Philipps Universität Marburg

Integrating citizens into Digital Climate Health Technologies:

A case study of air quality monitoring platforms

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Introduction

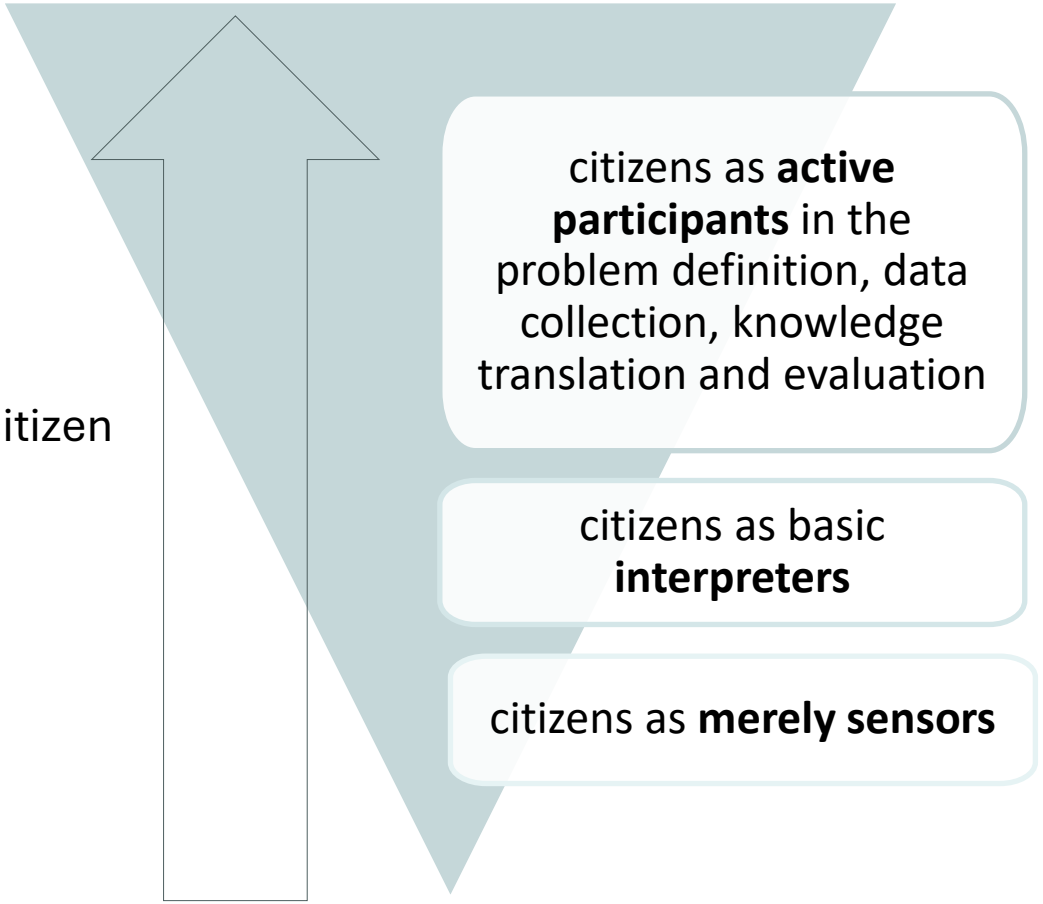
- Digital technologies, such as websites, platforms, sensors, and smartphone apps, play a key role in **protecting individuals and communities from environmental hazards including extreme weather, air pollution, and pollen** (Workman et al., 2024; Johnston et al., 2018).

- These technologies provide **new opportunities as environmental and epidemiological tools** by enabling real-time symptom reporting, measuring health parameters, and monitoring air quality, thereby supporting behaviour change and self-management (Jones et al., 2020; Bousquet et al., 2022).

- Air quality and health monitoring technologies increasingly **integrate citizen science**, **engaging lay people in producing scientific information** for both research and community use (Lupton, 2015; Bousquet et al., 2022).

