Personal Air Pollution Monitoring Technologies: User Practices and Preferences

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Abstract. Long-term exposure to air pollution can cause adverse health effects. Many efforts are underway to develop affordable, portable, and accurate technologies to help people monitor air pollution regularly. Although personal, wearable air pollution monitoring technologies are popular among some technology enthusiasts and citizen scientists, we know little about air pollution monitoring practices and preferences of lay individuals. We conducted a sequential explanatory mixed-methods study (*n* = 321) to understand people's current air pollution monitoring practices and their requirements for personal air pollution monitoring technologies. Although concerned about the adverse effects of air pollution (94%), less than 10% reported checking the levels of air pollution at least once a week. Respondents were more likely to carry a monitoring device as a bag accessory (74%) or wear it on their wrist (42%), than around their shoes, waist, or neck. If monitoring were available, however, it was unclear how much that would manifest behavior changes in individuals. We discuss how our findings can inform future technology design.

Keywords: Air Pollution Monitoring, Wearable, User Survey, Ubiquitous Computing, User Requirements, Design.

1 Introduction

Long-term exposure to air pollution is a well-established risk factor for several chronic diseases [1, 2, 3]. The World Health Organization attributes about 7 million premature deaths globally to air pollution [4]. Most recently, an increase of 1 $\mu g/m^3$ in $PM_{2.5}$ exposure was reported to be associated with an 8% increase in the COVID-19 (coronavirus disease) death rate [5]. Air pollution exposure accumulates over time, as individuals repeatedly come in contact with air pollutants, such as Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Ozone (O_3), or Particulate Matter (PM).

Traditionally, air pollution exposure is assessed retrospectively, at the population level, using kriging or land-use regression modeling based on highly sophisticated monitoring networks that collect data over time [6, 7]. In recent years, many low-cost air quality sensors have emerged. While there are some limitations to their performance, including sensitivity to relative humidity and aerosol composition [8, 9, 10], the latest generation of sensors have been found to have good long-term performance

[9] and reasonable accuracy and precision with calibration [11, 12]. These sensing advances have inspired many ubiquitous computing solutions to better understand the air pollution landscape of urban areas—via mobile measurement stations [13, 14, 15] or participatory urban sensing [16, 17].

The advances in low-cost air quality sensors have also made personal air pollution monitoring feasible, i.e., directly monitoring one's own exposure to air pollution over time. While the traditional air quality sensors (found in governmental monitoring stations) are large, expensive (> $20,000), stationary, and needs routine maintenance, the latest sensors are small (~ 5 cm), mobile, low-cost ($50 – $500), and do not require domain expertise to use when paired with appropriate data processing algorithms. Systems utilizing these low-cost air quality sensors can now (reasonably) accurately measure different air pollutants—from volatile organic compounds, like CO and O_3, to particulate matters, like PM_{10} and $PM_{2.5}$ [17, 18, 19, 20].

Nevertheless, the design and development of personal air pollution monitoring systems have just begun. Although portable and stationary indoor air quality monitoring devices have garnered some popularity among mainstream consumers [21], wearable environmental monitoring systems [22] still largely cater to citizen science and scientific research [17, 20, 23, 24]. Only a few, introduced most recently, target the general public [25, 26]; the extent of their acceptance, challenges, or use, however, remains unexplored.

Although prior research has repeatedly demonstrated the technological feasibility of affordable and accurate personal air pollution monitoring wearables [18, 19, 27], we know little about how people currently monitor air pollution around them or their preferences in personal air pollution monitoring technologies. To address this gap in the human-computer interaction (HCI) literature, we conducted a mixed-methods study to understand people's current air pollution monitoring practices and elicit their requirements for personal air pollution monitoring technologies. Drawing on empirical data, this paper contributes user requirements and design tradeoffs for personal air pollution monitoring technologies.

2 Methods

We adopted a sequential explanatory mixed-methods design to examine air pollution monitoring practices and preferences [28]. A mixed-methods design combine quantitative and qualitative methods to complement each other and allow for a more robust analysis than using only either one of the methods. A sequential explanatory mixed-methods design include two distinct phases: collecting and analyzing quantitative data followed by collecting and analyzing qualitative data. The quantitative phase informs the research questions of the qualitative phase. In turn, the qualitative data provides refinement and explanation of the statistical results in the quantitative data.

