

PARTICULATE MATTER AIR POLLUTION IN CENTRAL ASIA: A CASE STUDY OF BISHKEK, KYRGYZSTAN

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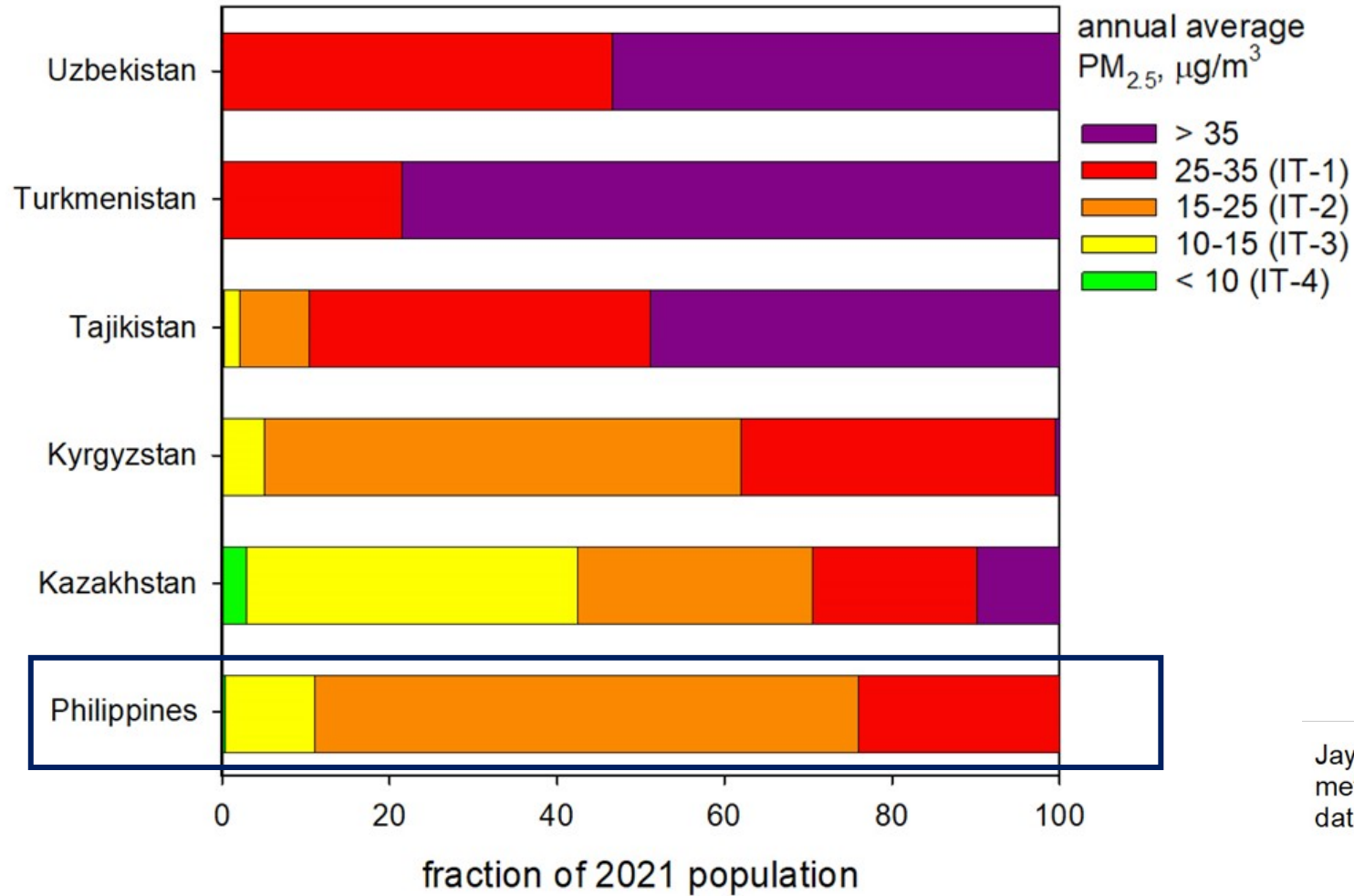
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2021 population exposures to outdoor fine particulate matter (PM_{2.5})

