ADVANCED POWER & ENERGY PROGRAM
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Improvements in U.S. Air Quality have not Addressed Pollution Inequalities - Especially among Minority and Elderly Populations

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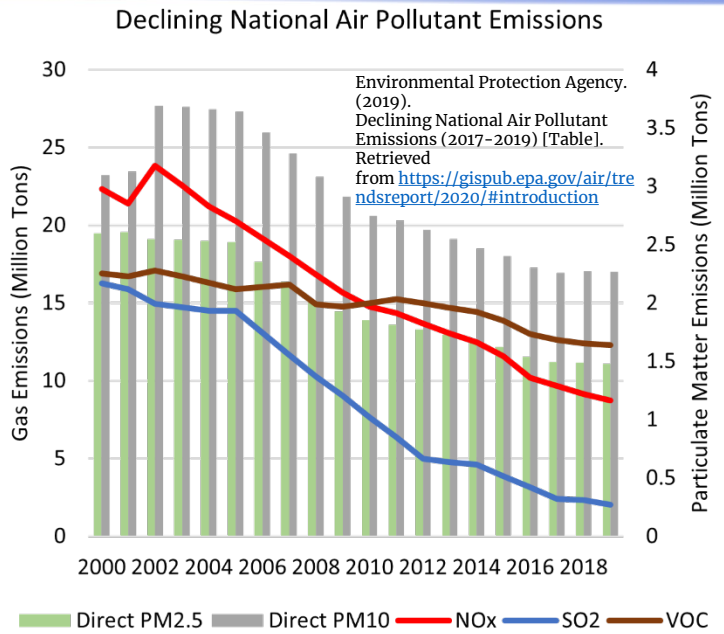
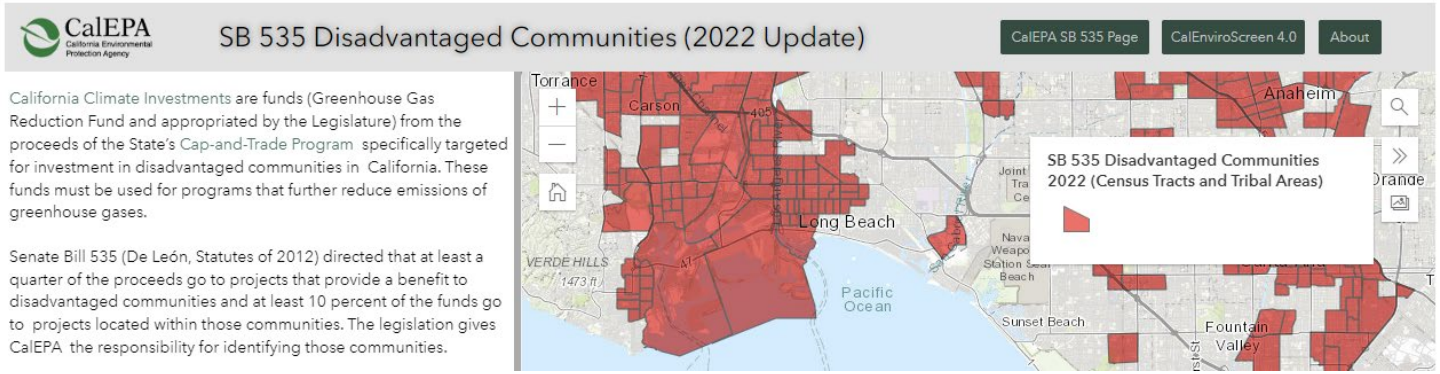
Introduction

- Significant air quality improvements in last two decades attributed to reductions in criteria air pollutant emissions resulting from air quality regulations.
- Remarkable achievement given the growth in population, energy demands, and economy.
- However, past regulations have not addressed the inequality of air pollution burdens among racial and socio-economic groups.





Smog fills the air new the ports of Long Beach and Los Angeles. Photo by Thomas R. Cordova.

