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Characterising sources of PM2.5 exposure for school children with asthma: a personal exposure study across six cities in sub-Saharan Africa

Air pollution in Africa

- SDG 3.9

Mortality from environmental pollution : Reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination

- SDG 11.6

By 2030, reduce the adverse per capita environmental impact of cities, including special attention to air quality and municipal and other waste management

- Adverse effects of air pollution in Africa

- Scarcity of regulatory air quality monitoring equipment

Okello, G Nanthanda, R Awokola et al. Air quality management strategies in Africa: A scoping review of the content, context, co-benefits and unintended consequences. Environ int. 2023; 171,107709

The Sustainable Development Goals report 2022 https://unstats.un.org/sdgs/report/2022/

Air pollution in Africa

- Air pollution - the second largest health risk in Africa
- Particle pollution from fine particulates ($PM_{2.5}$)
- Is considered to be the greatest health threat of all air pollution measures
- WHO $PM_{2.5}$ exposure health guideline of 15 $\mu g/m^3$
- Only 9 studies recorded personal exposure to $PM_{2.5}$ - looked at $PM_{2.5}$ exposure in urban school children
- Uncertainty about the magnitude and sources of $PM_{2.5}$ exposure to children in urban areas

Fuller, R · Landrigan, PJ · Balakrishnan, K · et al. **Pollution and health: a progress update** *Lancet Planet Health*. 2022; **6**:e535-e547

Air pollution in Africa

- In Africa only nine of 111 systematic review studies showed recorded personal exposure to $PM_{2.5}$ (particulate matter <2·5 μm in diameter)
- Only one small study to date has measured $PM_{2.5}$ exposure in urban school children in Africa
- The magnitude and sources of $PM_{2.5}$ exposure to children in urban areas in sub-Saharan Africa data is limited

ACACIA and CAPPA

- Achieving Control of Asthma in Children in Africa (ACACIA) project
- School children aged 12–16 years with symptoms of asthma
- Children's air pollution profiles in Africa (CAPPA)
- Personal exposure to particulate matter (PM) in children with symptoms of asthma in urban centres in Africa

6 sub-Sahara cities

Blantyre - Malawi
Durban - South Africa
Harare - Zimbabwe
Kumasi - Ghana
Lagos - Nigeria
Moshi - Tanzania

