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Perceptions about air quality of individuals who work outdoors in the San Joaquin Valley, California

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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.

1. 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 μm or smaller (Schwartz and Pepper, 2009). Particulate matter specifically 2.5 μm 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 and 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.

2. Materials and methods

2.1. 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 three approaches used to survey residents of the

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SJV in partnership with a Community Advisory Group who shared research interest in perceptions of air quality. Surveys during community meetings were conducted by members of the research team that visited community organizations (e.g., Boys Club, etc.) during regularly scheduled meetings and administered the survey to consenting participants. The survey was also administered in public locations such as outdoor markets, local malls, and public parks that vulnerable populations were likely to access. In order to access participants from across the broader SJV, a survey was distributed to members of an on-line survey panel recruited by a survey company. The survey was restricted to residents of the SJV (via the zip code of their home address). 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. In order to have enough participants in this study, multiple R^2 method suggested by Green, 1991 for determining the sample size were applied. According to multiple R^2 method:

$$N \geq 50 + 8(k) \quad (1)$$

Where, N is the sample size and K stands for the number of independent variables. Based on this, 82 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. The occupation of the participants was not included in the questionnaire. Institutional Review Board approval was obtained from University of California at Merced prior to initiation of the study.

2.2. 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).

2.3. 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 $PM_{2\cdot5}$ 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 $\mu g/m^3$.

2.4. 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.

3. Results

3.1. Sample

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

3.2. 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.

3.3. 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

Table 1
Demographic of the 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)

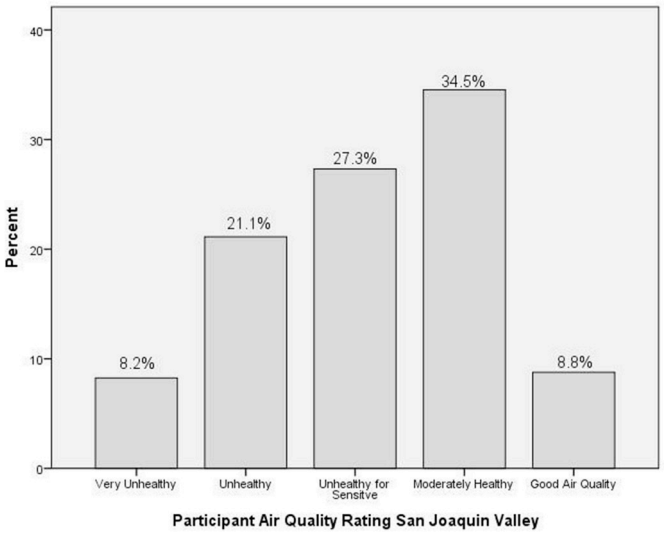

Fig. 1. Percentage of responses recorded for air quality rating.

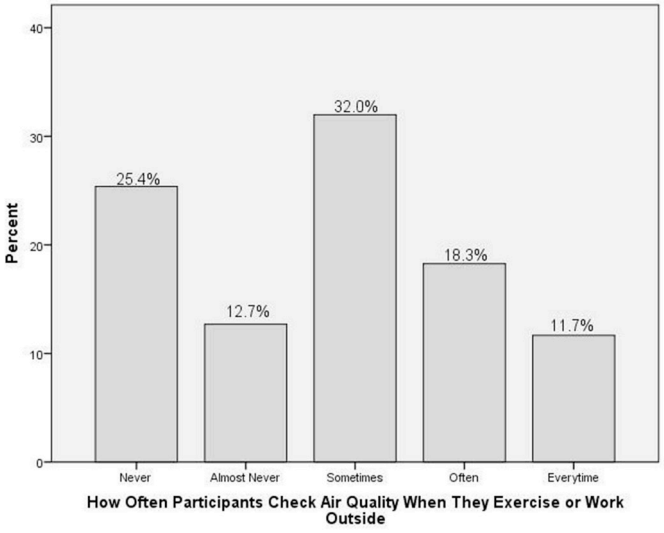

Fig. 2. Percentage of responses recorded of how often participants check air quality when exercising or working outside.

