Healthy Living in Cities - The Way Forward

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Background information

- Exposure to elevated levels of particulate matter (PM) is harmful to human health → cardiovascular, respiratory and neurological diseases[1,2]
- City dwellers' daily exposure to PM takes place in several indoor and outdoor microenvironments (MEs): e.g., residential home, office, multiple modes of transport.
- The conventional approach is to measure PM at fixed monitoring stations and assess related health risks; **Limitation**: No data on actual personal exposure.
- The recent trend is to use hand-held, wearable sensors with high accuracy to account for personal exposure under various pollution scenarios in the outdoor environment.[3,4,5]

Key knowledge gap

- Lack of realistic health risk data based on assessment of the integrated 24-hour daily personal exposure to PM across diverse indoor and outdoor MEs in cities.

Objective

- To study the personal exposure to PM & its components and to evaluate the potential associated health risks from continuous 24-hour personal exposure measurements in Singapore, a major urban environment in Southeast Asia.

Novelty

- This work represents the first study of its kind conducted on the assessment of integrated personal exposure to $PM_{2.5}$ (fine particles), $PM_{0.1}$ (ultrafine particles) and its key component (black carbon) involving a multi-disciplinary, multi-institutional collaboration as part of the Global Alliance project.

Approach and Methods

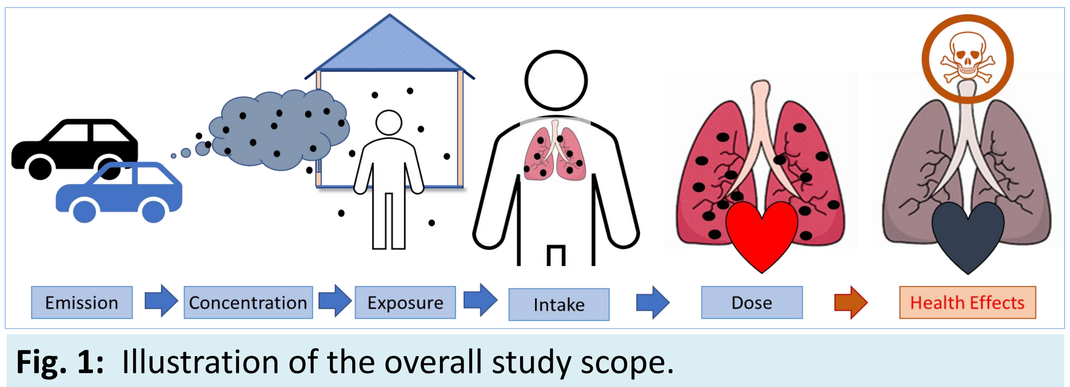


Fig. 1: Illustration of the overall study scope.

