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Particulate Pollution and Childhood Health: Citizen Science Approach

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Abstract

Air pollution is one of the most serious threats to children worldwide. Measuring air quality is crucial for effective responses and actions. The use of static sensors in local communities helps to inform people about air pollution in their area and raise awareness of the need to reduce pollution levels. This paper aims to highlight the usefulness of these new low-cost portable sensors in assessing personal exposure, identifying hotspots as well as aid advocacy for cleaner air in the local community. Citizen science entails the public's participation in scientific research and the use of this approach in our ongoing study in Bradford, UK using low-cost sensors has proven to be beneficial because it allows citizens to be involved in the research and data collection process. The study results show the level of harm they are exposed to, which might evoke behavioural change in lifestyles that can improve public health. Although, short targeted citizen science campaigns cannot replace static sensor data. They can however, supplement static data, increase engagement and can also be used in regions with limited air quality data.

Keywords:
Citizen Science,
Low-cost sensors,
Air pollution,
Exposure,
Public participation.

Résumé

La pollution de l'air est l'une des menaces les plus graves pour les enfants dans le monde. La mesure de la qualité de l'air est essentielle pour des réponses et des actions efficaces. L'utilisation de capteurs statiques dans les communautés locales aide à informer les gens de la pollution de l'air dans leur région et à les sensibiliser à la nécessité de réduire les niveaux de pollution. Cet article vise à mettre en évidence l'utilité de ces nouveaux capteurs portables à faible coût dans l'évaluation de l'exposition personnelle et l'identification des points chauds, ainsi que dans le plaidoyer pour un air plus pur dans la communauté locale. La science citoyenne implique la participation du public à la recherche scientifique et l'utilisation de cette approche dans notre étude en cours à Bradford, au Royaume-Uni, à l'aide de capteurs à faible coût, qui s'est vraiment serviable car elle permet aux citoyens d'être impliqués dans le processus de recherche et de collecte de données. Les résultats de l'étude montrent le niveau de préjudice auquel ils sont exposés, ce qui peut évoquer un changement de comportement dans leur mode de vie et qui peut améliorer la santé publique. Bien que les campagnes de science citoyenne d'une courte durée, et ciblée ne puissent pas remplacer les données statiques des capteurs, elles peuvent cependant compléter les données statiques, accroître l'engagement et peuvent également être utilisées dans les régions où les données sur la qualité de l'air sont limitées.

Mots-clés :
Science citoyenne,
Capteurs à faible coût,
Pollution de l'air,
Exposition,
Participation du public

Introduction

There is now extensive evidence that short- and long-term exposure to air pollution can lead to a range of adverse health effects in children. The World Health Organization estimates that in high-income countries, 52 percent of children under the age of five are exposed to levels of fine particulate matter $PM_{2.5}$ that exceed WHO air quality guidelines, whereas 100 percent of all children under the age of five are exposed in the WHO African and Eastern

Mediterranean regions (1). Children are the most vulnerable members of the population to the health risk of air pollution due to their immune systems, lungs and brains still developing (2).

Air pollution has been found to have a greater impact on people with lower socioeconomic status. As a result, they are more likely to develop respiratory illnesses(3). Although the difference in exposure may not be significant on low exposure days, it is fully evident during high air pollution episodes (4). $PM_{2.5}$ pollution in under-five children increased with low levels of education spending and poor sanitation service (5). As a result, the health effects of air pollution in low and middle-income countries are greater than in high-income countries, necessitating stricter policies and more research in the world's poorest and most populous countries.

Many high-income countries use air monitoring stations in and around urban areas to monitor $PM_{2.5}$ concentrations. These static sensors provide information on local pollution levels but are expensive to install and run. For this reason, the number of air monitoring stations in low and middle income countries are very limited. People in these regions lack access to information about pollution levels in their area and the effects of air pollution are underestimated because air pollution is not monitored to the same extent as in developed countries (6).

In the last 5-10 years, several brands of static low-cost sensors ($250 to $750) have become commercially available (e.g. Purple Air, Air Beam and Aeroqual). These sensors show encouraging levels of accuracy and reliability and they are already being used to provide communities in low and middle income countries with real time, accessible local air quality data (7-11).

When these static sensors are installed in collaboration with local communities, they can be a key resource for informing people about the air pollution in their area and raise awareness of the need to reduce pollution levels (8, 10). Static sensors, however, only measure in a single location and thus, cannot reflect people's personal exposure to pollution. For example, a child's exposure will change as they engage in various daily activities. Understanding this pattern of exposure, and the link between exposure and behaviour, allows researchers to understand where the exposure occurs for a specific person and allows individuals to make informed choices to manage levels of exposure. This additional information is essential for public health research, as it can also be used to engage communities in air pollution research. In this paper, we present a case study in which portable sensors are used in citizen science research. The paper argues that these new portable sensors can be useful in assessing personal exposure and identifying hotspots as well as in the advocacy for cleaner air in the local community.