Hybrid Model with All Sources



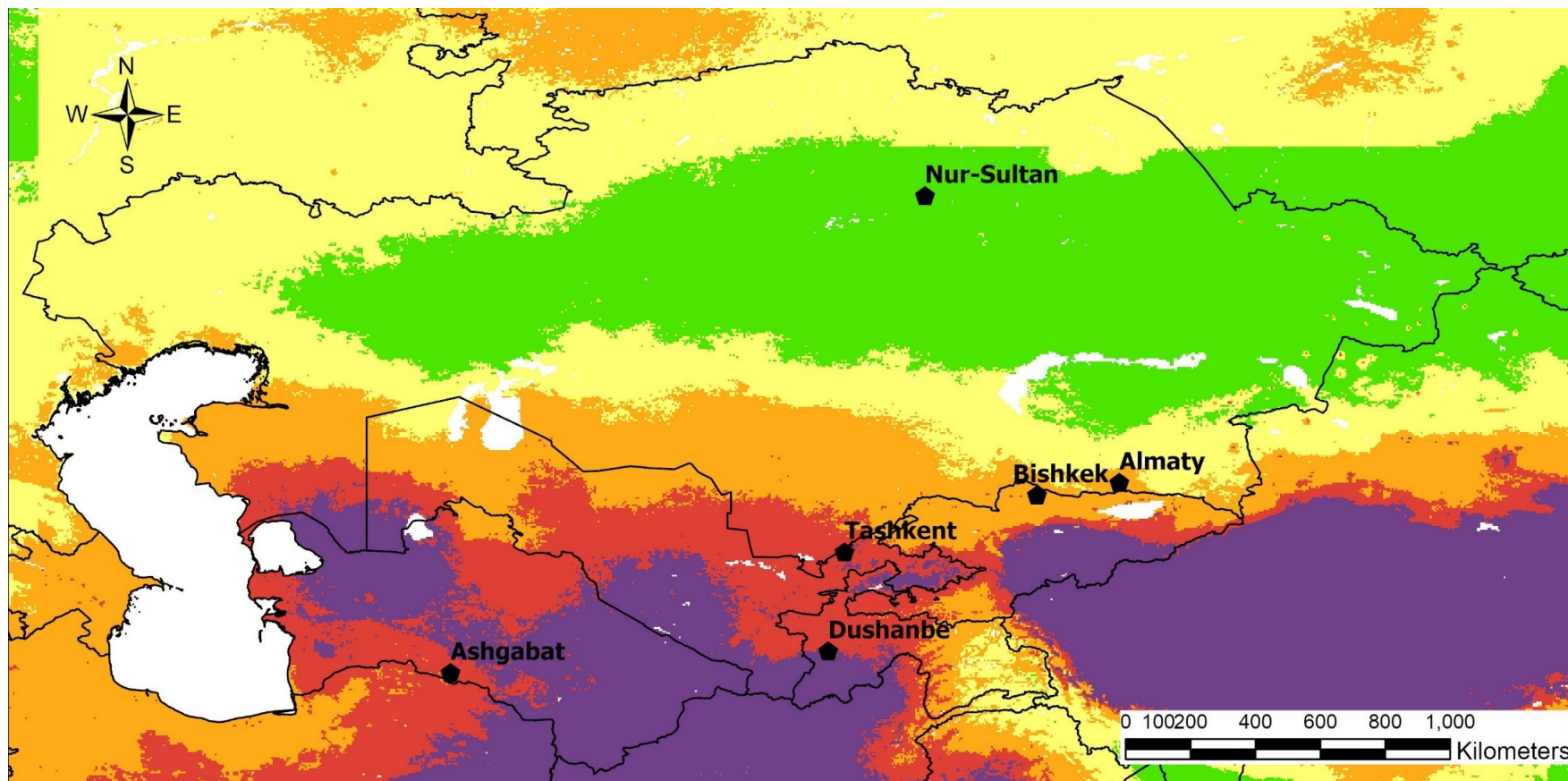
Jay Turner, Washington University in St. Louis, USA
 methodology from van Donkelaar *et al.* (2021)
 data from <https://sites.wustl.edu/acag/> (accessed 09 Nov 2023)

IT-x = WHO Interim Targets (Air Quality Guideline = 5 µg/m³)



Annual Average PM_{2.5} (2018)

