elsa English Longitudinal Study of Ageing

Concurrent use of personal air quality monitoring and accelerometry in older adults

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Why personal air quality monitoring?

Air pollution is among the most pressing determinants of health[1]

- Vulnerable populations such as older adults may be particularly susceptible

Air quality estimates are usually tied to residential address

- Modelled using land-use regression or governmental estimates
- Misses indoor air pollution
- Misses a large amount of variability in exposure

Answer: small, light-weight personal air quality monitors that can be worn on the person

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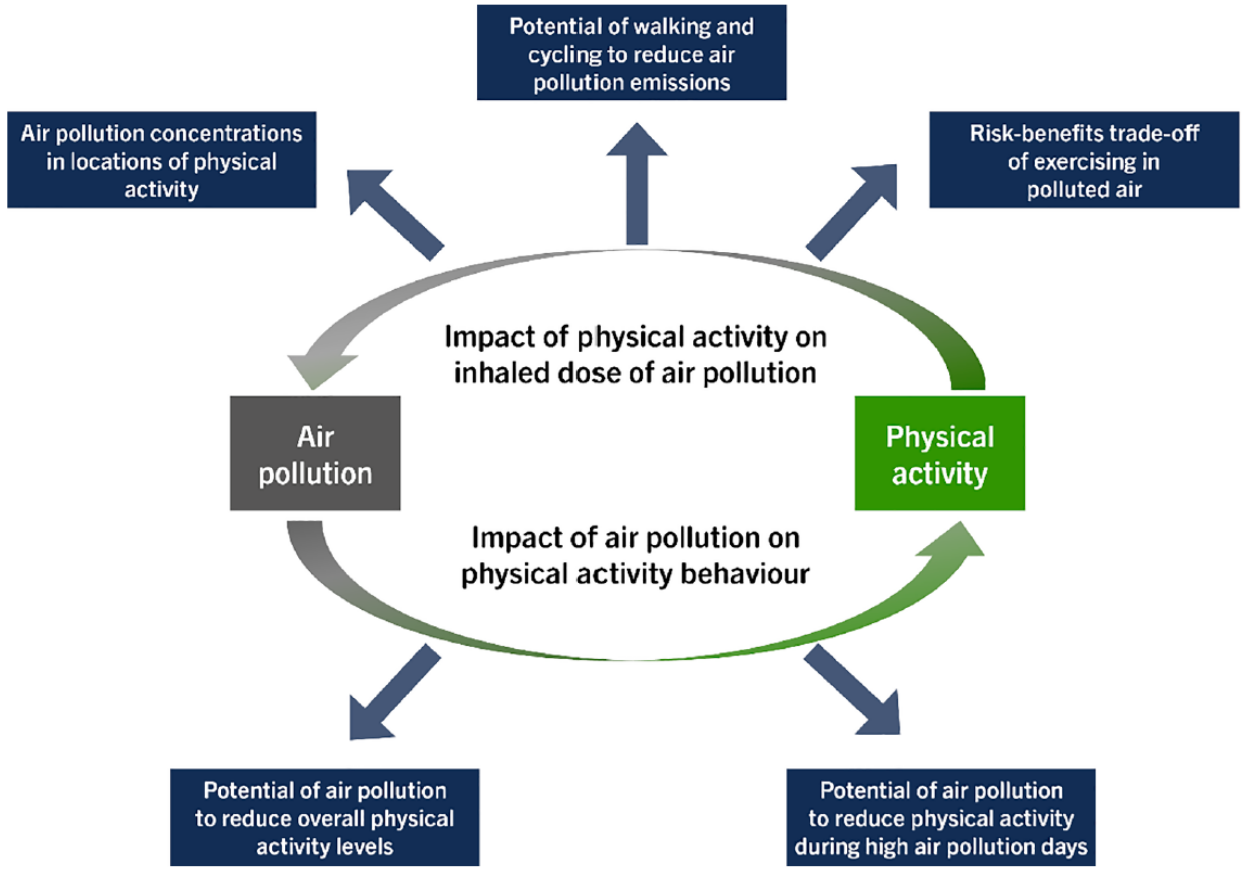
1. WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide, 2021.

Why combine with accelerometry?

Evidence suggests exposure to air pollution may modify physical activity patterns[1]

Maintaining a physically active lifestyle is central to healthy ageing and cardiovascular health

Self-reported physical activity shows poor concordance with objectively measured activity[2]



From: Tainio et al. 2021. doi: 10.1016/j.envint.2020.105954

1. Tainio et al. 2021. doi: 10.1016/j.envint.2020.105954.
2. Cerin et al. 2016. 10.1249/mss.0000000000000870.

Pilot project overview

Objectives

1) Establish feasibility of concurrent accelerometer and personal air quality monitor wear in older adults for use in the English Longitudinal Study of Ageing (ELSA)
2) Examine relationships between personal exposure to air pollution and activity patterns in older adults

