SALUD URBANA EN AMÉRICA LATINA

Ambient fine particulate matter in Latin American cities:

Levels, population exposure, and associated urban factors

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Salud Urbana en América Latina

LAC-URBAN HEALTH
Urban Health Network for Latin America and the Caribbean

Motivation

- **80%** of the population resides in urban areas
- over **110 million** people exposed to unhealthy levels of air pollution (WHO, 2014)
- **58.000 deaths** per year could be attributable to air pollution (WHO, 2014)
- Only **117 cities** had ground level monitors
- annual mean of PM_{10} and $PM_{2.5}$ **higher** than WHO-AQG
- **< than 5%** of cities complying with guidelines

Objectives

- Examine current levels of $PM_{2.5}$ in LAC and how they compare to WHO-AQG
- Quantify population exposed to levels above WHO-AQG
- investigate urban factors as predictors of $PM_{2.5}$ levels

Methods

1) Population

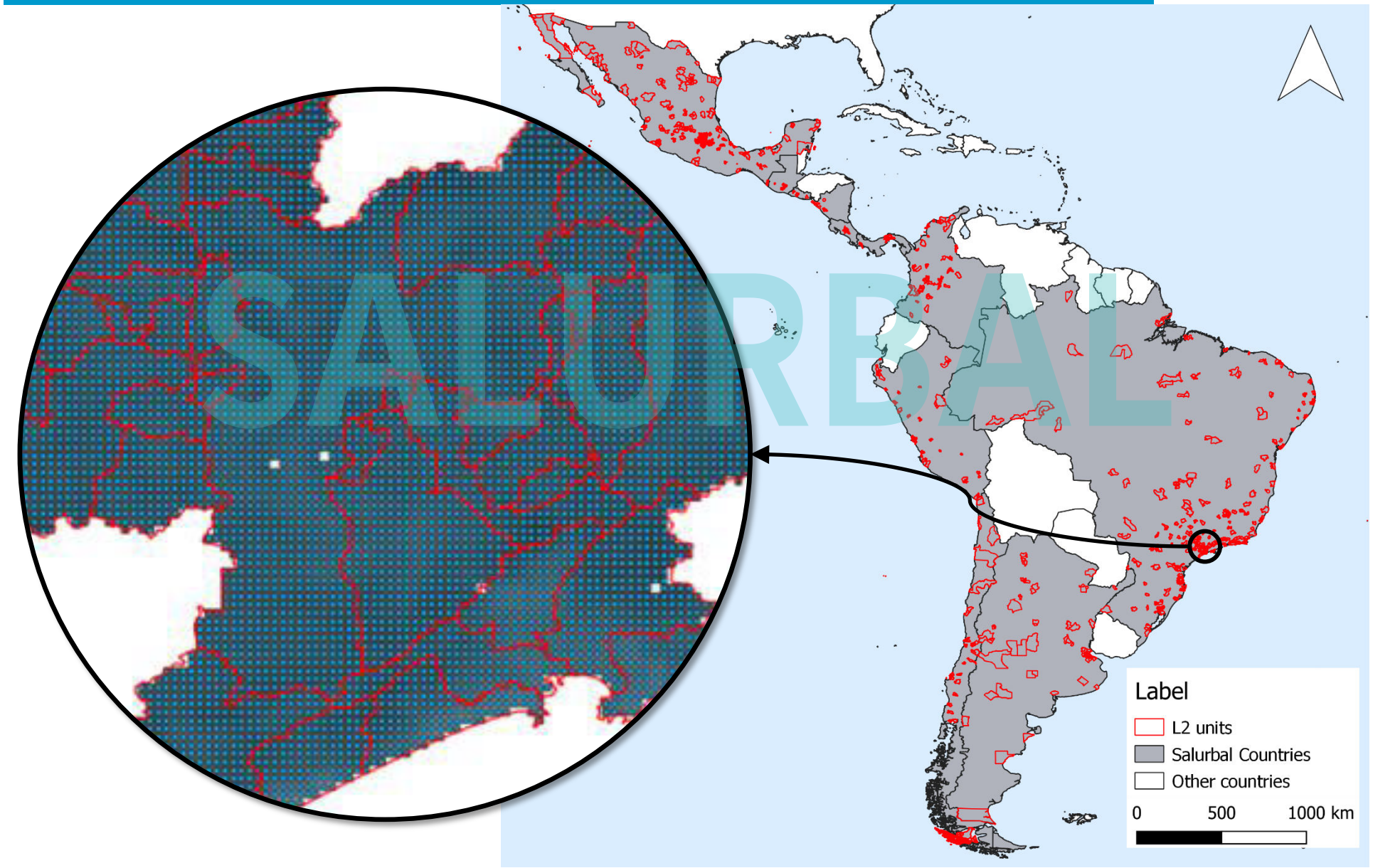
- 11 countries
- All cities ≥ 100,000 habitants
- "**cities**" defined administratively, quantitatively from satellite imagery, and based on country-defined metropolitan areas
- three-level tiered system to define **cities** (L1) and their smaller subunits (**sub-cities – L2**) using census hierarchies