In our study, a set of qualitative interviews with technology probes (n = 7) followed an online survey (n = 314). Next, we discuss the quantitative results from the survey in Section 3 and the qualitative interviews in Section 4.

3 User Survey

3.1 Method

We designed an online survey with twenty-seven multiple-choice questions (Appendix A) to elicit (1) air pollution monitoring practices, (2) preferences about monitoring air pollution exposure, (3) sociodemographic characteristics, and (4) environmental attitudes. The survey was open for responses between April and November 2019. The target population was adults living and/or working in a metropolitan area. Recruitment occurred via advertisements on social media outlets, university mailing lists, and distributed by local community organizations. One participant was randomly selected to receive a $50 gift card. This study was reviewed and approved by the university's institutional review board (IRB).

3.2 Results

Demographics. A total of 314 respondents completed the survey. Respondents were 53.8% male and 43.3% female. Most of the respondents were between 18 to 44 years old (88.8%), Caucasian (44.1%), and employed (63.7%). Nearly half of the respondents' annual household income was less than $50,000 (46.6%), and only a quarter reported to be in a technical industry (25%). Respondents were largely from the greater Chicago area in midwestern United States. Detailed demographics are shown in Table 1.

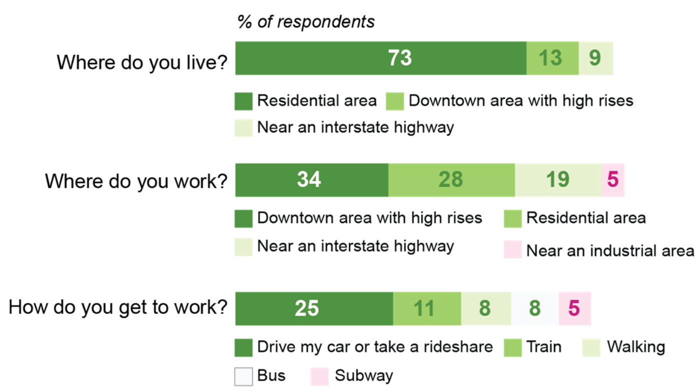

Fig. 1. Most of the respondents lived in a residential area (73%) and worked in a downtown area with high rises or residential area (62%).

Most respondents lived in a residential area (73%), worked in a downtown or residential area (62%), and went to work by car (Figure 1). Most respondents considered environmental pollution as an important global problem and expressed concern about the adverse health effects of chronic exposure to air pollution (Figure 2).

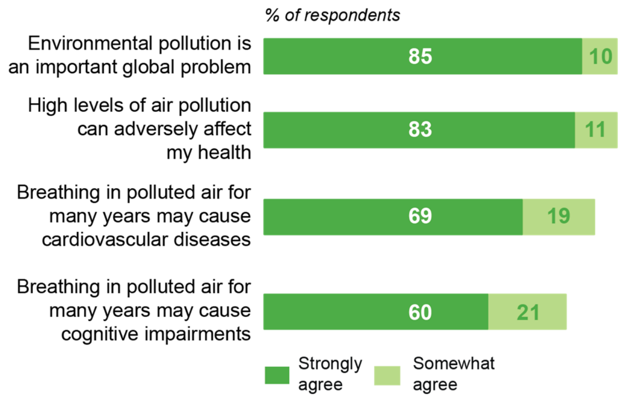

Fig. 2. A majority of respondents showed concern about the adverse health effects of air pollution. (5-Point Likert Scale)

Table 1. Participant Sociodemographics.

Participant Characteristics (*n* = 314)	Descriptive Statistics
Gender, *n* (%)	
Male	169 (53.8)
Female	136 (43.3)
Other	9 (2.9)
Age, *n* (%)	
18 – 24	164 (52.2)
25 – 44	115 (36.6)
45 – 64	24 (7.6)
65 or older	11 (3.5)
Ethnicity, *n* (%)	
Caucasian	137 (44.1)
African American	24 (7.7)
Hispanic or Latino	52 (16.6)
Education Level, *n* (%)	
Less than 4-year college	127 (40.5)
4-year college or more	187 (59.5)
Annual household income, *n* (%)	
Less than $50,000	132 (46.6)
$50,000 – $100,000	84 (29.7)
More than $100,000	67 (23.7)
Employed, *n* (%)	200 (63.7)
Primary industry, *n* (%)	
Scientific or Technical Services	29 (10.2)
Software	42 (14.8)
Computers and Electronics Manufacturing	17 (6)

Pollution Monitoring Practices. Although concerned about air pollution and its adverse effects (Figure 2), less than 10% of the respondents reported checking the levels of air pollution at least once a week. A majority of the respondents (60%) never checked air pollution levels (Figure 3).

