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The politics of airing grievances: an analysis of air quality knowledge and ignorance in Pittsburgh

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ABSTRACT

Pittsburgh's airshed is among the most surveilled and studied in the United States, yet its residents continue to endure some of the worst air quality in the United States. In 2016, in response to the decades-long failure of the local Board of Health to take decisive action against regional polluters, Pittsburgh residents began documenting their air quality complaints using the Smell Pittsburgh app. Drawing from an analysis of thousands of Smell Pittsburgh users' reports, interviews with local air activists, and observations of Board of Health meetings, we investigate why air quality authorities dismiss the information generated by Smell Pittsburgh. By examining the Smell Pittsburgh data and asking what is being ignored by environmental regulators, we show that the app is threatening insofar as it serves as a repository of uncomfortable knowledge that testifies to the extent of environmental suffering generated by the region's hazardous air.

Introduction

Over the past twenty years, Pittsburgh, PA has consistently been lauded as one of the most liveable cities in the U.S. (Torrance 2019), while also ranking amongst the worst for air quality. Allegheny County, which encompasses the city of Pittsburgh and several surrounding smaller cities, townships and boroughs is in the top 2% of all counties in the U.S. for lifetime cancer risk from exposure to hazardous air pollutants such as formaldehyde, benzene, coke oven emissions, carbon tetrachloride, and diesel particulate matter (Michanowicz et al. 2012). The county also leads the country in excess deaths and illness from exposure to particulate matter (4th) and ozone (16th) (Cromar, Gladson, and Ewart 2019). While transportation and residential activities contribute to the problem, large industrial operations (i.e. manufacturing facilities, landfills, and electricity generation stations) account for more than half of the region's air pollution emissions inventory. Of the nearly 400 local industrial sources, only ten large facilities produce 90% of the county's emissions of six "criteria pollutants", consisting of ground-level ozone, particulate matter, carbon monoxide, lead, sulphur dioxide and nitrogen dioxide (Kelly 2023). While the risks associated with air pollution are certainly pervasive, existing research also demonstrates that exposure is conditioned by race and class. For example, Black people in Pittsburgh are at a higher risk of cardiovascular disease due to a greater likelihood of living near major sources of pollution, including high-volume roadways and industrial facilities (Erqou et al. 2018).

Given the severity of the local air pollution problem, it is perhaps unsurprising that Pittsburgh is also home to a large number of civic groups dedicated to addressing the region's hazardous air

quality. These include organisations like the Group Against Smog and Pollution (GASP), Allegheny County Clean Air Now (ACCAN), PennEnvironment, the Breathe Collaborative (a coalition of over 50 organisations), and research centres at Carnegie Mellon University and the University of Pittsburgh, among others. In addition to advocacy, political organising, and educational efforts, these groups draw on their own toolkit of methods and instruments for surveilling the offending industrial polluters. For instance, the Breathe Project operates cameras trained on all of U.S. Steel's sites in the region. Meanwhile, groups like GASP and ACCAN have helped residents become trained and certified in visually evaluating industrial smokestacks for emissions violations. At the same time, local air activists coordinate an ever-growing network of residential outdoor air quality monitors (such as PurpleAir monitors) that capture data on particulate matter and volatile organic compounds independent of the instruments used by the state to regulate hazardous emissions.

Since 2016, thousands of residents in the Greater Pittsburgh region have used a smartphone application, Smell Pittsburgh, to report and monitor the region's disturbingly frequent poor air quality. While regulators initially applauded the use of this tool, they later reversed their support, denouncing the app's utility and casting doubt on the validity of the information collected by its users. As a result, the app's thousands of smell reports (which had been previously included in the count of air quality complaints at Allegheny County Board of Health meetings) were excluded from the official record. Instead of using the Smell Pittsburgh app, air quality regulators urged residents to contact the Department of Health directly via phone or by filing a complaint online.

As residents of the city and sociologists concerned with environmental politics, this turn of events raised a puzzling question. Why would air quality regulators reject a tool generating knowledge concerning the public's experience with air quality – especially one that is more accessible and user-friendly than the existing official channels for airing grievance? We argue that this situation, in which a regulatory institution responsible for protecting environmental health dismisses a vital tool and source of information about an ongoing crisis, demonstrates how the politics of knowledge is highly relevant to socioenvironmental dynamics, especially when it comes to air quality.

Contemporary environmental politics is rife with disputes that revolve around knowledge and ignorance. Consider, for example, the persistent and organised denial of climate change (McCright and Dunlap 2010; Norgaard 2011), the minimisation of risks associated with mega-dams (Huber 2019) and mining operations (Lawrence 2022), or the reoccurring problem of research agendas prioritised by social movements and civic organisations remaining underfunded, incomplete, or entirely ignored (Frickel et al. 2010). As for air quality, research suggests that *more* air quality knowledge does not necessarily result in the resolution of such a complex socioenvironmental problem.