Methods

2) Air pollution data ($PM_{2.5}$)

- Estimated from **satellite measurements** obtained from the Atmospheric Composition Analysis Group of the Dalhousie University
- Annual means for 2015
- Gridded format with each grid cell representing 0.01 degrees by 0.01 degrees (~ 1.1km by 1.1km)

Methods


Label
L2 units
Salurbal Countries
Other countries
0
500
1000 km

Methods

3) city and sub-city factors related to urban form and transportation:

- Population density in 2015 (pop/area of urban patches)
- Fragmentation (number urban of patches/total area)
- Gas price (adjusted for minimum wage)
- Mass Transit (BRT + metro + tram/area)
- Motorization rate
- Intersection density (node density of the set of nodes with more than one street emanating from them)
- Travel delay index
- Greenness (NDVI)

City (L1)

Sub-city (L2)

Methods

4) Other variables:

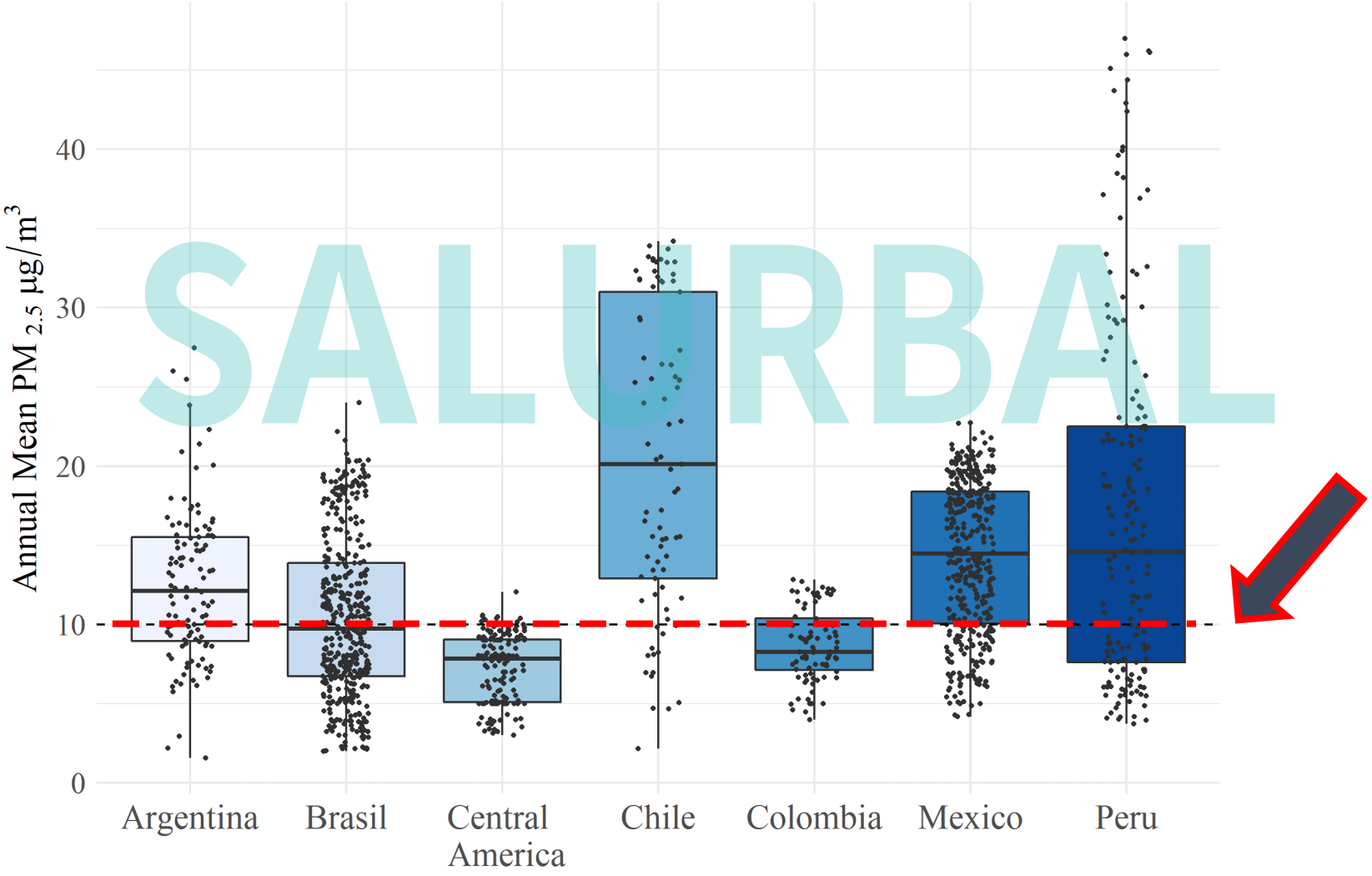
- Country GDP/capita
- population in 2015 by age
- pop growth (2010-2015)

