



“I have to stay inside ...”: Experiences of air pollution for people with asthma

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ABSTRACT

Asthma, characterized by airway inflammation, sensitization and constriction, and leading to symptoms including cough and dyspnoea, affects millions of people globally. Air pollution is a known asthma trigger, yet how it is experienced is understudied and how individuals with asthma interact with air quality information and manage exacerbation risks is unclear. This study aimed to explore how people living with asthma in Scotland, UK, experienced and managed their asthma in relation to air pollution. We explored these issues with 36 participants using semi-structured interviews. We found that self-protection measures were influenced by place and sense of control (with the home being a “safe space”), and that the perception of clean(er) air had a liberating effect on outdoor activities. We discuss how these insights could shape air quality-related health advice in future.

1. Introduction

Asthma, characterized by inflammation, sensitization, and airway constriction, causes symptoms such as cough, wheeze, chest tightness and breathlessness. It is globally the most widespread chronic respiratory condition (Chan et al., 2019), and more than 368,000 people (7% of the Scottish population) receive treatment for asthma in Scotland (Scottish Government, 2020). While there are several genetic and environmental factors that contribute to the onset, exacerbation and deterioration of asthma (WHO, 2023), air pollution, including pollutants such as particulate matter (PM), ozone (O₃), nitrogen dioxide (NO₂) and sulfur dioxide (SO₂), has emerged as a significant environmental trigger (Guarnieri and Balmes, 2014).

The air quality-related aetiology of asthma is well established (Tiotiu et al., 2020) and is supported by a robust literature base that includes systematic reviews and meta-analyses (e.g., Fuller et al., 2023). Epidemiological studies highlight the adverse effects of air pollution on asthma-related health outcomes, often utilizing population-level data, such as emergency room visits (e.g., Yadav et al., 2021) or hospitalizations (e.g., Priyankara et al., 2021). Notably fewer studies have focused

on individual-level evidence, investigating the impact of personal exposures on health outcomes such as symptom prevalence and medication use (e.g., Williams et al., 2019) or on patient wellbeing and quality of life (e.g., Šcibor et al., 2022). Such patient-reported outcomes provide a more holistic understanding of the consequences of air pollution on the individual and allows for a more nuanced assessment of the health impacts of air pollution, such as if or how air pollution exposure impacts their physical activity, or how use of their medication can help combat pollution-triggered exacerbations.

While air pollution as an environmental entity is objectively measurable and uninfluenced by personal subjectivity, air pollution has also been defined as a hybrid phenomenon at the intersection of environmental processes and social practices (Booker et al., 2023). Peoples' experiences of air pollution differ. Even within a seemingly homogenous group, such as those with asthma, physical symptoms can vary greatly (McCarron et al., 2023; WHO, 2023) resulting in individual realities, and therefore experiences, that differ from person to person (Hauge, 2013). Additionally, personal exposure to air pollution varies between individuals, influenced, at least in part, by the places a person spends their time, such as where they live and work and how they commute (e.g.,

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Panchal et al., 2022; Reis et al., 2018). Not only does this influence their 'objective' personal exposure to air pollution, but these experiences, in turn, influence how individuals come to understand, make sense of, and perceive air pollution (Bickerstaff and Walker, 2003), which can be more influential than objective information (Calvillo and Garnett, 2019), though may not necessarily align with measured pollution concentrations. Additionally, perception as a construct is influenced by several factors, including the social, economic and political context and individuals' previous knowledge and experiences (Noël et al., 2022). In addition, individuals' demographic characteristics such as gender, socioeconomic status, age and level of education are known to play a role in influencing and shaping perceptions (Guo et al., 2016; Kowalska-Pyzalska, 2022). Consequently, the way in which individuals experience and make sense of air pollution is contextual and highly subjective (Noël et al., 2021) which influences behavioral responses. To date, there has been limited attention paid to the lived experiences of individuals with asthma regarding air pollution and its actual impacts on their condition and management strategies (An et al., 2018).

Personal exposure to air pollution can be modified – to a considerable degree – through behavior changes (Chatzidiakou et al., 2019; Ma et al., 2021; Riley et al., 2021). Health behaviors have frequently been explored through psychological theories and models identifying and measuring determining factors. A key approach is the Theory of Planned Behavior (TPB; Ajzen, 1991), a psychological model that predicts and explains intention and behavior based on three constructs: subjective norms, attitudes and perceived control. These factors explain the underlying mechanisms which influence individuals' intentions and subsequent actions. As such, understanding how individuals with asthma practically experience and manage their condition in the context of air pollution is valuable. Gaining insight regarding how and why people with asthma adhere to current advice, access healthcare resources in relation to pollution exposure, and access air quality information for their local area is an important part of this. Understanding the nuances of the challenges faced and strategies employed for managing asthma in relation to air pollution is vital for developing effective interventions, enhancing asthma management strategies, reducing health inequalities and improving overall quality of life (Apps et al., 2019). Therefore, this study aimed to explore how people living with asthma in Scotland experience and manage their asthma in relation to air pollution.

2. Methodology

2.1. Study overview

To explore how people living with asthma in Scotland experience and manage their asthma with respect to air pollution, this study adopted a qualitative research approach using semi-structured interviews. Ethical approval was granted by the University of Stirling's General University Ethics Panel [GUEP 2021 2506 1892].

2.2. Data collection

Semi-structured interviews were conducted with non-smoking adults living in Scotland who reported having been diagnosed with asthma by a healthcare practitioner. Participants were recruited as part of a larger randomized control trial design study whereby, following the interview, participants conducted personal exposure monitoring (McCarron et al., 2023) and co-developed exposure reducing behavioral interventions (McCarron et al. *in review*), hence smoking being an exclusion criterion. Recruitment was conducted primarily via Facebook marketing, but also through a more targeted campaign launched at the research mid-point (and following review of participation) at sports centers to promote participation of younger males. The number of interviews conducted was determined by the number of participants enrolled as part of the larger study, however our focus was on topic coverage, quality and depth, rather than assigning a required sample size. Interviews took

place between September 2021 and August 2022. Owing to the COVID-19 pandemic, all interviews took place online. Informed signed consent was obtained from all participants and demographic information collected via survey prior to participation.

Semi-structured interviews were used to gain both retrospective and real-time accounts of participants' experiences of air pollution. A topic guide was developed to ensure interviews flowed easily and to aid interaction between the interviewer and interviewee. The topic guide was separately piloted with five individuals (meeting the same eligibility criteria as participants) prior to the main study taking place and amended according to feedback. Questions were designed to be open and comprehensive, with the aim of prompting participants to provide detailed responses, however, prompts and probes were also prepared to facilitate and stimulate elaboration when necessary. To address our specific research aim, this analysis focused on one section of the interview which covered discussion of participants' experiences of air pollution. The air quality section of the interview topic guide can be found in [Supplementary Material A](#). All interviews were conducted by the lead author and were transcribed verbatim.