Background

level of participation in citizen science
(Golding, 2022)



Research Questions

- What are **different pathways and approaches** for integrating citizens into air quality monitoring technologies?
- What are the **challenges** associated with engaging citizens in these technologies?
- How can we **improve citizen engagement** in digital climate health technologies?

Materials and Methods

1. Internet-based Survey

- Explored the project databases from WHO, EEA, OECD and the European Commission for best practices.
- Identified **105** climate health tools including **23** air monitoring platforms and compiled a comprehensive database

2. Structured Survey

- Conducted an interne-based survey to gather complementary
- between 01 December 2024 and 07 February 2025
- **5** responses were received from the air monitoring platforms

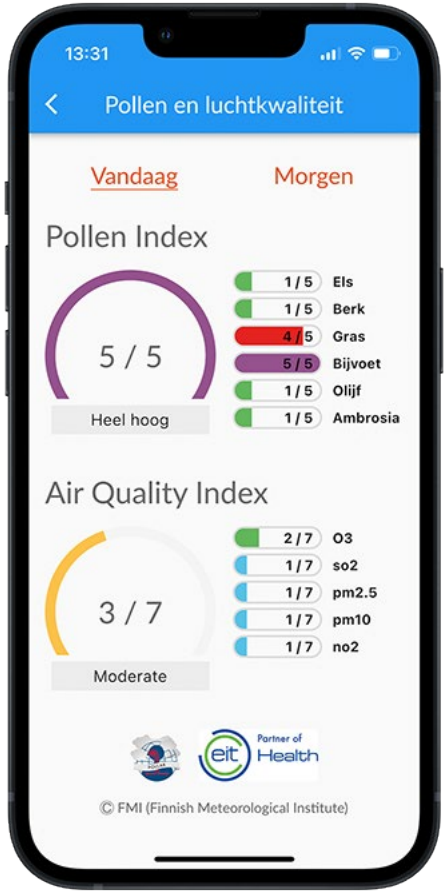
3. Case Studies

- **3 citizen science case studies** were selected
- Comprehensive literature review of the case studies
- 3 semi-structured in-depth interviews held with project managers
- between April and August 2025
- Interviews were transcribed, coded and analyzed using MAXQDA 24 software

