergies (60%), stuffy nose (60%) and skin irritation (56%) while runny nose (84%), cough (80%), and stuffy nose (71%) were more prevalent during the fall. There was a statistically significant difference in the proportions of reported health complains for wheezing, dry eyes, cough, sneezing, stuffy nose, runny nose, and throat infection between the summer and fall. ($p = 0.031$, $p = 0.004$, $p = 0.001$, $p = 0.004$, $p = 0.013$, $p = 0.006$, $p = 0.017$) **Discussion:** .Different bacteria and fungi were reported during the summer and fall. Study findings also indicate a statistically significant difference in both coarse and fine bioaerosol concentrations for fungi and bacteria by season. In addition there was no correlation between temperature and bioaerosols or between bioaerosols and RH. Some of the reported health outcomes by participants were associated to the different seasons, with higher reported health outcomes in the fall. As per our knowledge, this is the first study conducted in El Paso to characterize and correlate bioaerosols throughout two distinct seasons involving low-income communities. The information obtained will help to develop future interventions and guidelines on how to have better indoor air quality and reduce exposure to bioaerosols.

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CHAPTER 1: BACKGROUND AND SIGNIFICANCE

1.1 ***Overview of Bioaerosols***

Indoor air quality can be affected greatly by sources that release gases or particles into the air creating indoor air quality problems in homes (US EPA, 2013). Combustion sources, tobacco products, household chemical products, or central heating and cooling systems are all factors that create indoor air pollution. Research has determined that biological contaminants also affect indoor air quality. Environmental factors such as temperature, relative humidity, and season, play an important role in the dispersion of biological aerosols throughout the air (Flores et al., 2009). Biological aerosols are aerosols or particulate matter of microbial, plant or animal origin. Bioaerosols reside of pathogenic or non-pathogenic bacteria and fungi, viruses, high molecular weight (HMW) allergens, bacterial endotoxins, mycotoxins, pollen, plant fibers, and other compounds (Douwes et al., 2003). The size distribution of bioaerosols can vary from 20 nm to bigger than 100 µm, as well as in composition, depending on the source, aerosolization mechanisms, and environmental conditions prevailing at the site. Non-industrial places such as homes tend to generate bioaerosols through human activities and some of the fungal spores can be released through house plants and flower pots, house dust, pets and their beddings, textiles, carpets, wood material and furniture stuffing (Mandal & Brandl, 2011). Several studies have indicated that the number of people and pets present significantly affect the levels of indoor bioaerosols. Humans spend 90% of their time in an indoor environment and at home which makes them prone to exposure to harmful bioaerosols if the ideal conditions are present (Wang et al., 2013).

1.2 ***Environmental Parameters***

Homes or buildings that have moisture accumulation, dampness, or water damage may result in many types of indoor air pollution and adverse health outcomes (Nevalainen & Seuri, 2005). The excess of moisture, temperature, nutrients, and oxygen are favorable factors for fungal growth inside buildings. Fungi can release fungal spores and toxins which can induce respiratory effects like asthma, wheezing, and pneumonitis (Nevalainen & Seuri, 2005; Park & Cox-Ganser, 2011).

A study conducted by Mudarri and Fisk in 2007, examined literature covering dampness and mold in schools, offices, and institutional buildings in the United States. Their findings concluded that risk from exposure in these buildings is similar to the risks from exposures in homes when it came to reported respiratory complains. In addition, from the 21.8 million people who reported to have asthma, about 4.6 million cases were estimated to be attributed to dampness and mold exposure in their homes (Mudarri & Fisk, 2007). Indoor environments are recommended to have a relative humidity (RH) between 30-60% for comfort range as higher levels can cause mold growth and increase health complaints. This is further supported by a study conducted by Mentese et al in Ankara, Turkey in 2012, in which they found significant relationships between RH ranging from 15-65% and bioaerosol levels: fungi levels ($p< 0.05$) and total bacteria count levels ($p< 0.001$).

The presence of water accumulation indoors, such as in roofs, carpets, or walls, can cause a significant amount of mold to grow. Research conducted on the effects of water-damaged homes after flooding in 595 households in Japan showed indoor dampness (chi-square test: $p < 0.001$; coefficient of association: $\varphi = 0.640$, $p < 0.001$) and visible mold growth (chi-square test:

$p < 0.001$; coefficient of association: $\varphi = 0.553$, $p < 0.001$) increased as the flood level increased (Azuma et al., 2014).

Microbial growth in heating, ventilation, and air condition systems (HVAC) is likely resulted from deposition of dust, and the presence of liquid water or high relative humidity inside the HVAC systems (Tang, 2008). Findings from the National Institute of Occupational Safety and Health (NIOSH) collected from 80 office buildings located throughout the United States showed an association between increased prevalence of work-related lower respiratory symptoms and moisture in ventilation systems ($p < 0.05$) (Seppänen & Fisk, 2002). Likewise, a study conducted in five schools located in Edirne City, Turkey found positive correlation between the concentrations of bacteria and air humidity ($p=0.002$, $R^2=0.726$) (Aydogdu et al., 2005).

Inadequate maintenance of cooling systems has shown to cause community-acquired legionellosis outbreaks. A systematic review of 19 legionellosis outbreaks in the United States noted that several of those outbreaks reported a temporal association of outbreaks with inadequate maintenance or renovation interventions on the cooling systems (Walser et al., 2014).

Several studies conducted in the United States estimate the prevalence of indoor dampness or mold at homes to be approximately 50%, with indoor dampness tending to be relatively higher in low-income communities (Douwes, 2009). Evidence is shown in a study conducted of 1,954 young mothers in the United Kingdom, in which those who lived in rented accommodations reported higher dampness (58% vs 52%) and mold (56% vs. 24%) than those who lived on owner-occupied accommodations (Baker & Henderson, 1999). Likewise, a study in eastern Germany among 25,864 schoolchildren demonstrated that the children of parents with

low levels of education were 4.8 times more likely to live in damp houses than those of parents with a higher level of education (Du Prel, Kramer, & Ranf, 2005).

1.3 ***<u>Respiratory and Other Health Effects</u>***

Exposure to indoor bioaerosols in occupational and residential settings can lead to a variety of health effects. The most common studied effects caused by bioaerosols are respiratory symptoms and lung function impairment (Douwes et al., 2003). Particle deposition and the potential health effects are determined by the size and composition of the aerosols. Particles that are greater than 5 μm tend to accumulate in the extrathoracic region, while smaller sizes can penetrate and reach the lower respiratory tract (Sturm, 2012). People experience respiratory symptoms as a result of airway inflammation caused by specific exposures to toxins, pro-inflammatory agents or allergens (Douwes et al., 2003). The presences of these bioaerosols can also cause sick building syndrome (SBS) and building related illness (BRI) (Flores et al., 2009; Douwes et al., 2003).

Fungi such as *Cladosporium, Penicillium, Alternaria, and Aspergillus* are some of the common aeroallorgen molds found in indoor homes that have warm, damp, and humid conditions (Centers for Disease Control and Prevention, 2014). Sensitization to molds such as *Alternaria alternata* may be involved in severity of asthma in children and young adults. A prospective cohort study in Wagga Wagga and Moree, Australia of 399 school children who had positive skin tests to one or more aeroallergens showed 91% of them testing positive for skin prick test for this fungi (Haleem & Mohan Karuppayil, 2012).

Findings from a study conducted by Gent et al. (2002) found high levels of measured *Penicillium* significantly associated with both wheeze (relative risk = 2.15; $p < 0.05$) and persistent cough (relative risk = 2.06; $p < 0.05$) in infants born in Connecticut and western

Massachusetts between September 1996 and December 1998. Fungal bioaerosol impacts on humans is further supported by a systematic review conducted on MEDLINE from 1996-2002, displaying five case control studies, 17 cross-sectional surveys and 7 case reports showing a correlation between health effects and fungal exposure, especially when excessive moisture was present (Fung & Hughson, 2003).