For instance, Ottinger (2009) analyses the case of Chalmette, Louisiana, where residents, regulators, and ExxonMobil oil refinery technicians deployed air quality monitoring instruments at the facility's fence-line, investigating the question of whether fence-line air quality monitoring erodes the epistemic boundaries dividing lay and expert air quality knowledge. Her analysis reveals that despite the use of similar air monitoring instruments and data, a major shift in epistemic boundaries did not occur because of the divergent contexts – of regulation, problem-solving, or systemic danger – in which air quality data are deployed and interpreted. In subsequent research, Ottinger (2010) further argues that atmospheric surveillance is not in and of itself empowering to the citizens that deploy air quality monitoring tools in an attempt to protect their community's health. Instead, Ottinger contends that community-based air quality monitoring is only empowering to the extent that the context in which the surveillance data is deployed and interpreted empowers the groups using it. Thus, when utilised in the context of direct contact with industrial facilities, citizen scientists deploying bucket air monitors in Louisiana used their surveillance data to define their exposure to dangerous chemicals in the air as an important issue. Whereas, when used in a context of interaction with regulators, surveillance data could give citizens the power to enforce the law, particularly when measurements indicated air pollutants in excess of the regulatory standards. Most importantly for us, however, Ottinger's research suggests that the prevailing forms of air quality knowledge regarded as valid, and thus actionable, emerge from processes of social

construction and political contestation, in which ignorance constitutes a pivotal element (Kleinman and Suryanarayanan 2013).

As much is true in Pittsburgh, where people mobilise various forms of air quality knowledge in divergent contexts – from cancelling another afternoon run because hydrogen sulphide hangs in the air (as indicated by the "rotten eggs" smell) to the government issuing yet another "Code Orange Air Quality Action Day" (as indicated by the air quality index) to the courtroom where health department lawyers argue that a corporation must again pay fines for violating air quality standards (as indicated by a visible emissions test at its coke oven battery). Nonetheless, while a Pittsburgh-area resident might ignore the smell of rotten eggs in the air or the air quality index on any given day at their own peril, it is in the context of governing air quality – the dynamic between residents, activists, civic organisations, corporate polluters, and the regulatory state – that the political significance of ignorance is most salient.

In this article, we shed light on the politics of air quality knowledge in Pittsburgh by considering why regulatory actors would ignore, dismiss, and disavow the knowledge generated by Smell Pittsburgh users. We show that the app is threatening insofar as it serves as a repository of experiential knowledge that testifies to the extent of "environmental suffering" generated by the region's hazardous air. In using the term environmental suffering we draw on the work of Auyero and Swistun (2009) who define environmental suffering as "a particular form of social suffering caused by the concrete polluting actions of specific actors" (17). Experiential knowledge and environmental suffering are *uncomfortable* for regulators because they underscore institutional inefficacy as well as highlight contradictions in the official narrative of "progress" regarding air quality issues. In the following section, we briefly outline our methods. Next, we discuss how the epistemic form associated with air quality governance in Pittsburgh has shifted over time. We then turn to the Smell Pittsburgh application and our analysis of the information generated by its users to think about why local air quality authorities would reject such a tool. Finally, we conclude by unpacking the implications of our analysis.

Data and methods

On a reflexive note, since moving to Pittsburgh, we have both experienced the air pollution problem rather acutely, even though we live in different neighbourhoods on opposite sides of the city. We have experienced how industrial air pollution can wake you up in the middle of the night or greet you in the morning as you head out for a morning walk. We know the frustration of contacting local authorities in hopes of immediate remediation of an acute situation, only to feel as though our complaints ultimately vanished into thin air. We, too, have come to rely on the Smell Pittsburgh application to navigate daily life in a city inundated with ambient air toxics. For these reasons, we have had no choice but to approach this research as both concerned residents and sociologists.

For the present study, we draw from several different sources of data, including the publicly accessible Smell Pittsburgh data, observation of board of health meetings, participant-observation with local air quality activist groups, and semi-structured interviews with people involved with air advocacy in the Pittsburgh region. We initially started research on the politics of air pollution in Pittsburgh in 2018. To gain a better sense of the dynamic between citizens mobilising for better air quality and the governmental institution responsible for protecting public health, we began attending, observing, and participating in events held by air quality activists as well as meetings of the Allegheny County Board of Health's public meetings. In both settings, we noticed the importance that the residents placed on the Smell Pittsburgh app, while figures in governance were dismissive of its utility. In April 2019, during the initial phase of our ethnographic research, a local non-profit organisation focused on air quality extended an invitation for us to receive training to become certified citizen "smoke readers". We were delighted at the opportunity to become more acquainted with one of the primary methods of air quality surveillance, especially since we had learned that smoke reading was one of the tools that air quality activists had relied upon in trying to hold

polluting facilities accountable. We attended a two-day visible emissions training programme, known as "Smoke School", in which we learned to visually read the opacity of industrial plumes in accordance with EPA methods. We were then tested and certified as smoke readers.

