Chapter 12
Leveraging Citizen Science to Address Indoor Air Quality and Health in Educational and Occupational Settings

Renata Cervantes, Pedro Pena, and Carla Viegas

Abstract Citizen science has emerged as a transformative approach to tackling complex societal challenges, such as environmental health and occupational exposure to pollutants. Its application in occupational settings fosters collaboration between employees, employers, and researchers, providing critical insights into workplace conditions that external observers often cannot access. By engaging participants actively, citizen science ensures higher data reliability, promotes awareness, and encourages behavioral changes toward healthier environments. Despite its potential, its integration in occupational exposure research remains limited. The InChildHealth project demonstrates the impact of citizen science by combining participatory methods with educational initiatives to improve indoor air quality (IAQ) and occupant health. This study involved 11 schools in Lisbon, with 1150 children participating in various activities, such as IAQ surveys, microbial sampling, and hands-on experiments. The main outcomes were the development of methods and models to guide citizen science activities, enabling effective data collection, analysis, and participant engagement. These approaches integrated both educational and scientific components, fostering awareness and empowering individuals to take action toward healthier environments. By adapting these tools and participatory approaches to occupational exposure monitoring, researchers can generate actionable insights and co-develop interventions that enhance workplace health and safety, offering context-specific and practical solutions tailored to the needs of workers and employers.

Keywords Citizen science · Science communication · Public health · Occupational exposure · Environmental health

---

R. Cervantes (✉) · P. Pena · C. Viegas
NOVA National School of Public Health, Public Health Research Centre, Comprehensive Health Research Center, CHRC, REAL, CCAL, NOVA University Lisbon, Lisbon, Portugal

H&TRC – Health & Technology Research Center, ESSL – Escola Superior de Saúde de Lisboa, Lisbon, Portugal
e-mail: renata.cervantes@essl.ipl.pt; pedro.pena@essl.ipl.pt; carla.viegas@essl.ipl.pt

J. S. Baptista et al. (eds.), *Occupational and Environmental Safety and Health VII*, Studies in Systems, Decision and Control 617,
https://doi.org/10.1007/978-3-032-02052-9_12

12.1 Introduction

Citizen science is increasingly recognized as a valuable approach to addressing complex societal challenges, including environmental health and occupational exposure to pollutants and contaminants [2, 5, 7]. In occupational settings, involving employees and employers in research provides critical contextual insights into workplace conditions — details that are often inaccessible to external observers [6]. Furthermore, active engagement of workers not only facilitates recruitment but also ensures greater participation and data reliability [4]. These collaborative methods have been shown to enrich research outcomes, promote awareness, and encourage behavioral changes that lead to healthier environments [3]. Despite its potential, the integration of citizen science in occupational exposure studies remains underexplored, presenting an opportunity to leverage this approach for impactful research and policy development. The InChildHealth project exemplifies the transformative power of citizen science, particularly in educational contexts. By combining principles of living labs with participatory science, this initiative has catalyzed individual and collective actions to improve indoor air quality (IAQ) and occupants' health. The project engages school communities to generate localized data, adopt healthier routines, and contribute to regulatory measures for indoor air quality (IAQ). Its methods, including the development of training materials and curriculum integration, provide a replicable model for different indoor environments (occupational, clinical…). By actively involving students, teachers, and policymakers, InChildHealth highlights the broader societal benefits of citizen science. This chapter explores how such participatory approaches can be adapted to occupational exposure research, fostering collaboration between researchers, employees, and employers to create safer and healthier work environments.

12.2 Materials and Methods

This study adopts a citizen science framework, engaging students, teachers, school staff, and researchers in a collaborative investigation of the relationship between indoor air quality (IAQ) and health outcomes. Ethical considerations were rigorously addressed, with informed consent obtained from all participants and their legal representatives prior to involvement in the study's activities. Additionally, the projects were submitted and approved by Escola Superior de Tecnologia da Saúde de Lisboa Ethical Council (Lisboa, Portugal) (CE-ESTeSL-N° 63-2019; CE-ESTeSL-N°.18-2019). The study is in accordance with the Helsinki Declaration and Oviedo Convention and in Agreement with the Portuguese law n° 58/2019 of 8 of August regarding data protection.