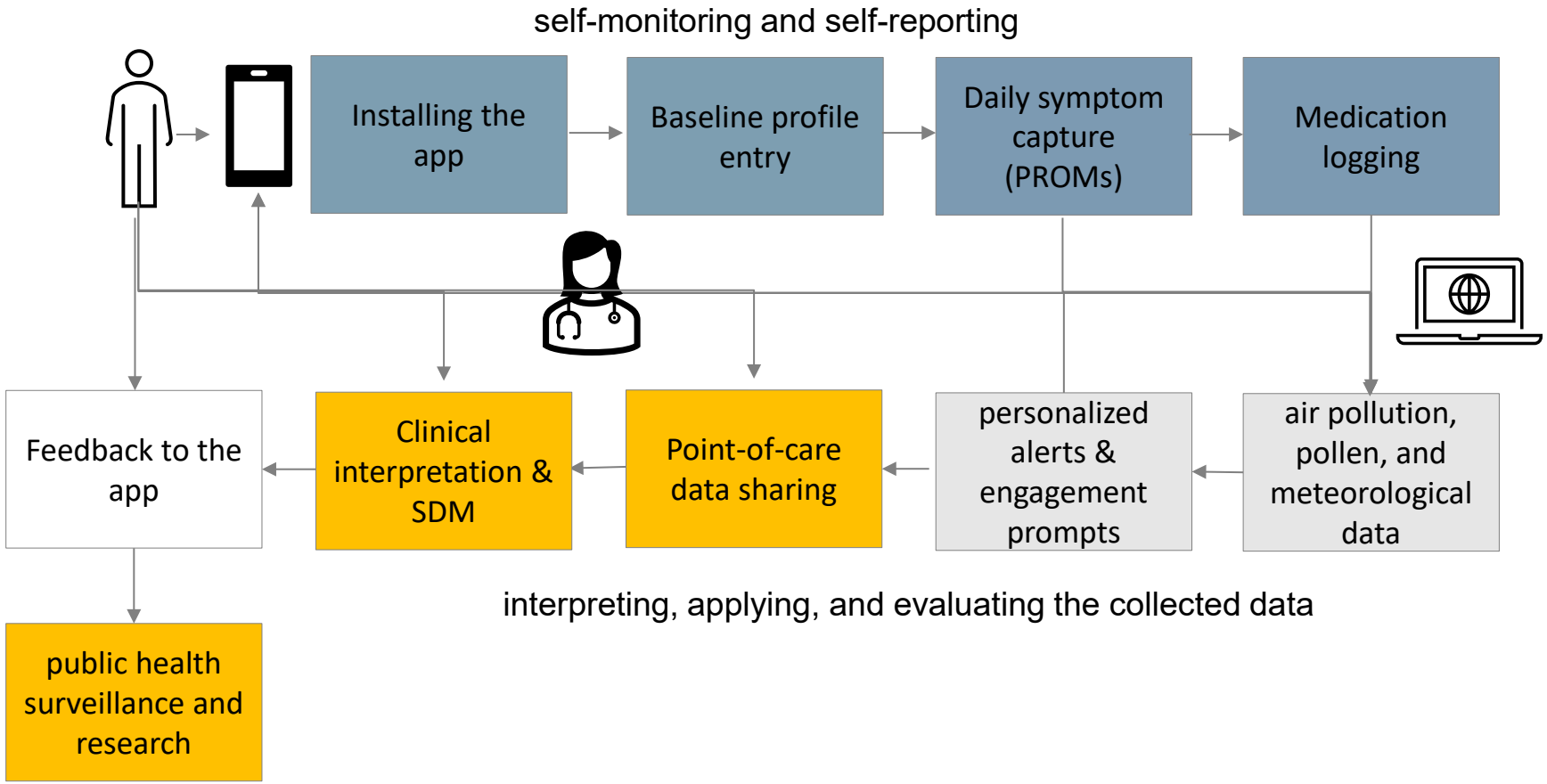
Case Studies

Mask-air

- A free digital health tool and mobile app developed by ARIA group launched in 2015, operational in 27 countries and 20 languages
- Designed for managing allergic rhinitis and asthma through remote patient monitoring.
- Includes **a daily monitoring questionnaire** that allows patients to **report their symptoms and medication use**.
- The app generates a **large-scale patient-reported dataset** and supports self-monitoring, medication logging, and feedback for both **individual care and aggregated research insights.**