2.3. Data analysis

To explore patterns across the dataset, reflexive thematic analysis was undertaken following Braun and Clarke's (2022) six phase approach. Reflexive thematic analysis aligns with the lead author's ontological and epistemological stances ([Supplementary Material B](#)), and was a suitable approach given that, though this work set out to be inductively orientated, connections with pre-existing theory could be recognized within the data (e.g., Theory of Planned Behavior). Additionally, the flexibility of reflexive thematic analysis allowed the possibility of capturing both semantic and latent meanings to gain a comprehensive understanding of the participants' experiences of air pollution and uncover deeper insights.

Given that interviews were conducted over the course of a year, familiarization with the data was an important initial stage of the analysis process in order to have equal familiarity with all cases, but also to engage with the data more critically than was permitted at the point of collection. Coding was a systematic and iterative process conducted using NVivo software v1.7.1. Several rounds of coding were conducted before generating initial themes which were then refined to ensure they were descriptive, interpretative and explanatory. Four final themes were developed from the data.

3. Results

Interviews were conducted with 36 participants ([Table 1](#)) and lasted between 25 and 86 min. Most participants did not report respiratory comorbidities which minimized the likelihood of symptom confusion. Participants were relatively well dispersed by health board, though we had no participants residing within NHS Ayrshire and Arran, NHS Orkney or NHS Shetland. Most participants (61%) resided in urban areas and were from areas categorized as least deprived as indicated by Scottish Index of Multiple Deprivation (SIMD) quintiles (>50% from quintile 4 and 5), however it has been shown that within the Scottish context, SIMD decile and ambient pollution concentrations are not strongly associated (Bailey et al., 2018).

Exploring how people living with asthma experience and manage their condition with respect to air pollution, we have developed four themes: 1) Home is a safe space; 2) Disconnection from air quality information; 3) Behavior change ultimately depends on perceived control; and 4) Clean(er) air is liberating. We elaborate on and explain these in sections 3.1 to 3.4 (summarized in [Fig. 1](#)).

3.1. Theme 1: Home is a safe space

The theme 'home is a safe space' reflected the interpreted contrast

Table 1

Interview participant demographic information. [†]n = 33 due to nonresponse. *SIMD: Scottish Index of Multiple Deprivation.

Participant characteristic	Statistic
Age (mean years (range))	49 (24–74) [†]
Sex (n (%))	
Female	25 (69.4)
Male	11 (30.6)
Other respiratory condition (n (%))	
No	32 (88.9)
Yes	1 (2.8)
Missing	3 (8.3)
SIMD* Quintile (n (%))	
1	0 (0.0)
2	5 (13.9)
3	12 (33.3)
4	6 (16.7)
5	13 (36.1)
Health Board (n, %)	
NHS Ayrshire and Arran	0 (0.0)
NHS Borders	1 (2.8)
NHS Dumfries and Galloway	2 (5.6)
NHS Fife	2 (5.6)
NHS Forth Valley	5 (13.9)
NHS Grampian	8 (22.2)
NHS Greater Glasgow and Clyde	5 (13.9)
NHS Highland	3 (8.3)
NHS Lanarkshire	3 (8.3)
NHS Lothian	3 (8.3)
NHS Orkney	0 (0.0)
NHS Shetland	0 (0.0)
NHS Tayside	3 (8.3)
NHS Western Isles	1 (2.8)
Urban-rural Classification (n (%))	
Large urban area	10 (27.8)
Other urban area	12 (33.3)
Accessible small town	2 (5.6)
Remote small town	3 (8.3)
Accessible rural	6 (16.7)
Remote rural	3 (8.3)

between the home environment (being somewhere that is secure and controllable) and the external outdoor environment (where air pollution exists and is inflicted upon people). Air pollution was described as something that engulfed the home from the outdoor environment, and many participants described the need to close windows as a defense mechanism to prevent air pollution from entering their homes.

... if it's bad you know the traffic's heavy, I'll make sure that the windows are shut rather than open. (Participant 12, Female, 45–49).

I suppose just like, if it's smoky outside, I would shut all the windows. (Participant 9, Female, 55–59).

Frequently, this defensive behavior was to directly combat air pollution enforced upon them from their adjacent outdoor environment (Fig. 2). In particular, neighbors' solid fuel burning behaviors were highlighted by participants.

... if they light that (pizza oven) I've got to shut every window in my house. (Participant 9, Female, 55–59).

I've a neighbor a few doors down who has a fire in his garden ... I have to stay inside and shut all the windows when he's got it on because once the smoke comes into my garden, and it just makes my chest congested and feels a bit wheezy. (Participant 13, Female, 45–49).

Participants suggested that the behaviors of others, in this case solid fuel burning behaviors, had a significant impact on their home environment and/or their asthma symptoms. The concept that air pollution originated and was imposed from the outdoor environment was reinforced with some participants reflecting on the need to stay indoors – in their safe home environment-when air quality was poor.

Every vent's to be shut it can stop me going out. (Participant 30, Female, 55–59).

If the air quality is poor, I just don't go out ... I wouldn't go out. I stayed indoors, um, did what I had to do from home. (Participant 25, Female, 55–59).

Participants were proactive and had a willingness to take measures to protect themselves by staying indoors or creating a barrier between the outdoor environment and their living space. In this sense, the home became a refuge, providing relief from air pollution exposure.

Within the home, there was a confidence over the decisions participants could make and action they could take to directly control pollution within their home (Fig. 2; center circle).

... something that affected my asthma is washing powder and softeners. So again, I use unscented washing powder. (Participant 19, Female, 55–59)

I avoid frying stuff now ... (Participant 11, Male, 30–34)

Away from the immediate home environment, participants' no longer actively and directly faced air pollution, but rather evaded air pollution (Fig. 2), indicating the need to create physical distance between themselves and air pollution. The need to 'outrun' air pollution was a short-term, in-the-moment response.

Then [I] have to cycle further just to kind of get rid of it. (Participant 31, Female, 30–34).

I would like always walk quickly through Charing Cross [Glasgow] when I was going into town ... I guess subconsciously I always walk a bit faster if it's next to busy roads to like get away from it [air pollution]. (Participant 24, Female, 25–29).

This was not limited to active travel users, but vehicle users also.

I took the step with the dust in the atmosphere of actually driving somewhere else ... Driving to get away from it. (Participant 32, Male, 50–54).

Outrunning air pollution was not specific to avoidance behaviors but also encapsulated participants consciously seeking out and moving toward areas perceived to have better air quality, namely more natural areas such as parks and wooded areas.

There's a nature trail about five minutes' walk away from me. So I can go there and it is trees and it, there's no cars allowed. It's just footpaths. And I can go there and that is really nice. So just being able to do, go to that and it is only literally five minutes from my, my house. It's, it's comforting ... (Participant 30, Female, 55–59).

... I like to spend time in the, in the woods - so that I can have some nice clean air. Erm, so I tend to do that ... Erm, so I tend to do a lot of walking in the woods if I, if I just need to like catch a breath. (Participant 22, Female, 40–44).

Similar to the home environment, natural environments were regarded as havens for participants, offering a retreat from air pollution. These areas served as comforting spaces, allowing them to escape the sources of air pollution and find relief from their symptoms.