Numerous studies that have been conducted throughout the world have reported a correlation between the presence of mold or dampness and adverse health effects that include infections, allergic or hypersensitivity reactions, and irritation (Bernstein et al., 2008; Portnoy et al., 2005; Bush et al., 2006). A study conducted 2008 in Iowa, focused on sampling and administering a health questionnaire to assess bioaerosol exposure and health symptoms to everyone who had their homes affected by the Cedar River flooding. The residents who lived in homes undergoing home repairs had a significant higher prevalence of doctor-diagnosed allergies (adjusted OR=3.08; 95% CI: 1.05, 9.02), had elevated prevalence of self-reported wheeze (adjusted OR=3.77; 95% CI: 2.06, 6.92) and prescription medication use given for breathing problems (adjusted OR=1.38; 95% CI: 1.01, 1.88) after the flood (Hoppe et al., 2012).

The presence of certain types of bacteria in the air is important to study as they can lead to many health complications. A study conducted in 60 apartments of 15 towns in the Upper Silesian Poland conurbation showed the size distribution and characterization of bacteria and fungi occurring in the air of human dwellings. Common bacteria found indoors included *Micrococcus/Kocuria* spp., *Staphylococcus* spp., *Aeromonas*, and *Pseudomonadaceae*. The presence of *Aeromonas* is of concern as it has the ability to produce protein enterotoxin and gastroenteritis (Górny et al., 1999). A similar study was conducted in 70 dwellings, including homes and offices, in the Upper Silesia industrial zone. Analysis of the bacteria showed the

presence of *Staphylococcus aureus* in nearly 47% of the homes, *Micrococcus* spp. (100%) as well as other bacteria (Pastuszka et al., 2000). People who have compromised immune systems can potentially be harmed by both of these pathogens. *Micrococcus* spp. is an opportunistic pathogen that can cause pulmonary infections or other infections such as meningitis (Smith et al., 1999). *Staphylococcus aureus* is commonly found in skin of humans but can still cause complications by causing furuncles, carbuncles, pneumonia, and can also become methicillin resistant making it difficult to threat infections (Honeyman et al., 2002).

A systematic review of the literature on indoor bioaerosols in central and eastern European countries showed different concentrations of indoor bioaerosols and over 167 microbial species identified. Some of the common pathogens identified were *Micrococcus* spp. and *Rhodococcu*s spp. *Staphylococcus epidermidis*, *Staphylococcus aureus,* and *Acinetobacter,* all with a potential to cause infections in humans (Górny & Dutkiewicz, 2002).

Respiratory symptoms have also been seen in people who reside in poor living conditions. A cross sectional study conducted in North Carolina assessed the relationship between respiratory symptoms and indoor housing conditions among migrant farmworkers. Adult Latino farmworkers (n=352) were administered a questionnaire looking at reported health complains experienced while living in barracks, houses, trailers, apartments, mobile homes, or communal residences. Furthermore, self-reported and independent observations were made to evaluate environmental respiratory risk factors and indoor housing conditions (Kearney et al., 2014). Findings for respiratory health included prevalence of wheezing (11.4%), coughing up phlegm (17.3%), tightness of chest (16.8%), and runny or stuffy nose (34.4%). Indoor risks identified included use of pesticides or bug sprays for cockroaches (31.5%), rat or mouse poison

(19.5%), visible signs of water damage in the bathroom (22.5%), and mold in the sleeping room (11.1%) (Kearney et al., 2014).

1.4 ***Seasonality***

Temporal variation has shown to affect bioaerosol concentrations and compositions. Rainy seasons can remove aerosol particles in air environments, although continuous long-term rain events like monsoons create humid environments that help generate higher concentrations of bioaerosols (Heo et al., 2014). Microbes and fungi also have the ability to travel long distances through the air with the help of wind and precipitation. African dust storms are known to carry dust-containing bioaerosols to the Americas, the Caribbean, and the Sargasso Sea (Creamean et al., 2013). Physical environmental stresses have limited their survival times but some organisms have adapted to these harsh conditions by means of forming endospores and aggregation into long chain of spores (Al-Dagal et al., 1990).

Majority of studies have found a greater abundance of bioaerosols during summer and fall seasons, but there are some exceptions as bioaerosols differ by the regions climate and atmospheric changes (Sudharsanam, 2012; Chew et al., 2003; Hyvarinen et al., 2001; Lugaskas, Svestyte, & Ulevicius, 2002). This can be seen in a study aimed toward identifying the profiles of airborne fungi from 1,717 buildings located across the United States. Fungal levels were highest during fall and summer and lowest in the winter and spring seasons ($p = 0.0001$). Geographically, the southwest, far west, and southeast contained the highest fungal level concentrations, with *Cladosporium*, *Penicillium*, nonsporulating fungi, and *Aspergillus* being the most common fungi found indoors throughout every season (Shelton et al., 2002).

Bioaerosol sampling has been very common in occupational settings, like facilities of waste collection and disposal, due to various types of wastes that generate complex mixtures of

dust and biological agents that pose various health risks (Wéry, 2014). A sludge composting facility in the Silver Spring, Maryland was sampled for a year to monitor bioaerosol emissions. Months containing high downwind events from the sludge composting facility showed increase concentrations for aerobic bacteria and thermophilic fungi ($p < 0.05$) (Chiang et al., 2003) Another study conducted throughout the four seasons in sewage treatment plant in Iran identified *Cladosporium* (summer mean=90, spring mean=86, and fall mean=83) and *Aspergillus* (summer mean=85, spring mean=77, and fall mean=76) most abundant fungal genera, with higher levels occurring in the summer than in other seasons. This was seen in Switzerland as well, in which higher concentrations of fungi were observed during the summer than in winter (2331 ± 858 versus 329 ± 95 CFU/m^3) (Roodbari et al., 2013; Oppliger et al., 2005).

A study conducted in 20 residential apartments within the metropolitan area in South Korea showed high-level of bacterial contamination (76% of the samples gathered in the summer and 56% of the samples gathered in fall) having over 2000 CFU/m^3 with the most common gram-positive bacteria being *Staphylococcus* (Moon et al., 2014). A recent study conducted in 76 indoor urban environments in Ankara, Turkey during the winter and summer season showed the predominant genera being *Micrococcus* spp., *Staphylococcus spp*. and *Bacillus* spp., with higher bacterial concentrations in the summer (322 CFU/m^3) than in the winter (247 CFU/ m^3) (Mentese et al., 2012).

Findings from a study conducted in the summer in 414 different low-income urban homes in the Bronx, Boston, Chicago, Dallas, New York, Seattle, and Tucson found that majority of the homes (81%) contained *Cladosporium* when sampling for airborne fungi (O'Connor, Walter et al. 2004). Similar results were obtained by Cho and associates (2008),

detecting *Cladosporium* in 47 low-income inner city households in Minneapolis, MN, as the most common fungi and also detecting high fungal peaks in May and September.

1.5 ***Bioaerosols in El Paso, Texas***

Few bioaerosol studies have been conducted in the El Paso, Texas region. One of the earliest studies conducted sought to describe the relationship of indoor airborne pollen and fungal spores in occupied mobile homes with outdoor concentrations and other environmental factors within geographically diverse areas of Texas (Houston and El Paso) (Sterling & Lewis, 1998). Results showed that during the summer there was an increase in the indoor/outdoor ratios for pollen (ratio of the geometric mean in summer=0.8, versus spring, 0.44) (Sterling & Lewis, 1998).