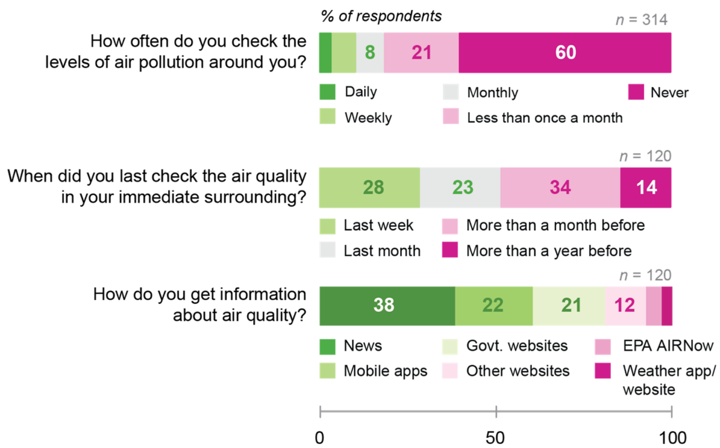

Fig. 3. Most of the respondents reported never checking the levels of air pollution around them. Among those who did, the top three sources of information were news, mobile apps, and government websites.

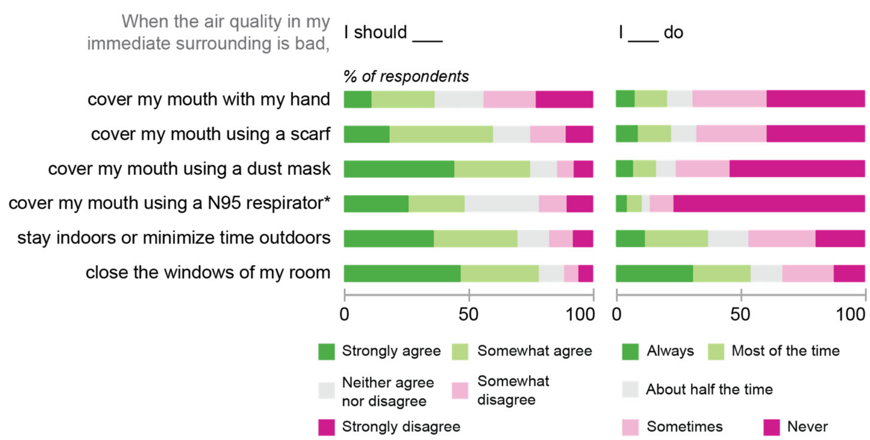

Fig. 4. Most respondents were aware of how to minimize exposure to air pollution, but few always took those steps. (*survey conducted before the 2019 – 20 coronavirus pandemic)

Among respondents who did check the air quality around them, diverse sources of information were used, including: the news (38%), mobile apps (22%), government websites (21%), or other websites (12%). Only nine (2.9%) respondents (either college students or people with an annual income of $100,000 or more) reported using any air quality monitoring devices. Those devices varied widely, from custom-made sensor boards to off-the-shelf products, like AirBeam[1], Dyson Pure Cool[2], Foobot[3] and Awair[4]. Two respondents reported using air purifiers as air quality monitors, although such devices do not directly offer air quality data to users. One person referred to his body as an air pollution monitoring device.

Most respondents were aware of how to minimize exposure to air pollution when air quality was poor, such as: to use a dust mask (74.5%), minimize time outdoors (69.4%), or close the windows of a room (78%). Respondents, however, rarely took all those steps (Figure 4).