5) Statistical approach:

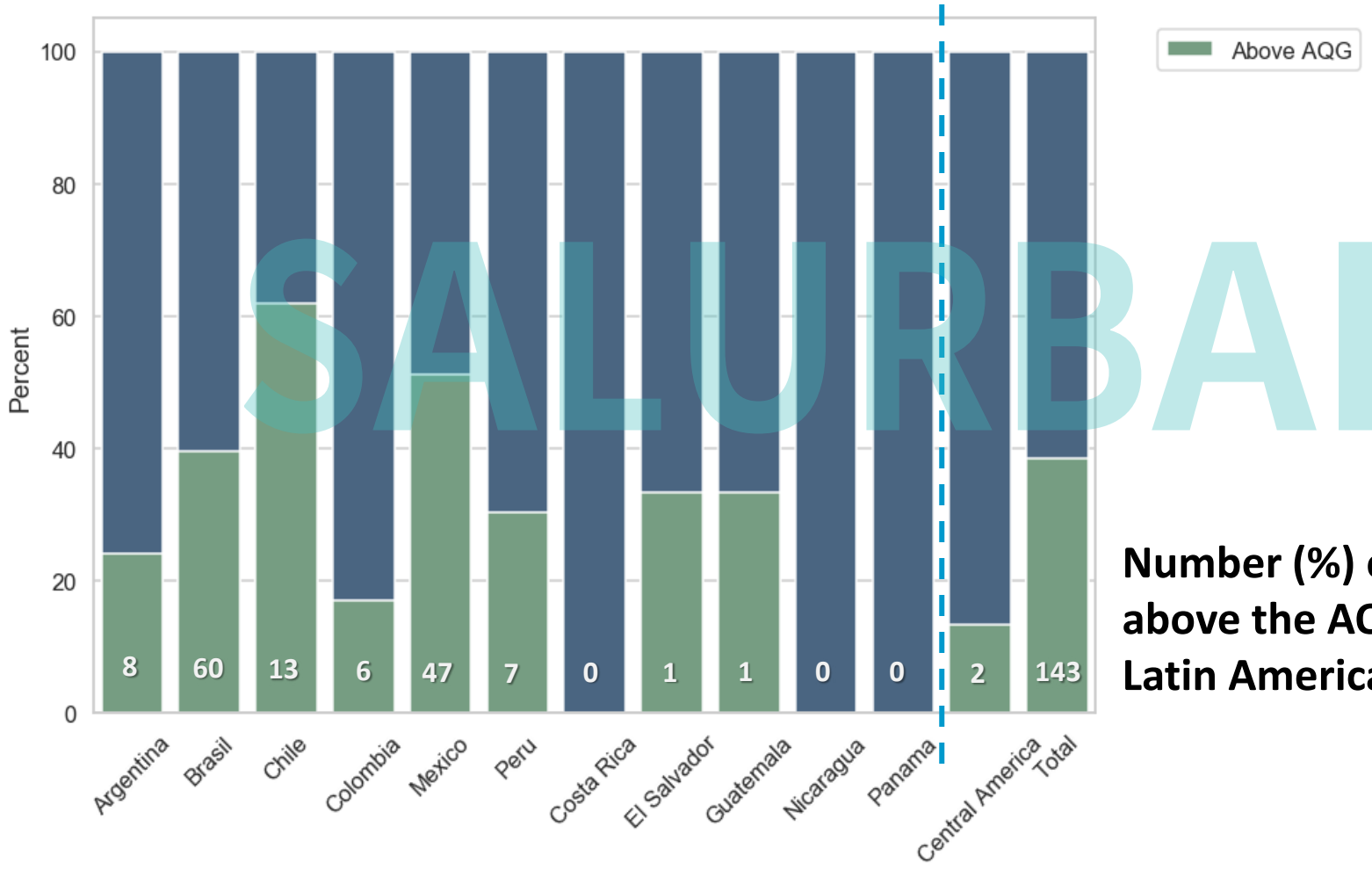
- Descriptive statistics
- Intraclass correlation coeficient
- Linear Mixed Models
  - Random intercept for country (2-level)
  - Random intercept for country and L1 (3-level)
- Test for multicollinearity

