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Perception of Air Quality in the San Joaquin Valley

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in

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by

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Explanation of Abbreviations

Acronym	Explanation
AQI	Air Quality Index
BC	Black Carbon
CAG	Community Advisory Group
CBM	Community Based Monitroing
CBPR	Community-Based Participatory Research
CEnR	Community-Engaged Research
COPD	Chronic Obstructive Pulmonary Disease
CRT	Community Research Team
ED	Emergency Department
EPA	Environmental Protection Agency
GIS	Geographic Information Systems
ID	Identification
NAAQS	National Ambient Air Quality Standards
PACE	Prevention Agricultural Chemical Exposure
PM_{10}	Particulate matter less than 10 microns in aerodynamic diameter
$PM_{2.5}$	Fine particulate matter less than 2.5 microns in aerodynamic diameter
PM	Particulate matter
PPE	Personal Protective Equiptment
PTSD	Post-Traumatic Stress Disorder
RAAN	Real-Time Air Advisory Network
SES	Socioeconomic Status
SJV	San Joaquin Valley
WHO	Wold Health Organization

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Abstract

Air pollution sources have been a major concern in the United States since the 1960's. An estimated 200,000 early deaths are attributed to air pollution in the United States (Caiazzo et al., 2013) According to the World Health Organization (WHO) approximately 7 million deaths worldwide are attributed to air pollution. Air pollution is known to be a major environmental risk to health and by reducing air pollution levels there would be a reduction of the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma (C. T. Fowler, 2003; Maantay, 2007; Meng et al., 2010; Schwartz & Pepper, 2009).

However understanding air pollution perception and how the public perceives risk associated to it is also a growing concern. There has been research regarding pesticide perception and what protective behaviors individuals take in various countries, yet very few research has been done regarding how people perceive air pollution and what precautions they take to protect themselves. There are many sources that contribute to air pollution in the San Joaquin Valley (SJV) such as such as industry, agriculture, transportation, and wildfires. Although there has been efforts to improve current risk communication strategies that aim to inform the public on avoiding exposure of increased levels of air pollutants (Johnson, 2011, 2012; King, 2015), there exists a gap in research that focuses to understand perception of air pollutants in the SJV.

This dissertation aims to examine and cover the following areas:

1. Provide an overview of previous research in form of a literature review and identify gaps.
2. Assess perceptions about air quality of individuals who work outdoors.

3. Analyze three methods of recruitment and perceptions of air quality in the San Joaquin Valley.
4. Explore recruitment and retention of citizen science participants when attempting to assess air quality perception.
5. Examine perceived air quality, extent of concern, and perceived air pollution contributors.

Chapter 1 General Introduction

The San Joaquin Valley is home to over four million Californians (4.3 million) and it is known for having the most polluted air in the United States (Billings et al., 2016). Air pollution sources such as agriculture, transportation, and wildfires all have major effects in the San Joaquin Valley (SJV). In particular, particulate matter ($PM_{2.5}$) and pesticide exposure are a big concern. Air pollution control districts have made efforts to educate the public about ways to reduce pollution in the San Joaquin Valley, including providing real time access to $PM_{2.5}$ data that residents can use to plan daily activities and avoid outdoor activities when there are increased levels of air pollution ("Real-Time Air Quality Advisory Network," n.d.). Other efforts, such as the Air Quality Flag Program that provides public organizations and institutions such as schools with a flag system that indicates current air quality information have also been implemented ("Air Quality Flag Program," n.d.; Shendell et al., 2007). All these efforts have a common goal to protect human health as it requires the individual's awareness of air quality in order to manage potential exposures (Cairncross, John, & Zunckel, 2007; Laumbach, Meng, & Kipen, 2015).

Although there has been many efforts to reduce pollution and to improve current risk communication strategies that aim to aid the public in avoiding exposure to harmful air pollutants (Johnson, 2011, 2012; King, 2015), not much is known about the effectiveness of current communication efforts. By attempting to understand the public's perception of air quality, further efforts of risk communication can be implemented to develop better tools to inform the public of environmental exposures such as air pollutants (Johnson, 2011, 2012; King, 2015). More research is necessary to understand the public's perceptions of air quality and there exist a lack of research that studies public perception

of air quality in the SJV. Few studies of perception of air pollution research has been conducted worldwide, yet more research needs to be conducted to examine how different populations react to environmental risks such as air pollutants.

In order to study awareness and perception of air pollution a well-designed study with the appropriate research methods is necessary to establish a sense of certainty in this type of work. Researchers have already identified that traditional recruitment methods are often ineffective in minority communities and have specified that community members often have a distrust towards researchers or members of the research team (Shedlin, Decena, Mangadu, & Martinez, 2011). Therefore it is recognized that there exist a need to analyze multiple recruitment methods in vulnerable populations such as those here in the SJV. This can often be a challenging when conducting any type of research due to lack of responses or even participant bias. Thus this dissertation examines recruitment methods and differences as well as air quality perception in the SJV.

The second chapter of this dissertation consist of a literature review that provides an overview of the existing literature on the health impacts caused by air pollution and epidemiological studies on forest fires and health. Since pesticides are also contributors to air pollution, studies regarding pesticide use were also summarized along with studies on pesticide perception. Furthermore existing air pollution perception studies were also examined and reviewed to better understand perception.

The third chapter is a published study that examined many aspects of perceptions of air quality in the SJV with emphasis on the population who works outdoors. The study also examined attitudes, in addition to behaviors related to air pollution and whether there was differences among asthmatics and non-asthmatics.

The fourth chapter is a study that examined differences in methods of participant recruitment by comparing recruitment from public places in Merced and recruitment from community organizations in Modesto to Web recruitment. This study also examined perceptions of air quality with and without controlling for demographic factors.

Chapter 5 describes a study that took the initiative to explore recruitment and retention of participants when attempting to assess air quality perception as citizen scientist. In addition this study discusses challenges in recruitment methods and describes participant retention outcomes.

The last study in Chapter 6 examined perceived air quality, extent of concern, and perceived air pollution contributors of Merced and Stanislaus County residents. Furthermore this study took a different approach to previous studies and also analyzed whether living near a major freeway or highway impacted perception.

Hypotheses

Four Hypothesis were specifically developed for this dissertation.

1. Extent of worry about air quality is driven by air pollution exposure levels of individuals who work outside.
2. There exist differences regarding perception of air quality among participants recruited from public places and community organizations compared to those recruited from web.
3. Involving community members as citizen scientist to report air quality perceptions is an effective way to engage community members in air quality perception research.
4. Individuals who live near a major freeway or highway have a different perception of air quality than those individuals who do not reside near freeways or highways.

Chapter 2 Literature Review

Air Pollution Health Impacts

Research on the effects of air pollution on human health have been key in the monitoring and regulating many pollution sources. The World Health Organization estimates that particulate matter (PM) pollution contributes to approximately 800,000 premature deaths each year (World Health Organization, 2002). This rate ranks it the 13th leading cause of mortality worldwide. Although particulate pollution is measured and regulated to protect the public, its composition and effects on health are far more complicated. This is due to the fact that particulate matter is just a portion of pollution that is made up of very small particles and liquid droplets that contain acids, metals, organic chemicals and soil/dust particles. Particulate matter is categorized by size PM 10 which describes inhalable particles that with diameter of 10 micrometers and smaller, and PM 2.5 which describes inhalable particles with a diameter of 2.5 micrometers and smaller. Particulate matter has been shown to contribute to cardiovascular disease and respiratory illness (Anderson et al., 2012).

In recent studies particulate matter and ozone have been linked to hospital visits pertaining to asthma, poor birth outcomes, and respiratory diseases (Padula et al., 2013). A study conducted by Stanford University and University of California Berkeley concluded that PM10 and traffic density may possibly contribute to the occurrence of pulmonary valve stenosis and ventricular septal defects. Even though the results were mixed for other pollutants and had little consistency with previous studies it is distinctive in terms of the area of research (Padula et al., 2013).

A previous study conducted in the San Joaquin Valley aimed to examine air pollution impacts to health also indicated an association of ozone and particulate matter to frequent asthma symptoms and asthma related emergency department visits (Meng et al., 2010). These respiratory related illnesses are due to the small size of these fine particles that can penetrate in the respiratory system overtime, causing long term health effects. Those most vulnerable to the increased risk of these diseases are children and the elderly, along with individuals who spend most of their time outdoors working or exercising.

Air pollution is known to be associated with many types of asthma attacks, however, the role air pollution plays in initiating asthma is still being researched. Children often spend the majority of their time outside and this has a great impact on their health due to the fact that their bodies are still developing at the time of exposure. A Children's Health Study at the University of Southern California found that children who participated in several sports, outdoor activities, and lived in communities with high ozone levels were more likely to develop asthma than similar age active children living in areas with less ozone pollution (Meng et al., 2010).

An exploratory ethnographic study conducted to examine health disparities, social suffering, and childhood asthma among Mexican Americans in the San Joaquin Valley uncovered that not only are children suffering from the effects of asthma, but also many residents felt that their children's health concerns are being ignored (Schwartz & Pepper, 2009). Results show a growing and common concern for respiratory health of children residing in the San Joaquin Valley many of who lack access to health insurance and medication. In depth ethnographic interviews in this study revealed concerns about high

rates of asthma related to poor air quality in the valley especially in Fresno and Kern counties (Schwartz & Pepper, 2009).

In New York, asthma is extremely prevalent in the Bronx, affecting people of all ages and diminishing their quality of life (Maantay, 2007). Juliana Maantay examined the correspondence between asthma and pollution in the Bronx, New York as a case study using Geographic Information Systems (GIS) found that people living near contaminated land uses were up to 66 percent more likely to be hospitalized. It also found that 30 percent of the people were more likely to be of low Socioeconomic Status (SES) and 13 percent more likely to be a minority. Children in the Bronx are especially affected by asthma. Asthma hospitalization rates for children is 70 percent higher in the Bronx than in New York City as a whole and 700 percent higher in the Bronx than for the rest of New York State excluding New York City (Maantay, 2007).

Forest Fires; Epidemiological Studies

Even though wildfires pose a threat to human health in the United States, only a few health studies have been conducted. This is an important subject as it might impact vulnerable populations, including the elderly, children, and people with compromised immune systems. In a study conducted in Southern California, the strongest effect on asthma hospitalizations related to particulate matter less than 2.5 microns in aerodynamic diameter ($PM_{2.5}$) during a wildfire was found for people ages 65-99 (Delfino et al., 2008). The second strongest association was found for children ages 0-4 years of age.

Studies in the United States have found significant associations between exposure to wildfire smoke and increased self-reported respiratory symptoms (Künzli et al., 2006; Mirabelli et al., 2009), and increases in respiratory physician visits (Lee, Falter, Meyer,

Mott, & Gwynn, 2009), respiratory Emergency Department (ED) visits (Rappold et al., 2011) and respiratory hospitalizations (Delfino et al., 2008). Lee et al., (2009) and Mirabelli et al., (2009) reported that adults with pre-existing respiratory conditions or weakness (i.e. small air way size) were more likely to seek care or have additional symptoms after wildfire exposure than individuals without those conditions. A few studies have engaged methods to separate the effects of PM generated by fires from other sources. A recent study ran a dispersion model with and without fire emissions. The researchers found a slight but significant increase in respiratory ED visits for increases in $PM_{2.5}$ from wildfires while controlling for $PM_{2.5}$ from non-fire sources (Thelen et al., 2013).

Studies have documented significantly increased ED visits (Duclos, Sanderson, & Lipsett, 1990; Rappold et al., 2011) and hospitalizations (Delfino et al., 2008) for asthma in association with wildfire smoke exposure. Vora, Renvall, Chao, Ferguson, & Ramsdell (2011) demonstrated no significant changes in acute lung function related to $PM_{2.5}$ from wildfires among asthmatics. This may be because people with an established diagnosis of asthma are better at self-management of symptoms such as exposure avoidance and increased use of rescue medication in response to elevated levels of smoke (Vora et al., 2011a). People with asthma reported elevated levels of rescue medication usage during a wildfire in Southern California (Künzli et al., 2006; Vora et al., 2011a). Kunzli et al. (2006) reported that children without pre-existing asthmatic conditions had a greater increase in respiratory symptoms under exposure than did other children with pre-existing asthmatic conditions. The authors suggested that children with pre-existing asthmatic conditions tended to be on medication and have better access to care and as a result there was a smaller increase in symptoms when exposed to wildfire smoke.

Two studies, one conducted in California and the other in North Carolina, found association in ED visits for Chronic Obstructive Pulmonary Disease (COPD) related to wildfire smoke (Duclos et al., 1990; Rappold et al., 2011). Rappold et al. (2011) found an association with elevated risk of pneumonia and acute bronchitis in counties exposed to smoke from peat fires. Duclos et al. (1990) found a higher number of hospitalizations for bronchitis and pneumonia to be associated with PM_{10} from wildfire. A study in southern California found that $PM_{2.5}$ during a wildfire was associated with increased hospital admissions for exacerbations of COPD (Delfino et al., 2008).

The evidence for impacts of wildfire smoke exposure to respiratory infections in general is inconsistent. Duclos et al. (1990) found an association of ED visits for respiratory infections during major wildfires in California. This is contrary to Rappold et al. (2011) who found no association between ED visits for upper respiratory infections in smoke-affected counties during a peat fire in North Carolina.

Few studies have documented evidence of adverse effects for some specific cardiovascular diseases associated with exposure to wildfire smoke. One study in North Carolina showed significant increases for ED visits for congestive heart failure associated with wildfire smoke exposure (measured using satellite Atmospheric Optical Depth measurements) during a peat fire (Rappold et al., 2011). However, when diseases were grouped together by age and sex, the association between cardiovascular disease and smoke exposure was not found (Rappold et al., 2011).

Another study in Southern California found no association between hospitalizations for congestive heart failure and $PM_{2.5}$ during a wildfire (Delfino et al., 2008). Delfino et al. (2008) also found no association between $PM_{2.5}$ from wildfire and hospital admissions for

cardiac dysrhythmias; and no association to hospital admissions for ischaemic heart disease (Delfino et al., 2008). In a study conducted in Northern California near the Hoopa Valley Indian Reservation, particulate matter less than 10 microns in aerodynamic diameter (PM_{10}) was a significant predictor of clinic visits for coronary artery disease, known as heart disease, in a Native American reservation during a wildfire event (Lee et al., 2009). More work needs to be conducted in this area, hence existent studies are inconsistent and few. Thus, the association between cardiovascular outcomes and exposure to wildfire smoke is unclear at this point.

A study of a population seeking emergency relief services after a wildfire found that having difficulty breathing because of smoke or ashes was significantly associated with the probability of Post-Traumatic Stress Disorder (PTSD) or major depression three months after the fire occurred (Marshall, Schell, Elliott, Rayburn, & Jaycox, 2007). Duclos et al. (1990) found no increase in mental health hospitalizations during the 1987 California fires.

Very few studies have investigated an association for exposure to smoke from wildfires and poor birth outcomes, which prevents any conclusive associations. Holstius, Reid, Jesdale, & Morello-Frosch (2012) found a small but significant decline in birth weight for babies that gestated during the 2003 Southern California wildfires in comparison to babies from the same region who were born before or more than nine months after the fires. The effects were significant for wildfire exposure during the second and third trimester of pregnancy however not during the first trimester. Since this study did not quantify air pollution exposures for the pregnant women in the study, it cannot be

determined if the observed effect was due to smoke exposure to smoke from wildfires or the stress of living in an area that was experiencing a wildfire.

More epidemiological research that examines the health effects of Forest Fires is needed. Typical studies have only looked at short term fire incidents, thus lack statistical power. Studies conducted for longer periods of time are required to confirm the inconsistencies and determine groups that are most affected by smoke. Additionally, the health impacts and relative risk from prescribed, managed, and wildfire (mega-fire) smoke must be understood for forest management to effectively produce the best health outcomes.

Pesticide Use

Research on pesticide exposure has been key in regulating pesticides known to cause health impacts in the United States. California itself produces half of the United States' fruits and vegetables and generates 38 billion in annual sales of agricultural produce (California Department of Pesticide Regulation, 2015). Although California only accounts for two to three percent of farmland in the U.S. its pesticide use accounts for 25 percent of agriculture pesticides in the United States (Harrison, 2011). Concerns for pesticide exposure are apparent in many ways, such that alternatives to a few of these compounds are being developed to protect the public (Harrison, 2011). While there is a growing concern to pesticide/chemical free farming techniques in the United States only about 0.8 percent of all U.S. cropland and 0.5 percent of all U.S. pasture was certified organic in 2011 (United States Department of Agriculture, 2012). Given current practices pesticide use will continue to rise in the Unites State's agricultural community and it is critical that farmworkers exposed to pesticides are provided with the necessary information they need to effectively asses and manage risks associated to pesticide use especially in California

where the majority of farmworkers are poor and Latina/o predominantly from Mexico (Burgarian and Lopez, 1998).

However, communicating risk-based information about pesticides and other environmental exposures to farmworkers has many challenges especially among minorities (Cabrera & Leckie, 2009).Ultimately the goal of communicating the risk of exposure to communities and individuals would help protect themselves and their families from hazards eventually preventing many health effects. For pesticides, a broad range of practices have been implemented to reduce both direct and indirect exposures ,however, many guidelines to the applications of pesticides in place are not effective in changing farmers' behaviors. Evidence from current research suggest that this information itself does not change pesticide related practices (Flocks, Kelley, Economos, & McCauley, 2012; Roxanne Parrott, Katherine Wilson, 1999). In farm communities research has shown that there is no clear relationship between farmer's knowledge and safety practices (Salazar, Napolitano, Scherer, & McCauley, 2004). In some, cases farmers know very well that there exist risks faced in their occupation, but their behaviors are influenced by other factors (Cabrera & Leckie, 2009). Knowledge and understanding of risks is important however it may only be one of many influences on how to react to these risks (Slovic, 1997).

Pesticide Risk Perception

Risk perception which goes hand in hand with risk communication is a complex process that reflects on many variables such as cultural, social, and environmental factors (Slovic, 1997). Research on risk perception is rapidly growing and it suggest that not all people react to risks in the same way. Social and demographic variables such as gender, age, and ethnicity have been shown to play a role in how people perceive and assess

risks. Perceptions may have intrinsic characteristics of the hazard in this case "pesticides" themselves as whether they are undertaken voluntarily or are part of the common place and practice (Slovic, 1997).Understanding farmers' perceptions of pesticide risks is important and it requires an assessment of a range of underlying factors that shape people's attitudes and perceptions (Arcury, Quandt, & Russell, 2002).

Current literature on attitudes and risk perceptions in settings of occupational exposures consists of workers or operators in developing countries and migrant or seasonal farmworkers in the United States. Some of these groups were more vulnerable due to the limited information or resources necessary to promote awareness by using protection for safe (Roxanne Parrott, Katherine Wilson, Katherine Wilson, Carolyn Buttram, Karyn Jones, 1999). High illiteracy and poverty rates also played a role along with language barriers in the development of risk communication and safety training (Salameh, Baldi, Brochard, & Saleh, 2004). Increased levels of illiteracy were also present in studies conducted in developing countries. The illiteracy levels were a contributor to difficulties in understanding pesticide use instructions and safety precautions among farmers and farmworkers. This key finding demonstrates that illiteracy impedes risk communication efforts in both developing countries and countries that employ migrant and seasonal farmworkers.

Risk Perception of Immigrant Workers in the United States

Early evidence on lack of safety practices in the United States came from research that focused on reduction of pesticide exposure by developing education programs to target specific groups such as farmworkers (Arcury et al. 2002; Austin et al. 2001.) Arcury et al. (2002) examined the levels of knowledge, attitudes, and risk perceptions of Hispanic

farmworkers in North Carolina using Data from the Prevention Agricultural Chemical Exposure Program (PACE). The data used from PACE is a community based participatory research project designed to reduce farmworker pesticide exposure by developing and implementing culturally appropriate safety education programs. The farmworkers who participated were majority male and from Mexico. 60% of participants reported to be under 30 years of age and 60% reported to have been working in the United States 2 years or less. Out of all 293 participants, two-fifths reported the inability to understand the English language in which safety and training materials were provided. The main findings of this study concluded that the majority of the Hispanic farmworkers perceived to have no control over the reduction of personal pesticide exposure (Arcury et al. 2002). This demonstrated that providing workers with a rational for new behaviors is not enough in terms of knowledge to have an effect and change perceptions or sense of control over workplace safety (Arcury et al. 2002). Overall, farmworkers in this study knew they were at risk, but would not take action to reduce risk when they felt they had no control over their work situation.

Austin et al. (2001) also examined risk perceptions among farmworkers and pesticide exposure in North Carolina using data from PACE. Participants in this study perceived preventative pesticide exposure to be outside of their control due to the inability to speak the same language that trainings were provided in. This was concluded due to workers not reporting behaviors that reflected what they had learned in their pesticides trainings. Both Acury et al. (2002) and Austin et al. (2001) found that participants reported very little use of protective equipment by immigrant workers due to reasons such as lack of provided protective equipment in the workplace and work pressure.

A more recent study showed that immigrant workers in Oregon were aware of risks associated with pesticide exposure. However, in this study participants perceived that adverse health effects associated with the by-product of their work would only affect the weaker workers. This was due to their lack of knowledge of pesticides since they had strong beliefs that weaker workers were most vulnerable (Salazar et al. 2004). These findings reinforce and demonstrate that stress in the workplace affects the ability to access and use protective equipment (Salazar et al. 2004: Parrot et al 1999: Flocks et al. 2012).

Another study conducted in Oregon by McCauley et al. (2002) developed a pesticide knowledge test of 20 true or false question derived from content of the U.S. EPA Worker Protection Standard Training information for farmworkers. Results indicated that 33% of the 102 participating farmworkers received pesticide training and only 50% of their sample stated to have used protective equipment while working with pesticides (McCauley et al. 2002). McCauley et al. (2002) also noted that 40% of their sample of 102 farmworkers believed they had never been exposed to pesticides and 79.4% of participants reported the belief that pesticides could cause health problems. Another key finding was half of the participants reported having fears about potential health effects, however, they believed they had limited control in protecting themselves from pesticides.

A similar study conducted in California's Salinas Valley also examined pesticide risk perception and pesticide education among farmworkers. A questionnaire was developed to examine and assess farmworker understanding, perception, and self-protective behaviors in regards to pesticides. Cabrera and Leckie (2009) noted that the majority of the sample could not read or speak English, the language the training materials were provided in. Their findings show that only 50% of the farmworkers received any kind

of pesticide use training. Another important finding was that the majority of their participants identified a range of long and short term health effects when asked questions of potential effects of pesticide exposure. Although the farmworkers had high perceptions of pesticide exposure risk and ability to understand potential health effects many still participated in risky pesticide-related activities. Risky activities and behaviors such as not changing work clothes prior to returning home and washing work clothes with non-work clothes (Cabrera and Leckie 2009).