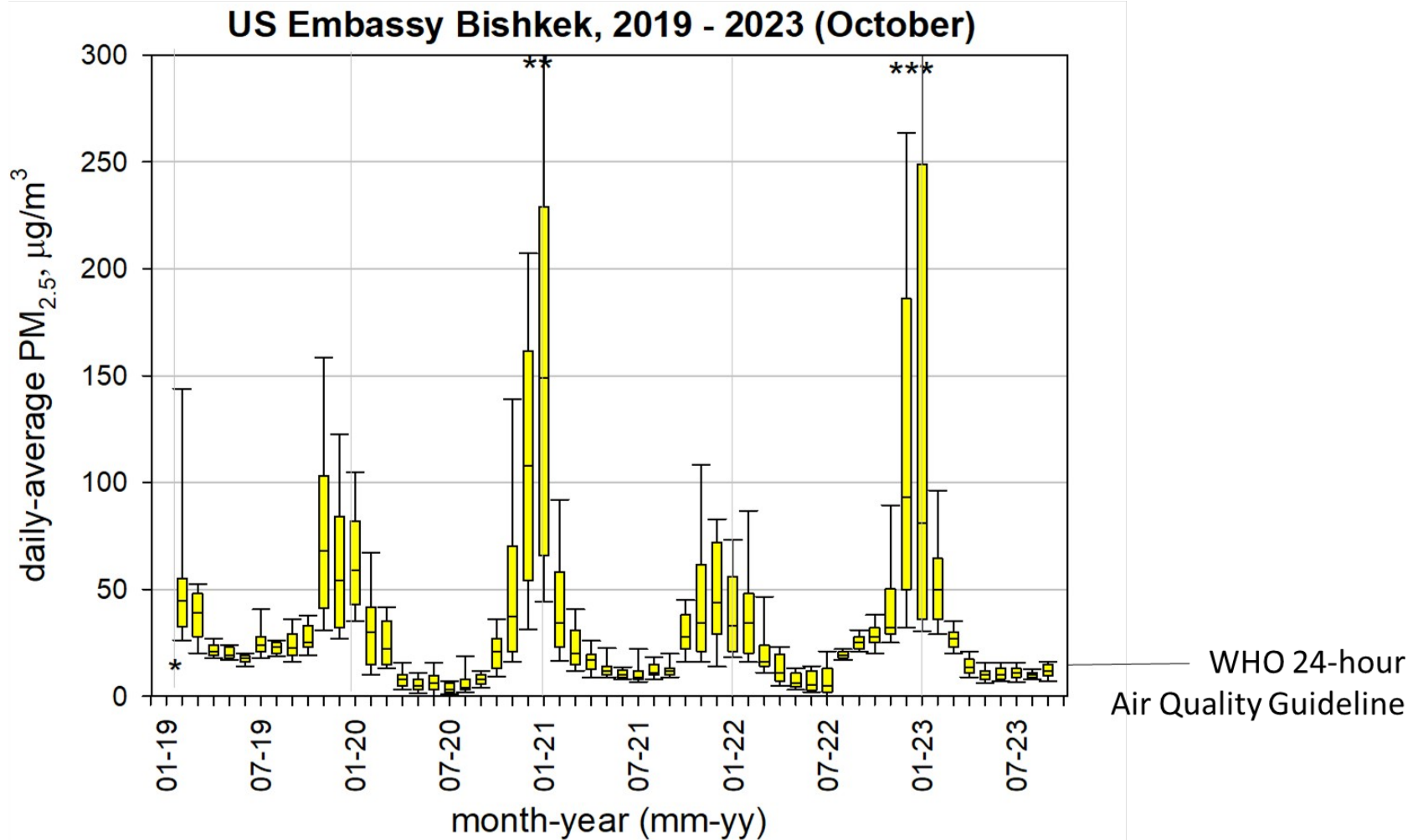
Hybrid Model with All Sources



map created by Jay Turner, data from Hammer et al. 2020

IT-x = WHO Interim Targets (Air Quality Guideline = 5 $\mu\text{g}/\text{m}^3$)

Bishkek, Kyrgyzstan (pop. ~1 million)



Bishkek Wintertime PM_{2.5}, like many Central Asian cities, is a mostly local problem

Bishkek



Ala Archa National Park,
30km from Bishkek city center
20km from the peri-urban extent



UNICEF Project Acknowledgements

Project Team

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Outdoor Air Quality Data

- Asian Development Bank
 - Jules Hugot, Kristian Rosbach
- KyrgyzHydromet
 - Begaim Alipova, Lyudmila Nyshanbaeva
- Clarity Movement Co.
 - Levi Stanton, Sean Wihera

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HEALTH AND SOCIAL
IMPACTS OF AIR POLLUTION
ON WOMEN AND CHILDREN
IN BISHKEK, KYRGYZSTAN

ENTRY-POINTS FOR ACTION



ICM Kyrgyzstan/2022 Shalo Dzhakshibaev



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the People of Japan

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for every child

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Objectives and Approach

- Examine the health and social impacts of fine particulate matter (PM_{2.5}) air pollution on children and women in Bishkek
- Assess entry points for action to reduce air pollution exposures



