Making the invisible visible: Engaging school children in monitoring air pollution in London

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Abstract

Exposure to air pollution is a public health concern accountable for numerous health problems and tens of thousands of premature deaths each year in the UK. Despite this evidence, public understanding and awareness of the issue is low in comparison to other public health risks. Improved methods for engaging with the public to communicate this risk are required. This study aimed to investigate the impact of collecting personalized air pollution exposure data on children and parents from a London primary school in terms of perceptions of and responses to air quality. Drawing on a participatory research approach, 400 children from a London primary school learnt about air pollution. A subset of ten children measured the air pollution they were exposed to as they travelled to and from school using portable exposure monitors and GPS watches, and shared the data they collected with the whole school. Data on the impact of the approach on the school community were collected using observations, surveys distributed to all school children and their parents, and interviews with the parents and children who collected the air pollution data. Most participants said that having access to personalized data that they themselves collected increased their air pollution awareness and their desire to reduce their air pollution exposure. The children’s participation in the project inspired them to think about ways in which they could influence other people’s behaviour, such as proposing anti-idling campaigns and encouraging their parents to cycle or walk to school. The use of participatory methods has the potential to facilitate the dissemination of information from a small group of individuals to a bigger audience. This study suggests that participatory methods can be implemented in practice, and they have the potential to be effective and engaging tools for raising awareness of air pollution as a health risk in communities.

Keywords: community engagement; personalized air pollution data; air pollution exposure, public participation; public health risk; participatory research

Key messages

- Personalized air pollution data can have an impact on participants’ attitudes towards air quality.
- Participatory methods encouraged proactive attitudes towards avoidance of harmful pollutants.
- Having access to personalized self-collected air pollution measurements appeared to increase individuals’ understanding of the causes and consequences of local air pollution.
Introduction

Air pollution has been associated with a wide variety of health problems including heart disease and stroke (Shah et al., 2015), exacerbation of pre-existing respiratory conditions, and cognitive development issues in children (COMEAP, 2010; Atkinson et al., 2015; Miller and Hurley, 2006; Liu and Lewis, 2014). Children are particularly vulnerable to the harmful effects of air pollution due to their relatively high inhalation rate and developing immune system and lungs (World Health Organization, 2005). The problem of air pollution is particularly significant in large urban settings. Recent research estimated that the total mortality burden of air pollution in London for the year 2010 was up to 140,000 life-years lost, which is equivalent to 9,416 premature deaths at typical ages (Walton et al., 2015).

Meeting legal limits is a challenge faced by major cities across Europe. In London, several measures have already been introduced in order to tackle air pollution (Greater London Authority, 2015b), such as encouraging sustainable travel, reducing emissions from transport through the promotion of technological change and cleaner vehicles, and restricting polluting vehicles from entering central London through the implementation of the London Low Emission Zone (LEZ) (Greater London Authority, 2010). Despite these measures, the levels of air pollution in several areas of London remain high and above legal limits (Department for Environment Food and Rural Affairs, 2015).

Some studies have shown that reducing exposure to ambient fine particulate matter can contribute to significant health improvements (Brook et al., 2010; Laden et al., 2006). Furthermore, there are several choices that individuals can make in order to immediately reduce their exposure to air pollution and therefore reduce the risk of an adverse impact on their health (Holgate et al., 2016). Such choices include, for example, opting for a running or walking route that avoids traffic, closing windows when driving along busy roads and setting the car’s ventilation system to recirculate (Laumbach et al., 2015). However, public understanding and awareness of air pollution remains low in comparison to other public health risks (House of Commons Environmental Audit Committee, 2010). This is partly a reflection of undeveloped methods for information dissemination and public engagement. Hence, it is of particular importance that we identify engaging and effective ways to communicate the health risks of air pollution to the general public (ibid., 2014). One strategy might be to enable people to ‘see’ air pollution to encourage them to avoid it, but how can we ‘see’ modern air pollution, which, unlike the infamous smogs in 1950s London, is essentially invisible?

Personal, wearable technology, similar to that worn by individuals to track physical activity, can be used to raise individuals’ awareness of exposure to air pollution (Snyder et al., 2013). A number of studies have used portable air pollution monitors and GPS tracking devices to measure children’s exposure to a range of pollutants (Branco et al., 2014; Nieuwenhuijsen et al., 2015; Jeong and Park, 2017; Buonanno et al., 2013). Most of these studies focused on assessing exposure to air pollution, documenting the different activities and places where children were most likely to be exposed to high levels of black carbon (BC). Some of these studies highlighted the value of using wearable technology to document personal exposure to air pollution (Nieuwenhuijsen et al., 2015; Snyder et al., 2013).

Participatory research methodologies have been used extensively in the air pollution field as a tool for engaging with people, creating projects aimed to achieve social objectives. Studies have highlighted the potential of using low-cost air pollution sensing devices and web-based tools to gather information about changes
in individuals’ perceptions of air quality as a consequence of taking part in such interventions (Sîrbu et al., 2015; Commodore et al., 2017).