Demographic differences in risk perceptions were present among farmworkers in the United States. For instance, Cabrera and Leckie (2009) noted that risk perception scores were elevated in females in California's Salinas Valley. Female participants in this study demonstrated the ability to identify a larger range of long and short-term health effects associated with pesticide exposure compared to males. These findings of higher risk perception among women were also noted by Flocks et al. (2012). Using focus groups to examine perceptions of pesticide exposure Flocks et al. (2012) found that female were also aware of hazards associated with pesticide exposure during pregnancy, and could recall in detail incidents where exposure affected their health. Many of these women felt that in addition to general pesticide related issues there were also a number of impacts on fetal health. Several women in the focus groups even mentioned to know somebody who had experienced a miscarriage and believed it was due to work related chemical exposure. Women also frequently mentioned concerns that maternal pesticide exposure caused children to develop respiratory illness such as asthma.

Strong, Starks, Meischke, & Thompson (2009) also examined knowledge and attitudes of immigrant female farmworkers and mothers in farm-working households. The

study took place in Washington State and used in-depth interviews to try to understand perspectives of mothers in farmworkers households and reduce take-home pesticide exposure. Strong et al. (2009) stated that female workers could describe exposure and how pesticides entered their home but were less able to make a connection between pesticide exposure and their children's. Women reported to experience difficulty in integrating the prevention behaviors into their everyday lives due to household responsibilities, as well as the conflict created with their husband's intentions and health beliefs. This may explain why majority of farmworkers reported delaying showering after work as they believed it was a health precaution to have their bodies cool down. Similar behavior was noted by Cabrera and Leckie (2009) where 32% of participants did not change clothes until several hours after returning home and 14% (male participants) did not change clothes until bedtime.

Risk Perception of pesticide use in Europe

In Europe there exist a gap in research on risk perception in terms of pesticide application by operators and farmworkers when compared to developing countries and seasonal/immigrant workers in the United States. An explanation for less research on exposure risk perception in Europe may be due to their more effective training and legislations. The available research does not demonstrate major differences in patterns of pesticide perception and behavior. Damalas and Hashemi (2010) examined pesticide risk perception and use of protective equipment by surveying cotton growers in Northern Greece. Their study found that educational knowledge was higher among younger farmers who were below 35 years of age compared to older farmers who were 50 years or older. A key finding was that older farmers perceived lower risk and higher benefits from the use

of pesticides (Hashemi & Damalas, 2010).This proved that older farmers were less risk adverse compared to younger farmers. Young cotton growers showed higher levels of adoption of pest management practice that were related to Integrated Pest Management (IPM) compared to older growers although their adoption of IPM was generally low. Another main finding was that older farmers used protective equipment less frequently comparted to younger farmers in the study. Damalas et al. (2006) had conducted previous research in Greece and his findings suggest that almost all Greek tobacco farmers believed that handling pesticides could cause potential serious health effects. However, these farmers did not show high levels of adoptions of safety precautions since only about half of the participants reported to use personal protective equipment when spraying pesticides (Damalas, Georgiou, & Theodorou, 2006).

Perception of Pesticide application in Other Countries

Blanco-Muñoz and Lacasaña (2011) examined practices related to safe handling of pesticides and use of personal protective equipment among agricultural workers in Mexico. Results indicated low rate of correct usage of personal protective equipment although the majority of participants regarded pesticide handling as hazardous to their health. Participants also reported storage of pesticides at home which implies a potential exposure risk for family member. This observed behavior was due to lack of resources and education. Perceiving pesticides as risky by farmers was not associated with use of personal protective equipment (PPE). However, pesticide risk was positively correlated with educational level but not influenced by age or gender (Blanco-Muñoz & Lacasaña, 2011).

Devi (2009) examined the levels of awareness regarding pesticide use and handling in farms in the state of Kerala which lies the southernmost part of India. Using a

questionnaire and face to face interviews Devi (2009) reported higher literacy levels compared to other studies. Even though the majority of participants could read and write in the local language they reported not being able to understand toxicity levels on pesticide levels. Participants in this study reported not attending any training on pesticide use and care and operators admitted not using protective equipment. Operators reported not using PPE due to cost and discomfort associated with the equipment. Surprisingly, a quarter of workers believed that there existed no adverse health effects in the long run associated with pesticide exposure but the rest were aware of health risk and impacts of pesticides and could recall episodes of health effects after application (Devi, 2009).

A Brazilian Study also examined knowledge, attitudes, and practices associated with pesticide use and exposure in an agricultural community of Culturama. Recena et al. (2006) noted that most participants were aware of risks associated with the use of pesticides and considered them to be poisonous. Although participants expressed their concerns regarding the adverse health effects and effects to the environment many of them did not take adequate protective measures to avoid increased exposure. Most reported to have received information from the government regarding pesticides and the majority read the product labels with instructions and warnings but that knowledge was not found to influence safe practices (Recena et al., 2006).

Air Pollution Perception in the United States

In the United States there has been a handful of studies that aim to understand air pollution perception. In the early 1960's only a few research projects were conducted in regards to climate and air pollution but very few if any were primarily were concerned with public opinion. The New York State Health Department took initiative and gathered data

utilizing questioners to conduct air quality reports and to study people's opinions on air pollution.

In Buffalo New York a study examined questions relative to the levels of awareness and concern about air pollution using two population samples in 1959 and 1962. Face to Face interviews were conducted by the University of Buffalo for 466 participants of the 1959 sample and 334 interviews were done by telephone for the 1962 sample. Findings suggested that both populations were well aware and concerned about air pollution needing more attention and support. Overall 93 percent of the 1959 sample and 80 percent of the 1962 sample thought that industries contributed most heavily to pollution (Degroot, Loring, Rihm, Samuels, & Winkelstein, 1966a). Respondents were highly concerned about the possible effects of air pollution on their health and property, however, neither sample indicated that awareness and concern resulted in them taking any action (Degroot et al*.,* 1966). In general participants seemed to agree air pollution control was a good thing but needed information that such control could be achieved due to unemployment and other community concerns (Degroot et al*.,* 1966).

In the early 1970's researchers in Utah began to examine why people perceive environmental pollutants such as air pollution differently. Creer, Gray, and Treshow, (1970) analyzed responses of 100 surveys in regards to air pollution as an environmental health problem aiming to understand why some people perceive air quality to be a problem and others don't even if individuals lived in the same community. Cognitive dissonance was tested to predict how individuals would perceive a given problem and was found to be a good predictor of behavior. In addition, this study suggested that individuals who are highly dependent economically on a source of pollution were much less concerned with

local air pollution similarly considered the pollution control efforts to be greater in comparison to non-dependent individuals in the same community. Three variables were controlled in this study being for age, sex, and education. However they had very little effect on the relationship.

Despite the research and overall air quality improvements since the 1970s, air pollution continues to be an environmental issue for both the public and health officials. In Texas a spatial and statistical analysis was conducted as part of a study to examine localized air quality patterns and air quality perception. This study aimed to improve the understanding of major risk factors that shape public perceptions, by mapping the spatial pattern of local air quality perceptions using Geographic Information Systems (GIS) across Dallas and Houston metropolitan areas. Results indicate that perceptions of air quality are not significantly correlated with air quality conditions based on readings from air monitoring stations (Brody, Peck, & Highfield, 2004).Respondents who lived in zip codes with concentrated urban centers were more likely to perceive air as more polluted in comparison to those living in suburban and urban areas. These findings suggested that perceptions of air quality may be contingent on the area's overall setting and not necessary different in the two cities.

A survey of Paterson New Jersey residents took a different approach and tested acculturation associations with attitudes and air pollution management, knowledge, and self-reported behaviors concerning air pollution. Branden B. Johnson (2011) used Linguistic and temporal proxy measures for acculturation as independent variables along with ethnicity, controls for gender, education, age, and income in a multivariate analysis. Findings indicate that one fifth of contrast between non-Hispanic whites, non-Hispanic

blacks, English-interviewed Hispanics, and Spanish-interviewed Hispanics were statistically significant. Knowledge variables featured the most significant differences especially among the Spanish-interviewed Hispanics which reported less concern, familiarity with pollution, recognition of high pollution, and vigorous outdoor activities than English-interviewed Hispanics. Another important finding was English-interviewed Hispanics did not differ from non-Hispanic Whites, but did on several variables from non-Hispanic blacks (Johnson, 2011).

Another study conducted by Branden B. Johnson aimed to understand experiences and implications with urban air pollution in Paterson New Jersey. A telephone survey of Paterson, New Jersey residents was conducted to examine perceived air quality. This study analyzed the protective step of staying indoors during high pollution episodes and its relationship to perceived local air quality, perceived vulnerability, sensitivity to air pollution, or poor health. Johnson also explored the seeking of AQI information and its relationship to perceived vulnerability of self and others as well as to trust in the environmental agency source. In addition, actual monitored air quality and perceived air quality were also examined and the results indicated that Paterson air quality data only slightly replicated the current literature of correlated perceived and monitored air quality (Johnson, 2012). Overall this study confirmed previous qualitative findings that official communications about air quality are only partly successful due to a mix of contradictions with different personal cues and information mislaid by the Air Quality Index communications.

In Chicago Catherine E. King investigated residents' perceptions of air quality by linking objective data on built and social environments with multiple measures of pollution

and a representative survey of Chicago residents. The results showed that air quality is rated worse where minorities and poverty are concentrated after adjusting for objective pollution and built environment measures. Although respondents' perceptions did match up to some extent with objective measures the available objective measures actually line up poorly with the general public's perception of their own risks. Overall perceptions of air quality in this study were said to be driven by neighborhood socioeconomic positon rather than the respondents' ability to perceive pollution.

In New York a pilot study was conducted to understand perception and reality of particulate matter exposure in taxi drivers. Drivers' knowledge, attitudes, and beliefs were measured and compared with direct measures of exposure. Both roadside and in vehicle levels of PM2.5 and black carbon (BC) over a single work shift on each subject and exposures levels were compared with central site monitoring. Fifty-six out of the 100 drivers believed they were more exposed more than non-drivers and eighty-one believed that air pollution caused health problems. Findings suggest that the air pollution exposures that drivers faced would likely exceed the EPA recommendations if experienced for 24 hours. The survey results also indicated that the drivers had limited awareness and further research should focus reducing exposures and encourages increasing awareness of taxi drivers (Gany et al., 2017a).

Air Pollution Perception in other Countries

In England a few studies have aimed to explore and understand perceptions of air quality. Bickerstaff and Walker recognized that relevant research conducted in the United States consisted of mostly public opinion-based surveys so they utilized mixed methodology involving questionnaire surveys followed by in depth one-to-one interviews

to obtain a wider perspective on how members of the public think about the problem of current urban air pollution. Their findings suggested that for most people there was a diverse array of localized, physical and social encounters with air pollution that were important in the development of perception. For instance when looking at perception of health impacts almost half of those surveyed (45%) identified some form of impact related to breathing, irritation, and allergic reactions. A high level of worry was also expressed by 53.2% of participants where half were very concerned about personal health impacts of poor air quality.

Another study in North-East England set out to explore potential influences on public views of air quality in two different but geographically close districts via postal surveys. The two districts were chosen to contrast material deprivation and proximity to industry to analyze if there was a difference on influences of views of respondents by their gender, age, and illness status. Howel et al. (2002) found that the strongest influence on views were found to be proximity to industry in Teeside one of the districts, and to a lesser extent, age and illness status. The work of this study revolved around a larger study in Northeast England that aimed to gain insights on public views of air pollution, air quality information, health risks from air pollution using both quantitative and qualitative methods.

This study only examined residents' perceptions but did not involve actual air monitoring. Four thousand nine-hundred eighty-three questionnaires were sent out via mail with an overall response rate of 59% in Teeside and 65% in Sunderland. Howel et al. (2002) found that the strongest associations were proximity to industry and to a much less extent age and presence of chronic illness. Despite the links to proximity to industry, there was minimal evidence of an independent association between material deprivation and views

on air quality (Howel, Moffatt, Prince, Bush, & Dunn, 2002). These findings suggest that further research is necessary in this area. Howel et al. (2002) suggest that the focus should be as much on place based factors as on characteristics of individual to understand if influence of the presence of industry, landscape, and environment play a key role in shaping views of local air quality.

A more recent study designed as a pilot in areas of Greater Nottingham England aimed to explore lay perceptions of air quality and health. Participants were selected to represent three different social categories, age, health status, and geographical location. Similar to previous studies conducted in England, this study aimed to examine possible differences in perception between two economically and geographically distinct areas using semi-structured interviews. Edgley et al. (2011) found that perceptions of good air seem to vary with age and health whereas experiences of air quality are associated with socio-economic status. In addition, place and health status were suggested to likely be significant in mediating how different geographic places were perceived. These findings suggest that there exists difficulty in establishing the extent to which these perceptions are liked specifically to health status due to most of the older participants having asthma (Edgley et al., 2011).

In Sweden Forsberg et al. (1997) conducted a study to explore if people could detect poor air quality well below the guideline concentrations examining annoyance reactions and air pollution from traffic using a postal questionnaire. A total of 8250 surveys were randomly sent to 55 (150 subjects per area) urban areas throughout Sweden that had operating air quality monitoring stations. The survey contained questions on perception of air quality as well as annoyance of exhaust fumes. Results indicated that town dwellers

could detect poor air quality at concentrations below current guidelines for outdoor pollution. This study's results also indicated that people with negative attitudes to traffic, women, and those with respiratory sensitivity such as asthma were more likely to be annoyed by exhaust fumes and perceive the outdoor air as irritating (Forsberg et al., 1997). In an earlier Swedish study, women were found more annoyed than men by vehicle exhausts (Ewetz et al.,1983)This suggest that questionnaire studies do have a place in monitoring air quality and therefore improvements in air quality will lead to a reduction of complaints or annoyance among populations.

A more recent study aimed to understand the role of perceived pollution and health risk perception in annoyance and health symptoms in a Swedish community. The study tested a model that described interrelations between odorous air pollution at non-toxic exposure levels. A population-based survey was sent to 1,118 residents (ages 18-75 at random) living near a biofuel facility that emitted odorous substances. Out of all participants who obtained the survey only 65% (722) agreed to participate. Claeson et al. (2012) concluded that exposure level does not directly influence annoyance and symptoms and that the relations are mediated by perceived pollution and health risk perception. According to Berglund et al. (1987) annoyance is a complex concept that involves an individual's perceptions, emotions, and attitudes toward the exposure. This adds to previous research that had suggested annoyance to be a mediating factor between exposure and health effects (Berglund et al., 1987; Claeson et al., 2012).

A study in Greece took a different approach aiming to understand air quality perceptions in an urban outdoor Mediterranean environment using a field survey approach. Participants of this study were people passing by or visiting the monitoring sites who were

asked to report some personal characteristics and evaluations on environmental quality/conditions at the time of the interview. Pantavou et al. (2016) concluded that people were more likely to perceive poor air quality or dusty conditions when overall pollutant concentrations increased. In addition this study demonstrated that air quality perception is affected by personal factors such as age, health symptoms, thermal sensation, and areas of residence (Pantavou et al., 2016).

In China only a few studies have been done in trying to understand residents' perceptions of air quality and pollution sources. Liao et al. (2015) examined the understanding of main sources of pollution in Nanchang and factors that influenced air quality perception. Data was collected in children's hospitals and four kindergarten classes in Nanchang by surveying parents of children 2 to 10 years old. Findings clearly showed that current poor air quality has been a major concern in Nanchang where 97% of the participants supporting increased funding and action to improve air quality in the region(Liao et al., 2015).

An earlier study that examined the perception of environmental hazards among Hong Kong Chinese. The study rated levels of threat of 25 environmental hazards and gave quantitative judgements to six risk characteristics for each hazard. Lai and Tao (2003) found that older participants, women, and less educated individuals found hazards to be more threatening to the environment than younger participants, men, and individuals with more education. In addition, cultural factors were also related with perceived level of threat associated with environmental hazards. This is due to a number of the participant's perception of risks being shaped by the influences of values associated with Confucianism (Lai & Tao, 2003)

In Canada a few studies have examined air quality perception, health risk, and environmental risk and reaction in communities. Elliot et al. (1999) analyzed the power of perception and health risk attributed to air pollution in an urban industrial neighborhood by conducting a quantitative health risk assessment with input of community groups concerned about air quality impacts on health. Respondents of the survey were asked whether or not they had any concerns about various types of pollutions as well as the intensity of the concerns such as slight, moderate, and extreme. Results indicated that it was evident that air pollution was a major part of concerns in the community. Twenty-eight percent of respondents reported they considered moving due to black soot pollution and half of those actually made moves towards actually changing residences. In addition to concerns, 35% of respondents reported that newspapers, and magazines were the main sources of information, 20% reported television was their main source, while 13% reported they had no main sources of information in regards to air pollution (Elliott et al., 1999)

Another study in Canada analyzed risk and reaction to air quality, health and civic involvement in an urban industrial neighborhood (Wakefield, Elliott, Cole, & Eyles, 2001). In-depth interviews were conducted in order to determine the relative influence of social capital and place attachment when deciding to take civil action in an area of well documented history of adverse air quality. Interview findings demonstrated the complexity of understandings of air pollution. Overall results indicated that social capital is the primary contributor to the decision to take civic action while place attachment played a lesser role. Although this research supports previous theories that social capital is the primary contributor to taking civic action Wakefield et al. (2001) suggest that more research is

necessary to examine the role of informal community involvement to determine the role of social trust in civic action.

A more recent study investigated the factors of influencing perceptions of air quality in the industrial city of Hamilton, Canada. Data was collected via telephone surveys of 1,002 adult residents in three neighborhoods to examine perceptions by individual socio-demographic factors in addition to perceived health status. Perceptions varied by neighborhood, where participants residing in the Southwest Mountain neighborhood being over 6 times more likely to report a "good" perception of air quality than those residing in the lower city neighborhood. Another important finding when comparing location was that perceived neighborhood problems strongly influenced perceptions of air quality in the lower city and central areas. Overall there was consistency in all three neighborhoods in regards to air quality affecting their choice to go outside.

Perception of Air Pollution from Forest Fires

In addition to research on public perception of air pollution many studies have aimed to understand diverse public opinions towards smoke from wildland fire. However, there exists a very limited amount of research conducted in this topic and very little is known about public perceptions of smoke. It is very difficult to understand public perceptions and tolerance of smoke from wildland fires and what factors influence public tolerance of smoke. This is due to current research focusing primarily on wildfires and less on smoke.

However, there are different levels of beliefs, knowledge, and understanding of current fire and smoke issues that can influence public smoke. Higher tolerance has been found to be associated with knowledge about necessities to take action involving smoke,

positive effects of wildland fire such as forest health, and steps agencies have taken to minimize smoke impacts on surrounding communities (Blades & Hall, 2012). Although greater knowledge does not always lead to higher tolerance due to other factors that play a role in perceptions such as concerns about personal health, property, and recreation, tourism and past experiences with fire and smoke.

Smoke from wildland fires can impact surrounding community residents in many ways either by health effects, ash deposition, impaired visibility, public nuisance, and economic impacts. Smoke from wildland fires pose risk to health although there are many individuals who are at greater risk of exposure such as firefighters, nearby residents, and individuals who actively participate in outdoor activities (C. Fowler, 2003). Most individuals and communities that have existing health issues are more aware of health impacts caused by smoke and are usually less tolerant of smoke from wildfires. Although there are fears about human safety and worry in regards to increased levels of smoke from wildfires, only a small percentage of the U.S. population considers smoke from wildfires to be a serious problem (Blades, Shook, & Hall, 2014; Bunson & Shindler, 2004; McCaffrey & Olsen, 2012)

National Forest and protected areas are usually visited by individuals who seek to enjoy solitude and scenery. However concerns arise when both wildfire season coincides with peak tourism and recreation season. This is due to smoke from wildland fires often times being perceived as a negative impact on aesthetic quality and recreation, resulting in substantial revenue losses when there is a decline in visitations (Bunson & Shindler, 2004; Sandberg, 2002; Thapa, Holland, & Absher, 2004; Winter, Vogt, & Fried, 2002). Recent research conducted in the United States found that the public perceives the likelihood of

smoke impacts on outdoor recreation, scenery, and school recess to be greater than the likelihood of impacts to personal health. Another finding is that individuals from rural areas are more concerned about such impacts compared to individuals from urban areas (Blades et al., 2014). In addition, the public is more tolerant of smoke when there is an accurate understanding of the positive effects of wildfires such as the improvement of forest health and ecosystem (Bowker et al., 2008) Therefore, reinforcing and improving the public's understanding about the role of fire in improving ecosystem health and reducing the community's wildfire risk should be a principle focus when aiming to increase the public's tolerance of smoke.

Conclusion

Research in perceptions is critical in assisting policy-makers and other activist in designing effective risk reduction measures. Health effects can result from environmental exposures and it is important to understand how different groups perceive these risks. This review aimed to summarize the current literature that considered attitudes, knowledge, and perception towards environmental risks and exposures such as pesticides and air pollution across different populations.

Current research suggest that knowledge and awareness of risks and perception were not shown to influence self-protective behavior or safe handling and storage of pesticides. These findings suggest that more perception research needs to be conducted in order to design more effective training programs to increase safer behaviors in developing countries and the United States. Not all people perceive risks the same and therefore effective training and awareness material need to be tailored particularly among minorities (London et al. 2002).

Many studies have proven there exists relationship between poor air quality and health, however, there is a higher need to examine the role perception plays in exposure. There is a research gap in regards to attitudes and perceptions of environmental exposures. Community perceptions on exposure to air pollution are critical in determining people's responses and acceptance on policies and interventions. According to current literature many factors can influence perception such as social capital, age, gender, areas of residence, culture, health status, and education. Although research validates that exposure to pesticides and air pollution causes serious health impacts more research is needed to fully understand how to influence protective measures and actions from these environmental exposures. All studies describe the current challenges researchers encounter when trying to understand what factors influence air quality perception worldwide and encourage further research to be conducted.

Chapter 3.0 Perceptions about air quality of individuals who work outdoors in the San Joaquin Valley, California (Published)

Abstract

The San Joaquin valley (SJV) is known for having poor air quality and high rates of respiratory illnesses including asthma. This study was aimed to assess the perceptions about air quality of individuals who work outdoors in the San Joaquin Valley, California. Surveys were conducted with SJV residents (n=198) to understand attitudes, perceptions of air quality, and behaviors related to air pollution of individuals who work outdoors. The results suggest that people who worry more about air quality tend to check air quality more often. It was found that individuals who suffer from asthma are more likely to check air quality when working and exercising outdoors. In addition, the differences on how people utilize informational sources regarding air quality were observed. Conclusion: Therefore, there is a need to further study attitudes and perceptions about air quality among populations who work outdoors.