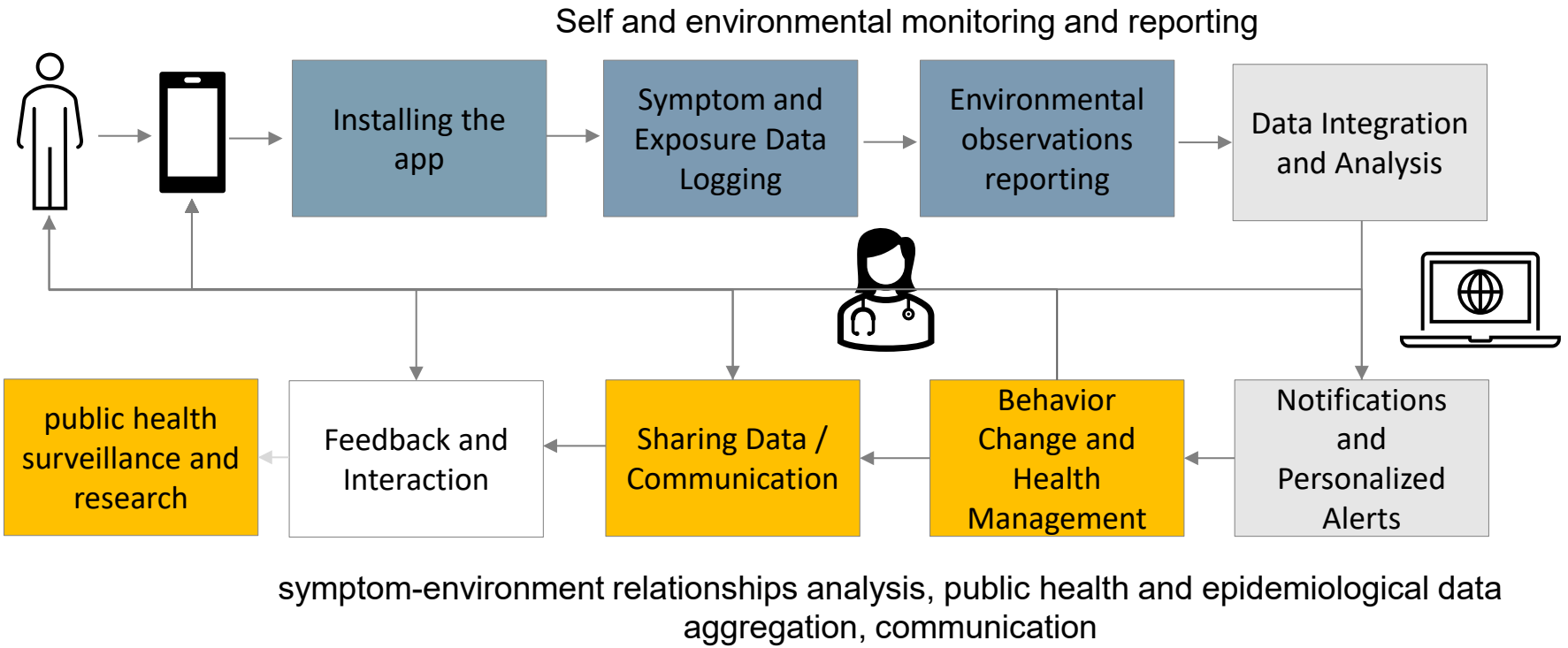
Mask-air


self-monitoring and self-reporting
Installing the app
Baseline profile entry
Daily symptom capture (PROMs)
Medication logging
Feedback to the app
Clinical interpretation & SDM
Point-of-care data sharing
personalized alerts & engagement prompts
air pollution, pollen, and meteorological data
interpreting, applying, and evaluating the collected data
public health surveillance and research

AirRater

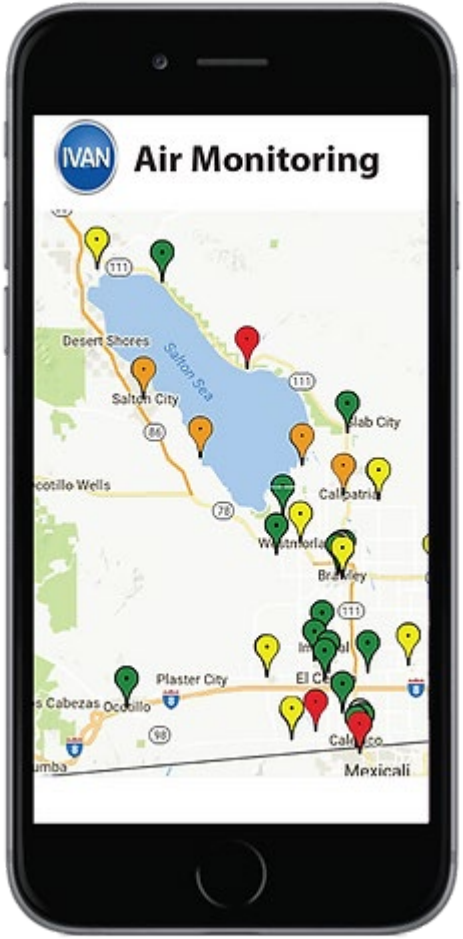
- An integrated online platform and a free app developed by University of Tasmania, Australia in 2015
- Combines **symptom surveillance, environmental monitoring**, and notifications of changing environmental conditions
- Provides location-specific and near real-time air quality, pollen and temperature information and **personal symptom tracking functionality**.
- Integrates **user-generated crowd-sourced, and geo-located health data with environmental monitoring**

