SALUD URBANA EN AMÉRICA LATINA

Association between ambient PM2·5 and under-5, infant, and child mortality in Latin American cities, 2010- 2015

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wellcome

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Urban Health Network for Latin America and the Caribbean

Background

Countries in the Global South face critical air pollution problems resulting from rapid urbanization

In Latin American cities, the effect of ambient PM2·5 on child health has not been extensively explored

Why is this important in Latin America?

- Almost 10% population is under 5 years of age.
- More than 80% population live in cities, where air pollution levels are among the highest in the world
- Limited evidence on the effect of air pollution on child health in small and medium-sized cities.

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Children are more vulnerable to air pollution

- Immature airways and lungs

- Immature kidneys and liver , less ability to filter toxins

- High breathe rate

- Mouth breathing

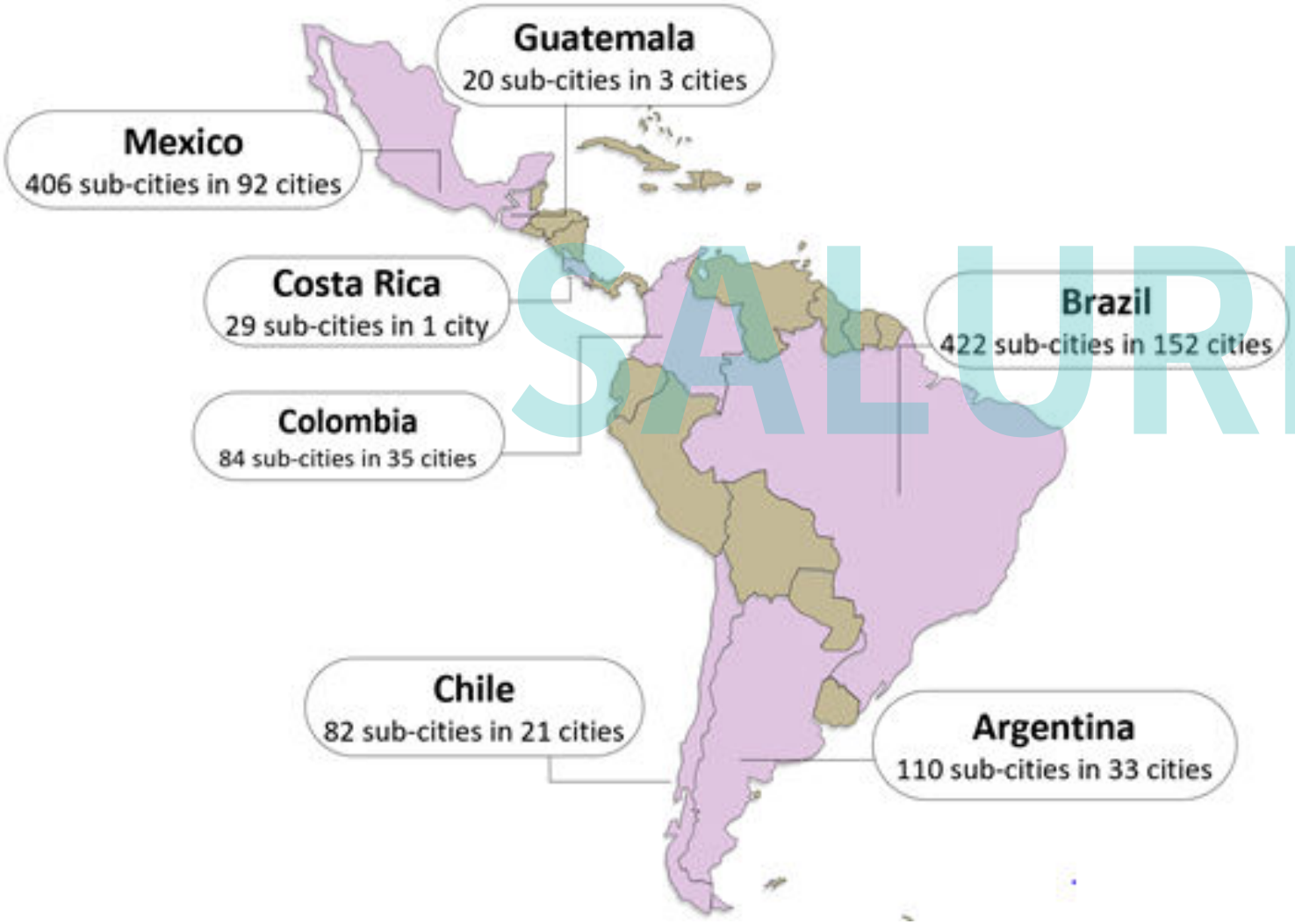
- Lots of time outside

Research questions

Are increases in ambient levels of PM2.5 over time linked with mortality among children under 5 years of age?