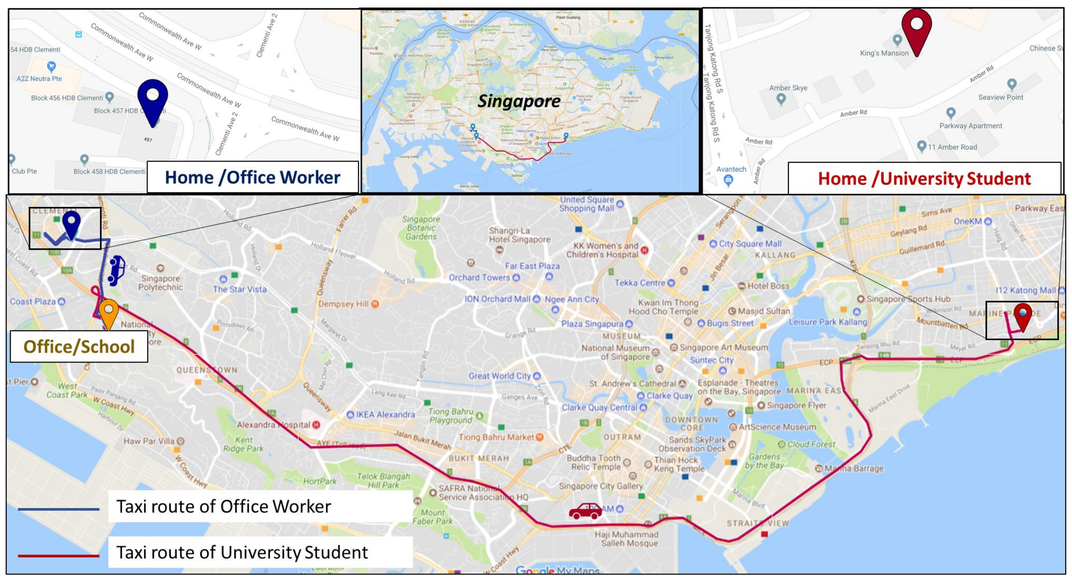


Fig. 2: Daily commute of 2 subjects from home to office/school and back using multiple modes of transport.

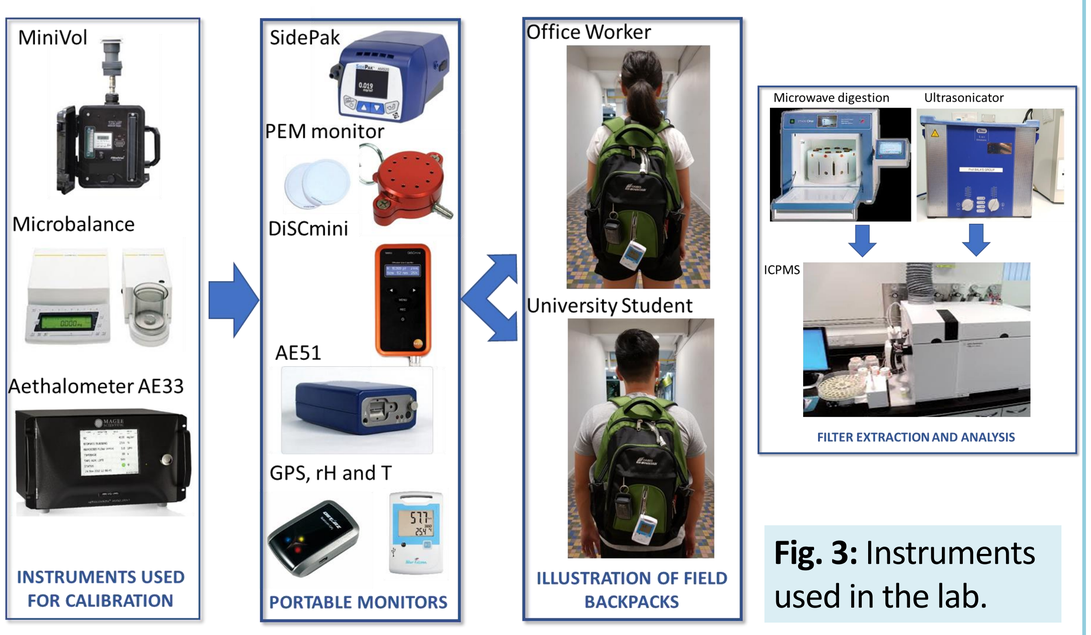


Fig. 3: Instruments used in the lab.

Results

Office Worker		University Student	
Travel by non-motorized vehicles (walking, cycling, e-scooter)	Travel by motorized vehicles (bus, taxi)	Travel by public transport (bus, bus + MRT)	Travel by non-public transport (car/taxi)