AirRater


Self and environmental monitoring and reporting
Installing the app
Symptom and Exposure Data Logging
Environmental observations reporting
Data Integration and Analysis
public health surveillance and research
Feedback and Interaction
Sharing Data / Communication
Behavior Change and Health Management
Notifications and Personalized Alerts
symptom-environment relationships analysis, public health and epidemiological data aggregation, communication

ICAMP

- A community-based air quality monitoring system in Imperial County,California, US, began in 2014
- A community-based environmental monitoring process, with **community members** and researchers playing key roles in determining **study direction, research protocols, and data collection**
- A community-based air networks producing real-time particulate matter data from **40 low-cost sensors** throughout Imperial County
- Citizens as local experts, assisting in the siting of monitors, maintenance of sensors, and troubleshooting.



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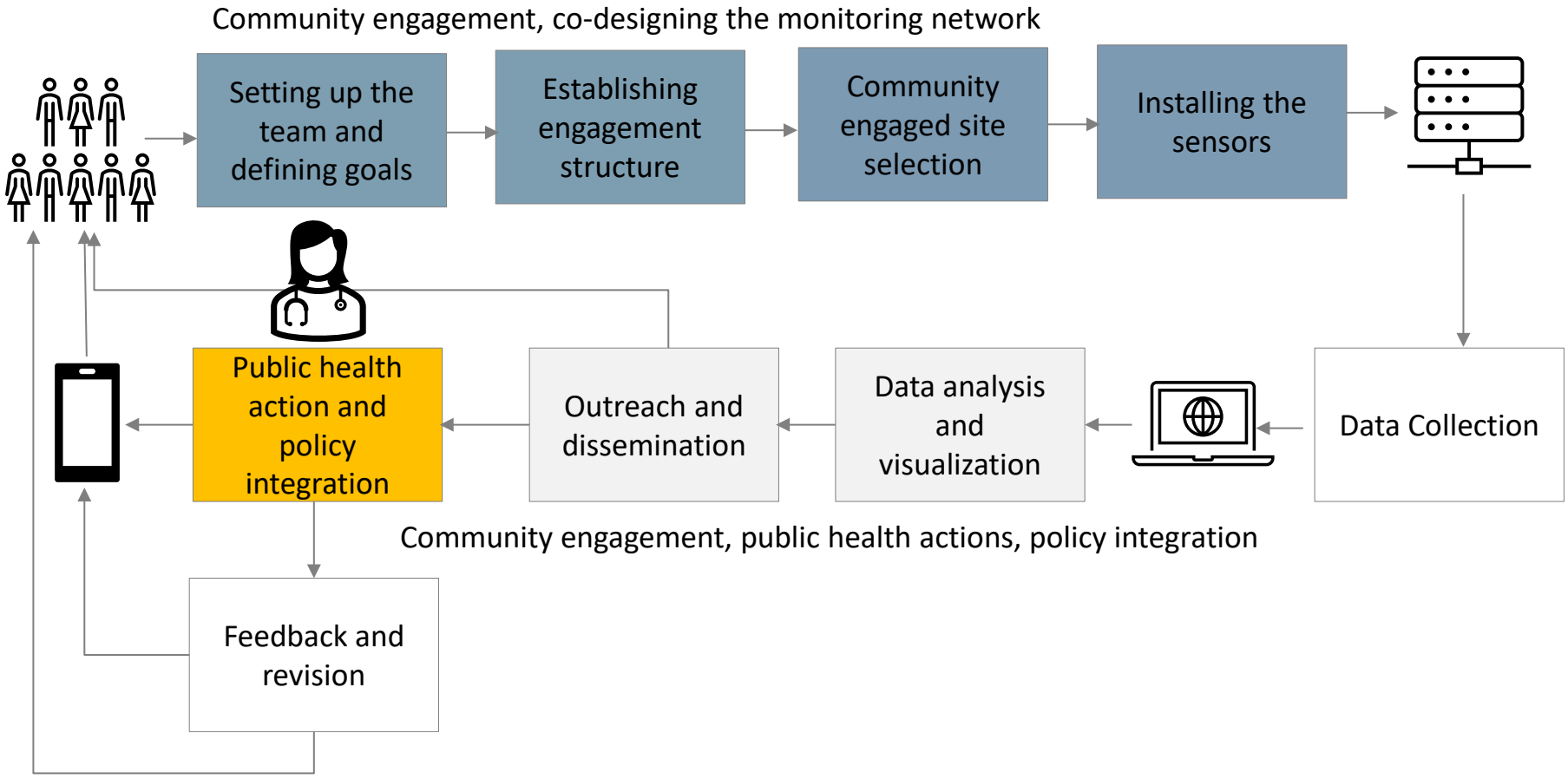