Findings from a subsequent study focused on the seasonal fine (1–8 μm) and coarse (>8 μm) culturable fungal constituents and concentrations from indoor and outdoor air samples collected from 50 houses that had no air quality issues. (Mota et al, 2008). Common fungi identified in these homes were *Alternaria, Bipolaris, Stemphylium, Phoma, Aspergillus, Cercospora, Cladosporium,* and *Rhizopus,* with *Cladosporium* having the greatest concentrations throughout all seasons than the other genera. When comparing fungal constituents and concentrations, the fine-size range was 12 times and 6 times greater than the coarse-size range for indoor and outdoor samples (Mota et al., 2008). In addition, this study was further expanded to characterize seasonal indoor and outdoor bioaerosols. A correlation between indoor temperature and indoor fine bacteria ($p = 0.03$) and significant correlation coefficient between indoor and outdoor concentrations of coarse bacteria and fungi ($p < 0.05$) and fine bacteria and fungi ($p < 0.05$) (Mota et al., 2008) was noted.

A correlation between self-reported respiratory symptoms and residential indoor bioaerosol concentrations of 50 homes was assessed through a health questionnaire. Analysis of the data collected showed an association between indoor respirable bacterial concentrations and homeowners that reported at least eight respiratory symptoms ($p=0.045$) (Flores et al., 2009). In addition, 24 houses were randomly selected for isolation, speciation, and antimicrobial susceptibility testing in order to evaluate the levels of *Staphylococcus aureus* and antibiotic-resistant *S. aureus* in colony-forming units (CFU) per cubic meter of air. As a result of this study it was shown that the average recovered concentration of respirable heterotrophic organisms found inside each home was 15.39 CFU/m^3 for *S. aureus*, with an average resistance of 54.59% to ampicillin and 60.46% to penicillin (Gandara et al., 2006).

CHAPTER 2: STUDY RATIONALE

Studies have shown different indoor concentrations of bioaerosols throughout the seasons and a correlation between exposure to bioaerosols and health effects. Evidence also suggests that indoor environmental parameters affect bioaerosol concentrations especially in low-income homes. The Environmental Protection Agency (EPA) has noted many reports and studies indicating that low-income and minority communities may be disproportionately impacted by indoor asthma triggers, secondhand smoke, mold, radon and other indoor pollutants (US EPA, 2013). In addition, the American Lung Association states that asthma is disproportionately more common in low-income communities, especially Hispanic (American Lung Association, 2010).

In 2011, El Paso had 1,457 cases of upper respiratory infections, 4,320 cases of pneumonia, and 4,223 cases of asthma (Texas Department of State Health Services, 2012). Furthermore, a study conducted by Grineski et al. (2013) suggests that sociospatial disparities in respiratory infection rates might be linked to environmental inequalities. This brings an important issue to study air quality in low-incomes communities to further support their claim.

With the unique desert hot climate with little humidity, dry summers, and an arid windy climate that brings dust storms, El Paso house's indoor environment and the health of the people can be affected greatly. Bioaerosol monitoring has been conducted in industrial places, schools, middle-income communities and office buildings yet there is a lack of studies of indoor bioaerosol sampling in low-income communities, especially here in El Paso. This study will be the first in El Paso to focus on low-income communities, consisting mostly of public housings. Also the information obtained will help to develop future interventions and guidelines on how to have better indoor air quality and reduce exposure to bioaerosols.

CHAPTER 3: STUDY OBJECTIVES AND HYPOTHESIS

3.1 ***Study Objectives***

The overall objective of the proposed exploratory study was to investigate indoor bioaerosols and reported health outcomes associated with bioaerosol exposure between summer and fall in 2014, in low- income communities in El Paso, Texas. The aims of this study were to:

(1) Characterize bioaerosols (bacteria and fungi) collected in low-income communities.

(2) Describe bioaerosol concentrations, meteorological factors, and reported health outcomes during the summer and fall seasons.

(3**)** Compare bioaerosol concentrations by season.

(4) Compare meteorological factors to bioaerosol concentrations by season.

(5) Compare reported health outcomes associated with bioaerosols by season.

3.2 ***Hypothesis***

The third, fourth and fifth aims will require hypothesis testing to determine a seasonal association. It is hypothesized that bioaerosol concentrations will vary by season, a correlation between meteorological factors and bioaerosol concentrations by season exists, and there is seasonal differences for health outcomes associated with bioaerosols.

CHAPTER 4: METHODS AND MATERIALS

3.1 ***Description of study population***

The City of El Paso lies in the United States/Mexico border region. El Paso, County is located in the western tip of Texas, and borders the state of Chihuahua, Mexico to the south as well as the state of New Mexico to the northwest. The 2010 census for El Paso, Texas was 649,121 with 80.7% of the population classifying themselves as Hispanic or Latino. One of the issues encountered in this border city is the poverty (Rutt & Coleman, 2005). In 2010 the federal poverty level (FPL) was $10,830 for a one-person household and $22,050 for a family of four. Nearly 36% of children live in poverty with 95% of them being Hispanic. El Paso has residents living in the Southeast, Central, and Northwest sectors with residents living in FPL (City of El Paso, 2013). From 2007-2011, it was estimated that 23.3% of all El Paso residents were living below the poverty line and from the El Paso households around 20.1% lived below the poverty line (US census, 2013).

Subject Recruitment and Selection

The participants were recruited through a convenience sampling from an ongoing project funded by the National Institute of Health entitled “The Association of Chronic Exposure to Particulate Matter Air Pollutants, Inflammation, and Atherogenesis in At-Risk El Paso Children” [NIH RO1 349873-6]. This proposal got approved by UTEP IRB as an amendment [Project #34987-5] on January 22, 2014 under “The Association of Chronic Exposure to Particulate Matter Air Pollutants, Inflammation, and Atherogenesis in At-Risk El Paso Children”. This study consisted of three distinctive exposure zones of particulate matter (low, middle, and high exposure) that included participants from High Performing public housing authority (PHA) in the Housing Authority of the City of El Paso (HACEP). Housing authority provides low-income residents of

the City of El Paso with access to low-cost housing. Participants were given a short consent form to sign before participating in the study (Appendix 1).

Sample Size

The study included 45 participants.

Bioaerosol Collection

The Two-Stage Viable Anderson Cascade Impactor, (manufactured by Pelican Products, Torrance California USA, serial numbers 2193 and 2194) was used for the collection of bioaerosols (Appendix 2). An air pump with the flow rate of 28.3 L/min (manufactured by Pelican Products Torrance California USA, serial numbers 0811015444 and 1013008485) was connected to the impactor for maximum collection efficiency (Appendix 2). The cascade impactor was placed indoors during the morning, in the middle of the living room, one meter above the surface of the floor to simulate the normal breathing zone. Air sampling was taken for 15 minutes, as an extended sampling period will yield numerous colonies making it hard for identification and counts. Studies also showed sampling for shorter periods of time tend to yield low counts. The cascade impactor's two-stages were loaded with 100-mm×15-mm plastic Petri dishes with 20 mL of Trypticase Soy Agar (TSA) containing 5% sheep blood as the collection media for bacteria and Malt Extract Agar (MEA) to determine fungal growth (Flores et al, 2009; Mota, Gibbs, Green, Flores, et al., 2008; Mota, Gibbs, Green, Payan, et al., 2008; Gandara et al., 2006).

Relative Humidity and Temperature

The data logger model HOBO UX100-011 (manufactured by Onset Computer Corporation Bourne, Massachusetts, USA, serial numbers 10482190 and 10482191) was simultaneously

deployed with the bioaerosol sampling, for measurements of relative humidity and temperature (Appendix 2).

Health Questionnaire

A health quality questionnaire containing five sections: demographic characteristics, general health history, health complains and symptoms, severity of symptoms, and other attributing factors was be adapted from previous studies (Appendix 3) (Flores et al., 2009). The questionnaire was administered face-to-face in Spanish or English depending on the preference of the participant. A technical survey was also administered to check house conditions (Appendix 4).

