Journal of Environmental Protection, 2023, 14, 583-601
https://www.scirp.org/journal/jep
ISSN Online: 2152-2219
ISSN Print: 2152-2197

How Attitudes towards Air Pollution May Impact Public Health: A Case Study of Almaty, Kazakhstan

Alua Bekbossynova[1], Dinissa Duvanova[2*], Niko Jones[1], Kate Lyden[1], Tess McGinley[1], Hannah Moss[1]

[1]Lehigh University, Bethlehem, USA
[2]Department of International Relations, Lehigh University, Bethlehem, USA
Email: alb225@lehigh.edu, *did214@lehigh.edu, njj224@lehigh.edu, kel224@lehigh.edu, tem223@lehigh.edu, ham323@lehigh.edu

How to cite this paper: Bekbossynova, A., Duvanova, D., Jones, N., Lyden, K., McGinley, T. and Moss, H. (2023) How Attitudes towards Air Pollution May Impact Public Health: A Case Study of Almaty, Kazakhstan. *Journal of Environmental Protection*, **14**, 583-601.
https://doi.org/10.4236/jep.2023.147034

Received: April 19, 2023
Accepted: July 25, 2023
Published: July 28, 2023

Abstract

Using an original public opinion survey, we study public attitudes and behaviors toward air pollution in Almaty, Kazakhstan. In the Health Belief Model (HBM) framework previously used to understand an individual's health decision-making, we evaluate citizens' awareness of the poor air quality, their perception of risk, and their willingness to devote time and resources to reduce their air pollution exposure. We find that although citizens are aware of the gravity and general harms of air pollution, they significantly underestimate their individual health risks, and, as a result, often engage in daily routines that exacerbate their exposure to pollution. We find that behaviors increasing the risk of pollution exposure are related to the underlying beliefs about personal health risks, self-efficacy, and material and economic limitations. This means that treating pollution as an individual health problem rather than social issue in public discourse may promote behaviors reducing exposure and improving personal and public health outcomes.

Keywords

HBM, Air Pollution, Environment, Public Opinion, Public Health, Kazakhstan, Almaty

1. Introduction: Ambient Air Pollution and Public Health

Air pollution poses major threats to public health around the world. The World Health Organization (WHO) that 99% of world population lives in areas where air pollution exceeds the WHO air quality guidelines. This constitutes a signifi-

cant threat to public health. In 2019, 4.2 million premature deaths worldwide were attributed to ambient air pollution [1]. Yet existing research reveals that the general public [2] [3] [4], and even physicians [5] remain inadequately informed about the health risks of air pollution. Studying the prevailing attitudes towards air pollution is extremely important for designing effective public education calpains to ensiling citizens to "adapt preventive measures for the interest of safeguarding public health" [2] and informing governmental approaches to dealing with this problem [3].

The health impact of air pollution is particularly severe in the rapidly growing urban environments of developing nations, where rising electricity consumption, availability of personal automobile, and continuing reliance on outdated heating, power generation, and household technologies contribute to unsafe levels of air pollution [6]. In this paper we study the attitudes towards ambient air pollution in one such rapidly growing urbanized area—Almaty, Kazakhstan. The city of Almaty, located in the center of Eurasian continent is the largest urban area in an upper middle-income country of Kazakhstan. Almaty is quite emblematic of the complex nature of the global public health problem presented by air pollution [7]. A former capital of the most prosperous of the Central Asian republics, Almaty nearly doubled its population over the past two decades from 1.1 million to 2 million residents and is projected to continue to grow at a rate of 1.2% - 1.5% annually [8]. A major exporter of oil and minerals, Kazakhstan is an industrialized and dynamically growing economy. Unlike many provincial Kazakh cities that host industrial production, Almaty's economy is primarily service oriented. With no major polluting industries around the city, population growth and increased prosperity have been the major factors contributing to increasingly poor air quality. Central heating system and traffic in a megapolis surrounded by the world's highest mountains (Tian-Shan Mountain range is part of the Himalayas) are the major culprits of air pollution.

A 2020 study that analyzed most common air pollutants between 2013 and 2018 reported that annual averages of PM2.5, PM10, and NO_2 pollution concentrations in Almaty exceeded the WHO annual limits by 5.3, 3.9, and 3.2 times respectively [9]. The US Environmental Protection Agency considers PM2.5 (particulate matter 2.5 micrometers or smaller) pollution to pose the most severe health risks because the particles are small enough to penetrate lungs and get into the bloodstream [10]. According to the World Bank, in 2013 the levels of PM10 and PM2.5 in Almaty cost the city an additional 486 million US dollars in medical care [9]. These health costs increase the number of people with asthma, chronic obstructive pulmonary disease (COPD), and other cardiovascular health issues.

Prior research has conclusively linked air pollution across Kazakh cities to higher-than-average instances of respiratory and cardio-vascular disease. Air pollution is estimated to contribute 16,000 cases per year to the national mortality estimate [11]. The poor air quality contributes to the severe visible smog, accumulation of dust and residue inside buildings, and residents reporting diffi-

culty breathing. According to the environmental researchers and NGO activists in Almaty, air pollution is so severe, everyone can visually observe it when traveling through the city (Public Meeting at the American Corners, May 27, 2022). In 2018, city residents spontaneously organized online groups and traditional civil initiatives to seek more information about the extent of air pollution, its sources, health effects, and to pressure the government to enact environmental measures. Still, Kazakh meteorological services or medical institutions do not issue air quality alerts to the general public, nor do they advise vulnerable populations to avoid outdoor pollution. The information from the existing government and privately operated air quality monitors remains a purview of a narrow group of specialists and enthusiasts. No individual protection and mitigation measures, such as air filtration systems, avoidance of outdoor activities for vulnerable populations, or face mask wearing are being promoted in the city.