Never, 32% responded Sometimes, 18.3% Often, and 11.7% answered Every time.

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.

Table 2
How often participant checks AQ and asthma.

Check Air Quality	Do you have Asthma?		Total (%)
	Yes (%)	No (%)	
Never	8 (4.1)	42 (21.4)	50 (25.5)
Almost Never	6 (3.1)	18 (9.2)	24 (12.2)
Sometimes	11 (5.6)	52 (26.5)	63 (32.1)
Often	18 (9.20	18 (9.2)	36 (18.4)
Every time	11 (5.6)	12 (6.1)	23 (11.7)
Total	54 (27.6)	142 (72.4)	196 (100%)
	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.

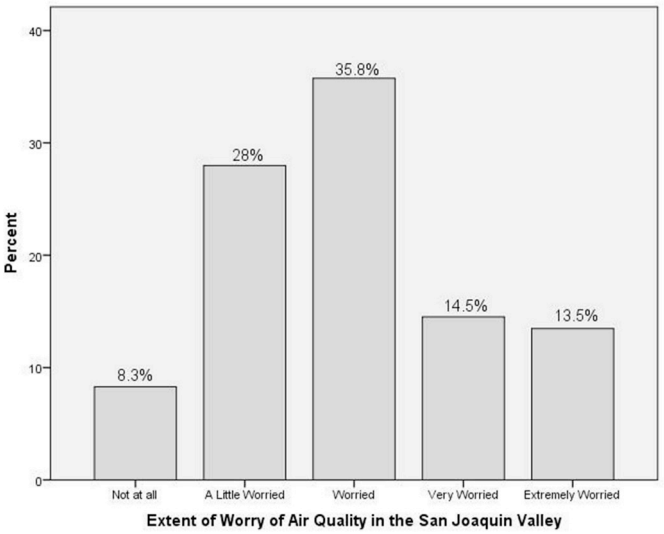

Fig. 3. Percentage of responses recorded for extent of worry for air quality rating.

3.4. 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.

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.

3.5. 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. About 38% of respondents stated that they would stay inside if air quality was

Table 3
Extent of worried about air quality in San joaquin valley (SJV)β.

	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.

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.

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%

unhealthy or very unhealthy. About 33.7% of the participants responded that they are unlikely and very unlikely to take other precautions if air quality was unhealthy or very unhealthy.

3.6. 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.

3.7. 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.

3.8. Sources of information about air pollution

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

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.

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

SD: Standard Deviation.

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% 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). The difference between asthmatic and non-asthmatic individuals in regard to the source of information is not statistically significant. A two sample *t*-test method was applied and the results are shown in Table 8.

4. 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 and 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 and 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. 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 outside workers with asthma tend to be more precautious

Table 8
Sources of information about air pollution.

Asthma	Look Outside or at the Sky	Can See Mountains Clearly	Check Reports on TV	Check Reports on Radio	Look Online or Internet	Use Phone App	Check Smell of Air	Check Air Quality Flags	Check Air Quality Index
Yes	79.2%	71.2%	83.3%	60.4%	63%	50%	77.4%	39.6%	50.9%
No	78%	79.1%	80.9%	56.1%	59%	52.1%	68.8%	43.9%	45.7%
p-value	0.85	0.24	0.69	0.58	0.61	0.79	0.23	0.58	0.51

in comparison to outside workers who are non-asthmatic.

When analyzing the 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 and Walker, 2001; Degroot et al., 1966), 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 aligned 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.

4.1. Limitations

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. This is the first study in the United States that focuses on air quality perception of individuals who work outside.

5. 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 the regression analysis suggested that, 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.

CRediT author statement

David Veloz: Methodology, Software, Data curation, Writing – original draft, Investigation, Formal analysis. Paul Brown: Writing – Review & Editing, Validation. Mariaelena Gonzalez: Writing – review & editing. Hamed Gharibi: Software, Validation. Ricardo Cisneros: Conceptualization, Validation, Writing – review & editing, Supervision, Project administration.

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