Key words: Air quality perception; Air quality attitude; Awareness; Asthma; San Joaquin Valley

Introduction

The San Joaquin Valley (SJV) is known for having the most polluted air in the United States (Billings et al., 2016). Poor air quality in the SJV contributes to high rates of respiratory and cardiovascular diseases including asthma, atherosclerosis, and myocardial infarction (Meng et al., 2010). This ethnically diverse and economically deprived region fails to comply with current federal standards for particulate matter with the diameter of 2.5 microns or smaller (Schwartz & Pepper, 2009). Particulate matter specifically 2.5 micrometers in diameter or smaller ($PM_{2.5}$) is regulated under the National Ambient Air Quality Standards (NAAQS) to protect public health (USEPA, 2014). Many efforts and campaigns have been conducted by local air pollution control districts to better educate the public regarding ways to reduce pollution and increase awareness of health impacts of poor air quality (Shendell et al., 2007; USEPA, 2014).

Although there has been efforts to improve current risk communication strategies that aim to aid the public in avoiding exposure of increased levels of air pollutants (Johnson, 2011, 2012; King, 2015), there is a lack of research that focuses to understand perception of air quality of individuals who work outdoors. Previous research conducted has focused more on pesticide perception amongst agricultural workers (Arcury et al., 2002; Austin et al., 2001; Cabrera & Leckie, 2009; Salazar et al., 2004), however, no research has focused on ambient air quality perception amongst the population that works outdoors. This population is perhaps at greater risk of exposure to air pollution and there exist a need to understand their perception in order to develop effective educational campaigns to increase awareness and self-protective behaviors.

A survey was conducted with SJV residents to understand perceptions of air quality and behaviors related to air pollution. The survey was developed through an advisory group and the Health Services Research Institute at University of California Merced. The purpose of this study was to assess how SJV residents who work outdoors perceive air quality. In addition the survey assessed the extent of worry regarding air quality and how often they check air quality prior to working or exercising outside. In this study, it was hypothesized that air pollution exposure levels of individuals who work outdoors and extent of worry about air quality are associated.

Materials and Methods

Sample

For this study, residents (n=198) of SJV of the California Central Valley were surveyed via online panels, community organizations, and public locations. The participants surveyed online resided in all locations of the SJV and those surveyed in person resided in Modesto and Merced. The survey was conducted from November 2014 to January 2015 and its data was collected for the 198 participants. There was a total of 24 questions utilized including demographic information: gender, age, education level, and zip-code. Institutional Review Board approval was obtained from University of California at Merced prior to initiation of the study.

Survey Method

Out of the 24 questions, six questions of the survey were utilized because of their relation to assessing perceptions about air quality.

1. “In the past month, what was the air quality like in other areas of the San Joaquin Valley?” (1=Very unhealthy, 2= Unhealthy, 3= Unhealthy for sensitive groups, 4=Moderately healthy, and 5= Good air quality.

2. “In the past month, on days when you went outside to exercise or work, how often did you check the air quality for that day?” (1=Never, 2= Almost never, 3= Sometimes, 4= Often, 5= Every time)

3. “To what extent are you worried about air quality in the San Joaquin Valley?” (1= Not at all, 2= A little worried, 3= Worried, 4= Very worried, 5= Extremely worried)

4. “If you knew that the air quality was unhealthy or very unhealthy, how likely is it that you would (a) exercise less, (b) run fewer errands, (c) work outside less, (d) stay inside with window and doors closed, and (e) take other precautions?” (1= Very Unlikely, 2= Unlikely, 3= Not Sure, 4= Likely, 5=Very Unlikely)
5. “Have you ever been told by a doctor that you have asthma?” (1=Yes, 2= No)
6. “What did you do to decide whether the air quality is good? Did you (a) look outside or at the sky, (b) look to see how clearly you can see mountains, (c) check reports on TV, (d) check reports on the radio, (e) look online or on the internet, (f) use a phone app, (g) check the smell of the air, (h) look at the air quality flags in front of public buildings, and (i) check the Air Quality Index in the newspaper?” (1=Yes, 2=No)

Ethics approval was obtained from the University of California, Merced Institutional Review Board (UCM14-0033).

Air Quality Data

The applied air quality data in this study was obtained from the California Air Resource Board website as part of a preceding study to assess the participant's exposure to $PM_{2.5}$. Based on a previous study, the two month average was utilized to assess exposure to $PM_{2.5}$ (Cisneros et al., 2017). Air quality data collected was based on the participant's county of residence. $PM_{2.5}$ mean concentrations were also grouped into three different categories based NAAQS and European Air Quality Standards. The categories consisted of low or good $PM_{2.5}$ concentrations that ranged from 0 to 12 $\mu g/m^3$, medium or moderate that ranged from 12 to 25 $\mu g/m^3$, and high or unhealthy concentrations that were greater than 25 $\mu g/m^3$.

Analysis

Descriptive Statistics were used to describe participant's demographics and responses to the survey. A multivariable regression was used to determine factors associated with the participant's awareness of ambient air quality in the SJV. Statistical analysis was performed utilizing SPSS 20 and statistical significance was considered at the $p<0.05$ level.

Results

Sample

Data was collected from 198 individuals. The demographics of the study of the population are shown in Table 1.

Table 1 Demographics of Participants

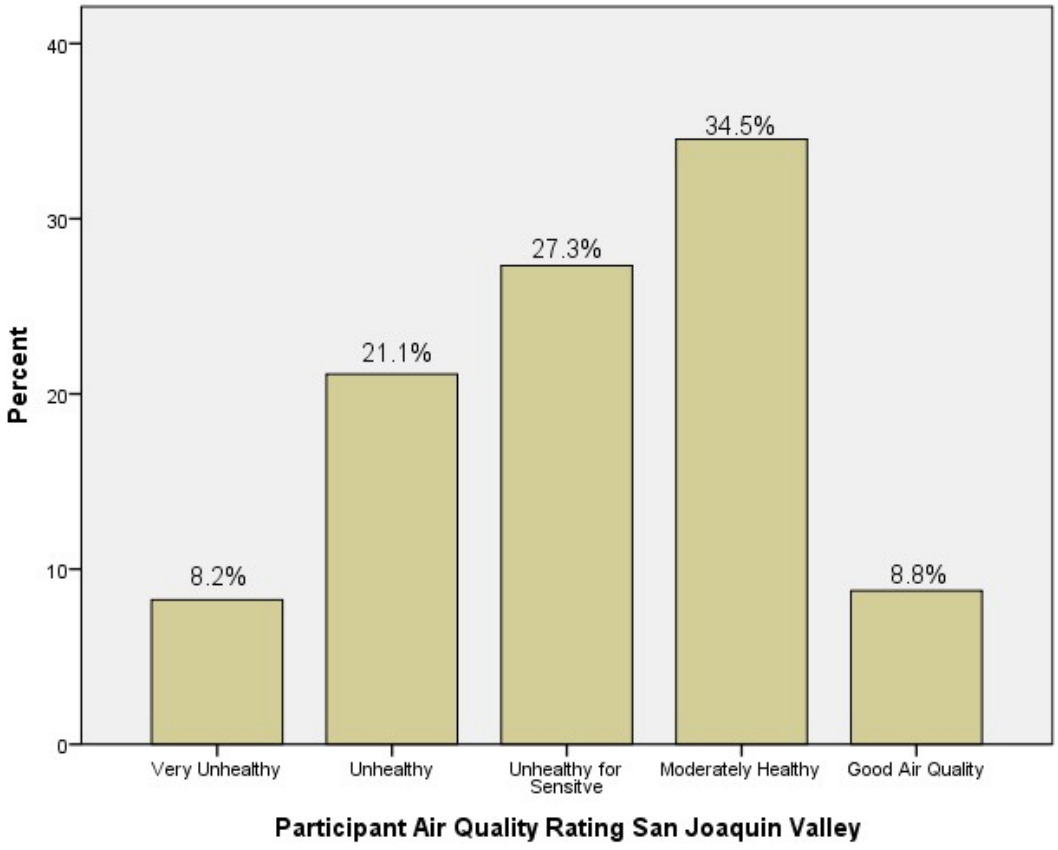
	Participant (%)
Gender	
Male	111 (56.1)
Female	87 (43.9)
Age	
≤40	103 (52.0)
>40	95 (48.0)
Education	
≤ High School	112 (56.6)
≥ College	86 (43.4)
Race	
White	51 (26.6)
Latino	103 (53.6)
Black	8 (4.0)
Asian	12 (6.1)
Other Races	24 (12.1)

The average age of the entire sample was 38.76 years, which is similar to the average age of the population of the San Joaquin Valley (40 years old). The entire sample had 56.1% self-identified males and 43.9% self-identified females. In the sample, 56.6% of participants had less than or equal to a high school education and 43.4% had greater than or equal to college education. Overall, the sample consisted of 53.6% self-identified Latinos, 26.6% self-identified White, 4% self-identified Black, 6.1% self-identified Asian, and 12.1% other races.

Participant Perception of Air Quality

Fig. 1 Shows that 8.2% of respondents perceive air quality as Very unhealthy, 21.1% responded Unhealthy, 27.3% responded Unhealthy for sensitive groups, 34.5% answered Moderate, and only 8.8% perceived the air quality to be good.

Figure 1



Checking Air Quality When Working Outside

Fig. 2 Shows that 25.4% of respondents stated to Never check air quality when they exercise or work outside, 12.7% responded Almost Never, 32% responded Sometimes, 18.3% Often, and 11.7% answered Every time.

Figure 2

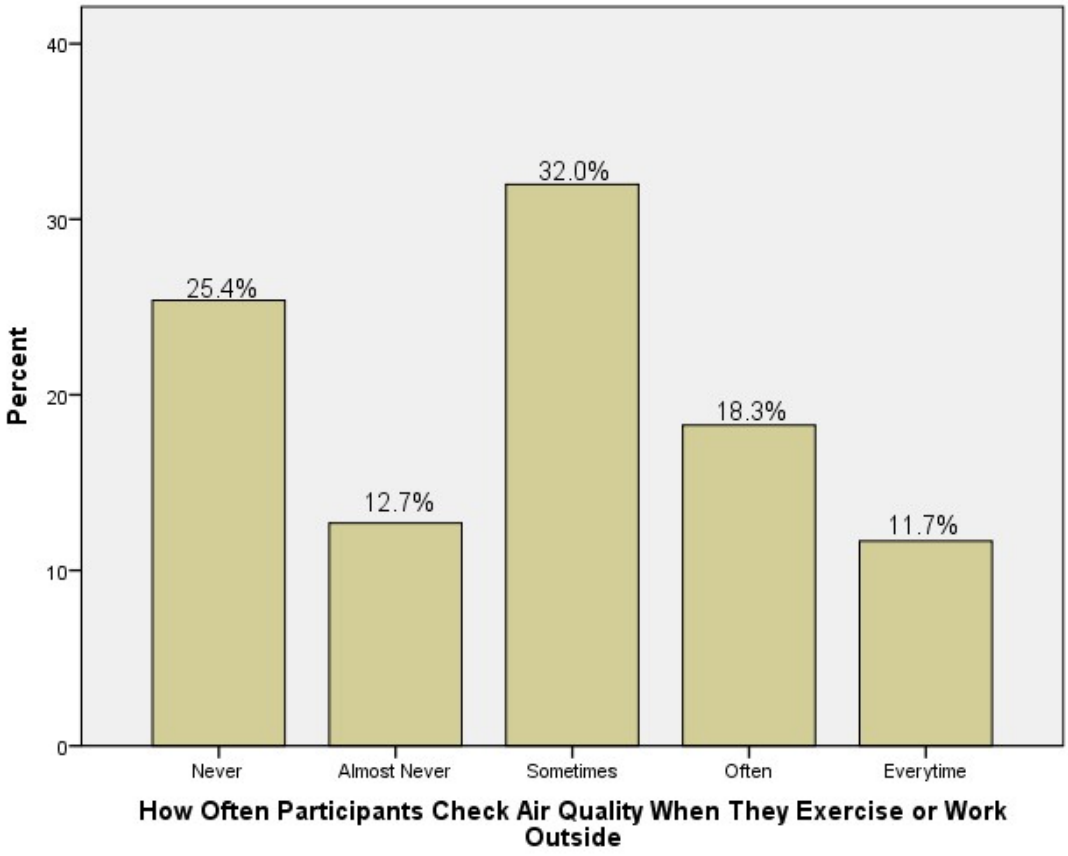

Percent
40
30
20
10
0
25.4%
12.7%
32.0%
18.3%
11.7%
Never
Almost Never
Sometimes
Often
Everytime
How Often Participants Check Air Quality When They Exercise or Work Outside

Table 2 How Often Participant Checks AQ and Asthma

Check Air Quality	Do you have Asthma?		
	Yes	No	Total
Never	8	42	50
Almost Never	6	18	24
Sometimes	11	52	63
Often	18	18	36
Every time	11	12	23
Total	54	142	196
	Value	**df**	***p* value**
Pearson Chi-Square	20.460[a]	4	0.000
Likelihood Ratio	19.697	4	0.001
Linear-by-Linear Association	12.707	1	0.000

df: degree of freedom; significant at p value < 0.05

Table 2 shows that 54 individuals out of our sample suffer from asthma. From our sample 14.8% of individuals who suffer from asthma stated they Never check air quality prior to exercising or working outdoors, 11.1% responded Almost Never, 20.4% Sometimes, 33.3% Often, and 20.4% answered Every time. Regarding the non-asthmatics in our study 29.6% reported to Never check air quality when working or exercising outdoors, 12.7%, answered Almost Never, 36.6% responded Sometimes, 12.7% Often, and 8.5% responded Every time. Results from a Pearson's Chi Square Test analysis is presented in Table 2 demonstrates a significant (p <0.05) association between checking air quality when working and exercising outside and participants who suffer from asthma.

Extent of Worry of Air Quality

Fig. 3 Shows that 8.3% respondents answered Not at all to be worried of air quality, 28% answered a Little Worried, 35.8% Worried, 14.5% Very Worried, and 13.5% responded to be Extremely Worried.

Figure 3

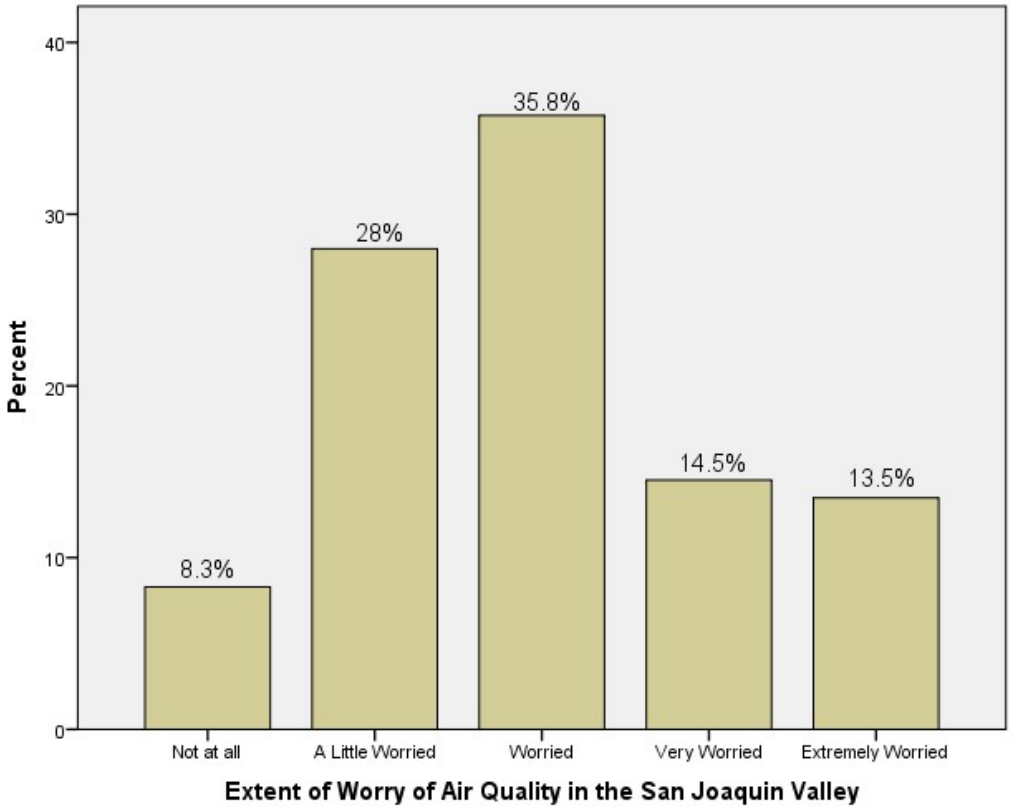


Table 3 Extent of Worried About Air Quality in San Joaquin Valley (SJV)

	β	SE	p value
Intercept	2.517	0.445	0.000
Age	0.186	0.170	0.274
Female	0.206	0.171	0.230
Latino	0.097	0.173	0.576
Education (High School or below)	0.241	0.172	0.163
Air pollution exposure levels	0.047	0.187	0.802

SE: Standard Error; β: Coefficient; significant at p value < 0.05

As presented in Table 3, our results from multivariate linear regression analysis demonstrates that there are no significant factors associated with participant's worry regarding air quality in the SJV. However, results from a multivariate linear regression

analysis presented in Table 4 shows there is a significant association with participants checking air quality and extent of worry.

Table 4 How Often People Check AQ When Exercise and Work Outside

	β	SE	p value
Intercept	1.510	0.557	0.007
Age	-0.035	0.197	0.858
Female	0.323	0.199	0.106
Latino	-0.067	0.200	0.740
Education (High School or below)	-0.165	0.200	0.410
Air pollution exposure levels	0.225	0.216	0.298
Extent of worry about AQ SJV	0.253	0.087	0.004

SE: Standard Error; β: Coefficient; significant at p value < 0.05

Participant Precautions If Air Quality Was Unhealthy or Very Unhealthy

Table 5 shows that 32.5% of respondents are likely and very likely to exercise less if air quality was unhealthy or very unhealthy. Over a third (36.6%) of the participants responded that they would work outside less if air quality was unhealthy or very unhealthy. In fact 38% of respondents stated that they would stay inside if air quality was unhealthy or very unhealthy.

Table 5 Participant Precautions if Air Quality was Unhealthy or Very Unhealthy

	Exercise Less	Run Fewer Errands	Work Outside Less	Stay Inside	Take Other Precautions
Very Unlikely	21.5%	22.9%	25.1%	26.0%	17.1%
Unlikely	27.2%	26.1%	22.0%	18.2%	16.6%
Not Sure	18.8%	18.1%	16.2%	17.7%	23.5%
Likely	21.5%	22.9%	24.6%	25.0%	24.6%
Very Likely	11.0%	10.1%	12.0%	13.0%	18.2%

Factors Associated with Perception of Air Quality

Results from a multivariate linear regression analysis of factors associated with participant's air quality perceptions are presented in Table 6. There is no significant association between perceptions of air quality in the San Joaquin Valley and Age, Gender, Education, Air pollution exposure levels, or being Latino.

Table 6 Perceived Air Quality in San Joaquin Valley

	β	SE	p value
Intercept	3.782	0.428	0.000
Age	-0.073	0.164	0.655
Female	-0.121	0.165	0.465
Latino	0.279	0.166	0.095
Education (High School or below)	-0.091	0.166	0.584
Air pollution exposure levels	-0.322	0.181	0.078

SE: Standard Error; B: Coefficient; significant at p value < 0.05

Participants' Perception of Sources of Air Pollution

Individuals' responses about sources of air pollution is shown in Table 7. Most of the participants ranked cars and trucks as the main contributing source of air pollution. Factories were ranked as number 2 source of pollution. Wind blowing dust was ranked number 3. Participants ranked forest fires as number 4 source of pollution and pollution from the Bay Area as number 5. Farms and agriculture were ranked number 6 source of pollution. Blowers and lawnmowers were ranked as number 7 source of pollution and construction was ranked as number 8.

Table 7 Participants' perception of contributors to air pollution in the San Joaquin Valley

	Mean	SD	Rank
SJV-Cars & Trucks	3.29	0.852	1
Factories	3.17	0.803	2
Wind blowing dust	3.11	0.881	3
Forest Fires	2.99	1.058	4
Pollution from Bay Area	2.92	0.909	5
Farms and agriculture	2.88	1.037	6
Blowers and lawn mowers	2.67	0.961	7
Construction	2.65	0.935	8

81.6% of individuals in our sample reported to check air quality reports on television to obtain air quality information and 78.5% look outside or at the sky. 76.6% of respondents rely on additional cues and assess air quality by whether they can see the mountains clearly and 70.8% respondents use their olfactory senses and check the smell of air quality. Over half (60.3%) of respondents stated to look online or use the internet to get information about air quality and 50.3% reported using a phone application. Similar amount of respondents also indicated to check reports on radio (57.5%) and less than half check air quality flags (43%) and Air Quality Index (46.9%) to obtain their air quality information.

Asthmatics in our sample demonstrated slight differences on how they acquired their air quality information 60.4% responded to check radio reports and 83.3% television reports. 79.2% took a different approach and looked outside or at the sky, 71.2% checked whether they can see the mountains, and 77.4% smelled the air to assess air quality. Out of our sample 63% of participants look online or utilized the internet, 50% used a phone application, 39.6% checked air quality flags 50.9% checked the Air Quality Index (AQI)

Discussion

During the last two decades, there has been various studies conducted on the perceptions of air quality in cities worldwide (Guo et al., 2016; Oltra & Sala, 2014; Xu, Chi, & Zhu, 2015). Many factors have been correlated with perceptions of air quality, including sociodemographic and contextual factors (i. e. urban and rural settings and proximity to industry) (Brody et al., 2004; Howel, Moffatt, Bush, Dunn, & Prince, 2003; Oltra & Sala, 2014). However, very few research has investigated the perception of air quality and levels of concern in the San Joaquin Valley which is known to be impacted by increased levels of air pollution (Meng et al., 2010).

Given that previous research found that air quality in the SJV was perceived as either moderate or unhealthy for sensitive groups (Cisneros et al., 2017), this study was aimed to understand the perception of air quality among the population that works outdoors. The results indicate that only a small percentage (8.8%) of the participants perceived the air quality in the region to be good air quality in the SJV. Yet, a very similar small percentage (8.2%) of the participants also perceived the air quality to be very unhealthy. However, nearly half of the respondents 48.4% reported the air quality to be Unhealthy and Unhealthy for sensitive groups. The results are in line with the previous research where 54% of participants reported the air quality to be Unhealthy and Unhealthy for sensitive groups (Cisneros et al., 2017).