In addition to ethnographic data collection, between 2018 and 2021, we conducted semi-structured interviews with 20 air pollution activists from several different organisations based in Pittsburgh, including the developers of the Smell Pittsburgh application from Carnegie Mellon University's Community Robotics, Education and Technology Empowerment Lab (Create Lab). Note that we use pseudonyms for the people that we interviewed for this project. We also collected and examined documents from Allegheny County Health Department's website, including, but not limited to, all public meeting minutes (2015–2020) and reports on air quality enforcement actions. Most importantly for the present analysis, we examined the Smell Pittsburgh reports dating back to the app's launch in June of 2016 through March 2020, which totalled 43,402. Of these, we extracted reports with written comments which resulted in 7789 entries. Our research team then coded these 7789 individual smell reports to get a better understanding of the kind of information being communicated by Smell Pittsburgh users. The categories we coded for included emotional tone (affect), mention of quotidian disruption, health issues, perceived sources of pollution, and general appeals for intervention on the part of the government.

The politics of air quality knowledge/ignorance in Pittsburgh

Pittsburgh's atmospheric issues are as old as the city itself (Tarr 1996, 2002). As a young settlement, Pittsburgh's growth was sustained by the coal-laden hills encompassing the region. By the early 1800s, people had begun to associate the city with smoke, describing its atmosphere as filthy and gloomy (Zipper, Adams, and Skousen 2021). Although some residents expressed discontent with smoke around this time, the city's first attempts to regulate its atmosphere did not begin until the 1890s with a series of weakly enforced smoke control ordinances (Davidson 1979). In 1941, the city passed a more serious smoke control ordinance that established the Bureau of Smoke Prevention under the city's Department of Health. The Allegheny County Health Department (ACHD), created in 1957, combined city and county efforts towards air pollution control.

At the state level, the Pennsylvania Department of Environmental Regulation (now known as the Department of Environmental Protection) was founded in 1960, and three years later Congress passed the landmark Clean Air Act of 1963, a federal statute that regulates air emissions from stationary and mobile sources and includes National Ambient Air Quality Standards (NAAQS). Created in 1970, the federal Environmental Protection Agency (EPA), assumed responsibility for implementing the Clean Air Act through rulemaking and setting air quality standards. Today, the EPA provides funding to state and local programmes, and is responsible for creating and disseminating the technology for monitoring pollution (e.g. local EPA ambient air monitors). In conjunction with this, state and local programmes are responsible for measuring air quality, regulating, enforcing, and issuing permits to pollution sources, implementing federal rules, developing plans to meet NAAQS, and tracking emissions.

ACHD's Air Quality Programme employs approximately 45 staff members, including engineers, scientists, administrators, technicians, clerical staff, and several attorneys. As administrators of the local air programme, ACHD is empowered to enforce federal, state, and local regulations stemming from both the Clean Air Act, the PA Air Pollution Control Act, and the Local Health Administration law (Article XXI). Of these, the first two Acts are the most technical, and rely heavily on numeric measurements of air pollutants to determine what action is possible. As one ACHD official stated publicly in 2020, "When you work for a state agency you only enforce the numbers … you know, the Clean Air Act says x. You have a standard and all you're trying to do is meet that standard". In contrast, the local law provides much broader authority to the agency to take actions to protect public health, such as the use of enforcement orders that can compel local industry to pause production ("hot idle") when weather events are predicted to trap pollutants close to the ground for an extended period of time.

The Air Quality Programme itself is composed of five core sections that contribute to regulatory efforts through (1) emissions inventory, (2) planning and data analysis, (3) permitting, (4) enforcement, and (5) air quality monitoring. Despite their different roles in air quality governance, each section is in part dependent upon information generated by the network of 13 air quality monitoring stations sited strategically throughout the county.

Before the rise of automated air quality monitoring, government smoke inspectors responded to complaints by citizens and patrolled city streets looking for signs of industrial or domestic burning that violated air pollution control laws. These early attempts to govern the atmosphere relied more directly upon human sensory perception, as "[n]o instrument more complex than the human eye and the Ringelmann chart" was ever used to assess the density of smoke (Longhurst 2005). The advent of automated sampling devices for several pollutants, as well as advances in digital technologies during the 1960s, meant that by 1970 ACHD was operating seven stations which provided regulators with constantly updated and automatically reported air pollution measurements from across the county. These measurements were then used by the county's air pollution control engineers to construct Pittsburgh's first air pollution index (API) in 1971 (Longhurst 2005).