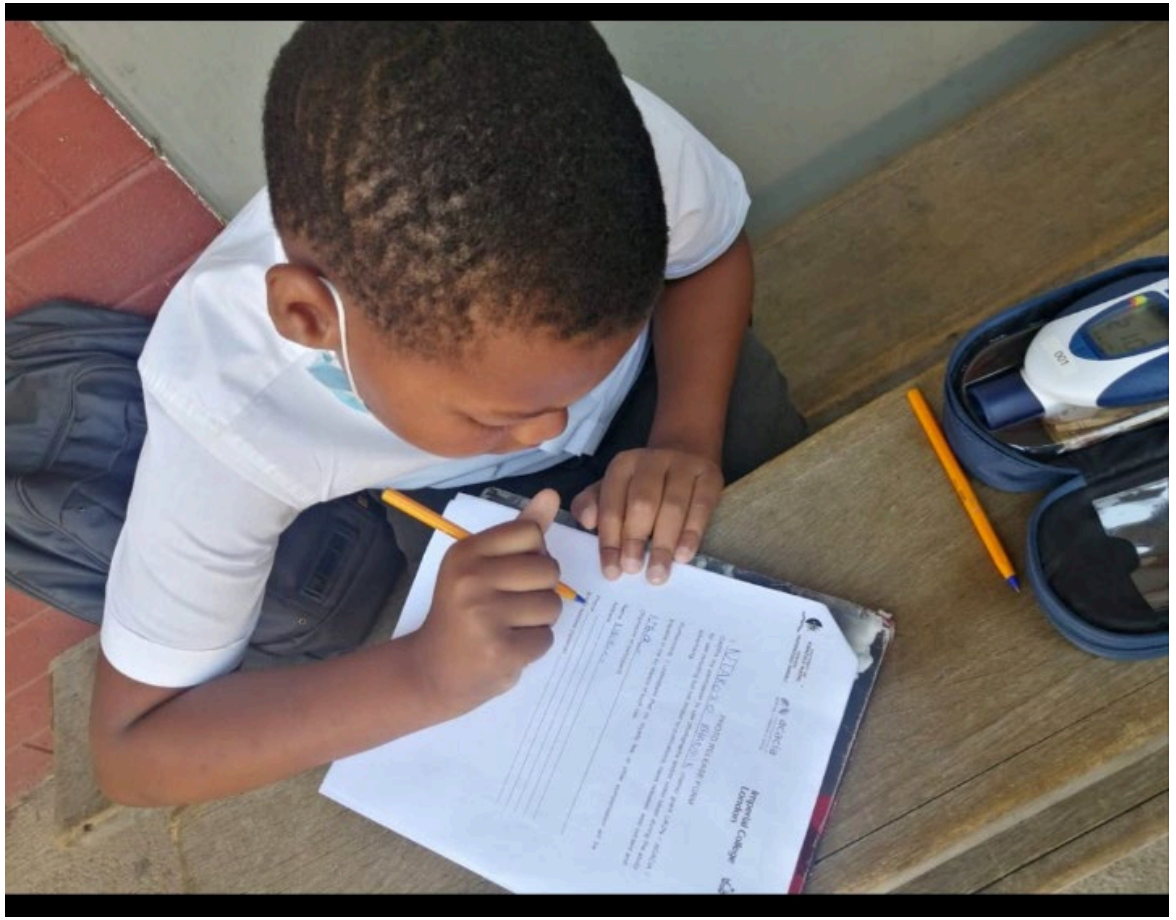
CAPPA

- Describe the burden of personal air pollution exposure
  - Particulate matter 10, 2.5 micromol/l, NO
- To analyse personal air pollution data for exposure patterns and peak exposures.
- To compare air pollution as well as activity profiles of children in relation to their socioeconomic and geographical backgrounds both within and between countries
- To explore potentially detrimental effects of air pollution, and feasibility of mitigation strategies in children with asthma symptoms identified by ACACIA.

Methods

- Backpacks (Dyson) equipped with a small air pollution monitoring unit devices that collect particulate matter, nitrogen oxide, humidity and temperature