The local government of Almaty has taken steps to address the air pollution problem in their city. These include regulatory initiatives, infrastructural changes, and renovation of the central heating plants.[1] Starting in the late-1990s the city introduced environmental inspection block posts to enforce traffic emissions standards [12]. It invested in municipal tree planting and banned unauthorized logging of trees, which are widely regarded as essential components of air pollution mitigation, it invested in expanding the residential access to natural gas for individual house heating to replace coal burning stoves. In 2018, the city government launched a program to develop a more sustainable bus system, and became a customer of Eurobus, an electric bus service, in an attempt to reduce pollution from traffic [13]. In 2021, the city awarded a contract to upgrade the existing coal and natural gas-powered heating plants that supply hot water and heat to the vast majority of city's residential and business buildings [14]. The purpose of the upgrade is to reduce harmful emissions that contribute to nearly half of particulate matter pollution during a 6-month long heating season. Nonetheless, these measures did not bring about any improvements in air quality. Growing city population and rising incomes mean more traffic and expanding centrally heated housing.[2] These factors make a reduction in air pollution highly unlikely in the near future.

As the air pollution continues to affect Almaty residents, preserving their health becomes the most paramount concern. Unfortunately, the city takes no preventative public health measures to mitigate adverse health effects of air pollution. Majority of the citizens of Almaty are not taking the necessary steps to

[1]Also known as district energy systems, centralized heating uses large powerplants to convert fossil fuels into steam or hot water distributed through a system of underground piles to residential and commercial buildings for heating and hot water use. Kazakh government's high share of ownership in the energy sector allows it to subsidize central heat and makes coal and natural gas the most cost-effective sources of residential heating. Outside Kazakhstan, district power systems provide heat to the majority of urban consumers in the People's Republic of China, Russia, and many other formerly communist countries. Such systems also operate in a number of cities across Western Europe and the USA.

[2]Average incomes are high enough for gas-powered vehicles, but not sufficient for more expensive electric cars.

keep themselves safe. Moreover, they often preserve unhealthy and environmentally damaging practices, such as obligatory outdoors activities in educational institutions, outdoor sports in highly polluted areas, and opening their windows for temperature control during the heating season. The latter simultaneously increase citizens' exposure to ambient air pollution and the demand for more heat generated by burning fossil fuel. Due to the lack of governmental and individual effort to mitigate the health risks of poor air quality, it is pertinent to identify factors associated with avoidance of healthier behavior. That is a necessary step in designing effective government and societal responses to the negative public health consequences of air pollution. To understand why most Almaty citizens do not take action to reduce their air pollution exposure, in 2022 we conducted a public opinion survey, distributed electronically throughout the city of Almaty. By analyzing responses to our questions, this paper strives to identify attitudinal correlates of behaviors that may exacerbate individual exposure to air pollution. Our analysis of these attitudes and behaviors suggests promising areas for the community-outreach activities to promote healthy behaviors and consumer choices.

2. Study Design

The survey was designed to evaluate the general level of public awareness environmental pollution and its health effects in Almaty. To our knowledge, there are no national surveys that tell us what the population knows about air quality. A 2013 study measured the awareness Kazakhs had of the health effects of smoking. Roberts *et al*. found that only 61.6% and 58.2% of people in Kazakhstan are aware that smoking can cause heart disease and bronchitis respectively and found that only 19.4% of Kazakhs had the characteristics associated with a high knowledge of the harmful effects of tobacco [15]. Because poor air quality causes many of the same health problems, but is a more obscure problem, it is unlikely that Almaty residents have high levels of knowledge of the negative health effects of air pollution.

To analytically disintegrate various aspects of an individual's opinion on air quality's health effects we design survey questions about awareness, perception of harm, self-efficacy, and behaviors. Our approach is inspired by the theoretical framework of Rosenstock's Health Belief Model (HBM). The HBM is a collection of five perceived attitudes of a certain health risk, which theoretically can predict if a person will make a health behavior change. These attitudes include: 1) Perceived severity, 2) Perceived Susceptibility, 3) Barriers to Preventive Action, 4) Benefits of Preventative Action, and 5) Self-efficacy [16]. The sixth factor of this model is cue to action, which is the trigger for the health behavior. The model posits that, if perceived susceptibility and severity are high, barriers to preventive action are low, benefits of preventive action are high, and self-efficacy is high, a person is likely to positively respond to the calls for healthier behavior.

The HBM had be used to predict taking a medication, managing healthy

weight, attending a program, getting a screening test, vaccination, and many other positive health behaviorы [17] [18] [19] [20]. We use this model to analyze individual behaviors to reduce air pollution exposure as well. In other words, we expect that the lack of awareness of individual harm and belief in the efficacy of individual actions can explain why some Almaty residents engage in practices that increase their exposure and aggravate the negative public health effect of pollution. From a practical standpoint, assessing HBM factors can tell us whether efforts to promote preventative practices around air pollution in Almaty are likely to be effective.

HBM is a well-established framework. However, the predictive quality of all the factors of the model is not certain. In a meta-analysis of 18 studies that used HBM framework, benefits and barriers were the only strong predictors of longitudinal behavior change [21]. However, the model is found to have stronger predictive power when applied to preventative care versus an existing illness [21]. In a study that tested when Jordanians adhered to home quarantine instructions during the COVID-19 pandemic using the HBM, researchers found that seriousness (or severity), benefits, and barriers were significant predictors [22]. These results are significant in the case of air quality because reducing exposure to air quality requires many of the same actions as reducing exposure to COVID-19. The literature debates whether self-efficacy should be officially included in the HBM. However, a 2021 study found that self-efficacy was the only predictive factor of healthy eating in young adults [23]. We decided to include self-efficacy questions in our survey.

3. Attitudes and Behavior

To better understand various ways Almaty residents are being affected by and respond to air pollution, between May 19th, 2022 and May 29th, 2022 we conducted observational field research in Almaty. We observed public behavior in public areas, transport, outdoor recreational and sporting activities, studied city government's position of air pollution, followed public social media influencers, and attended public events in Almaty. On May 27 we attended in a public discussion forum organized by the American Corners Kazakhstan NGO for environmental activists, educators, and university students who discussed Almaty air pollution issues. We identified common themes dominating public discourse around air pollutions as well as commuting, recreational, and outdoor activity practices. This knowledge helped us design survey questions to capture different attributes in the HBM and indicators of good health choices in the Almaty population.

We learned that people in Almaty are not oblivious to the poor air quality around them, but often view the problem as an unavoidable consequence of living in the city. Air quality issues are being introduced and discussed as early as elementary school. Statements about air quality being poor in Almaty comparing to other parts of the world, are common to public discourse. The day-to-day ex-

posure to poor air quality seemingly makes people apathetic to the issue. Many activists blame the construction of high-rise buildings for disrupting air flow in the city, but these claims are unsupported by scientific evidence.