Consequently, in a matter of decades, the epistemic form associated with atmospheric governance in Pittsburgh (and the broader United States) shifted significantly. Yet, as Kleinman and Suryanarayanan (2013, 492) argue, dominant epistemic forms, or "the suite of concepts, methods, measures, and interpretations that shapes the ways in which actors produce knowledge and ignorance in their professional/intellectual fields of practice", rarely reflect the intrinsic superiority of institutionalised practices, and can lead to the marginalisation or dismissal of knowledge produced by alternatives. For example, in 1971 when ACHD introduced their newly developed Air Pollution Index (API) to the public, activists immediately pointed out major flaws which ACHD did little to address. The Group Against Smog and Pollution (GASP) highlighted what the network of monitoring stations – as part of the newly predominant epistemic form – enabled ACHD to *ignore* about the quality of Pittsburgh's air. They criticised the API for being "'laundered' sufficiently to produce 'acceptable' readings often enough", which was only possible because the government was "averaging readings from seven telemetered stations – any one of which can sit adjacent to an unspeakably [*sic*] dirty mill and read acceptably clean" (Longhurst 2005, 36). Thus, the rise of air quality monitoring and modelling as the dominant epistemic form associated with governing atmospheric conditions is not without political consequences. To some extent, reliance on these instruments alone leaves little room for the air quality knowledge generated by nongovernmental actors to be consequential in the fight to stem this public health crisis.

Within this framework of governance, when residents experience poor air quality they are encouraged to report bad smells, signs of smoke, or other emissions to ACHD. Official complaints are reported by calling a designated air quality hotline or by filling out a form online, with the latter option being preferred by ACHD. Another way for residents to share their air quality grievances is by making public comments on air quality planning documents (e.g. permits and state implementation plans) at public meetings convened by the Allegheny County Board of Health (BOH), a nine-member governing body comprised of members appointed by the County's Chief Executive. For the past several years, over half of the BOH members have been medical doctors. BOH members appoint and advise the County Health Director who leads ACHD, and perform duties that include formulating rules and regulations for disease prevention; preventing or addressing conditions that threaten public health; and reviewing and approving expenditures. Public meetings of the BOH convene every other month throughout the year and they reserve time at the end of each meeting for public comment. The relative infrequency of these meetings, and the fact that they take place in the middle of the work day, mean that they are inaccessible to wide swathes of the public.

Even still, a handful of air quality advocates are present at nearly every BOH meeting. Our analysis of meeting minutes between 2015 and 2020 revealed that roughly 68% (or 197 of 289) of public comments at BOH meetings directly referenced air quality. This figure alone shows the prominence of the issue in the public consciousness and residents' commitment to bringing the issue to the

attention of local government officials. And yet, as we saw firsthand, the public comment period is often the least well-attended portion of BOH meetings in terms of the active presence of government officials. Our observations revealed that it was not unusual for board members to excuse themselves to take phone calls or depart early while concerned citizens were delivering their comments. Tellingly, in all the meetings we attended between 2018 and 2019, we never witnessed a BOH member offer any kind of verbal response to the individuals who testified. Several of our informants remarked on the BOH's frigid reception to public comment, including Elizabeth, a woman who told us that she testified multiple times over the years on issues related to fracking and air quality:

> The first time we went it was as a group regarding fracking … and [the response from the Board of Health] was such a dismissal … you know, you go up there, you speak your comments, and then people are looking at their phones, or they walk away, and there's no response, and then there is never a follow up, right? So, you're just like 'this is a complete waste of time.'

Frustration in response to the BOH's perceived lack of genuine or empathetic public engagement was expressed by several residents we spoke with and helps to explain why some residents have sought alternative avenues for expressing their concerns with the region's air pollution problem.

In 2016, Carnegie Mellon's CREATE (Community Robotics, Education and Technology Empowerment) Lab officially launched Smell Pittsburgh, a mobile phone application that crowdsources smell reports in order to track how pollutants disperse across Pittsburgh. In brief, the app contains a simple form consisting of four fields which ask the user to (1) rate the strength of the smell on a colour coded 5-point scale, (2) describe the odour, (3) list any physical symptoms linked to the odour, and/or (4) provide additional comments or feedback. Another prominent feature of the app is a map which populates with smell reports throughout each day, allowing users to see how others have rated the air quality across the city in real-time. On days with extremely poor air quality, it is common to see the map filled with dark red triangles signifying reports of a strong stench.

