Urban health and air quality in Brazil
Latin America

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Presenter Information

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**Motivation**

- Air pollution is a major public health concern
- Global inequalities in air quality monitoring capacity
- Approximately 60% of countries, comprising 1.3 billion people, lack ground-level PM\(_{2.5}\) monitoring capacity (Martin et al., 2019)
- Scarcity of air quality monitoring especially in LMICs
- **80%** of the population in LAC resides in urban areas
- Only **117 cities** had ground level monitors

**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
The SALURBAL Project

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 and their smaller subunits (sub-cities) using census hierarchies

2) Air pollution data (PM$_{2.5}$)
- Estimated from satellite measurements obtained from the Atmospheric Composition Analysis Group of the Washington University in St Louis
- Annual means for 2015
- Gridded format with each grid cell representing 0.01 degrees by 0.01 degrees (~ 1.1km by 1.1km)
Methods

3) Built environmental (urban form / transportation):

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

4) Socio-environmental variables:
   • Country GDP/capita
   • Population in 2015 by age and gender
   • Pop growth (2010-2015)

5) Statistical approach:
   • Linear Mixed Models
     • Random intercept for country (2-level)
     • Random intercept for country and city (3-level)

Results

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

<table>
<thead>
<tr>
<th>Country</th>
<th>Argentina</th>
<th>Brasil</th>
<th>Central America</th>
<th>Chile</th>
<th>Colombia</th>
<th>Mexico</th>
<th>Peru</th>
</tr>
</thead>
</table>
## 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

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

*considering above 10µg/m³

### Mean differences in annual mean PM$_{2.5}$ µg/m³ concentrations at the sub-city level associated with a 1 SD higher value of city and sub-city -level characteristics

<table>
<thead>
<tr>
<th>City factors</th>
<th>Univariable Estimate (95% CI)</th>
<th>Full model Estimate (95% CI)</th>
<th>Full model with motorization rate** Estimate (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP per capita</td>
<td>1.00 (0.52, 1.47)</td>
<td>0.87 (0.43, 1.32)</td>
<td>0.65 (0.22, 1.09)</td>
</tr>
<tr>
<td>Population</td>
<td>2.57 (1.49, 3.68)</td>
<td>0.01 (-1.54, 1.57)</td>
<td>-0.71 (-2.60, 1.18)</td>
</tr>
<tr>
<td>Population growth %, 2010 to 2015</td>
<td>-0.13 (-0.55, 0.30)</td>
<td>-0.29 (-0.66, 0.09)</td>
<td>-0.06 (-0.45, 0.32)</td>
</tr>
<tr>
<td>Mass transit infrastructure*</td>
<td>1.17 (-0.19, 2.53)</td>
<td>-1.91 (-3.39, -0.42)</td>
<td>-1.87 (-3.40, -0.34)</td>
</tr>
<tr>
<td>Gas cost</td>
<td>-0.17 (-1.68, 1.33)</td>
<td>-0.09 (-1.74, 1.56)</td>
<td>-1.75 (-4.36, 0.86)</td>
</tr>
<tr>
<td>Patch density**</td>
<td>0.47 (-0.31, 1.25)</td>
<td>0.64 (-0.18, 1.46)</td>
<td>0.67 (-0.21, 1.56)</td>
</tr>
<tr>
<td>Population density</td>
<td>-0.71 (-1.41, -0.01)</td>
<td>-0.99 (0.50, -0.20)</td>
<td>-0.84 (-1.87, 0.18)</td>
</tr>
<tr>
<td>Travel delay index</td>
<td>1.05 (0.13, 1.97)</td>
<td>0.26 (-0.70, 1.22)</td>
<td>-0.62 (-2.09, 0.84)</td>
</tr>
<tr>
<td>Motorization rate</td>
<td>1.59 (0.03, 2.18)</td>
<td>0.78 (0.12, 1.43)</td>
<td></td>
</tr>
<tr>
<td>Sub-city factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intersection density</td>
<td>1.92 (1.70, 2.14)</td>
<td>1.91 (1.65, 2.17)</td>
<td>1.96 (1.67, 2.25)</td>
</tr>
<tr>
<td>Groundness</td>
<td>-1.39 (-1.72, -1.07)</td>
<td>0.13 (-0.23, 0.49)</td>
<td>0.06 (-0.34, 0.46)</td>
</tr>
</tbody>
</table>

*binary presence or absence of MTT
**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)

Gouveia et al. Science of the Total Environment 772 (2021) 145035
(https://doi.org/10.1016/j.scitotenv.2021.145035)
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)

POLICY IMPLICATIONS: WHAT CAN CITIES DO?

Green spaces
- Urban gardens
- Tree lines
- Superblocks

Traffic congestion
- Unique lanes for public transport
- Bike lanes
- Pedestrian paths
- Street improvements

Mass Transit
- Network expansion
- Accessible & affordable public transportation
- Public safety

Better air quality monitoring

Environmental protection policies at national levels
Gracias

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