Is this association different for infants (<1 year) compared to young children (1-4 years)?

Setting



- Study period 2010- 2015
- 337 cities of 100K+ residents
- 1,152 sub-city administrative units

Main variables

Air pollution exposure

Average annual levels of PM2.5 per cubic meter of air for each sub-city unit & for the same year mortality rates were estimated

Outcomes

Under 5 mortality rate: deaths before the fifth year of life per1,000 live births
Infant mortality rate: deaths during the first year of life per 1,000 live births
Child mortality rate: deaths of children 1-4 years of age per 10,000 children

Other urban characteristics

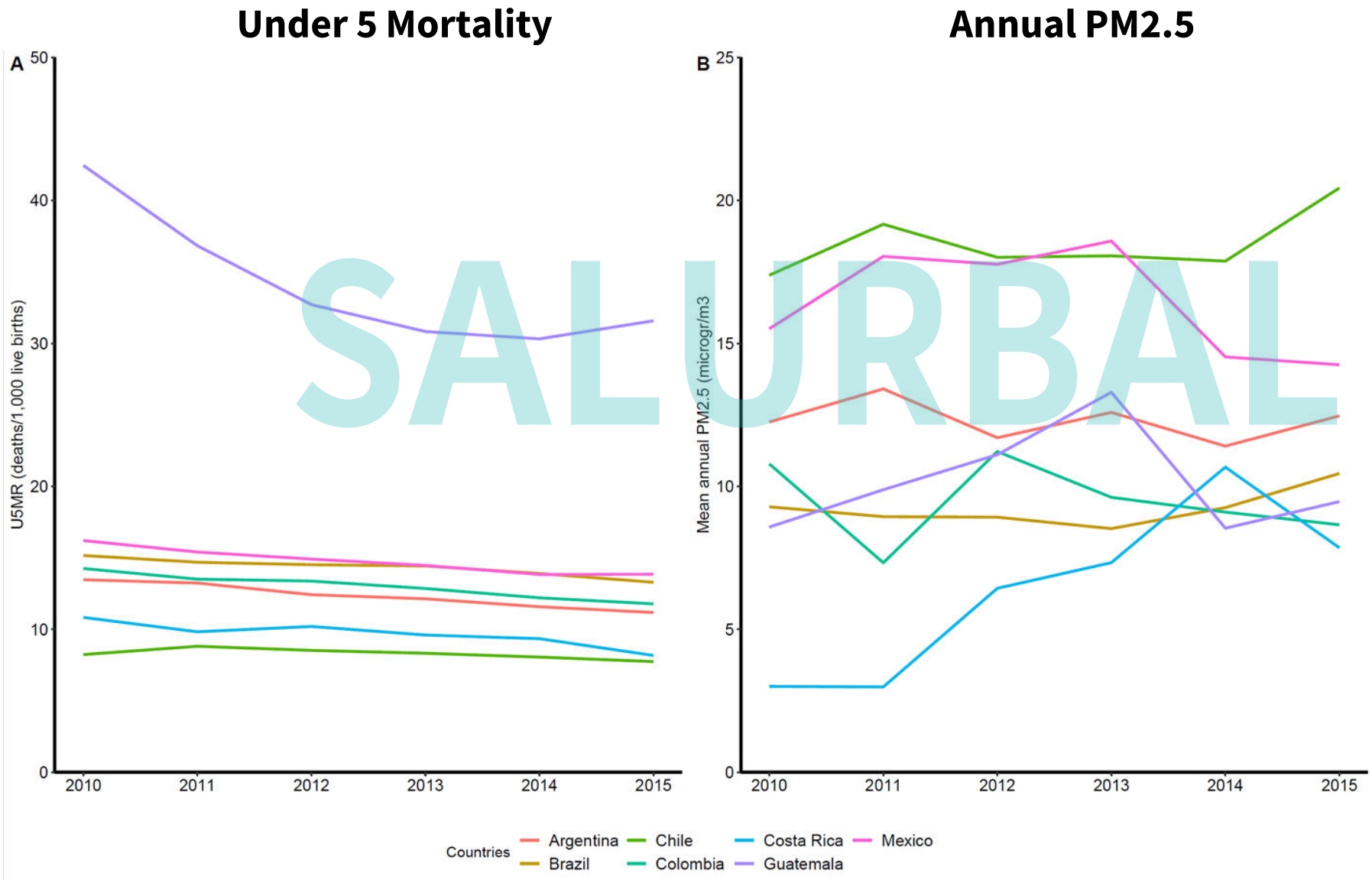
Sub-city	Population size and growth	City population size 2010-2015
Sub-city	Housing & living conditions score	% households with piped water in the house % of households with overcrowding conditions,3+/room % population 15-17 age attending school
Sub-city	Service provision score	% of households with water connected to municipal network % of households with sewage system connected to municipal network
Sub-city	Population education score	% population 25+≥ high school level % population 25+≥ university level
City	Mass transit availability	Presence of either subway or bus rapid transit (BRT) networks
City	GDP per capita	Yearly Gross Domestic Product per capita for each city