Rapid urbanization within the city of Almaty has not only led to the construction of new high-rise buildings, but increased transportation and energy demands as well. This has resulted in decreasing air quality, but has not led to changes in behaviors. In peak stand-still traffic cars sit idle with their windows open, even when functioning air conditioning is available. This exposes passengers and drivers to PM2.5 concentrations of over 35 μg/m^3 in summer months when air quality is considered best.[3] Homes and professional buildings equipped with air conditioning chose to open windows when it is hot regardless of proximity to major pollutants, letting particulate matter contaminate cleaner indoor air. This is due to the widespread belief that air conditioning can cause illnesses like the cold.

In winter months air quality is at its worst due to pollution from coal heating plants, residential furnaces used for heating, and vehicle emissions. In homes built before 2005, residents are unable to regulate the temperatures of their heating radiators. The heating is centrally regulated and the heating plant sets the temperature of the water that travels out to every home. Many homes then become too hot, with residents subsequently deciding to open their windows for relief, which, in turn, allows in polluted air.

While we were able to observe idle and operating air conditioning units thought the city, air filtration units are rare. We were not able to identify any household use air filtration devices offered by local electronics and appliance retailers. It is agreed these units are too expensive for most people to purchase. The lack of demand results in the lack of supply. Although city planning integrates parks and walking paths away from major roadways, we observed dozens of playgrounds and outdoor gyms located in immediate proximity to major roadways and busy intersections.[4] City foot traffic flows usually stay close to the major roadways.

4. Electronic Survey

The survey was developed on the Qualtrics platform and distributed electronically in Almaty, Kazakhstan. We used two distribution methods. The first distribution method was via a QR code displayed on posters at a major outdoor sporting event and at an outdoor sporting facility. The second method was a direct email solicitation to the faculty, graduate, and upper-level undergraduate students of a private university that offers no student housing and hence is primarily attended by the Almaty residents. The Qualtrics platform ensures anonymity and prevents multiple submissions. Confidentiality of respondents is enhanced in electronic distribution: they can answer survey questions in the

[3]This statement is based on repeated measurements we took in May and June 2022 with CanAirIO air monitors (https://canair.io/).

[4]Previous research suggests that outdoor exercise and physical activities may accelerate negative health effects of air pollution [24] [25].

privacy of their homes and at the time most convenient for them. At the end of the survey, the respondents had an opportunity to send the survey invitation to their friends and families, forwarding the anonymous survey link to phones or emails they identify.

The Qualtrics survey solicits participants' informed consent, explains the purpose of the study, and provides the PI's and local contact information. The survey was offered in local languages, Kazakh and Russian, and respondents had an option to choose their preferred language. At the end of the survey the participants received a debriefing statement that more specifically outlines the air quality focus of the research. Our survey questions encompassed the following areas: awareness of air pollution, concern regarding air pollution and its health effects, behaviors increasing risk of exposure to air pollution, and the willingness to change behavior and/or pay. These categories were intended to capture different attributes in the HBM in a way that would help us assess whether they are associated with good health choices in the Almaty population.

Our first category, awareness of air pollution, was assessed by seven questions positioned at the beginning of the survey. These questions were either scale or ranking based, so as to give us a better understanding of awareness regarding air pollution, as a single-input approach may have not provided the larger picture that a ranking system of questions does. Furthermore, we placed these questions at the beginning of the survey to get as unbiased responses as possible, as information later in the survey may have influenced participants to select answers indicating more awareness of air pollution.

Closely related to our first category of questions are questions gauging the level of concern regarding air pollution and its health effects. These questions were somewhat intermixed with the first category regarding awareness to protect against potential contamination by learning information from other questions. The next category included self-reported behaviors increasing risk of exposure to air pollution. This was the longest and most comprehensive part of the survey, as it gives us a direct look into what actions and behaviors people in Almaty are partaking in. These questions are framed in ways that do not immediately relate customary behaviors to air pollution to minimize biases. They focused on home life, travel, and outdoors activities, as actions and habits regarding these settings often account for the vast majority of air pollution exposure in Almaty. Possible response options range in format, so we could capture both specific and generalizable behaviors and habits. Furthermore, we sacrificed detail granularity of response options to keep survey reasonably short (10 - 15 minutes of respondents' time) to ensure satisfactory completion rates. We also included questions and response options that would allow us to identify social, economic, and infrastructure-related resources and limitations on individual preventive actions, such as flexible commute options, access to air conditioning, personal or public transportation,[5] outdoor sporting and work-related activities, children, house-

[5]Faghri at al. review the socio-economic and environmental dimensions of access to and use of public transportation [26].

hold location, and socio-economic status of the respondents. The survey also included a battery of standard socio-demographic questions.[6] These demographic questions were placed throughout the survey, and often overlapped with other categories of questions.

Lastly, we included a question aimed at gaging individual resolve to solve the air pollution problem that follows a standard approach to measuring "willingness to pay" WTP. The question proposed a hypothetical scenario in which a meaningful and feasible reduction in individual's risk of death from air-portion related causes can be achieved at a cost of individual's monetary contribution. We design this question in a form of survey experiment that randomly veined informational priors of the health risks of air pollution and/or efficacy of individual-level preventative measures. The WTP question was placed at the end of the survey and utilized graphics to more accurately convey the magnitude of health risk.

The survey contained a total of 49 questions. Between the spring and late fall of 2022, we were able to collect 314 responses, 189 respondents answered every survey question. Just under 7 percent of university email invitations responded to the survey. The response rate for QR-code distribution could not be established. About a quarter of people who started the survey did not finish it.

5. Descriptive Results

In accordance with the HBM, we expect that beliefs about severity of air pollution, susceptibility to the associated risks, benefits of preventative measures, and self-efficacy should be associated with higher likelihood of adopting routines and behaviors minimizing negative health effects of air pollution. Barriers to such behaviors, on the contrary, are expected to correlate with less safe practices. In accordance with the HBM, we expect separate and positive effects of various measures of awareness and harm perception on individual pollution-mitigation practices.