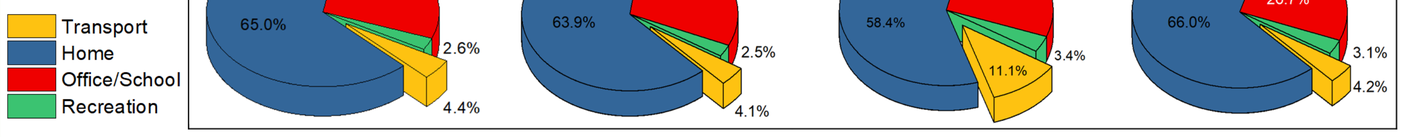
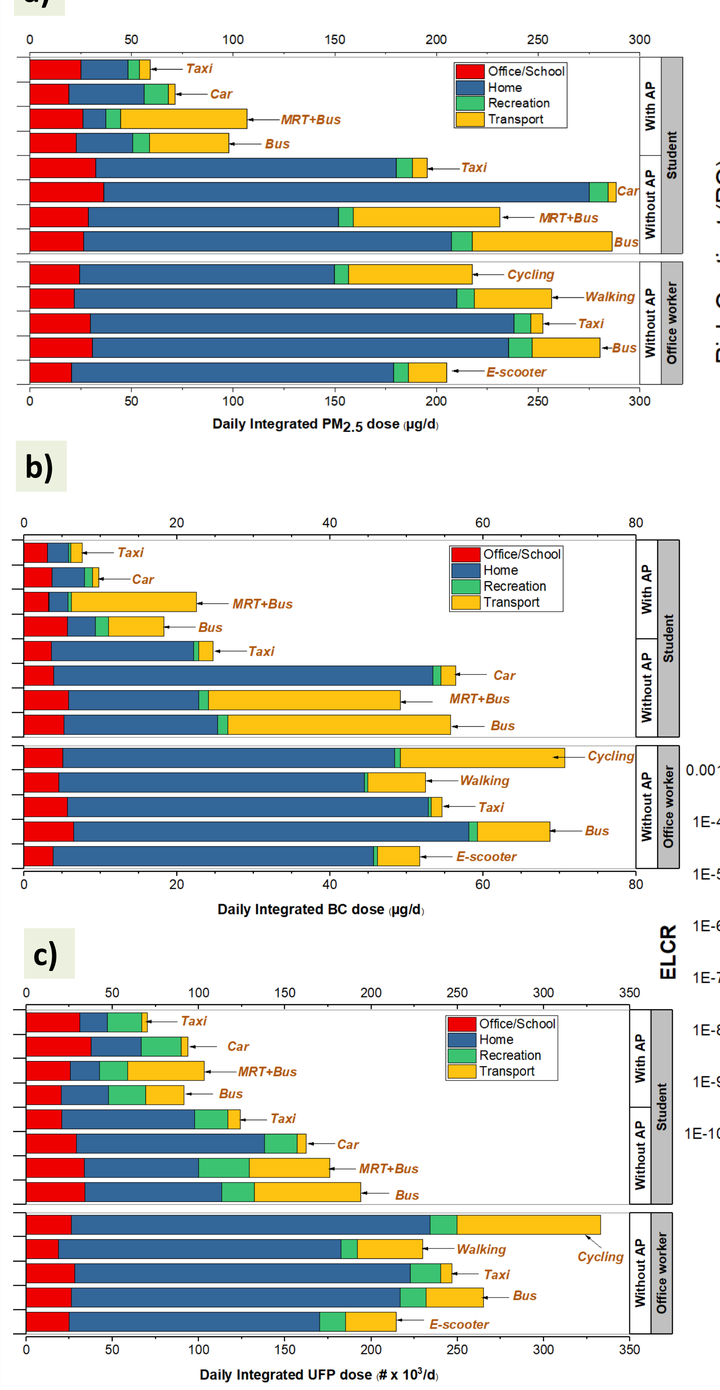


Fig. 4: Daily time – activity patterns of study participants in diverse MEs.