The design activities aimed to enable participants to assume varied roles, including research on collecting and analyzing data, and co-designing aspects of the research process. By integrating air quality and health topics into the school curriculum, the study provided children, aged 6–12, with a comprehensive understanding of environmental health issues. Additionally, it empowered all participants to actively contribute to the scientific process, ensuring a hands-on and inclusive approach to learning and research. This citizen science initiative involved 11 schools in the Lisbon area, with the findings contributing to a broader European study, though the results discussed here are focused on the Portuguese context. All 11 schools, encompassing 46 classrooms and involving 1150 children, participated in the first part of the study regarding the sampling devices, and pre-and-post questionnaires from these 6 schools implemented additional Citizen Science activities, encompassing 30 classrooms and involving 750 children. Various indoor and outdoor areas were included in the study, such as classrooms, canteens, libraries, gymnasiums, bathrooms, and outdoor spaces. The activities conducted by the students included a walkthrough survey, swab sampling, electrostatic dust cloth (EDC) extraction, inoculation of samples, and microscope observation (Table 12.1).

12.2.1 Study Design and Participant Roles

Students took on three roles: researchers, study subjects, and learners. Educational materials on air contaminants and health effects were incorporated into classroom activities to provide foundational knowledge. Participants (N = 1150) were taught about bioaerosols and IAQ including active sampling (one point in time measurement using devices like pumps) and passive sampling (long-term pollutant collection without continuous power) [8]. Hands-on demonstrations and interactive sessions reinforced these concepts. The Citizen Science activities across the 11 participating schools involved various hands-on and observational methods.

For citizen science activities, students were divided into small groups to rotate through activity stations, ensuring every participant engaged with all tasks, blending theoretical learning with practical application.

Table 12.1 Overview of citizen science activities and participant involvement in schools

Activities	Schools	Classrooms (n)	Teachers (n)	School staff (n)	Children (n)
Sampling activities	**11**	**46**	**–**	**–**	**1150**
Questionnaires	11	27	–	–	625
Hands-on citizen science activities	6	30	30	–	750
Teachers' interviews	3	–	4	–	–
School staff interviews	3	–	–	5	–
Walkthrough SURVEY engagement	11	–	46	22	750

The table summarizes the number of schools, classrooms, teachers, school staff, and children involved in different citizen science activities

Fig. 12.1 Students applying the walkthrough survey

12.2.2 Walkthrough Survey

The walkthrough survey for children was designed to offer insights into various factors influencing indoor air quality (IAQ). These factors included behaviours such as wearing the same shoes indoors and outdoors, perceptions of window openings and ventilation practices, the presence of pets and indoor plants, and indoors' cleaning routines. Children completed the survey with guided support from teachers and researchers, who intervened solely to clarify questions or assist with interpretation as needed. The resulting dataset, reflecting children's perceptions and understanding of IAQ, will undergo detailed analysis and subsequently be presented to them to enhance their awareness and understanding of the subject. Figure 12.1 shows students participating in the walkthrough surveys, where they documented environmental factors in classrooms, gymnasiums, and bathrooms.

12.2.3 Swab Sampling

After explaining the correlation between dust accumulation and microbial contamination, as well as the efficiency of swab sampling for assessing microbial presence on surfaces, each student was provided with a sterile cotton swab. Students were instructed to identify and swab the dirtiest surface within their classroom that could potentially serve as a source of microbial contamination. Under the guidance of the research team, students were then shown how to inoculate the collected samples directly onto nutrient media plates. The plates were securely sealed to prevent contamination and handed over to the teachers for storage in a warm, stable environment for 3–4 days to promote microbial growth. During the incubation period, students monitored the plates for microbial colonies. Upon completion, each class documented the observed growth, reported their findings to the research team, and provided photographic evidence of the results. Comprehensive safety instructions, including proper hygiene practices and handling protocols, were communicated to

Fig. 12.2 Swab sampling explanation

all participants prior to the commencement of the activity to ensure a safe and controlled experiment. Figure 12.2 shows students preparing to preform sampling in their classrooms with swabs.