REPORTS

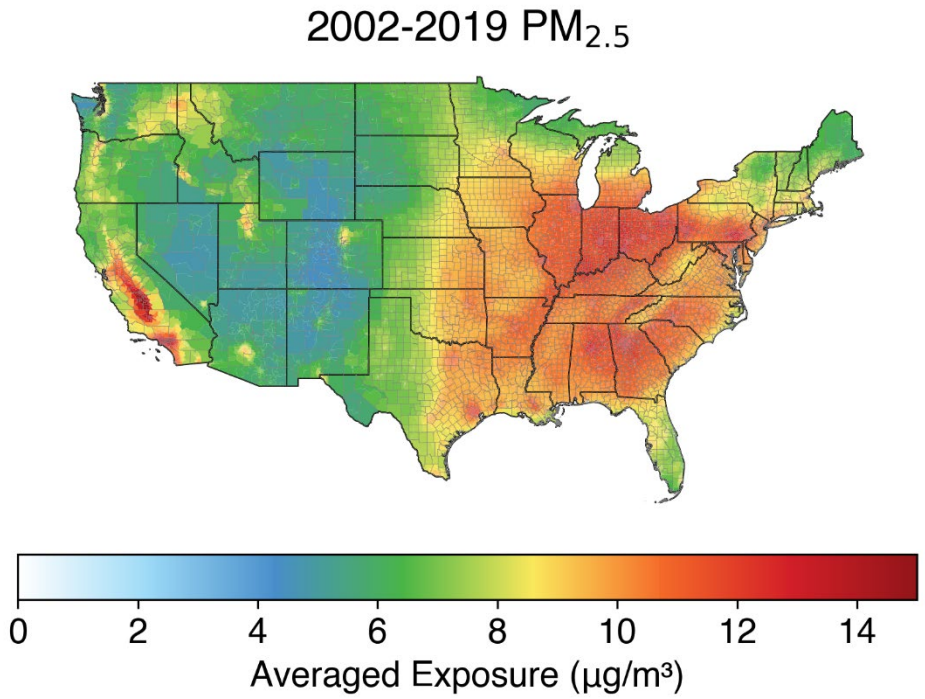
OCT 22 2019 12:26 PM

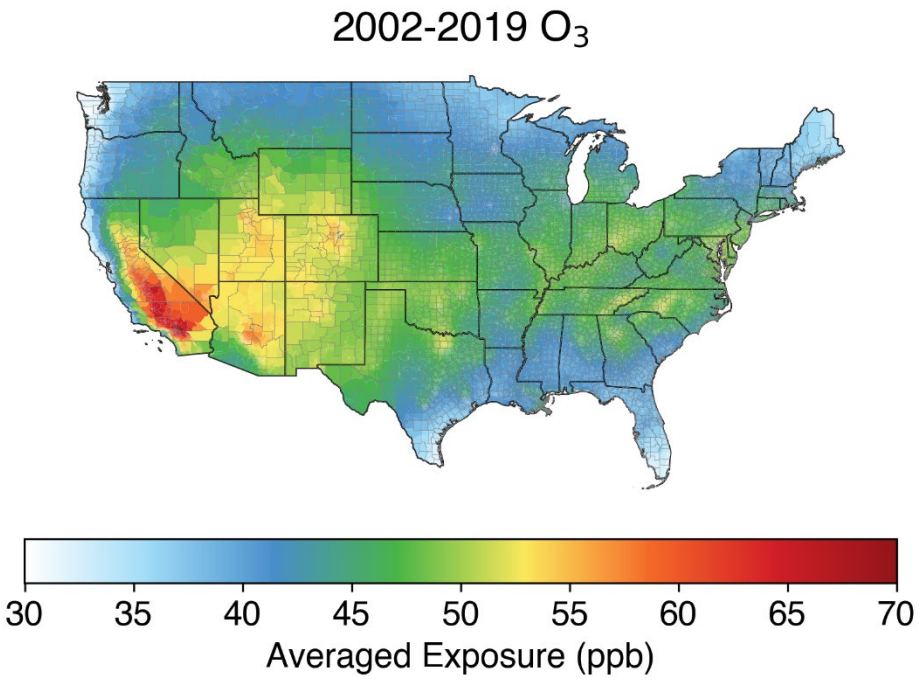
Report: Long Beach, L.A. worst in nation for air quality

Disclaimer: The views expressed in this presentation are those of the authors and do not necessarily reflect the views or policies of the Georgia EPD.

Data: Air Quality

- Census tract level daily O_3 and $PM_{2.5}$ concentration between 2002 and 2019 obtained from EPA's Remote Sensing Information Gateway (RSIG): Fused Air Quality Surface Using Downscaling (FAQSD) Files
  - A Bayesian space-time down-scaler model is used to "fuse" daily ozone (8-hr max) and fine particulate air (24-hr average) monitoring data from the National Air Monitoring Stations/State and Local Air Monitoring Stations (NAMS/SLAMS) with 12 km gridded output from the Models-3/Community Multiscale Air Quality (CMAQ) model.