Community engagement, co-designing the monitoring network
Setting up the team and defining goals
Establishing engagement structure
Community engaged site selection
Installing the sensors
Data Collection
Data analysis and visualization
Outreach and dissemination
Public health action and policy integration
Community engagement, public health actions, policy integration
Feedback and revision

Main findings

Different pathways to citizen science

Level of citizen involvement

Data Analysis

Data Gathering

Extreme citizen science

Incorporating local knowledge

Participation in problem definition, data collection, analysis and interpretation

ICAMP

Crowdsourcing and volunteered citizen science

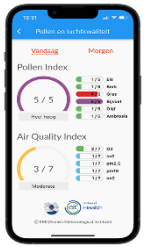
Limited participation in environmental and health data collection

AirRater

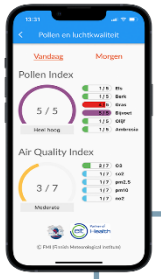
Basic citizen science

Limited participation in health data collection only (actively or passively)

Mask-air



Challenges of citizen science



Mask-air

- Irregular usage and data gaps preventing accurate VAS score calculations
- Subjective symptom reporting which raises validity issues
- Technical issues like notification inconsistencies
- Bias due to non-representativeness or self selection

AirRater

- Sustaining continuous engagement of users
- Reflecting populations with sufficient digital, health, and language literacy
- Potential gaps in inclusivity and representativeness
- Privacy and trust concerns in sharing health data linked with environmental exposure

ICAMP

- Legitimacy and regulatory uptake of community-generated sensor data (agencies hesitant to use it in policy)
- Issues regarding user gathered data reliability, credibility and quality
- Technical issues regarding instrument calibration and validation and electronic transfer and storage of data

Improving citizen science

in digital air quality monitoring projects

Approaches	Challenges	Solutions	
Basic citizen science	Data quality challenges	Standardized protocols for citizen engagement	Automated validation and data cleaning
	Sustaining adherence and continuity	Capacity building and training	Regular feedback and communication
Crowdsourcing and volunteered citizen science	Privacy of health data	Data anonymization	Secure data storage and access controls
	Inclusivity and accessibility	User-friendly digital tools and visualizations	Flexible participation options
Extreme citizen science	Technical and resource constraints	Cloud-based and scalable infrastructure	Lightweight, low-bandwidth apps
	Integration into policy and practice	Standardized reporting and data interoperability	Early and continuous stakeholder engagement

Thank you for your attention!