Similarly, unpublished participatory research interventions have highlighted the value of involving children in the research process for raising awareness and stimulating positive changes in practice, especially in regard to active travel (Coates, 2016). However, little is known about the impact of participation in such interventions on study participants’ perceptions of, and attitudes towards, air quality.

This paper reports findings from the first of a series of interventions where community group members were invited to monitor their own exposure to air pollution in order to test the feasibility and impact of this approach to awareness raising. The case study presented was conducted with 400 children from a London primary school, aged 7 to 11 years, including a subset of 10 children (and their parents) who measured the air pollution they were exposed to as they travelled to and from school using portable exposure monitors and GPS watches, who then shared the data they collected with the whole school.

Quantification of child exposure to air pollution in the study neighbourhood was also obtained, with measurements feeding into larger ongoing studies modelling personal air pollution exposure in London (not presented here). This paper reports the impact of collecting personalized air pollution exposure data on the individuals who participated and on the wider school community in terms of perceptions of, and responses to, air quality.

**Background**

**Air pollution: A public health crisis**

While air quality in the UK has improved significantly since the 1950s, the concentration levels of some pollutants, such as fine particulate matter ($PM_{2.5}$) and nitrogen dioxide ($NO_2$), have remained persistently high and may even have latterly increased in some areas (Department for Environment Food and Rural Affairs, 2015) due to the rapid growth in the number of diesel vehicles on the road. Both of these pollutants have detrimental effects on human health (Miller, 2010; Miller and Hurley, 2006; Holgate et al., 2016). $NO_2$ causes inflammation of the airways and impaired lung function (World Health Organization, 2013). Fine particulate matter can penetrate the deepest parts of the lungs, and has been linked to a range of adverse health effects including cardiovascular disease, impaired lung function, lung cancer, and exacerbating existing illnesses, such as asthma (World Health Organization, 2013; Atkinson et al., 2015; World Health Organization, 2012a). Children are particularly vulnerable to the harmful effects of air pollution (Gehringer et al., 2013; Kim, 2004; Holgate et al., 2016; Suglia et al., 2008). The highest levels of exposure to traffic-related air pollution for children are often when travelling to and from school, particularly if their route is along heavily trafficked roads (Mölter and Lindley, 2015).

**Public perceptions of air pollution**

In the last couple of years, the UK’s failure to comply with EU regulations has not only prompted court cases against the UK government, but has also spawned a large amount of media coverage, which, combined with the increase of awareness campaigns (Biomedical Research Centre at Guy’s and St Thomas NHS Foundation Trust and King’s College London, 2015; ClientEarth, 2015; Greater London Authority, 2015a),
have significantly increased the profile of air pollution issues among the general public (House of Commons Environmental Audit Committee, 2014).

In 2006, People Science and Policy Ltd (PSP), on behalf of the UK Department for Environment, Food and Rural Affairs (Defra), assessed public views of air quality. This study comprised a literature review and a citizen’s jury (People Science and Policy, 2006). The jury was asked what improvements they would like to see in air quality and how these should be achieved. After receiving information about the causes of air pollution, and effects and mitigation measures, the jury compiled a list of recommendations for Defra, which included the use of a portable ‘meter’ that could measure the quality of the air as individuals went about their normal daily routine, as this could help individuals make informed choices to reduce air pollution exposure. They also recommended that information about air pollution should always be accompanied with advice for reducing exposure to harmful pollutants. Similar results were found in another study commissioned by Defra in 2014 (Kilbane-Dawe et al., 2014) that aimed to develop resources to help public health teams to communicate about air pollution with local decision makers and the general public. This enquiry found that there were low levels of air pollution health risks awareness among participants, but a firm desire to obtain additional information and advice on the topic.

Communicating air pollution as a health risk can be challenging (Beaumont et al., 1999) due to its invisible and odourless nature. However, as suggested by the findings documented in the Defra study (People Science and Policy, 2006), it is thought that the development of new technologies such as portable air pollution sensors and smartphones, which have geopositioning systems (GPS), can support communication campaigns. The use of these technologies potentially offers individuals and community groups the opportunity to gather personal exposure data at a specific location (Nieuwenhuijsen et al., 2015; Nieuwenhuijsen et al., 2014; Steinle et al., 2013). This could make the data personal and relevant, allowing individuals to ‘see’ where they are most or least likely to be exposed to air pollution. However, while this approach could increase the provision of information, it has been widely acknowledged that this on its own is insufficient to change behaviour (Skov et al., 1991; Bush et al., 2001; Beaumont et al., 1999).

Conceptual framework

This study builds on a number of existing participatory models, such as participatory-action research, community-based participatory research, action research, street science and ethnographic action research (Hughes, 2008; Waterman, 2001; Corburn, 2005; Dick, 2006; Heron, 1996; Schein, 2008) and encompasses many of the key principles of these participatory approaches. Participatory research is based on the idea that research should be conducted in a way that benefits individuals through direct participation, or by using the research findings to produce positive changes (Israel et al., 1998). Participatory research emphasizes that research should be carried out in a way in which research subjects are transformed into researchers by involving individuals in the research process, for example in the design of the project, the analysis of the results and the implementation of the findings, as well as in the dissemination of the information and knowledge gained (Waterman, 2001; Israel et al., 1998; Corburn, 2005; Altman et al., 2008; Ramirez-Andreotta et al., 2014). One of the strengths of participatory approaches is that the research is an empowering process in which information is gathered in order to promote action (Israel et al., 1998), such as the case studies presented by Minkler et al. (2008), where communities that were subject to the
effects of various polluted conditions generated environmental information and used it to improve environmental health decision making.