When asked how often participants check air quality prior to exercising or working outside about one quarter of our participants stated to never check air quality. Also, 36.6% of the participants responded that they would work outside less if air quality was unhealthy or very unhealthy. In addition, 38.1% of the participants in our study reported to never and

almost never check the air quality prior to exercising or working outdoors. However, over a quarter (27.3%) of our sample suffers from asthma and 53.7% of participants with asthma stated to check air quality prior to exercising or working outdoors. This finding suggest that those who are asthmatic and work outside tend to be more precautious in comparison to non-asthmatic.

When analyzing extent of worry of air quality in the San Joaquin Valley we observed that over a third (35.8%) of the population in our sample worries about air quality. Considering that previous research did not examine extent of worry of air quality in the San Joaquin Valley among individuals who work outdoors (Brown et al., 2016; Cisneros et al., 2017), our study was aimed to understand if age, gender, education, air pollution exposure levels, or ethnicity were associated to worry or perception of air quality; and, no significant association was found in this regard. This is in contrast to previous research that has found evidence that females tend to perceive air quality as being more harmful or slightly poorer than men (Brown et al., 2016; Howel et al., 2003).However, our study found that there is a significant association between checking air quality and extent of worry among those who work outside.

Our findings is in line with early air pollution perception research which suggest that individuals are well aware and show concern for air pollution issues and demand more attention and support (Bickerstaff & Walker, 2001; Degroot, Loring, Rihm, Samuels, & Winkelstein, 1966b), since nearly half (48.4%) of our respondents perceived air quality to be unhealthy and unhealthy for sensitive groups. In addition, the findings in this work are align with previous perception of air quality research where not all populations react in the

same manner when exposed to environmental pollutants, particularly sensitive groups (Brown et al., 2016).

Previous research has only focused on how the general population in the SJV obtains their sources of information about air quality (Brown et al., 2016). However, our study took a different approach and examined how people who work outside obtain their sources of air quality information to analyze if there exist any differences. Interestingly, a 13 percentage point increase in use of checking reports on the radio was observed among those who work outside, in comparison to the study conducted by Cisneros et al. 2017 in which the participants are a representation of general population (i.e. those who work inside and outside). Also, there was an 11.5 percentage point increase in use of checking the Air Quality Index (AQI) amongst those individuals who work outdoors, suggesting that people who work outdoors may make more use of the AQI than the general population. Furthermore, there was an 8.9 percentage point difference in the use of a phone application and an 8.8 percentage point difference in checking the smell of the air when checking air quality in individuals who work outdoors and the general population. Understanding these differences can be crucial in developing communication strategies to further inform and protect individuals who work outdoors regarding the importance of checking and obtaining reliable air quality information.

Limitations and Strength

There are several limitations to this study as well as improvements that could be made if further analysis were to be conducted. First, the questionnaire did not ask the occupation of the participant which may have an impact on their perception of air quality regardless of them working outdoors. In addition, the questionnaire only asked if the

participant had a job that required them to work outdoors without specification of duration or period of time. The strength of this work lies in the type of participants who work outside, rather than those who work on a group of people whose exposure to the ambient air pollution is different to each other. The weakness of this study is that the data collected is self-reported survey data.

Conclusion

This study was aimed to assess the attitudes and perceptions about air quality of individuals who work outdoors in the San Joaquin Valley, California. The results in this study indicated that asthmatics check air quality more when working and exercising outside compared to non-asthmatics. In addition, we found that checking air quality is driven by participant's extent of worry. Interestingly we found that there was a slight increase in use of various sources of information about air quality among individuals who work outdoors in comparison to those individuals who do not. These results suggest air quality is a concern among individuals who work outdoors and that this population has higher interest in obtaining air quality information. Amongst individuals who work outdoors, Age, Gender, Education, Air Pollution exposure levels, or being Latino were not found to be significantly associated with perceptions of air quality. There is a need to continue to monitor and study air quality perceptions of populations who work outdoors in the SJV.

Chapter 4.0 Analyzing three methods of recruitment and perceptions of air quality in the San Joaquin Valley

Abstract

The San Joaquin Valley (SJV) is known to have poor air quality and very few research has studied public perception of air quality in the region. Traditional recruitment methods are often ineffective in minority communities and community members often have a distrust towards researchers or members of the research team. Therefore further research is needed to examine differences in recruitment method for this type of work. This study aims to look at different responses of participants in three types of recruitment methods controlling for factors such as age, gender, ethnicity, and educational attainment as well as not controlling for such factors. Overall differences in perception were observed with and without controlling for demographic factors when comparing recruitment from public places in Merced and community organizations in Modesto to Web recruitment.

Introduction

Previous research has recognized a need to analyze multiple recruitment methods in vulnerable populations. Traditional methods of recruitment are often ineffective in minority communities (Shedlin, Decena, Mangadu, & Martinez, 2011) and previous studies have identified multiple factors that can affect recruitment in some communities including distrust towards researchers in general (Ross, Loup, Nelson, Botkin, Kost, Smith, & Gehlert, 2010)

In addition inaccessibility due to geography, physical limitations, economic and social barriers (Ross, Loup, Nelson, Botkin, Kost, Smith, & Gehlert, 2010; Fahrenwald & Stabnow, 2008), potential language barriers (Sadler, Lee, Lim, & Fullerton, 2010), perceived risks of discriminatory repercussions of volunteering research data (Tung et al., 2008), and prior abuses due to minority status or beliefs can have an impact on recruitment (Russell et al, 2008).

For instance, in Hispanic immigrant groups, previous studies have identified barriers to recruitment that include stigma, discrimination, fear of immigration authorities, cultural norms, the environments, characteristics of the populations, and the sensitive nature of the topic to be studied (Shedlin, Decena, Mangadu, & Martinez, 2011). The recognition of these barriers has led to calls for more research on recruitment measures and methods, particularly in rural populations (von Schirnding, 2002).

One methodology that has been widely discussed having the potential to increase participation and recruitment in the research process is Community-Engaged Research (CEnR; Ross, Loup, Nelson, Botkin, Kost, Smith, & Gehlert, 2010). CEnR calls for forming research alliances with community members and integrating their contribution into

all phases of the research process (Srinivasan, O'Fallon, & Dearry, 2003;). Another method is Community-Based Participatory Research (CBPR) which is a type of CEnR, where there exist a partnership model that aims to involve community members in the research process in order to enhance the relevance and value of collaborative research (Minkler, 2004).

Although CBPR holds the promise of overcoming many of the barriers that exist to recruitment in diverse, rural, and difficult-to-reach communities, its implementation varies with the specific research environments. For instance the SJV has great ethnic diversity (59% Latino, 38% White, 8% Asian) and this ethnically diverse population creates a number of barriers to accessing research participants, as does the rural nature of communities. Therefore working with local community groups and members of the community, the academic researchers (hereafter: Research Team) developed a collaborative research project that focused on a problem identified by the community as being a particular concern: Air quality and health behaviors. The cities in the San Joaquin Valley (SJV) of California are consistently rated as having among the nation's worst air quality. Previous studies have linked poor air pollution with high rates of asthma and other respiratory diseases, particularly among the regions vulnerable populations.

Due to limited research, very little is known about the most appropriate way to recruit participants in this region. Therefore, the Community Research Team (CRT) decided to trial three methods of recruitment: Active recruitment through direct contact with potential participants at public locations in the targeted county (Merced), visits to community groups at their regular meetings, and using an internet panel through a commercial provider with the purpose of describing the process of recruiting for a study in

the San Joaquin Valley (SJV) of California and to examine differences in recruitment methods.

Methods:

Development of Community Advisory Group and the Community Research Team

The Community Advisory Group (CAG) arose from a series of open public meetings conducted by the members of the research team with community members over a period of three months. The purpose of the meetings was to identify research topics that were of mutual interest (i.e., need in the community but with unanswered questions that would require new research). One topic addressed during these initial meetings was appropriate methods for recruiting participants. The discussions highlighted the dearth of experience in the community with research and researchers. Because the community members had little experience with research and thus little knowledge of what would be appropriate or not-appropriate methods, the research team in consultation with the CAG members proposed trialing two methods: Recruitment through community groups (hereafter referred to as Community Groups Approach) and recruitment by sending research assistants to public places (Public Places Approach). As a comparison, the research team contracted with a national on-line data collection firm to recruit participants from the San Joaquin Valley.

To avoid cross contamination of the two local methodologies (Community Groups and Public Places Approaches), the Collaborative Research Team (CRT) decided to conduct the research in two comparable but geographically distinct cities (Merced and Modesto, CA). Because of the difference in the communities and the proposed methodologies, the CAG was split into two groups; One in Merced to help guide the Public

Places approach, and the second in Modesto to help guide the Community Groups approach. Though there were some members who were on each group, the groups operated independently, each with its own community leader to help organize and run the meetings.

Development of the research focus

Based on the results of the initial consultation with community members, the research team identified air quality as an important issue facing the people in the region. The cities in the San Joaquin Valley (SJV) of California are consistently rated as having among the nation's worst air quality, and air pollution has been linked to the high rates of asthma and other respiratory diseases among the vulnerable populations in the region. The research team proposed this topic to the Community Groups and Public Places CRT, whose members agreed that that it was an important issue in the region, and that it would be an appropriate research topic to raise with community members. Based on the discussions in these meetings, the members agreed that the initial research would focus on perceptions of air quality, related illnesses, and preventative health behaviors.

The research team drew up and distributed a draft of the survey to the members, received feedback and altered the survey accordingly. The measures were translated from English into Spanish and Hmong, and then piloted on three English speakers, one Spanish speaker and one Hmong speaker. In accordance with basic translational research elements (Woolf, 2008), surveys were checked to ensure that they would yield information that would lead to new interventions or policy recommendations.

Participants

The Community Groups and Public Places CRTs decided that the survey would target people 18 years of age and older in the San Joaquin Valley. All participants were

required to be functioning at a developmental level sufficient for completion of the survey and speak fluent English, Spanish, or Hmong.

Community data collection methods: The use of university students

The members of the CRTs discussed the options for recruitment, including having members of the research team do the actual recruitment, employing members of the community, and contracting with a professional research organization. The members decided that a group of trained university students would be the best option, especially if they were students from the region and bilingual (Spanish and English or English and Hmong).

Recruitment Method 1: Community Groups Approach

The Community Groups CAG met twice: once to inform data collection methods and once to review the results and develop dissemination methods. This method was only used in Modesto. During the first meeting, the members reviewed the research methodology, including survey duration, and design, and discussed the goal of the recruitment. When discussing the recruitment strategy, the members were asked to identify community organizations that would likely to result in a large number of participants and would offer the opportunity to recruit low income and/or Latino community members. The members identified a number of meetings based on their knowledge of the community groups in the region. The members recommended that the participants be offered a gift certificate worth $25 or a shirt from the local university in appreciation of their participation.

Following the meeting, members of the research team and a member of the Community Groups CAG contacted the organizations identified by the Community Groups

CAG, explained the purpose of the study, and asked to schedule a time at a future meeting to recruit and survey attendees. In all, multiple community groups where identified, and 9 agreed to participate.

The process for recruitment was identical at each meeting. After going over a script with information about the study and having the opportunity to ask questions, participants were asked to sign informed consent forms. The survey was then administered in English or Spanish (no participant requested the survey in Hmong). When all participants at that session had completed the survey, the research team member and the students thanked the participants, and distributed a gift card or a shirt. In all, the data collection took place over 9 days.

At the conclusion of the data collection, the Community Groups CAG was reconvened. The research presented the results from the study, and the members discussed the implications and next steps.

Recruitment Method 2: Public Places Approach

This method was only used in Merced. The Public Places CAG also met twice: once to inform data collection methods and once to review the results and develop dissemination methods. During the first meeting, the members reviewed the research methodology, including survey duration, and design, and discussed the goal of the recruitment. When discussing the recruitment strategy, the members were asked to consider sites that would be safe for the student research assistants, would likely result in a large number of participants, and would offer the opportunity to recruit low income and/or Latino community members. The members recommended a number high-traffic sites, including the local shopping mall, flea market and a community resource facility. To access low

income members of the community, the members identified a number of local government-led events, such as a turkey give-away and other community events. Finally, the members agreed that the participants should be offered a gift certificate worth $25 or a shirt from the local university in appreciation of their participation.

Following the meeting, members of the research team and a member of the Public Places CAG contacted the organizers of the sites or owners of the establishments to request ask for permission to recruit and survey community members at their sites. In all multiple owners or organizers where identified, and 5 agreed to participate.

The process for recruitment was identical at each meeting. After going over a script with information about the study and having the opportunity to ask questions, participants were asked to sign informed consent forms. The survey was then administered in English or Spanish (no participant requested the survey in Hmong). When all participants at that session had completed the survey, the research team member and the students thanked the participants, and distributed a gift card or a shirt. In all, the data collection took place over 3 days.

At the conclusion of the data collection, the Public Places CAG was reconvened. The research presented the results from the study, and the members discussed the implications and next steps.

Recruitment Method 3: On-Line survey

A common method of recruitment for survey studies such as used here is an on-line survey administered to a panel formed by a commercial research company. The research team contracted with a national company that claimed to be able to target their survey to members of the SJV. The company also claimed that it could access Spanish speaking

members of the region. The contract was for 175 English speaking residents and 75 Spanish speaking residents of the SJV.

A member of the research team prepared the on-line versions, which were then tested by the research team members. After verifying that the surveys were the same as those used in the Community Groups and the Public Places, the survey went live. In all, the data collection took place over 14 days.

This study aims to look at different responses of participants in three types of recruitment methods controlling for factors such as age, gender, and educational attainment as well as not controlling for such factors. Data collection differences were observed with and without controlling for demographic factors in the three types of recruitment

Analysis

The regression analysis throughout this chapter compares the recruitment from Public Places and Community Organizations to Web recruitment. Descriptive statistics were used to describe participant's demographics and responses to the survey. Statistical analysis was performed utilizing SPSS 20 and statistical significance was considered at the $p<0.05$ level. Regressions were first entered into SPSS to look at differences in responses without controlling for factors such as age, gender, ethnicity, and educational attainment. Overall differences were observed with and without controlling for demographic factors when comparing recruitment from public places in Merced and community organizations in Modesto to Web recruitment.

Results

Sample

The demographics of the study of the population are shown in Table 8. Data was collected from 719 individuals in total from all methods of recruitment. There were 244 participants recruited from public places in Merced, 244 participants recruited from community organizations, and 231 participants recruited via online using Qualtrics. The average age of the entire sample was 41.8 years of which 37.4% self-identified as Male and 62.5% Female. The average age for community organization participants in Modesto was 48.4 years of which 24% identified as Male and 76% Female. As for the average age for participants recruited from public places in Merced was 34.6 years of which 43% identified as Male and 57% female.

The entire sample had 37.6% participants who self-identified as White, 42.8% Latino, 4.7% Black, 5.7% Asian, and 9% other race. For Modesto Community Organization participants there were 50% self-identified White, 32% Latino, 5% Black, 2% Asian, and 11% other. In Merced's participants there were 14% White, 57% Latino, 7% Black, 2% Asian, and 14% other. As for online participants, 49% self-identified as White, 39% Latino, 3% Black, 6% Asian, and 2% other.

Table 8 Participant Demographics

	Modesto			Merced			Qualtrics			Total	
Average Age	48.4	Of category	Of site	34.6	Of category	Of site	42.4	Of category	Of site	41.7	
Age											
≤40	92	26%	38%	154	44%	63%	105	30%	45%	351	100%
>40	152	41%	62%	90	25%	37%	126	34%	55%	368	100%
Gender											
Male %	58	22%	24%	106	39%	43%	105	39%	45%	269	100%
Female %	186	41%	76%	138	31%	57%	126	28%	55%	450	100%
Education											
≤High school	127	35%	52%	134	37%	63%	104	28%	45%	365	100%
≥College	117	33%	48%	110	31%	45%	127	36%	55%	354	100%
Have asthma?											
Yes	52	30%	22%	68	39%	28%	55	31%	24%	175	100%
No	188	35%	78%	174	32%	72%	176	33%	76%	538	100%
Health problems made worse?											
Yes	83	36%	34%	79	34%	33%	70	30%	30%	232	100%
No	158	33%	66%	164	34%	67%	161	33%	70%	483	100%
Ethnicity											
White	122	45%	50%	35	13%	14%	114	42%	49%	271	100%
Latino	78	25%	32%	139	45%	57%	91	30%	39%	308	100%
Black	11	32%	5%	16	47%	7%	7	21%	3%	34	100%
Asian	6	15%	2%	21	51%	2%	14	34%	6%	41	100%
Other	27	42%	11%	33	51%	14%	5	7%	2%	65	100%
N	244			244			231			719	

Participant Perception of Air Quality in the SJV Compared to Web

When analyzing differences in public locations in Merced, community organizations in Modesto and comparing them to Web, several differences were observed. Without controlling for demographic factors and comparing public locations and community organizations to web there was a significant difference (p=.039) between web and public locations. Results shown in Table 9 demonstrate that after controlling for multiple factors there still existed a significant difference (p=.022). In addition there was a significant difference in air quality perception and being Latino or female. Latinos were more likely to perceive air quality to be better while females on the other hand were less likely to perceive air quality to be better.

Table 9 Air Quality Perception in the SJV

	β	SE	p value	β	SE	p value
Intercept	3.203	.067	.000	3.370	.115	.000
Public Location	-.195	.094	.039	-.224	.097	.022
Community Organizations	-.043	.096	.609	-.001	.096	.994
Age				.020	.080	.802
Latino				.228	.092	.013
Other Race				-.014	.113	.899
Education (High School or below)				-.084	.078	.278
Female				-.162	.080	.044
Health Problems				-.404	.090	.000
Asthma				-.034	.097	.724

SE: Standard Error; β: Coefficient; significant at p value < 0.05*

Participant Outdoor Average Exercise in Comparison to Web

When analyzing the three methods of recruitment and average exercise outdoors without controlling for any demographic factors for public locations in Merced and community organizations in Modesto, a difference (p<.001) was observed in comparison

to online web recruitment. When controlling for other factors the difference remained significant. Participants recruited from public locations (p=.003) and community organizations (p<.001) were more likely to participate in outdoor exercise on average compared to those recruited online/web.

Table 10 Participant Outdoor Exercise

	β	SE	p value	β	SE	p value
Intercept	2.381	.084	.000	2.567	.147	.000
Public Location	.405	.117	.001	.372	.124	.003
Community Organizations	.427	.118	.000	.495	.121	.000
Age				-.152	.102	.138
Latino				-.038	.117	.744
Other Race				.132	.143	.357
Education (High School or below)				.000	.099	.996
Female				-.216	.102	.035
Health Problems				.002	.115	.985
Asthma				.060	.123	.626

SE: Standard Error; β: Coefficient; significant at p value < 0.05

Participants Who Work Outside in Comparison to Web

When looking at how often our participants work outside more than 30 minutes on average without controlling for any factors, public locations in Merced (p<.001) and community organizations in Modesto (p=.047) differed in comparison to Web. After controlling for other variables significant differences were still observed meaning participants from public locations (p<.001) and community organizations (p=.006) were more likely to work outside in comparison to Web. In addition there was a significant differences (p<.001) in being Latino and female when exercising outside for more than 30 minutes. Latinos were more likely to report working outdoors while females were less

likely to work outdoors compared to males. Shown in Table 11 a significant difference was also observed for Other Races and Education.

Table 11 Participants Working Outdoors

	β	SE	p value	β	SE	p value
Intercept	2.338	.085	.000	2.468	.147	.000
Public Location	.683	.120	.000	.567	.124	.000
Community Organizations	.239	.120	.047	.330	.120	.006
Age				.134	.102	.190
Latino				.369	.116	.002
Other Race				.341	.142	.017
Education (High School or below)				-.249	.098	.012
Female				-.505	.102	.000
Health Problems				-.052	.114	.651
Asthma				.173	.122	.158

SE: Standard Error; β: Coefficient; significant at p value < 0.05

Checking Air Quality When Exercising or Working Outdoors in Comparison to Web

In terms of analyzing if differences existed among the three recruitment methods and how often participants check air quality when exercising or working outdoors it was noted that in comparison to Web, Modesto participants recruited from community organizations were less likely ($p<.001$) to check air quality when exercising or working outdoors before and after controlling for demographic factors. As seen in Table 12 being Latinos and suffering from health problems was also significantly associated ($p<.001$) with checking air quality prior to working or exercising outdoors. Where Latinos and those participants who reported to suffer from health problems were more likely to check outdoors prior to exercising or working outside.

Table 12 Checking Air Quality When Exercising or Working Outside

	β	SE	p value	β	SE	p value
Intercept	2.174	.138	.000	2.174	.138	.000
Public Location	-.198	.116	.088	-.198	.116	.088
Community Organizations	-.452	.113	.000	-.452	.113	.000
Age				.029	.096	.765
Latino				.452	.109	.000
Other Race				.530	.133	.000
Education (High School or below)				-.124	.092	.179
Female				-.008	.095	.931
Health Problems				.512	.107	.000
Asthma				.078	.115	.498

SE: Standard Error; β: Coefficient; significant at p value < 0.05

Participant Perception of Air Quality and Pollution in Comparison to Web

When looking at differences in recruitment methods a significant difference (p=.014) was observed in community organizations in Modesto in comparison to Web without controlling for demographic factors. However when controlling for the factors not only was Modesto significantly different (p=.024) but Merced also resulted to be significantly different (p=.008). As seen in Table 13 Latinos were more likely to perceive that air pollution (e.g. Ozone, Particulate Matter, Carbon Monoxide) affected air quality (p=.003).

Table 13 Perception of AQ and Pollution (e.g., Ozone, Particulate Matter, Carbon Monoxide)

	β	SE	p value	β	SE	p value
Intercept	1.148	.020	.000	1.139	.036	.000
Public Location	-.055	.028	.055	-.080	.030	.008
Community Organizations	-.071	.029	.014	-.066	.029	.024
Age				-.021	.025	.396
Latino				.083	.028	.003
Other Race				.035	.035	.317
Education (High School or below)				-.015	.024	.519
Female				.007	.025	.785
Health Problems				-.028	.028	.315
Asthma				-.010	.030	.740

SE: Standard Error; β: Coefficient; significant at p value < 0.05

Participant Perception of Air Quality and Pollen in Comparison to Web

When analyzing differences in Merced, Modesto, and Web participants a significant difference was observed (p=.005) in participants recruited from community organizations in Modesto. After controlling for various factors Modesto no significance was observed (p=.055) when comparing to Web. As seen in Table 14 age, gender, being Latino, and Female were also significantly associated to participants believing high pollen counts contribute to "bad" or "unhealthy" air quality. Latinos (p=.003) and participants over the age of 40 years (p<.001) were less likely to perceive that bad air quality was associated to high pollen counts. Females (p=.005) were also less likely to report that bad or unhealthy was due to high pollen counts. In addition participants who reported having health problems made worse by air quality were less likely to perceive that bad air quality was due to high pollen counts (p=.001).