Rapid Situational Assessment

Outdoor Urban Air Quality

Residential Indoor/Outdoor Air Quality

Exposure Estimation

Health Impact & Economic Burdens Assessment

Value of Statistical Life, Willingness to Pay Estimates

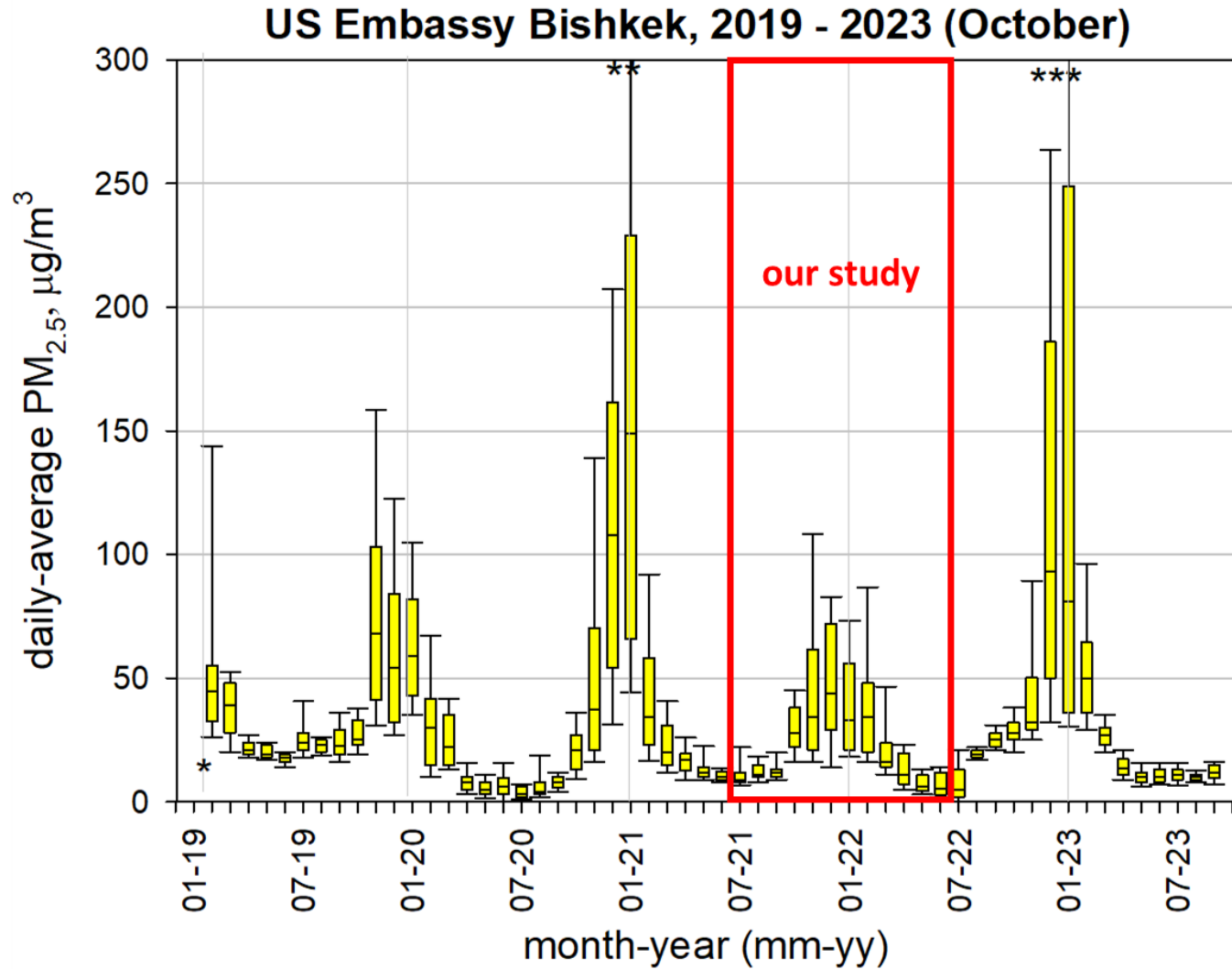
Household Survey

Phase I
(demographics & residential characteristics)

Phase II
(contingent valuation)