This study embraces these ideas, but differs from conventional participatory models in the level and magnitude of participant engagement, as explained later in this paper. As highlighted by Pain and Francis (2003), in practice, when carrying out participatory research, it is unusual to follow one rigid approach, and flexibility and adaptability are often needed.

Study setting
This study took place during the spring term of 2015 in a London primary school, located in an area with particularly poor air quality; at the time of writing there was a designated Air Quality Management Area (AQMA) across the whole borough as the current national air quality objectives (Department for Environment, 2016) for nitrogen dioxide \((\text{NO}_2)\) and particulate matter \((\text{PM}_{10})\) were not being met. In this area, as for most of London, the emission sources for these pollutants are dominated by road transport (Lambeth Council, 2014).

At the time of the study, 509 pupils between the ages of 3 and 11 years were attending the school. About 400 pupils from Year 2 to Year 6 (7 to 11 years old) were involved in one or more phases of the study. The majority of the pupils attending this school were from minority ethnic groups (for example, African-Caribbean and Somali), and the proportion who spoke English as an additional language was well above UK average. Additionally, over half of the children attending the school received free school meals, an indicator of lower socio-economic status. The school's admission criteria require children to live within its catchment area, meaning that most of the pupils live within walking distance.

Participatory methods
This study followed a participatory research approach. First, to raise awareness and interest in the subject and hence in the project, participants were provided with information about the causes and effects of air pollution. Second, to stimulate exposure reduction, participants were invited to measure for themselves the levels of air pollution present in their area and then to discuss the implications of the data collected.

Aiming to follow a participatory approach, school teachers, children and parents were encouraged to contribute to the planning and execution of the air pollution monitoring stage of the project, as well as the dissemination of the results.

Qualitative data on the impact that personalized air pollution exposure data had on the participants and the wider school community in terms of perceptions of, and responses to, air quality were collected using observations, surveys and interviews.

Negotiating access
The school was recruited with the help of the local council environmental officer, who was known to the researcher and who arranged an initial meeting with the school deputy head teacher, given the pseudonym ‘Mrs M’ throughout this paper. During the first meeting with Mrs M, the researcher explained the background and rationale of the project, which was in line with Mrs M’s interests and desire to promote environmental
activities in the school. After this meeting, Mrs M granted access to the school and became an active stakeholder throughout the project.

**Intervention procedure**

Pupils from Year 2 to Year 6 attended an information session about the causes and effects of air pollution. The first author gave an introductory talk that aimed to engage the children with air pollution issues, described how the project would take place in the school and explained how they could be part of it. The presentation was carefully designed to take into consideration the audience. The presentation avoided the use of technical jargon and explained difficult concepts with clear practical examples.

Following the introductory talk, the first author held a short meeting with 12 children, chosen by class teachers to include a mix of children, based on the following criteria: (1) children who were enthusiastic about the subject and who wanted to take part, and (2) children who were considered to be introverted and in need of encouragement to participate in school activities. During this meeting, children were given specially designed project information sheets to read and were given the opportunity to ask questions. Children were also given project information sheets for their parents, and a consent form, to be signed by their parents, and returned to school. Ten consent forms were signed by parents and sent back to school by the deadline.

Ten children aged between 7 and 11 took part in the air pollution exposure monitoring phase of the project – six girls and four boys from various ethnic backgrounds, including Bangladeshi, Somali, African-Caribbean, Chinese, Portuguese and White British. This subset of children (monitoring team), accompanied by their parents, used portable monitors and GPS watches, to measure the air pollution to which they were exposed on their normal journey to and from school.

**Air pollution measurements**

The air pollution measurements took place over five days. On each of these days, two children accompanied by an adult (parent/guardian) carried an air pollution monitor as they travelled back home from school. Half of the children also carried the monitor the next day as they travelled to school in the morning. The air pollution monitor was coupled with a GPS watch, which recorded where the children were when they were breathing the pollution levels the instruments recorded. In line with the participatory ethos of this project, participants were encouraged to choose the routes they wanted to monitor. Some children and their parents decided to walk the same route they walked every day to and from school, while others decided to take a different route for part of their journey.

The instrument used during this study was a portable black carbon aerosol monitor (Micro-aethalometer model AE51, Aethlabs, California, USA). The Micro-aethalometer has been used extensively across the world for air pollution exposure studies, and has demonstrated robust performance against full-size reference ‘gold-standard’ instruments (Viana et al., 2015). The log-in time was set at 30 seconds at a pump rate of 100 mL/min, which is the recommend setting by the manufacturer for personal exposure monitoring (AethLabs, 2015) (see Figure 1).

