Effect of Air Quality Alerts on Intended Behavior Change

Megan Peaslee(✉), Josh Nelson, Ellen Reed, and Lukas Sexton

University of Washington, Seattle, WA, USA
{mpeaslee, jn42, ellencr, lukas2}@uw.edu

Abstract. In 2015, Air pollution caused 8.8 million premature deaths worldwide and has reduced life expectancy by 2.9 years [6]. The increasing impact of wildfires and other emissions will lead to more days and locations with poor air quality. This research references and builds on previous work on how visual anchoring within the Air Quality Index (AQI) Alerts rating affects intended behavior change to ultimately protect against adverse health outcomes. Additionally, this study examines how past behavior and personality may impact future behaviors. Results show a significant effect of past behavior change specifically on intent to wear a face mask ($t = -2.069$, $p = 0.0413$). However, no effect of behavioral change was found between the two AQI Alert visuals presented as well as no effect between dominant or passive personality. As air quality continues to decrease worldwide the importance of understanding AQI Alerts on resulting behavior change becomes more critical.

Keywords: Human factors & health · Air quality alert · Behavior change

1 Introduction

In 2015, Air pollution caused 8.8 million premature deaths worldwide and has reduced life expectancy by 2.9 years [6]. Today, wildfires in the United States burn on average 78 days longer and cover twice the area compared to 50 years ago [12]. The increasing impact of wildfires and other emissions will lead to more days and locations with poor air quality. In 2018, the California wildfires caused California cities to rank as the world's most polluted cities over places in India and China [1]. Researchers have studied the effect of Air Quality Index (AQI) Alerts on actions, primarily focusing on avoiding the outdoors and physical activity [8, 10]. Building on the aforementioned research and other similar studies, this research looks to understand how visual anchoring within the AQI rating affects intended behavior change (i.e. staying home, changing location to be inside, reducing time outside, wearing a face mask) to ultimately protect against adverse health outcomes. Additionally, this study examines how past behavior and personality may impact future health-conscious behaviors.

1.1 Preventative Actions

To date, there have been studies on protective actions people can take from poor air quality. For example, Laumbach et al. [5], compiled the methods to protect against

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poor air quality. These protective behaviors include staying indoors, cleaning indoor air, reducing physical activity outside, reducing exposure to microenvironments of high air pollution (highways, etc.), and using face masks (air respirators). All protect to a degree, but none of which guarantee full protection from poor air quality [5].

1.2 Changing Behavior with AQI Alerts

AQI alerts are a way for the United States Environmental Protection Agency and other government agencies to keep track and publish the air quality ratings. This measure is built around ground-level ozone, particulate matter, carbon monoxide, and sulfur dioxide to give a safety range value to the air [2].

Various authors have researched behavior change associated with poor AQI alerts. The primary findings of past studies have been avoidance of poor air quality from at-risk groups such as the elderly and children. Noonan [8] found these at-risk groups to exhibit greater avoidance behaviors, specifically in reducing outdoor physical activity, with the presence of alerts. A separate study conducted in Portland, OR and Houston, TX revealed that only a third of participants were aware of alerts provided to the public. Only a small portion of alert-aware participants self-reported behavior change due to the perception of poor air quality [11] with a person's perception of low air quality and professional advice leading to greater self-reported behavior change [5].

Several authors cite that AQI Alerts do not alter behavior across the population; a person's behavior will change between context and the activities in question [3, 8]. Furthermore, demographics do not predict if a person will follow an AQI Alert, instead, psychosocial factors have a larger influence (knowing how and where to check AQI, impact belief; i.e., symptoms are caused or antagonized by air pollution, perceived severity of air pollution, and professional health advice) [3].

Given the above review, present research addresses gaps in the existing research bodies. One clear gap is understanding causes and behaviors around wearing a face mask as a preventative measure. Little research has connected wearing a face mask and AQI Alerts other than a short piece examining the effects of mask wearing on systolic blood pressure [5]. Hansstein et al. looked at psychosocial reasons for why young adults in urban China wear face masks, finding that social norms and the individual's social circle's attitude shapes intention to wear a face mask [4].