Citizen science in Air Pollution Monitoring

Citizen science allows the public to contribute to the research process by collecting data on a topic that affects them. Citizen science monitoring projects democratized research and creates new knowledge that more closely resemble the community's experiences of air pollution (12). Some citizen science researchers raise concerns over monitoring projects being used as a low-cost replacement for local authority or national monitoring and argue that short, targeted citizen science campaigns cannot replace static sensor data (13).

However, this approach is increasingly being included on the research agenda. The goal is to raise awareness of air pollution and encouraging new partnerships between social actors in the hope of building community resilience (12). This approach differs from participatory action research or participatory citizen science. Participants play a larger role in developing the research agenda, designing the intervention, and assisting with data analysis. (14, 15).

In time, some citizen science monitoring projects may become participatory by empowering communities to shape the direction of research toward resolving local issues that are important to them (15).

Citizen science study results can illustrate the level of harm participants are exposed to, which may evoke behavioural changes in their lifestyles. This can ultimately provide positive health benefits. A study by Varaden *et al.*, found out that citizen scientists, who used portable air quality monitors were relieved to discover that there were actions they could take. This includes walking along quieter streets which could reduce their exposure to air pollution. A total of 24% of the parents surveyed reported behavioural change in how they travel to school in response to the project (9).

A similar approach is currently in use in our ongoing project in Bradford to monitor the exposure of school aged children to particulate pollution exposure, it is summarized in a framework in Figure 1.

BiB Breathes: A citizen science case study measuring children's exposure to air pollution

Born-in Bradford (BiB Breathes) study is located in Bradford, UK an urban, multicultural city in the North of England, UK. Bradford is the sixth largest metropolitan district in the UK with a population of >530,000. It has a multi-ethnic population with 63% identifying as White British and 20% as Pakistani. It also has a growing Eastern European community(16). It is a deprived city, with 40% of Bradford residents living in areas that rank in the most deprived quintile. It has high levels of ill health, noticeably amongst children (17). In the study, over 100 school children from 12 primary schools in Bradford have been asked to carry a portable $PM_{2.5}$ sensor (Atmotube Pro) and mobile phone with GPS enabled on their journey to and from school for six-four week periods spread over two years. During the day, the sensors are placed to charge in the classroom. The participants were also asked to complete a daily travel diary on how they travel to school. Figure 2 shows some citizen scientists (primary school children) involved in our current study in Bradford, wearing a mobile portable sensor (Atmotube Pro) attached to a bum bag tied around their waist. The sensors monitor their exposure as they go about their commuting s0 as to give a more accurate picture of their exposure whilst travelling to and from school than the static sensors.

The Atmotube Pro records particulate matter, some meteorological parameters (Temperature, Pressure and Relative Humidity) and GPS location is recorded every minute using a mobile phone. A typical example of the time series from an Atmotube Pro in our current study with school children is shown in Figure 3. These mobile sensors provide a more detailed picture of each child's exposure to air pollution and the activities that are most likely to cause these peaks during the course of the daily routine.