Black carbon, is one of the components of fine particulate matter (PM\(_{2.5}\)), and it is created by the incomplete combustion of fuels. Black carbon is a strong indicator of diesel vehicle emissions (Buonanno et al., 2013; Invernizzi et al., 2011), which has been classified by the World Health Organization (WHO) as a class 1 carcinogen (World Health Organization, 2004).
Organization, 2012b) and represents a component of air pollution thought to have among the greatest potential risk to public health. The GPS watch used was a Foretrex 301 model (Garmin, USA) (see Figure 1). All devices were subject of an extensive performance check before being handed out to participants and after the data was collected. The instruments were operated in line with manufacturer's guidelines and best practice procedures. BC measurements were downloaded immediately after each sampling session to minimize data handling errors.

Children and parents received instructions on turning the monitor and the GPS watch on and off, and they were advised to make sure that the tube connected to the monitor at one end was placed near the child’s breathing zone at the other end at all times (see Figure 1). This advice was given in order to measure the black carbon present in the air inhaled by the children.

The data gathered was processed and analysed by the researcher, who is a qualified air-quality scientist and who employed scientific rigour in the data analysis.

Figure 1: Micro-aethalometer and GPS used (left) and a child carrying a monitor and wearing the GPS watch (right)

Air pollution data results reports and feedback

The children who took the measurements received personalized reports of the data they collected. The air-quality data recorded while the participants were in motion (walking, biking or in a vehicle) was presented to the participants using graphs, tables and maps. The maps were produced using the Real-time Geospatial Data Viewer (RETIGO) which is an Environmental Protection Agency (EPA) developed web-based tool (www.epa.gov/hesc/real-time-geospatial-data-viewer-retigo).

These reports were given to children face-to-face during a meeting. During this meeting, the information contained in each of the reports (graphs and maps) was explained, and children had the opportunity to ask questions. Having access to this data helped the children to clearly identify air pollution hotspots and/or routes in their local area. Some children were also able to propose alternative less polluted routes for their school journey. During this meeting, children were asked if they would like to
share their monitoring findings with the rest of the school, and, if so, what they thought would be the best way for disseminating these findings.

**Dissemination of results back to community groups**

All of the children agreed to share their findings to the rest of the school during an assembly using a PowerPoint presentation. This presentation contained the graphs and reports from each of the children involved in air pollution monitoring. The children were very enthusiastic; one of them commented after the presentation, ‘That was awesome! I want to do that again’ (Child G, age 7).

At the end of the children’s presentations, the researcher highlighted to the whole school community that, although to reduce ambient concentrations of air pollutants around their school and in their local area, policy changes were required, there were several choices that individuals could make to immediately reduce their exposure to air pollution. For example, children and parents could reduce their exposure to polluted air by: (1) walking or cycling to school; (2) choosing a low pollution walking or cycling route to school by avoiding busy roads; and (3) if travelling to school by car, closing windows when driving along busy roads or sitting in queuing traffic while setting the cabin air to recirculate.

On the advice of the teacher, the researcher made the message as concise as possible to increase the likelihood of the advice being remembered by the children in the long term. All children at the school were given a written summary of the project, with advice about reducing air pollution exposure.

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**Figure 2: Study diagram**

![Study diagram](image_url)
Evaluation design

To assess the feasibility and impact of this participatory approach to awareness raising, an ethnographic approach was used (Atkinson et al., 2001; Brewer, 2000) to provide insights into individuals’ views and actions throughout the project. This approach involved the use of surveys, semi-structured interviews and observation. Two surveys were conducted with the children participating in the information session. The first was conducted immediately after the assembly at which the results were presented, and the second was conducted three months later. Qualitative interviews were carried out with the monitoring team and their parents three months after the air pollution monitoring took place. Observational field notes were kept by the first author throughout the project. Figure 2 provides an outline of the step-by-step development of the study.

Data collection and analysis

The two surveys were offered to all 400 children in the school. The first survey aimed to capture the children’s initial response towards the personalized air quality data gathered, and the advice and information received. The second survey aimed to assess: (1) if participants adopted new routines in order to reduce their air pollution exposure; and (2) whether they were able to disseminate the information they received to other members of their family and community. Both surveys were distributed to the children by the class teachers.

Semi-structured interviews were planned with the ten children that carried out the air pollution monitoring and with their parents. However, Child J had to travel unexpectedly with his family and Child I’s parent did not attend the interview appointment. This brought the final number of interviews to nine children and eight parents. The semi-structured interviews aimed to capture participants’ views and experiences of participation in the project. Interview questions focused on: (1) motivation for taking part; (2) responses to the data; (3) impact on participants’ behaviour; and (4) dissemination of project findings with family, friends and community. The interviews with the children lasted between 8 and 10 minutes. The interviews with the parents lasted between 10 and 20 minutes – these were kept short as parents agreed to be interviewed only if the interview was short and they could do it after dropping off the children at school before going to work. Children and parents were interviewed separately. The teacher, Mrs M, was interviewed on two occasions. The first time, immediately after the results were presented and the second time three months after receiving the results. The teacher interviews lasted 15 minutes on average; she also requested that the interviews be kept brief. With the permission of the participants, all interviews were digitally recorded and transcribed in full. The qualitative data were imported to NVivo (version 11) for thematic analysis (Bazeley and Jackson, 2013). All transcripts were read and systematically coded in full. Codes were then organized to construct larger themes.