Creating physical distance between themselves and the air pollution inflicted upon them from the outdoor environment was also a longer-term, more permanent option for some participants, both as a prospective action, or, in one case, an implemented action.

I'm planning to move somewhere more rural. I've not did it at the moment but erm that's in my head to do that. (Participant 13, Female, 45–49).

And my GP said that the only way my asthma would improve is if I moved over to somewhere like [redacted] and that's how we moved up to [redacted]. (Participant 20, Female, 55–59).

1st order concepts	2nd order themes	Aggregate dimensions
The need to travel further to get away from air pollution Remove self from situation with poor air quality Go (towards) somewhere with better air quality Only option is to relocate home to place with better air quality (hypothetical) Only option is to relocate home to place with better air quality (actual) Need to 'block out' air pollution from outdoors 'They' cause air pollution	Outrunning air pollution (short-term) Move away from air pollution (long-term) Trapped indoors by air pollution	Home is a safe space
Knowing about air quality doesn't change anything I don't need to know about air quality I don't want to know about air quality I don't think about air pollution Laziness prevents me from accessing air quality data Air quality information isn't easily understandable Air quality information isn't easily accessible Accessing air quality information takes time	Ignorance is bliss Barriers prevent me from accessing using air quality data	Disconnection from air quality information
Nothing I can do about air pollution You cannot avoid air pollution Try to avoid air pollution (self-efficacy) It's not always possible to avoid air pollution (external factors) I can avoid air pollution I want to avoid air pollution I do not try to avoid air pollution Air pollution will not stop me doing what I enjoy (determination)	Conceding to air pollution Attempt to avoid air pollution I am able to avoid air pollution I don't avoid air pollution	Behaviour change ultimately depends on perceived control
I can't do some things that I want to do Air pollution can be smelled Air pollution can be tasted Air pollution is dark and dirty (can be seen) Air pollution is stuffy and warm (can be felt) Air pollution makes me feel ill Air pollution causes my asthma symptoms Air was brighter during lockdown (visual) Air was fresher during lockdown (feeling) Lack of inhaler use during lockdown Able to be more active during lockdown	Air pollution limits me Air pollution causes a negative sensory experience Air pollution makes me feel ill Senses are liberated in the absence of air pollution Lockdown was liberating	Clean(er) air is liberating
Order of process →		

Fig. 1. Codes (1st order concepts), initial themes (2nd order themes) and final codes (aggregate dimensions) (based on Gioia, Corley and Hamilton, 2013).

3.2. Theme 2: Disconnection from air quality information

Our second theme, 'disconnection from air quality information' was developed from participants' discussions around accessing air quality data and information as something that they did not generally do. Generally, participants indicated that they had a limited understanding of air pollution. Many participants expressed a desire to access air quality data and information to enhance their knowledge on the subject.

I would like for my own knowledge to actually see what links and stuff there is ... (Participant 12, Female, 45–49)

I don't know enough about it to be honest with you ... if someone was to explain to me exactly what's going on then I'd be a lot happier, I'd be a lot more knowledgeable and I'd know whether I could go to certain places or avoid, you know, avoid them, yeah. (Participant 28, Male, 60–64)

This demonstrated a belief that increased knowledge can enhance self-confidence in making informed decisions, particularly with reference to identifying places or areas to avoid.

Regarding accessing air quality information (and as discussed later, implementing behavior changes to reduce exposures), participants could be categorized into one of four categories sharing common characteristics: *able*, *attempting*, *conceding* or *resisting* (Fig. 3).

Some participants *conceded* to being unable to access local air quality data and information, and highlighted barriers that had hindered their access to information and subsequent knowledge. In addition to

accessibility, the practical aspects of effectively utilizing these data and information were addressed.

... I wouldn't know where to go to get live information to be honest. I also wouldn't know what use to make of it ... (Participant 26, Female, 55–59)

Even when participants were aware of how and where to access information, some expressed that the inaccessibility of the language was a cause of disconnectedness. Specifically, complex 'jargon' and an overall lack of comprehensibility deterred them. Although they technically had the ability and *attempted* (Fig. 3) to engage with the data and information, its complexity was off-putting.

I think if it was more easily accessible, more readily understandable because, I mean, while I can read things like textbooks and academic articles ... it becomes boring after a while, because it becomes jargon and then, there's no explanation of that jargon and so you're just there like well I'm off (Participant 36, Male, 25–29)

In addition to external barriers related to access and comprehensibility of air quality data and information, participants also emphasized the presence of internal barriers that hindered their ability to access and utilize such resources. They expressed that the burden of responsibility of finding and utilizing air quality data and information lay with them as individuals and required the investment of their own time and effort.

... it's not something that I would normally have time to sit down and look at, you know. (Participant 10, Male, 50–54)

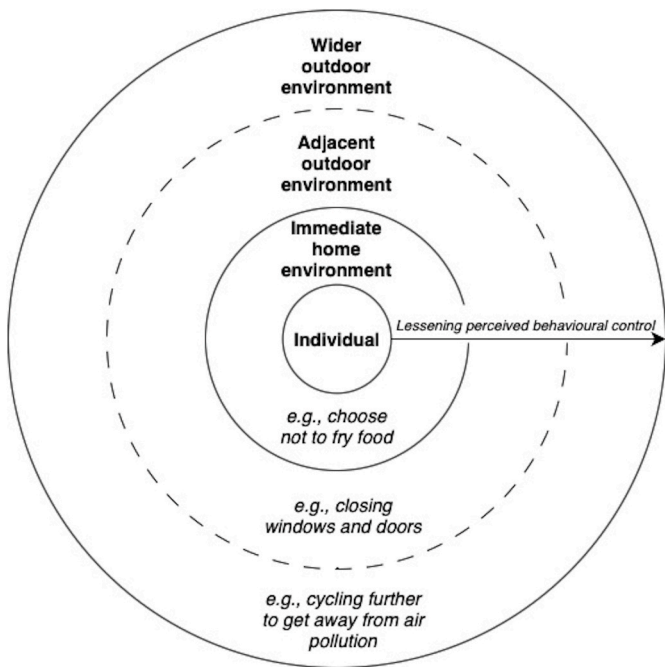


Fig. 2. Constructed from the theme ‘home is a safe space’, participants’ response to air pollution was determined by perceived behavioral control over the environment in which the individual found themselves. In the home, participants had the greatest perceived control and could choose what behaviors to perform to preserve indoor air quality. Individuals protected indoor air quality by closing windows and doors. Away from the home, perceived control diminished and thus participants response switched to avoidance.