- Inbuilt Global Positioning System (GPS) data logger
- Personal questionnaires filled in, detailing potential sources of air pollution during monitoring
- three different *microenvironments* (school, commute, and home) with GPS coordinates
- Survey : environmental exposure and symptoms
- Peak flow measurements twice daily

Air pollution diary



Methods

- Asthma symptoms for the day
- Transport modes to and from school
- Other potential activities (smoking, cooking)
- GPS coordinate data collected, combination of rule-based algorithms and reverse geocoding used

Results

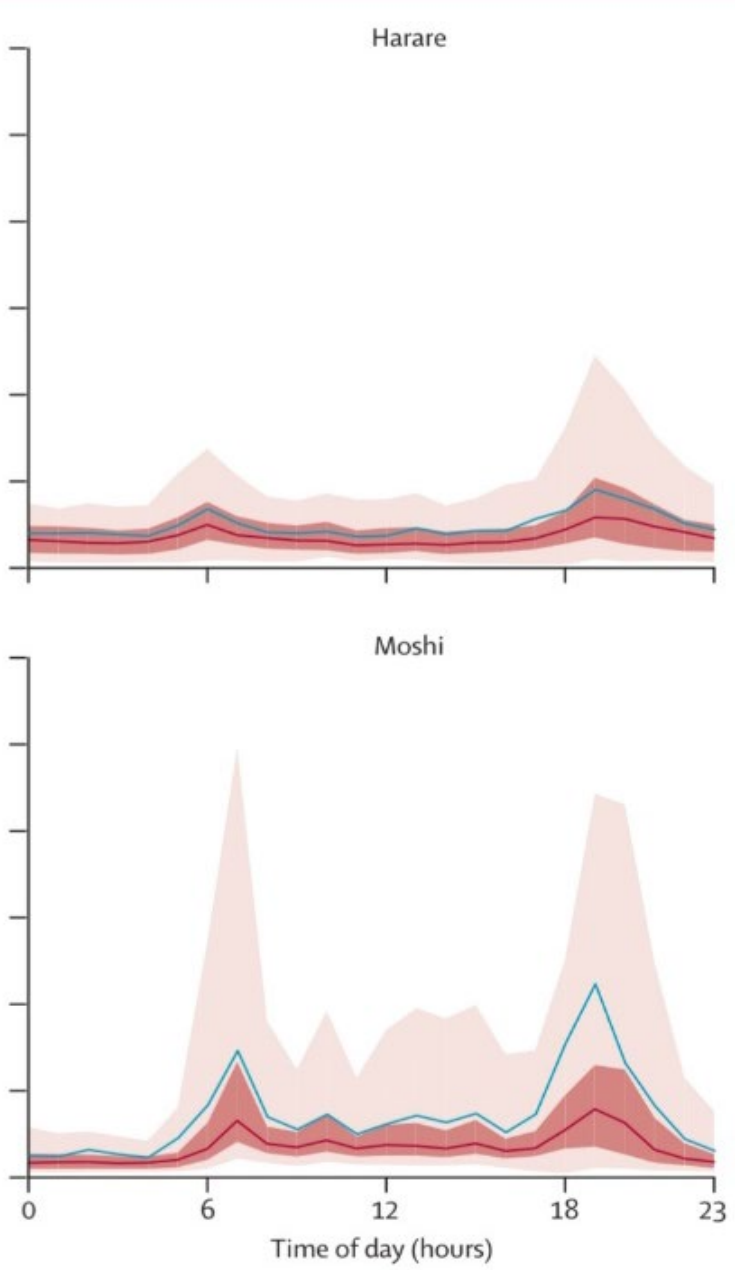
- 330 children were recruited across 43 schools
- 297 had valid monitoring data
- 1109 days of valid data were analysed