Table 14 Perception of AQ and High Pollen Counts

	β	SE	p value	β	SE	p value
Intercept	1.316	.029	.000	1.513	.049	.000
Public Location	-.053	.041	.192	-.039	.042	.356
Community Organizations	-.115	.041	.005	-.078	.040	.055
Age				-.141	.034	.000
Latino				-.114	.039	.003
Other Race				-.099	.048	.039
Education (High School or below)				.032	.033	.329
Female				-.095	.034	.005
Health Problems				-.125	.038	.001
Asthma				.037	.041	.363

SE: Standard Error; β: Coefficient; significant at p value < 0.05*

Participant Perception of Air Quality and Difficulty Breathing Comparison to Web

When analyzing differences in Merced, Modesto, and Web participants a significant difference (p<.001) was observed in participants recruited from community organizations in Modesto. After controlling for multiple factors a significant difference was observed for Modesto (p=.001) and Merced (p=.001). As seen in Table 15 significant differences were observed based on age (p=.010), gender (p=.001), and being Latino (p<.001), when examining the belief that when air quality is "bad" or "unhealthy" it is hard to breath. In addition there was also a significant difference among asthmatics, where they were less likely (p=.040) to perceive that when it is hard to breath it is due to air quality being "bad" or "unhealthy".

Table 15 AQ Perception of Air Quality and Breathing

	β	SE	p value	β	SE	p value
Intercept	1.297	.027	.000	1.374	.047	.000
Public Location	-.070	.038	.065	-.126	.039	.001
Community Organizations	-.160	.038	.000	-.129	.038	.001
Age				-.083	.032	.010
Latino				.130	.037	.000
Other Race				.115	.045	.012
Education (High School or below)				-.014	.031	.648
Female				-.103	.032	.001
Health Problems				-.042	.036	.244
Asthma				-.079	.039	.040

SE: Standard Error; β: Coefficient; significant at p value < 0.05*

Participant Perception of Air Quality and Exercise Comparison to Web

As seen in Table 16 there was a significant difference (p=.033) in community organizations in Modesto comparted to web without controlling for demographic factors regarding exercising less if air quality was unhealthy. However, when controlling for other factors it was observed that there was no longer a significant difference for Modesto but there was for participants of public places in Merced (p<.001). Results from a regression analysis revealed that there are significant differences in participant perception of air quality and exercise based on age, ethnicity, gender, and being asthmatic. Participants over the age of 40 years were less likely to perceive it was unhealthy to be exercising if air quality was bad or unhealthy (p=.005). Females (p=.004) and asthmatics (p=.008) were also less likely to perceive that it was unhealthy to be exercising if air quality was bad or unhealthy. In contrary to Latinos who were more likely to perceive o perceive that it was unhealthy to be exercising if air quality was bad or unhealthy (p=005).

Table 16 Participant Perception of Air Quality and Exercise

	β	SE	p value	β	SE	p value
Intercept	1.297	.028	.000	1.355	.048	.000
Public Location	-.072	.040	.073	-.157	.041	.000
Community Organizations	-.085	.040	.033	-.061	.039	.121
Age				-.094	.033	.005
Latino				.170	.038	.000
Other Race				.236	.047	.000
Education (High School or below)				-.026	.032	.425
Female				-.097	.033	.004
Health Problems				-.024	.037	.527
Asthma				-.106	.040	.008

SE: Standard Error; β: Coefficient; significant at p value < 0.05*

Perceptions of Air Pollution Contribution and SJV Cars & Trucks

As shown in Table 17 when examining if there exist differences in perception of pollution contribution of cars and trucks among Merced, Modesto, and Web participants, it was found that there is a significant difference for community organization participants from Modesto (p<.001). This difference was observed prior to controlling for demographic factors and after the inclusion of such factors. Participants recruited from community organizations in Modesto were more likely to perceive SJV cars and trucks contribute to air pollution (p=.001).

Table 17 Participant Perception of Air Pollution Contribution and SJV Cars & Trucks

	β	SE	p value	β	SE	p value
Intercept	3.212	.054	.000	3.106	.096	.000
Public Location	.120	.076	.113	.128	.080	.112
Community Organizations	.277	.076	.000	.271	.078	.001
Age				.015	.066	.819
Latino				.043	.075	.569
Other Race				-.084	.093	.368
Education (High School or below)				.039	.064	.540
Female				.061	.066	.353
Health Problems				.107	.074	.148
Asthma				.018	.079	.822

SE: Standard Error; β: Coefficient; significant at p value < 0.05*

Perceptions of Air Pollution Contribution and Bay Area Pollution

Results presented in Table 18 demonstrate there are significant differences observed among participants of Merced (p<.001) and Modesto (p=.008) in comparison to Web in terms of perception of air pollution contribution from the Bay Area. There was also a significant difference (p=.005) in perception of pollution contribution from the Bay Area and being Latino. Latinos were less likely to perceive bay area pollution contributed to air pollution in the SJV.

Table 18 Participant Perception of Air Pollution Contribution from Bay Area

	β	SE	p value	β	SE	p value
Intercept	2.820	.063	.000	2.893	.112	.000
Public Location	.255	.090	.005	.338	.095	.000
Community Organizations	.244	.090	.007	.244	.092	.008
Age				-.033	.078	.672
Latino				-.252	.089	.005
Other Race				-.233	.109	.033
Education (High School or below)				.105	.076	.166
Female				.013	.077	.863
Health Problems				-.030	.087	.732
Asthma				.036	.093	.699

SE: Standard Error; β: Coefficient; significant at p value < 0.05*

Participant Perceptions of Air Pollution Contribution of Farms and Agriculture

When analyzing differences in Merced, Modesto, and Web in terms of perception of air pollution contribution from farms and agriculture a significant difference was observed in participants recruited from community organizations in Modesto (p=.005) and participants recruited from public places in Merced (p=.007). As shown in Table 19 after controlling for multiple factors a significant difference was observed for Modesto (p=.014) and Merced (p=.022). In addition participants who reported having health problems made worse by air quality were more likely to perceive that pollution from farms and agriculture contributes to pollution in the SJV (p=.014).

Table 19 Perception of Air Pollution Contribution of Farms and Agriculture

	β	SE	p value	β	SE	p value
Intercept	2.813	.064	.000	2.501	.113	.000
Public Location	.248	.091	.007	.220	.096	.022
Community Organizations	.256	.091	.005	.228	.092	.014
Age				.090	.079	.254
Latino				.102	.090	.256
Other Race				.145	.110	.189
Education (High School or below)				.132	.076	.083
Female				.119	.078	.129
Health Problems				.219	.088	.014
Asthma				.018	.094	.850

SE: Standard Error; β: Coefficient; significant at p value < 0.05*

Participant Perceptions of Air Pollution Contribution of Factories

As seen in Table 20 when examining differences in Merced, Modesto, and Web in terms of perception of air pollution contribution from factories a significant difference was observed in participants recruited from community organizations (p<.001) and public locations (p=.007). However, after controlling for other variables a significant difference was only observed for community organizations in Modesto (p=.001). In addition a statistically significant difference in perception contribution from factories based on age and gender. Elder participants were less likely (p<.001) to perceive pollution from factories contributed to pollution in the SJV. Contrary to elders, females were more likely (p=.006) to perceive pollution from factories contributed to air pollution in the SJV.

Table 20. Perception of Air Pollution Contribution from Factories

	β	SE	p value	β	SE	p value
Intercept	3.013	.056	.000	3.064	.096	.000
Public Location	.220	.081	.007	.104	.083	.207
Community Organizations	.305	.080	.000	.273	.080	.001
Age				-.362	.068	.000
Latino				.114	.077	.141
Other Race				.156	.095	.099
Education (High School or below)				-.067	.066	.309
Female				.184	.067	.006
Health Problems				.142	.076	.062
Asthma				-.070	.081	.386

SE: Standard Error; β: Coefficient; significant at p value < 0.05*

Participant Concern about Air Quality

As seen in Table 21 there were significant differences observed in recruitment from public locations in Merced when analyzing concerns about air quality. Without controlling for any other factors Merced (p=.006) demonstrated significant differences in comparison to Web. After controlling for demographic factors Merced remained significant (p=.011). Also, results from a regression analysis show no significant difference in older participants and concern about air quality (p=.054). However, Being Latino and having health problems were associated with being concerned about air quality. Latinos (p=.017) were more likely to have concerns about air quality as well as participants with health problems (p<.001).

Table 21 Participant's Concern and Air Quality

	β	SE	p value	β	SE	p value
Intercept	2.905	.072	.000	2.436	.118	.000
Public Location	.279	.100	.006	.252	.099	.011
Community Organizations	.196	.101	.052	.179	.096	.063
Age				.156	.081	.054
Latino				.223	.093	.017
Other Race				.065	.114	.566
Education (High School or below)				.068	.079	.387
Female				-.023	.081	.778
Health Problems				.767	.090	.000
Asthma				.130	.097	.179

SE: Standard Error; β: Coefficient; significant at p value < 0.05*

Participant Precaution If Air Quality was Unhealthy or Very Unhealthy

Results presented in Table 22 show that there exist a significant difference (p=.001) Merced compared to Web when examining if participants would stay inside if air quality was "unhealthy" or "very unhealthy" without controlling for demographic factors. Although after controlling for multiple factors a difference was observed in Merced (p=.001) and Modesto (p=.025). In addition result indicate females were more likely to stay inside if air quality was unhealthy or very unhealthy (p<.001). Participants with health problems made worse by air quality were also more likely to stay indoors if air quality was unhealthy or very unhealthy (p=.003).

Table 22 Precaution of Staying Indoors if AQ was Unhealthy or Very Unhealthy

	β	SE	p value	β	SE	p value
Intercept	3.274	.089	.000	2.855	.155	.000
Public Location	-.403	.125	.001	-.431	.129	.001
Community Organizations	-.160	.126	.204	-.284	.126	.025
Age				.021	.106	.843
Latino				.112	.122	.359
Other Race				.003	.149	.982
Education (High School or below)				-.055	.103	.592
Female				.509	.106	.000
Health Problems				.358	.119	.003
Asthma				.030	.128	.811

SE: Standard Error; β: Coefficient; significant at p value < 0.05*

Participants Required to Work Outdoors Regardless of Air Quality

Table 23 shows there exist a significant difference in participants recruited from public locations at Merced with (p=.032) and without (p=.003) controlling for demographic factors when analyzing whether their job required them to work outside regardless of air quality. Likewise there was a significant difference in Latinos, Females, and respondents with health problems. Latinos (p=.006) and participants with health problems (p=.002) were less likely to report having a job that required them to work outside regardless of air quality. In addition females were more likely to report to have a job that required them to work outside regardless of air quality (p<.001).

Table 23 Participants Working Outside Regardless of Air Quality

	β	SE	p value	β	SE	p value
Intercept	1.758	.029	.000	1.700	.049	.000
Public Location	-.122	.040	.003	-.089	.041	.032
Community Organizations	.054	.040	.179	.009	.040	.829
Age				-9.133E-5	.034	.998
Latino				-.107	.039	.006
Other Race				-.078	.048	.102
Education (High School or below)				.044	.033	.179
Female				.218	.034	.000
Health Problems				-.116	.038	.002
Asthma				.001	.041	.981

SE: Standard Error; β: Coefficient; significant at p value < 0.05*

Discussion

This study describes observed differences in the methods of recruitment when studying air quality perception in the San Joaquin Valley with and without controlling for demographic factors. Various questions were analyzed to identify how people perceive air quality and whether they take precautions to avoid air pollution exposure. Previous research has been conducted in this topic are however, it was done without controlling for different recruitment methods.

Results from this study indicate there are differences in perception of air quality among participants recruited from public locations in Merced in comparison to online participants. This difference was observed with and without controlling for multiple variables. In addition it was noted that Latinos were more likely to report better air quality. This may be due to the recruitment in public places in Merced surveying a higher percentage of Latinos

overall. Females tended to report worse air quality which aligns with similar findings reported by Brown et al, (2016) without controlling for recruitment method.

The results in this study also show that there exist a differences in terms of exercising and working outdoors between public places in Merced and community organizations in Modesto in comparison to Web. Females were less likely to exercise and work outdoors comparted to males and Latinos were more likely to work outside comparted to Non-Latinos. However, Latinos and participants with health problems were more likely to check air quality prior to working outdoors. Participants from community organizations in Modesto also demonstrated to be significantly different comparted to Web participants in terms of checking air quality prior to working outside, perception of air pollution, and high pollen counts contributing to unhealthy air quality.

The current study also found several differences in perception if air quality was said to be unhealthy among participants from Merced and Modesto in comparison to participants recruited online. Latinos were more likely to believe that when air quality was bad or unhealthy it was due to air pollution such as ozone, particulate matter, and carbon monoxide but less likely to be attributed to high pollen counts. In addition Latinos seemed to perceive that if it is difficult to breathe it was due to air quality being unhealthy. Surprisingly asthmatics and females in this study were less likely to perceive that when air quality was bad or unhealthy it was hard to breath and unhealthy to be exercising.

Furthermore this study found differences in perception of pollution contribution among its participants from Merced and Modesto in comparison to Web. Participants recruited from public places were more likely to have a higher perception that Bay area pollution and pollution from farms and agriculture contributed to air pollution in the San

Joaquin Valley. Similarly, participants in community organizations in Modesto were more likely to have a higher perception that pollution from factories, SJV cars and trucks, Bay Area pollution, farms and agriculture contributed to air pollution in the San Joaquin Valley. Previous research has examined participant's perceptions of contributors however it only took rank into account (Cisneros et al., 2017).

Conclusion

1. Participants recruited from public places in Merced differ in comparison to Web participants in terms of perception of air quality in the San Joaquin Valley
2. Latinos are more likely to perceive air quality to be better in the San Joaquin Valley.
3. Females are less likely to perceive air quality to be better in the San Joaquin Valley.
4. Latinos and participants who reported to have health problems were more likely to express concern regarding air quality.
5. Latinos are more likely to check air quality prior to exercising or working outdoors.
6. Females are less likely to work outdoors compared to males
7. Latinos were more likely to perceive that there is pollution such as Ozone, Particulate Matter, and Carbon Monoxide when air quality is bad or very unhealthy.
8. Individuals who reported to have health problems were more likely to perceive that farms and agriculture contributed to air pollution in the San Joaquin Valley.
9. Participants who tended to be older were less likely to perceive that factories contributed to air pollution in the San Joaquin Valley
10. Females and participants with health problems were more likely to stay indoors if air quality was unhealthy or very unhealthy.

Chapter 5 A pilot study exploring recruitment and retention of citizen science in attempt to assess air quality perceptions.

Abstract

Citizen Science also known as crowd science has been used worldwide by many organizations to encourage the involvement of community members in research. However, it has not been used to involve community members in reporting their perceptions of air quality. This pilot study discusses the steps taken to engage community members as citizen scientist and also examines the retention of participants by day of the week. Multiple challenges were encountered and future research is necessary to understand if citizen science is the best way to recruit participants to report their perceptions of air quality.

Introduction

Citizen science has the potential capacity to change public perception of the value of science to individuals in today's society. With ongoing advances in technology citizens not only can collect an impressive amount of data but also contribute to scientific research as scientist (Newman et al., 2012). Citizen science is a process where citizens and stakeholders are involved in science as researchers (Kruger and Shannon 2000) Citizen Science is also known as crowd science, community-based monitoring, civic science, volunteered monitoring or networked science. Citizen science has been used worldwide by many organizations to encourage the involvement of community members and activist to enhance the monitoring and management of natural resources (Keough and Blahna 2006).

It has been reported that since the 1990's there has been an increase in established monitoring programs that involve citizen science groups to participate in research in environmental and social contexts (Pretty, 2003). This increase in participation in citizen science has been attributed to an increase in public knowledge and concerns about anthropogenic impacts on health and ecosystems (Conrad and Daoust, 2008; Whitelaw et al., 2003). Although the goal of citizen science is to increase participation of the public in science to consider possibilities for increased involvement in decision-making around issues related to environmental risk and threat the process still faces some challenges today.

The need to have a comprehensive understanding of scientific integrity, including the study design and structure, is often challenged by a lack of, or inadequate and incomplete, data and monitoring initiatives by volunteers in non-profit organizations and government agencies (Aceves-Bueno et al., 2015; Cooper et al., 2007). However, citizen organizations have emerged all over the world to track trends and to work towards effective

and meaningful science. Previous citizen science studies have engaged data survey data collection in bird monitoring, amphibian monitoring, water quality monitoring, and air quality to promote public awareness and conservation (Bonney et al., 2014; Conrad and Daoust, 2008; Gany et al., 2017; Jollymore et al., 2017; Keough and Blahna, 2006). Although it is difficult to ascertain the impact to conservation that the collaboration between volunteers, amateur and professional scientist have, many improvements have been made to citizen science also referred to by some researchers as community-based monitoring (CBM) (Conrad and Daoust, 2008; Sullivan et al., 2009; Whitelaw et al., 2003).

This study aimed to understand perceptions of air quality by recruiting participants to become members of a citizen science group and also to examine the retention of citizen science participants by day of the week. Therefore this paper will also discuss steps taken to engage community members as citizen scientist and the challenges faced.

Methods and Materials

Paper based surveys were collected in public places in order to recruit community members to share their views and responses regarding their perception of current air quality in the region and sign up to become citizen scientists. Numerous tabling at efforts took place in Merced and Stanislaus County to be specific in Downtown Merced Street Fair, Merced Applegate Park, Merced Mall, Merced Mall car wash, and Agricultural Health Fairs in Ballico and Turlock.

Study Design

The design of the study consisted of having participants fill out an initial questionnaire used and validated in previous studies revolving public perception of air

quality. In addition participants were asked if they would be interested in participating in a secondary research project and becoming citizen scientists.

Participant Compensation

In order to compensate participants for their time, all participants who filled out the initial survey and those who decided to take part in the study as citizen scientists received a ten dollar gift card. Compensation gift cards were provided by the UC Merced Health Science Research Institute. Participants were able to select from various types of gift cards ranging from gas station gift cards to general merchandise retail stores. Participants were also informed that consistent participation as citizen scientist throughout the 5 weeks entered them in a one hundred fifty dollar gift card raffle.

Tabling Efforts

Tabling efforts initially began inside Merced Mall on July 9, 2017 however, there was a lack of interest among participants who approached rarely approached the tabling booth which resulted in 4 completed surveys. The Second tabling effort took place in Downtown Merced Street Fair where there were more surveys successfully completed by members of the community passing by who took the initiative to approach the tabling booth. The third tabling effort and took place in outside Merced Mall Carwash parking lot. The fourth tabling effort took place at Ag Worker Health Fair that took place at the Ballico Cressey Unified School District. The table below represents the number of surveys obtained for each part of the study.

Table 24 Participant Recruitment and Outcomes

Location	**Event**	**Initial Participants**	**Citizen Science Recruits**
Downtown Merced	Street fair	82	62
Merced, Applegate Park	P.D. Kiddie Land	9	5
Merced	Mall	4	4
Merced	Merced Mall Carwash	22	12
Ballico	Agricultural Fair	24	18
Turlock	Agricultural Fair	29	18
Total		170	119

Data collection

Data from the physical surveys was double checked and inputted by research assistants into Qualtrics a survey software tool used to design, send, and analyze, surveys online. In addition, a shorter version of the survey was created to be sent to citizen science recruits via email or text message depending on what the participant signed up for at the completion of the initial survey at the site.

A Google Voice account was created and tested prior to sending the SMS text message or email with a link regarding their participation of the citizen science study. Participants were assigned an ID and were notified via SMS text message/email a week prior to the initiation of the Citizen Science study with a message indicating the date that the study would begin (See Appendix). Prior to the beginning of the study there was a total of 118 participants who signed up to be part of the study. However, some participants decided to drop prior to the first week and only 105 participants remained.

Participants who had an ID number ranging from 1 to 36 were messaged Monday. Participants with ID numbers ranging from 37 to 70 were messaged Tuesday. Participants with ID numbers ranging from 70 to 103 were messaged Wednesday. Participants with ID

numbers ranging from 103 to 134 were messaged Thursday and participants with ID numbers ranging from 134 to 166 were messaged Friday.

To analyze the retention of citizen science participants by day of the week and the total number of participants was divided into 5 groups to represent 5 days of the week (Monday-Friday). Each group of participants that represented a certain day of the week consisted of an average of 21 participants. For instance Monday had a total of 23 participants, Tuesday a total of 21, Wednesday a total of 21, Thursday a total of 20 participants, and Friday a total of 20 participants. This was done in in order to also attempt to determine what day of the week yielded a better outcome for survey response rates.

Table 25 Survey Distribution and Days of the Week

Day of The Week				
Monday	Tuesday	Wednesday	Thursday	Friday
23	21	21	20	20

Survey Distribution Outcomes

The surveys were at 3:00 PM every afternoon for every day of the week. During Week 1 of the survey being distributed there was no participants who officially dropped the study for Monday, Tuesday, and Wednesday. However, there were two participants who officially replied and dropped from the study one on Thursday and one on Friday.

During Week 2 of the survey distribution, the same process was repeated and the surveys were sent at 3:00 PM at each assigned day to keep the consistency throughout the study. On Monday there were a total of 5 participants who did not officially drop but ignored or didn't reply to the message sent with the survey link. On Tuesday there were a total of 14 participants did not officially drop but ignored or didn't reply to the message

sent with the survey link. Wednesday there were a total of 11 participants that did not officially drop but ignored or didn't reply to the message sent with the survey link. Thursday there were a total of 14 participants that did not officially drop but ignored or didn't reply to the message sent with the survey link. Friday there were a total of 9 participants who did not officially drop but ignored or didn't reply to the message sent with the survey link. However, one participant did officially drop the study and reply with the request to "STOP" participating making it a total of 10 participants who did not complete the survey for Friday.

During Week 3 the same process was followed regarding the survey distribution time. Monday the same 5 participants who failed to respond or reply during Week 2 did not officially drop but ignored the message sent with the survey link. In addition one participant responded with "STOP" requesting to be dropped from the study making it a total of 6 non-responses. For Tuesday 13 of the same participants who failed to respond or reply during Week 2 did not complete the survey link. However, there was participant who did request to be dropped out of the stop by replying "STOP" to the message sent leaving us with the same amount 14 non-responses. Wednesday the same 11 participants from the previous week did not reply or respond to the message and did not complete the survey. However, in addition to the 11 there was one participant who did request to be dropped from the study and replied "STOP" to the message sent making it a total of 12 non-responses. Thursday same 14 participants who failed to respond or reply during Week 2 did not officially drop, but ignored the message sent with the survey link. Friday same 9 participants who failed to respond or reply during Week 2 did not officially drop but ignored the message sent with the survey link as well.