Colony Forming Units Calculations

Calculation of colony forming units per cubic meter (CFU/m^3) of air sampled was conducted using the formulas (TML/MSH Microbiology, 2005):

Flow rate = ***a*** L/min

Sampler running times = ***b*** minutes

Volume of air sampled = ***a*** x ***b*** = *ab*/1000m^3 = ***d*** m^3

Bacterial or mold count = ***c*** CFU

Total CFU/m^3 air sampled = ***c***/***d*** CFU/m^3 air

Bacteria Analysis

Bacterial samples were incubated at 37°C using the Imperial III Incubator (model Number 302) for 24 hours and enumerated (Appendix 2). The gram stain technique was used to differentiate bacterial species and differentiation between gram positive organisms and gram negative organisms. Once this was done, the samples were run through the SIEMENS Microscan autoSCAN 4 ® (serial number 10879) system for automated bacterial identification and

susceptibility testing (Appendix 2). All results shown above 85% mark of probability of correct identification of the bacterial species were considered significant. Samples were then stored in 0.700 ml of glycerol for preservation for polymerase chain reaction (PCR).

Fungi Analysis

Fungal media plates were incubated at 25°C and enumerated after 10 days. Samples were sent to EMLab P&K Mold & Bacteria Laboratory in Houston for Genus Identification. The samples that were unable to be sent to the EMLab were identified via microscopy using reference books at University of Texas at El Paso (Watanabe, 2010; Emmons, Binford, & Utz, 1970; Koneman, Allen, Janda, Schreckenberger, & Winn, 1988).

Paired Data Analysis

The data collected was analyzed using Statistical Product and Service Solutions (IBM SPSS Statistics v.22.0).

Univariate Analysis by Season

To assess the second aim, descriptive statistics were conducted for all measures including bioaerosol concentrations, meteorological factors, and reported health outcomes. The descriptive statistics included sample size (n), mean, and standard deviation (SD) for continuous variables or 5 point summary if not normally distributed. Frequencies and percentages were used for categorical variables.

Bivariate Associations by Season

For continuous variables, differences in means were tested using the Wilcoxon signed-ranked test for paired data if not normally distributed or a paired t-test if normally distributed. For paired nominal categorical data, the McNemar's test was used. Lastly, the Spearman Correlation was

used to measure the linear relationship between two continuous variables. Statistical significance for all tests were determined with a $p\text{-value} < 0.05$.

CHAPTER 5: RESULTS

A total of 45 houses were sampled throughout the summer and fall seasons. All of the participants reported having swamp coolers (100%) in their homes. Also, some of the participants reported to have pets (38%) and indoor plants (40%). Visible mold (35.6%), leaky roofs (8.9%), and leaky pipes (4.4%) were commonly seen in the summer than in the fall (0%). Homes had more visible water damage (11.1%) in the summer than in the fall (6.7%).

Bioaerosol Identification

The identification for bioaerosols (bacteria and fungi) for summer and fall are shown on table 1. The most common bacteria identified indoors during the summer was *Micrococcus lylae* and during the fall *Staphylococcus epidermis.* The most common fungi identified during the summer was *Cladosporium* spp. and during the fall *Bipolaris* spp.

Table 1: Identified Bioaerosols and Number of Isolates (n=45)

Bioaerosol	**Summer**	**Fall**
Coarse Bacteria	*Number of isolates*	*Number of Isolates*
Staphylococcus simulans	1	1
Streptococcus pneumoniae	1	1
Dermacoccus nishinomiyaensis	2	2
Staphylococcus hominis-novo	1	-
Kocuria varians	3	5
Micrococcus lylae	7	9
Rhodococcus equi	1	3
Staphylococcus epidermis	4	10
Staphylococcus hominis- homin	4	16
Staphylococcus auricularis	4	3
Rothia mucilaginosa	1	1
Aerococcus urinae	1	1
Staphylococcus cohnii-cohnii	-	5
Staphylococcus auricularis	-	-
Acinetobacter lwoffii	-	2
Proteus penneri	-	1
Chromobacterium violaceum	-	1
Staphylococcus sciuri	-	1
Staphylococcus hominis-novobiosepticus	-	1

Staphylococcus auricularis (Methicillin resistant)	-	1
Staphylococcus haemolyticus	-	-
Staphylococcus haemolyticus (Methicillin Resistant)	-	-
Fine Bacteria	*Number of Isolates*	*Number of Isolates*
Staphylococcus simulans	-	-
Streptococcus pneumoniae	-	-
Dermacoccus nishinomiyaensis	-	-
Staphylococcus hominis-novo	-	-
Kocuria varians	-	-
Micrococcus lylae	-	-
Rhodococcus equi	-	8
Staphylococcus epidermis	3	1
Staphylococcus hominis- homin	3	3
Staphylococcus auricularis	4	1
Rothia mucilaginosa	-	-
Aerococcus urinae	-	-
Staphylococcus cohnii-cohnii	1	-
Staphylococcus auricularis	2	-
Acinetobacter lwoffii	-	-
Proteus penneri	-	-
Chromobacterium violaceum	-	-
Staphylococcus sciuri	1	-
Staphylococcus hominis-novobiosepticus	-	-
Staphylococcus auricularis (Methicillin resistant)	-	-
Staphylococcus haemolyticus	1	-
Staphylococcus haemolyticus (Methicillin Resistant)	-	1
Coarse Fungi	*Number of Isolates*	*Number of Isolates*
Cladosporium spp.	14	1
Rhizopus spp.	1	-
Acremonium spp.	1	-
Candida spp.	1	-
Alternaria spp.	2	-
Cercospora spp.	8	4
Aspergillus spp.	-	-
Bipolaris spp.	-	9
Fine Fungi	*Number of Isolates*	*Number of Isolates*
Cladosporium spp.	-	6
Rhizopus spp.	1	-
Acremonium spp.	-	-
Candida spp.	5	-

Alternaria spp.	-	2
Cercospora spp.	11	-
Aspergillus spp.	2	-
Bipolaris spp.	-	-

Univariate and Bivariate Analysis

Bioaerosols and Seasons

Bioaerosol's mean coarse max concentrations were the same for summer and fall at 106 CFU/m^3 and highest for mean fine max concentrations in the fall at 134 CFU/m^3. A Wilcoxon signed-rank test showed that both fine and coarse bioaerosol concentrations for bacteria and fungi did elicit a statistically significant change between summer and fall ($p < 0.001$) (Table 2).

Meteorological Factors and Seasons

The mean temperature for the summer was 27.58 °C and for the fall it was 23.35 °C. The relative humidity for the summer was 56.97% and for the fall it was 35.59%. There was a significant difference between the temperature means in the summer and fall ($p<0.001$). There was also a significant difference between the relative humidity means in the summer and fall ($p<0.001$). (Table 2.)

Health Outcomes

During the summer and fall the most report health complain experienced was sneezing (60% and 86%). An exact McNemar's test determined that there was a statistically significant difference in the proportions of reported health complains for wheezing, dry eyes, cough, sneezing, stuffy nose, runny nose, and throat infection between the summer and fall. (p =0.031, p =0.004, p =0.001, p =0.004, p =0.013, p =0.006, p =0.017) (Table 2).