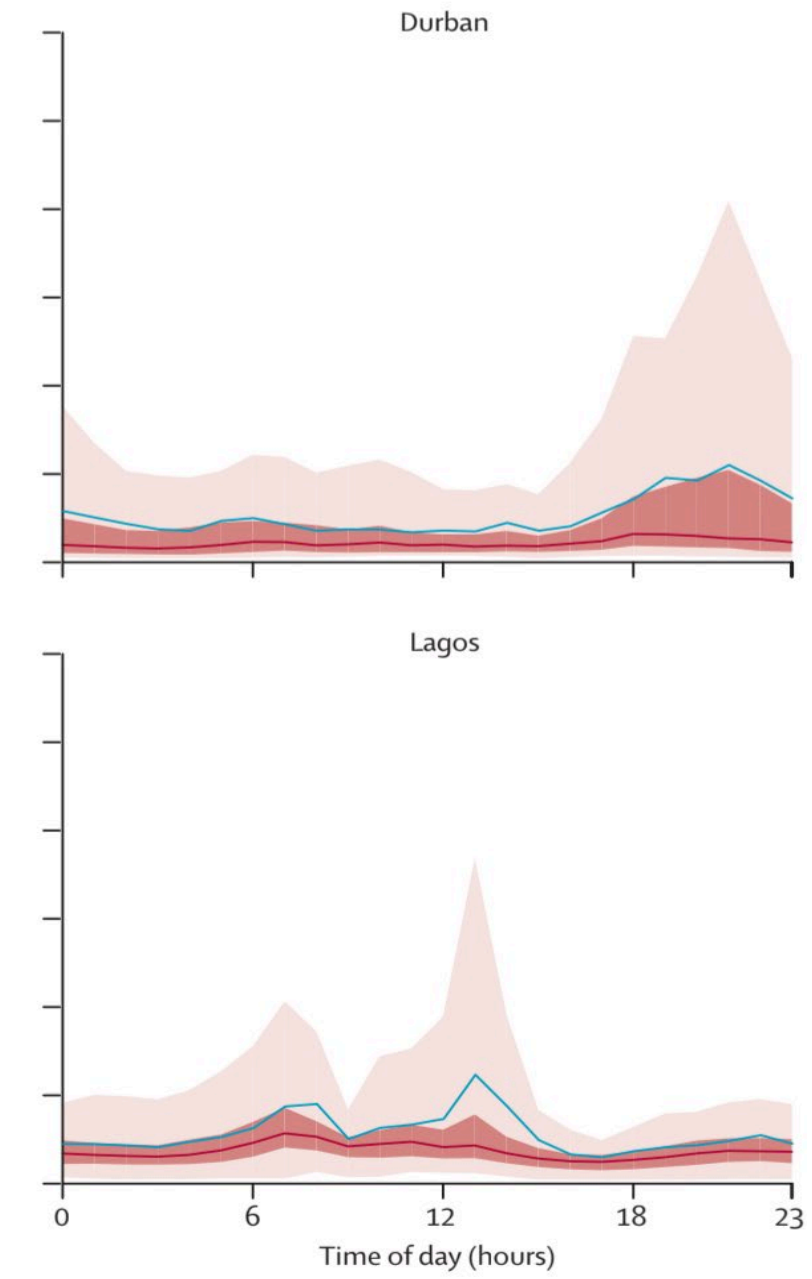
Results

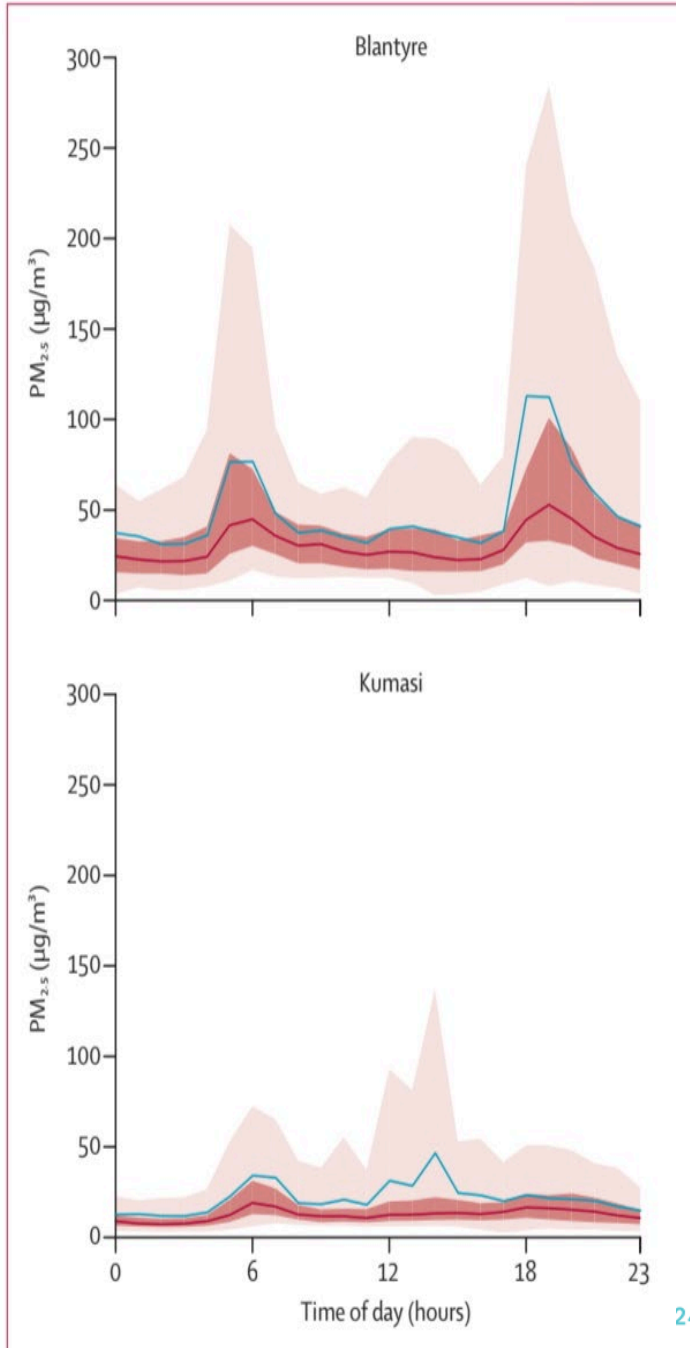
- 227 (20%) of 1109 days monitored were lower than the current WHO $PM_{2.5}$ exposure health guideline of 15 µg/m^3
- Highest $PM_{2.5}$ exposures (median 41.8 µg/m^3) in Blantyre
- Lowest $PM_{2.5}$ exposures - in Durban (16·0 µg/m^3) and Kumasi (17·9 µg/m^3)
- Significantly higher $PM_{2.5}$ exposures at school than at home in Kumasi, Lagos, and Moshi
- Blantyre, Durban and Harare had significantly higher $PM_{2.5}$ exposures at home and while commuting than at school.