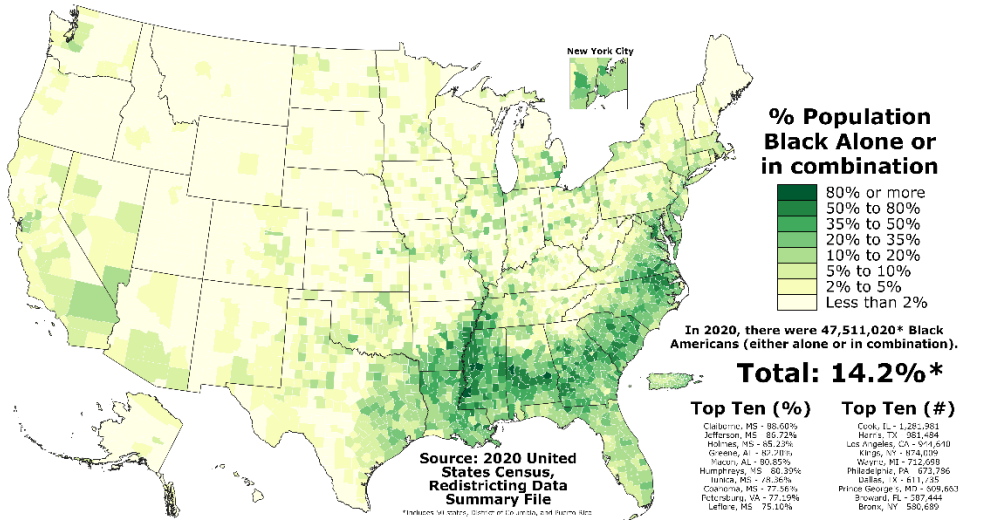


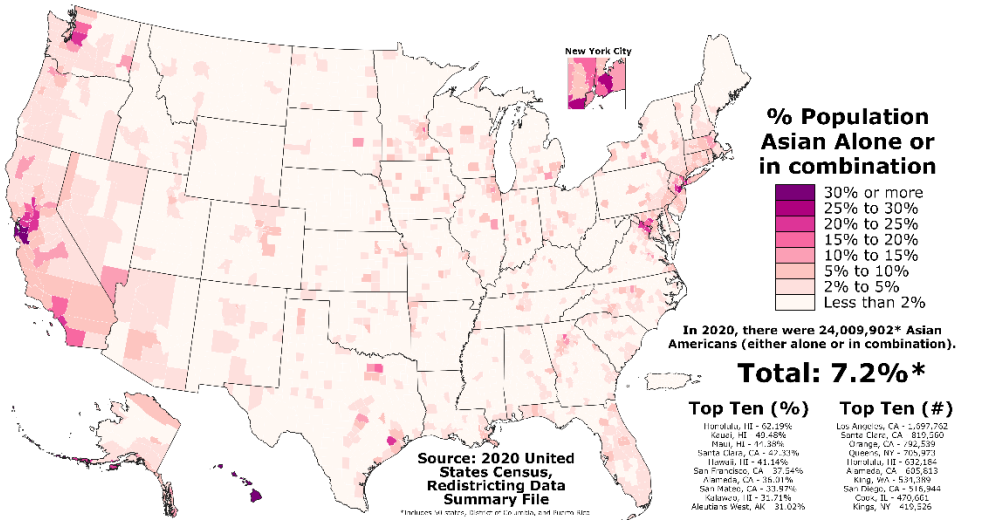


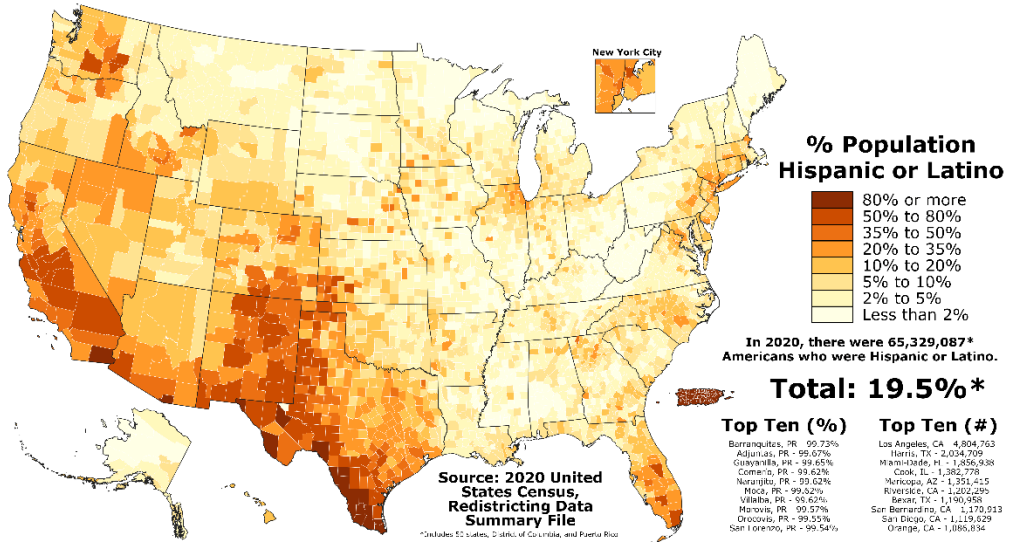
Data: Demographic

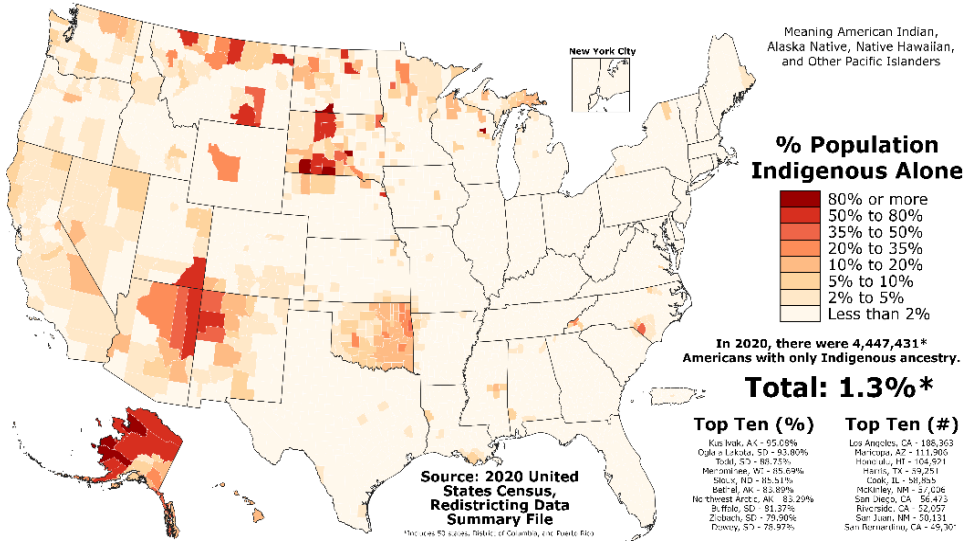
Age, race and ethnicity specific population data is generated for each year with EPA's PopGrid program based on 2010 US Census block data.