Table 2: Characteristics of Bioaerosols, Meteorological Factors, and Health Outcomes by Season, Univariate and Bivariate Analysis (n=45)

	Summer	Fall	Test
Bioaerosol	(Min,Q1,Median,Q3,Max)	(Min,Q1,Median,Q3,Max)	p-value*

Bacteria			
-Coarse	(4,18,28,42,106)	(0,16,35,62,106)	p<0.001
-Fine	(0,37,64,92,124)	(7,32,53,86.5,134)	p<0.001
Fungi			
-Coarse	(0,0,4,11,375)	(0,7,14,23,141)	p<0.001
-Fine	(0,4,11,49,438)	(0,18,32,72.5,219)	p<0.001
Meteorological Factors	Mean(SD)	Mean(SD)	p-value**
-Temperature °C	27.58 (3.7)	23.35 (3.1)	p<0.001
-Relative Humidity (RH%)	56.97 (6.2)	35.59 (3.6)	p<0.001
Health Outcomes	Frequency (%)	Frequency (%)	p-value***
-Asthma	(40%)	(31%)	p=0.289
-Wheezing	(24%)	(9%)	p=0.031
-Shortness of breath	(24%)	(24%)	p=1.000
-Allergies	(60%)	(58%)	p=1.000
-Hay Fever	(47%)	(51%)	p=0.791
-Dry eyes	(36%)	(64%)	p=0.004
-Eyes irritated	(47%)	(58%)	p=0.332
-Watery eyes	(40%)	(47%)	p=0.607
-Headaches	(53%)	(49%)	p=0.804
-Cough	(47%)	(80%)	p=0.001
-Sneezing	(62%)	(86%)	p=0.004
-Nausea/ Vomiting	(24%)	(27%)	p=1.000
-Fatigue	(40%)	(38%)	p=1.000
-Drowsiness	(31%)	(27%)	p=0.804
-Dizziness	(20%)	(24%)	p=0.754
-Skin irritation(dryness, rash)	(56%)	(62%)	p=0.629
-Stuffy nose	(60%)	(84%)	p=0.013
-Runny nose	(38%)	(71%)	p=0.006
-Throat irritation	(38%)	(64%)	p=0.017

* Wilcoxon signed-ranked test
** Paired t-test
*** McNemar's test

Meteorological factors and bioaerosols (bacteria and fungi)

There was a no significant correlation between bioaerosol concentrations (bacteria and fungi) and temperature during the summer and fall. In addition, there was a no significant correlation between bioaerosol concentrations (bacteria and fungi) and relative humidity during the summer and fall.

Table 3: Spearman Correlation between Bioaerosol Concentrations and Meteorological Factors by Season (n=45)

Meteorological Factors	**Summer**	**Fall**
Temperature		
Bacteria		
-Coarse	r=-0.017	r=-0.150
-Fine	r=0.043	r=0.100
Fungi		
-Coarse	r=-0.147	r=0.201
-Fine	r=-0.029	r=0.020
RH		
Bacteria		
-Coarse	r=0.011	r=-0.030
-Fine	r=-0.353	r=0.139
Fungi		
-Coarse	r=-0.106	r=-0.162
-Fine	r=0.199	r=-0.035

CHAPTER 6: DISCUSSION

There is minimal published literature on bioaerosols in low-income communities especially in El Paso Texas. In this study different species of bacteria were found in the summer and the fall. Majority of the microorganisms identified are non-pathogenic or commonly reside in the skin and mucous membranes of humans or other organisms. Studies in El Paso have not focused on identification of bacteria besides antibiotic-resistant *S. aureus*. This study found important pathogens such as *streptococcus pneumoniae*. *Streptococcus pneumoniae* is a pathogen which causes invasive diseases such as sepsis, meningitis, and pneumonia especially in children and the elderly (Bogaert, de Groot, & Hermans, 2004). During the fall, two different pathogens were found to be methicillin resistant: *S.haemolyticus* and *S. auricularis*. *Staphylococcus haemolyticus* is the second most frequently isolated from human blood cultures in hospital settings yet it was seen in one of the homes (Ruzauskas et al., 2014). By being highly antibiotic resistant, *S.haemolyticus* is a very difficult pathogen to treat. Similar studies conducted have also found these kind of pathogens indoors (Mentese et al., 2012; Rintala, Pitkäranta, Toivola, Paulin, & Nevalainen, 2008). A limitation present when characterizing bacteria was the selection of specific culture media since it narrows the selection of only certain species. In addition, using culture base methods for sampling lacks detection of non-culturable and dead microorganism, all which may have the potential to have toxic or allergenic properties (Heseltine & Rosen, 2009). Future research needs to address other microorganisms present and the health risks they possess.

Studies have demonstrated the presence of *Cladosporium, Penicillium*, and *Aspergillu*s to be the most common indoor fungi found in buildings or homes (Mota et al., 2008; Shelton, Kirkland, Flanders, & Morris, 2002; Li & Kendrick, 1995). In this study, *Cladosporium* was seen

to be the most common fungi found indoors, which supports the claim from other studies. This fungus rarely causes any illnesses in people but can cause several infections, including skin, eye, sinus, and brain infections. *Cladosporium* has been mainly associated with allergies and asthma, which might support many of the reported health outcomes reported by the participants in this study (Centers for Disease Control and Prevention, 2012). The second most common fungi identified was *Cercospora* spp. which is commonly found in leaves. These fungi are harmless and the spores produced do not have a significant effect on indoor air quality (Yang & Heinsohn, 2007). It is important to note that the other fungi identified have a great significance when it comes to health as they act as aeroallergens. Some of the most common aeroallergens to be found in the atmospheric environment are *Aspergillus, Cladosporium,* and *Alternaria.* Allergic reaction from inhaling these fungi normally occurs depending on the site of allergen deposition which can then cause nasal or ocular symptoms or severe complications due to asthma (Horner, Helbling, Salvaggio, & Lehrer, 1995).

Bioaerosol concentrations for bacteria were highest during the fall (134 CFU/m3) while concentrations for fungi were highest during the summer (438 CFU/m3). The results presented are similar to that of the Mota and co-authors study. Although this is true for bacteria, this study found higher fungal concentrations during the summer than in the fall compared to the Mota and co-authors study. Furthermore, it was observed that the bioaerosol concentrations for bacteria and fungi changed by season similarly to the Mota and co-authors study. The sample size for this study was quite similar to that of Motas which further supports the results attained.

Temperature and RH were found to be highest during the summer. Factors aiding to high temperature and relative humidity indoors may be attributed to air conditioners not working properly and individuals not opening other sources for ventilation. Again, the results were quite

similar for temperature and RH as the Mota and co-authors study, taking into account this study focused on sampling in low-income communities. There was a significant difference between the temperature means in the summer and fall besides the fact that El Paso tends to not have radical temperature changes between seasons (Mota et al., 2008).

In regards to the participant's reported health outcomes, participants reported different health outcomes by season. There was a notable significant change in the proportions of reported health complains for wheezing, dry eyes, cough, sneezing, stuffy nose, runny nose, and throat infection between the summer and fall. During the summer many reported sneezing (62%), allergies (60%), and stuffy nose (60%) to be most common health outcomes. This could be a result of fungal spores and molds being present during this time especially when temperature is high and if the homes have high humidity. Also, poorly maintained HVAC systems have been associated with many building-related illnesses and complaints which might aid to the reported health outcomes (Cox & Wathes, 1995). During the fall, the most common health outcomes reported by participants were sneezing (86%), runny nose (84%), and cough (80%). Many studies have documented that cough is one of the most common health outcomes reported by those who live in damp indoor environments and there is presence of mold (Heseltine & Rosen, 2009). Given the fact that flu season starts during the fall, a high prevalence of these outcomes is more likely to be seen, which might make it difficult to differentiate between sickness and bioaerosol exposure. To overcome this self-reporting bias, it is important to consider assessing indoor dampness, including its severity and the presence of mold (Heseltine & Rosen, 2009). Despite seeing differences in reported health outcomes by the participants, sneezing was the highest reported health outcome for both the summer and fall season (62% vs 86%).

Several studies have indicated a correlation between meteorological conditions and bioaerosol concentrations. A high relative humidity favors fungal and bacterial growth thus contributing to higher bioaerosol concentrations (Zhu et al., 2003). The Mota and co-authors found a contradiction in this and stated that El Paso has a very dry climate with little variance in environmental conditions between seasons. Another point they made was that bioaerosol size ranges need to be taken into account when sampling. The results in this study are similar to that of Mota's, finding no correlation between temperature and bioaerosols and also no correlation between RH and bioaerosols.

This study is essential as it helped differentiate bioaerosol concentrations between two distinct seasons in low-income communities. In addition, it helped characterize bioaerosols and report the health outcomes reported by participants. Further studies need to sample bioaerosols throughout all the seasons in low income communities to assess the seasonal bioaerosol concentrations as well as the potential health effects they may cause to individuals.