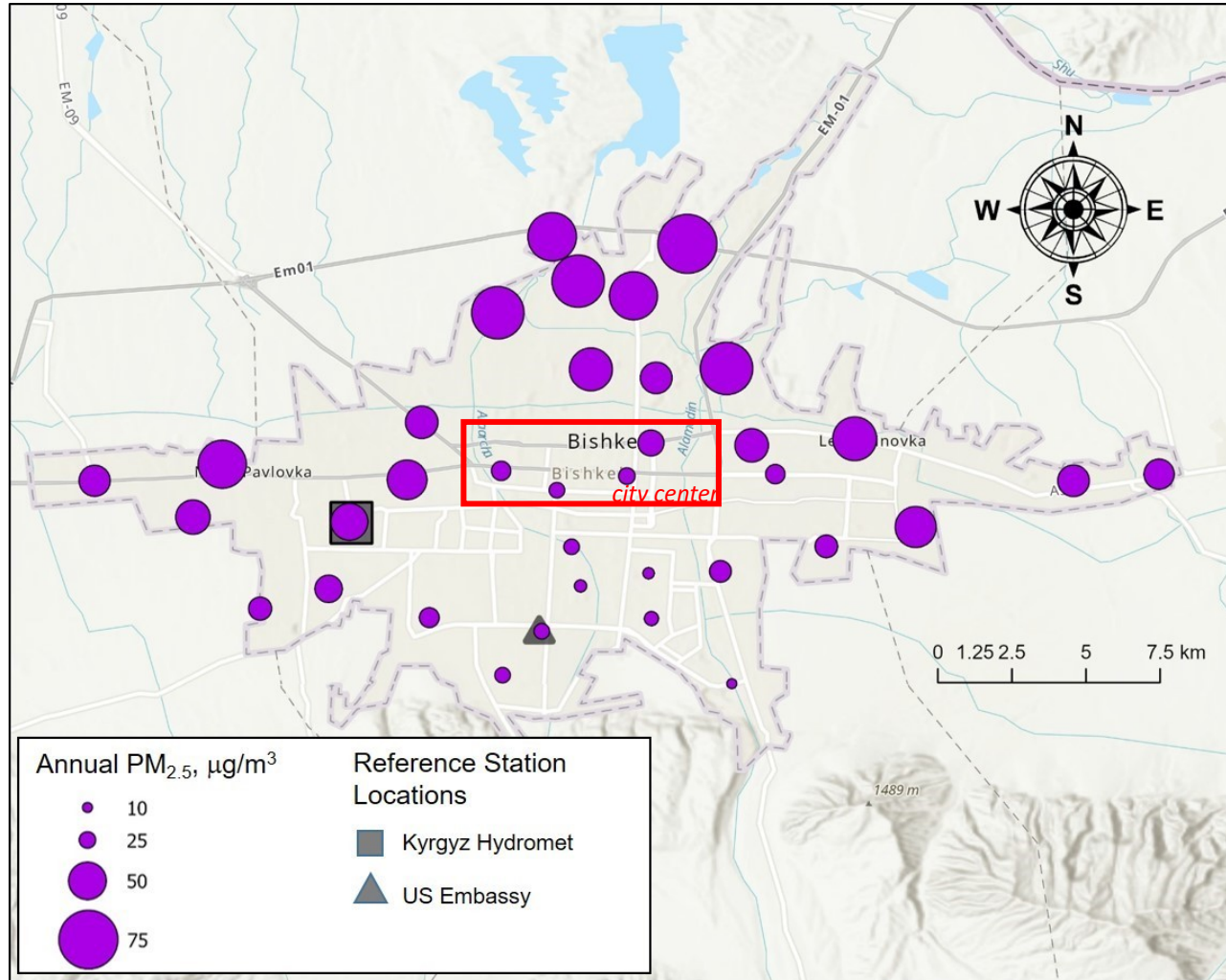
unicef 
for every child

Our July 2021-June 2022 Study Period was Relatively Less Polluted



This propagates through to the health and economic impact results

PM_{2.5} 12-month average (“annual”), July 2021-June 2022



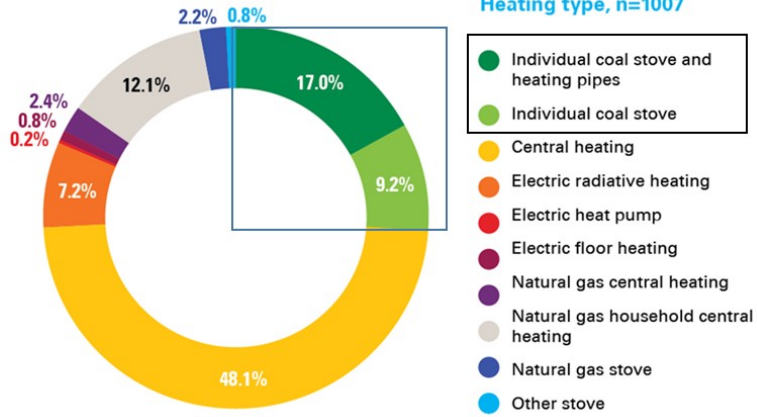
Clarity Movement Co.

~400% difference in outdoor concentrations across Bishkek

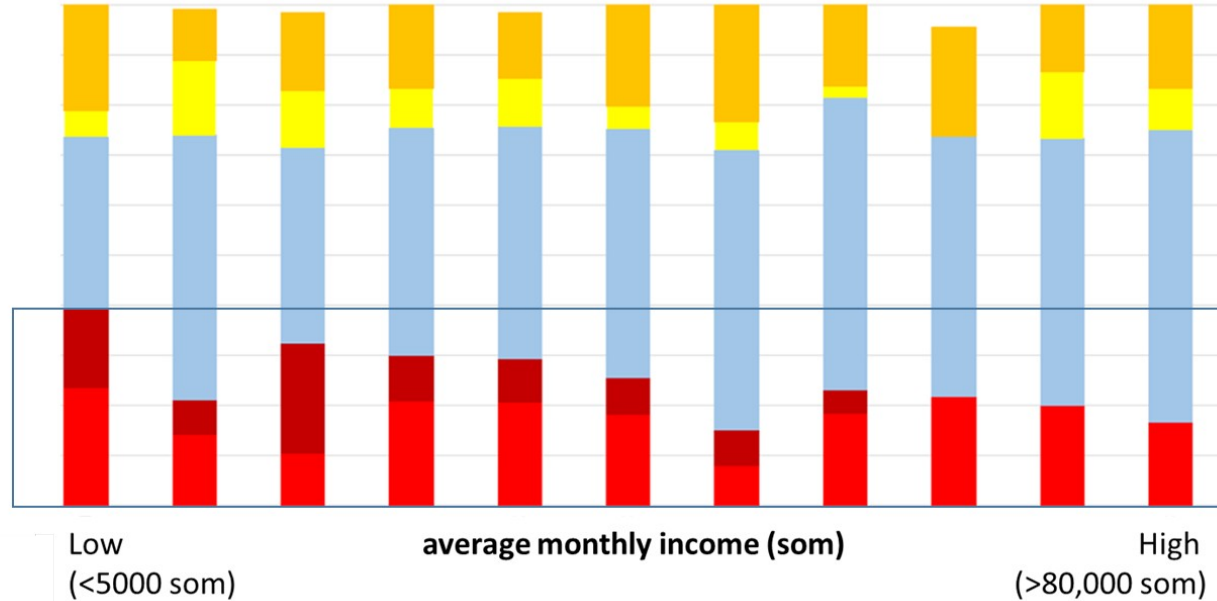
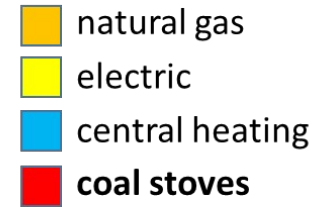
Where you live/work/play matters!

Raw data from KyrgyzHydromet/ADB Clarity sensor network; validated, adjusted and analyzed by the UNICEF project team

Heating type, n=1007



Coal Stoves are used by ~25% of surveyed households...