Age groups:
Every 5 years for: age 0-84
One group for: age 85+



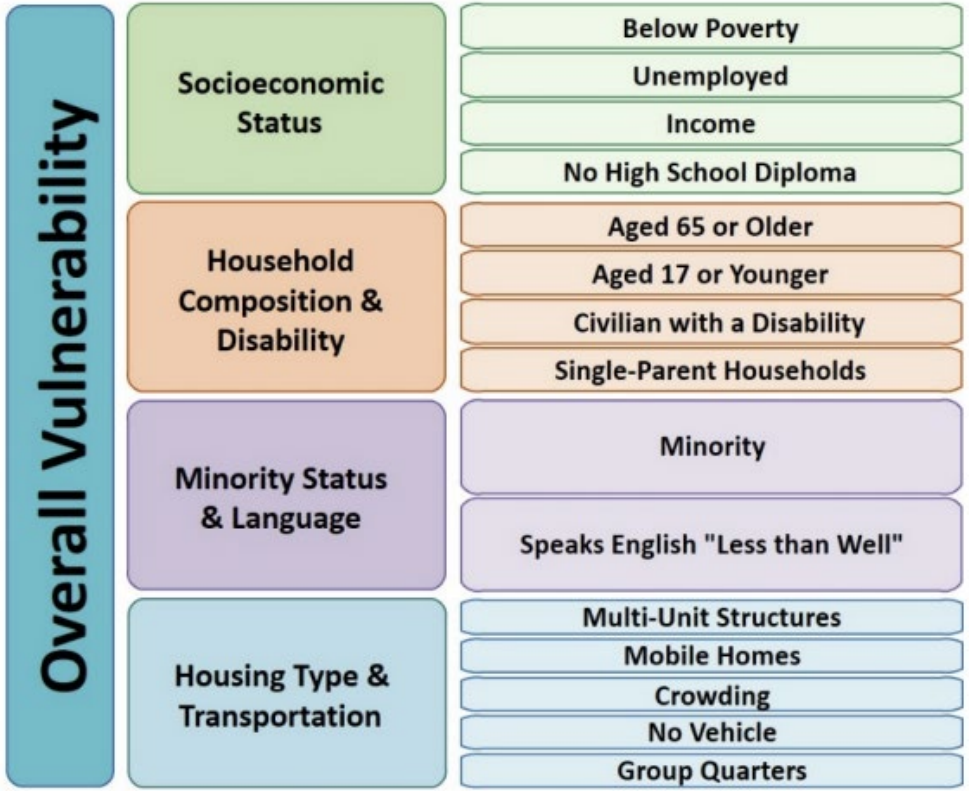


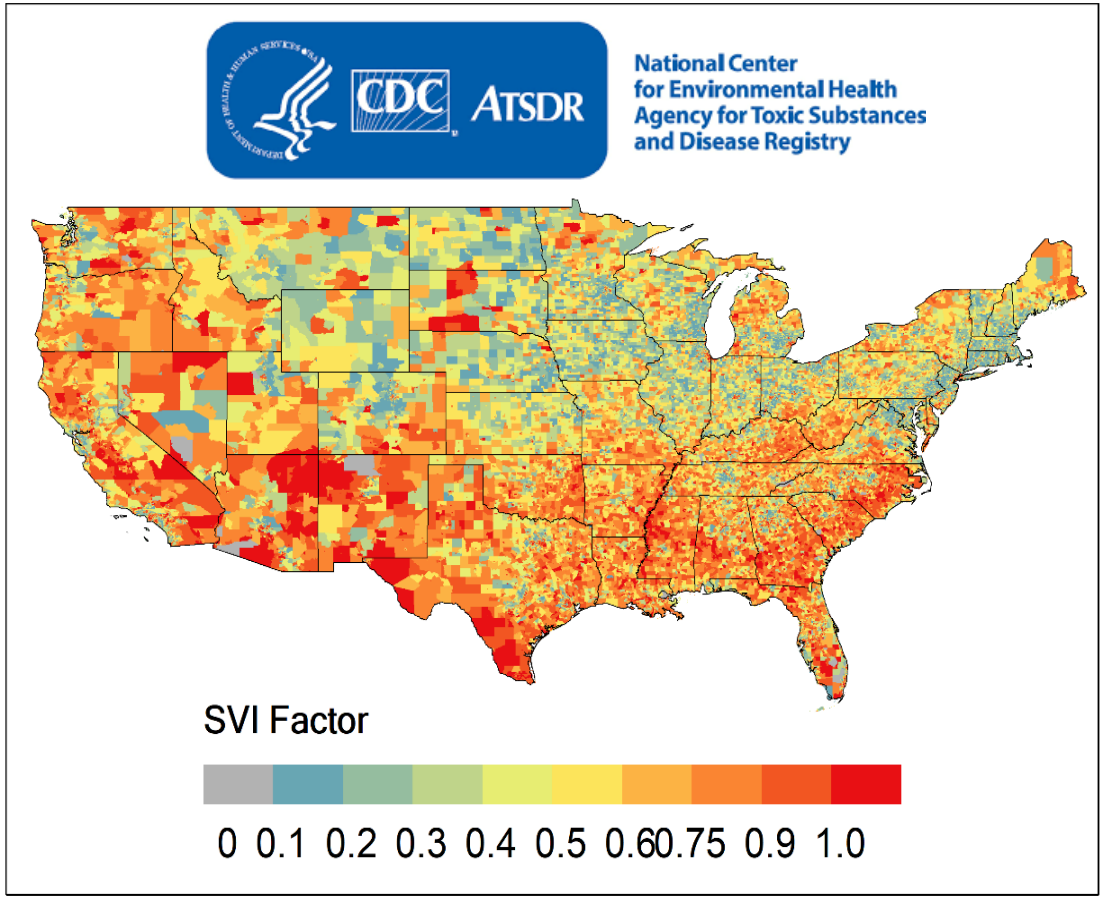




Data: Social Vulnerability

- CDC/ATSDR Social Vulnerability Index (SVI) were used to rank the risk level of communities, the top 10% communities are considered as “high vulnerability” (HV) communities.





Method: Exposure and Mortality

- Environmental Benefits Mapping and Analysis Program - Community Edition (BenMAP-CE) from EPA is used for health impact analysis. Two sets of EPA's core health impact functions (long-term effects) are applied for two age groups:
  - Age group 30-99: Universal ($PM_{2.5}$: Mortality, All Cause) functions and universal (O3: Mortality: Respiratory) from Turner et al. 2018
  - Age group 65-99: Racial and ethnicity specific ($PM_{2.5}$: Mortality, All Cause) functions and universal (O3: Mortality: All Cause) from Di et al. 2017

Table E-1. Core Health Impact Functions for Particulate Matter and Long-Term Mortality

Effect	Author	Year	Location	Age	Co-Poll	Metric	Beta	Std Err	Form	Notes
Mortality, All Cause	Turner et al.	2016	Nationwide	30-99	O_3	Annual	0.005827	0.000963	Log-linear	

Table E-8. Core Health Impact Functions for Particulate Matter Sensitivity Analyses of At-Risk Populations

Effect	Author	Year	Location	Age	Co-Poll	Metric	Beta	Std Err	Form	Notes
Mortality, All Cause	Di et al.	2017	Nationwide	65-99	O_3	Annual	0.0061	0.0001	Log-linear	Non-Hispanic White
Mortality, All Cause	Di et al.	2017	Nationwide	65-99	O_3	Annual	0.0110	0.0008	Log-linear	Hispanic White
Mortality, All Cause	Di et al.	2017	Nationwide	65-99	O_3	Annual	0.0189	0.0004	Log-linear	Black
Mortality, All Cause	Di et al.	2017	Nationwide	65-99	O_3	Annual	0.0092	(0.0010)	Log-linear	Asian
Mortality, All Cause	Di et al.	2017	Nationwide	65-99	O_3	Annual	0.0095	0.0019	Log-linear	Native American

Table F-1. Core Health Impact Functions for Ozone and Mortality*

Effect	Author	Year	Location	Age	Co-Poll	Metric	Beta	Std Err	Form	Notes
Long-term Mortality, Respiratory	Turner et al.	2016	Nationwide	30-99	$PM_{2.5}$, NO_2	Annual (D8HourMax)	0.007696	0.001176	Log-linear	Warm season.