Our respondents' awareness of air pollution was surprisingly high. When asked how concerned they were of environmental pollution, on a scale from 0- not concerned to 10- very concerned, 40.5% of participants responded with a ten. More than 80% of respondents ranked their concern at 7 - 9 points. Air pollution received the highest concern score with 71% of respondent ranking it as of the most important concern, placing it above water pollution, loss of wild life and urban green space, melting of glaciers, and development of river banks. On a zero-to-ten-point scale 84 percent of our respondents ranked Almaty air quality below six with a quoter of our respondents giving it 0 - 1 points. Moreover, 96% of our respondents believed air pollution has a negative health effect.

Given the recent public mobilization against air pollution in Almaty, these responses are not surprising. We wanted to measure the extent of the perceived

[6]A study by Wilkinson *et al.* [27] found that a higher level of education and income lead to increased knowledge about cancer and, as a result, healthier practices like not smoking. It is important, therefor, to incorporate socio-economic characteristics in our analysis.

severity of air pollution-related health threats. We found that while 60% of our respondents fully agreed with the statement "Air pollution can lead to serious health problems," nearly 13% of participants strongly disagreed with this statement, other responses ranging in their levels of agreement or disagreement. To further probe the issue of severity, we asked: "In your opinion, what are the major causes of health problems you and your relatives have?" Respondents were given an opportunity to select multiple answers ranging from hereditary and lifestyle causes to socio-economic conditions and access to high quality medical care. Over 69% of respondents selected air pollution as one of the major causes of health problems. Only chronic stress (74%) and unhealthy lifestyle (71%) received more mentions. Poor nutrition was mentioned by 44% of respondents. Financial limitations, occupational hazards, age, and hereditary causes received less than 30% mentions each. Most of our respondents think air pollution is connected to health problems, although some may underestimate the overall severity of such health effects.

Almaty ambient air quality fluctuates significantly depending on a season, location, and time of day. Since the sources of pollution lie outside of the households in the majority of residential buildings, outdoors air pollution may exceed air pollution many folds. Still, only 21.3% of our respondents fully agreed that "sometimes air outside is worse than in my house." We find that 42% of our respondents ranked their agreement with the above statement at 5 or below on a 0 to 10-point scale. As much as 68% of participants fully agree that it is important to spend time outside to get fresh air (other 19.5% rather agree than disagree). Moreover, nearly 67% of the respondents believe it is important to ventilate their homes to let in fresh air (additional 24.5% rather agree than disagree). Only 10.26% respondents agreed with the statement that "sometimes it is better to stay inside not to breath bad air." Just over one thirds of our respondents indicated some degree of agreement with this statement.

Despite high awareness of the negative health effects of air pollution, the majority of our respondents take no steps to reduce their exposure. In fact, many engage in easily avoidable daily routines that likely increase their exposure to harmful ambient pollution. Only 10% of respondents check air quality reports. Forty four percent of respondents agreed that the best way to make their house comfortable when the heat is on is to open windows, and this was validated by observations and conversations during our fieldwork. This is an extremely dangerous habit given air pollution is at its worst during the winter months. Forty five percent reported keeping their windows open for ventilation while they sleep. Another quarter of respondents reported ventilating their houses by opening windows 1 - 2 hours daily, while only 10% of respondents ventilate their houses for less than 30 minutes a day. Over a half of respondents agreed they like to open windows in buses or cars for fresh air. Again, this habit only increases exposure to air pollution, as traffic is one of the main contributors to air pollution in Almaty, and air pollution readings are extremely high on roads.

Twenty eight percent or our respondents believed that "on hot days, it is better to open the windows than to run air conditioning". Air conditioning, when used instead of ventilation with ambient air may help attenuate exposure to ambient air pollution because it often entails air filtration and recirculation. We checked whether attitudes towards air conditioning depend on its affordability and availability. Just over a half of our respondents (50.9%) reported having an air conditioning unit at home and 86%--at the place of work or study.[7] Still, 17.3% of those who reported having an a/c at home and 35% of those who have it at work report not using air conditioning. While the use of air conditioning that may provide air filtration as a by-product of indoor cooling is far from universal, use of air filtration devises is even less popular. Seventy three percent of our respondents either didn't know what air purifiers are or never used them, 19% believe they have air purifiers at home or at work but reported not using them, and only 5% of respondents report using their home or office air purifiers.

Only 20% of respondents report avoiding outdoor activities on days when the air quality is bad. Given that on average our respondents report spending 4.1 hours per day communing, 3.6 hours at leisure activities, 2.7 hours a day doing some type of physical activities, including working or biking and the total of 7.8 hours per day outside of their homes, exposure to ambient pollution is a serious threat. With most popular form of city transportation for our respondents being public busses—44% of our respondents identify it as the most frequent choice of transportation, followed by private car (24.2%), walking (16.2%) ride shares and taxies (13%), exposure during city commute is of primary concern. Most of our respondents are very consistent with their commuting routes in the city. Only 27.7% of respondents would change their commute depending on atmospheric conditions. Moreover, 76% of respondents report not wearing face mask outdoors and 61% report not seeing other people wearing masks outdoors. These expressed habits, predictably, are not mitigating the effects of air pollution.

To probe the self-efficacy component of the health-belief model we asked if our respondents agree with the following statement: "I can take actions to prevent negative effects of air pollution." Thirty seven percent of our respondents tend to disagree with this statement, 37.8% percent tend to agree, and 25.2% picked a middle category of neither agreeing or disagreeing. The responses on this question suggest that the majority of people in Almaty are either not as informed as is necessary to protect themselves from air pollution or remain unconvinces individual preventative measures may be effective in reducing exposure and safeguarding one's health.

To investigate whether information about negative health effects and effectiveness of individual protection strategies may influence respondent's willingness to make individual contributions towards solving pollution-related public health problems we use an embedded random treatment assignment design. We

[7]Our field research indicates the most common type of air conditioning soled and installed in Almaty is the room-capacity wall unit. Very small number of buildings in the city features central air conditioning and some older apartments have window-mounted units.

randomly assigned our respondents to a control group that received no informational priors and two information treatment groups that receive prompts discussing 1) health risks of air pollution and 2) and health risks and benefits of preventive actions. Respondents then were asked to select their willingness to pay (WTP) for a marginal reduction in the premature mortality risk.[8] We asked what percentage of monthly income they would be willing to contribute towards measures that would reduce the risk of getting seriously sick from air pollution by 33%: a reduction in risk from 6 in 1000 to 4 in 1000. This question is based on the methodology used by international economic organizations to establish country-specific values of statistical life (VSL) [30]. Because for the most part people rarely directly compare small statistical probabilities and routinely underestimate or overestimate their substantive importance, visual representation may help convey the magnitude of risk reduction mentioned in the question. Our WTP question was accompanied by a graphic illustrating the risks (**Figure 1**).