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References

- Agache, Ionna; Sampath, Vanitha; Aguilera, Juan; Akdis, Cezmi; Akdis, MÃ¼beccel; Barry, Michele et al. (2022): Climate change and global health: A call to more research and more action. DOI: 10.1111/ALL.15229.
- Alami, Hassane; Rivard, Lysanne; Lehoux, Pascale; Ag Ahmed, Mohamed Ali; Fortin, Jean-Paul; Fleet, Richard (2023): Integrating environmental considerations in digital health technology assessment and procurement: Stakeholders' perspectives. In Digital health 9, 20552076231219113. DOI: 10.1177/20552076231219113.
- Balogun, Abdul-Lateef; Marks, Danny; Sharma, Richa; Shekhar, Himanshu; Balmes, Chiden; Maheng, Dikman et al. (2020): Assessing the Potentials of Digitalization as a Tool for Climate Change Adaptation and Sustainable Development in Urban Centres. In Sustainable Cities and Society. DOI: 10.1016/J.SCS.2019.101888.
- Başci, Özge Kama; Yorgancioglu, Arzu; Gunes, Soner; Kirmaz, Cengiz (2025): Feasibility of MASK-air® use in allergic rhinitis patients receiving immunotherapy and the effect on quality of life. In Allergologia et immunopathologia 53 (3), pp. 106–114. DOI: 10.15586/aei.v53i3.1208.
- Benis, Arriel; Tamburis, Oscar; Chronaki, Catherine E.; Moen, Anne (2021): One Digital Health: A Unified Framework for Future Health Ecosystems. DOI: 10.2196/22189.
- Black, Gillian F.; Jamrozik, Euzebiusz; Khan, Wesaal; Peralta, Stephanie; Havenga, Benjamin; Merritt, Maria W.; Kelley, Maureen (2024): Making the case for community involvement in research on climate and health: opportunities and lessons. In Front. Clim. 6, Article 1456417. DOI: 10.3389/fclim.2024.1456417.
- Bousquet, Jean; Anto, Josep M.; Haahtela, Tari; Jousilahti, Pekka; Erhola, Marina; Basagaña, Xavier et al. (2020): Digital transformation of health and care to sustain Planetary Health: The MASK proof-of-concept for airway diseases-POLLAR symposium under the auspices of Finland's Presidency of the EU, 2019 and MACVIA-France, Global Alliance against Chronic Respiratory Diseases (GARD, WH0) demonstration project, Reference Site Collaborative Network of the European Innovation Partnership on Active and Healthy Ageing. In Clinical and Translational Allergy 10, p. 24. DOI: 10.1186/s13601-020-00321-2.

References

- Campbell, Sharon L.; Jones, Penelope J.; Williamson, Grant J.; Wheeler, Amanda J.; Lucani, Christopher; Bowman, David M. J. S.; Johnston, Fay H. (2020a): Using Digital Technology to Protect Health in Prolonged Poor Air Quality Episodes: A Case Study of the AirRater App during the Australian 2019–20 Fires. In *Fire* 3 (3), p. 40. DOI: 10.3390/fire3030040.
- Clavier, Carole; Sénéchal, Yan; Vibert, Stéphane; Potvin, Louise (2012): A theory-based model of translation practices in public health participatory research. In Sociology of health & illness 34 (5), pp. 791–805. DOI: 10.1111/j.1467-9566.2011.01408.x.
- Curtis, S. E.; Oven, K. J. (2012): Geographies of health and climate change. In Progress in Human Geography 36 (5), pp. 654–666. DOI: 10.1177/0309132511423350.
- Dunn, Jessilyn; Coravos, Andrea; Fanarjian, Manuel; Ginsburg, Geoffrey S.; Steinhubl, Steven R. (2024): Remote digital health technologies for improving the care of people with respiratory disorders. In The Lancet. Digital health 6 (4), e291-e298. DOI: 10.1016/S2589-7500(23)00248-0.
- English, paul; Amato, Heather; Bejarano, Esther; Carvlin, Graeme; Lugo, Humberto; Jerrett, Michael et al. (2020): Performance of a Low-Cost Sensor Community Air Monitoring Network in Imperial County, CA. In Sensors (Basel, Switzerland) 20 (11). DOI: 10.3390/s20113031.
- English, Paul B.; Olmedo, Luis; Bejarano, Ester; Lugo, Humberto; Murillo, Eduardo; Seto, Edmund et al. (2017): The Imperial County Community Air Monitoring Network: A Model for Community-based Environmental Monitoring for Public Health Action. In Environmental health perspectives 125 (7), p. 74501. DOI: 10.1289/EHP1772.
- Golding, Brian (2022): Towards the “perfect” weather warning. Bridging disciplinary gaps through partnership and communication. DOI: 10.1007/978-3-030-98989-7.