12.2.4 Samples Extraction

Once outlining the potential of Electrostatic Dust Collectors (EDCs) for bioaerosol sampling, an EDC extraction activity was conducted with the participation of students. The activity began by equipping each student with disposable gloves and emphasizing the critical importance of maintaining a clean and disinfected environment. This practice was essential both for their safety and to prevent cross-contamination of samples. The EDC extraction procedure was systematically performed under the guidance of the researcher, who ensured the students followed each step precisely. The process involved inserting an EDC, previously exposed to ambient air, into a 50 mL Falcon tube containing sterile distilled water. The tube was then vigorously shaken by students to remove particles adhered to the EDC surface. Following this, the EDC was carefully squeezed using sterilized tweezers to extract any residual liquid. Subsequently, a Pasteur pipette was used to transfer two drops of the resulting liquid suspension onto a nutrient agar plate. The agar plates were then securely sealed to prevent contamination and handed over to the teachers. Teachers were instructed to store the plates in a warm, stable environment within the classroom, for an incubation period of 3–4 days. During the incubation phase, students observed microbial growth on the agar plates and documented their findings. They recorded the results systematically, including the morphological characteristics of the colonies, and shared photographic evidence with the research team for further analysis. Figure 12.3 depicts students engaged in sampling activities, like electrostatic dust cloth (EDC) extractions.

Fig. 12.3 EDC extraction procedure

Fig. 12.4 Microscope observation by the children

12.2.5 *Microscopic Observation*

In each participating school, a dedicated microscope station was established utilizing microscopes available on-site. This setup enabled all classes to examine prepared slides from samples collected during the bioaerosols sampling campaigns. The activity served as an interactive educational opportunity, during which researchers provided explanations about the prevalence and nature of microbial contaminants within the school environment. Figure 12.4 illustrates children observing bioaerosols under microscopes.

12.3 Results

The primary outcomes of this citizen science initiative were the instruments developed to facilitate participatory engagement and educational activities. These included customized walkthrough survey designed to assess factors affecting indoor air quality (IAQ), such as ventilation practices and cleaning routines, tailored for use by children with guided support from teachers and researchers (Fig. 12.5).

From all the answers obtained, only the most relevant to the study's objectives are presented here. Of the 625 children surveyed, 269 answers were successfully retrieved. Regarding school location, 71.7% (193 out of 269) reported having their