Smell Pittsburgh's creators told us that when the app was initially launched in 2016, ACHD received an email for every smell report submitted to the app. Soon though, the volume of the data became overwhelming for the agency. To date, it is unclear to what extent ACHD views or utilises the data they receive from the app. What is evident, however, is that ACHD has attempted to distance itself from the app. Between September 2018 and May 2019, ACHD's Deputy Director of Environmental Health included Smell Pittsburgh reports in the total number of air quality complaints reported at BOH meetings. At the July 2019 BOH meeting, however, this practice had ceased and the Deputy Director began to encourage residents to submit complaints via ACHD's own complaint hotline and webform. The agency's unfavourable attitude towards the app was also underscored in multiple conversations with an ACHD air quality hotline employee who repeated the assertion that Smell Pittsburgh data were compromised, and told us that app users were engaging in "slacktivism". This claim about the data, however, was not supported by our findings. Our analysis of over 7000 smell reports made over 4 years found very few (<25) reports that appeared disingenuous.

Initially, we found ACHD's dismissal of the Smell Pittsburgh app baffling. The app's ease of use invited greater civic participation in air quality governance while also supplying a large volume of timestamped and geo-located data on air pollution. We also found it puzzling that ACHD would reject a tool that it had contributed to developing. As the creators of Smell Pittsburgh write,

> We met and worked with staff in ACHD to determine how they hoped to utilize smell report data and adjusted elements of the application to better suit their needs, such as sending data directly to their database and using these data as evidence of air pollution. Based on their feedback, the system submitted all smell reports to the health department, regardless of the smell rating. This approach provided ACHD with a more comprehensive picture of the local pollution landscape (Hsu et al. 2020, 32).

To make sense of why ACHD, the institution tasked with protecting public health and monitoring and regulating air pollution, would choose to ignore such a tool, we closely examined the information generated by Smell Pittsburgh.

Smell Pittsburgh, environmental suffering, and uncomfortable knowledge

After analysing the corpus of air quality knowledge generated by Smell Pittsburgh users, we better understand why a regulatory agency like ACHD would want to quash it: the app is a source of deeply "uncomfortable knowledge". As Steve Rayner writes, "In the context of wicked problems [like air pollution] and clumsy solutions [like air quality governance], uncomfortable knowledge is disruptive knowledge. It may be information or understanding that is available to certain parties, but cannot be acknowledged by others" (2012, 113). He argues that there are at least four ways that institutions or organisations respond to such knowledge: denial, dismissal, diversion, and displacement.

What makes the knowledge generated by Smell Pittsburgh uncomfortable knowledge? We contend, first and foremost, that it is uncomfortable because the descriptions of environmental suffering embedded in the comments raise legitimate questions about the extent to which the agency charged with regulating air quality is able and willing to protect the public from industrial pollution. This is embarrassing to the agency and also threatens to undermine its authority and image. Secondly, nearly all of the data collected by the app falls into the category of experiential ("lay") knowledge of the environment, a type of knowledge that is not highly valued in the context of the modern, technocratic system of governance in the United States. In the following sections, we expand on these arguments as we identify and discuss three broad categories of experiential knowledge that appear in the Smell Pittsburgh reports. This knowledge relates to: (1) health impacts, (2) disruptions to daily life, and (3) emotion/affect.

Health impacts

Air pollution's deleterious impacts to human health are extremely well-documented, with research indicating that exposure to airborne pollutants negatively impacts nearly every system within the body including the lungs (Kurt, Zhang, and Pinkerton 2016), heart (Lee, Kim, and Lee 2014), brain (Peeples 2020), skin (Kim, Cho, and Park 2016) and even the eyes (Lin et al. 2022). The Smell Pittsburgh app provides a window into the health experiences of Pittsburgh-area residents by inviting users to list any symptoms they experience when they report a smell event (e.g. difficulty breathing, sore throat, cough). In fact, analysis of the 7789 comments coded by our research team revealed that 62% specified one or more health impacts. Notably, many Smell Pittsburgh comments that mention health impacts also describe the onset of *acute* symptoms during pollution events. For example, in July 2018 one person writes: "I awoke from a deep sleep due to an asthma attack brought on by the foul air. The smell is so bad that we cannot run our window AC!" The following month, another writes: "The air has caused me a severe asthma attack that has also caused great pain and anxiety. This is not ok!!! Please stop the steel industry from killing us!!" (August 2018).