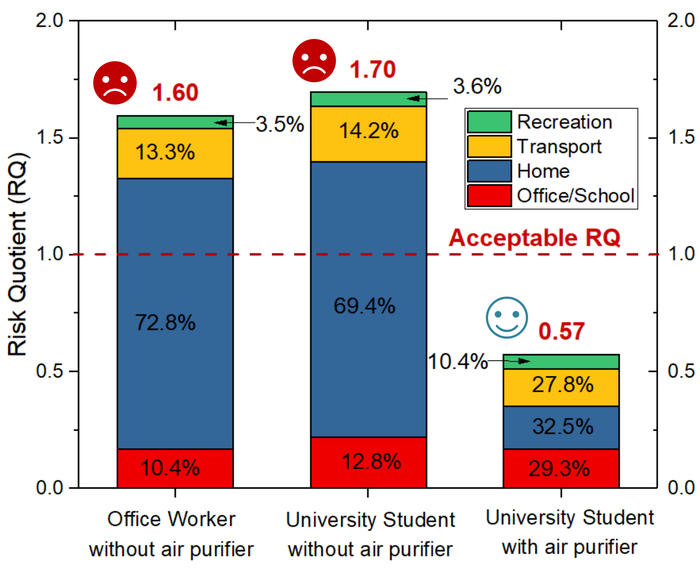


Fig. 6: Potential non-carcinogenic health risk estimates of $PM_{2.5}$.

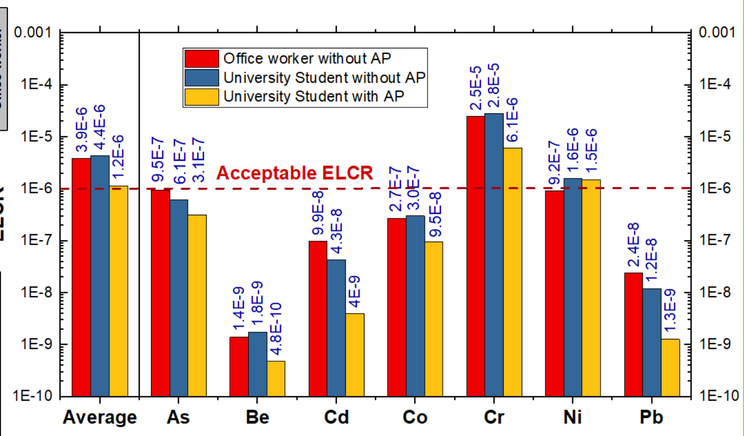


Fig. 7: Potential carcinogenic health risk estimates of $PM_{2.5}$ *(ELCR: Excess lifetime cancer risk, AP: Air purifier).*

Fig. 5: Contributions of various MEs to the total daily integrated exposure: (a) $PM_{2.5}$, (b) BC, and (c) UFPs *(AP: Air purifier).*

Major conclusions

[1] Short-term personal exposure events generally cause true exposure to be significantly higher than that predicted by using outdoor ambient $PM_{2.5}$ to generate health risk estimates .
[2] Active modes of commuting to work are generally encouraged, but raise health concerns due to high inhaled doses of $PM_{2.5}$, BC, and UFPs which are influenced by on-road vehicle emissions and by increased inhalation rates due to the intense physical activity.
[3] The inhaled dose during these active commuting modes could be reduced by creating designated cycling/walking routes through park connector networks, i.e. away from local traffic emissions. Alternatively, the density of urban forestry should be increased as vegetation acts as a bio-filter to capture air pollutants.
[4] Traffic emissions adversely affect the indoor air quality in naturally-ventilated apartments and hence the health of building occupants. Indoor cooking activities can further exacerbate the health condition of exposed individuals. Human health risk in such exposure scenarios can be mitigated with the use of a portable air purifier.

Practical implication

Integrating "citizen-oriented" exposure assessments and real-time location tracking with "city-scale" air quality monitoring would provide long-term health benefits to city dwellers.

[a]Recent Publications

Tran, T.M.P., Ngoh, J.R., and Balasubramanian, R., *Aerosol Air Qual. Res* (tentatively accepted).
Tran, T.M.P., Adam, M.G., and Balasubramanian, R., EFCA 2019.
Ngoh, J.R., Tran, T.M.P., and Balasubramanian, R., IAC 2018.

References

1. Heal, M.R., et al., Chem Soc Rev, 41, 6606-6630, 2012.
2. Landrigan, P., et al., The Lancet, 391, 462-512, 2018.
3. Steinle, S., et al,. Sci Total Environ, 508, 383-394, 2015.
4. Dons, E., et al., *Atmos Environ,* 55, 392-398, 2012.
5. Ham, W., et al., *Atmos Environ,* 167, 335-345, 2017.