CHAPTER 7: STRENGTHS AND LIMITATIONS

As per our knowledge this was the first scientific approach that identified and quantified the presence of bacteria and fungi in low-income at risk El Paso households. Other factors that strengthen this study include the willingness of participants to participate in the study throughout the two seasons without incentives. Another strength was having worked with these communities prior to this study helped facilitate participant recruitment. Recruitment for participants was also done with the help of community leaders making it easier to find those who were never at home.

Limitations of this study include only sampling two seasons instead of the four seasons that limits the possibility of finding diversity of organisms and concentrations indoors throughout all the seasons of the year. Another limitation was that we did not take into account many confounding variables such as particulate matter, volatile organic compounds, dust mites and so forth which can also have respiratory health effects on individuals. Many reported health outcomes are similar to those of the flu and common cold which is hard to differentiate if bioaerosols are contributing to those reported health outcomes especially during the fall season when many get sick. Also, we were unable to identify non-culturable bacteria that can also have respiratory and other health effects on individuals. The results warrant further investigation.

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APPENDICES

Appendix 1. Study Consent Form in Spanish and English

Comité Institucional de Ética, Universidad de Texas en El Paso (UTEP)

Formulario de Consentimiento Informado para Investigación que Involucra Sujetos Humanos

Título del Protocolo: La Exposición Crónica a Contaminantes del Aire, Inflamación, y Aterosclerosis en Niños en riesgo en El Paso.

Investigador principal: Rodrigo X. Armijos, MD, ScD

UTEP: Departamento de Ciencias de la Salud Pública, Facultad de Ciencias de la Salud

Tengo el conocimiento de que se pondrá una maquina en mi casa por 15 minutos para medir los niveles de bacteria y hongos. Se me harán unas preguntas sobre mi salud y las condiciones de mi casa.

Nombre impreso del participante: ______________________________________

Firma del participante: ___________________________________

Domicilio: ____

Número de teléfono: ______________________________

Fecha: ___/___/___

Hora: ___/___/___

Consentimiento escrito explicado/atestiguado por:

Firma: ______________________________________

Nombre impreso: ___________________________________

Fecha: ___/___/___

Hora: ___/___/___

University of Texas at El Paso (UTEP) Institutional Review Board Informed Consent Form for Research Involving Human Subjects

Protocol Title: The Association of chronic exposure to particulate matter air pollutants, inflammation, and atherogenesis in at-risk El Paso children

Principal Investigator: Rodrigo X. Armijos, MD, ScD

UTEP Department of Public Health, College of Health Sciences

I acknowledge that a machine will be placed in my house for 15 minutes to measure the levels of bacteria and fungi. I will be asked some questions about my health and the condition of my house.

Participant Printed Name: ______________________________________

Participant or Parent Printed Name: ______________________________

Participant Signature: ___________________________________

Date: ___/___/___

Time: ___/___/___

Apartment # ____

Phone number____

Consent form explained/witnessed by:

Signature: ______________________________________

Printed Name: ___________________________________

Date: ___/___/___

Time: ___/___/___

Appendix 2: Instruments

Instrument	***Description***
Data logger model HOBO UX100-011 (manufactured by Onset Computer Corporation Bourne, Massachusetts, USA, serial numbers 10482190 and 10482191)	Records temperature and relative humidity (within 2.5% accuracy) in indoor environments with its integrated sensors.
Two-Stage Viable Anderson Cascade Impactor, (manufactured by Pelican Products, Torrance California USA, serial numbers 2193 and 2194)	This sampler divides particles into two stages; stage1 coarse (>8 µm) and stage 2 fine (1–8 µm) size ranges. The impactors also collects 95 -100% of the viable particles above 0.8 microns in an aerosol on a variety of bacteriological agar.
Air pump (manufactured by Pelican Products Torrance California USA, serial numbers 0811015444 and 1013008485)	The air pump is a 10 to 30 L/min, constant flow area sample pump.
SIEMENS Microscan autoSCAN 4 ® (serial number 10879)	Provides accurate and reliable bacterial identification and susceptibility evaluation. Processes panels in seconds, simplifying identification and antibiotic susceptibility testing (ID/AST) while standardizing results. Exceptional instrument reliability and conventional panel technology - with the fewest FDA limitations in automated ID/AST. An excellent supplemental system for

	difficult organisms or as a primary instrument for low-volume usage.
Imperial III Incubator (model Number 302)	The incubator has temperature control up to ±0.5°C from 5°C above ambient to 65°C with over temperature protection

Appendix 3. Health Questionnaire

University of Texas at El Paso-CHS/DPHS

Nombre del Entrevistador y fecha **Numero de ID del Sujeto**

Bioaerosols and Respiratory Health Effects

PART I. Sociodemographic Information

1. Domicilio/Address____ ______________________

2. ¿Incluyendo a usted, cuantas personas viven en su casa?/ Including you, how many people currently live in the household?

   O1. Uno/One

   O 2.Dos/Two

   O 3. Tres/Three

   O 4.Cuatro/Four

   O 5. Cinco/Five

O 6.Mas de Cinco/More than Five

O 7. No Sabe/Does not know

O 99.Rechazar/Refused

3. ¿Cuál es su estado civil?/ What is your marital status?

O 1.Nunca se ha casado/Never married

O 2. Casado/Married

O 3.Separado/Seperated

O 4. Divorciado/Divorced

O 5. Viudo/Widowed

O 6. Viven Juntos/Living together

O 88. No Sabe/Don't know

O99. Rechazar/Refused

4. cuál es el ingreso total anual/ total household income

O 1. Ninguno/None

O 2. Menos de $5,000/ Less than $ 5,000

O 3. De $5,000 a $9,999 / From $5,000 to $9,999

O 4. De $10,000 a $19,999/ From $10,000 to $19,999

O 5. From $20,000 a $29,999 From $20,000 to $29,999

O 6. $30,000 o más/ $30,000 or more

O 88. No Sabe/Don't Know

O 99. Rechazar/Refused

5. Educación Completada/ Education Completed

____

O 88. No Sabe/Don't know

O99. Rechazar/Refused

6. Ocupación/
Occupation____

7. ¿Tiene mascotas dentro de la casa?/Do you have indoor pets?

O 0. No

O1. Si/Yes Cuales/Which ones ____

O 88. No Sabe/Don't know

8. Ha presenciado alguna plaga en su casa?(ratas, ratones o cucarachas)/ Have you had plagues in your house? (Rats, mice or cockroaches)

O 0. No

O1. Si/Yes Cuando y cuáles?/When and which ones?
____

O 88. No Sabe/Don't know

9. Te tipo de combustible uiliza para cocinar?/what type of fuel do you use to cook with?

O1. gas

O 2.electricidad/electricidad

PART II. Health History

10. Fuma o alguna vez ha fumado? Do you smoke or have smoked?

O 1. Fuma/Smoke

O 2. Fumaba/Smoked

O 3. Nunca/Never -------------------------- pase a la pregunta 14/skip to question 14

11. ¿Fuma o alguna vez ha fumado en su casa?/Do you smoke or have smoked indoors?

O 0. No

O 1. Si/Yes

O 88. No Sabe/Don't know

12. Alguien más es su casa fuma?/ Someone else smokes indoors?

O 0. No

O 1. Si/Yes

O 88. No Sabe/Don't know

13. ¿Alguien más fuma o ha fumado en su casa?/ Someone else smokes or has smoked indoors?

O 0. No

O 1. Si/Yes

O 88. No Sabe

Part III. Quejas y Sintomas de su Salud/Health symptoms and complains

Usando un mes(4 semanas) como tiempo de referencia *(Lea lo siguiente)*: Voy a leer las siguientes quejas y sintomas que la gente tiene concerniendo el aire interior. Por favor Responda Si o No basendose en las quejas o sintomas usted haya experimentado más de dos veces a la semana por el último mes *(Después de cada declaración pregunte lo siguiente):*"Ha sentido esto? Si o No?"