Ethnographic field notes were recorded by the researcher to capture how situations developed during the project, such as the recruitment, monitoring and results feedback stages. The field notes were transcribed in full and pseudonyms were used to safeguard the anonymity of participants.

The study received ethical approval from the King’s College London (KCL) Biomedical Sciences, Dentistry, Medicine and Natural and Mathematical Sciences Research Ethics Subcommittee (BDM RESC). Ethics Ref number: BDM/14/15-39.
Results

Air pollution data results

The results from the measurements carried out by the ten school children were unmistakable; children walking through the main roads were exposed to significantly higher levels of black carbon (representing airborne black carbon particles) than those walking through quieter back streets. Figure 3 shows the average concentrations of black carbon to which children were exposed as they travelled from and to school during an average 18-minute journey.

Figure 3: Average black carbon concentration during school trip

Given that neither a safe level nor a toxic threshold of black carbon has been identified yet, the results were presented to the children using relative comparisons in the context of what they could do to reduce their air pollution exposure based on precautionary principles (Jeong and Park, 2017). For example, Figure 3 shows that the average exposure for Child C, who walked mostly through busy roads, was twice as much as the average exposure of Child E, who walked through the back streets. In this case, Child C could also walk through the back streets if he/she wanted to. Another example is Child B’s data findings, which were a clear representation of the very busy road he/she uses to go to and from school. For Child B, as for most of the children, alternative quieter routes could be taken for at least part of the journey. The biggest surprise for two of the participants and the school teachers was to find out that they could potentially be exposed to high levels of air pollution when vehicles are idling. These data were gathered by Child H and Child G, both aged 7, when they stopped to buy an ice cream at a van parked just outside the school gate (see Figure 4). Both children were exposed to remarkably high levels of diesel exhaust emissions ‘black carbon’ during the five minutes they stood next to the ice-cream van, compared to their rest of the route back home.

The findings from the air pollution monitoring were presented to the children using simple maps with colour scales produced from the data obtained. Figure 5 shows an example of the maps given to the participants where higher concentrations...
of air pollution (represented in colour red) were measured along busy roads and lower concentrations (represented in colour blue) were measured in back streets and parks. The specific maps are not shown as they would allow identification of the location of the school and children’s homes.

Figure 4: Air pollution monitoring results, Child H and Child G

These maps helped the children to clearly identify where along their route the highest or lowest levels of air pollution were recorded so that they could, if feasible, change their route accordingly.

Figure 5: Example of the maps given to the participants

Real Time Geospatial viewer (RETIGQ)
US Environmental Protection Agency
Survey and interviews results

The purpose of the surveys conducted during this study was not to provide statistical associations between variables, but rather to complement the other data collection methods (observations and semi-structured interviews) in order to aid with the contextualization of the participants’ narratives. The first survey aimed to capture the children’s initial response towards the personalized air quality data gathered and the advice and information received. This survey, administered to all 400 children in the school, had a 50 per cent response rate (n=200). Of these, 42 per cent (n=85) reported learning ‘a little bit’ and 35 per cent (n=70) reported learning ‘a lot’ about air pollution as a result of the project. When children were asked if they would put into practice the advice they received for reducing the amount of air pollution to which they are exposed, 58 per cent (n=116) said they would. The percentage of children that said that they would tell family and friends what they learned at school about air pollution was 48 per cent (n=97), while 39 per cent (n=77) of the children reported that they were not sure whether their route to and from school was affected by air pollution.

The second survey aimed to identify if children had disseminated the information they received to other members of their family and community, and to assess the extent to which new routines were adopted by the children to reduce their air pollution exposure. This survey was also given to all 400 children in the school, and had a response rate of just over 20 per cent (n=93). This low response rate could be attributed to the fact that the survey was offered during the last week of term before the summer holidays. Hence, there was not enough time to remind teachers and children about the surveys. About half of the children who took part in the second survey said that they spoke to family and friends because they thought they should know about air pollution as it was important and interesting. The other half said that they did not talk about the project because they ‘forgot’. Over 60 per cent (n=58) of the children surveyed said that after the project they walked or cycled more to go to school instead of using the car.

The results from the semi-structured interviews provided the following information about participants’ views and experiences of participation in the project.

Deciding to participate

The school felt encouraged to participate in the project as they felt that this was an opportunity for promoting the adoption of environmental activities at the school, which, in turn, could help raise the children’s awareness and understanding of environmental issues. As Mrs M said, ‘I just think it is very good to educate children concerning, you know, environmental issues particularly when they live in central London, which, you know, is very congested, and particularly our area’ (Mrs M).