There is a gap in understanding visuals in the AQI alert to motivate a person to change their behavior. In a similar field, Zikmund-Fisher et al. [13] studied the visual effect of understanding medical laboratory results. This study examined the effect of visually anchoring medical laboratory results when outside of a safe range through different visual treatments. Zikmund-Fisher et al. found that visual anchoring with harm anchors could help patients understand what is dangerous or unsafe [13]. Similarly, an AQI Alert represents a safe and unsafe range. This study looks to understand how seeing the AQI number in the context of the full-scale impacts the intention to change behavior.

Combining gaps assessed with AQI Alert visuals, face mask-wearing habits, and harm anchoring as a visual treatment, this study examines three hypotheses.

Hypothesis 1: The usage of a sliding scale in AQI Alerts to visually anchor the rating compared with a single number will affect intended behavior change. Hypothesis

2: Past behavior change related to air quality will affect intended behavior change related to air quality. Hypothesis 3: Personality traits such as decision making, opinion leadership, and social connection will factor into intended behavioral changes related to air quality.

2 Methods

2.1 Study Design

The study used a between-subjects design. Visuals associated with the AQI rating (single AQI rating number or the AQI rating number in the context of the full scale) served as the independent variable. Researchers posed a scenario where participants planned to attend the local outdoor market on a day with a poor AQI Alert. Dependent variables included five different behaviors a person could take, (a) reschedule for a better day, (b) hang out with your friend, but go somewhere else inside, (c) attend the outdoor market to hang out with your friend, but spend less time outdoors, (d) hang out with your friend at the outdoor event while wearing an air mask or respirator, and (e) attend the outdoor market to hang out with your friend as planned with no changes. Behaviors were measured through participants rating the likelihood to do each behavior using a slider scale from Very Unlikely 0 to Very Likely 100. Post-task questions included cataloging past behavior change due to air quality alerts and assessing personality. Personality questions centered around opinion leadership, decision making, and social behaviors which were systematically translated into the dominant and passive personality groupings. Past behavior and personality were chosen based on previous studies indicating their influence on behavior change in relation to viewing AQI.

2.2 Participants

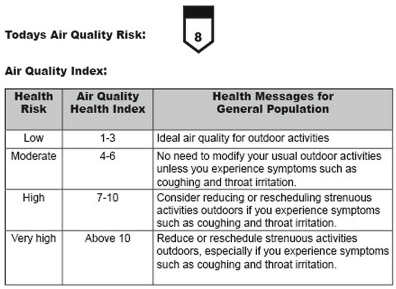
The participants were in the United States over the age of 18, using a laptop/desktop computer recruited through Amazons Mechanical Turk. A total of 140 respondents were paid $0.20. Of the 140 responses 113 qualified, the remaining 27 were eliminated for the following reasons: incomplete survey, not meeting requirements, and inconsistent open response questions (Table 1).

Table 1. Participant information

Gender	53 male, 58 female, and two non-binary/declined to respond
Age range	18–24 (13); 25–34 (33); 35–44 (28); 45–54 (13); 55–64 (15); 65+ (11)
Visual group	51 in the single number AQI rating and 62 in the AQI full scale

2.3 Tasks and Materials

Amazon's Mechanical Turk provided respondents and Survey Monkey was used to build and host the survey. The survey took on average three minutes to complete. Each participant saw the following scenario and one of two different visual scales with the AQI of "8", (see Figs. 1 and 2). The scenario provided was: *Air pollution in your city has become more common, often contributing to sore throat and coughing. Today, you are planning to go to an outdoor market to meet a good friend to shop and eat together. As you are deciding whether or not to bring a jacket you notice you have a slight sore throat. You check the weather application on your smartphone and notice your city's air quality rating below.*



Health Risk	Air Quality Health Index	Health Messages for General Population
Low	1-3	Ideal air quality for outdoor activities
Moderate	4-6	No need to modify your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	7-10	Consider reducing or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very high	Above 10	Reduce or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

Fig. 1. Group 1-single number AQI alert

The visuals were presented in black and white in order to control for the effect of color on the perception scale severity. The Canadian AQI scale was used to control for previous exposure, language, and actionability of the associated health message which has been shown to drive behavior change [9].