During Week 4 of the survey distribution, the same process was followed and the surveys were sent at 3:00 PM at each assigned day to keep the consistency throughout the study. Monday there was a total of 5 non-responses that consisted of the same participants who continuously ignored the messages sent and did not officially drop by replying "STOP" to be dropped out of the study. Tuesday 12 of the same participants who failed to respond or reply during Week 3 did not complete the survey link. However, there was and additional participant who did request to be dropped out of the stop by replying "STOP" to the message sent leaving us with 13 non-responses. Wednesday the same 11 participants from the previous week did not reply or respond to the message and did not complete the survey. Thursday of Week 4 had the same outcome as Thursday of Week 3, where the same 14 participants who failed to respond or reply during Week 2 did not officially drop, but ignored the message sent with the survey link. Friday of Week 4 had the same outcome as Friday of Week 3 and Week 2, where the same 9 participants who failed to respond or reply and did not officially drop, but ignored the message sent with the survey link as well.

During Week 5 the distribution remained the same. Monday there was a total of 5 non-responses that consisted of the same participants who continuously ignored the messages sent and did not officially drop by replying "STOP" to be dropped out of the study. Surprisingly for Monday it was the same 5 non-responders for Week 2 through Week 5. Tuesday 12 of the same participants who failed to respond or reply during Week 4 did not complete the survey link. Wednesday there were a total of 10 that included the same participants who did participate the previous week did not respond to the message with the survey link. However, one additional participant did reply "STOP" making it sum of 11 who failed to complete the survey Wednesday during Week 5. For Thursday of Week 5 a

similar outcome was obtained as Thursday of Week 4, where the 13 out of the 14 participants in Week 4 that failed to respond or reply and did not officially drop, but ignored the message sent with the survey link. One participant did reply "STOP" requesting to be dropped from the study and the count of individuals who did not complete the survey remained at 14. For Friday of Week 5 the outcome was similar to Friday's of previous weeks where 8 participants failed to respond or reply and only one additional participant officially dropped by replying "STOP" to the message sent with the survey link.

Throughout the study as the surveys were being distributed responses were inputted and recorded by research assistants and double checked by the primary investigator. Each weekly response was recorded and analyzed by day of the week throughout the five weeks.

Results and Discussion

Overall throughout the 5 weeks Week 1 had a total of 28 recorded responses with 26.7% response rate, Week 2 had a total of 17 recorded responses with a 16.5% response rate, Week 3 had a total of 7 recorded responses with a 6.9% response rate, Week 4 had a total of 15 recorded responses with a 15.2% response rate, and Week 5 had a total of 13 recorded responses with 13.4% response rate. As seen in the table below there was a noticeable decrease in responses as the study progressed into the later weeks. Week 3 had the least response rate out of the 5 week period. As observed in the table below the response rate decreased by half from the first week to the fifth week of the study.

Table 26 Responses and Percentages Over 5 Weeks

Response Totals by Week				
Week 1	Week 2	Week 3	Week 4	Week 5
28	17	7	15	13
26.7%	16.5%	6.9%	15.2%	13.4%

In regards to the days of the week Mondays and Thursdays seemed to have better response rates throughout the five weeks. Mondays accumulated a total of 22 responses with self-reported ID numbers corresponding to the survey. Tuesdays accumulated a total of 8 responses with self-reported ID numbers corresponding to the survey. Similar to Tuesday, Wednesday obtained a low response of 7 with self-reported ID numbers. Thursday accumulated 18 responses with self-reported ID numbers corresponding to the survey and Friday only yielded one response throughout the whole 5 weeks.

Table 27 Weekday Response Outcomes

Total Responses By Day of The Week				
Monday	Tuesday	Wednesday	Thursday	Friday
22	8	7	18	1

Effective Use of Technology

The use of Google Voice technology worked effectively in terms of messaging and sending out a text message with an attached survey qualtrics link. This was very effective in concerns to keeping the participants responses anonymous and protecting their identity. The messages were always delivered in a timely manner and never received a notification

"Message Delivery Failed". In addition providing the qualtrics survey link via text message provided immediate data regarding the participant's responses and made the data collection more expedient. Overall the use of google voice technology in citizen science has not been implemented and would beneficial if used in future studies.

Technological Challenges

The use of technology was beneficial to the survey distribution, however, there were a few issues on the end of the participant. Towards the end of the study a few participants responded to the message sent stating they had phones with lack of internet services that were provided by the government agencies. These cellphones which were provided to them at no cost did not allow them to surf the web and participants were not aware of the issues at the time of signing up to be part of the study. This potentially affected the response rates of the surveys and overall outcome of the study, but it is difficult to say. Perhaps if it was known prior that some of the participants did not have internet access via their cellphones, the primary investigators could have provided an accommodation for participants continue to take part in the study. In addition to the lack of responses, the incentives provided at the beginning of the study might not have been enough to motivate the participants to be engaged throughout the five weeks.

Potential Improvements

If further funding were provided perhaps the incentives provided to the participants could have been increased to increase motivation and participation throughout the five weeks. Furthermore, the response rate could have been improved if there were follow-up calls to participants who did not respond or ignored the messages sent. This could have possibly encouraged the participants to make an effort to be involved in the study as citizen

scientists. In addition a better explanation of the commitment during the study would have been beneficial to avoid citizen science recruits that volunteered to be part of the study just to receive the incentive. This would possibly have reiterated the importance of the study and why we needed dedicated participants to be involved in our research.

Previous Citizen Science Research

Previous studies have shown that many citizen science programs have been implemented in various types of context. The programs implemented tend to fall under data collections and monitoring mainly for research and others have a more community based approach either for natural resource management or educational outcomes (Conrad and Hilchey, 2011). For instance previous research utilizing the citizen science approach involved mainly nature watch programs. Those studies with community based monitoring initiatives varied from monitored water quality and air quality to bird, amphibians, plants, fish, and worms monitoring. Although there are pros and cons of all these types of citizen science/community based monitoring, one of the main outcomes was an increase in engagement with local issues among citizens of local communities (Whitelaw et al. 2003;Pollock and Whitelaw 2005).

Limitations and Strengths

A limitation of this study was that messages with links to the survey were not sent weekends. It is unpredictable what the outcomes would have been if the survey had also been distributed during the weekends. Perhaps there would have been more survey responses since individuals tend to have more free time during weekends or perhaps there would have been less responses depending on the individual's occupation. The survey did

not have a question pertaining to the individual's occupation therefore those assumptions can't be made.

A strength of this study is it is that it is the first study conducted in the United States that has attempted to involve community members as citizen scientist to participate in assessing awareness and perceptions of air quality during an extended period of time. In addition it is the first study that aims to understand what recruitment methods are effective for this type of research in regions of the San Joaquin Valley.

Conclusion

Although there exist limited citizen science research in water and air quality, there has not been any studies conducted that attempt to understand perception of air quality using citizen science. Given that the aim of the study was to attempt to understand perceptions of air quality, future studies should train participants on how to check air quality using real time monitored data available to the public and further explore perceptions. This could possibly encourage participants to take part and engage in scientific investigations of air quality perception and awareness in communities that are affected by poor air quality.

In addition, involving community members in this type of research can promote increased involvement in decision-making around issues related to environmental exposures. Although there are challenges in recruitment and retention of participants more research is necessary in order to fully comprehend what can drive a successful citizen science project in research that focuses on community based environmental monitoring including air pollution. Perhaps recruiting participants from Asthma Coalitions or

community events that promote health awareness may yield more dedicated volunteers to take part in becoming citizen scientist than individuals recruited in public places.

Chapter 6 Examining perceived air quality, extent of concern, and perceived air pollution contributors in Merced and Stanislaus County.

Introduction

The San Joaquin Valley (SJV) consist of 8 counties and it is known for having the most polluted air in the United States (Billings et al., 2016) . However, very few research has focused on ambient air quality perception amongst smaller communities in the San Joaquin Valley (SJV) (Brown et al., 2016; Cisneros et al., 2017; Veloz et al., 2020), and there is need to understand air pollution perception of individuals who live near a major freeway or highway in these communities. There are only a few studies that have focused on focused on this population since most studies have focused on emissions and proximity to industry (Howel et al., 2003). This population is perhaps at greater risk of exposure to air pollution due to a lack of resources and there exist a need to understand their perception in order to develop effective educational campaigns to increase awareness and self-protective behaviors (Forsberg et al., 1997; Pattinson et al., 2015).

A survey was conducted in summer of 2017 with Merced and Stanislaus County residents to understand perceptions of air quality and behaviors related to air pollution in these communities. The survey was developed through the Health Services Research Institute at University of California Merced. The purpose of this study was to assess how residents in this region perceive air quality and to see if living near a major freeway or highway impacted their perception. Similar to previous research, this survey assessed the extent of worry regarding air quality and how often individuals check air quality prior to working or exercising outside. In this study, it was hypothesized that individuals who live

near a freeway or major highway have a different perception of air pollution and the negative impacts it may pose on their health.

Materials and Methods

Sample

For this study, residents (n=176) of Merced and Stanislaus county were surveyed via, health fairs, community events, and other public locations. Surveys during community health fairs were conducted by members of the research team that visited local schools and churches where these health fairs took place and administered the survey to consenting participants. The survey was also administered in outdoor markets, local malls, street fairs, and public parks that vulnerable populations were likely to access. The survey was conducted from July 2017 to August 2017 and its data was collected for the 176 participants. In order to have enough participants in this study, the multiple R^2 method suggested by Green 1991 for determining the sample size was applied. According to multiple R^2 method:

$$N \geq 50 + 8(k) \qquad \text{Eq. 1}$$

Where, N is the sample size and K stands for the number of independent variables. Based on this, 98 participants are adequate for conducting this study.

There was a total of 24 questions utilized including demographic information: gender, age, education level, and zip-code. Institutional Review Board approval was obtained from University of California at Merced prior to initiation of the study. Ethics approval was obtained from the University of California, Merced Institutional Review Board (UCM14-0033).

Survey Method

Out of the 40 questions 19 questions of the survey were utilized because of their relation to assessing perceptions about air quality.

1. "In the past month, what was the air quality like in your city today?" (1=Very unhealthy, 2= Unhealthy, 3= Unhealthy for sensitive groups, 4=Moderately healthy, and 5= Good air quality.
2. "In the past month, what was the air quality like in other areas of the San Joaquin Valley?" (1=Very unhealthy, 2= Unhealthy, 3= Unhealthy for sensitive groups, 4=Moderately healthy, and 5= Good air quality)
3. "When you hear that the air quality in your area is "***bad" or "very unhealthy"***, do you think it means that it is hard to breath?" (1=Yes, 2= No)
4. "When you hear that the air quality in your area is "***bad" or "very unhealthy"***, do you think it means that it is unhealthy to be exercising?" (1=Yes, 2= No)
5. "In a normal year, what is the air quality like in **your city** in Summer?" (1=Very unhealthy, 2= Unhealthy, 3= Unhealthy for sensitive groups, 4=Moderately healthy, and 5= Good air quality)
6. "In a normal year, what is the air quality like in **your city** in Fall ?" (1=Very unhealthy, 2= Unhealthy, 3= Unhealthy for sensitive groups, 4=Moderately healthy, and 5= Good air quality)
7. "In a normal year, what is the air quality like in **your city** in Winter?" (1=Very unhealthy, 2= Unhealthy, 3= Unhealthy for sensitive groups, 4=Moderately healthy, and 5= Good air quality)

8. “In a normal year, what is the air quality like in **your city** in Spring?” (1=Very unhealthy, 2= Unhealthy, 3= Unhealthy for sensitive groups, 4=Moderately healthy, and 5= Good air quality)
9. “In the past month, on days when you went outside to exercise or work, how often did you check the air quality for that day?” (1=Never, 2= Almost never, 3= Sometimes, 4= Often, 5= Every time)
10. “In the past month, how many days did you work outside for more than 30 minutes on average?” (1= Never, 2= 1 or 2 times per week, 3= 3 or 4 times per week, 4=5 or 6 times per week, 5= Everyday)
11. “To what extent are you worried about air quality in the San Joaquin Valley?” (1= Not at all, 2= A little worried, 3= Worried, 4= Very worried, 5= Extremely Worried)
12. “How serious of a problem is each of the following (a) car accidents, (b) unemployment, (c) crimes, (d) air pollution, (e), (f) infectious disease, (g) forest fires, (h)obesity”? (1= Not at all serious, 2= A little Serious, 3= Somewhat serious , 4= and Serious, 5= Very Serious)
13. How much do each of the following contribute to air pollution in the San Joaquin Valley? (a) cars and trucks in the SJV, (b) pollution from the Bay Area, (c) farms and agriculture, (d) factories, (e) forest fires, (f) wind blowing dust, (g) construction, (h) blowers and mowers (i) oil drilling/fracking (j) high pollen counts, and (k) other?” (1= Not at all, 2= A little bit, 3= Somewhat , 4= A lot, 5= Don’t know)
14. What do you do to decide whether the air quality is good (a) ask family or friends, (b) look at the sky , (c) check to see if I can see the mountains, (d) check the newspaper, (e) check reports on the TV, (f) check reports on the radio, (g) look online

or the internet, (h) use a phone application (i) check the smell of the air (j) look at the air quality flags in front of buildings, (k) Check the Real-Time-Air Advisory Network, and (l) other sources?" (1= Never use this, 2= Once in a while, 3= Sometimes, 4= Often, 5= Always use this)

15. "If you knew that the air quality was unhealthy or very unhealthy, how likely is it that you would (a) exercise less, (b) run fewer errands, (c) work outside less, (d) stay inside with window and doors closed, and (e) take other precautions?" (1= Never, 2= Almost Never, 3= Sometimes, 4= Fairly Often, 5=Very Often)
16. What do you think the chances are of having problems with your health because of the air quality in this region? (1= Almost Zero, 2= Very Small, 3= Small, 4= Moderate, 5= High, 6= Very High, 7= Almost Certain)
17. If you continue to live in this region, what do you think the chances are that the air quality will lead to health problems at some time in your life? (1= Almost Zero, 2= Very Small, 3= Small, 4= Moderate, 5= High, 6= Very High, 7= Almost Certain)
18. "Have you ever been told by a doctor that you have asthma?" (1=Yes, 2= No)
19. Do you live within 1 mile of a freeway or highway? (1=Yes, 2= No)

Analysis

Descriptive Statistics were used to describe participant's demographics and responses to the survey. A multivariable regression was used to determine factors associated with the participant's awareness of ambient air quality in the SJV. Statistical analysis was performed utilizing SPSS 20 and statistical significance was considered at the $p<0.05$ level.

Results

Sample

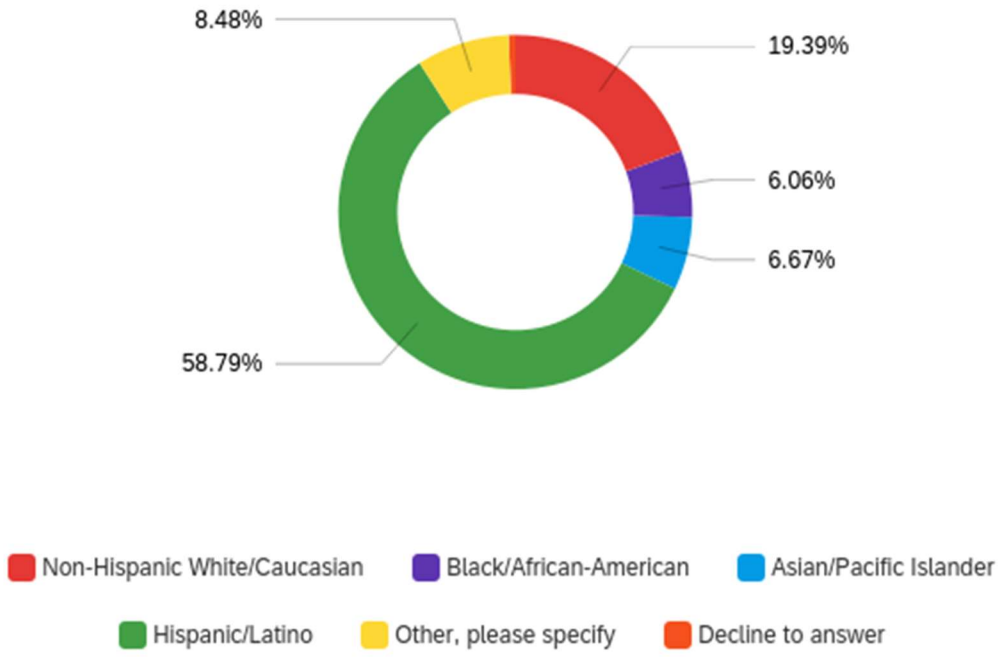
Data was collected from 176 individuals during community events. The demographics of the study of the population are shown in Table 28 and illustrated in Fig.4.

Table 28 Demographics of Participants

	Participant (%)
Gender	
Male	65 (36.9)
Female	97 (55.1)
Missing	14 (8.0)
Age	
≤40	112 (70.0)
>40	48 (30.0)
Education	
≤ High School	91 (56.5)
≥ College	70 (43.5)
Race	
White	32 (19.4)
Latino	97 (58.8)
Black	10 (6.1)
Asian	11 (6.7)
Other Races	15 (9.0)

The average age of the entire sample was 38.37 years, which is similar to the average age of the population of the San Joaquin Valley (40 years old). The entire sample had 36.9% self-identified males, 55.1% self-identified females, and 8.0% declined to answer. In the sample, 56.5% of participants had less than or equal to a high school education and 43.5% had greater than or equal to college education. Overall, the sample consisted of 58.8% self-identified Latinos, 19.4% self-identified White, 6.1% self-identified Black, 6.7% self-identified Asian, and 9.0% other races.

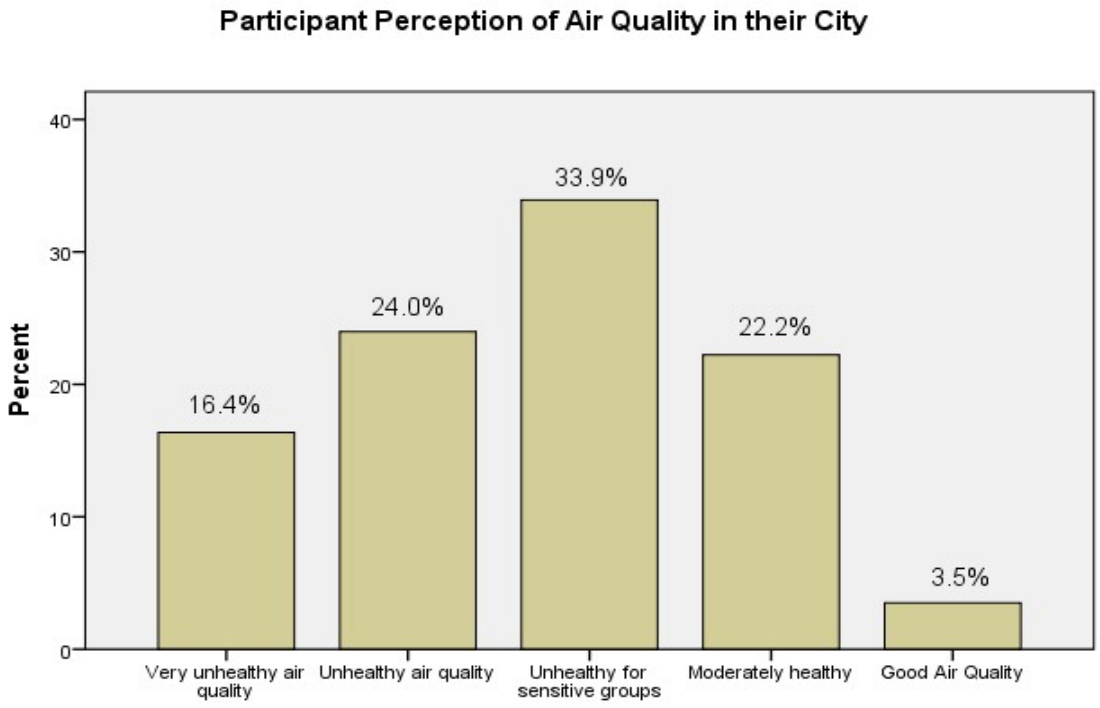
Figure 4


8.48%
19.39%
6.06%
6.67%
58.79%
Non-Hispanic White/Caucasian
Black/African-American
Asian/Pacific Islander
Hispanic/Latino
Other, please specify
Decline to answer

Participant Perception of Air Quality in their City

Fig. 5. Shows that 16.4% of respondents perceive air quality to be Very unhealthy, 24.0% reported airy quality to be Unhealthy, 33.9% Unhealthy for sensitive groups, 22.2% responded Moderate, and 3.5% perceived air quality to be good.

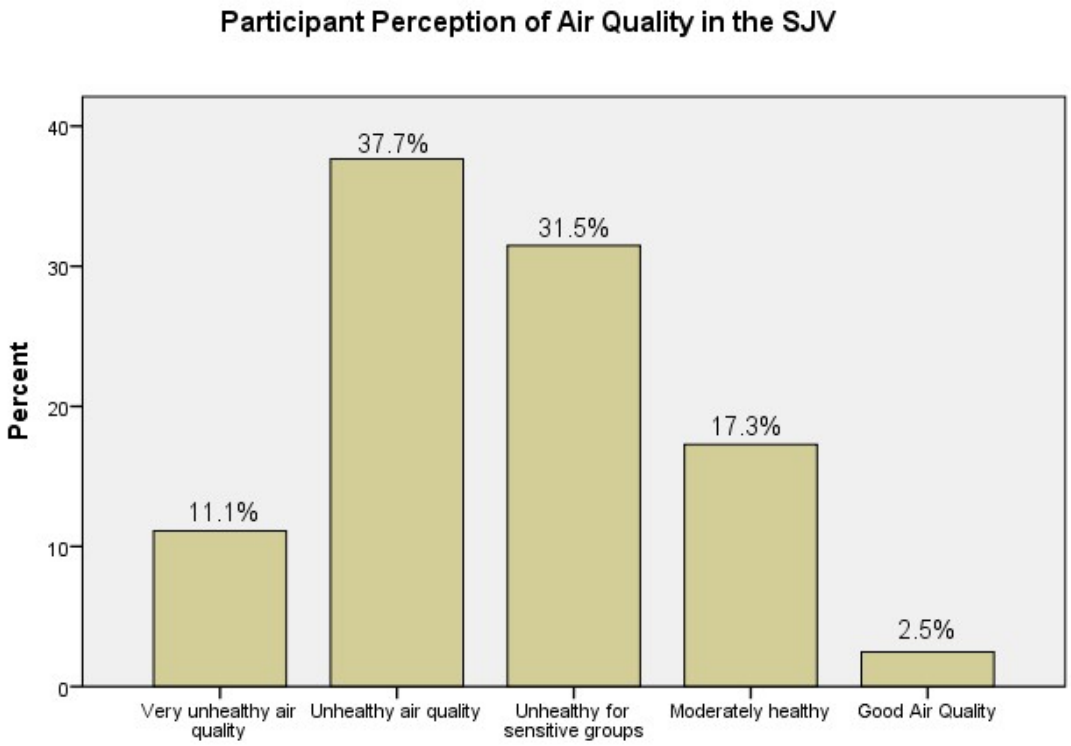
Figure 5



Participant Perception of Air Quality in the SJV

Fig. 6. Shows that 11.1% of respondents perceive air quality to be Very unhealthy, 37.7% reported airy quality to be Unhealthy, 31.5% Unhealthy for sensitive groups, 17.3% responded Moderate, and 2.5% perceived air quality to be good.