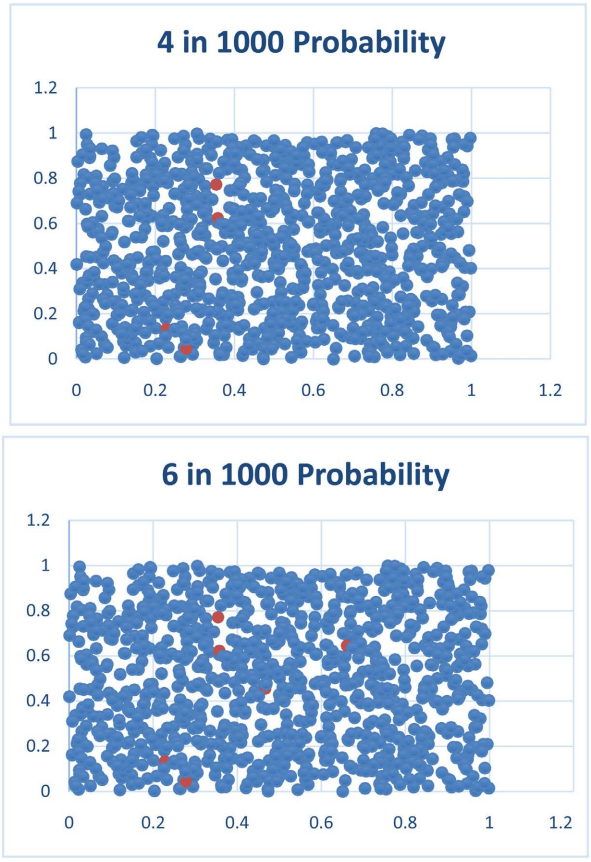

Figure 1. Visualization of WTP for pollution-related health risks. These figures were presented to survey respondents to aid in evaluating the magnitude of potential health risk reduction. Probabilities are based on the HWO estimates of pollution-related health risks.

[8]In behavioral economics WTP is the maximum price (sacrifice) one is willing to pay (make) to obtain the desired product (outcome). This concept acknowledges the trade-offs associated with obtaining desirable goods or outcomes and ultimately allows assessing the expected utility of obtaining the desired outcomes. See Miller, *et al.* [28] and Breidert, *et al.* [29] for methodological discussions.

Responding to the WTP question, 12% of respondents indicated they would make no contribution to reduce their pollution-related health risks, 49.4% replied they would contribute 1% - 5% of their income, 26.3% responded they would contribute 6% - 10%, 7.7% and 2.6% replied they would contribute 11% - 15% and above. To access whether information about air pollution affects the respondents' WTP, we analyzed differences in mean WTP scores across three randomly assigned groups of respondents. As stated earlier, the control group received no information priors. The second group saw the following statement: "Air pollution is one of the leading causes of premature mortality and acute morbidity in Almaty. Coal burning and transportation cause an unhealthy level of PM2.5 (particulate matter with a diameter of less than 2.5 micrometers) to be present in the air [9]. Exposure to PM 2.5 is associated with an increased risk of heart disease, lung cancer, asthma, and COPD along with a host of other illnesses [10]." The third group, in addition to the above information about health risks of air pollution also saw the following statement about preventive measures: "Measures such as wearing masks, staying inside on bad air quality days and using an air purifier can help individuals limit their exposure to pollutants such as PM 2.5. Choosing to bike away from roads or use public transportation instead of driving can also reduce exposure to harmful air pollutants. These involve some monetary costs and may be inconvenient sometimes, but would reduce the risk of acute morbidity or premature mortality caused by air pollution."

We found that the mean WTP scores for the group that received risk and benefit statement was 0.13 point higher and risk only statement was 0.03 point higher than the control group (the combines samples' mean scores were 1.47 and 1.52 respectively) but such difference was not statistically significant in the t- and z-statistics mean comparison tests. In other words, informational priors had no effect on the percentage of monthly income our respondents were willing to contribute towards measures that would reduce their risk of getting seriously sick from air pollution. This tells us that information along might be insufficient for changing behaviors towards mitigation and prevention of pollution-related health effects. Our respondents exhibited high levels of awareness of pollution and its health effects but at the same time hold attitudes and beliefs incongruent with common preventive measures. To get a better understanding of the most crucial determinants of self-reported preventive practices we turn to HBM.

6. HBM and Preventive Actions

As discussed earlier, HBM is used to model person's health behavior change on the basis of five perceived attitudes about certain health risk: perceived severity, susceptibility, benefits and barriers to preventive action, and self-efficacy. The sixth element of this model—cue to action—is conceptualized in terms of professional intervention to trigger health behavior. Because of our non-intervention survey method, we omit the cue to action element. Multiple survey question taped into five non-intervention elements of HBM. However, some questions

did not reveal substantial variation in attitudes making them poor candidates for explaining variation in self-reported preventive actions. Table 1 gives the descriptive statistics for the questions that capture various components of the HBM and provide sufficiently large variation in answers. We operationalize severity, susceptibility and self-efficacy with attitudes towards air pollution, its health risks, and prevention. Perceived benefits and barriers are harder to operationalize because different individuals may value different outcomes and different preventive actions may have different barriers. We use self-assessment of once health and adherence to positive general health practices as a proxy for assigning higher value to preventive air pollution practices. For barriers, we use specific limitations imposed by physical infrastructure, and individuals' socio-economic status. For all of the categories, except barriers, a high level of perception works in favor of healthy behavior.

Table 1. Summary statistics of HBM independent variables.