Comments like these illustrate the well-established connection between air pollution events and the onset of acute symptoms. In fact, peer-reviewed research has shown that even relatively short exposures to air pollution can trigger life-threatening health emergencies such as asthma and heart attacks (Khanum, Chowdhury, and Sant 2021; Künzli and Tager 2005). However, because many current air pollution standards still rely on 24-h averages, sudden and dramatic spikes in ambient air pollution may not register as official, actionable, exceedances from the viewpoint of regulators. In practice, this technicality can permit stationary sources to cause short-lived, dangerous, extreme pollution events while still remaining in compliance with local air quality regulations. It is also worth noting that Allegheny County frequently experiences outright exceedances of 24-h pollution standards. As of March 2021, the region had already experienced seven air quality exceedances for hydrogen sulphide and fine particulate matter ($PM_{2.5}$). A local air advocacy group found that the hydrogen sulphide standard was violated an average of 52 times per year between 2012 and 2019, with 87 violations in 2015 alone (Group Against Smog and Pollution 2019). Against this backdrop, Smell Pittsburgh users' comments, which often consist of first-

person accounts of environmental suffering caused by acute toxic air events, constitute a form of uncomfortable knowledge that draws attention to such regulatory loopholes.

In addition to capturing information on acute symptoms, Smell Pittsburgh comments frequently mention chronic health conditions related to air pollution, including conditions like asthma, emphysema, and cancer. As one person writes,

> With the steel mill, and Eastman chemical plant all within a mile it is no coincidence my husband who is only 44 has terminal cancer along with many of our neighbours. Money is more important than his life and our children's lives. (January 2020)

Conversations with local residents also reveal the burden of chronic disease within the region. Matt, a former steelworker and environmental activist who has lived in and around Pittsburgh since the mid-1970s, told us about the remarkably high incidence of cancer within his circle of friends and family:

> I have a daughter-in-law who has stage four cancer, I have a niece that has stage four cancer. We don't have a family in our conservation group that doesn't have somebody that doesn't have some serious disease or cancer … and that was unheard of when I was your age. The people that got cancer were in their 50s, 60s, 70s, 80s, or whatever. Now they're in their 20s and 30s.

Personal anecdotes like this highlight what public health experts already know: toxic air is sickening and killing people en masse. As previously mentioned, a 2013 study by Michanowicz et al. showed that residents of the Pittsburgh region have some of the highest lifetime risk for cancer in the nation due to exposure to hazardous air pollutants. In the same vein, a study conducted by the RAND Corporation examining the relationship between air quality and economic growth in Pittsburgh found that reaching compliance with NAAQS for ozone and particulate matter could result in improved health outcomes valued at $128 million and $148 million, respectively (Nataraj et al. 2013). With high economic and public health stakes, it becomes easier to see why a regulatory agency with a poor track record might be threatened by the introduction of a new, highly accessible, platform for documenting concerns about air quality. Smell Pittsburgh's publicly available dataset comprised of tens of thousands of individual smell reports is a testament to both the severity of the health impacts of air pollution, and ACHD's failure to fulfil its public health mandate – a failure which threatens to undermine the agency's legitimacy in the eyes of the public. Thus, contesting the Smell Pittsburgh app on the grounds of data validity and reliability is a strategic way for agencies like ACHD to deflect the uncomfortable knowledge of ongoing environmental suffering caused by inadequate regulation.

Disruptions to daily life

In addition to documenting health impacts, Smell Pittsburgh reports provide a wealth of information regarding the ways in which toxic air disrupts people's daily lives and routines. Quotidian disruption is another aspect of environmental suffering that is often overshadowed by research that addresses the physical health impacts of environmental contamination. Yet, as the Smell Pittsburgh data show, many residents report significant distress as the result of air pollution curtailing their daily activities, whether it be taking a walk, going for a bike ride, or simply sitting outside to enjoy a morning cup of coffee. Throughout the process of analysing smell reports, we noted the reoccurrence of comments pertaining to one mundane daily activity: opening and closing windows for ventilation. Compared to other major cities in the United States, Pittsburgh has the third-oldest housing stock in the nation (Gough 2014; Korsh 2022), with an estimated 63,000 homes lacking central air conditioning. Thus, open windows are often the only source of cool air available to residents during hot months. To be clear, closing doors and windows does not prevent pollution from entering homes either, as smell reports like the following attest: "It's 1:27 am and the smell of rotten eggs from outside is pervasive with every window shut and an air purifier running" (January 2020). When air quality is

particularly bad, residents who lack central AC face a terrible dilemma: swelter inside a closed-up house, or open the windows and inundate their home with toxic pollution.

> This is by far the worst it's ever smelled. There's a heavy burning tar (maybe tires) smell? I've had to close all of my windows because it's permeating through the house. I don't have air conditioning and [I'm] getting very uncomfortable. (July 2017)

> Our family does not have air conditioning and sleeps with the windows open at night. Last night I woke up at 3:30 and smelled the awful "Stanton Heights" smell. I closed some of our windows, but as I wake up this morning it is still very present. I am worried for my five-year-old daughter. (July 2017)

The likelihood of living in a dwelling equipped with central AC is also tied closely to race and socio-economic status (Romitti et al. 2022), as is the relative proximity to major pollution sources (Liu et al. 2021). More affordable, and widely used window air conditioning units are problematic because they too, draw air from outside, and their basic air filters are typically unable to filter out the smallest (and most dangerous) particulate matter.