Results

Boxplots of $PM_{2.5}$ mean concentration in cities in Latin America countries



Results



Number (%) of cities (L1) above the AQG for $PM_{2.5}$ in Latin America, 2015

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Results

AIR POLLUTION EXPOSURE

Exposed to unhealthy levels of air pollution:

- 38.5% of cities
- 55% of sub-cities
- 171.1 million people total
- 12.3 million children ages under 5 years of age
- 14.1 million adults over age 65

Country	Proportion of urban population exposed to unhealthy levels of air pollution
Argentina	**71%** (21,227,417 people)
Brazil	**53%** (62,236,144 people)
Central America	**10%** (1,139,304 people)
Chile	**86%** (10,968,452 people)
Colombia	**38%** (10,965,939 people)
Mexico	**67%** (51,444,741 people)
Peru	**74%** (13,160,574 people)

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Table 2
Percentage of residents living in sub-cities with levels of $PM_{2.5}$ above the WHO Guideline annual mean concentration of 10 μgm^3, by age (in parenthesis population above WHO-AQG in each category).

Country	Age < 5	Age ≥ 65	All ages
Argentina	71% (1,812,862)	74% (2,366,978)	71% (21,227,417)
Brazil	50% (4,030,336)	60% (5,374,538)	53% (62,236,144)
Central America	10% (95,853)	10% (79,564)	10% (1,139,304)
Chile	85% (744,906)	86% (1,107,322)	86% (10,968,452)
Colombia	38% (875,061)	36% (793,365)	38% (10,965,939)
Mexico	65% (3,769,308)	70% (3,471,367)	67% (51,444,741)
Peru	72% (1,052,541)	79% (953,185)	74% (13,160,574)
Total	56% (12,380,868)	62% (14,146,319)	58% (171,142,571)

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Mean differences in annual mean $PM_{2.5}$ µg/m^3 concentrations at the sub-city level associated with a 1 SD higher value of city and sub-city -level characteristics

	Univariable	Full model	Full model with motorization rate***
	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
City factors			
GDP per capita	**1.00 (0.52, 1.47)**	**0.87 (0.43, 1.32)**	**0.65 (0.22, 1.09)**
Population	**2.57 (1.49, 3.65)**	0.01 (-1.54, 1.57)	-0.71 (-2.60, 1.18)
Population growth %, 2010 to 2015	-0.13 (-0.55, 0.30)	-0.29 (-0.66, 0.09)	-0.06 (-0.45, 0.32)
Mass transit infrastructure*	1.17 (-0.19, 2.53)	**-1.91 (-3.39, -0.42)**	**-1.87 (-3.40, -0.34)**
Gas cost	-0.17 (-1.68, 1.33)	-0.09 (-1.74, 1.56)	-1.75 (-4.36, 0.86)
Patch density**	0.47 (-0.31, 1.25)	0.64 (-0.18, 1.46)	0.67 (-0.21, 1.56)
Population density	**-0.71 (-1.41, -0.01)**	**-0.90 (-1.60, -0.20)**	-0.84 (-1.87, 0.18)
Travel delay index	**1.05 (0.13, 1.97)**	0.26 (-0.70, 1.22)	-0.62 (-2.09, 0.84)
Motorization rate	**1.55 (0.93, 2.18)**		**0.78 (0.12, 1.43)**
Sub-city factors			
Intersection density	**1.92 (1.70, 2.14)**	**1.91 (1.65, 2.17)**	**1.96 (1.67, 2.25)**
Greenness	**-1.39 (-1.72, -1.07)**	0.13 (-0.23, 0.49)	0.06 (-0.34, 0.46)

* binary presence or absence of MTI
** measure of urban fragmentation that is additionally adjusted for z-standardized % built-up area
*** based on subsample with 241 cities.
Note: figures in bold are statistically significant (p<0.05)

Results

SALURBAL: 371 cities → ~300 Million

- 38.5% (143) cities above WHO AQG (62% in Chile, 51% in Mexico and 13% in CA)
- 58% of residents (~172M) exposed to levels above AQG
- ~12 Million children 0-4 exposed to levels above AQG
- 85.5% of the population in Chile and 9% in Central America
- No difference by gender
- No striking difference by education (SES)
- % of **elderly** exposed to levels above AQG higher than the rest of the population, except for Colombia and Central America where young population more exposed

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Results

CITY CHARACTERISTICS AND AIR POLLUTION LEVELS

- Larger cities
- Higher per capita GDP
- Higher motorization rate
- Higher traffic congestion
- Higher street intersection density

higher pollution

- Higher population density
- More green space
- Presence of mass transit

lower pollution

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