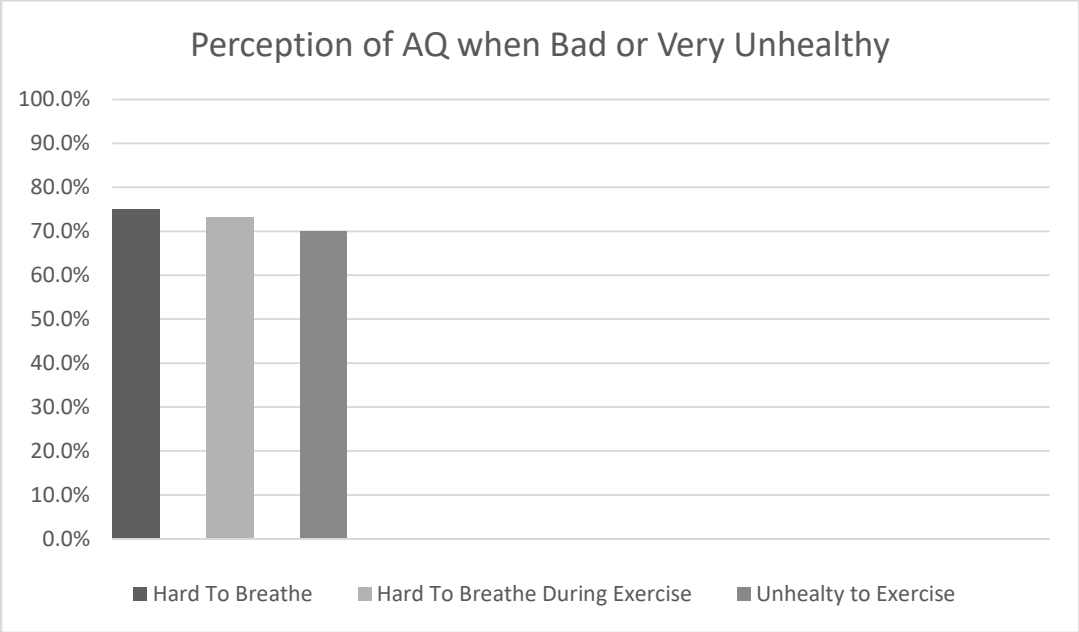
Figure 6



Participant Perception of Air Quality when Bad or Very Unhealthy

Fig.7. Shows air quality perception where 74.9% of participants believe when air quality in their area is bad or very unhealthy it is hard to breathe, 73.1% hard to breath during exercise, and 70.0% think it is unhealthy to be exercising.

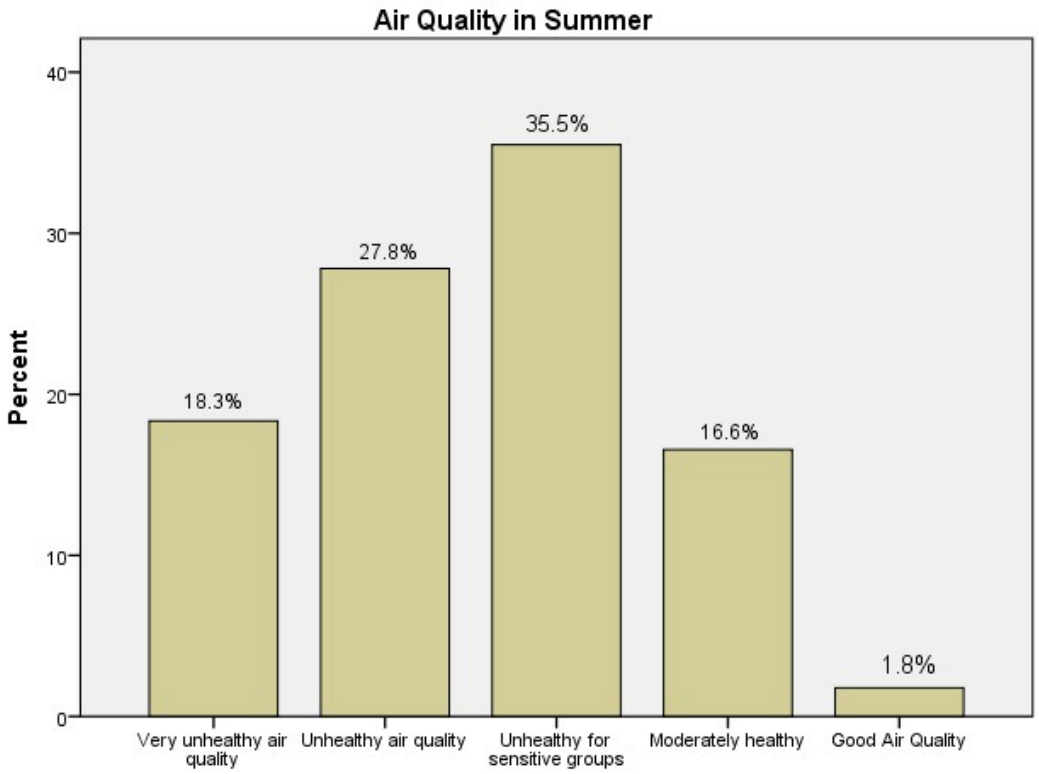
Figure 7



Participant Perception of Air Quality in Summer

Fig 8. Shows that 18.3% of participants believe air quality during summer is very unhealthy air, 27.8% unhealthy, 35.5% unhealthy for sensitive groups, 16.6% moderately healthy, and only 1.8% think it is good.

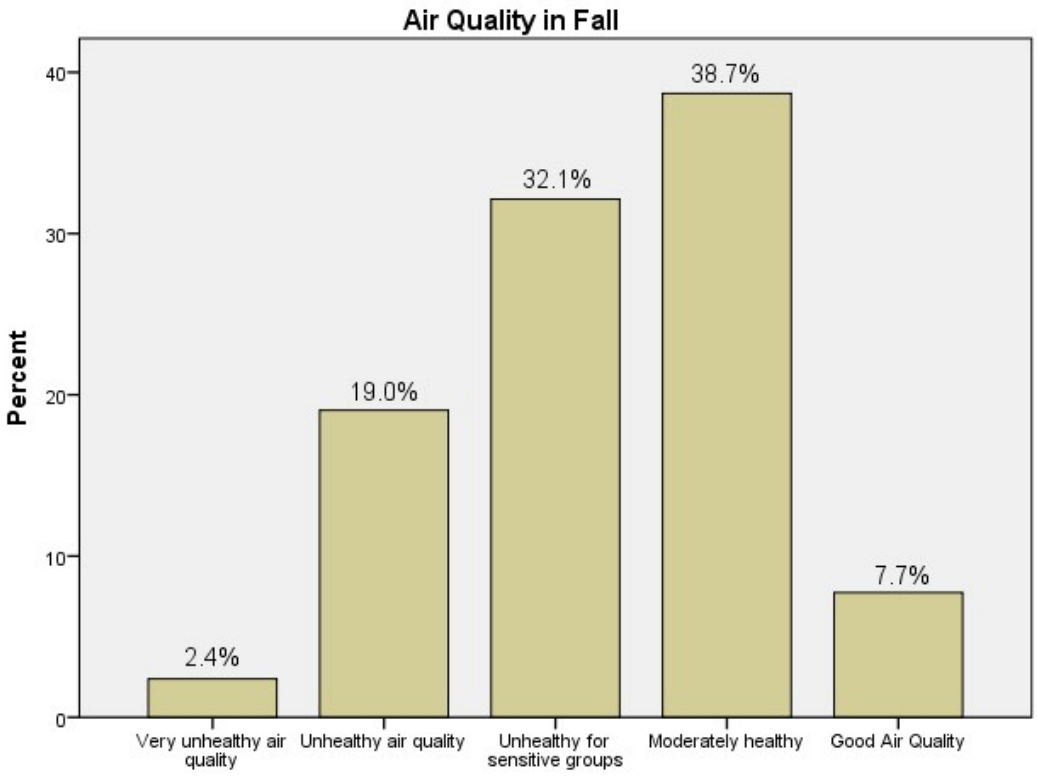
Figure 8



Participant Perception of Air Quality in Fall

Fig 9. Shows that 2.4% of participants believe air quality during fall is very unhealthy air, 19.0% unhealthy, 32.1% unhealthy for sensitive groups, 38.7% moderately healthy, and 7.7% think it is good.

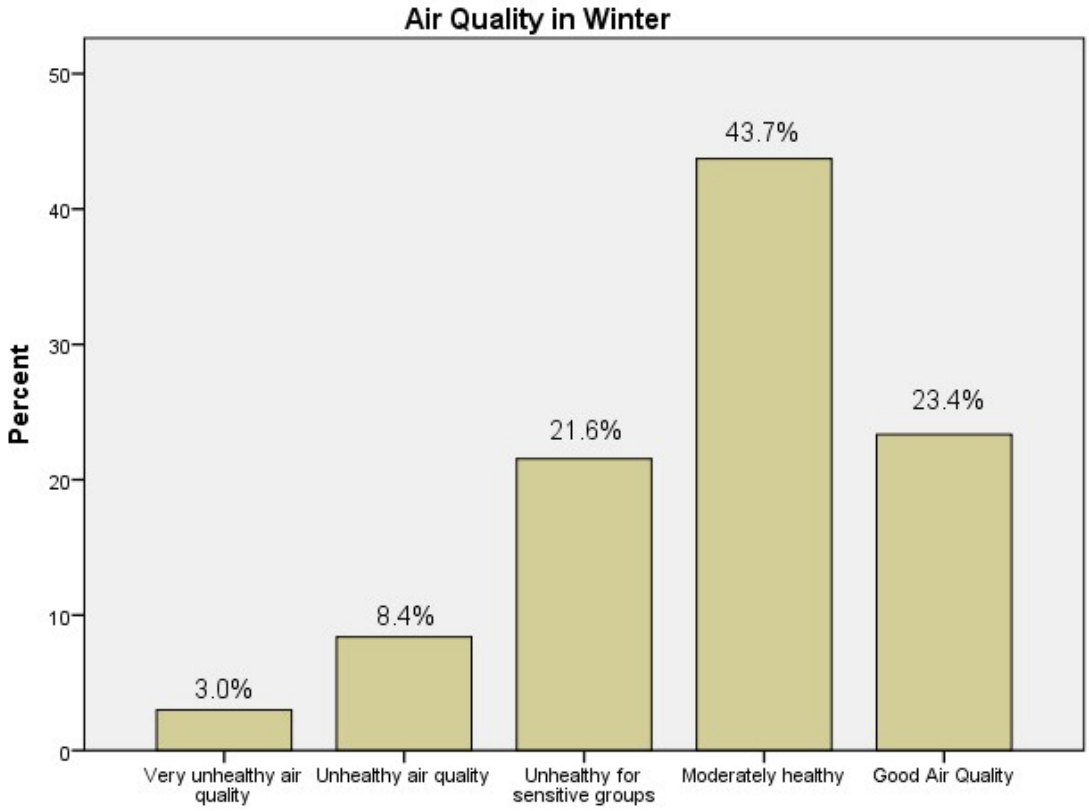
Figure 9



Participant Perception of Air Quality in Winter

Fig 10. Shows that 3.0% of participants believe air quality during winter is very unhealthy air, 8.4% unhealthy, 21.6% unhealthy for sensitive groups, 43.7% moderately healthy, and 23.4% think it is good.

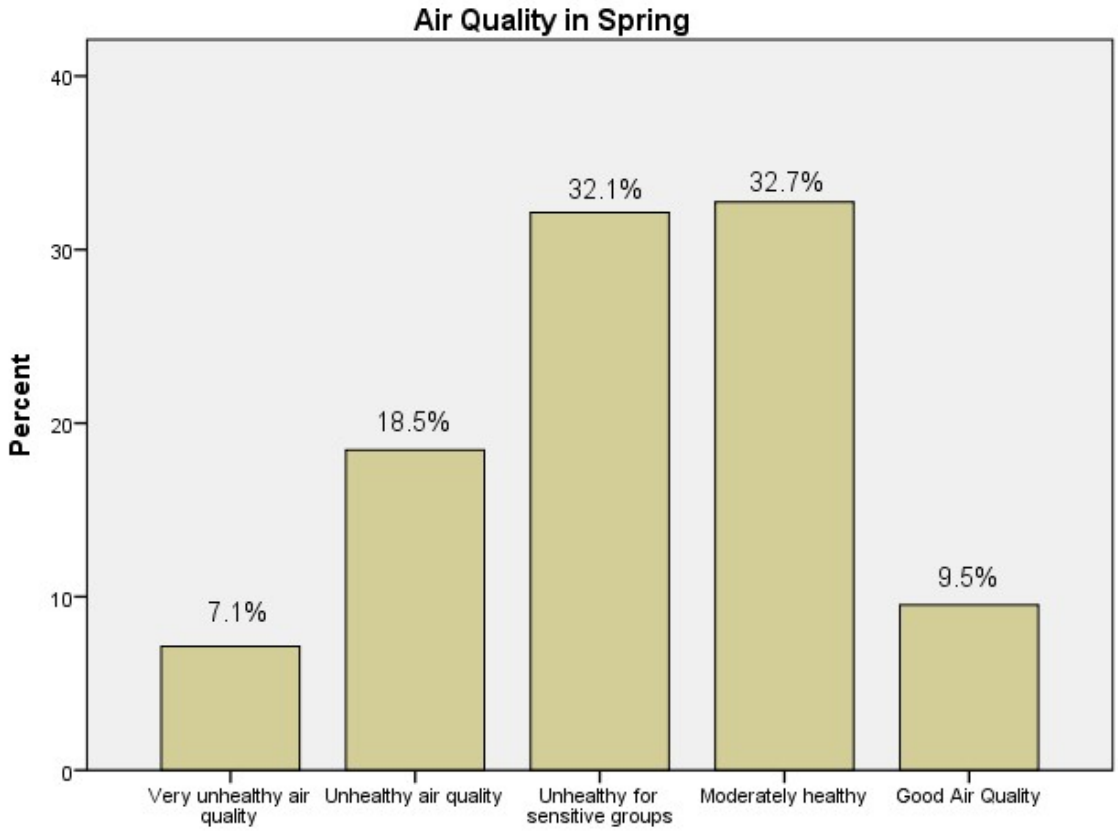
Figure 10



Participant Perception of Air Quality in Spring

Fig 11. Shows that 7.1% of participants believe air quality during spring is very unhealthy air, 18.5% unhealthy, 32.1% unhealthy for sensitive groups, 32.7% moderately healthy, and 9.5% think it is good.

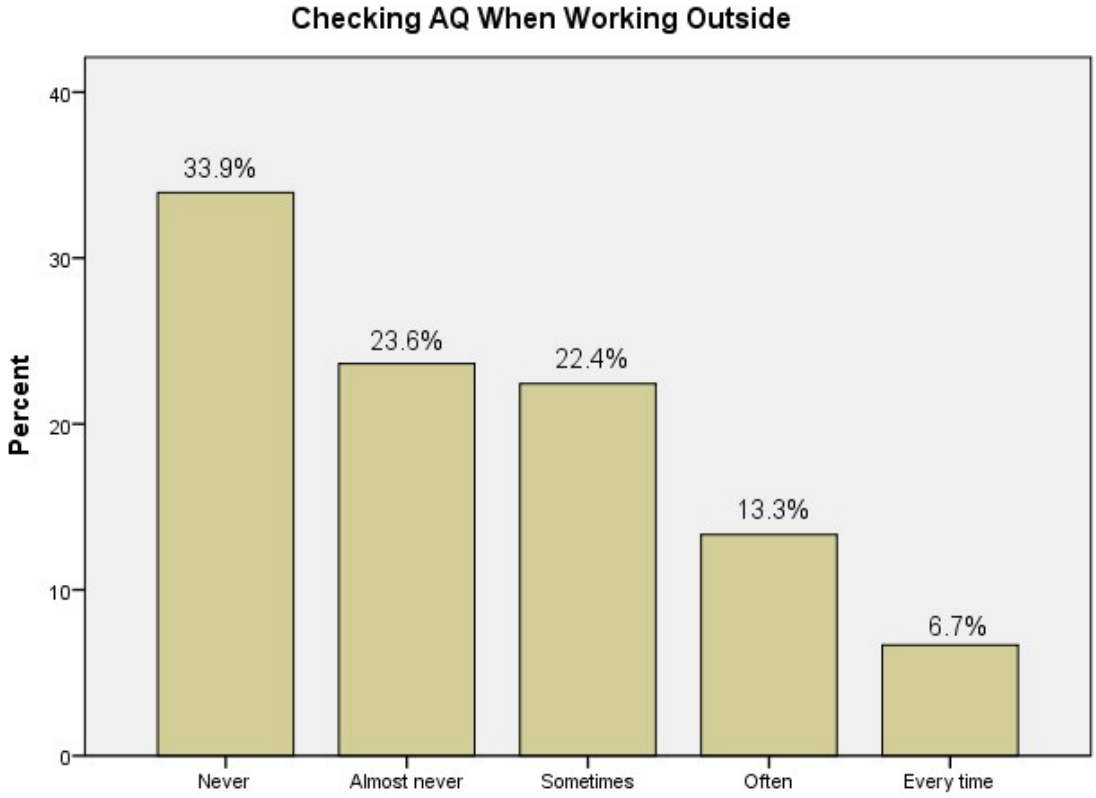
Figure 11



Checking Air Quality When Working Outside

Fig. 12 Shows that 33.9% of respondents stated to Never check air quality when they exercise or work outside, 23.6% responded Almost Never, 22.4% responded Sometimes, 13.3% Often, and 6.7% answered Every time.

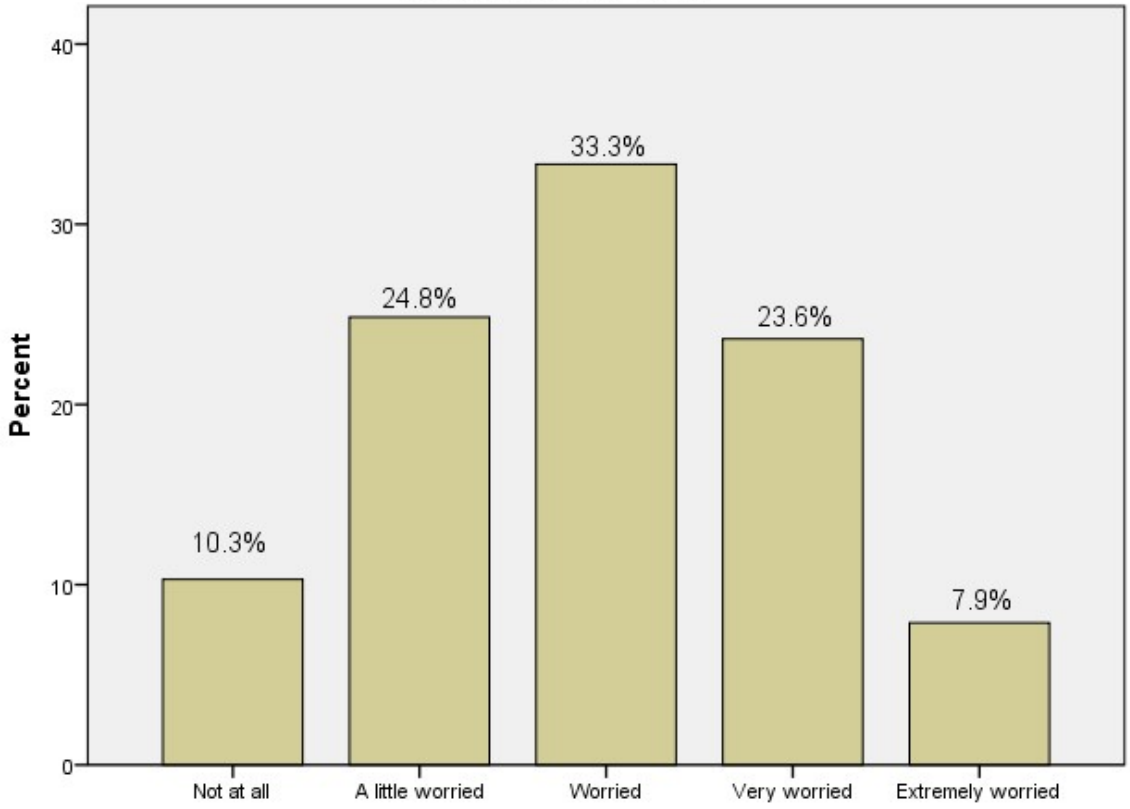
Figure 12



Extent of Worry of Air Quality

Fig. 13 Shows that 10.3% respondents answered Not at all to be worried of air quality, 24.8% answered a Little Worried, 33.3% Worried, 23.6% Very Worried, and 7.9% responded to be Extremely Worried.

Figure 13
Extent of Worry of AQ



Asthmatics Precautions of Checking Air Quality

Table 29 below shows that 45 individuals out of our sample suffer from asthma. From our sample 35.6% of individuals who suffer from asthma stated they Never check air quality prior to exercising or working outdoors, 17.8% responded Almost Never, 22.2% Sometimes, 22.2% Often, and 0.6% answered Every time. Regarding the non-asthmatics in our study 33.6% reported to Never check air quality when working or exercising outdoors, 25.2%, answered Almost Never, 22.7% responded Sometimes, 10.1% Often, and 8.4% responded Every time. Results from a Pearson's Chi Square Test analysis is presented in Table 29 demonstrates there is no significant association between checking air quality

when working and exercising outside and participants who suffer from asthma in our sample.

