

Extreme-Heat and Air-Pollution Risks for Early Childhood Development in Latin America and the Caribbean

Angelo dos Santos¹, Oscar Morales¹, Jere Behrman¹, Florencia Lopez Boo², Emily Hannum¹, Fan Wang³

1. University of Pennsylvania; 2. New York University; 3. University of Houston



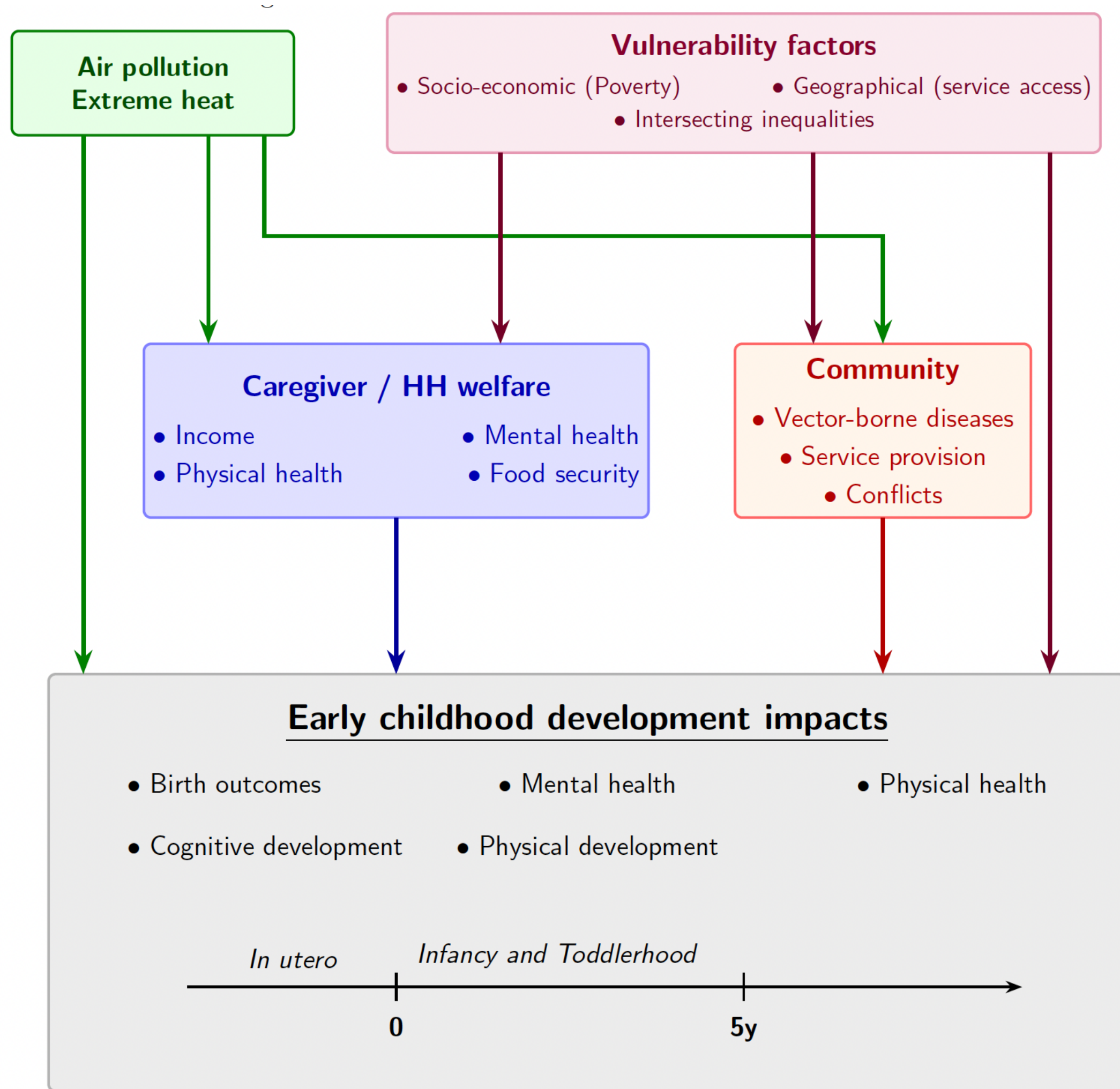
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Introduction