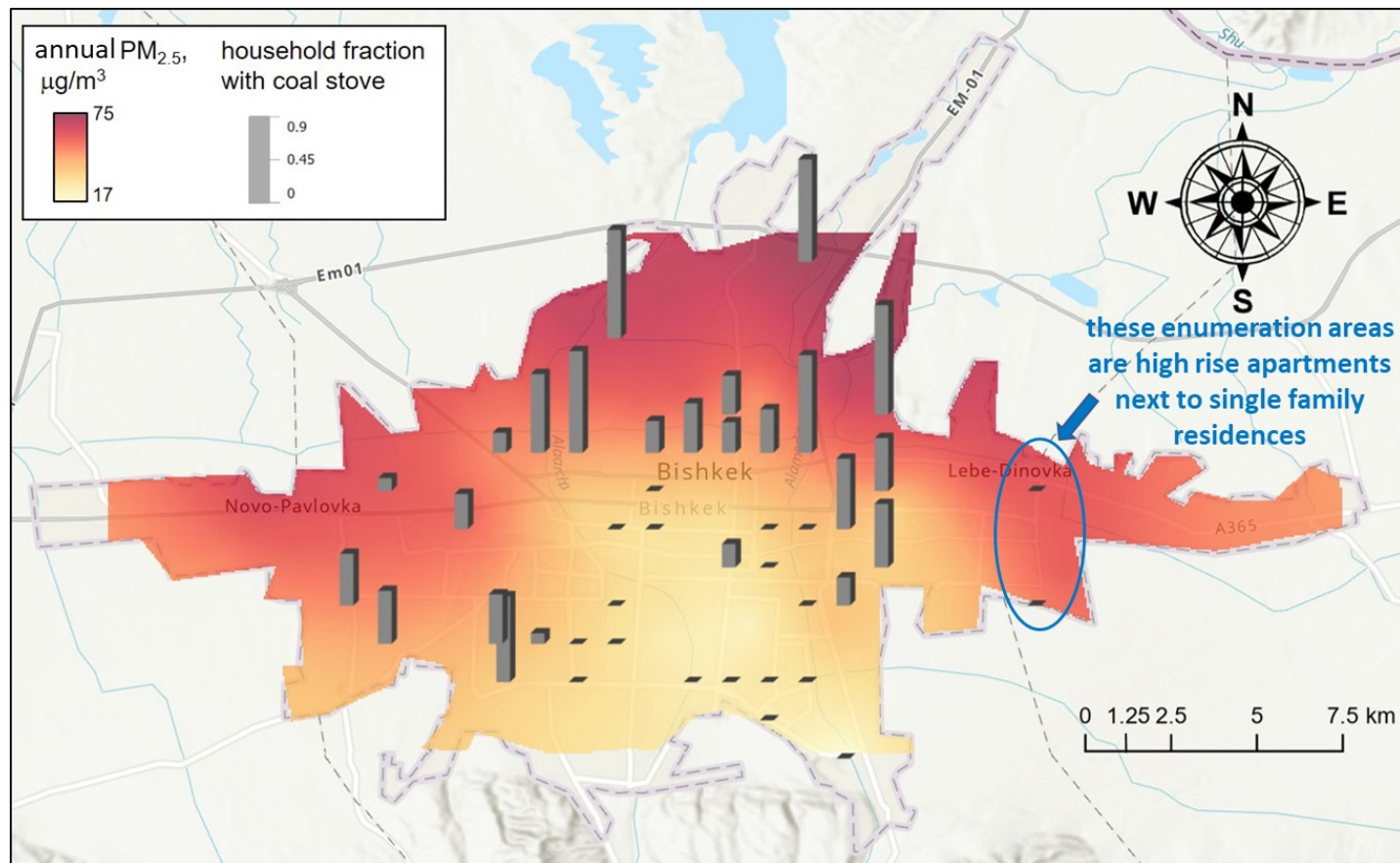


... and Coal Stove use broadly distributed across all income brackets

primary energy source for residential space heating

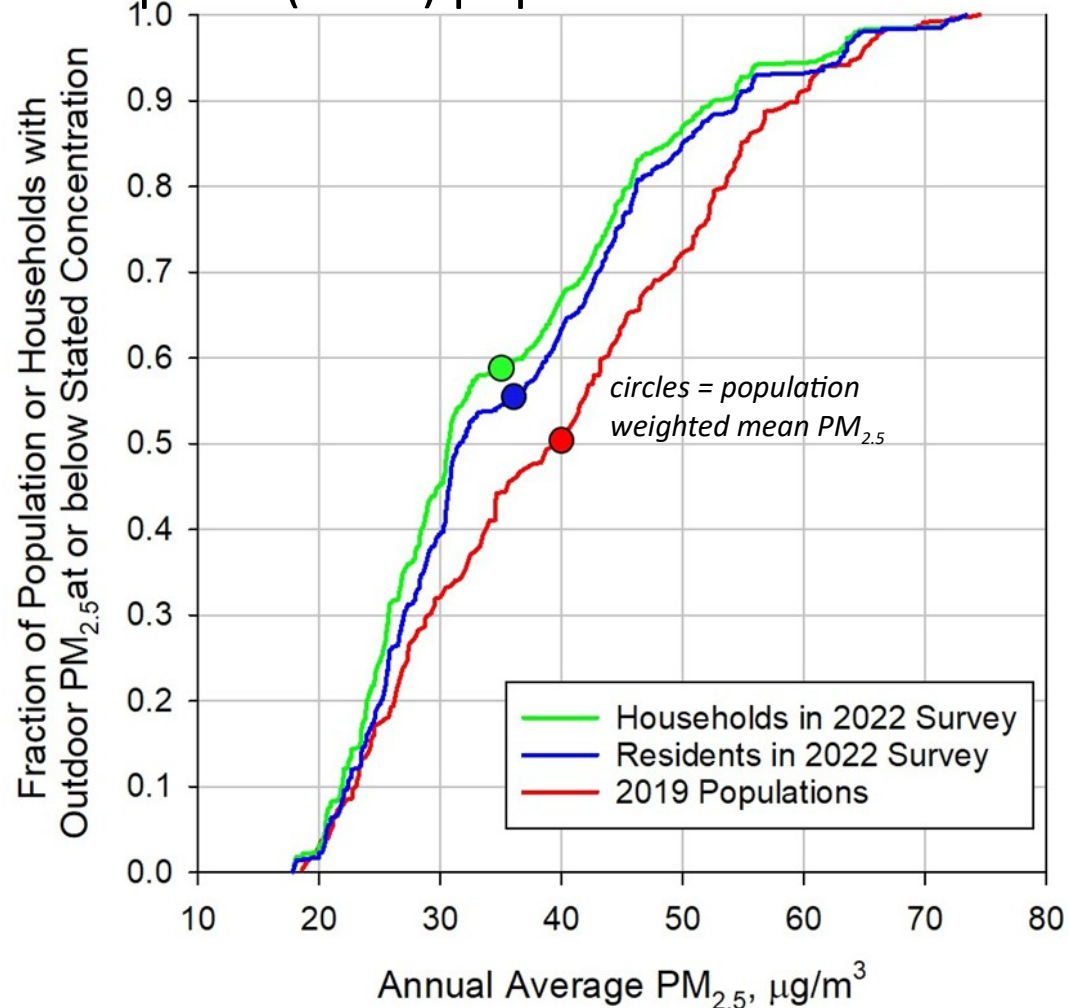
PM_{2.5} Outdoor Concentrations Strongly Correlated with Residential Coal Use