Analytic sample

Convenience sample of 89 ambulant adults in the UK aged 50+ years (mean, 66 years; 63% female) asked to wear personal air quality monitors and accelerometers for a five-day wear period

Atmotube PRO

Small, lightweight light-scattering optical particular counter

Estimates mass concentrations of particles with an aerodynamic diameter of <1 µm, <2.5 µm and <10 µm (PM_1, $PM_{2.5}$, and PM_{10} respectively)

Moderate-to-good correlation with reference-grade PM monitors in 14-week outdoor collocation study[1]

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1. Shittu et al. 2025. doi:10.5194/amt-18-817-2025

Atmotube PRO

Participants asked to wear the personal air quality monitor during waking hours using the provided clip or lanyard and place the device in their bedroom overnight

Atmotube was set to collect data every 15 minutes

Matrix 003 accelerometer

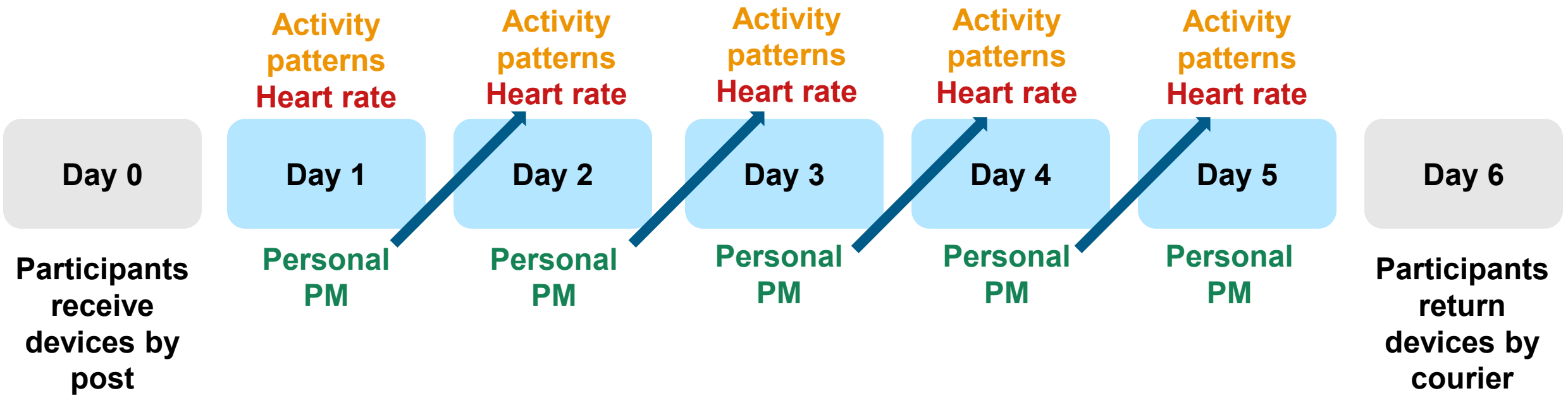
Wrist-worn triaxial accelerometer + heart rate monitor

Used in 20,000 CHARLS participants

Provides raw acceleration data comparable with the Axivity AX3 (used in the UK Biobank)[1]

Participants asked to wear device 24-hours per day for same five-day period as air quality monitor

Pilot project overview



67 participants with valid PM/accelerometery data → 304 observations

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Results

Figure 1. Estimated differences in next-day movement behaviour associated with more-than-usual exposure to air pollutants.

	Next-day MVPA	Next-day LPA	Next-day SB	Next-day sleep
Usual PM 2.5	Reference	Reference	Reference	Reference
More-than-usual (+1 IQR) PM 2.5	0 (-5 to +3)	-7 (-11 to -1)	+7 (-2 to +21)	0 (-12 to +8)