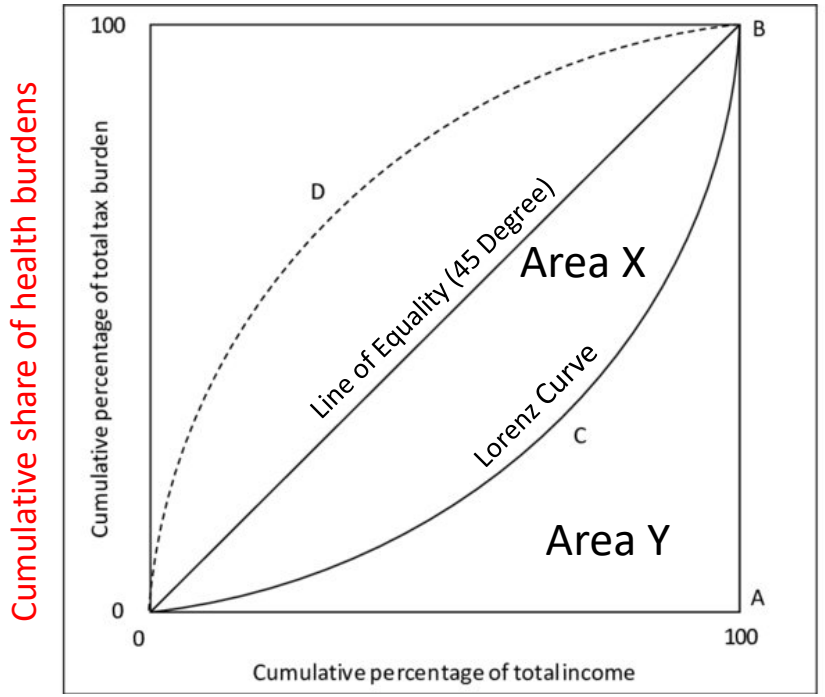
Table F-6. Core Health Impact Functions for Ozone Sensitivity Analyses

Effect	Author	Year	Location	Age	Co-Poll	Metric	Beta	Std Err	Form	Notes
Mortality, All Cause	Di et al.	2017	Nationwide	65-99	$PM_{2.5}$	Annual (D8HourMax)	0.001094	0.000050	Log-linear	All Cause, warm season

Exposure

Method: Environmental Justice Index

- A matrix is needed to evaluate the overall distribution of air pollution-associated health burdens across different racial and socioeconomic groups.
- A Lorenz Curve based method (the Suits Index) is adopted to calculate the "Environmental Justice Index" (EJI):
  - $\mathrm{EJI} = \frac{Area\ X}{Area\ X + Area\ Y}$
  - Evaluates the overall distribution of health burdens across the entire spectrum of communities.
  - Normalized index for different spatial or time period assessment regardless of the absolute total health burdens
  - A positive EJI (e.g., line C) indicates more health burdens attributed to more vulnerable communities.
  - A negative EJI (e.g., line D) indicates more health burdens attributed to less vulnerable communities.
  - A larger EJI indicates a poorer environmental justice level.
- The liner regression method is applied for the overall annually variation trend/slope of different variables.



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Article

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Decarbonization will lead to more equitable air quality in California