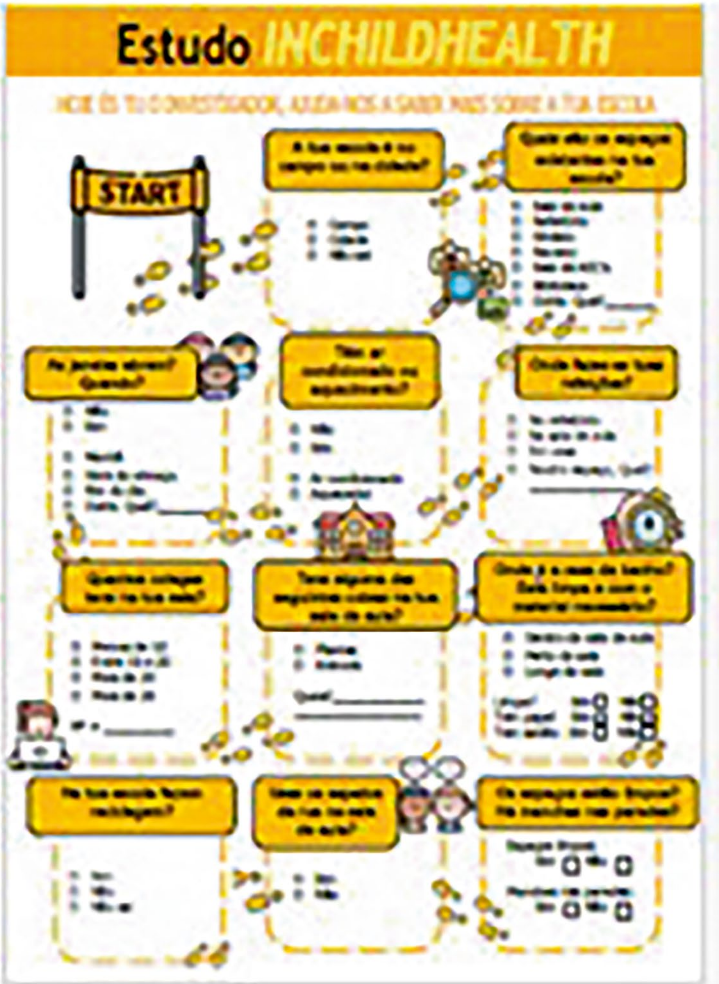

Fig. 12.5 Walkthrough survey developed for children

school located in the city, 17.5% (47 out of 269) in the countryside, and 10.8 (29 out of 269) did not answer. Concerning classroom occupancy, 76.6% (206 out of 269) students reported having more than 20 classmates, 19% (51 out of 269) reported having between 10 and 20 classmates, 2.2% (6 out of 269) reported more than 26 classmates, 0.7% (2 out of 269) reported less than 10 classmates, and 1.5% (4 out of 269) did not answer.

When questioned about the presence of stains, 51.3% (138 out of 269) denied it, while 42% (113 out of 269) reported stains, and 6.7% (18 out of 269) did not answer. Upon inquiry regarding the cleanliness of the space, 86.2% (232 out of 269) said "Yes", while 9.7% (26 out of 269) said "No", and 4.4% (11 out of 269) did not reply.

When questioned about the opening windows, 98.5% (265 out of 269) of students reported that they were regularly opened, with 72.5% reporting having windows opened in the morning, 38.1% at the end of the day and 29.1% during lunchtime.

Additionally, hands-on sampling tools, such as swab kits as exemplified in Fig. 12.6 and Electrostatic Dust Collectors (EDCs), Fig. 12.7, were adapted to allow safe and effective participation by young students. These instruments not only enabled data collection on microbial contamination and bioaerosol presence but also provided practical learning opportunities that linked environmental science to daily routines.

Microscopic observation stations, equipped with school-available microscopes, further enhanced the hands-on aspect of the activities, enabling students to directly observe microbial growth from their collected samples. Collectively, these tools and methodologies represent replicable instruments that can be adapted to other educational and occupational settings, highlighting their dual role in both data generation and promoting awareness about IAQ and health.

Fig. 12.6 Swab kit

Fig. 12.7 EDC extraction kit

12.4 Discussion

This citizen science study, involving a range of activities across 11 schools, provides valuable insights into the relationship between indoor air quality (IAQ) and health, as well as the potential benefits of engaging students and teachers in scientific research. The active involvement of students in collecting air quality data through walkthrough survey, sampling, and bioaerosol analysis aligns with previous studies highlighting the effectiveness of citizen science in raising awareness and improving environmental health outcomes. These hands-on activities enabled students to directly observe and interact with environmental data, fostering a deeper understanding of IAQ and its impact on health. This approach is consistent with findings from similar studies that emphasize the importance of involving local communities in environmental research, as it increases the relevance and applicability of the data collected [European Citizen Science Platform]. The high level of engagement observed in this study, particularly with students and teachers, confirms that citizen science can bridge the gap between scientific research and everyday experiences [1]. Teachers played a key role in facilitating data collection and ensuring the study's integration into the school curriculum, thereby enhancing the educational value of the project. Moreover, the involvement of school staff in interviews provided additional insights into daily practices that may influence IAQ, such as cleaning routines and ventilation practices, which are often overlooked in traditional studies. As teachers and staff members were not able to fully engage in these activities, similar targeted training sessions could address practical aspects of IAQ such as optimizing cleaning routines and procedures, ventilation practices, and identification of sources of contamination. By actively engaging teachers and staff, these activities not only strengthen their role in educational initiatives, but also empower them to adopt and promote sustainable practices. In future research, it will be important to further investigate the long-term effects of student and teacher involvement in citizen science projects, particularly regarding their lasting impact on environmental behavior and health awareness. Expanding the study to include more diverse educational contexts and comparing results across different countries could provide additional insights into the global applicability of these methods for improving indoor air quality and public health.