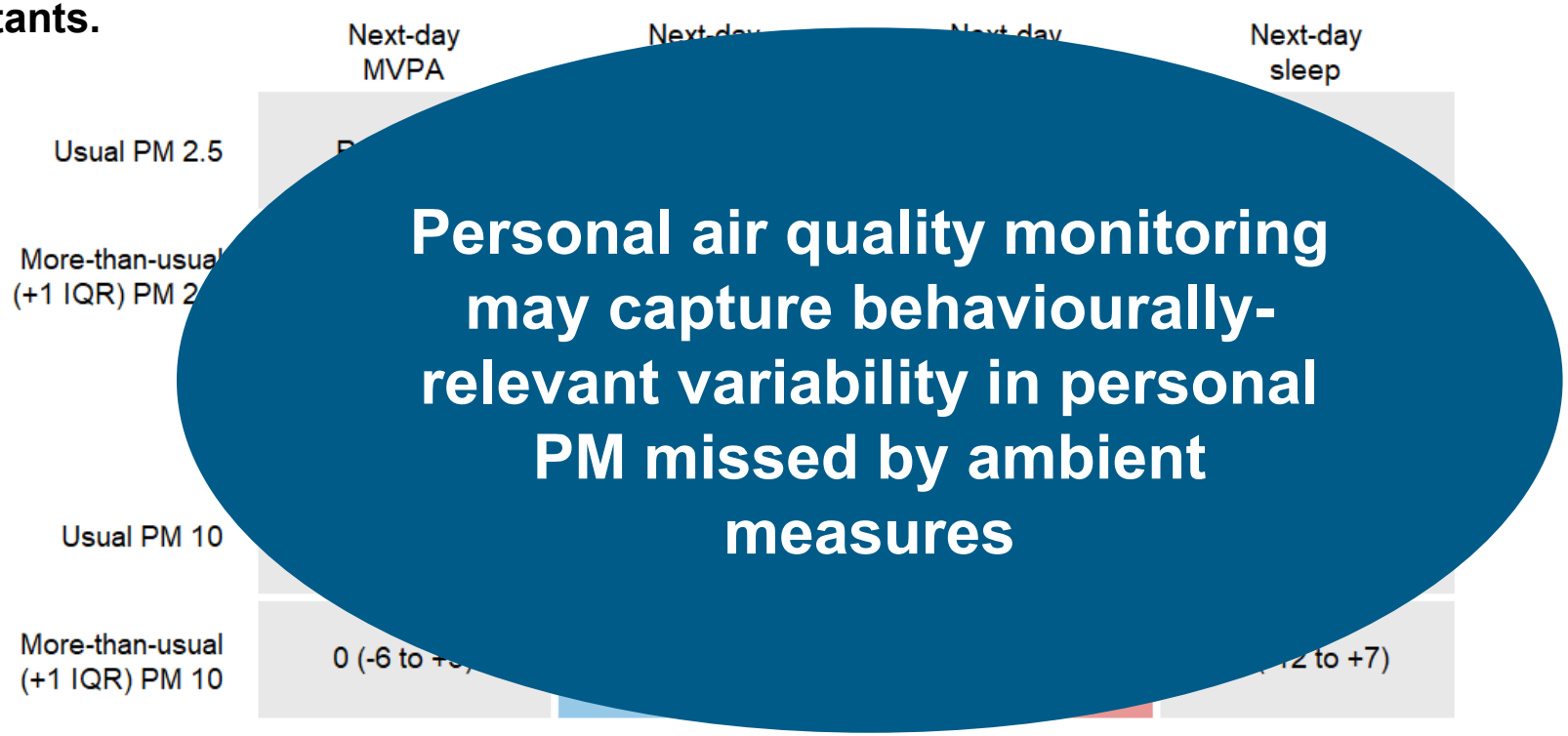
	Next-day MVPA	Next-day LPA	Next-day SB	Next-day sleep
Usual PM 10	Reference	Reference	Reference	Reference
More-than-usual (+1 IQR) PM 10	0 (-6 to +3)	-7 (-11 to -2)	+8 (0 to +22)	-1 (-12 to +7)

No associations with area-level estimates

Predicted average differences (95% confidence interval) in minutes per day spent in each movement behaviour, relative to the reference value (individual mean exposure to given air pollutant during the study period). IQR for $PM_{2.5}$ is 2.6 μg/m^3; IQR for PM_{10} is 2.8 μg/m^3. Positive values indicate more time in the given behaviour compared to the reference and negative values indicate less. Estimates are derived from compositional models adjusted for age, sex, day of the week, temperature, and precipitation.

Results

Figure 1. Estimated differences in next-day movement behaviour associated with more-than-usual exposure to air pollutants.



Personal air quality monitoring may capture behaviourally-relevant variability in personal PM missed by ambient measures

Predicted average differences (95% confidence interval) in minutes per day spent in each movement behaviour, relative to the reference value (individual mean exposure to given air pollutant during the study period). IQR for $PM_{2.5}$ is 2.6 μg/m^3; IQR for PM_{10} is 2.8 μg/m^3. Positive values indicate more time in the given behaviour compared to the reference and negative values indicate less. Estimates are derived from compositional models adjusted for age, sex, day of the week, temperature, and precipitation.

Researcher perspectives: Atomtube PRO

Pros

- Devices are lightweight, easy to ship
- Extracted data is intuitive to process and analyse

Cons

- Design decisions are intended for consumer use
- Bluetooth sync requires users to download application
- Other methods of uploading data are not straightforward
- Inconsistent storage issues
- Not well-suited to scaling

Participant perspectives

Most participants (80%) reported no issues with the wear protocol

Most complaints were about the Atomtube:

- Difficult to exercise with
- Accidental button presses turning the device on/off

Conclusions

Personal air quality monitoring may capture behaviourally-relevant PM exposure that is not well identified using standard residence-linked estimates of air pollution

But available devices are currently not suitable for scaling for larger research purposes

New products are in development in collaboration with researchers that explicitly aim to address these issues:

- Atmotube PRO 2
- AirGradient

Next steps

Associations between daily personal PM exposure and other accelerometer-based metrics (e.g., heart rate)

Extent to which PM exposure is behaviourally vs. externally generated

Trial AirGradient device and determine potential for scalability in ELSA

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