Methodological approach

Statistical analysis

- **linear multilevel hybrid models with random effects for city and sub-city**
- **log-transformed** mortality rates in sub-cities (added 1 death to all units)
- **weighted** observations in each sub-city unit and year by
  - square root of the number of live births (for U5MR and IMR) in each sub-city unit
  - Square root the population 1-4 years (for child mortality)

Mean sub-city under-five mortality and annual PM2.5 by country over the study period (2010-2015)



Mortality by PM2.5 levels in 1,152 sub-cities nested in 337 cities, 2010- 2015

	Total	6- year PM 2·5 annual average		
		< 7·6 µg/m³	≥7·6 and < 16·5 µg/m³	≥ 16·5 µg/m³
Total number of sub-city units	1,152	288	576	288
Number of sub-city units by country, n (row %)				
Argentina	110	16 (14·5 %)	80 (72·7%)	14 (12·7%)
Brazil	422	172 (40·8%)	233 (55·2%)	17 (4·0%)
Chile	81	4 (4·9%)	33 (40·7%)	44 (53·2%)
Colombia	84	30 (35·7%)	54 (64·3%)	-
Costa Rica	29	29 (100%)	-	-
Guatemala	20	-	20 (100%)	-
Mexico	406	37 (9·1%)	156 (38·4%)	213 (52·5%)
Mortality at sub-city level				
U5MR (per 1,000 births), mean (SD)	14·2 (6·8)	14·2 (6·2)	13·4 (6·6)	15·6 (7·8)
IMR (per 1,000 births), mean (SD)	12·1 (6·1)	12·2 (5·5)	11·4 (5·8)	13·4 (6·8)
CMR (per 10,000 children), mean (SD)	4·8 (4·5)	4·9 (4·1)	4·8 (4· 5)	5·1 (4·9)

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Adjusted % difference in mortality rates associated with time-varying and time-invariant predictors, 2010-2015

	Under 5 mortality	Infant mortality	Child mortality
Time-varying predictors	% difference (95%CI)	% difference (95%CI)	% difference (95%CI)
Sub-city level			
1 µg/m3 increase in annual PM2·5	**0.4 (0.1; 0.7)**	**0.5 (0.2; 0.9)**	-0.1 (-0.8; 0.6)
100,000 residents increase in population	**2.5 (0.3; 4.7)**	**1.9 (-0.4; 4.3)**	-1.6 (-6.0; 3.1)
Secular trend (per year)	**-3.1 (-3.7; -2.9)**	**-2.9 (-3.3; -2.4)**	**-3.2 (-4.0; -2.4)**
City- level			
US$ 1,000 increase in GDP per capita	**1.2 (0.1; 2.2)**	0.8 (-0.2; 1.9)	1.3 (-0.7; 3.3)
Time-invariant predictors			
Sub-city level			
1 µg/m3 higher mean PM2·5 over 2010-2015	0.1 (-0.3; 0.4)	0.3 (-0.1; 0.6)	-0.1 (-0.5; 0.3)
100,000 resident higher population size over 2010-2015	**0.6 (0.2; 1.1)**	**0.6 (0.2; 1.1)**	**0.2 (0.03; 0.5)**
1SD higher living condition score	**-4.0 (-4.9; -3.1)**	**-3.4 (-4.3; -2.4)**	**-5.8 (-6.8; -4.7)**
1SD higher services provision score	**-3.1 (-4.1; -2.1)**	**-3.3 (-4.4; -2.3)**	**-4.5 (-5.8; -3.2)**
1SD higher population education score	-1.6 (-3.3; 0.1)	-1.6 (-3.3; 0.2)	-0.8 (-2.8; 1.3)
City-level			
US$ 1,000 higher GDP per capita over 2010- 2015	**-0.4 (-0.6; -0.2)**	**-0.4; (-0.6; -0.2)**	**-0.6 (-0.9; -0.4)**
Availability of Mass transit	-2.2 (-5.7; 1.3)	-2.9 (-6.5; 0.8)	**-3.6 (-7.6; -0.6)**