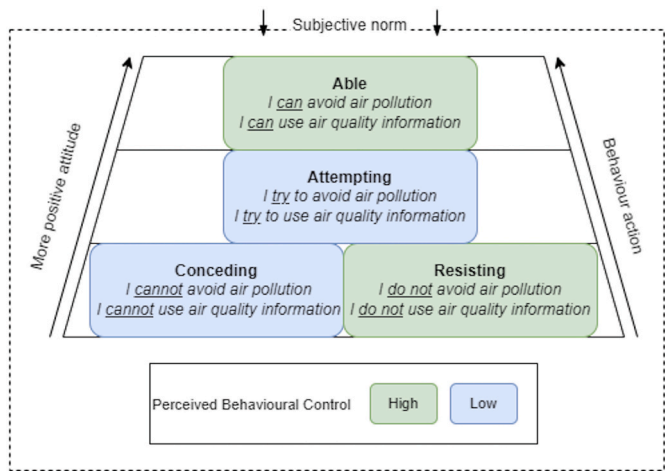


Fig. 3. Categories of behavior action observed in themes two and three in the context of the Theory of Planned Behavior (Ajzen, 1991). The *able* group possess the most positive attitudes and high perceived behavioral control resulting in action. *Attempting* also have a positive attitude but are constrained in their actions by a low perceived behavioral control. *Conceding* evaluate behavior change more negatively (negative attitude) and low perceived behavioral control, resulting in inaction. *Resisting* similarly have a more negative attitude toward behavior change but high perceived behavioral control over their (in)action. Subjective norms are the external social influences acting across all groups. See [Supplementary Material C](#) for a more detailed description of each category.

Relating to the effort required, some participants discussed that their own ‘laziness’ was a preventative barrier to access.

Laziness I suppose because you’re not, you’re not affected by it, so you don’t think about it. (Participant 9, Female, 55–59)

Sometimes you’re just lazy ... (Participant 22, Female, 40–44)

The perceived effort of seeking out air quality data and information, interpreting technical language or investing time and energy into understanding the information was a deterrent and thus ‘laziness’ stemmed from the perceived difficulty of the task, influencing individuals’ motivation and willingness to engage with the data. As well as being an extrinsic barrier, this bridged with internal barriers. This self-referenced ‘laziness’ also suggested a general apathy, a lack of motivation, willingness and energy to engage with air quality data and information and indicated a general lack of interest or desire to take action. For some participants, air pollution was not something that they prioritized or thought about and as such resisted (Fig. 3) to act on it.

No, it’s not something I regularly think about ... I don’t really ever think about it. (Participant 2, Male, 20–24)

I’ve never [engaged with air quality information] but I suppose I would go to one of these sites that gives information about the weather. But I’ve never thought about going to ... (Participant 17, Male, 70–74)

While some exhibited ambivalence towards accessing air quality information, for others, this was motivated by a perceived lack of necessity, referencing a lack of pollution where they live.

I certainly don’t think about it where I live. I’m up in Perthshire [rural area]. So you know I don’t think about air pollution here. (Participant 18, Male, 60–64)

I think I don’t engage with it because I feel where I live is not, it’s not heavily polluted so it’s not an issue. (Participant 34, Female, 45–49)

In contrast with those who believed knowledge was empowering and could lead to better, more informed decision-making, others suggested that knowing about air quality does not bring about any significant changes, interpreted as a perceived lack of behavioral control. Some individuals expressed feelings that acquiring information about air quality would not result in any meaningful impact or give them greater control over the situation.

I think definitely it would have made me more aware, but I wouldn’t- I don’t know that I’ve done anything differently as a result of it. (Participant 7, Female, 55–59)

... I’d sort of check that on occasion, but I sort of feel because there’s not necessarily much I can do about it, I just put up with it. (Participant 12, Female, 45–49)

Those who were *able* (Fig. 3) to access air quality data and information, used it as an explanatory tool to verify their symptoms, rather than using it as a reference tool to inform their decision-making.

So just kind of check the air quality to see if it’s matching, sort of how I am feeling. (Participant 33, Female, 20–24)

Erm, I think it’s more to figure out if the increase in wheeziness is because of outside or if it’s something with me, you know ... I might be starting to come down with something else. It sort of helps me differentiate between the two. (Participant 12, Female, 45–49)

Finally, some participants did not make the connection between air pollution and their own health. Rather than referring to themselves, participants referred to air pollution as something that impacts other people.

Well, I know obviously that for some people air pollution will affect their asthma (Participant 9, Female, 55–59)

I mean it can really affect some, some people (Participant 29, Female, 50–54)

In summary, both external factors (such as air pollution being considered as an outdoor phenomenon) and internal factors (such as perceived control) prevented people from accessing air quality data and information which in turn resulted in, or at least contributed to, inaction.

3.3. Theme 3: Behavior change ultimately depends on perceived control

Our third theme was developed from participants' descriptions of adapting their behaviors to limit their exposure to air pollution and the differing approaches taken and perspectives on these behavior changes.

There was a consensus amongst participants, whether explicitly stated or not, that the avoidance of air pollution was a 'normal' and sensible thing to do. Avoiding air pollution was something that they had been told by a healthcare professional or something that was "common sense" and learned from previous experience.

But that's the only advice I received [from a healthcare professional], basically to avoid exposure to allergens, or to like pollution ... (Participant 33, Female, 20–24)

I think I just kind of realize certainly anything strong like bonfires I couldn't erm, you know be next to them. Erm, I don't think anyone ever sort of, I think it's just kind of common sense I suppose? (Participant 19, Female, 55–59)

However, for many participants, air pollution was something that they *concede* to and consider themselves to have no control over. Inaction in these cases was driven by impotence and apparent inability to alter air quality.

... because I live in the city and there's not really, yes, there's nothing I feel like I can do really. (Participant 16, Female, 30–34)

And at the end of the day, I can't see that pollution levels are ever going to change in my lifetime to make a difference to my asthma so there's no point in getting into it too deeply for me because nothing's going to- I can't change anything anymore than I've done already, you know ... (Participant 23, Female, 55–59)

Because I feel impotent, there's nothing I can do about traffic pollution, I just have to live with it. (Participant 5, Female, 70–74)

Participants emphasized the externality of air pollution (e.g., existing in the 'city' or related to 'traffic pollution') as the reason for their lack of control. In addition to a sense of futility, some participants had come to regard air pollution as a part of day-to-day life that they had no option but to accept and endure.

It just became a way of life for me. (Participant 30, Female, 55–59)

Just live, you don't have an alternative, get on with life. (Participant 32, Male, 50–54)

While *conceding* implied giving into or accepting air pollution and its impacts, some participants demonstrated inaction stemming from *resistance* or defiance; either as defiance to not be stopped by air pollution or determination to not give in to their asthma. In contrast to those who *conceded*, these individuals seemed to actively oppose developing adaptive behaviors, such as avoidance of a place or area.

But I've never thought about going to – I doubt whether I would change my plans if I found out that Glasgow is high in [air pollution]. I would still go. It wouldn't stop me going. (Participant 17, Female, 70–74)

... I wouldn't avoid an area because of air pollution. (Participant 24, Female, 25–29)

No. No, I would not change what I do because I don't let it define me. I won't let it be- I'm not going to give into it. I don't think I'll ever give into it. I'll have it. I've always had it. (Participant 23, Female, 55–59)

While both *conceding* and *resisting* ultimately result in inaction and thus no impact in relation to exposure-related behavior change, the fundamental difference between the two is attitude and perceived control (Fig. 3). *Conceding* reflected a sense of defeat, accepting that "there is nothing [they] can do" about air pollution owing to it being a problem where they live and caused by outdoor sources and as such, do not actively engage in developing adaptive behaviors to reduce exposures. In contrast, the *resisting* standpoint conveyed a defiant or determined stance, actively opposing or challenging the need for adaptive behaviors. Despite both resulting in inaction, it was the contrasting attitudes and perceived control that distinguished these two positions.