The frequency of unhealthy air days in the Pittsburgh region means that residents concerned with limiting their exposure to hazardous air pollution routinely make the choice to forgo or limit their outdoor activities. On such days, our analysis of Smell Pittsburgh reports found that users frequently expressed frustration and sadness over what they had to give up in order to protect their health.

> On a beautiful and cool summer morning I cannot spend time outside with my family nor can I walk comfortably the two blocks to the bus stop on my way to work. My asthma kicks in, my anxiety is high and all I can wonder is why we are allowed to be poisoned in our own neighbourhoods? (July 2018)

> Planned to spend the holiday morning on a bike ride with my husband but now we're stuck indoors on our devices waiting and hoping for the stench to dissipate. (May 2018)

These comments, like many others, reveal another form of environmental suffering measured not in the technical terms of parts per million, but in terms of peoples' everyday lived experiences of air pollution invading their homes, disrupting their sleep, compelling them to rearrange and reschedule planned activities, while also depriving them of the ability to safely enjoy time outdoors. Viewed in this light, Smell Pittsburgh data is uncomfortable and inconvenient for the Health Department, not only because the data contradict the agency's narrative of progress, but also because the comments reveal the deficiency of the regulatory framework which relies on technical assessments of air pollution that have little correspondence to actual quality of life. In 2021, the ACHD and County Executive, Rich Fitzgerald, celebrated attaining federal air quality standards for the first time since the EPA created the standards in 1999 stating:

> This is exciting news for our county and region as we meet federal air quality standards for the first time ever at all eight of our monitors. Acting as the EPA's enforcement arm, the Health Department has continued to use its regulatory power to improve air quality. It's extremely rewarding to see this measure of success. We are grateful for the continued support of our federal and state elected officials including Congressman Doyle, State Senator Jay Costa, State Senator Jim Brewster and State Representative Austin Davis and the work they've done to encourage industry to continue improving its pollution controls. We still have much work to do. By continuing to work together, we can ensure that we continue to improve our air and quality of life. (ACHD Press Release, 2021)

These celebratory comments are only possible when one ignores the information compiled by residents who use the Smell Pittsburgh App to document how poor air quality affects their daily lives.

Emotion/affect

With a large number of Smell Pittsburgh reports mentioning health impacts and daily disruptions caused by air pollution, it was no surprise that strong emotions were also detectable. While emotional disturbance may be less tangible than other forms of environmental suffering, there is a growing body of literature that uses concepts like "ecological grief" (Cunsolo and Ellis 2018),

"solastalgia" (Michelin 2020), and "eco-anxiety" (Stanley et al. 2021), to explore the impact of environmental conditions on emotional well-being. With this in mind, we looked for evidence of emotional impacts in addition to coding for health effects and disruption to daily life. Of the 7789 reports with written comments that our research team examined, we found that over 5,000 reflected a detectable emotion tone (e.g. fear, anxiety, frustration, anger, contentment). In cases where this was not true, we coded the comment as neutral. Of these categories, frustration, anger, concern, and desperation were the most commonly detected emotions. Where multiple emotions were detected, we chose the most prominent one. For example, the following comment was coded as *desperation*:

> This is so bad I am literally crying. We have nowhere to go unless I wake my son up and go to Rite Aid and just sit there. The smell takes over our whole house. I can't breathe. It's very scary. Can't go outside. The smell is so strong it chokes you. This is not normal living. We are suffering here. The air is so bad, I fear for my health. It's too bad because there are many good things about Pittsburgh. It is 1:30 am. I do not get much sleep here nights. Not a good quality of life. Horrible! (January 2016)

Another comment, typed with all caps and multiple exclamation points, gives the impression that the person is yelling, which signalled to us an angry emotional state:

> INTOLERABLE!! NO AIR TO BREATHE!! WHY IS THIS STILL HAPPENING?? WHILE CORONA VIRUS IS KILLING US? … STOP THIS NOW!! DO YOUR JOB!!! (March 2020)

One of the reasons we felt comfortable coding for strong emotions was because interviews with local people also revealed a deep sense of outrage, frustration and sadness. For example, Joseph, a chemically sensitive resident who lives in the Pittsburgh neighbourhood of Squirrel Hill shared with us during an interview:

> I'm in therapy, and one of the things on the list of stuff that we deal with is basically CPTSD [Complex Post-Traumatic Stress Disorder] for constant abuse by a huge industrial bully that is threatening my life that I can't do anything about. And every time they pollute, I have feelings like I'm getting punched in the face … I literally feel that way. (September 2020)

This metaphor of local industries behaving like "bullies" was also echoed by a local resident named Daniel who testified at a Health Department sponsored virtual public hearing on coke oven emission regulations, saying:

> Am I satisfied with the way you, the health department, are treating this matter? The answer to that question is definitely not because I think that it's kind of like the big bully and the little sissy … They're [U.S. Steel] killers. They've been killing people in the valley and pets and shrubbery and trees and everybody else for over 100 years. (January 2021, public testimony)

What would it look like to quantify the emotional toll of living in one of the worst airsheds in the United States? How does emotional distress exacerbate health impacts and vice versa?