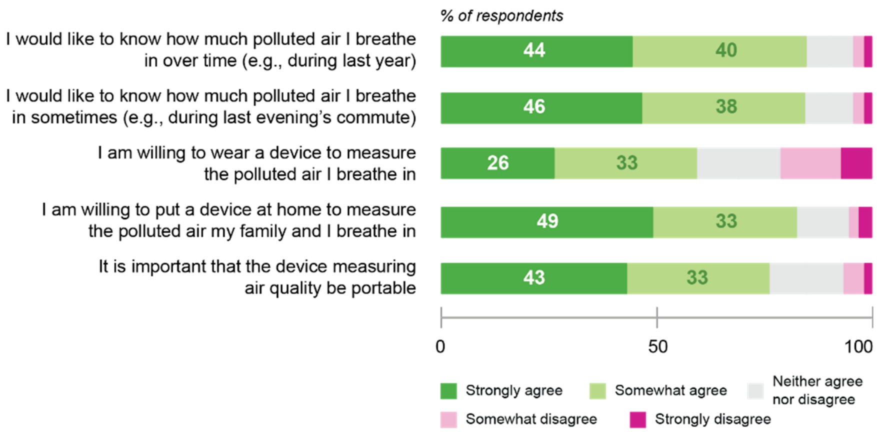

Fig. 5. The majority of respondents (84%) wanted to know how much air pollution they breathe in with time and were more willing to have a portable air quality monitoring device at home (82%) than to wear a device (59%).

Pollution Monitoring Preferences. Majorities of respondents wanted to know how much air pollution they breathe in, both over the long-term (e.g., over the last year, 84%) and short-term (e.g., during last evening's commute, 84%). While 82% of respondents were willing to have a portable air quality monitoring device at home, 59% were willing to wear one. Most respondents (76%) valued portability in an air quality monitoring device (Figure 5). When suggested that a personal device may more accurately measure their exposure to air pollution than estimates across neighborhoods from fixed monitoring sites, respondents were more likely to carry a device as a bag accessory (74%) or wear a device on their wrist (42%), than a device on or near their shoes, waist, or neck (Figure 6).

1 https://www.habitatmap.org/airbeam
2 https://www.dyson.com/purifiers/dyson-pure-cool-overview.html
3 https://foobot.io/
4 https://getawair.com/

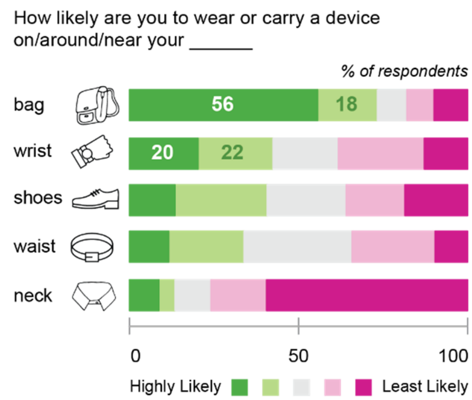

Fig. 6. The top two form-factor choices for a personal air quality monitoring device were bag accessory and wristwear.

Summary. In a convenience sample of 314 people living/working in a midwestern US metropolitan area, who were concerned about the adverse effects of air pollution, we found a considerable preference for monitoring personal pollution exposure (Figure 5). However, most respondents reported that they currently do not check or measure air pollution levels around them (Figure 3). Nevertheless, more people wanted to have a portable at-home air quality monitoring device than a wearable (Figure 5).

Greater Chicago has relatively low air pollution than many other parts of the world, which may have been why many respondents in this study reported never checking air pollution levels. The infrequent use of air pollution monitors may be due, in part, the relatively high cost of consumer-grade air quality monitoring devices ($200+), and/or their recent availability in the marketplace.

With respect to the design of personal air quality monitoring devices, respondents preferred to clip it on a bag or wear it on the wrist (Figure 6). Note that the age of our survey respondents was skewed toward the young (Table 1); thus, all our results may not extend to an older population. Furthermore, the levels of education and income do not appropriately reflect the full gamut of socioeconomical statuses (SES); air pollution monitoring practices and preferences of people with low SES or less formal education might be different from our survey findings.

While the survey results indicated a general preference toward personal air pollution monitoring, the data could not clarify 1) why people might not want to monitor air pollution, 2) why they preferred a keychain or wrist-wear like form factor, and 3) how would they use the monitoring data (given that most people rarely take actions to reduce their air pollution exposures). To find out, we designed an in-depth qualitative study with a technology probe.