Using one month (4 weeks) as a time of reference *(Read the Following)*:

I am going to read some complaints and symptoms people have concerning indoor air. Please respond Yes or

No based on the complaints or symptoms you may have experienced more than two times a week over the last month. *(After each statement ask the following):* "Have you experienced this? Yes or No?"

14 . Temperatura de la casa demasiado caliente/Household temperature too hot

□ S/Y □ N □ NS/DK

15. Temperatura de la casa demasiado fría/Household temperature too cold

□ S/Y □ N □ NS/DK

16. Falta de circulación (congestión, olor)./ Lack of air circulation (stuffiness, odor).

□ S/Y □ N □ NS/DK

17. Muy poca luz/Not enough light

□ S/Y □ N □ NS/DK

18. Demasiada luz/Too much light

□ S/Y □ N □ NS/DK

19. Polvo en el aire/Dust in the air

□ S/Y □ N □ NS/DK

20. Ruidos perturbadores/Disturbing noises

□ S/Y □ N □ NS/DK

21. Asma/Asthma

□ S/Y □ N □ NS/DK

22. Chiflido al respirar/ Wheezing

□ S/Y □ N □ NS/DK

23. Falta de aire/Shortness of breath

□ S/Y □ N □ NS/DK

24. Alergias/Allergies

□ S/Y □ N □ NS/DK

25. Alergias nasals/Hay Fever

□ S/Y □ N □ NS/DK

26. Ojos secos/Dry eyes

□ S/Y □ N □ NS/DK

27. Ojos irritados/Eyes irritated

□ S/Y □ N □ NS/DK

28. Ojos lagrimeantes/Watery eyes

□ S/Y □ N □ NS/DK

29. Dolores de cabeza/Headaches

□ S/Y □ N □ NS/DK

30. Tos/Cough

□ S/Y □ N □ NS/DK

31. Estornudos/Sneezing

□ S/Y □ N □ NS/DK

32. Nausea/Vomito/Nausea/ Vomiting

□ S/Y □ N □ NS/DK

33. Fatiga/fatigue

□ S/Y □ N □ NS/DK

34. Somnolencia/Drowsiness

□ S/Y □ N □ NS/DK

35. Mareos/Dizziness

☐ S/Y ☐ N ☐ NS/DK

36. Irritacion de la piel (resequedad, comezon)/ Skin irritation (dryness, rash)

☐ S/Y ☐ N ☐ NS/DK

37. Nariz congestionada/Stuffy nose

☐ S/Y ☐ N ☐ NS/DK

38. Secrecion nasal/Runny nose

☐ S/Y ☐ N ☐ NS/DK

39. Garganta irritada/Throat irritation

☐ S/Y ☐ N ☐ NS/DK

Part IV. Severity of Symptoms/ Severidad de los síntomas

40. Usualmente a qué hora nota que se le manifiestan los problemas?/ When do the problems you experience usually occur?

☐ 1 Mañana/Morning

☐ 2 Tarde/Afternoon

☐ 3 Noche/Night

☐ 4 Todo el dia/All day

☐ 5 No ha notado patron/no noticeable trend

☐ 88 No se/Don’t know

41. Que tan seguido le ocurren estos problemas?

(Indique todos los que apliquen)/ How often do the problems occur? ***(Mark all that apply)***

☐ 1 Todos los dias/Daily________________________________

☐ 2 Lunes/Monday________________________________

☐ 3 Martes/Tuesday________________________________

☐ 4 Miercoles/Wednesday________________________________

☐ 5 Jueves/Thursday________________________________

☐ 6 Viernes/Friday________________________________

☐ 7 Sabado/Saturday________________________________

☐ 8 Domingo/Sunday________________________________

☐ 88 No se/Don't know

42. Se le quitan los sintomas que menciono una hora despues que sale de su casa?/ Do the above symptoms clear up within one hour after leaving your home?

☐ 0 No

☐ 1 Si/Yes---------pase a la pregunta 45/go to question 45

☐ 88 No se/Don't know

43. Si los sintomas no se le quitan una hora despues de que sale de su casa, cuales sintomas persisten?/ If the symptoms persist one hour after leaving your home, which symptoms persist?

____
____

44. Tiene problemas de salud o alergias que expliquen alguno de los sintomas mencionados?/ Do you have any health problems or allergies, which might account for any of the above symptoms?

____
____

45. Podria anadir algun otro comentario u observacion acerca de su casa?/ Can you offer any other comments or observations concerning your home?

____
____

PART V. Attributing Factors/ Factores de atribución

46. Por favor responda Si o No a las siguientes declaraciones/ Please answer with Yes or No to the following statements:

Uso lentes de contacto/. I wear contact lenses☐ Si/Yes ☐ No ☐ NS/DK

Uso una terminal de pantalla de video por lo menos 10% del dia/I operate a video display terminal at least 10% of the day. ☐ Si/Yes ☐ No ☐ NS/DK

Uso una fotocopiadora por lo menos 10% del dia/ I operate a photocopier at least 10% of the day.☐ Si/Yes ☐ No ☐ NS/DK

Estoy tomando medicamentos/ I am currently taking medication. □ Si/Yes □ No □ NS/DK

Si está tomando medicamentos: ¿Cuál es el motivo?/If taking medicine: What is the cause?

---

47. Sufre usted de otras enfermedades? Si responde si, cuáles son? Do you suffer from other illnesses? If so, which ones?

---

48. Tuvo enfermedades previas antes de moverse a este hogar? Cuáles? Donde vivió? DId you have previous illnesses before moving to this home? If so, which ones? Where did you live?

Domicilio 1 (Address)________________________________from__________/___________(Month & Year) ex 5/2008-7/2013

Domicilio 2 (Address)______________________________from ___________/___________(Month & Year)

Appendix 4. Technical Survey

House Assessment Bioaerosols Checklist

Atmospheric Conditions

Temperature		**Relative Humidity**		
Indoor	**Outdoor**	**Indoor**	**Outdoor**	**Season**

House

Water Damage				**Visible Mold**		**Home Age**	**Cooling Type**	**Heating Type**
Yes		No		Yes	No			
Low	Moderate		High					

Leaky Roof		**Leaky pipes**	
Yes	No	Yes	No

Personal Data

Number of Occupants	Number of Indoor Pets	Types of Indoor Pets	Number of Plants	Types of Plants