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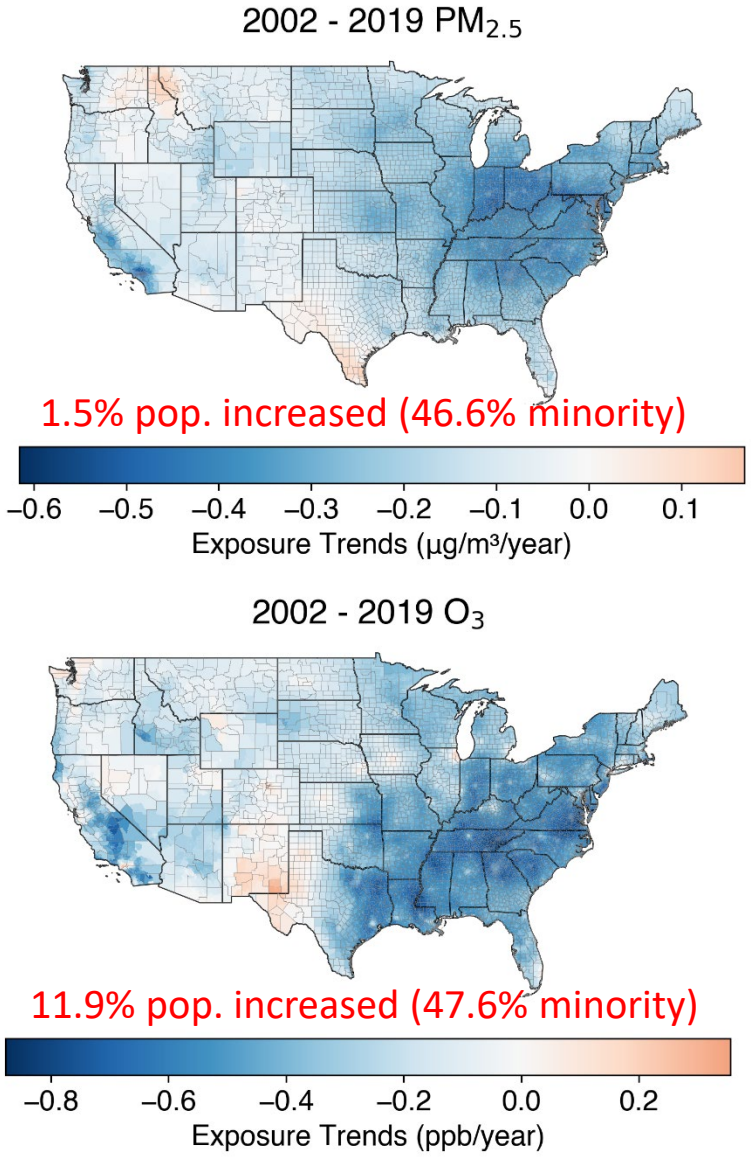
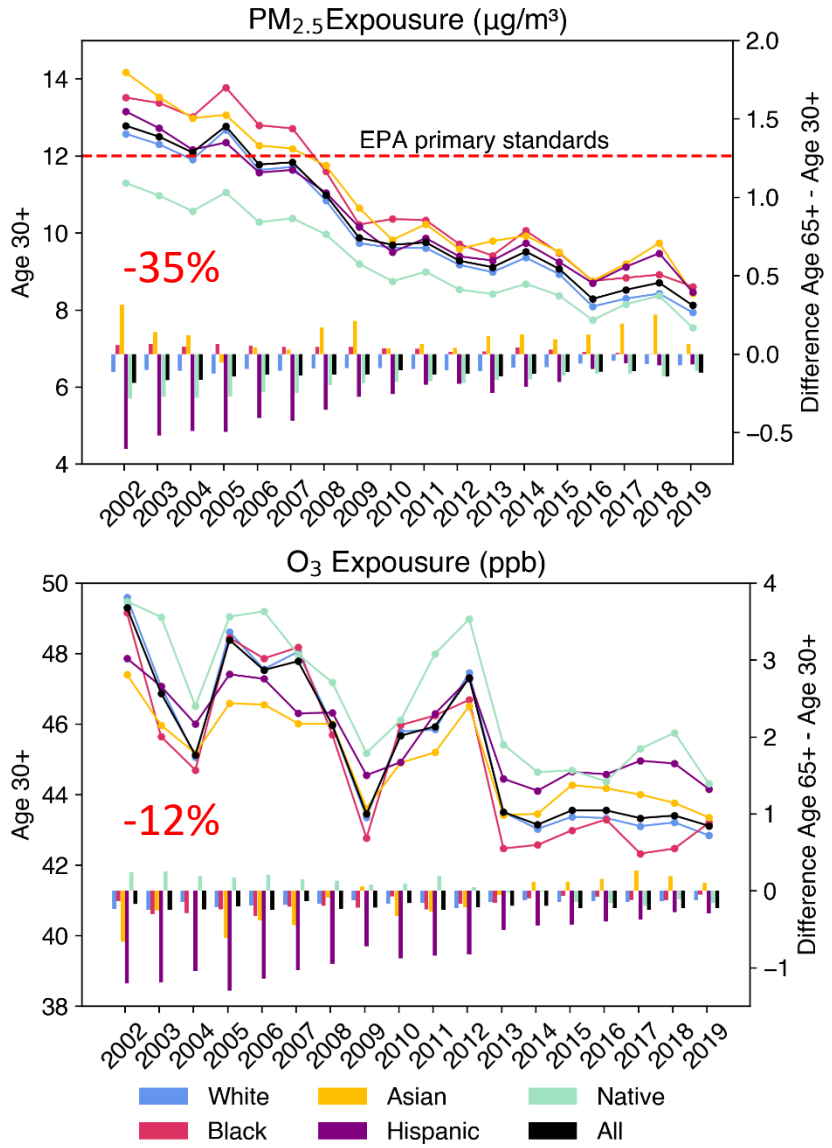
Suits, D. B. Measurement of Tax Progressivity. *Am. Econ. Rev.* **67**, 747–752 (1977).

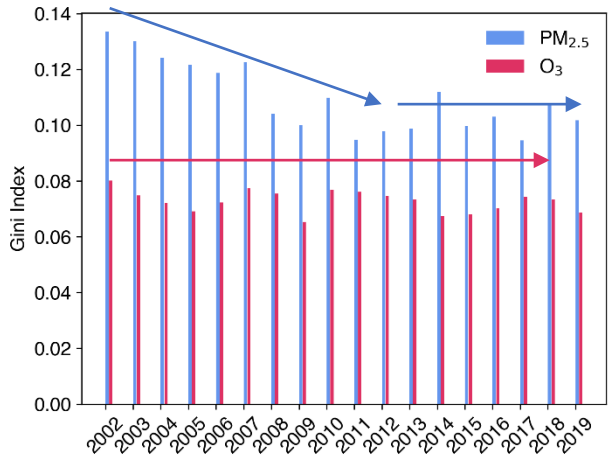
- Suits Index: A measurement of tax policy progressiveness

Results: Trends in air pollutants exposure





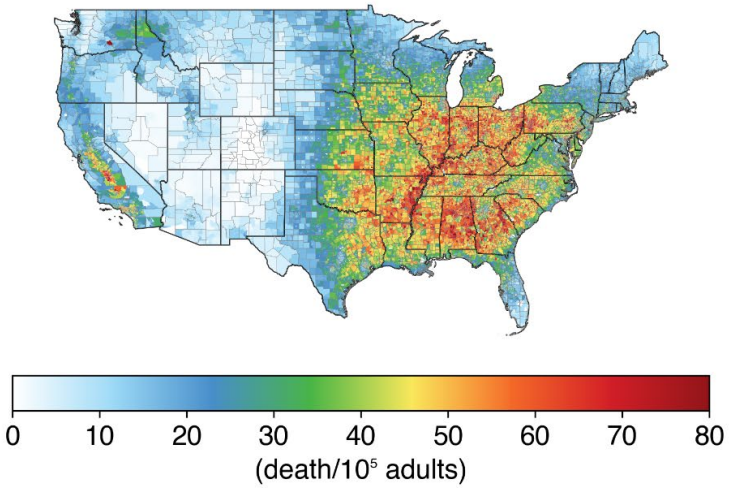
Elderly groups typically have lower exposure:
1.3% less for $PM_{2.5}$;
0.5% less for O_3.
Largest $PM_{2.5}$ exposure decrease: Black.
Largest O_3 exposure decrease: White.
Exposure disparities decreased before 2010 for $PM_{2.5}$.