4 Technology Probe Study

4.1 The Technology Probe

Technology probes are commonly used in HCI to collect information about the use and users of a technology. In this approach, users explore a fully functional technology prototype to think about how and whether the technology can support their needs and desires [29]. As a technology probe, we designed a personal air pollution monitoring tool using off-the-shelf air quality monitoring sensors (Figure 7).

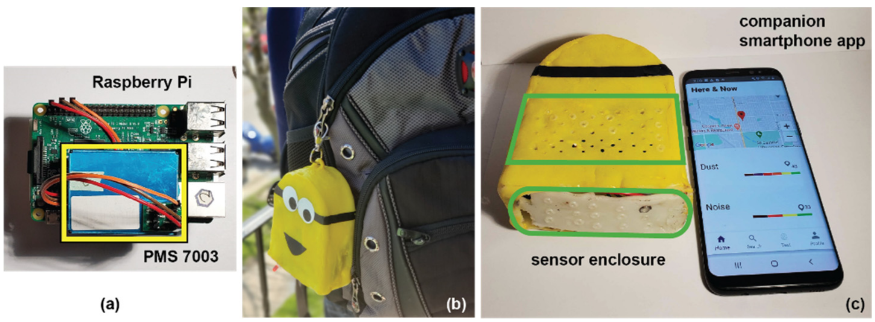

Fig. 7. Using a low-cost, off-the-shelf air quality sensor (a), we developed a technology probe for our interviews—a keychain device (b) with a companion smartphone application (c).

The probe used a $30 off-the-shelf particle concentration sensor, Plantower PMS7003 (48 mm x 32 mm x 12 mm). The PMS7003 operates using the principle of light scattering to measure the number concentration of airborne particles with aerodynamic diameters < 2.5 μm ($PM_{2.5}$) in real-time. The sensor was mounted on a third-generation single-board computer, Raspberry Pi 3b+ (85 mm x 56 mm x 17 mm), which included a 1.4 GHz 64-bit quad-core processor, a Bluetooth module, Wi-Fi, 1 GB RAM, and 16 GB storage. The Pi was powered with a 1000 mAh rechargeable LiPo battery at 3.7 V (30 mm x 40 mm x 7 mm). The device weighed about 100 gms.

Python scripts read data from the PMS7003, wrote data to a local or cloud database, and sent data to a companion smartphone application. When the device could connect to a wireless network, the sensor readings were logged to the cloud database (Amazon Web Services); otherwise, sensor readings were logged onto the smartphone via Bluetooth and sent to the cloud by the app when an internet connection became available. An Android application visualized the airborne particle concentrations so that users could monitor their current exposure to $PM_{2.5}$ (Figure 7c) and logged geolocation using the smartphone's global positioning system (GPS) receiver.

4.2 Method

In this phase, we targeted people who resided near an industrial area and/or belonged to a vulnerable group (e.g., older adults, people with cardiovascular or respiratory conditions). We chose this group as they could get a more immediate advantage from personal air pollution monitoring technologies as well as have specific system requirements that might not have emerged from the survey. Participants were recruited via social media posts and partnerships with local community organizations. Participants were not affiliated with the authors' institution.

Participants explored the technology probe, asked questions about it to the researchers, and then discussed whether they would use a similar technology, why or why not, and how. The study session lasted for about 30 to 40 minutes. The study was approved by the institutional IRB and participants were compensated with a $10 gift card for their time. Sessions were audio recorded, and iteratively analyzed for themes via memoing and group discussions.

Fig. 8. A study participant exploring the technology probe during the study.

4.3 Results

We interviewed seven individuals residing in the greater Chicago area. Their demographics are shown in Table 2. All participants reported strong concerns about the adverse health effects of air pollution. The first and last author open coded the data to uncover themes. Initial themes included how people see or smell air pollution around them, health concerns due to bad air quality, behaviors around bad air quality, advocacy, and interest in monitoring air pollution exposure. After further reflection and analysis via memoing and axial coding, the following five themes emerged[5].

[5] Negative or less than enthusiastic comments about personal air pollution monitoring are emphasized in red.