FIGURES

Figure1. gram staining protocol

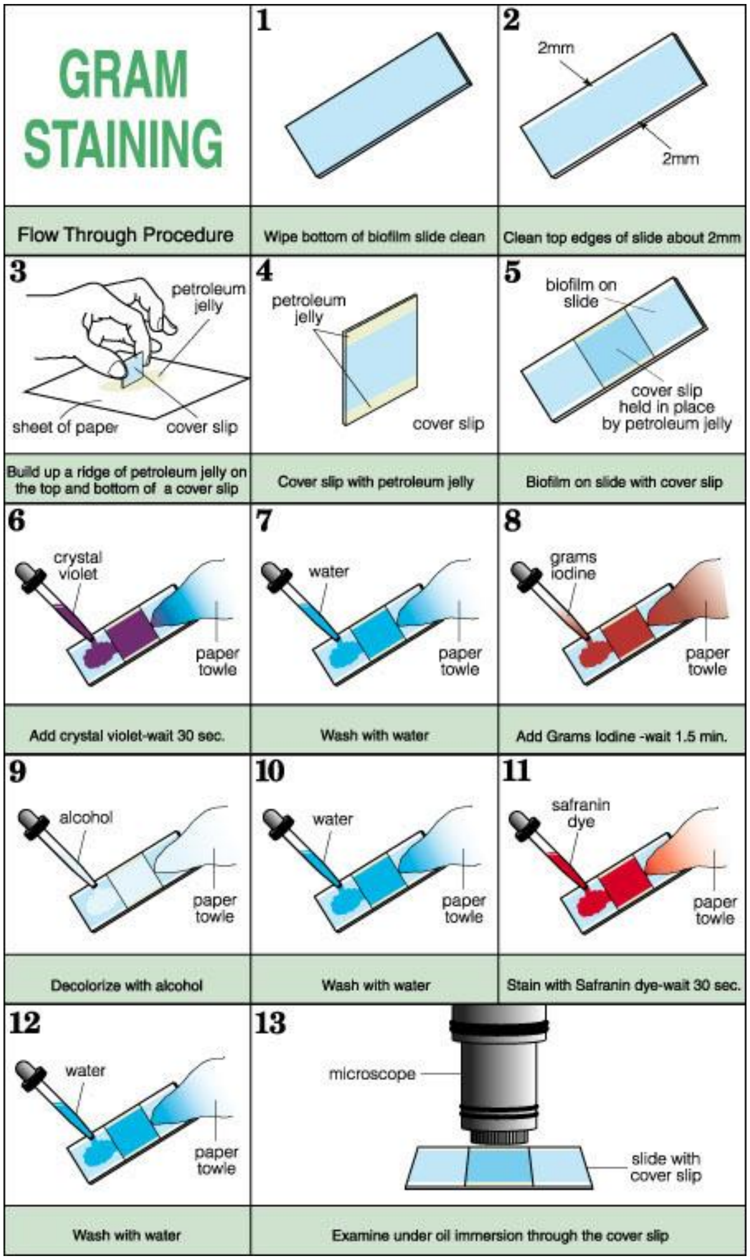
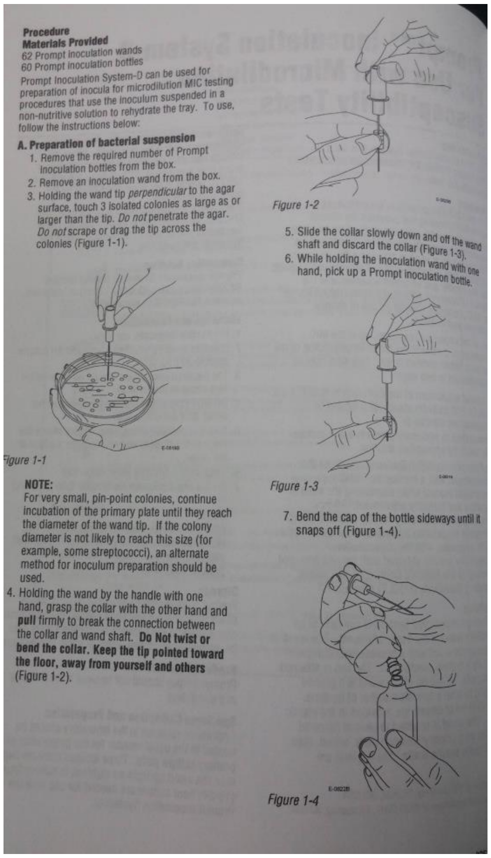


Figure 2. microscan protocol



Procedure

Materials Provided

62 Prompt inoculation wands

60 Prompt inoculation bottles

Prompt Inoculation System-D can be used for preparation of inocula for microdilution MIC testing procedures that use the inoculum suspended in a non-nutritive solution to rehydrate the tray. To use, follow the instructions below:

A. Preparation of bacterial suspension

1. Remove the required number of Prompt inoculation bottles from the box.
2. Remove an inoculation wand from the box.
3. Holding the wand tip *perpendicular* to the agar surface, touch 3 isolated colonies as large as or larger than the tip. *Do not* penetrate the agar. *Do not* scrape or drag the tip across the colonies (Figure 1-1).

Figure 1-1

NOTE:
For very small, pin-point colonies, continue incubation of the primary plate until they reach the diameter of the wand tip. If the colony diameter is not likely to reach this size (for example, some streptococci), an alternate method for inoculum preparation should be used.

4. Holding the wand by the handle with one hand, grasp the collar with the other hand and **pull** firmly to break the connection between the collar and wand shaft. **Do Not twist or bend the collar. Keep the tip pointed toward the floor, away from yourself and others** (Figure 1-2).

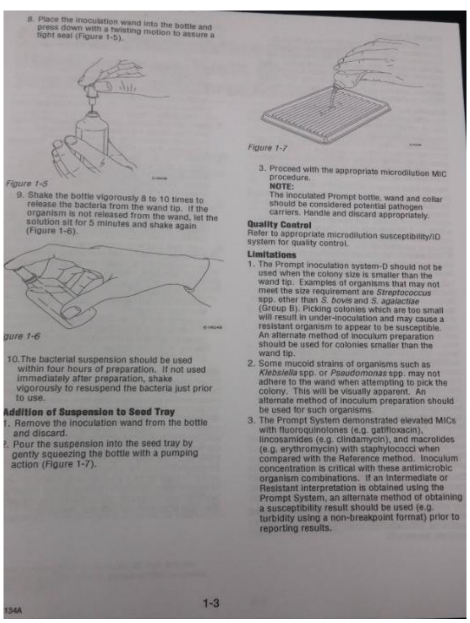
Figure 1-2

5. Slide the collar slowly down and off the wand shaft and discard the collar (Figure 1-3).
6. While holding the inoculation wand with one hand, pick up a Prompt inoculation bottle.

Figure 1-3

7. Bend the cap of the bottle sideways until it snaps off (Figure 1-4).

Figure 1-4



8. Place the inoculation wand into the bottle and press down with a twisting motion to assure a tight seal (Figure 1-5).

Figure 1-5

9. Shake the bottle vigorously 8 to 10 times to release the bacteria from the wand tip. If the organism is not released from the wand, let the solution sit for 5 minutes and shake again (Figure 1-6).

Figure 1-6

10. The bacterial suspension should be used within four hours of preparation. If not used immediately after preparation, shake vigorously to resuspend the bacteria just prior to use.

Addition of Suspension to Seed Tray

1. Remove the inoculation wand from the bottle and discard.
2. Pour the suspension into the seed tray by gently squeezing the bottle with a pumping action (Figure 1-7).

Figure 1-7

3. Proceed with the appropriate microdilution MIC procedure.

   NOTE:
   The inoculated Prompt bottle, wand and collar should be considered potential pathogen carriers. Handle and discard appropriately.

Quality Control

Refer to appropriate microdilution susceptibility/ID system for quality control.

Limitations

1. The Prompt inoculation system-D should not be used when the colony size is smaller than the wand tip. Examples of organisms that may not meet the size requirement are *Streptococcus* spp. other than *S. bovis* and *S. agalactiae* (Group B). Picking colonies which are too small will result in under-inoculation and may cause a resistant organism to appear to be susceptible. An alternate method of inoculum preparation should be used for colonies smaller than the wand tip.
2. Some mucoid strains of organisms such as *Klebsiella* spp. or *Pseudomonas* spp. may not adhere to the wand when attempting to pick the colony. This will be visually apparent. An alternate method of inoculum preparation should be used for such organisms.
3. The Prompt System demonstrated elevated MICs with fluoroquinolones (e.g. gatifloxacin), lincosamides (e.g. clindamycin), and macrolides (e.g. erythromycin) with staphylococci when compared with the Reference method. Inoculum concentration is critical with these antimicrobic organism combinations. If an Intermediate or Resistant interpretation is obtained using the Prompt System, an alternate method of obtaining a susceptibility result should be used (e.g. turbidity using a non-breakpoint format) prior to reporting results.

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1-3

CURRICULUM VITA

Eric Martinez was born in El Paso, Texas, the second son of Maria Teresa Martinez and Gonzalez Martinez. He graduated from the University of Texas at El Paso in fall 2011, obtaining the degree of Bachelor of Science in Biological Sciences. In the summer of 2014, Eric had the opportunity to do his practicum at the Texas Department of State Health Services. He participated in the project on assessment of knowledge, attitudes, and practice of respiratory infections in Ft. Hancock. That summer he also participated in the UTEP-EPA Border Air Quality internship in the project sampling bioaerosols in low income communities.

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