Table 29 How Often Participant Checks AQ and Asthma

Check Air Quality	Do you have Asthma?		
	Yes (%)	No (%)	Total (%)
Never	16 (9.7)	40 (24.4)	56 (34.1)
Almost Never	8 (4.9)	30 (18.3)	38 (23.2)
Sometimes	10(6.1)	27 (16.5)	37 (22.6)
Often	10 (6.1)	12 (7.3)	22 (13.4)
Every time	1 (0.6)	10 (6.1)	11 (6.7)
Total	45 (27.4)	119 (72.6)	164 (100%)
	Value	**df**	***p* value**
Pearson Chi-Square	6.264[a]	4	0.180
Likelihood Ratio	6.406	4	0.171
Linear-by-Linear Association	.023	1	0.880

df: degree of freedom; significant at p value < 0.05

Factors Associated with Extent of Worry

Table 30 below shows results from a multivariate linear regression analysis of factors associated with participant's extent of worry about air quality in the San Joaquin Valley. There is no significant association between extent of worry about air quality in the SJV and Education, Age, being Latino, Gender, having Asthma, or living near a freeway. However, results from a multivariate linear regression analysis presented in Table 31 shows there is a significant association (p=.023) with participants checking air quality and extent of worry.

Table 30 Extent of Worry and Air Quality in San Joaquin Valley (SJV)

	β	SE	p value
Intercept	2.716	0.260	0.000
Education (High School or below)	0.063	0.189	0.741
Age	0.062	0.214	0.772
Latino	0.048	0.194	0.806
Female	0.108	0.187	0.566
Asthma	0.190	0.218	0.384
Freeway	0.155	0.189	0.412

SE: Standard Error; β: Coefficient; significant at p value < 0.05

Table 31 How Often People Check AQ When Exercise and Work Outside

	β	SE	p value
Intercept	1.881	.377	0.000
Education (High School or below)	-0.151	0.168	0.467
Age	0.401	0.191	0.088
Latino	-0.222	0.170	0.298
Female	-0.148	0.165	0.472
Asthma	-0.021	0.190	0.930
Freeway	0.016	.207	0.940
Extent of worry about AQ SJV	0.209	0.091	0.023

SE: Standard Error; β: Coefficient; significant at p value < 0.05

Participant Precautions When AQ is Unhealthy or Very Unhealthy

Table 32 shows that 23.6% of respondents will fairly often and very often exercise less if air quality was unhealthy or very unhealthy. Approximately one third (32.3%) of the participants responded that they would work outside less if air quality was unhealthy or very unhealthy. More than one half (54.6%) of respondents stated that they would stay inside if air quality was unhealthy or very unhealthy. About 42.7% of the participants

responded that they would fairly often and very often take other precautions if air quality was unhealthy or very unhealthy.

Table 32 Participant Precautions If Air Quality Was Unhealthy or Very Unhealthy

	Exercise Less	Run Fewer Errands	Work Outside Less	Stay Inside	Take Other Precautions
Never	17.6%	21.2%	18.3%	12.3%	14.0%
Almost Never	17.0%	23.6%	17.1%	8.0%	6.7%
Sometimes	41.8%	32.1%	32.3%	25.2%	36.6%
Fairly Often	12.7%	15.2%	20.1%	24.5%	22.6%
Very Often	10.9%	7.9%	12.2%	30.1%	20.1%

Factors Associated with Perception of Air Quality in the SJV

As presented in Table 33, our results from multivariate linear regression analysis demonstrates that education is significantly associated (p=.003) with participant's air quality perception. Participants in our sample with some college or university education perceive air quality to be worse or more harmful compared to those with a High School education or below.

Table 33 Perceived Air Quality in San Joaquin Valley

	β	SE	p value
Intercept	3.114	0.235	0.000
Education	-0.362	0.168	0.033
Age	0.082	0.191	0.668
Latino	-0.244	0.170	0.154
Female	-0.037	0.165	0.824
Asthma	-0.203	0.190	0.287
Freeway	-0.293	0.165	0.078

SE: Standard Error; B: Coefficient; significant at p value < 0.05

Participants' Rank of Contributors of Air Pollution

Individuals' responses about sources of air pollution is shown in Table 34. Most of the participants ranked cars and trucks as the main contributing source of air pollution. Forest Fires were ranked as number 2 source of air pollution. Factories were ranked as number 3 source of pollution. Wind blowing dust was ranked number 4. Participants ranked farms and agriculture as number 5 source of pollution and pollution from the Bay Area as number 6. Construction was ranked number 7 source of pollution. Blowers and lawnmowers were ranked as number 8 source of pollution.

Table 34 Participants' perception of contributors to air pollution in the San Joaquin Valley

	Mean	SD	Rank
SJV-Cars & Trucks	3.25	0.852	1
Forest Fires	3.16	0.803	2
Factories	3.14	0.881	3
Wind blowing dust	3.09	1.058	4
Farms and agriculture	2.93	0.909	5
Pollution from Bay Area	2.82	1.037	6
Construction	2.60	0.961	7
Blowers and lawn mowers	2.40	0.935	8

SD: Standard Deviation

Perceived Contribution Sources of Air Pollution in the SJV

As seen in results from Table 35, there were various differences in perception of contributing sources of air pollution. The older people in our sample were less likely to perceive that air pollution from the Bay Area ($p=.033$), factories ($p<.001$), and forest fires ($p=.023$) contributed to air pollution in the SJV. Latinos were more likely ($p=.031$) to perceive air pollution from factories contributed to air pollution in the SJV. A difference in perception in females was also observed, where females were more likely to perceive

that wind blowing dust (p=.045) and construction (p=.002) contributed to air pollution in the SJV. Also participants who stated to live near a freeway or highway more likely (p=.024) perceived forest fires to be a contributing source of pollution.

Table 35 Perceived sources of air pollution in the San Joaquin Valley

	SJV-Cars & Trucks		Bay Area Pollution		Farms & Agriculture		Factories		Forest Fires		Wind Blowing Dust		Construction		Blowers & lawn Mowers	
	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
Intercept	3.019	0.187	2.954	0.226	2.867	0.24	2.972	0.204	3.068	0.25	2.819	0.228	2.198	0.22	1.928	0.226
Education	0.211	0.134	0.17	0.162	0.204	0.177	0.03	0.148	-0.087	0.178	*0.32	0.166	*0.416	0.16	0.194	0.165
Age	0.087	0.153	*-0.394	0.183	-0.18	0.203	*-0.69	0.17	*-0.482	0.209	0.045	0.198	-0.221	0.18	0.124	0.193
Latino	0.131	0.138	-0.34	0.169	-0.232	0.18	*0.335	0.154	-0.026	0.187	-0.146	0.17	-0.032	0.165	0.153	0.172
Female	0.016	0.136	0.038	0.163	0.208	0.175	0.205	0.149	0.262	0.177	*0.336	0.166	*0.515	0.159	0.293	0.165
Asthma	-0.277	0.161	-0.142	0.198	0.076	0.208	-0.109	0.177	-0.228	0.217	0.06	0.2	-0.089	0.187	-0.166	0.195
Freeway	0.237	0.135	0.174	0.163	0.06	0.178	0.221	0.149	*0.410	0.179	0.123	0.165	0.102	0.16	0.267	0.166

* Significant at $p < 0.05$, ß= Coefficient; SE = Standard Errors.

Perceived Impact of Air Pollution On Own Health

As shown in Table 36 there were no significant associations between education, age, being Latino, or Female on perceptions of air pollution impacting the participants own health. However, the results suggest that living near a freeway or highway impacts perception when controlling for education, age, and gender. Participants who stated to live within one mile of a highway or freeway were more likely (p=.025) to perceive that their health would be impacted if they continued living in that region.

Table 36 Perceived Impact of Air Quality on Own Health

	β	SE	p value
Intercept	3.659	0.338	0.000
Education (High School or below)	0.282	0.245	0.251
Age	-0.335	0.277	0.229
Latino	-0.005	0.252	0.984
Female	0.122	0.243	0.616
Asthma	0.535	0.282	0.060
Freeway	0.555	0.245	0.025

SE: Standard Error; B: Coefficient; significant at p value < 0.05

Asthmatics and Perception of AQ on Own Health

In addition Table 37 shows results from a multivariate linear regression analysis of factors associated with participant's perception on impact of air pollution on their own health sometime in their life, if they continue living in the region they are living. Asthmatics were more likely to perceive that their health would be impacted sometime in their life, if they continued living in the region where they were living (p=.042).

Table 37 Perceived Impact of Air Pollution On Own Health Cont.

	β	SE	p value
Intercept	3.785	.347	.000
Education	.323	.253	.204
Age	-.430	.285	.133
Latino	.021	.259	.934
Female	.174	.250	.489
Asthma	.593	.290	.042
Freeway	.525	.252	.039

SE: Standard Error; B: Coefficient; significant at p value < 0.05

Sources of Information about Air Pollution

Results of the how participants obtain sources of information about air quality and pollution are shown in Table 38 where 45.8% of individuals in our sample stated to never ask family or friends to obtain air quality information. 45.3% of respondents stated to look at the sky, 45.8% check air quality reports on television, and 30.7% check radio reports to obtain air quality information. 40.6% assess air quality by whether they can see the mountains clearly and 70.8% respondents use their sense of smell to check air quality. Over half (54.4%) of respondents stated to look online or use the internet to get information about air quality and 48.0% reported using a phone application. Less than a third (30.9%) of respondents check air quality flags and only 13.7% use the Real-Time Air Advisory Network (RAAN) to obtain their air quality information. In addition there were differences in obtaining air quality information shown in Table 39. Females were less likely to check if they could see the mountains (p=.004) or smell the air (p=.002). The older population was more likely to check television (p=.001) and radio reports (p=.034), but less likely to use the internet (p=.004). Latinos were more likely to check television (TV) reports (p=.049) than non-Latinos. Participants who stated to live within one mile proximity to the

freeway or highway were more likely to check the newspaper (p=.038) and television (TV) reports (p=.047) than those who stated to not live near freeways or major highways.

Table 38 Sources of Information about Air Pollution

	Ask Family Friends	Look at Sky	Can See Mountains Clearly	Check Newspaper	Check TV Reports	Check Radio Reports	Internet or Online	Phone App	Smell of Air	Check Air Quality Flags	Check RAAN
Never	45.80%	15.50%	19.40%	42.30%	20.80%	32.70%	13.20%	29.30%	26.90%	43.50%	64.90%
Once in a While	24.70%	13.70%	12.10%	13.10%	12.50%	15.80%	10.20%	9.00%	16.80%	12.50%	12.50%
Sometimes	21.70%	25.60%	27.90%	20.20%	20.80%	18.80%	22.20%	13.80%	26.30%	13.10%	8.90%
Often	5.40%	28.60%	23.00%	15.50%	23.80%	20.00%	28.70%	23.40%	15.00%	19.00%	6.00%
Always	2.40%	16.70%	17.60%	8.90%	22.00%	12.70%	25.70%	24.60%	15.00%	11.90%	7.70%

Table 39 Sources of Information about Air Pollution

	Ask Family		Look at Sky		Can See Mountains		Check Newspaper		Check TV Reports		Check Radio Reports		Internet		Phone		Smell of Air		Check Air Quality Flags		Check RAAN	
	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE	ß	SE
Intercept	1.646	0.248	3.065	0.302	3.39	0.306	1.945	0.313	2.32	0.316	2.006	0.328	3.516	0.296	3.512	0.361	2.956	0.311	2.119	0.347	1.587	0.291
Education	-0.125	0.18	-0.032	0.219	0.003	0.223	*-0.487	0.228	-0.009	0.23	-0.078	0.24	-0.064	0.216	-0.409	0.263	0.343	0.227	-0.012	0.252	0.034	0.212
Age	0.361	0.203	0.154	0.247	0.141	0.25	0.082	0.257	*0.893	0.258	*0.585	0.273	*-0.714	0.243	*-0.568	0.296	0.015	0.256	-0.373	0.284	-0.007	0.238
Latino	0.179	0.184	0.155	0.225	0.279	0.23	*0.454	0.234	*0.468	0.236	0.276	0.246	0.338	0.222	0.25	0.27	-0.092	0.233	0.109	0.259	-0.005	0.218
Female	0.122	0.179	-0.187	0.218	*-0.656	0.223	0.029	0.226	0.19	0.228	0.409	0.238	-0.015	0.214	-0.243	0.261	*-0.698	0.225	0.451	0.25	0.099	0.21
Asthma	-0.029	0.207	-0.237	0.253	*-0.503	0.259	0.085	0.263	-0.291	0.264	0.025	0.276	0.242	0.249	-0.006	0.302	-0.114	0.262	0.202	0.29	-0.056	0.244
Freeway	0.044	0.179	0.272	0.218	-0.06	0.222	*0.474	0.227	*0.457	0.228	0.159	0.241	-0.229	0.215	-0.24	0.261	0.228	0.225	0.089	0.251	0.25	0.211

*Significant at $p < 0.05$, ß= Coefficient; SE = Standard Errors.

Discussion

There has been various studies conducted on the perceptions of air quality in cities worldwide (Guo et al., 2016; Johnson, 2002; Oltra & Sala, 2014; Xu et al., 2015). Many factors have been correlated with perceptions of air quality, including sociodemographic and contextual factors (i. e. urban and rural settings and proximity to industry) (Brody et al., 2004; Howel et al., 2003; Oltra & Sala, 2014). However, very few research has investigated the perception of air quality in the San Joaquin Valley which is known to be impacted by increased levels of air pollution (Meng et al., 2010).

Given that previous research conducted in the SJV has focused on the general population as whole (Cisneros et al., 2017), this study aimed to understand the perception of air quality among the residents of Merced and Stanislaus County, a subpopulation of the SJV. The results indicate that only a small percentage (3.5%) of the participants perceived the air quality in their city to be good. An increased amount (16.4%) of the participants perceived the air quality to be very unhealthy. Notably over half of the respondents 57.9% reported the air quality to be Unhealthy and Unhealthy for sensitive groups in their city. When analyzing perception of air quality in the SJV in our sample, 69.2% of participants reported air quality to be Unhealthy and Unhealthy for sensitive groups These findings suggest there is a 15.2 percentage point increase from previous findings where 54% of SJV participants reported the air quality to be Unhealthy and Unhealthy for sensitive groups (Cisneros et al., 2017).

In addition perception of air quality was analyzed for summer, fall, winter, and spring (Fig.5-8). Overall participants perceive air quality in their city to be worse in summer, where 46.1% reported air quality as very unhealthy or unhealthy, fall 21.4%,

winter 11.4%, and spring 25.6%. Similar findings were noted by Brown et al. (2016) where 35% of SJV participants perceived air quality to be worse in summer months.

Although nearly three quarters of (74.9%) of participants perceive it is hard to breathe when air quality is bad or very unhealthy, still one third (33.9%) stated to never check air quality prior to exercising or working outside. However, approximately one third (32.3%) of the participants responded that they would work outside less if air quality was unhealthy or very unhealthy. In addition, 54.6% of the participants in our study reported they would often and fairly often stay inside if air quality was unhealthy or very unhealthy.

When analyzing the extent of worry of air quality in the San Joaquin Valley amongst our sample we observed that a third (33.3%) worries about air quality. Considering that previous research examined extent of worry of air quality in the San Joaquin Valley among individuals who work outdoors (Veloz et al., 2020), our study aimed to understand if age, gender, education, air proximity to freeway, or ethnicity were associated to worry or perception of air quality in our population; and, no significant association was found. On the contrary, previous research has found evidence that females tend to perceive air quality as being more harmful or slightly poorer than men (Brown et al., 2016; Howel et al., 2003).On the other hand, our study found that there exist a significant association between checking air quality and extent of worry among our population.

Our findings concur with early air pollution perception research which suggest that individuals are well aware and express worry for air pollution issues (Bickerstaff & Walker, 2001; Degroot et al., 1966b), In addition, the findings in this work coincide with previous research conducted by Cisneros et al, (2017) where participants perceptions of

contributors to air pollution sources differ from actual contribution sources. Although a few similarities and differences were observed on how participants ranked contribution sources. Previously participants had ranked forest fires as number 6 contributor to air pollution and our sample ranked forest fires as number 2 contributor. However, participants perception of cars and trucks in the SJV as the number 1 contributor, factories as number 3, and farms and agriculture as number 5 contributor remained the same in both studies (Cisneros et al., 2017).

The results of this study also suggest that perceptions of air quality are associated with education level and are in line with findings of previous studies (Kim et al., 2012). However, in terms of examining perceptions of impact of air quality on own health there were no statistically significant differences based on education, age, ethnicity, or gender similar findings to Brown et al, (2016). Yet, our study took a different approach and looked at whether living near a major freeway or highway played a role in perception of impact of air quality on health. Interestingly, it was found that participants who live within a mile of a freeway or highway are more likely to perceive that their health will be impacted if they continued living in that region. Not only were participants who live near close proximity to a freeway or highway perceive their health to be impacted, but also asthmatics were more likely to perceive that their health would be impacted sometime in their life if they continued living where they were living.

Previous research examined how the general population in the SJV obtains their sources of information about air quality (Brown et al., 2016). Still, our study aimed to examine how Merced and Stanislaus residents obtain their sources of air quality information to analyze if there exist any differences or similarities to previous findings on

SJV residents. Interestingly, there were a few differences in obtaining air quality information. Females were less likely to check if they could see the mountains or smell the air. Another difference to previous research in the SJV was observed in this study, where the older population was more likely to check the radio and television (TV), but less likely to use the internet. Also Latinos in this study were more likely to check TV reports than non-Latinos.

Limitations

There are several limitations to this study as well as improvements that could be made if further analysis were to be conducted. This study only focused on Merced and Stanislaus County with majority (75.6%) of the sample residing in Merced County. In addition this study relies on self-reported survey data. Also there could have been bias perceptions reported in Merced County due to the Detwiler fire taking place in Mariposa County (37 mile north east of Merced) around the same time the surveys were conducted.

Conclusion

This study aimed to assess the attitudes and perceptions about air quality of individuals who reside in Merced and Stanislaus County and found slight differences in and similarities in perception to previous studies in the SJV. In addition this study also aimed to examine air quality perception of participants who stated to live within one mile of a highway or freeway.

1. Comparable to previous research in the conducted with SJV residents, we found that checking air quality is driven by participant's extent of worry.
2. Participants continue to rank cars and trucks in the SJV to be the number one contributor to air pollution.

3. Participants perceive Air Quality to be worse or more unhealthy during summer.
4. One third (33.3%) of participants stated to be worried about Air Quality.
5. No association was found between checking air quality when working outside and asthmatics.
6. Females are more likely to perceive that wind blowing dust and construction contribute to air pollution.
7. Participants who reside near freeways or highways are more likely to perceive that forest fires contribute to air pollution.
8. Participants who live near a freeway or highway were more likely believe their health would be impacted if they continued living in the region they were living.
9. Asthmatics were more likely to believe their health would be impacted if they continued living where they were living.
10. Latinos and participants who resided near freeway or highway were more likely to check newspapers and television reports for air quality information.

Chapter 6.0 Conclusion and recommendations.

Research has shown poor air quality impacts human health in many ways. However, the field of perception of air quality can help inform us on how the public perceives air quality and what precautionary measures individuals take if they see it as a potential health risk. Similar research has been conducted in pesticide perception which has led to the understanding of how most individuals perceive pesticides and multiple campaigns have been launched to protect those more at risk. This proves that there a connection between pesticide perception and health. Hence if individuals perceive pesticide to impact their health and take precautionary measures to protect themselves, comparable research can be conducted to focus on air quality perception among vulnerable populations.

Although concerns for air pollution have existed for decades, there has been very few research conducted to study perception or air pollutants. Air pollution is prevalent in many areas of California which makes it an ideal region to further conduct air quality perception research. Thus this dissertation examined perceptions of air quality in the San Joaquin Valley and described differences in perceptions in various populations. In addition recruitment methods were described and analyzed to examine strengths and challenges in this type of research.

The first study (published) in Chapter 3 aimed to assess the attitudes and perceptions about air quality of individuals who work outdoors in the San Joaquin Valley, California. The findings indicated that asthmatics check air quality more when working and exercising outside compared to non-asthmatics. In addition, it was found that checking air quality is driven by participant's extent of worry. When studying outdoor workers it

was determined, age, gender, education, air pollution exposure levels, or being Latino were not significantly associated with perceptions of air quality. Overall our results indicate further research needs to continue to monitor and study air quality perceptions and take into account the participant's occupation to further understand perceptions of individuals who work outdoors.

The second study in Chapter 4 recruited individuals from public places in Merced, community organizations in Modesto and compared them to individuals recruited online/Web. Overall several differences were observed in the three methods of recruitment in terms of perception of air quality with and without controlling for various factors. When looking at differences in perception Latinos compared to Non-Latinos several key findings were observed. Latinos were more likely to perceive air quality to be better in the San Joaquin Valley and more likely to express concern regarding air quality. In addition Latinos were more likely to check air quality prior to exercising or working outdoors. When analyzing differences in gender, females were more likely to stay indoors if air quality was unhealthy or very unhealthy and less likely to perceive air quality to be good in the San Joaquin Valley. Other key findings were participants with health problems were more likely to stay indoors if air quality was unhealthy and more likely to perceive that farms and agriculture contributed to air pollution in the San Joaquin Valley.

The third study in Chapter 5 intended to engage community members as citizen scientist and also examine the retention of participants by day of the week. Although this study initially aimed to assess air quality perception of the recruited participants who volunteered to be citizen scientist, the study did not turn out as planned. There was low retention of participants and many never engaged in reporting their perceptions via the link

sent to their smartphones. Therefore this study provided a description of the study design and discussed the process of engagement on what improvements could be made if this study were to be repeated in the future. However, when looking at retention it was observed that Week 1 had the most responses while Mondays and Thursdays were found to be the days that yielded most responses overall.

The fourth study in Chapter 6 assessed the attitudes and perceptions about air quality of individuals who reside in Merced and Stanislaus County. There were a few differences and similarities were observed compared to previous findings in the San Joaquin Valley since results indicate that checking air quality is driven by the participant's extent of worry. Results also confirmed that participants continue to rank cars and trucks in the SJV to be the number one contributor to air pollution. However, there was not a significant association between checking air quality when working outside and asthmatics in this population.

The San Joaquin Valley has poor air quality that affects its diverse population. With high rates of asthma and other respiratory illnesses. More research should be devoted to examining air quality perceptions of individuals in the region. Air quality is a concern for SJV residents and by continuing to monitor air quality and understanding perceptions, communication strategies can be developed and implemented to target at risk populations. There is a need to continue studying perceptions of air quality in the SJV and surrounding areas with an improved and better developed survey accessible to more participants in different seasons of the year.

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