Variable	Mean	Std. dev.	Min	Max
Severity				
What do you think the quality of air is in Almaty? (0 - poor quality to 10 - good quality)	3.45	2.59	0	10
Susceptibility				
To what extent you agree or disagree with the following: Air pollution can lead to serious health problems	7.84	3.51	0	10
Self-efficacy				
To what extent you agree or disagree with the following: I can take actions to prevent negative health effects of pollution	4.85	2.91	0	10
Benefits				
How would you evaluate your health? 0 - 10 scale	7.22	1.55	2	10
I live a healthy lifestyle	0.43	0.50	0	1
I have regular medical check-up	0.28	0.45	0	1
Barriers				
Do you change the way you travel to work depending on weather?	1.69	1.17	0	4
Do you have an air conditioner? - Home	0.51	0.50	0	1
When you to move around the city what mode of transportation you use most frequently (1) to least frequently (6) - Bus/Trolley	2.27	1.50	1	6
Socio-demographics				
Age group (7 ordered categories)	2.15	1.44	0	6
Female	0.7	0.46	0	1
How would you describe the current material situation of your family? (5 ordered categories)	2.35	0.69	1	4
Education (6 ordered categories)	4.31	1.12	1	6

Table 2. Regression results of HBM and preventive actions around air pollution.

	Preventive Actions					Exacerbating Actions			
	Monitor air quality	Avoid going out	Wear mask outdoors	Spend time in countryside	Use a/c	Open windows in traffic	Better open windows	Open windows to cool	# hours ventilate home
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Air Quality	−0.112	−0.233	−0.190	−0.052	0.223	−0.015	−0.184	−0.206	0.159
0–poor, 10–good quality	(0.165)	(0.133)*	(0.230)	(0.093)	(0.114)*	(0.089)	(0.096)*	(0.087)**	(0.070)**
Susceptibility	−0.063	0.047	0.212	0.030	0.144	−0.098	0.061	0.062	0.018
agree pollution leads to health problems	(0.135)	(0.109)	(0.255)	(0.081)	(0.083)*	(0.084)	(0.084)	(0.074)	(0.079)
Self-efficacy	0.018	0.068	0.018	0.264	0.019	−0.107	0.021	−0.010	−0.058
can prevent health effects of pollution	(0.143)	(0.106)	(0.205)	(0.100)***	(0.102)	(0.095)	(0.097)	(0.080)	(0.068)
Health Assessment	−0.541	−0.011	−0.090	0.365	0.131	−0.479	0.125	0.247	−0.170
self-evaluation on 0 - 10 scale	(0.310)*	(0.215)	(0.343)	(0.201)*	(0.215)	(0.213)**	(0.198)	(0.179)	(0.144)
Lifestyle	0.959	−0.423	−0.645	0.798	−1.224	1.341	−0.155	−0.064	−0.220
live a healthy lifestyle	(0.947)	(0.654)	(1.028)	(0.533)	(0.620)**	(0.592)**	(0.563)	(0.510)	(0.432)
General Preventive Care	0.826	−0.159	−1.145	−1.234	−0.737	1.309	0.167	0.154	0.068
have regular medical check-up	(0.874)	(0.674)	(1.489)	(0.623)**	(0.611)	(0.642)**	(0.574)	(0.525)	(0.443)
AC at Home		−0.842		−0.007	1.533		−1.494	0.734	−0.062
		(0.639)		(0.523)	(0.556)***		(0.585)**	(0.481)	(0.397)
Bus Use		0.324	−0.571	0.258		−0.262			
use bus most (1) to least (6) frequently		(0.222)	(0.530)	(0.185)		(0.183)			
Flexible Commute		0.493				−0.123			
1–never, 4–often		(0.283)*				(0.254)			
Income	0.214	−0.438	0.292	−0.814	−0.385	0.452	−0.034	0.679	−0.275
7 ordered categories	(0.656)	(0.522)	(0.842)	(0.448)*	(0.460)	(0.417)	(0.421)	(0.398)*	(0.315)
Age	−0.249	0.011	−0.264	−0.082	0.235	−0.360	0.589	0.130	0.121
5 ordered categories	(0.394)	(0.315)	(0.525)	(0.222)	(0.242)	(0.233)	(0.230)**	(0.212)	(0.176)
Gender	0.090	0.041	−1.725	−0.230	−0.846	−0.488	−1.242	0.527	−0.798
female = 1	(0.949)	(0.728)	(1.133)	(0.598)	(0.646)	(0.630)	(0.596)**	(0.534)	(0.455)*
Level of Education	0.124	−0.401	0.787	0.204	0.128	−0.253	0.008	0.150	−0.074
6 ordered categories	(0.487)	(0.359)	(0.890)	(0.329)	(0.329)	(0.357)	(0.310)	(0.285)	(0.242)
Const.	0.829	0.375	−4.267	−3.590	−1.909	6.655	−1.286	−4.377	6.371
	(3.665)	(2.890)	(5.794)	(2.462)	(2.665)	(2.798)**	(2.468)	(2.222)**	(1.775)***
Pseudo R^2	0.090	0.176	0.181	0.201	0.214	0.170	0.206	0.121	0.138
Obs.	91	89	89	89	84	89	91	91	83

We regress variables from Table 2 on various self-reported attitudes and behaviors that may reduce individual's exposure to air pollution and mitigate its negative health effects. We consider self-reported monitoring of air quality, wearing masks, avoiding outdoors activities when air quality is poor, spending time outside the city, using air conditioners, and opening windows for temperature control and ventilation. The first five of these are healthy preventive behaviors, while those associated with window ventilation and cooling may increase an individual's exposure to ambient air pollution. We find that our respondents' assessments of air pollution problem are correlated with avoidance of outdoors activities, but have very inconsistent and even contradictory relationship with their behaviors around the use of air filtration and window ventilation of their houses. This is one area in which increased awareness of air pollution mitigation in indoor spaces is likely to promote more healthy preventive choices.

We find that bailiffs about susceptibility factor in the expected direction into the a/c use choices, but not into other preventive behaviors. Self-efficacy is positively linked to spending more time outside the city. At the same time, those respondents who believe they live a healthy lifestyle are less likely to use air-conditioning and instead prefer open windows in traffic. Expectedly, people who have a/c at home are likely to report using it and preferring it over open windows. Ownership of air conditioner, however, is not a proxy for higher incomes. In fact, older respondents, men, and people with higher incomes are more likely to prefer open windows for cooling and ventilation. Level of education is not correlated with any preventive or exacerbating behaviors.