- LAC countries face rapidly rising exposures to extreme air pollution and heat, with direct consequences for child health and development (UNOCHA & UNDRR 2023).
- Children are especially vulnerable: physiologically more susceptible to pollutants and heat stress, and early-life exposures can cause lasting developmental consequences across the life span.
- A “complex environment of risk drivers” in LAC amplifies impacts: dense urban inequality, high poverty, political instability, and limited access to health and social services.
- These exposures are widespread and cumulative: UNICEF estimates > 99% of children globally face at least one climatic or environmental shock; the Caribbean ranks among regions with the highest cumulative risk.

This paper

- Uses a theoretical framework for how air pollution and extreme heat affect Early Childhood Development (ECD) dimensions from in utero to age 5, via direct and indirect (caregiver/community) pathways.
- Provides distributional analyses of environmental burdens for children in LAC from 2000 to 2020, combining child population data with gridded $PM_{2.5}$ and UTCI heat exposure data.
- Identifies hotspots where children face overlapping air pollution and heat vulnerabilities.
- Reviews literature on the effects of air pollution and extreme heat on ECD outcomes in children under five.



Data

- Child population:** WorldPop gridded estimates (~1 km resolution), children 0–5 years, for 2000, 2010, and 2020.
- Air pollution:** Donkelaar et al. (2016) satellite-derived $PM_{2.5}$ at 0.01°, aggregated to 1°×1° annual averages.
- Temperature:** ERA5-HEAT Universal Thermal Climate Index (UTCI) at 0.25° hourly resolution.
- Overlapping exposure:** Merged cell-level data to compute the number of children simultaneously exposed to poor air quality and extreme heat.

Pollution and Heat Measures

- Air pollution:** Child population-weighted mean $PM_{2.5}$; severity assessed against WHO Interim Targets: IT4 = 10 $\mu\text{g}/\text{m}^3$, IT3 = 15, IT2 = 25, IT1 = 35 $\mu\text{g}/\text{m}^3$.
- Extreme heat:** Share of the year above UTCI 32°C (lower bound of “strong heat stress”) converted to months of exposure per year (0–1, 1–2, 2–3, 3–4, 4–5, 5+ months).

Air Pollution and Extreme Heat Exposures

- Mean child $PM_{2.5}$ exposure increased from 13.05 to 15.96 $\mu\text{g}/\text{m}^3$ between 2000 and 2020.
- In 2020, **40.6 million children** (87%) were exposed to air quality above 10 $\mu\text{g}/\text{m}^3$ (IT4) , 7.9 million more than in 2000.
- The mean share of the year above 32°C rose **3 percentage points** from 2000 to 2020. The number of children exposed to ≥ 3 months above 32°C **nearly doubled**, reaching 7.53 million (16% of the child population) in 2020.

Figure 1. Population-weighted distribution of air pollution ($PM_{2.5}$) and extreme heat (share of year above 32°C) for children in LAC, 2000–2020.