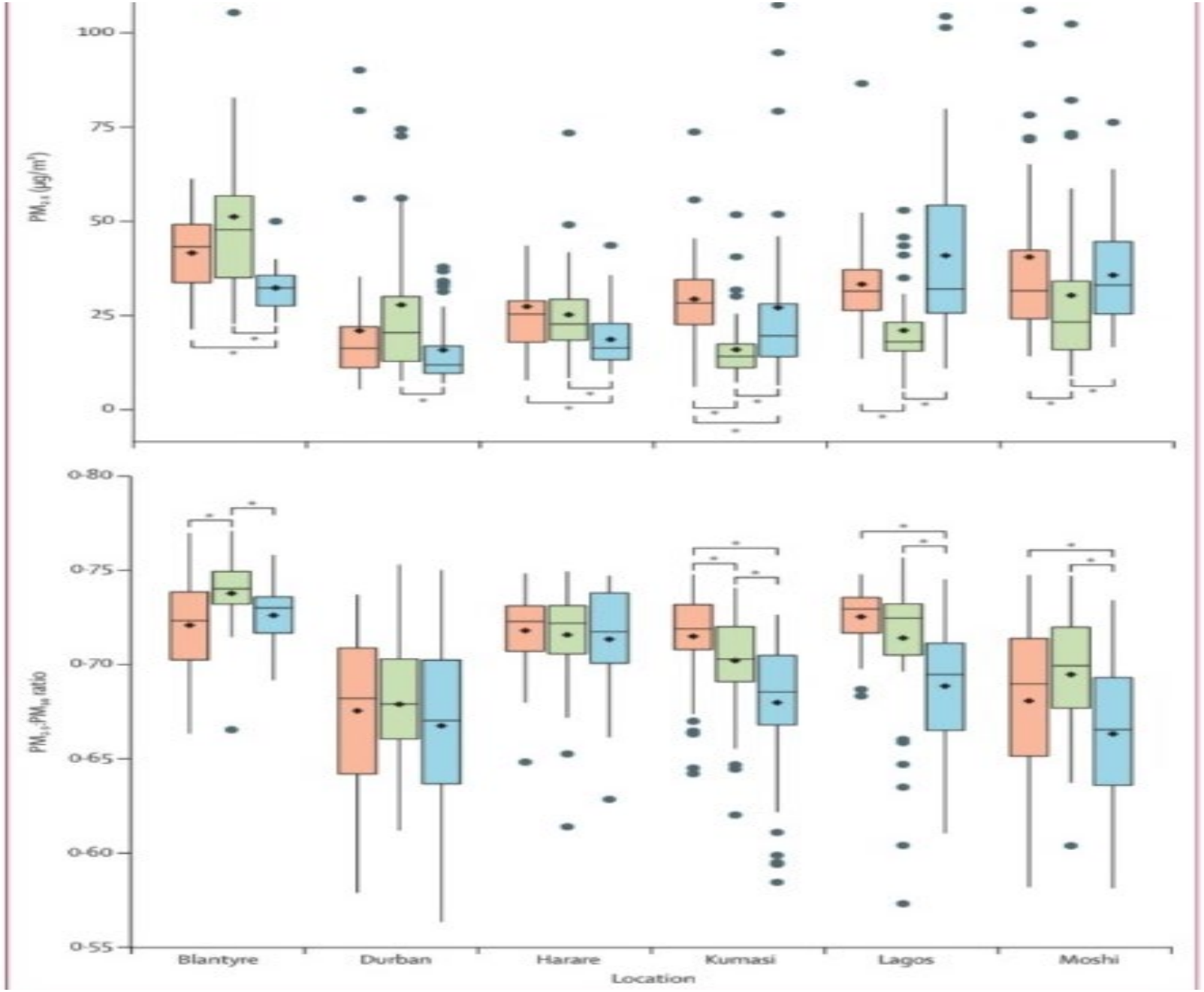
Results

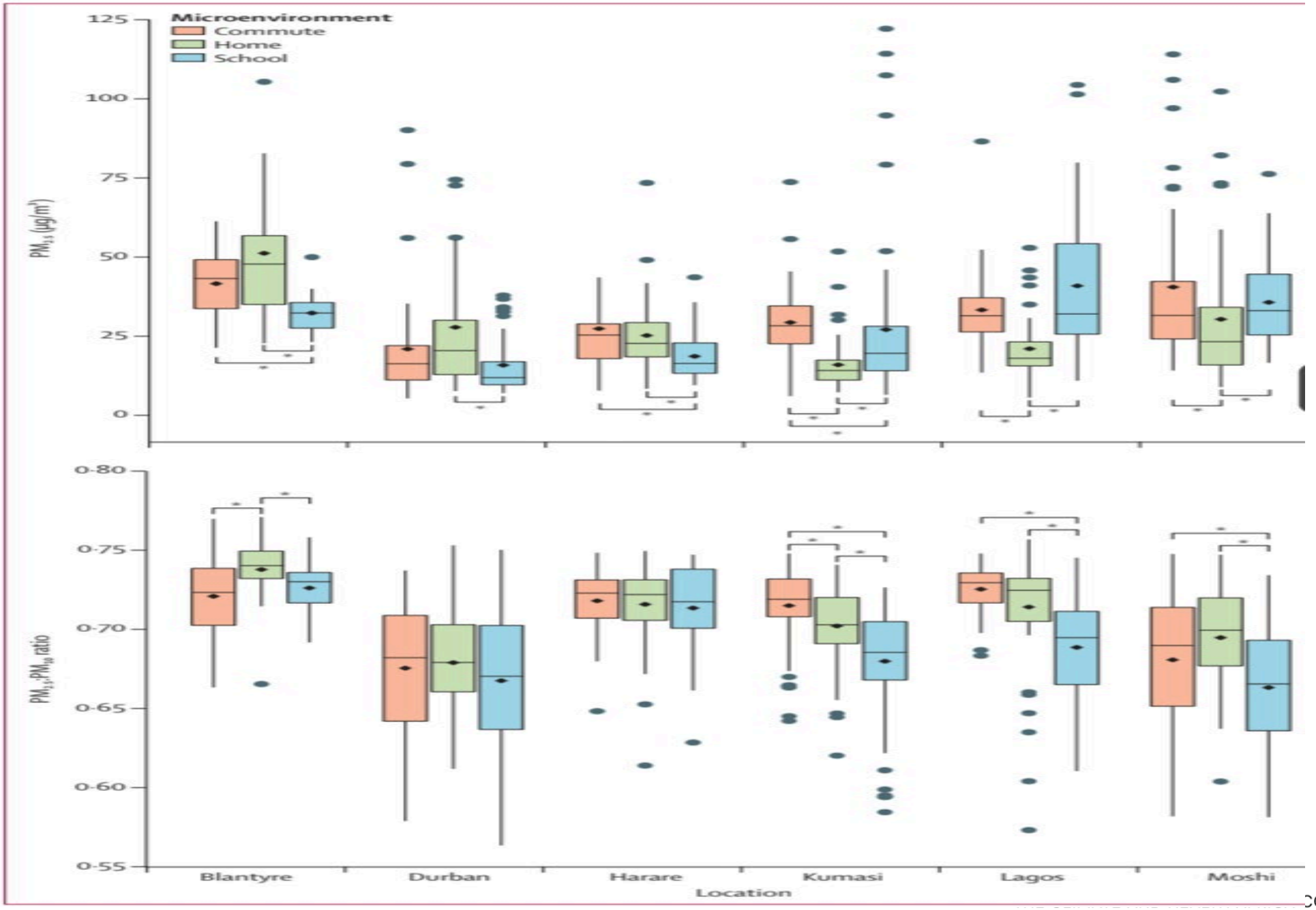
- Mixed-effects model highlighted determinants for higher $PM_{2.5}$ exposure
    - presence of smokers at home (+23%)
    - use of coal or wood for cooking (+27%), and
    - kerosene lamps for lighting (+30%)
- Lower exposures were for children who went to schools with paved grounds compared with those whose school grounds were covered with loose dirt (-37%)