References

- Grynne, Annika; Browall, Maria; Fristedt, Sofi; Ahlberg, Karin; Smith, Frida (2021): Integrating perspectives of patients, healthcare professionals, system developers and academics in the co-design of a digital information tool. In PloS one 16 (7), e0253448. DOI: 10.1371/journal.pone.0253448.
- Guimarães, Paula: 590877913.
- Jacob, Christine; Bourke, Steven; Heuss, Sabina (2022): From Testers to Cocreators-the Value of and Approaches to Successful Patient Engagement in the Development of eHealth Solutions: Qualitative Expert Interview Study. In JMIR human factors 9 (4), e41481. DOI: 10.2196/41481.
- Jayaratne, Madhura; Nallaperuma, Dinithi; Silva, Daswin de; Alahakoon, Damminda; Devitt, Brian; Webster, Kate E.; Chilamkurti, Naveen (2019): A data integration platform for patient-centered e-healthcare and clinical decision support. In Future Generation Computer Systems 92, pp. 996–1008. DOI: 10.1016/j.future.2018.07.061.
- Jebeile, Julie; Roussos, Joe (2023): Usability of climate information: Toward a new scientific framework. In WIREs Climate Change 14 (5), Article e833. DOI: 10.1002/wcc.833.
- Johnston, F. H.; Wheeler, A. J.; Williamson, G. J.; Campbell, S. L.; Jones, P. J.; Koolhof, I. S. et al. (2018): Using smartphone technology to reduce health impacts from atmospheric environmental hazards. In Environ. Res. Lett. 13 (4), p. 44019. DOI: 10.1088/1748-9326/aab1e6.
- Jones, Penelope J.; Koolhof, Iain S.; Wheeler, Amanda J.; Williamson, Grant J.; Lucani, Christopher; Campbell, Sharon L. et al. (2020a): Can smartphone data identify the local environmental drivers of respiratory disease? In Environmental research 182, p. 109118. DOI: 10.1016/j.envres.2020.109118.

References

- Katapally, Tarun Reddy; Bhawra, Jasmin; Leatherdale, Scott T.; Ferguson, Leah; Longo, Justin; Rainham, Daniel et al. (2018): The SMART Study, a Mobile Health and Citizen Science Methodological Platform for Active Living Surveillance, Integrated Knowledge Translation, and Policy Interventions: Longitudinal Study. In JMIR public health and surveillance 4 (1), e31. DOI: 10.2196/publichealth.8953.
- Kipp, A.; Cunsolo, A.; Gillis, D.; Sawatzky, Alexandra; Harper, S. (2019a): The need for community-led, integrated and innovative monitoring programmes when responding to the health impacts of climate change. In International journal of circumpolar health. DOI: 10.1080/22423982.2018.1517581.
- Skarlatidou, A., & Haklay, M. (Eds.). (2021). *Geographic citizen science design: No one left behind*. UCL Press.
- Sousa-Pinto, B.; Fonseca, J. A.; Bousquet, J. (2024): Contribution of MASK-air® as a mHealth tool for digitally-enabled person-centred care in rhinitis and asthma. In Journal of investigational allergology & clinical immunology, p. 0. DOI: 10.18176/jiaci.0994.
- Szylling, Anna; Samoliński, Boleslaw; Raciborski, Filip; Furmańczyk, Konrad; Chrzanowska, Mariola; Wojas, Oksana et al. (2025): Factors that influence user adherence of the Mask-air® application. In Clinical and Translational Allergy 15 (4), e70054. DOI: 10.1002/clt2.70054.
- Ventura, Maria Teresa; Giuliano, Antonio Francesco Maria; Buquicchio, Rosalba; Bedbrook, Anna; Czarlewski, Wienczyslawa; Laune, Daniel et al. (2022): Implementation of the MASK-Air® App for Rhinitis and Asthma in Older Adults: MASK@Puglia Pilot Study. In International archives of allergy and immunology 183 (1), pp. 45–50. DOI: 10.1159/000518032.
- Workman, A.; Jones, P.; Wheeler, A.; Campbell, S.; Williamson, G.; Lucani, C. et al. (2021a): Environmental Hazards and Behavior Change: User Perspectives on the Usability and Effectiveness of the AirRater Smartphone App. In International Journal of Environmental Research and Public Health. DOI