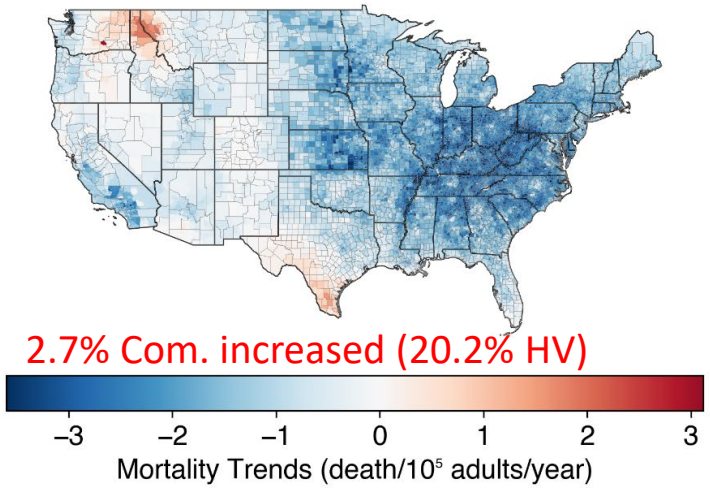
RESULTS ARE PRELIMINARY

$PM_{2.5}$ Mortality Trends

2002-2019 $PM_{2.5}$ Age 30+

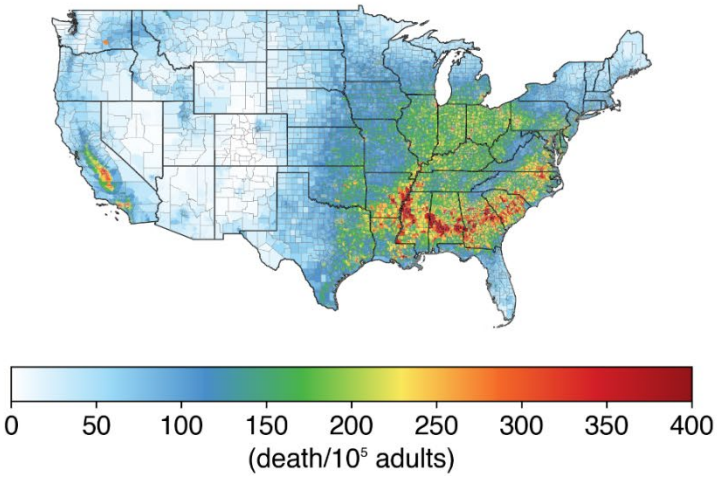


2002 - 2019 $PM_{2.5}$ Age 30+

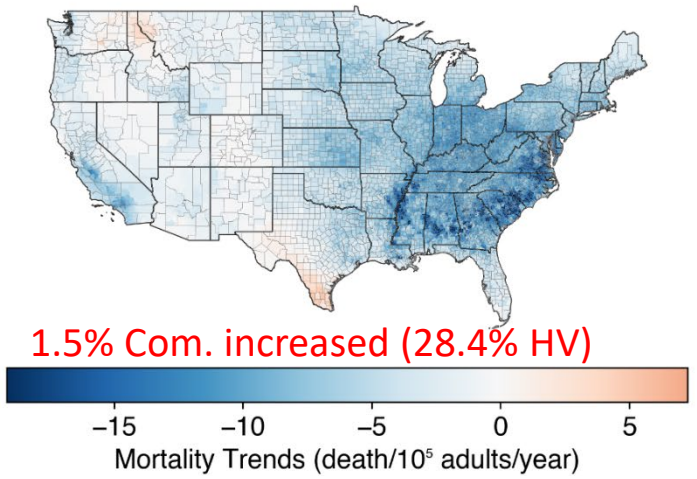


2.7% Com. increased (20.2% HV)