For most children and parents, the main reason for taking part in the project was to gather knowledge, ‘to know’. They wanted to find out whether they were exposed to air pollution or not, and if they were exposed to air pollution they wanted to know about the health implications of being exposed to air pollution:

Because I am concerned about the pollution, the levels of pollution, there is a lot of traffic on the roads and I am really concerned about the, you know, health! Especially respiratory health. Because, I see a lot of children, a lot with asthma and a lot of respiratory problems, and I think it’s due to pollution, nothing else. I wanted to know the levels of pollution because then we can, you know, see! what is going on (Child G’s mother).
In this case, Child G’s mother was aware of the respiratory health risks posed by air pollution. However, despite this general level of air pollution awareness, like her, many participants were unaware of the magnitude of the issue in their area. As Child B (age 10) stated: ‘I wanted to do this project because I wanted to see the difference – what the air pollution is around my area and if it is good or if it is a bit bad?’ For many parents and children, having the opportunity to gather information about the levels of air pollution in their own neighbourhood was a trigger for participation.

**Responses to the exposure data**

It was noted through informal conversations with many parents that they were inclined to associate high levels of air pollution with heavy traffic, even before seeing the results of the project. Thus, it was not particularly surprisingly for many of them to see in the results that the highest levels of BC were normally recorded along busy roads and at junctions:

> No, no, it’s not, no surprises there. Because, of course, on the main road, we have the vehicles all over the place and at least we don’t have them when the kids are using the back roads and most of the pollution is made by, you know, cars and all that, so I am not surprised (Child A’s father).

On the other hand, some children were surprised to find out that air pollution can vary from place to place and time to time: ‘I was surprised that there was not air pollution where I live, but that there was a lot of air pollution around the school because there is a lot of traffic’ (Child A, age 10).

One of the parents interviewed was particularly concerned about the recent council proposal to close some of the main roads in order to discourage drivers from entering this area of London and forcing them to find alternative routes outside the borough. She explained that closing the roads would only force cars to go through the, until now, quiet estate where she lives. She thought that the data collected by the children was valuable evidence that should be presented to the council:

> If these results could be shared and taken into consideration when they are trying to close roads, umm. They have to take it into consideration because in the estate, even though it’s less pollution now, by closing that road, yeah, they may decrease the pollution over here but it will increase close to our homes, so it is a bit … it is a bit of a gamble really, like taking – moving one problem from one area to move it to the other. It is not sorting out any problem really (Child F’s mother).

While it was obvious for many parents to associate air pollution with traffic, many were unaware that idling vehicles parked outside the school or anywhere in their neighbourhood can also contribute to the air pollution problem in their area:

> The most shocking news was like seeing the high pick up of pollution near the ice-cream van and, you know, just few metres from the school. It just makes me feel unsafe! I will never, I will never realize something like that, you know. I had to see it to believe it! (Child G’s mother).

Even though many parents agreed that air pollution can affect their children’s health, they also felt that priority should be given to other risks, which they perceived as more ‘imminent’. For example, Child A’s father stated that he would not let his daughter walk through the back streets as this was not safe. He would prefer for her to walk through the main roads, even though levels of air pollution on busy streets are considerably higher:
Well if anything happens there, there is no one that can really see and help, let’s say she gets attacked by, you know, any anyone down there, there is not enough people around to help. While on the main road, you know, people can easily spot what is going on and they can help (Child A’s father).

Another parent whose son became keen to cycle to school following participation in the project stated that his priority was his son’s safety on the road, to the point that he, with some embarrassment, reported that he is allowing his son to cycle while he follows behind in his car. He said: ‘The dangers of pollution to my son are so much less than the dangers of being knocked down by a lorry driver. Anybody on the road that is just not looking, I mean that is the greatest danger!’ (Child E’s father).

We need to learn about it and spread the word

Most children said that they did not have any previous knowledge about air pollution, its causes, effects or the ways in which they could reduce their own exposure. Child D stated that, although, she was in Year 6, she had never heard about air pollution and that it was thanks to the project that she learnt about it. Most of the children interviewed agreed that if they were to remember what they had learned about air pollution, the information must be repeated on a regular basis.

In general, children said that they talked about the project with their immediate family: mother, father, brothers and sisters. They described to their families how the project took place, the instruments they carried and some of their own results. Similarly, most parents indicated that they talked to family and friends about the project, as they thought it was an important issue that people needed to know about. However, some parents spoke of their frustration that some of their family and friends were not interested in the information and advice the project generated:

It is really hard to know, because, we talked and talked and talked and they just brush off and not listen. I don’t know, they are just not aware. I don’t think they are aware of the real dangers of air pollution; they are not or they don’t want to be. I don’t know! They are too busy you know their work, is difficult, I don’t know how to reach them, because I spoke to my friends we have, you know, a conversation about this but that is it. It is not really an interesting issue, only when something goes wrong with the child and they have asthma, and they try to find ways of dealing with that. Then they realize how bad it is (Child G’s mother).