3 Results

Hypothesis 1. The usage of a sliding scale in AQI Alerts to visually anchor the rating compared with a single number will affect intended behavior change. There were no significant differences between visual groups found. Table 2 contains each measured behavior change and the respective p-values. Due to no changes found between the visuals, the two groups were combined for analysis of Hypothesis 2 and Hypothesis 3.

Hypothesis 2. Past behavior related to air quality will affect intended behavior related to air quality. Past behavior has a significant effect on people's likelihood to Wear an Outdoor Air Mask in the future ($t = -2.07$, $p = 0.04$). While this represents a significant difference, test results display low statistical power (0.34). The remaining intended behavior changes were not significant. Although, staying at home yielded $t = -1.81$ and $p = 0.08$, showing promise for past behavior affecting willingness to stay at home in the future. Table 3 contains each measured behavior change and the respective p-values (Figs. 3 and 4).

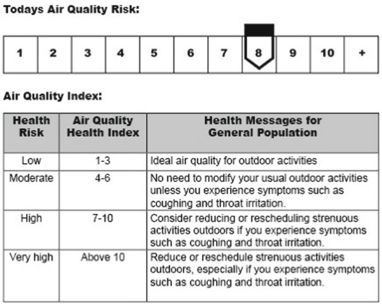


Fig. 2. Group 2-scale AQI alert

Table 2. AQI alert visual (single number vs scale) on intended behavior change

	Stay at home	Change to be inside	Less time outside	Outdoor with an air mask	Outdoor, no change
p-value	0.52	0.41	0.48	0.46	0.66
t-value	0.65	0.84	−0.71	0.75	−0.44

Table 3. Difference of past behavior on intended behavior change

	Stay at home	Change to be inside	Less time outside	Outdoor with an air mask	Outdoor, no change
p-value	0.08	0.29	0.78	**0.04**	0.75
t-value	−1.81	−1.06	0.28	**−2.07**	0.32

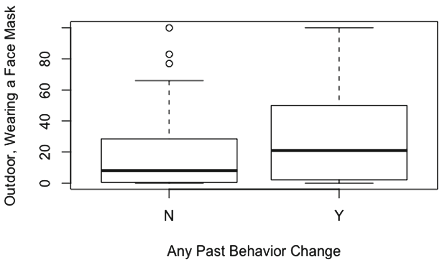


Fig. 3. Past behavior change & wearing a face mask

Hypothesis 3. Personality traits will factor into intended behavioral changes related to air quality. No difference found between dominant personalities and passive

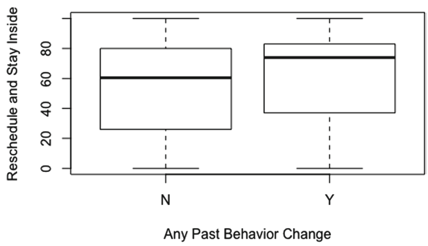


Fig. 4. Past behavior change & staying inside

personalities on intended behavior change. Table 4 contains each measured behavior change and p-values.

Table 4. Difference between dominant vs passive personalities on intended behavior change

	Stay at home	Change to be inside	Less time outside	Outdoor with an air mask	Outdoor, no change
p-value	0.98	0.33	0.25	0.94	0.22
t-value	0.03	0.97	−1.16	−0.08	−1.25

Miscellaneous Results: The lowest average rated intended behavior change was wearing an outdoor air mask. Figure 5 contains each measured behavior change and their average rating.