Table 2. Participant Sociodemographics

Participant	Age	Gender	Characteristic(s)
1	35	Male	lives in/near a heavy industrial area
2	72	Female	older adult, cardiovascular condition
3	27	Female	chronic respiratory condition, lives near a heavy industrial area
4	55	Female	chronic respiratory disease
5	70	Male	older adult
6	69	Female	older adult
7	47	Male	chronic respiratory condition

Smaller, Lighter, Modular. Participants wanted a system they could use both on-the-go and at home:

> *I'd think just with you. And then if you've it on your home, you could just mount it, if it needs to be charged, and that's your home syste*m —P1

> *I think it should be… especially for people like me...I have sinus problems and dust triggers sinus I think it will be very beneficial for people to use everywhere...in and out...with asthma and sinus infection* —P7

After exploring the technology probe, people wanted a smaller and lighter version ("*consolidated, compressed…size, maybe half of this*", "*an option of a watch is a good one"*, "*like a television remote control*", "*it's too bulky*"), something modular enough to wear, carry, or stow at home:

> *You can use a bigger one at home because you are putting it in one place [...] and then much more portable when you are out* —P5

> *Or almost similar to the air fresheners they have in the car and as you are driving wherever you go ... in the same context...because then you could just bring it home* —P1

To Monitor or not to Monitor. Monitoring attitudes differed across participants. Some wanted to know the air quality in their immediate surroundings to take actions, while others expressed apathy, anxiety, and almost a comfort in not knowing.

> *Well I guess I'd avoid if it was indicating that it was high levels ... I'd try to avoid it [the place] —P2*

> *It's good to know if the air around us is polluted with some of these [...] that could cause cancer at the long run right. So we get ahead of that [...] if we can detect it early enough then we can save the younger generation*
> *—P7*

> *Would I like to [monitor air quality]? Well ... the problem is if you monitor it what can you do about it. [...] To me it's almost better not to know. —P6*

> *If we went from red green yellow [...] will it give a person a sense of panic to a certain degree [...] I will be panicked..I will be like I gotta get out of here. I mean it's good but like do I really wanna panic all the time about seeing something..uhm..I don't know. —P3*

Access to Longitudinal Data. People wanted easy access to their long-time exposure data—to understand triggers to their chronic health conditions, inform others, and be aware of their neighborhood air quality.

> *Yeah, I think year long would be good. Just because I'd like to know if the pollutions are actually irritating me more and when ... are they really correlating to when I get sick because it's the cold or they're correlating because there is something in the air.* —P3

> *[...] it could tell you the quality of the air per where you were in the day. So now you have a better idea ok the air was terrible [...] you could look at where was I, what was I doing while I was there, and then you could even send that back to those people and say hey can you do something about your air quality there* —P1

> *I might consider at some point where can I move to where there is less pollution. If I can compare like living here in the city to maybe [...] depending on how it affected me personally like noticing that my health was being affected where can I live that there's less of this* —P4

Ambivalence toward Lifestyle Changes. If personal pollution monitoring were available, how much people would change their behaviors to reduce air pollution exposure was fraught with ambivalence. Some were optimistic about actions they could/would take, while others were realistic about the lack of actionable steps outside home.

> *I will analyze it and see how safe to live in that area and if it is not safe either we do something about it and if it's not in our power we move* —P7

> *how can I better it like presenting this stuff to your bosses and you coworkers to say this is how bad the air is here, what can we do to clean it* —P1

> *If it's indoors [...] I can maybe install a filtration or air cleaning system. I don't know what I can really do about it [pollution] as far as what's outside unless we start wearing those [...] protective masks or walk around in those hazmat suits* —P4

> *There's not much really that you can do other than promote like carpool or walking* —P3

Advocacy Goals. An interest in using the data to advocate for environmental changes at a community or state level emerged.

> *well if your neighbors all had something similar you could petition to your alderman to do something about the air quality or if there's a city bureau. I mean if you have data that's why you go up there [town hall, local government] you don't use opinions* —P6

4.4 Summary

The interview data elaborated our survey findings. The limited options in controlling personal exposure to air pollution appeared to demotivate the use of any personal air pollution monitoring tool. The qualitative data also elaborated the form factor requirements of a personal air pollution monitoring tool beyond a particular accessory type. Different ways of using exposure data emerged, such as to correlate with sick days, to decide which neighborhood to live in, or to share it with community leaders to facilitate changes beyond one's personal control. Next, we discuss the user requirements that emerged from the mixed-methods study and identify the associated design tradeoffs.