(July 2021-June 2022; same pattern using winter average PM_{2.5})



Distribution of Outdoor PM_{2.5} at Residences

Combining PM_{2.5} spatial map (previous slide) and spatial (1km²) population data...



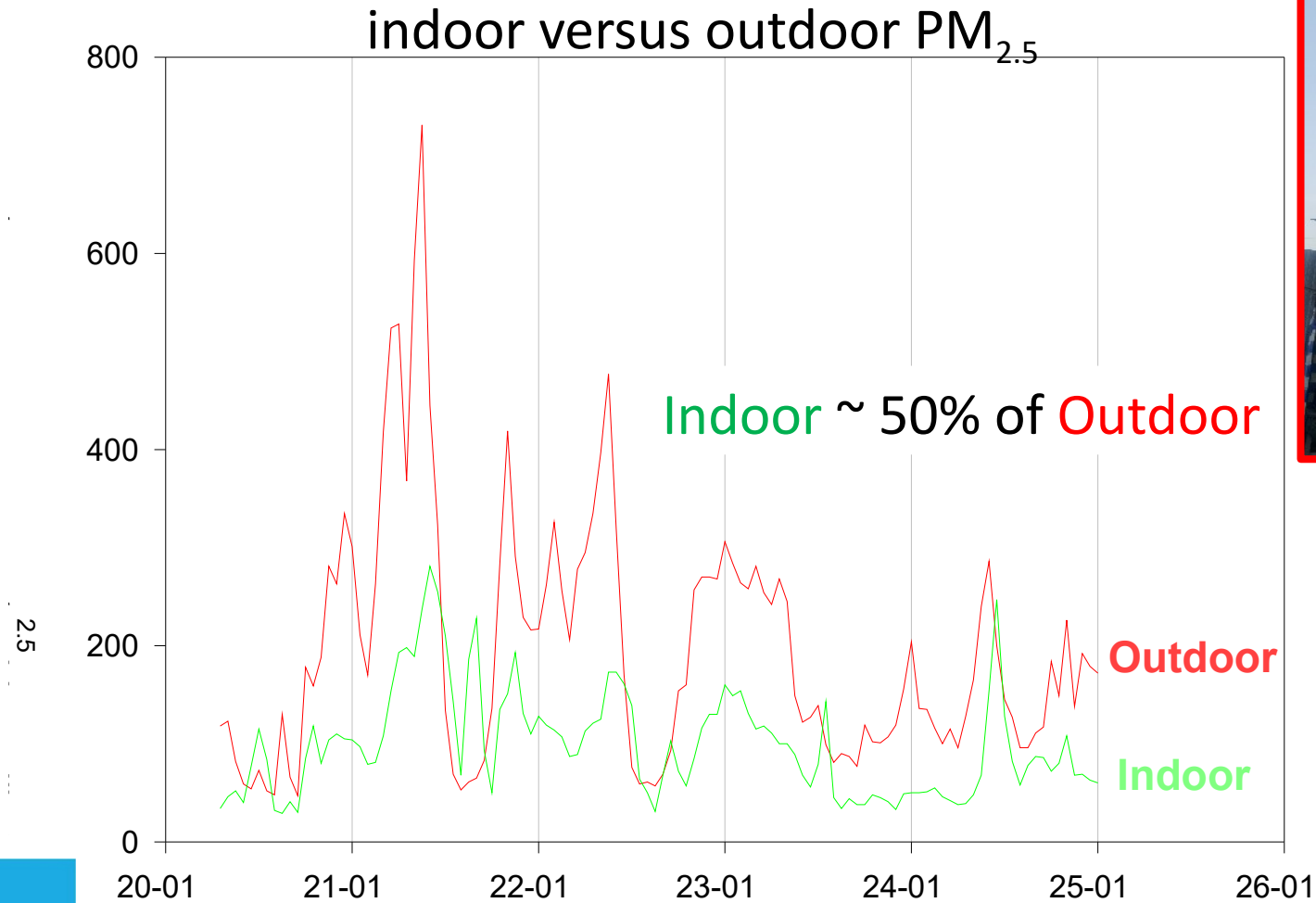
Population **mean concentration** does not well represent this broad **distribution of concentrations**

Using 2019 population data...