7. Conclusions

Our study indicates that people in Almaty generally understand that there is a severe air pollution problem that has consequences for public health; however they tend to underestimate air pollution consequences for their individual health outcomes. Moreover, on average, Almaty residents we surveyed do not feel confident they can do much about it. Although we see some evidence of physical and socio-economic constrains on practicing pollution-mitigating options, the attitudes and behaviors suggest respondents generally do not believe individual efforts would make a substantial difference to the health outcomes. While it is good that citizens understand the problem, more effort should go towards increasing awareness about the ease with which people can protect themselves. It is clear there is a negative attitude towards the city's air pollution, but the results of the survey indicate there are certain behaviors that we can now directly address. For example, considering only 59% of people use air conditioners regularly and only 6% of people use air purifiers regularly, targeting these two products by convincing more people to use them and increasing their accessibility would make a significant difference in people's indoor air pollution exposure.

Further, based on answers to a question about what influences views about the environment, people are open to receiving information from academics and scien-

tists, with 73% of respondents ranking academics/scientists within the top 3 ways they are influenced. This means initiatives of international and domestic research institutions, universities, and health organizations have the potential to influence citizens' views.

The major limitation of our conclusions is that they are based on a survey distributed electronically, and not on a representative sample of cities population. Nearly 44% of respondents fall into 18 - 24, while this age group, according to the 2021 national census, accounts for under 15% of city adult population [31]. 18.5% of our respondents are between 25 and 34 years of age, while this age group constitutes a quarter of city adult population. The 35 - 44 and 45 - 54 age groups account for 15% and 9% in our sample, while these groups represent 21 and 15 percent of city's adult population. Only 8% of our respondents fall into 55 - 64 age group years while this demographic group constitutes nearly 13%. The most underrepresented group is people over 65, who represent 1.3% of our sample, which is ten times smaller than this age group's share in adult population.

47% of respondents report having completed a college degree, which is somewhat higher than the country-average of 34.2% higher education coverage index [32]. 31% had some post-graduate or professional education, and 11% hold post-graduate degrees. These shares are significantly larger than national averages, however, given that one third of all college degrees in the country are earned in 42 Almaty colleges and universities, we believe our sample is reflective of the educational levels of the city population [33]. While in 2021 women constituted 54% of city population, in our survey we have twice as many women participants as men.

Most of the survey respondents are young, educated people, who are generally more environmentally educated and aware. This means that our results are not representative of Almaty's older citizens and recent uneducated and poor migrants. Ultimately, our findings are limited to select socio-demographics, but even with within that limited coverage, some clear attitudinal and behavioral patterns emerge. Even in the group of technology-savvy, young and better educated residents our survey uncovers an alarming lack of awareness of individual mitigation strategies and/or skepticism about their effectiveness. This reinforces our idea that action can be taken to better inform the public about their ability to mitigate the effects of air pollution, and that. We have identified important gaps in the awareness about beneficial pollution mitigation measures, low levels of resolve to preventive action, and widespread behaviors that may exacerbate exposure to harmful air pollution.

Our results identify areas promising directions for information campaigns, education, and professional intervention that may promote pollution-mitigating adjustments to citizens' habits and, ultimately, improve the public health in the city. Our paper identifies obstacles to sustainable public health and environmental outcomes that are not of technological, and even strictly economic nature. The

Almaty air pollution case shows that people's attitudes and behaviors may exacerbate negative health impacts of pollution, but also may impede environmentally conscious consumer behaviors. Because Almaty air pollution problem is not unique—sources of pollution, infrastructure, and development prospects of Almaty are similar to many urban centers in rapidly developing economies—we believe our approach, conclusions, and policy implications might be of interest to citizens, NGOs, and governments aiming at promoting equitable and sustainable development around the world.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] WHO (2022) Ambient (Outdoor) Air Pollution: Key Facts. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

[2] Liu, X., Zhu, H., Hu, Y., Feng, S., Chu, Y., Wu, Y., Wang, C., Zhang, Y., Yuan, Z. and Lu, Y. (2016) Public's Health Risk Awareness on Urban Air Pollution in Chinese Megacities: The Cases of Shanghai, Wuhan and Nanchang. *International Journal of Environmental Research and Public Health*, **13**, Article No. 845. https://doi.org/10.3390/ijerph13090845

[3] Chin, Y.S.J., De Pretto, L., Thuppil, V. and Ashfold, M.J. (2019) Public Awareness and Support for Environmental Protection—A Focus on Air Pollution in Peninsular Malaysia. *PLOS ONE*, **14**, e0212206. https://doi.org/10.1371/journal.pone.0212206

[4] Ramírez, A.S., Ramondt, S., Van Bogart, K. and Perez-Zuniga, R. (2019) Public Awareness of Air Pollution and Health Threats: Challenges and Opportunities for Communication Strategies to Improve Environmental Health Literacy. *Journal of Health Communication*, **24**, 75-83. https://doi.org/10.1080/10810730.2019.1574320

[5] Nazar, W. and Niedoszytko, M. (2022) Air Pollution in Poland: A 2022 Narrative Review with Focus on Respiratory Diseases. *International Journal of Environmental Research and Public Health*, **19**, Article No. 895. https://doi.org/10.3390/ijerph19020895

[6] Berry, B. (2015) The Battle to Breathe: Chile's Toxic Threat. Council on Hemispheric Affairs. https://coha.org/the-battle-to-breathe-chiles-toxic-threat/

[7] Ukaogo, P.O., Ewuzie, U. and Onwuka, C.V. (2020) Environmental Pollution: Causes, Effects, and the Remedies. In: Chowdhary, P., Raj, A., Verma, D. and Akhter, Y. Eds., *Microorganisms for Sustainable Environment and Health*, Elsevier, Amsterdam, 419-429. https://doi.org/10.1016/B978-0-12-819001-2.00021-8

[8] United Nations (2018) Revision of World Urbanization Prospects. https://population.un.org/wup/

[9] Kerimray, A., Azbanbayev, E., Kenessov, B., Plotitsyn, P., Alimbayeva, D. and Karaca, F. (2020) Spatiotemporal Variations and Contributing factors of Air Pollutants in Almaty, Kazakhstan. *Aerosol and Air Quality Research*, **20**, 1340-1352. https://doi.org/10.4209/aaqr.2019.09.0464

[10] EPA (2021) Particulate Matter (PM) Basics. EPA, Environmental Protection Agency, Washington DC.

https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM

[11] Kenessariyev, U., Golub, A., Brody, M., Dosmukhametov, A., Amrin, M., Erzhanova, A. and Kenessary, D. (2013) Human Health Cost of Air Pollution in Kazakhstan. *Journal of Environmental Protection*, **4**, 869-876. https://doi.org/10.4236/jep.2013.48101

[12] Badenko, G., Kemelzhan, A. and Dzhakupov, R. (2021) Almatinskie avtomobili proidut ecologicheskuiu proverku [Almaty Automobiles Will Undergo Environmental Inspection]. Khabar 24. (In Russian) https://24.kz/ru/news/social/item/513939-mobilnye-posty-proveryayut-avtomobili-na-ekologiyu-v-almaty

[13] Almaty, T.V. (2022) Novye ekologichnye avtobusy vyshli na dorogi Almaty [New Environmental Busses Went out to Almaty Roads].