Perceived control played a key role in fostering the development of adaptive behaviors. *Attempting* signified participants' endeavors to adapt their behaviors to reduce their exposure to air pollution. On a semantic level, this was evident in participants' use of the word "try".

... you can't obviously always avoid things, but I just try and be a bit aware of triggers and modify my life a little bit to avoid as much as I can. (Participant 13, Female, 45–49)

Outside I try not to like, we've got a main road which is very, you know it's gridlocked with cars most of the day. It's dreadful. So I try not to go via the main road, you know I take the back streets. I, having said that it's not always possible because you have to, the shops are down there. (Participant 19, Female, 55–59)

This conveyed an intention and willingness to act and adopt avoidance behaviors whilst also portraying an uncertainty of achieving the desired outcome. Individuals who *attempted* to alter their behaviors exhibited feelings of limited efficacy.

... I always felt like I was running through just, like pollution wherever I went. I tried different times of the day, and it was always just as bad. So I did change that route. (Participant 31, Female, 30–34)

Despite adopting adaptive action and choosing to run a different route to avoid pollution exposure, they could not escape air pollution and thus assessed a lack of impact from the behavior. Additionally, some participants referred to their adaptive behaviors with a sense of insignificance and triviality.

No probably not actually no. I don't really. Other than the wee air filter in my bedroom at night, no. I've nothing else. (Participant 27, Female, 40–44)

I must admit though when I get to that junction, this is daft, but when I get to that junction, rather than having my car having air coming in from the outside and circulate round the car, I close that off and just have it circulating inside the car until I get past it ... (Participant 9, Female, 55–59)

Despite participants taking what are viable actions to reduce their exposures, these were spoken about with a sense of worthlessness. Much like *conceding*, there was a sense of being constrained by perceived behavioral control.

Finally, some participants actively took steps to (and do) avoid air pollution. Participants acknowledged that they were in a privileged position in that they were *able* to avoid air pollution by not traveling to certain places or being able to stay indoors, recognizing that, as previously discussed in this section, it is simply not a choice many people are able to make.

I'm fortunate that I don't have to go, I don't have to travel on a daily basis. So you know, I've reached a stage in my life where I can avoid heavily polluted areas. (Participant 5, Female, 70–74)

Well I was working so I was in air-conditioned hotel, and I was thinking you know, 'thank God I'm in here' you know. (Participant 18, Male, 60–64)

3.4. Theme 4: Clean(er) air is liberating

The fourth and final theme, 'clean(er) air is liberating', was a theme of contrasts, developed from participants' reflections on their experiences of 'clean' air compared with polluted air arising from the various lockdown and travel restrictions brought about by the COVID-19 pandemic.

Air pollution was described as an unpleasant sensory experience that participants could see, smell, taste, hear and feel, and was portrayed as something which dulls and dampens the senses. In contrast, clean(er) air, or the absence of air pollution, liberates the senses and makes for a more pleasant sensory experience (Table 2).

The senses shape participants' experience of place. As well as the feeling of air pollution being superficial or external, participants described the 'internal' feeling of air pollution as something that can be sensed *within* the body. Moreover, some participants made the direct link between exposure to air pollution and their own ill-health.

... it would kind of make you cough a bit ... yes sometimes you feel a bit lightheaded as well with it ... (Participant 31, Female, 30–34)

It catches the back of my throat ... it does feature in the back of my throat, it catches my inhalations. (Participant 17, Male, 70–74)

Some participants developed this feeling deeper, describing it in a more severe way. They described the sensation of air pollution as making them choke, evoking a feeling of suffocation being imposed upon them.

... you know and it's nice to have a real fire – but I can't really ... it makes me wheezy and choked up. (Participant 13, Female, 45–49)

And I woke up choking in the middle of the night ... because obviously the air quality in London is shocking, so it affects me. (Participant 22, Female, 40–44)

... it just seems to sort of choke you ... (Participant 1, Female, 45–49)

Furthermore, some participants made the association between air pollution exposure and increased use of their inhaler, making the connection with how this was influenced by where they were.

... the air quality feels totally different to what it does when I'm at home in the country. Erm, so just memories of having asthma symptoms and coughing and needing to use my inhaler more frequently, just constant reminder to having asthma. (Participant 4, Female, 45–49)

I've been to Santiago in Chile and [the air quality] was horrible, it was actually like, I remember climbing, hiking and actually always my inhaler I took. (Participant 10, Male, 50–54)

In contrast to being constrained by their symptoms and their medication with exposure to air pollution, in the absence of air pollution in the outdoor environment, participants described the liberation from their asthma symptoms with 'clean' air relieving them from their asthma.

I wasn't having asthma attacks every day, and I connected it in my mind with the lack of road pollution ... Like I could go out I didn't need my salbutamol [reliever inhaler]. (Participant 13, Female, 45–49)

I think [the lack of air pollution] also helped me get less inflammations ... I think also the fact that the cut down based on the traffic, and exposure to that type of pollution, it was kind of like a rest for the lungs Yes, I kind of feel that I think partly the reason why I'm not taking that medication at the moment is because I kind of had like a rest from traffic pollution. (Participant 33, Female, 20–24)

In contrast to some of the interpretations in theme one specifically relating to being trapped indoors by air pollution, a shift in participants' experiences was detected during COVID-19 lockdowns. In the lockdowns air quality was perceived to be better, enabling engagement in various activities that would previously have been limited by air pollution. This ranged from simply being able to spend time outdoors, to being able to take exercise outdoors.

I could sit, sit for a couple of hours outside, which is something that I wouldn't have done before ... Because, you know, it would have been uncomfortable. (Participant 30, Female, 55–59)

Erm, I noticed that when I was going for walks, I wouldn't need masks, salbutamol [reliever] inhaler, and I was able to walk for longer and longer. Erm, and then so I was able to exercise a lot more ... (Participant 13, Female, 45–49)

Participants no longer had to outrun air pollution but could enjoy the outdoor environment.

4. Discussion

This study has explored how people living with asthma experience and manage their condition with respect to air pollution exposure. To our knowledge, this is the first qualitative study to explore how individuals with a respiratory condition experience air pollution in their day-to-day lives. We have identified four themes that describe how people experience air pollution and the various ways in which they manage (or do not manage) this: 1) Home is a safe space; 2) Disconnection from air quality information; 3) Behavior change ultimately depends on perceived control; and 4) Clean(er) air is liberating. Below

Table 2

Illustrative quotes of air pollution as a sensory experience emphasizing the contrast between polluted and clean(er) air. Key phrases relating to the senses are highlighted in bold.