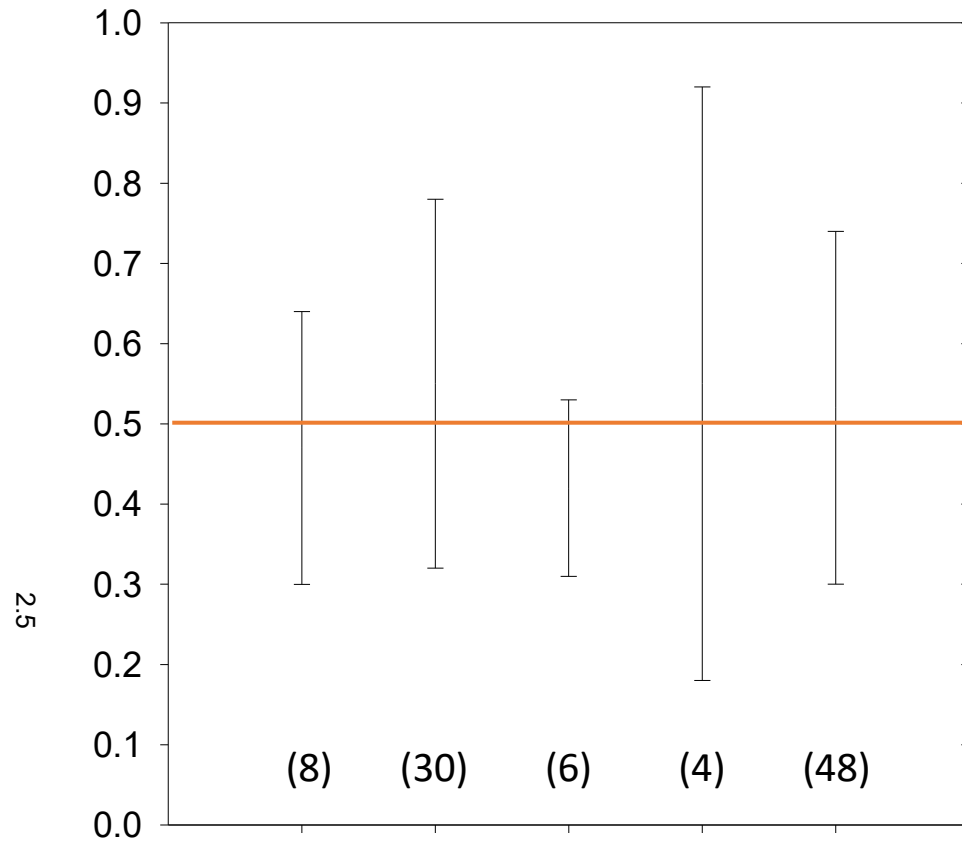
- 20% of population < 25 µg/m³ (IT-2)
- 50% of population > 40 µg/m³ (>IT-1)
- **10% of population > 60 µg/m³ (>>IT-1)**

But people spend most of their time indoors...

outdoor PM_{2.5} concentrations, PM_{2.5} indoor/outdoor ratios, and time-activity data → exposures



Household Indoor/Outdoor (I/O) PM_{2.5} Ratios



I/O ratio ~0.5 across all heating types...

Consistent with infiltration of neighborhood-scale outdoor PM

Health Outcomes Estimates – Bishkek, July 2021 to June 2022

- Annual health impacts from PM_{2.5} exposure were estimated to cause:
 - 112 Deaths (95% CI 97-131)
 - loss of 3,568 Disability Adjusted Life Years (DALYs) (95% CI 2,990-4,220)
- 2021-2022 estimated welfare loss from PM_{2.5} air pollution:
 - 24.9 million USD (95% CI 20.8-29.4)

Project report and three policy briefs available on the UNICEF Kyrgyzstan website

Residential Heating Interventions Options

Better temperature control of buildings on district central heating



Expand natural gas distribution network



HEAT PUMPS



air-to-air heat pump
(commercial building)

Summary I: Bishkek PM_{2.5} Air Quality

- **Moderately dense low-cost sensor (LCS) network (~5km²/LCS)**
 - Identified high PM_{2.5} spatial variability (factor of four) across Bishkek
 - Enabled PM_{2.5} exposure estimation at 1km² resolution
 - Determined influence of mountain-valley airflow on PM_{2.5} (not shown)
- **PM_{2.5} network and household survey**
 - Highlighted residential coal stoves as the dominant source of wintertime PM_{2.5}
- **Simultaneous Indoor/Outdoor Monitoring**
 - Generated relationships needed for PM_{2.5} exposure modeling
 - Identified indoor PM_{2.5} dominated by infiltration of ambient air
 - Emissions directly to the indoor air are low for vented, properly functioning stoves
 - “It is your stove and your neighbor’s stoves” leading to indoor exposures

Summary II: Bishkek PM_{2.5} Air Quality

- Large differences in PM_{2.5} exposures across the city
- Residential stoves drive high neighborhood-scale outdoor air pollution
- Interventions to **reduce PM_{2.5} emissions** must be at the neighborhood or larger scale to reduce household-level exposures
- Absent (or in addition to) emissions reductions, there are household-level actions to **reduce PM_{2.5} exposures** (e.g., air purifiers)



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