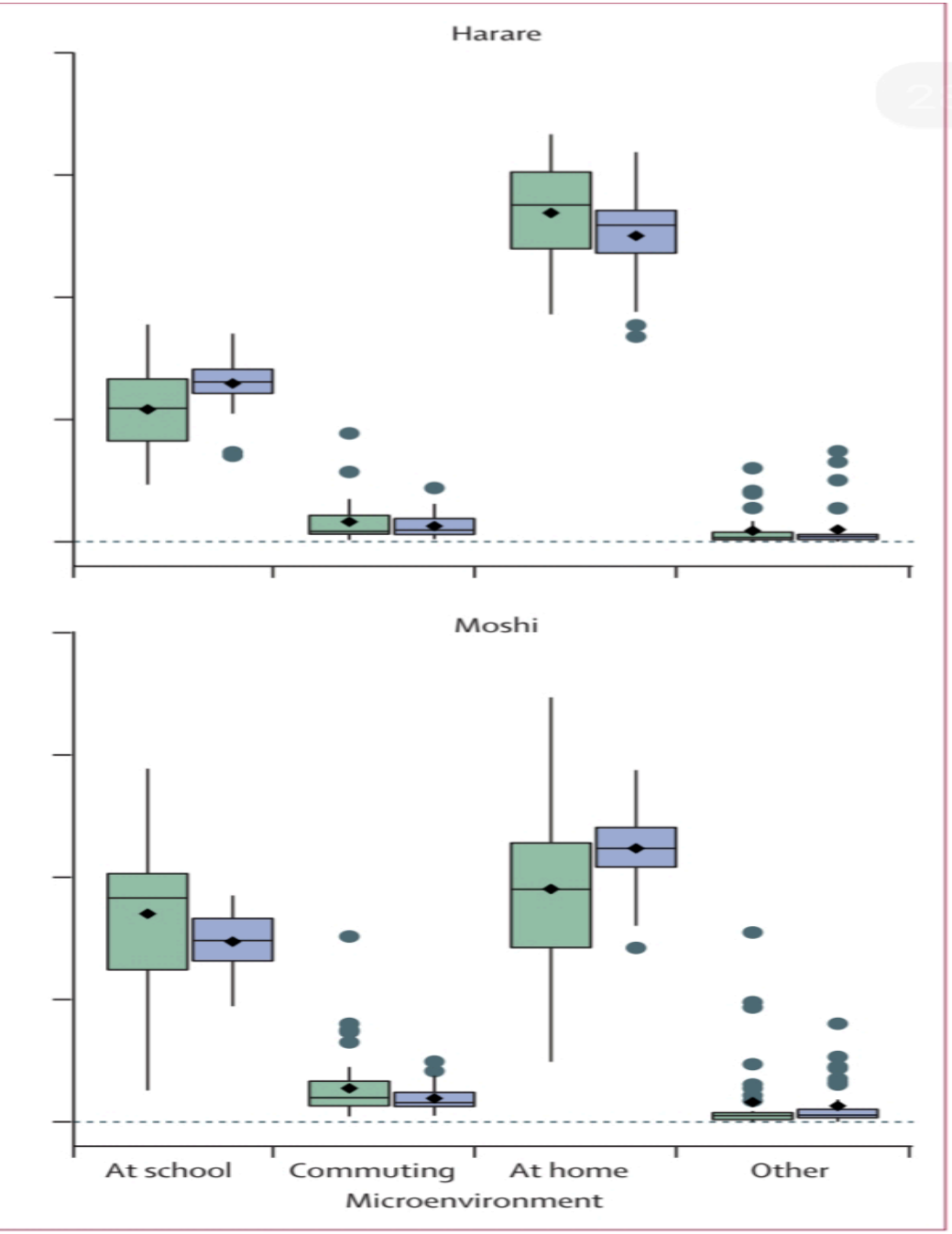

Harare
Moshi
0
6
12
18
23
Time of day (hours)

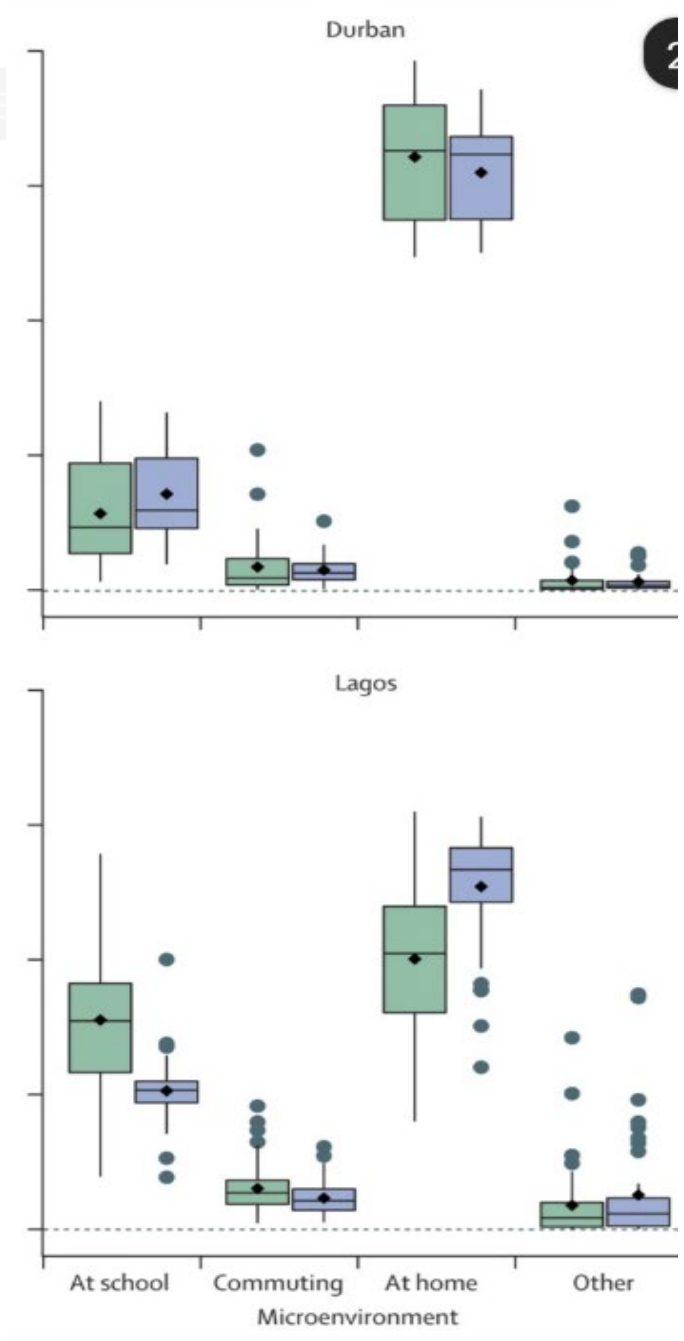

Durban
Lagos
0
6
12
18
23
Time of day (hours)