Illustrative quotes		
Sense	Polluted air	'Clean' air
See	<i>My husband always used to say when we were going back to Bo'Ness for a visit. Look there's the black clouds we're heading for Bo'Ness ... Just look for the black clouds and you'll see you're nearly at your granny's. (Participant 6, Female, 60–64)</i>	<i>... you know the air seemed cleaner somehow and the trees seemed brighter. Everything seemed brighter ... we were like, have trees always been so green? (Participant 9, Female, 55–59)</i>
Smell	<i>Sometimes the air's just heavy with the horrible scent. Yes, I think it's certainly to do with your sense of smell ... (Participant 19, Female, 55–59)</i>	<i>... I felt like when you were walking about the air smelled cleaner as well because you weren't smelling the exhaust fumes. (Participant 13, Female, 45–49)</i>
Taste	<i>... you can feel like a sweet taste in your mouth. (Participant 33, Female, 20–24)</i>	<i>You know the taste that I mentioned before, going away. I really only noted the taste actually in the street when the traffic is bad. (Participant 10, Male, 50–54)</i>
Hear	<i>It's just, you can just, there's a kind of constant hum of traffic I guess, yes, constant kind of hum of traffic. (Participant 29, Female, 50–54)</i>	<i>You know, because there was less cars on the road, you could hear the birds singing, you know, that's the type of thing we noticed, we could hear the birds outside ... (Participant 9, Female, 55–59)</i>
Feel	<i>And you just always notice the air quality it's so like warm and like you feel like you really breathe it in ... And it just feels like dirty ... (Participant 24, Female, 25–29)</i>	<i>... I mean, the air definitely felt clean ... It just – it felt fresher. It felt like there was more oxygen in it. (Participant 36, Male, 25–29)</i>

we will situate this in the existing theory with reference to the Theory of Planned Behavior (where applicable) and existing literature, and highlight the novel findings of this work.

4.1. The sensory experience of safety

The work of French philosopher Merleau-Ponty on the *Phenomenology of Perception* (1945) posits that individuals' perceptions, emotions and actions are shaped by their bodily experiences, and the body is a medium through which we engage with, and make sense of, the world. Embodiment theory, at its most fundamental level, recognizes that psychological processes are influenced by the body, including its sensory systems (Glenberg, 2010). Therefore, sensory phenomenology is fundamental to making meaning of the world.

Participants depicted their experience of air pollution as a lived embodiment of sensory phenomenology, describing air pollution, for example, as a visible manifestation (e.g., "black clouds"), a haptic manifestation (e.g., feeling "choked"), or, in some cases, making the direct association with their asthma symptoms, such as cough. The senses play a role in how we interact with and perceive our environment and thus shape our experience of place (Pramova et al., 2022). Air pollution as a sensory encounter is well explored (e.g., Bickerstaff and Walker, 2001; Noël et al., 2021), with the presence of air pollution resonating being associated with negative sensory experiences (e.g., Zajchowski and Rose, 2020). Within this study, the sensory experience of air quality was reframed by participants, as something which can be positive in the absence of pollution. The described sensory experience of clean(er) air, particularly during global COVID-19 travel restrictions, was in stark contrast to polluted air. They perceived it as an enlightening experience for their senses, using words like "brighter," "fresher," and "cleaner." Participants explained that this experience can lead to an alleviation in the physical symptoms of their asthma and provide relief from using their reliever inhaler.

Moreover, respite from the negative sensory and physical effects of air pollution enabled participants to engage in activities in the outdoor environment that would have been previously hindered by air pollution such as sitting outside or going for longer walks. In other words, the feeling of external liberation was driven by internal liberation. Based on embodiment theory, the sensory absence of air pollution, and the physical alleviation of asthma symptoms, can create a sense of freedom and agency in the behaviors and actions of individuals (Hauge, 2013). Feeling free from the burden of symptoms and/or medication may lead to a perception of greater control over their bodies and environments, and their ability to engage in activities that were previously restricted or limited by air pollution. Many studies have reported inactivity induced by increased concentrations of air pollution (e.g., Alahmari et al., 2015; An and Xiang, 2015; Zhang et al., 2021), while others have examined reduction in outdoor behaviors influenced by perceived air quality (e.g., Wen et al., 2009). This study, though theoretically aligning with these findings, explored this from a different perspective and suggests that an improved perception of air quality leads to greater outdoor activity amongst people with asthma. Therefore, air which is sensorily perceived to be cleaner and fresher, may have wider benefits than improved respiratory health, including improved physical and mental health and wellbeing. Reframing clean(er) air as enabling rather than polluted air as restrictive can increase perceived behavioral control (Barnes et al., 2020).

The senses clearly have a role to play in risk perception and participants' sense of safety (Bickerstaff, 2004) and this work has indicated, as previously published studies have, that this can oftentimes be more influential than data (Calvillo and Garnett, 2019; Kim et al., 2019). Our findings suggest that, contrarily to advice (Laumbach et al., 2015; Carlsten et al., 2020), people with asthma do not use air quality data as intended to inform their decision-making, but rather as a tool to explain and verify their symptoms and physical experiences. Promoting engagement with air quality data is critical for health decision-making

since it has previously been found that perceptions of air quality do not always match measured pollutant concentrations (e.g., Reames and Bravo, 2019), since some pollutants (e.g., carbon monoxide (CO)) are entirely imperceptible, meaning that behavioral choices to minimize personal exposure may be wrong (Marquart et al., 2022). Questions remain regarding how best to encourage engagement with air quality data and information to deliver behavior changes aimed at reducing exposures, which in turn, may improve asthma-related health. We have previously argued that personalizing air quality data and information could increase engagement (McCarron et al., 2022). With particular reference to 'vulnerable' groups, a potential approach to implement this could be via health professionals such as general practitioners (GPs) or asthma nurses. For example, Howard (2023) suggests that GPs can contribute to addressing air pollution by raising awareness and enhancing risk perception among patients, helping them identify their likely exposures. A shift towards personalizing air quality data and information may facilitate its more proactive utilization.

4.2. Facing or evading air pollution

Individuals' evaluations of safety in relation to air pollution were influenced by psychological processes, and our first theme, 'home is a safe space', described participants' differing opinions of (and responses to) air pollution within and outwith their home environment. Participants expressed a desire to protect and preserve the air quality within their home by barricading themselves in by closing vents, windows and doors, and with some expressing a willingness to relocate elsewhere to escape the air pollution which is imposed upon them from the outdoor environment. This suggests that participants viewed their homes as cleaner and more desirable environments. This aligns with the 'halo effect' (Thorndike, 1920), a cognitive bias whereby an individual's perception is shaped by a singular trait. In the context of air quality, this has been extensively studied (e.g., Hofflinger, 2019; Boso et al., 2020) and coined the 'neighborhood' or 'home' halo effect, whereby individuals subjectively perceive air quality in their neighborhood/home to be comparatively better than their wider environment or objective measurements. Our interpretations demonstrated that the home halo effect persisted for people with asthma.