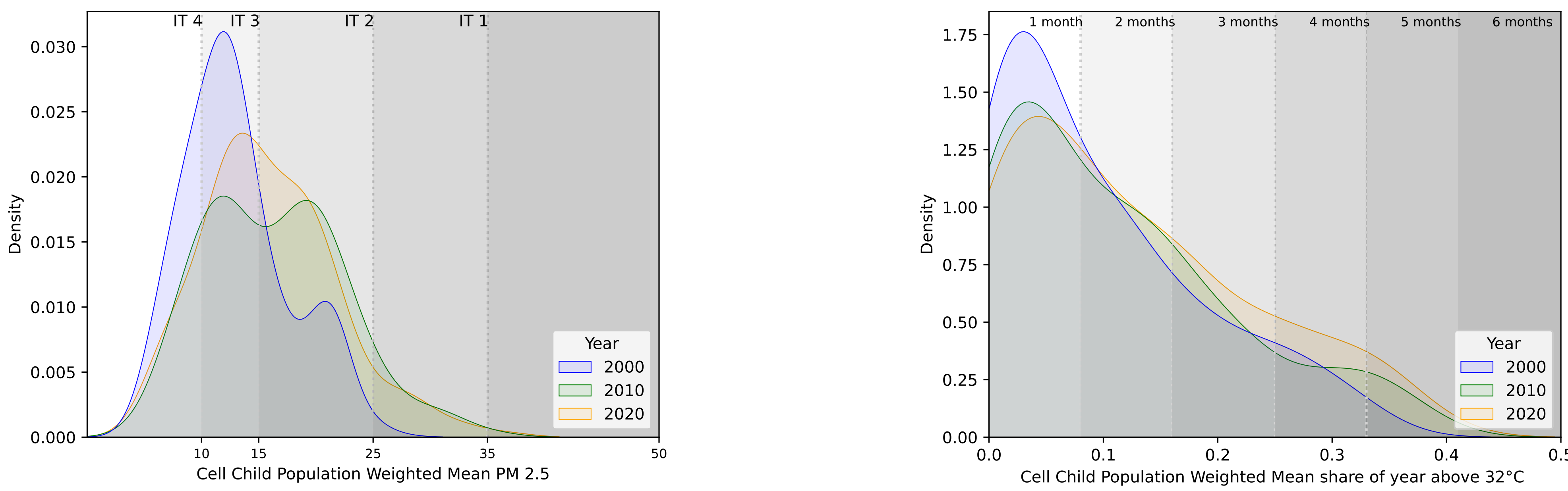
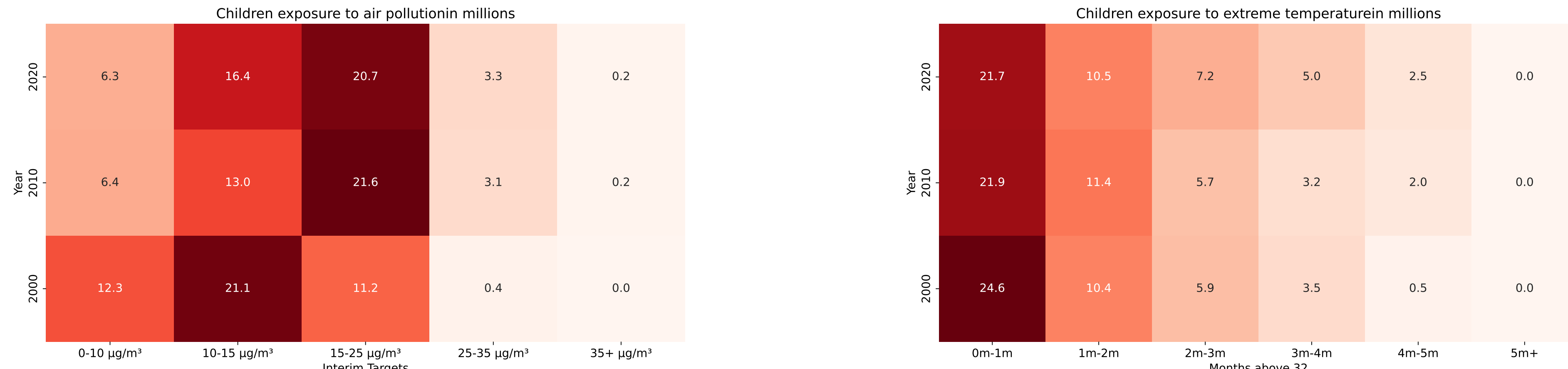