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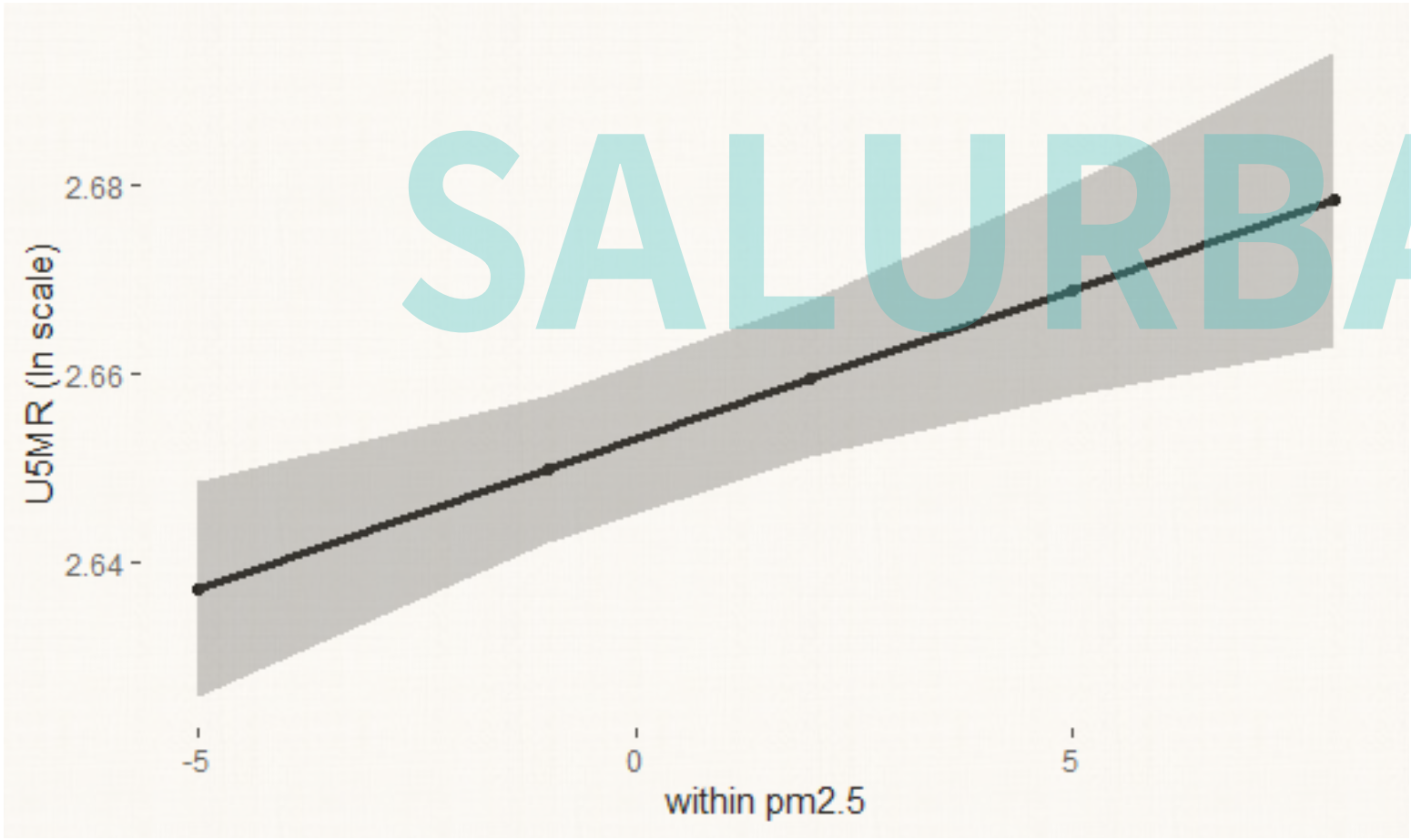
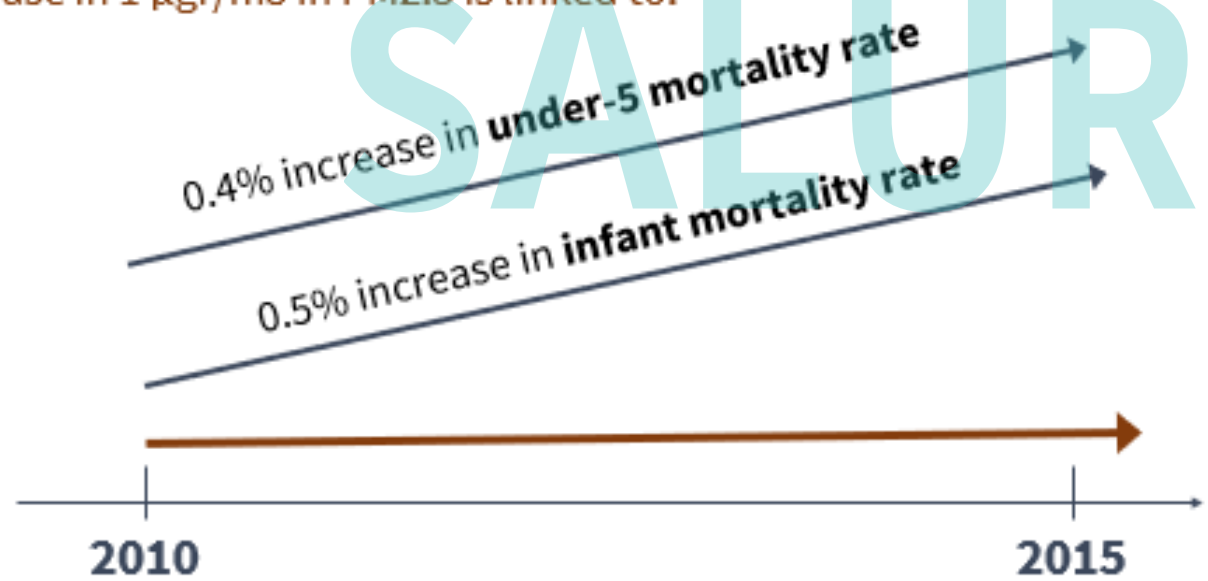