[14] Delovoi Kazakhstan (2020) Almatinskaia TETs-2: Gazifikatsiia [Almaty TPS: Gasification].

[15] Roberts, B., Stickley, A., Gilmore, A.B., Danishevski, K., Kizilova, K., Bryden, A., Rotman, D., Haerpfer, C. and McKee, M. (2013) Knowledge of the Health Impacts of Smoking and Public Attitudes towards Tobacco Control in the Former Soviet Union. *Tobacco Control*, **22**, e12. https://doi.org/10.1136/tobaccocontrol-2011-050249

[16] Rosenstock, I.M., Strecher, V.J. and Becker, M.H. (1988) Social Learning Theory and the Health Belief Model. *Health Education Quarterly*, **15**, 175-183. https://doi.org/10.1177/109019818801500203

[17] Dempster, N.R., Wildman, B.G., Masterson, T.L. and Omlor, G.J. (2018) Understanding Treatment Adherence with the Health Belief Model in Children with Cystic Fibrosis. *Health Education & Behavior*, **45**, 435-443. https://doi.org/10.1177/1090198117736346

[18] Fall, E., Izaute, M. and Chakroun-Baggioni, N. (2018) How Can the Health Belief Model and Self-Determination Theory Predict Both Influenza Vaccination and Vaccination Intention? A Longitudinal Study among University Students. *Psychology & Health*, **33**, 746-764. https://doi.org/10.1080/08870446.2017.1401623

[19] McFarland, D.M. (2013) Associations of Demographic Variables and the Health Belief Model Constructs with Pap Smear Screening among Urban Women in Botswana. *International Journal of Women's Health*, **5**, 709-716. https://doi.org/10.2147/IJWH.S50890

[20] Saghafi-Asl, M., Aliasgharzadeh, S. and Asghari-Jafarabadi, M. (2020) Factors Influencing Weight Management Behavior among College Students: An Application of the Health Belief Model. *PLOS ONE*, **15**, e0228058. https://doi.org/10.1371/journal.pone.0228058

[21] Carpenter, C.J. (2010) A Meta-Analysis of the Effectiveness of Health Belief Model Variables in Predicting Behavior. *Health Communication*, **25**, 661-669. https://doi.org/10.1080/10410236.2010.521906

[22] Al-Sabbagh, M.Q., Al-Ani, A., Mafrachi, B., Siyam, A., Isleem, U., Massad, F.I., Alsabbagh, Q. and Abufaraj, M. (2021) Predictors of Adherence with Home Quarantine during COVID-19 Crisis: The Case of Health Belief Model. *Psychology, Health & Medicine*, **27**, 215-227. https://doi.org/10.1080/13548506.2021.1871770

[23] Dumitrescu, C. and Iacob, C.I. (2021) Predicting Healthy Eating: Conscientiousness versus the Health Belief Model. Romanian *Journal of Applied Psychology*, **23**, 18-24. https://doi.org/10.24913/rjap.23.1.03

[24] Tainio, M., de Nazelle, A.J., Gotschi, T., Kahlmeier, S., Rojas-Rueda, D., Nieuwen-

huijsen, M.J., de Sá, T.H., Kelly, P. and Woodcock, J. (2016) Can Air Pollution Negate the Health Benefits of Cycling and Walking? *Preventive Medicine*, **87**, 233-236. https://doi.org/10.1016/j.ypmed.2016.02.002

[25] Carlisle, A.J. and Sharp, N.C.C. (2001) Exercise and Outdoor Ambient Air Pollution. *British Journal of Sports Medicine*, **35**, 214-222. https://doi.org/10.1136/bjsm.35.4.214

[26] Faghri, A., Boyle, P. and Lee, D. (2022) Review of Social Equity and Environment in Urban Transportation. *Current Urban Studies*, **10**, 556-574. https://doi.org/10.4236/cus.2022.104033

[27] Wilkinson, A.V., Vasudevan, V., Honn, S.E., Spitz, M.R. and Chamberlain, R.M. (2009) Sociodemographic Characteristics, Health Beliefs, and the Accuracy of Cancer Knowledge. *Journal of Cancer Education*, **24**, 58-64. https://doi.org/10.1080/08858190802664834

[28] Miller, K.M., Hofstetter, R., Krohmer, H. and Zhang, J.Z. (2011) How Should Consumers' Willingness to Pay Be Measured? An Empirical Comparison of State-of-the-Art Approaches. *Journal of Marketing Research*, **48**, 172-184. https://doi.org/10.1509/jmkr.48.1.172

[29] Breidert, C., Hahsler, M. and Reutterer, T. (2006) A Review of Methods for Measuring Willingness-to-Pay. *Innovative Marketing*, **2**, 8-32.

[30] OECD (2012) Mortality Risk Valuation in Environment, Health and Transport Policies. OECD Publishing, Paris. https://doi.org/10.1787/9789264130807-en

[31] Bureau of National Statistics (2023) Census Dashboard. Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. (In Russian) https://new.stat.gov.kz/ru/instuments/dashboards/8763/

[32] OECD (2007) Reviews of National Policies for Education: Higher Education in Kazakhstan. https://www.oecd.org/countries/kazakhstan/reviewsofnationalpoliciesforeducationhighereducationinkazakhstan.htm

[33] Bureau of National Statistics (2022) Higher Education in Republic of Kazakhstan. Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. (In Russian) https://new.stat.gov.kz/ru/industries/social-statistics/stat-edu-science-inno/publications/3921/