5 Discussion

Study results indicate that among people who are concerned about the adverse effects of air pollution, there is a high preference for monitoring personal pollution exposures over time (84%, Figure 5). However, despite that, and the current pollution monitoring technologies available at no additional cost, such as government websites[6] or smartphone apps, most people never check the levels of air pollution around them (60%, Figure 3). One could reasonably argue that this might be because those widely available air pollution monitoring technologies are rarely *personal*; they offer air pollution estimates at the county or neighborhood level. For instance, there are four $PM_{2.5}$ governmental monitoring stations in greater Chicago, and most operate on a 1-in-6 or 1-in-4-day sensing schedule [30]. Nevertheless, other factors emerged from our study that has important implications for the future uptake and use of personal air pollution monitoring technologies.

5.1 Design Issues

Our study revealed a set of preferences for a personal air pollution monitoring device, such as high mobility, lightness, and easy access to longitudinal data. From what we know technologically about how current personal air pollution monitoring works [22], user requirements did not always align with the optimal operating conditions. User preferences for form factors may have been biased by the ubiquitous computing devices in wide use today, like smartphones and smartwatches. Table 3 lists the user requirements that emerged from our study, some design solution examples, and design tradeoffs associated with those solutions. In describing the design requirements

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[6] https://www.airnow.gov/

for personal air pollution monitoring systems, we do not anchor to a particular technology or sensor; rather, we acknowledge the current technological limitations in the personal air pollution monitoring field [22].

Table 3. User Requirements for Personal Air Pollution Monitoring Systems.

User Requirement	Design Solution (for example)	Associated Design Tradeoff(s)
A small, light, carriable system	A wearable wrist-worn monitor using low-cost sensor components	• Accuracy may be unreliable at certain concentrations of air pollutants • A smaller battery implies repeated charging • Human skin emissions may interfere with air pollutant readings
Good accuracy	A correction model to calibrate the sensor performance	• Additional environmental sensors may be needed to achieve good calibration; thus, making the system bulkier and/or larger • Multiple calibrations may be needed to address sensor ageing effects, seasonal changes, or any prior calibration errors
Easy access to daily, weekly, monthly, and yearly average air pollution exposure data	Offer a companion app/website with daily, weekly, monthly, and yearly average air pollution exposure and levels for adverse health effects	• Long-term air pollution exposure affects health outcomes differently for different demographics, but that research is still in its early stages and not yet fully standardized • Data may generate anxiety and helplessness among users without the means to take any steps to reduce pollution exposure
Tangible actions to reduce air pollution exposure	Use time and location (GPS) information to identify pollution hotspots	• Asking users to have their GPS always on will have privacy issues • Logging users' location information to aggregate long-term pollution exposure data will make them vulnerable to security breaches

5.2 Socioeconomic Issues

Very few people (2.9%) reported owning/using an air pollution monitoring device. Furthermore, higher levels of education and income correlated with the ownership of a personal air pollution monitoring technology. This was expected given the current innovation stage of personal pollution monitoring technologies. As the sensing technology advances, these systems are expected to get affordable and widely available.

Nevertheless, the qualitative data indicated that people perceive air pollution as a public health issue, not a personal issue. Thus, participants expected air pollution monitoring devices to be made freely available by the city or state as a utility, not something they would want to buy personally. This view was expressed by three older participants (P4, 55; P5, 70; P6; 69) in our interviews. Older adults, however, are more vulnerable to air pollution and could get a more immediate advantage from personal air pollution monitoring. Note that participants self-selected for our study, which already indicated an interest in the technology. We observed that the willingness to pay (WTP) widely varied by age. Future controlled studies with larger sample sizes are needed to confirm this trend. Nevertheless, it is worth noting that personal air pollution monitoring can be most beneficial to the older adults and people with low SES.

5.3 Sociotechnical Issues

Our interviews revealed that even if an affordable and accurate air pollution monitoring device is available, some people may not want to use it regularly because of *the lack of tangible steps* available to an individual to reduce personal air pollution exposure. This finding unveils an interesting dichotomy. If enough people are monitoring and trying to reduce their personal air pollution exposure, apart from individual lifestyle changes, their awareness and advocacy can bring about big societal changes. Unfortunately, the prospect of only a long-term reward may not be enough for general technology adoption and use. Future personal monitoring systems must think about how to present tangible steps to users to not only monitor their air pollution exposure but significantly reduce it over time and thus, get personal health benefits. For example, predicting to a runner how running at a different time of the day or taking a different route may result in x% less PM exposure in the next month compared with the last. In sum, this is a hard sociotechnical problem that remains to be addressed.