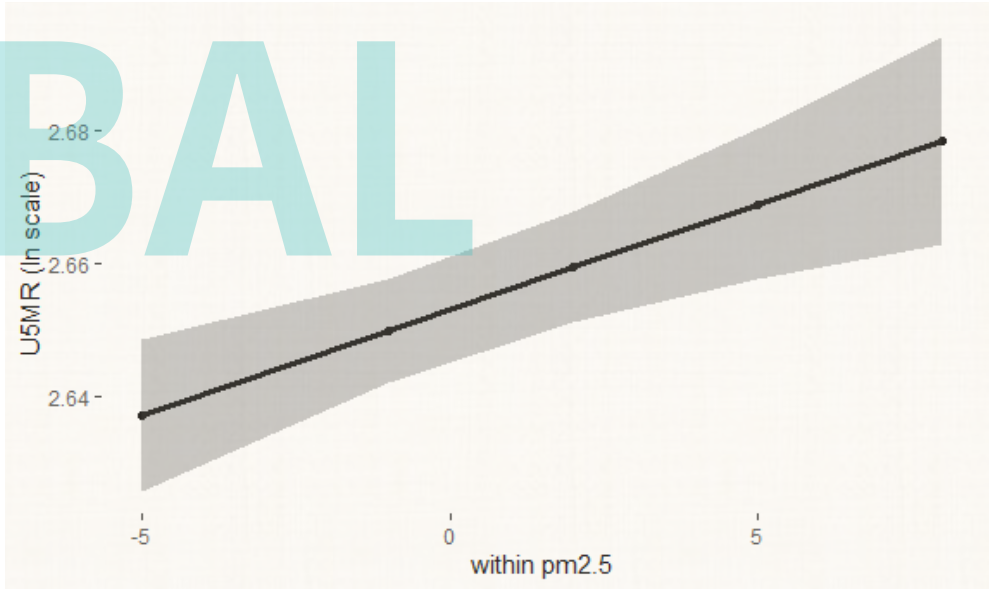
Association between U5MR and within- sub-city variability of PM2.5 over time