The home halo effect plays a key role in the development of coping strategies (Hofflinger, 2019), with a more positive perception of air quality - thus a reduced risk perception - reducing the likelihood of developing coping strategies within the home. Risk perception influences individuals' motivation for protective action with regard to personal exposure reduction (McCarron et al., 2022). Though the home halo effect was apparent in this study, the association with the development of coping behaviors did not hold true. Instead, our findings suggest that for people with asthma an inverse or reverse association occurs. The inverse: a more positive perception of air quality is linked to greater protective action, is feasible. Within the home, participants demonstrated the most proactive behaviors, taking the most opposing action to prevent air pollution from entering their homes and preserving the perceived 'good' air quality that already exists within their home. Szasz (2007) describes the development of coping behaviors to protect from health risks as an "inverted quarantine" whereby individuals engage in self-protection against potential dangers and threats that arise from the external environment. This can be linked with participants being more acutely aware of their own vulnerability as a person with asthma. Comparatively, in the wider outdoor environment, coping strategies weakened and switched from actively and directly facing the problem within the home to reactive avoidance, despite air pollution being more notably perceptible (Xu et al., 2017) (participants did not mention the sensory experience of air pollution in their home), with participants describing the ways in which they avoid air pollution. Rather than at-home coping behaviors being determined by perception of air quality as Hofflinger (2019) propose, this was dictated by control and the options available (or options perceived to be available) to the

individual and sense of control (as in Sun et al., 2017) (Fig. 2).

The reverse: taking (or being able to take) protective action creates a stronger sense of protection and invulnerability within the home is also possible. When participants perceived that they had the necessary resources and opportunities at home to improve indoor air quality and reduce their exposure (such as the ability to close windows or the choice to not fry food), they experienced a greater sense of autonomy and control over the air quality in their own environment and thus reduced risk. Control (or lack thereof) has a strong influence on risk perception. For example, Tomsho et al. (2022) found that sense of control over air quality within the home environment impacts the actions taken (or not) and the sense of security within the home environment. Therefore, perceived control over actions and environments plays a fundamental role in participants' experiences of air pollution and the formulation of their management strategies.

Though those with asthma considered home to be a safe space, several studies have found that indoor air quality can be worse than outdoor air quality, with increased concentrations of pollutants as a result of indoor behaviors, such as particulate matter (PM) from smoking, cooking and solid fuel burning; volatile organic compounds (VOCs) from consumer products and materials; and nitrogen dioxide (NO₂) from gas boilers and cookers, for example (Vardoulakis et al., 2020). Additionally, the home cannot be considered in isolation to the outdoor environment since air exchanges between the environments (e.g., Vu et al., 2022). Further, the timing of this study may have influenced this particular finding. "Stay at Home" was the UK Government's strapline during the pandemic, with this emphasized for the most vulnerable 'shielders', which included people with asthma. The message was clear, the home was a safe space, and it is possible that this message has had a residual effect beyond the context of coronavirus.

4.3. Control is pivotal to intention and action

The Theory of Planned Behavior (Ajzen, 1991) and its constructs provide a framework for understanding both participants' information-seeking (theme two) and protection action behaviors (theme three), as well as the limiting factors that influence these behaviors, since these theme directly related to participants' behaviors. Perceived behavioral control is an important construct within the Theory of Planned Behavior which directly influences both intention and action and governs the relationship between them. In addition to perceived behavioral control, behavioral intention, which precedes actual behavior, is influenced by subjective norms and attitudes (Supplementary Material D; Fig. S1). Although the constructs within the Theory of Planned Behavior are considered independent, complex interactions exist between them.

Subjective norms reflect the individual's perceptions of normative expectations and social influences surrounding a behavior of interest. It is influenced by salient others' beliefs and opinions of the behavior and what is perceived to be a socially desirable or acceptable behavior. In this study's context, participants demonstrated a common shared expectation and agreement that air pollution should be known about and avoided, even if they do not always adhere to this norm. They referenced advice from healthcare professionals, learnings from their own personal experiences and implied that avoiding air pollution is tacit knowledge, indicating a social expectation and external influence to mitigate exposure. Encouraging avoidance behaviors during episodes of poor ambient air quality is a common practice globally (e.g., Graff Zivin and Neidell, 2009; Yoo, 2021). In the UK, guidance from Asthma + Lung UK and the Daily Air Quality Index (DAQI) and its associated health advice, for example, recommend certain activities to be avoided during air pollution episodes and for outdoor exposure to be minimized for at-risk individuals, such as those with asthma. Our findings suggest that these messages are being received and may contribute to the 'normalization' of pollution avoidance in the outdoor environment, although adherence may vary (D'Antoni et al., 2019; Janke, 2014). Awareness

and action in relation to sources of indoor air pollution still lagged outdoor, which may, in part, be a result of the outdoor-centric nature of these messages. For most participants, subjective norms facilitate intentions to learn more about air quality and intention to take action to avoid it, even if this does not fully translate into action. The 'normalization' of information-seeking and protective action has a fundamental role to play in the development of behavior change strategies (Simpson et al., 2022) in both indoor and outdoor environments.

Regarding air quality information-seeking behaviors and the development of behavior change strategies to reduce personal exposures, the constructs of attitude and perceived behavioral control within the Theory of Planned Behavior appear to be more limiting. Attitudes represent individuals' general evaluations of a behavior as either positive or negative (Prestwich et al., 2018) and are shaped by their beliefs regarding the benefits and penalties associated with engaging in that behavior (Ajzen, 1988). This assessment is based upon individual beliefs about the consequences of a behavior or outcome expectancy (perceived positive or negative consequences of performing the behavior). Attitudes are further influenced by personal values, preferences, and emotional responses linked to the behavior, which in this case are embedded within place, and play an important role in the development of coping behaviors to protect from pollution exposure (Lin and Bautista, 2016; Xu et al., 2021).

A contrast in attitudes was observed amongst different categories of participants. The *resisting* and *conceding* groups demonstrated a more negative attitude towards accessing information (which in the Scottish context consists primarily of Daily Air Quality Index (DAQI) information and advice via air quality specific websites (e.g., <https://www.scottishairquality.scot>) and apps, or via non-specific resources such as weather apps) and taking action to reduce their exposures. This sentiment was reflected in quotes such as "... I don't know that I've done anything differently as a result of [accessing air quality information]", indicating a lack of positive evaluation or perceived benefits associated with information access or action. In contrast, the *attempting* group held a more favorable attitude towards the potential positive outcomes of altering behaviors to reduce personal exposures. These individuals believed that taking action can lead to tangible effects and displayed a willingness to make efforts to alter their behaviors or seek air quality information.