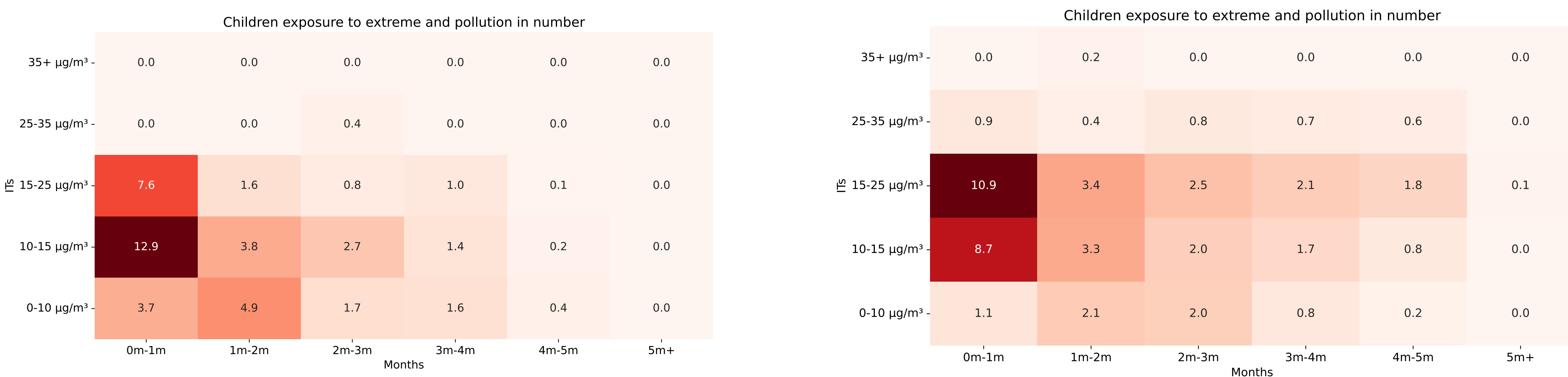