Many parents and children suggested that air pollution should be a topic taught at school, perhaps as part of science lessons. Parents also highlighted that teaching children about air pollution at school would also benefit them and their families, as children normally talk at home about what they did and what they learnt at school. As one parent said:

I think the best way is at school with children, you know, children tell everyone what they’ve done or what they haven’t done, to be honest. Oh yeah! They are good at disseminating information. Even if you don’t want to hear the information, they will give you the information [laughs] (Child H’s mother).
Air pollution awareness

Parents and children agreed that, in general, the project had boosted their level of air pollution awareness and, hence, their understanding of the issue. After the project, most of the children talked with familiarity about the effects that air pollution could have on their health, and about the main spots around their area where high levels of air pollution could be recorded. They also recognized that air pollution was a serious problem, which needed to be talked about:

> It is not good for like children, so I think they should know that this it is something that you should learn. And that people are always mistaking that air pollution – that it is not really a big thing and that it won’t hurt you but really it is really something that you should care about (Child D, age 11).

The findings from the ice-cream van emissions not only made parents pledge to never again allow their children to stand next to an ice-cream van, but also, helped them realize that idling vehicles were a contributor to the air pollution problem:

> Obviously, sometimes when we are out and about and obviously we are crossing over the road and there are a lot of cars going past and they are stationary. I never thought of that, to be honest. I just thought it was when they were moving, they are causing the pollution, but obviously when they are stopped is even worse with the findings (Child H’s mother).

Finding out that there was a potentially high source of air pollution right in front of the school gates was also a surprise for Mrs M and her staff. They said that although they had seen the van parked outside the school for years, they never really thought about it. They had asked the van driver to park on the other side of the school because it was blocking traffic, but had never considered it as a threat to the children’s health. As a result of this information, the school decided to ask the ice-cream van driver to park elsewhere, further from the school. However, this was not necessary as the ice-cream van driver did not come back to the school for reasons not related to the project.

Most participants, especially the children, stated that the project inspired them to change their route to school to reduce their exposure to air pollution: ‘I walk through the back way now, because I realized that there is too much air pollution around, and if I walk through the back streets there is not much air pollution around us anymore’ (Child B, age 10). ‘Me and my mum, we are walking through the park so we have less air pollution, and we play in the park and we don’t get too close to the main roads’ (Child G, age 7).

The participants’ air pollution awareness improvement also translated into different forms of action. For example, it made environmental issues a topic of discussion at school, where children voiced their concerns. This was observed by Mrs M during one of the school activities, where in order to highlight the general election taking place at the time, the children were asked to create their own political party, developing a party manifesto that explained plans for the school and their local area. To Mrs M’s surprise, most of the political parties formed had ‘environmental issues’ in their manifesto. If elected, children proposed to work towards better air quality around the school, and to improve the school’s recycling rate. Mrs M said that the children would not have thought about air quality issues if the air pollution project had not taken place.

Similarly, after seeing the air pollution data collected, Child E (age 9), a member of the school council, stressed his frustration with seeing parents parking and idling
outside the school gates. His remarks led Mrs M, together with the school council children, to talk about the issue and to plan a project for the next academic year. They planned to talk and give leaflets to the parents parked outside the school asking them ‘not to park in front of the school gates because of the air pollution’. Mrs M stated that Child E brought this problem to her attention because ‘he understood a little bit more about the fumes and what all this air pollution entails’.

Discussion and conclusion

In this study, ten children and their parents measured the air pollution they were exposed to using portable air pollution monitors and GPS watches, enabling them to ‘see’ where air pollution was present along their route. While some parents and children had some pre-existing knowledge about the potential health risks posed by pollutants, and intuitively tended to associate traffic with high levels of air pollution, they were unaware of the magnitude of the issue in their area.

The participatory research approach used throughout this study gave participants the opportunity to be part of the research process. This included aspects of the air pollution monitoring design, where parents and children chose the routes to be monitored; interpretation of the data, where children identified air pollution hotspots on the maps; and dissemination of the results, where the children (monitoring team) presented the findings to the school community at an assembly. This involvement facilitated the communication of the risks posed by air pollution in an engaging and effective way. Children quickly understood and assimilated the information and advice given, and they proved to be, in their parents’ own words, ‘fantastic disseminators of information’ within their school community, family and friends. Similarly, Mrs M, deputy head of the school (the gatekeeper), actively participated during the development of the project, providing valuable assistance. Mrs M arranged the required logistics for accessing the school and meeting with the children, helped to select the monitoring team, and gave recommendations about the amount and level of complexity of the information to be given to the children. This highlights the value of having the school officials (gatekeepers) support and commitment when undertaking these types of interventions.

The air quality data collected during this study was from the participants’ local area. This made the findings from the monitoring measurements relevant to the children’s daily commute to school and, therefore, it allowed for a contextualization of the presence of harmful pollutants in their local surroundings (Beaumont et al., 1999). Having information about air pollution and access to personalized self-collected air pollution measurements appeared to increase understanding of the causes and consequences of the local air pollution identified through the monitoring. Furthermore, the findings from this study suggest that this participatory approach has the potential to inspire individuals to not only reduce their own air pollution exposure but also to think about ways in which they could influence other people’s behaviour. For example, some children proposed anti-idling campaigns around the school, while others pledged to persuade their parents to walk or cycle more to school instead of using the car. All parents involved in the study agreed to do their best to support their children’s pledges.