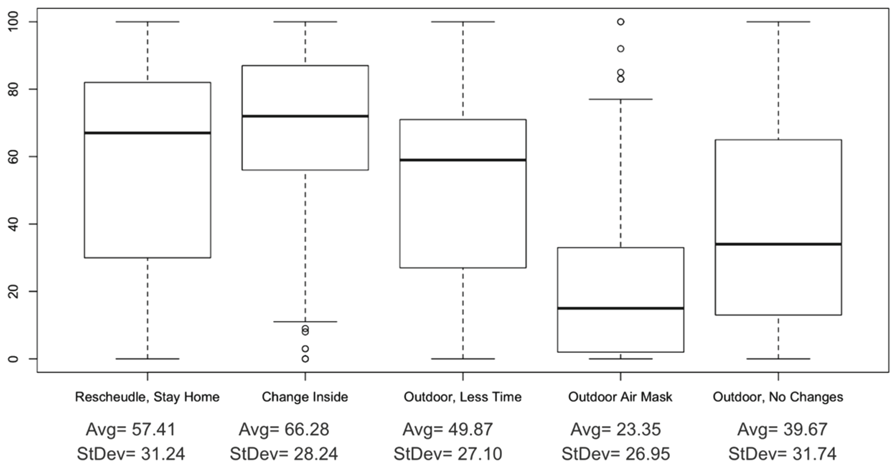


Fig. 5. Average of each intended behavior change across the group (0–100)

4 Discussion

When inspecting averages from each intended behavior change, the interesting takeaway is that the intention to wear a face mask's average rating is lower than the other methods, despite this being a known preventative and protective health measure. This could be due to the social stigma of wearing air masks in the United States. Continued findings show that past behavior had the strongest influence on the intention to wear a face mask in the future. In order to bolster global impact of these results, an effort in an area where mask wearing is more normalized, like Japan is advised. However, the climate in the US of wearing a face mask may have changed since this study took place due to COVID19, which has caused may more people to begin wearing a face mask for protection. Further research is needed in this area.

This study was inconclusive on anchoring visuals in AQI Alerts indicating that more research is needed in this area. Typically, an AQI alert contains the AQI rating number, an accompanying descriptor word (Good, Bad, Hazardous etc.), a color indicator (green to red/purple), a recommended health action, and some have visual illustrations to indicate severity. The current research team believes that the descriptive information provided underneath the scale may have outweighed any effect the anchoring visual may have had. Researchers should explore the impact that the different AQI alert components listed above have on behavior change.

Previous researchers found the primary reason for wearing a face mask to be the role of social norms and the attitude of one's social circle [5]. However, Hansstein et al. 2018 found that personality had a significant effect on behavior change [4] specifically within young adults; who may be ultimately more susceptible to social factors when making health decisions than older people. Further study of this potential correlation is clearly warranted. If social acceptance of behavior modification based on air quality is found to be an important factor in encouraging people to be proactive about their health decisions, it may behoove governments and public health organizations to orchestrate societal change through a variety of factors that are not necessarily connected.

Immediate next steps for this research include two primary efforts. First researchers should break down different aspects of visual communication for AQI Alerts to understand what could move the needle with behavior change. Next, test for any difference between AQI Alert information exposure (presence and absence) and AQI visual communication components (anchoring, color, severity, etc.) by utilizing an information absence condition as a control group.

Study Limitations. There were several key limitations to this study. 1) This study's sample size was too low due to limited time to collect data and needed 120 per group to have a strong enough statistical power (0.80) to gain confidence in findings. 2) The personality questions were not robust or validated, future research should look into refining these questions or exploring other psychological attitudes. 3) The activity chosen for the scenario was not pre-tested and could have unintentionally confounded behavior change. 4) While known limitations of using Mechanical Turk include low quality data, substandard open questions, and evidence of foreign workers using server farms [7]; the following steps were taken to ensure data quality. Questions were asked to ensure participants met survey criteria and open text questions were asked to ensure attention and literacy.

5 Conclusion

The most salient benefit of this research study points to what it takes to potentially increase intent to wear a face mask in the future focusing on past behavior and visual information displayed. This should be retested and expanded on in order to increase confidence. The impact of predicting this type of intended behavior change for both decreasing air quality and in today's pandemic climate is monumental. As health concerns continue, it is necessary to understand how to best communicate important information that has the best chance at influencing protective health behaviors.

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