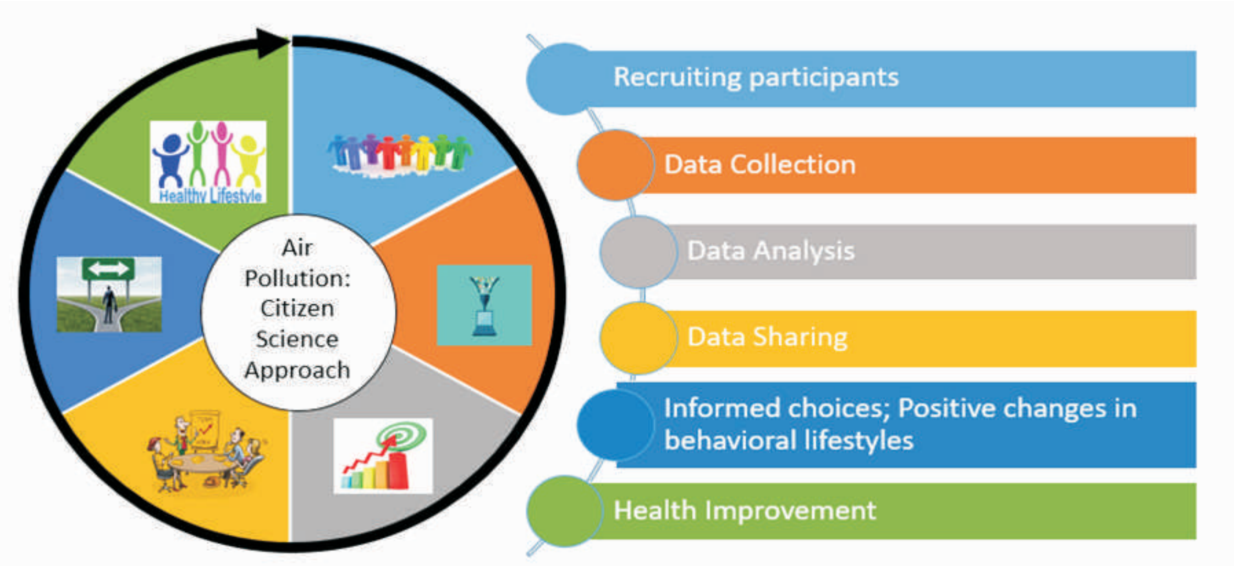

Figure1: A framework of the processes involved in air pollution exposure using citizen science

Figure 2: School kids with mobile sensors (Atmotube Pro), mobile phones in the bum bag record GPS position

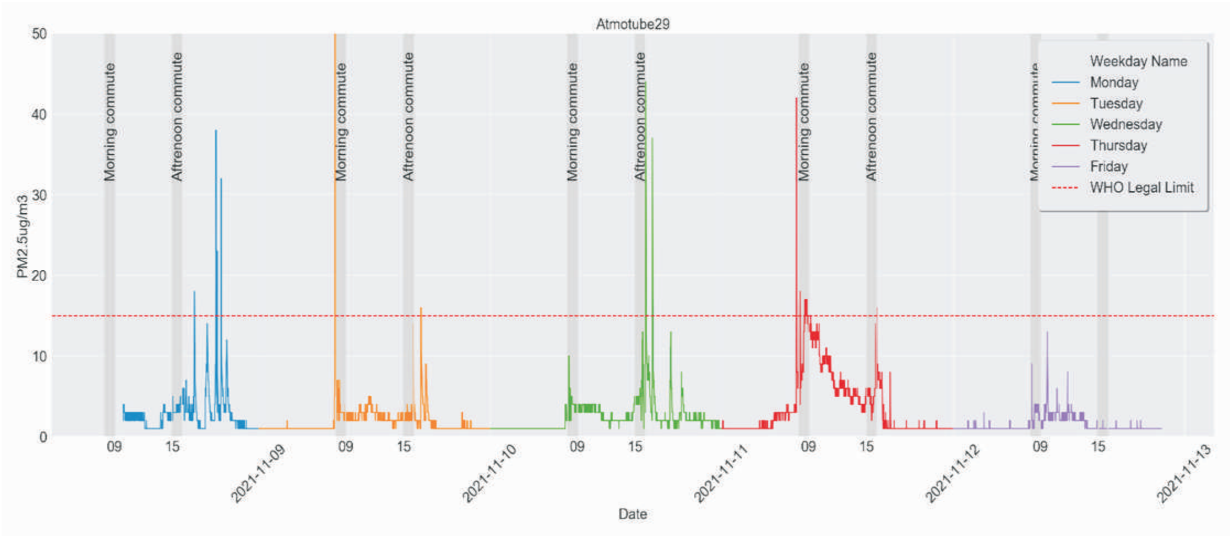

Figure 3: Time series of an atmotube showing peaks of PM2.5 during school commute

Scope for Expanding to other Regions

We have established a collaboration to replicate this air pollution exposure study among schoolchildren in Ibadan, Nigeria. Ibadan is the third largest city by population in Nigeria with a population of over 3.6 million. It is one of the cities, in West Africa that are expected to be megacities by 2100, and the rapid population growth especially in combination with increase in $PM_{2.5}$ significantly increases population exposure to hazardous pollutants (18). The study will contribute to limited data available in the region and also assist in informing the community on their level of exposure to air pollution especially among school aged children.

Conclusion

Air pollution is a major public health issue throughout the world, with over 90% of the global population exposed to levels of air pollution that exceeds WHO limits. This is of particular concern in Africa and Southern Asia where pollution concentrations are often higher but there are very few measurements. Community static monitoring stations provide an exciting opportunity to provide people with air pollution concentrations at a local level. Although static sensors provide essential baseline information, they cannot give information on varying levels of exposure throughout the day.

The first step in resolving any problem is to measure it. In this paper, we argue for the importance of portable personal exposure monitors, not only for understanding individuals' patterns of exposure, but also as a tool for engagement to drive positive lifestyle changes that can improve the health of people in a community, particularly children who are the most vulnerable.

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