Despite the benefits of giving individuals access to personal exposure data, it is important to consider that access to personalized data can reshape individuals’ perception of risk and hence, the way they understand risk and the way they cope with it. Whether and how to communicate individuals’ monitoring results is a matter of
concern for many researchers (Washburn, 2014). It has been argued that reporting back the findings of personal exposure monitoring could generate anxiety and frustration (Washburn, 2014; Quigley, 2012). During this study, in order to alleviate the possible negative consequences that access to personalized exposure data could have on the children and parents, it was paramount to not only identify and make individuals aware of the air pollution problem, but to provide them with clear advice as to how their exposure to harmful pollutants could be avoided or reduced (Beaumont et al., 1999).

When engaging with the public and presenting personalized reports, it is also important to consider how the personal exposure data is presented, as this may have a direct impact on the final outcome and the overall individual experience. Meaningful reports, where the personal exposure data presented can be easily and clearly understood and assimilated by the individuals, are essential. During this project, the use of maps showing the children’s routes to and from school, with colours highlighting the levels of air pollution along the routes, proved to be very valuable. These visual aids helped the children and their parents to easily identify their surroundings, major roads and intersections. The use of a colour scale permitted participants to see the different levels of air pollution encountered along their routes, and to compare results with other participants. This was particularly useful for giving the BC concentrations recorded some context, as BC does not currently have any health guidelines or limits. Therefore, participants were encouraged to interpret their results by comparing, for example, low (blue) concentrations measured in the back streets against high (red) concentrations normally measured on the main roads and junctions.

As seen in this study and previously reported, access to personalized information has the potential to enable individuals to make informed decisions about how to avoid or minimize their exposure to harmful pollutants and, hence, reduce the associated health effects (Brody et al., 2007). Furthermore, access to results from biomonitoring interventions has the potential to empower individuals and communities and inspire them to take action to advocate for better environmental conditions (Washburn, 2013; Altman et al., 2008; Adams et al., 2011; Minkler et al., 2008).

The findings of this study should be considered in light of some limitations. Although opting for behaviours that could lead to a reduction in air pollution exposure may seem obvious, there is not enough evidence on the actual health outcomes after personal interventions for reducing exposure have been adopted. This is a small study that took place in one school, in a single area of London. Therefore, the experiences disclosed by the children and parents interviewed may not entirely represent the different views that could arise from a wider variety of social and ethnic backgrounds normally present in an average London primary school. Similarly, while school teachers aimed to have a variety of children involved in the air pollution monitoring, it was not possible to assess participants in terms of demographic and other characteristics, making it difficult to generalize about who participates in such projects. Additionally, since behavioural impacts were not measured objectively, it is not possible to assess with certainty whether the intervention led to sustained behavioural change. Finally, it should also be acknowledged that the self-reported nature of the surveys may have led children to respond according to their idea of what the researcher and/or the teachers were expecting from them.

Although the use of a participatory research approach can facilitate the communication of the risks posed by air pollution, interventions where members of the public are involved can be challenging. These types of interventions tend to be time-consuming and resource intensive. Planned interventions can go well beyond schedule, affecting budgets and the meeting of deadlines (Israel et al., 1998). During
this study, the time allocation given by the researcher to each stage of the project had to be extended numerous times. This was due to, first, the school’s own agenda, for example, holidays, day trips and inset days, and, second, children’s sickness and parents’ work commitments, which affected their availability. Another challenge of working with community-based groups is convincing the gatekeeper to allow the research to be carried out; this may involve meeting the gatekeeper’s own priorities. Additionally, while doing this type of study, there is always the risk of engaging with highly motivated participants, which may not represent the broader population. Participatory research also requires researchers to learn to communicate and engage with members of the public in an accessible manner (ibid.). This could imply that before embarking on a participatory research intervention, researchers may require additional training, hence stretching budgets and deadlines.

One of the major strengths of this study is the communication approach, through which children and parents were made aware of the choices that they could make to immediately reduce their exposure to air pollution. Equally, by involving children in the dissemination of the results, this study also facilitated the dissemination of information from a small group of individuals to a bigger audience. This study suggests that participatory methods can be implemented in practice and they have the potential to be effective and engaging tools for raising awareness of air pollution as a health risk among communities. This translates into an increase in individuals’ knowledge about the causes and effects of air pollution, and control measures to prevent or limit exposure, which could lead to a more proactive attitude towards avoidance of harmful pollutants, at least in the short term. Furthermore, participatory methods can facilitate the dissemination of information and results of interventions carried out by a small group of individuals to a bigger audience.

This paper reports findings from a relatively small sample size study of a single intervention among school children who gathered a limited number of air pollution measurements. Therefore, further studies are required to: (1) demonstrate the feasibility and impact of this approach in other community groups; (2) gather empirical evidence on the impact of similar interventions regarding behaviour change and knowledge gain; and (3) gather evidence on the actual health outcomes after personal interventions for reducing exposure have been adopted.

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