12.5 Conclusions

This study demonstrates the potential of citizen science approaches in schools, which can easily be adapted to other indoor environments like workplaces and healthcare environments. By involving workers and employers in air quality monitoring, similar studies can empower participants to contribute valuable insights into their daily environments. The flexible methodologies used here—such as walk-through surveys and sampling—can be tailored to various workspaces, helping improve working conditions and health outcomes. Future research in occupational contexts could build on these methods, offering practical, context-specific solutions for enhancing worker health.

Acknowledgements The authors gratefully acknowledge FCT/MCTES UIDP/05608/2020 (https://doi.org/10.54499/UIDP/05608/2020) and UIDB/05608/2020 (https://doi.org/10.54499/UIDB/05608/2020. This work is also supported by national funds through FCT/MCTES/FSE/UE, 2023.01366.BD (https://doi.org/10.54499/2023.01366.BD). This project was partly funded by EU Horizon 2021 grant no. 101056883 and co-funding from the author's organizations and/or Ministries. Funding from Swiss SERI grant 22.00324, UKRI grant 10040524, and NHMRC grant APP2017786 and APP2008813. Views expressed are of the author(s) and do not necessarily reflect those of EU, Swiss SERI, UKRI, or NHMRC.

References

1. Citizen Science | Inchildhealth: (n.d.). Retrieved 30 December 2024, from https://inchildhealth.eu/citizenscience/
2. Den Broeder, L., Devilee, J., Van Oers, H., Schuit, A.J., Wagemakers, A.: Citizen science for public health. Health Promot. Int. **33**(3), 505–514 (2018). https://doi.org/10.1093/heapro/daw086
3. European Citizen Science Platform: (n.d.). Retrieved 30 December 2024, from https://eu-citizen.science/
4. Hadad, S., Zhitomirsky-Geffet, M., Shah, H., Rigler, D., Celentano, U., Tiensuu, H., Röning, J., Vallverdú, J., Csabella, E.J., Stepankova, O., Gialelis, J., Lantavou, K., Ignat, T., Masone, G., Winter, J., Dumitrasco, M.: Modeling intrinsic factors of inclusive engagement in citizen science: insights from the participants' survey analysis of CSI-COP. PLoS One. **18**(11), e0294575 (2023). https://doi.org/10.1371/journal.pone.0294575
5. Katapally, T.R.: The SMART framework: integration of citizen science, community-based participatory research, and systems science for population health science in the digital age. JMIR Mhealth Uhealth. **7**(8), e14056 (2019). https://doi.org/10.2196/14056
6. Michaelis, M., Preiser, C., Voelter-Mahlknecht, S., Blomberg, N., Rieger, M.A.: Uptake of voluntary occupational health care-assessments of German occupational health physicians and employees. Int. J. Environ. Res. Public Health. **19**(15), 9602 (2022). https://doi.org/10.3390/ijerph19159602
7. Pocock, M.J., Tweddle, J.C., Savage, J., Robinson, L.D., Roy, H.E.: The diversity and evolution of ecological and environmental citizen science. PLoS One. **12**(4), e0172579 (2017). https://doi.org/10.1371/journal.pone.0172579

8. Viegas, C., Peixoto, C., Gomes, B., Dias, M., Cervantes, R., Pena, P., Slezakova, K., Pereira, M.D.C., Morais, S., Carolino, E., Twarużek, M., Viegas, S., Caetano, L.A.: Assessment of Portuguese fitness centers: bridging the knowledge gap on harmful microbial contamination with focus on fungi. Environ. Pollut. (Barking, Essex: 1987). **350**, 123976 (2024). https://doi.org/10.1016/j.envpol.2024.123976