While it has been suggested that those most at risk from pollution exposure tend to have a more concerned attitude (De Pretto et al., 2015), our results indicate that this may not be universal for people with asthma. Although improving knowledge and awareness can enhance favorable attitudes (Hensher and Li, 2013; Unni et al., 2022), knowledge-centric strategies must be complementary to existing information dissemination techniques by acknowledging the intricate psychological processes at the individual-level that encourage engagement (or not) (McCarron et al., 2022; Riley et al., 2021). Persuasive messages can play a role in changing attitudes to promote health behavior change (Prestwich et al., 2018) and these are more likely to be more influential and elicit greater attitude change if delivered by an expert or someone viewed as an authoritative figure (Petty et al., 1986), such as healthcare professionals. Therefore, healthcare professionals, as health experts, could have an important role to play in forming and altering people with asthmas' attitudes relating to exposure-minimizing behaviors. Though conversations around exposure-minimizing behaviors should be current practice (e.g., NICE guideline NG149 and NICE Quality Standard QS181), more research into how to alter attitude towards such behaviors is needed.

Participants' actions were also limited by perceived behavioral control, as participants ultimately discontinued their efforts due to disbelief in their own ability to successfully carry out the behavior or comprehend the information, or doubt that the behavior can have a positive outcome. This was influenced by a combination of internal and external factors that shaped their confidence in their capability to execute the behavior successfully. Where attitudes represent an individual's feelings towards a behavior, perceived behavioral control is

based on control beliefs and refers to an individual's perception of the ease or difficulty of performing a behavior. It is influenced by external control factors, such as dependence on others and external barriers or constraints, and internal control factors, such as past experiences, self-efficacy beliefs and personal deficiencies (Prestwich et al., 2018). Within the *able* group, perceived behavioral control serves as an enabling factor (being the key distinction compared to the *attempting* group), supporting participants' abilities to access information and engage in effective behaviors to minimize exposures. Participants portrayed a sense of confidence and self-assurance in themselves that they could successfully and effectively take action to reduce their exposure or access information to inform their decision-making about air quality. In contrast, for the *attempting* group, perceived behavioral control was the limiting construct, preventing them from feeling like they can access necessary information for decision-making and impeding their ability to adopt successful and sustainable behaviors. Even when individuals possessed a positive attitude, they perceived themselves as incapable of responding (Barnes et al., 2020).

Previous research has shown a significant correlation between increased risk perception and a decreased sense of perceived behavioral control (Xu et al., 2021). Individuals with asthma, who may be more conscious of their own vulnerability owing to targeted messaging and advice, may therefore exhibit a higher risk perception, which could explain their reduced perceived behavioral control in outdoor environments. Since individuals need to feel that a behavior is within their capacity to enact (Barnes et al., 2020), self-efficacy (related to perceived behavioral control) has been found to exert the strongest influence on the development of intentions to engage in self-protective behaviors against air pollution exposure (Kim and Kim, 2021). This is evidenced in this study, as discussed in section 4.2, in the home environment where participants demonstrated the greatest confidence and perceived behavioral control to minimize their exposures. A focus on enhancing perceived individual control, for example by promoting small step changes such as changing walking route (Ahmed et al., 2020) or increasing use of extractor fans (Tang and Pfrang, 2023), would therefore be likely to promote greater uptake of protective actions across environments.

5. Study limitations

Undoubtedly this work has been influenced by the COVID-19 pandemic and the various lockdown restrictions in place as a result. Though this has offered a unique and novel perspective particularly on the sensory experience of air pollution, it is important to recognize, though difficult to estimate, the impact this may have had on participants' experiences and perceptions more generally (e.g., home as a safe space was a key message during lockdowns).

It is also important to note that though for the purpose of this study we have considered people with asthma as a homogenous group, different phenotypes exist (e.g., exercise-induced, allergic, occupational) meaning that the clinical features and symptomology of asthma varies between individuals. Though we have acknowledged that people with asthma experience air pollution differently, future work may wish to explore exactly how this differs by phenotypic subgroup separately.

Finally, the role of weather was not explored within this study. Weather is a potential confounding variable, influencing both ambient air pollution and the precipitation of asthma symptoms. Cold and calm weather conditions can exacerbate air pollution by creating still atmospheric conditions where pollutants accumulate and disperse more slowly, leading to a higher concentration of pollutants in the air. Cold weather can also exacerbate asthma symptoms as cold air can irritate the airways, leading to an exacerbation of asthma symptoms. It can therefore be difficult for people with asthma to distinguish between weather and pollution related triggering of their asthma.

6. Conclusions

Even within a homogeneous "vulnerable" group such as people with asthma, people experienced air pollution differently and adopted individual approaches to manage it based upon their personal experiences. Therefore, a one-size-fits-all approach to air pollution-related asthma management will be ineffective. Current exposure reduction advice, such as avoiding outdoor activities when ambient air quality is poor, is generic, failing to accommodate the specific options available to individuals and focusing solely on one environment. Our findings also suggest that these messages are being received and are helping to normalize the avoidance of air pollution. However, we suggest that these messages need to be updated to include advice across microenvironments, with a particular emphasis on indoor air quality (as a controllable environment) to raise awareness of sources of indoor air pollution and make indoor air quality exposure reduction behaviors a norm, for example with a strategy to engage people with asthma at regular intervals such as annual asthma reviews in GP surgeries.

Further, people with asthma rely on their own senses to shape their behaviors or use observed air quality data to verify how they are feeling, instead of using it proactively. There is no safe objective level of exposure to air pollution (Marks, 2022; World Health Organisation, 2023), and even at lower concentrations that do not produce a direct irritant and inflammatory effect (resulting in the precipitation of asthma symptoms such as cough and wheeze), exposure to air pollution can result in negative health consequences which may not be immediately perceivable by an individual (e.g., oxidative stress) (Guarnieri and Balmes, 2014). Therefore relying on senses or feelings to take protective health measures does not work. This could potentially lead to poor exposure-minimizing decision-making since perceptions of air quality do not always match measured concentrations. This highlights the need to promote proactive engagement with air quality data. Future work should explore the feasibility and efficacy of the proactive use of air quality data to inform decision-making and behavior change.

This study has emphasized the crucial role of personal agency in individuals' sense of safety and the influence this has on making behavioral changes. Individuals with asthma were more likely to embrace behavior change when they felt empowered and had a sense of control over their environment, as demonstrated within their homes. This highlights the importance of providing education, support, and resources that empower individuals to make informed choices and actively manage their exposure to air pollution across the microenvironments in which they spend their time. We suggest that expert guidance, such as that provided by GPs and asthma nurses, can be enhanced to increase engagement and better promote individual behavior change.

Ultimately, a reconceptualization of air quality communication, with clean(er) air framed as enabling (rather than polluted air being restrictive), and encouraging strategies which enhance an individual's personal control over their exposure to air pollution will enhance confidence to enact these protective behaviors to reduce exposures outwith the home environment.

Ethical approval

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CRediT authorship contribution statement

Amy McCarron: Conceptualization, Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Sean**

Sample: Conceptualization, Supervision, Writing – review & editing. **Vivien Swanson:** Conceptualization, Supervision, Writing – review & editing. **Christine F. Braban:** Conceptualization, Supervision, Writing – review & editing. **Colin Gillespie:** Conceptualization, Supervision, Writing – review & editing. **Heather D. Price:** Conceptualization, Supervision, Validation, Writing – review & editing.

Declaration of competing interest

None.

Data availability

The authors are unable or have chosen not to specify which data has been used.

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Appendix A. Supplementary data

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