Figure 2. Children exposed to air pollution and extreme heat by severity threshold in LAC, 2000 and 2020 (millions).



Overlapping Exposure

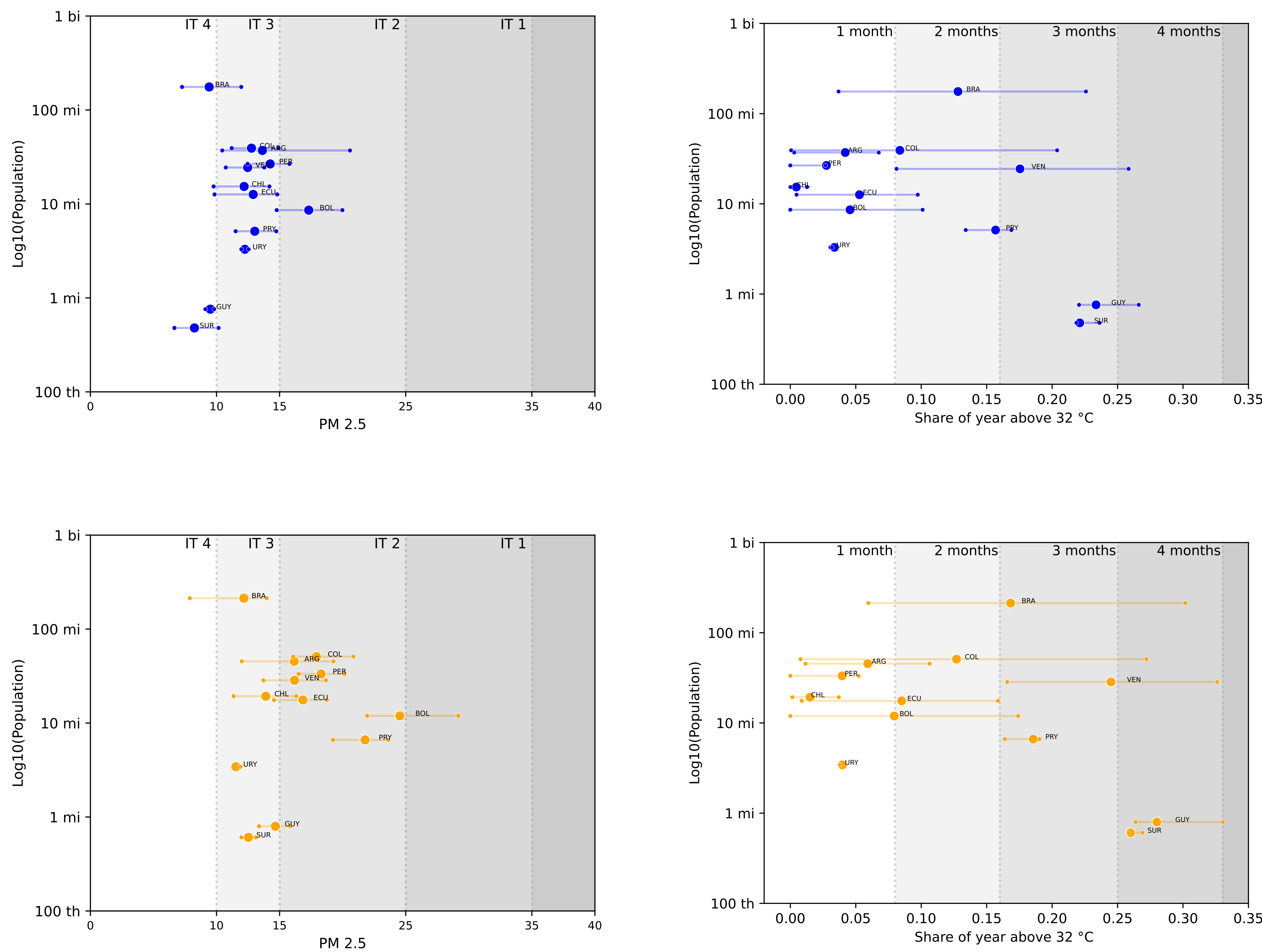
Figure 3. Children exposed to both air pollution and extreme heat simultaneously, by threshold combination, LAC 2000 and 2020 (millions).



- In 2020, **5.99 million children** (12.8% of the child population) were exposed to both $PM_{2.5}$ above IT3 (15 $\mu\text{g}/\text{m}^3$) and ≥ 3 months above 32°C, an increase of **4.85 million** since 2000.
- In 2000, **no children** faced the combination of $PM_{2.5}$ above IT2 (25 $\mu\text{g}/\text{m}^3$) and >3 months above 32°C. This double burden emerged by 2010 and grew considerably by 2020.

Subregional Dynamics

Figure 4. Population-weighted distribution of $PM_{2.5}$ and share of year above 32°C in South America, 2000 and 2020.



- Caribbean:**
 - Hottest subregion (18% of year above 32°C in 2020, +4 pp since 2000).
 - The share of **children above 15 $\mu\text{g}/\text{m}^3$** rose from 2% to 38% between 2000 and 2020.
- Central America:**
 - Most polluted subregion (18.10 $\mu\text{g}/\text{m}^3$ mean $PM_{2.5}$ in 2020)
 - The **only subregion with children exposed above IT1 (35 $\mu\text{g}/\text{m}^3$)** in 2020.
 - By 2020, 170,000 children faced ≥ 4 months above 32°C.
- South America:**
 - largest absolute increase in overlapping exposure 3.95 million additional children** facing both IT3 pollution and ≥ 4 months above 32°C compared to 2000.
 - Brazil (+830K)** and **Colombia (+270K)** are the largest contributors.

Conclusions

- Exposure to air pollution and extreme heat among LAC children rose substantially from 2000 to 2020.
- Overlapping exposures are concentrated in South and Central America and have grown sharply.
- Literature links these exposures to worse birth outcomes, impaired cognitive development, stunting, and increased mortality risk in children under five, with effects amplified by poverty and limited service access.
- Need for policy responses to protect LAC children that consider the considerable heterogeneity in environmental exposures.