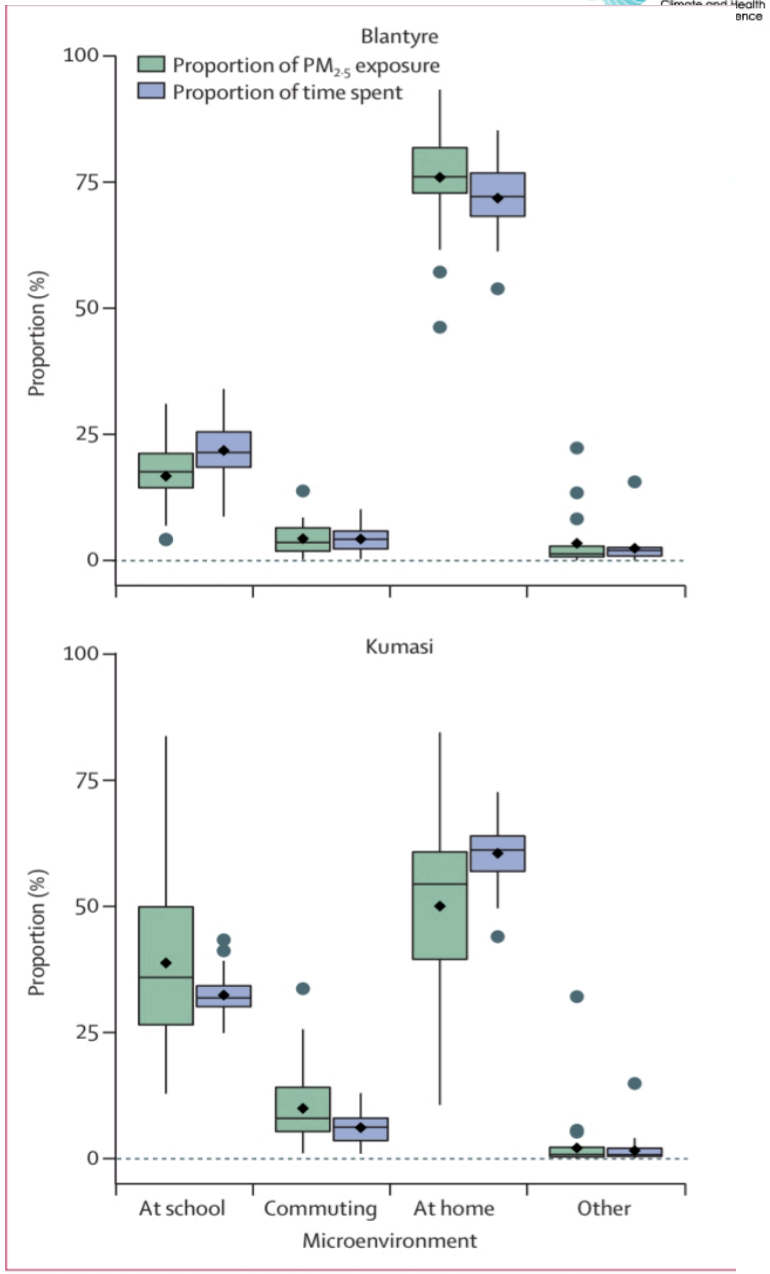

Blantyre
Kumasi
PM2.5 (µg/m3)
300
250
200
150
100
50
0
0
6
12
18
23
Time of day (hours)


100
75
50
25
0
$PM_{2.5}$ (µg/m³)
0·80
0·75
0·70
0·65
0·60
0·55
$PM_{2.5}$:PM_{10} ratio
Blantyre
Durban
Harare
Kumasi
Lagos
Moshi
Location


Microenvironment
Commute
Home
School
125
100
75
50
25
0
$PM_{2.5}$ (µg/m³)
0·80
0·75
0·70
0·65
0·60
0·55
$PM_{2.5}$:PM_{10} ratio
Blantyre
Durban
Harare
Kumasi
Lagos
Moshi
Location


Harare
Moshi
At school
Commuting
At home
Other
Microenvironment


Durban
Lagos
At school
Commuting
At home
Other
Microenvironment


Blantyre
Proportion of PM2·5 exposure
Proportion of time spent
Proportion (%)
100
75
50
25
0
Kumasi
At school
Commuting
At home
Other
Microenvironment

Conclusion

- Paving in school grounds will decrease $PM_{2.5}$
- Use of clean fuel in homes (cooking and lighting)
- Tailored interventions to prioritise different exposure-reduction policies

Acknowledgement

- UK National Institute for Health and Care Research
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- Schools
- Authors