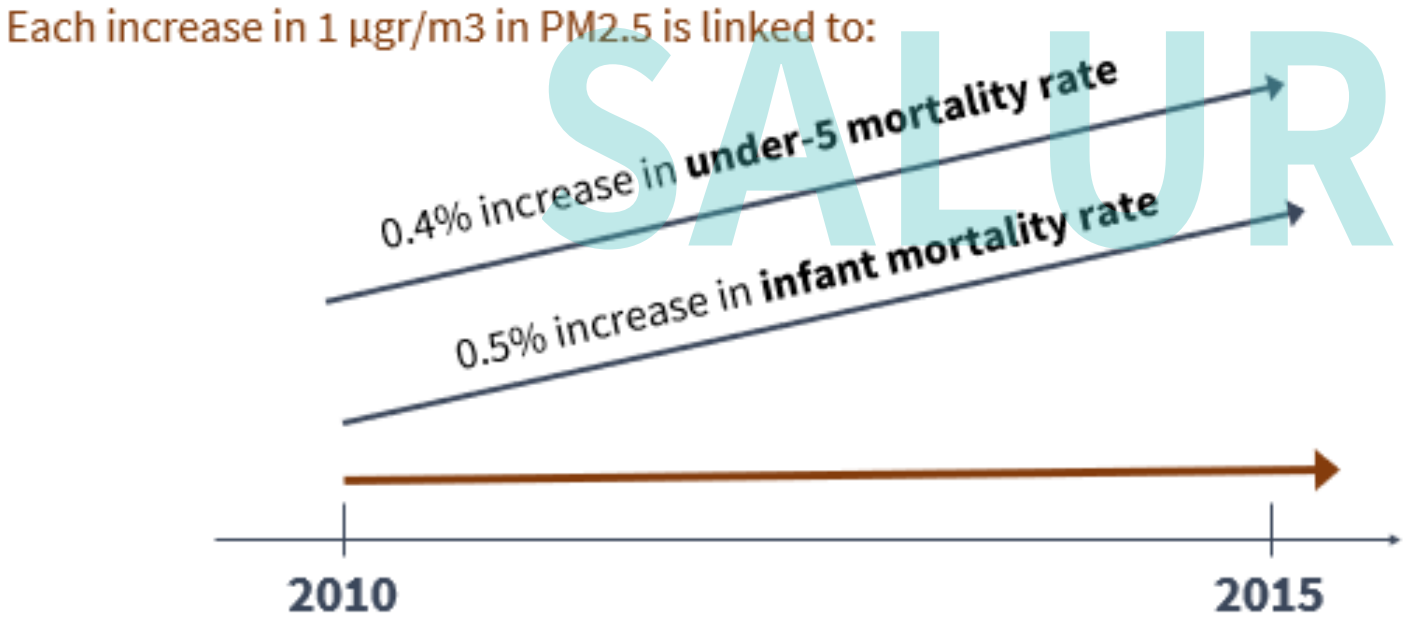


Each increase in 1 µgr/m3 in PM2.5 is linked to:





Difference between 90th & the 10th percentiles of PM2.5 observed in our sample (~ 17·4 micrograms/m3)



- Increase by 8·7 % in IMR
- 1 additional infant death per 1,000 live births.
- 4,300 additional infant deaths each year

  given the absolute number of live births observed in sub-cities over a year (~4,3 M live births)

Strengths

- Longitudinal approach strengthens causal inferences
- Fixed effects models allows to account for unobserved confounder that remain invariant over time
- Characterization of PM2.5 in sub-cities with a wide range of PM2·5 levels (2·2 to 30·0 µg/m3)

Limitations

- Individual PM2·5 exposures may be poorly represented by ambient estimates
- No levels of indoor air pollution, an established major adverse exposure for child health.
- No information on composition of ambient PM2.5
- Use of annual averages of PM2.5 and contemporaneous measures of deaths could imply misspecification of exposure.

Conclusions

Increases in air pollution (PM2.5) are associated with increased under-5 mortality

Infant population most vulnerable to effects of PM2.5 exposure

Urban interventions along with environmental protection and air quality policies are key to reduce preventable deaths among infants and children

The role of cities

London, 2021

Convergencia para la Accion, 2020

Glasgow Times, Aug 2019

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