5.4 Study Limitations

Our study is not without limitations. The survey used a convenience sample, which may have impacted the results. Greater Chicago does not have pollution levels comparable to some of the most polluted areas globally. People residing in those areas may have different perceptions and practices toward air pollution monitoring, not only because of the levels of pollution but also due to sociocultural factors. Future studies focusing on vulnerable populations may elicit additional user requirements that we missed due to our participant demographics.

6 Conclusion

In this paper, we presented empirical data on people's air pollution monitoring practices and preferences. Results indicate a preference for air pollution monitoring devices that can be used both outside and inside home. Whether people would adopt and heavily use personal air pollution monitoring devices will depend on how monitoring devices offer tangible steps for them to reduce pollution exposures. At present, few people monitor the levels of air pollution around them, and way fewer own or use an air pollution monitoring device. But the increasing affordability of these systems, as technology advances, may increase adoption in the future. Nevertheless, the sociotechnical issue of short-term vs. long-term reward may hinder a wider uptake and use of personal air pollution monitoring technologies.

Acknowledgements

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Appendix A: Survey Questions

Q1. How often do you check the levels of air pollution (i.e., air quality) around you?
Never Less than once a month Monthly Weekly Daily

Q2. When did you last check the air quality in your immediate surrounding? (e.g., measured using a device or visited a government website, such as https://airnow.gov)
Never More than a year before More than a month before Last month
Last week

Q3. How do you get information about air quality? (Choose all that apply.)
News Government website Other websites
EPA AIRNow mobile app Other mobile apps Other I don't

Q4. Do you use any air quality monitoring devices?
Yes No

Q5. Do you own/use any of the following air quality monitoring devices? (Choose all that apply.)
Dylos Airbeam Foobot Dyson Pure Cool Xiaomi Mi Air Purifier Pro
Awair uHoo PurpleAir Healthy Home Coach by Netatmo
AirVisual Pro Blueair Aware Other I don't own any device.

Q6. The air quality in your immediate surrounding is bad. Now consider the following statements.
I should cover my mouth with my hand.
Strongly disagree Somewhat disagree Neither agree nor disagree
Somewhat agree Strongly agree

I should cover my mouth using a scarf.
I should cover my mouth using a dust mask.
I should cover my mouth using a N95 respirator.
I should stay indoors or minimize time outdoors.
I should close the windows of my room.

Q7. The air quality in your immediate surrounding is bad. How often do you?
Cover your mouth with your hand.
Strongly disagree Somewhat disagree Neither agree nor disagree
Somewhat agree Strongly agree

Cover your mouth using a scarf.
Cover your mouth using a dust mask.

Cover your mouth using a N95 respirator.
Stay indoors or minimize time outdoors.
Close the windows of your room.

Q8. Research has shown that pollution levels measured with a personal device are little different and more personal than estimated across neighborhoods from fixed monitoring sites. Please state how much you agree or disagree with the following statements.

I would like to know how much polluted air I breathe in over time (e.g., during last year).

Strongly disagree Somewhat disagree Neither agree nor disagree
Somewhat agree Strongly agree

I would like to know how much polluted air I breathe in sometimes (e.g., during last evening's commute).
I am willing to wear a device to measure the polluted air I breathe in.
I am willing to put a device at home to measure the polluted air my family and I breathe in.
It is important that the device measuring air quality around me be portable.

Q9. You are offered a device that can measure your daily exposure to air pollution. The device needs to be worn outside, over your topmost layer of clothing, to accurately measure the air quality around you. How likely are you to wear or carry a device like this? Please rank in the order of your preference. (Rank 1 means highly likely, rank 5 means least likely. Images show some examples.)

___on or near your bag
___around or near your waist
___around or near your neck
___on or near your shoes

Q10. Please state how much you agree or disagree with the following statements:

Environmental pollution is an important global problem.

Strongly disagree Somewhat disagree Neither agree nor disagree
Somewhat agree Strongly agree

High levels of air pollution can adversely affect my health and my family's health.
Breathing in polluted air for many years may cause cardiovascular diseases.
Breathing in polluted air for many years may cause cognitive impairments.

Demographics