These are certainly important questions, but ones that the current regulatory framework for air quality does not address or mark as important. After all, the public's emotional wellbeing is certainly not factored into the highly technical process of setting pollution standards. But human emotion, nonetheless, flows through Smell Pittsburgh comments revealing collective anger, frustration, and despair with the status quo. As discussed earlier, ACHD (even at in-person public meetings) makes no attempt to engage with residents on a personal level, much less an emotional one. From these observations, it is clear to us that emotions constitute a third kind of "uncomfortable knowledge", one that is highly illegible to any agency geared towards achieving specific numeric pollution standards.

Discussion and conclusion

We began our research with a simple question: why would air quality regulators reject a tool generating knowledge concerning the public's experience with air quality? To be clear, without

being in the room where decisions are made, we can only speculate as to the agency's motives. Yet, as we argue throughout this paper, there is strong evidence which suggests that this decision – like so many socioenvironmental dynamics – is inseparable from the politics of knowledge and ignorance. As scholars before us have persuasively demonstrated, all knowledge is not viewed equally, especially when it comes to knowledge of environmental conditions like air quality.

Long before the creation of the EPA, and the development of national air quality standards, residents of cities across the United States relied solely upon olfaction (their sense of smell) to detect problems with air quality. In fact, it was largely urban dwellers outcries over putrid stench which led to the formation of the first boards of health in the latter half of the nineteenth century. However, as these agencies sought to establish themselves as qualified authorities, they placed a strong emphasis on "scientific" knowledge of environmental conditions (i.e. objective and quantitative knowledge) being more legitimate and credible than citizen-generated "lay" knowledge (which tended to be subjective, and more qualitative) (Kiechle 2017). Over a century later, this kind of epistemic gatekeeping continues in many forms, and as we have argued here, is one highly plausible explanation for the Allegheny County Health Department's discomfort with Smell Pittsburgh's citizen-generated reports and comments.

However, as our analysis of the Smell Pittsburgh data reveals, it is not only the type of knowledge but the substance which ACHD may find threatening. This is because much of the knowledge generated by Smell Pittsburgh speaks to a high degree of environmental suffering, a form of "uncomfortable knowledge". This knowledge is uncomfortable precisely because it shows the degree to which ACHD has failed, and is currently failing, to protect the public from toxic air. At the same time, the Smell Pittsburgh reports are uncomfortable because they also gesture to the inadequacy of the prevailing technocratic apparatus for regulating air quality in the United States, a system which measures success almost exclusively by whether regions can attain compliance with specific numeric-based pollution standards.

The reality is that compliance with pollution standards often has little connection to daily, lived experience, as thousands of Smell Pittsburgh reports attest. As previously mentioned, Allegheny County reached compliance with federal air quality standards for the first time in history in 2020 (Allegheny County Health Department 2021). While this is certainly a milestone, "compliance" with federal standards does not directly translate to significant gains in quality of life. For instance, EPA data on pollution trends for the year 2020, which was factored into the January 2021 compliance announcement, also showed that residents of the Pittsburgh-area experienced 57 days of unhealthy air – nearly two months of the year when it was not safe for residents to be outdoors (Allegheny County Health Department 2021). One reason for this is that not all pollutants are subject to federal regulation. Moreover, even those that are federally regulated are often assigned a threshold well above what is recommended as "safe" by other authorities such as the World Health Organization (WHO).

A final implication of our work which also presents avenues for future research, is the challenge it presents to the common assumption that more knowledge/environmental data necessarily leads to greater chances of success when it comes to addressing environmental problems. What both our research, and Ottinger's work (2009, 2010) show, is that the impact of environmental knowledge on a given situation is heavily mediated by both the context (and the type) of data being deployed and interpreted. Historically, scientific knowledge on air quality has been largely restricted to those with the expertise and access to complex scientific instruments. Over the past few years, however, sophisticated mass-marketed scientific instruments (such as residential outdoor air monitors) have become increasingly available to consumers. In this evolving scenario, it will be important to pay attention to the ways in which regulatory agencies find ways to either incorporate, deflect or ignore scientific knowledge based upon who is leveraging it, and the so-called "quality" of the technology they are utilising.

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Data availability statement

All Smell Pittsburgh data are publicly available for download at: https://smellpgh.org/data

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