2002-2019 $PM_{2.5}$ Age 65+

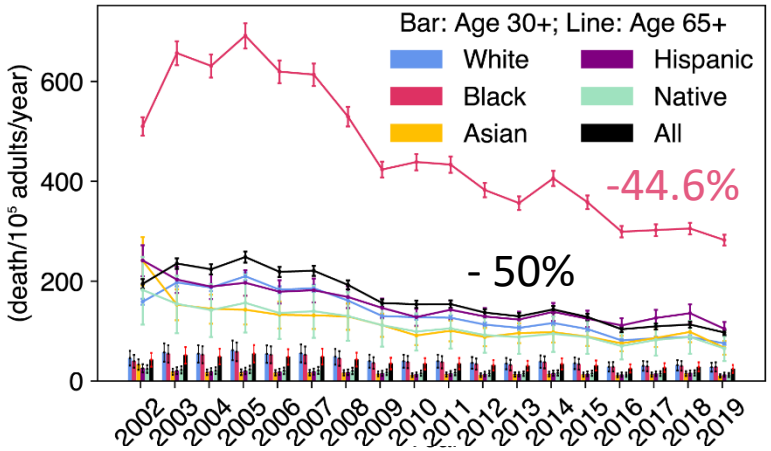


2002 - 2019 $PM_{2.5}$ Age 65+

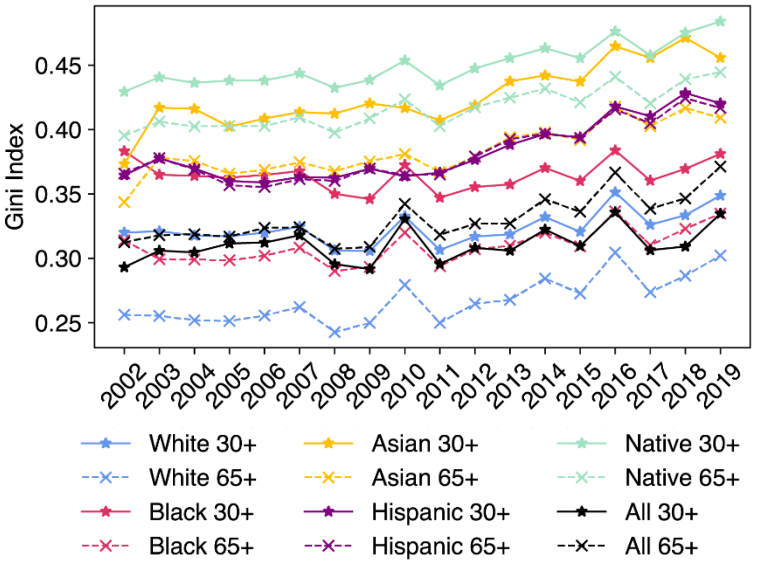


1.5% Com. increased (28.4% HV)

$PM_{2.5}$ Mortality Risk

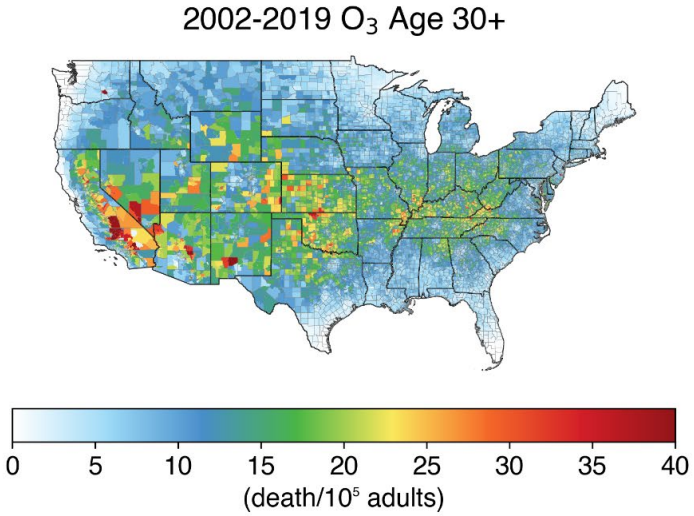


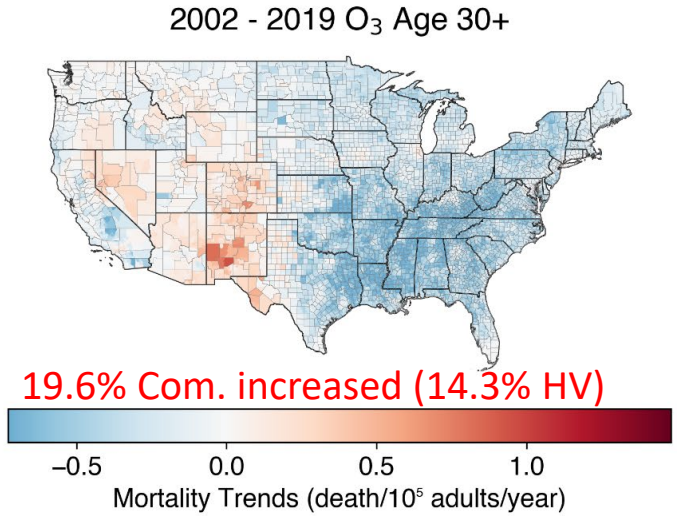
$PM_{2.5}$

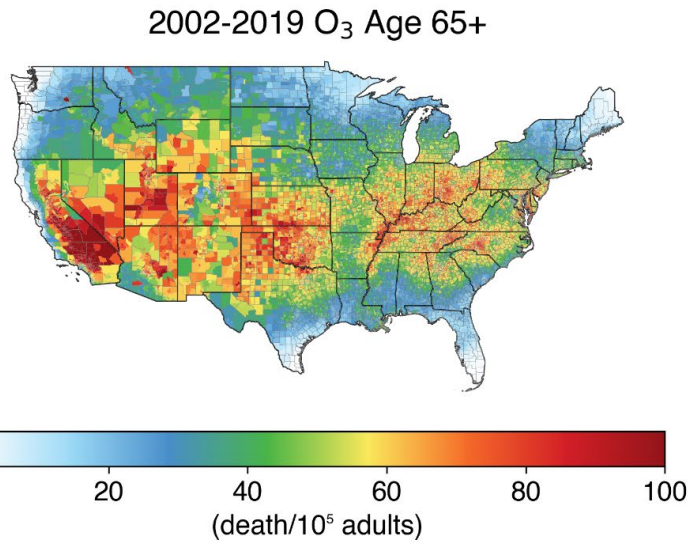


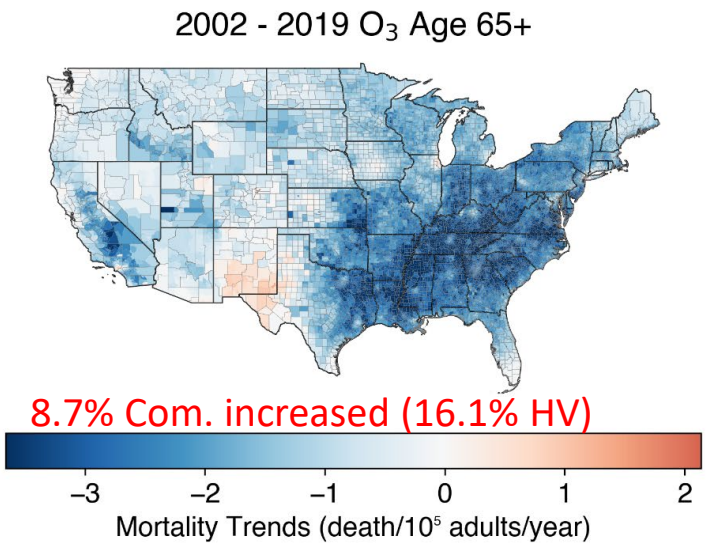
RESULTS ARE PRELIMINARY

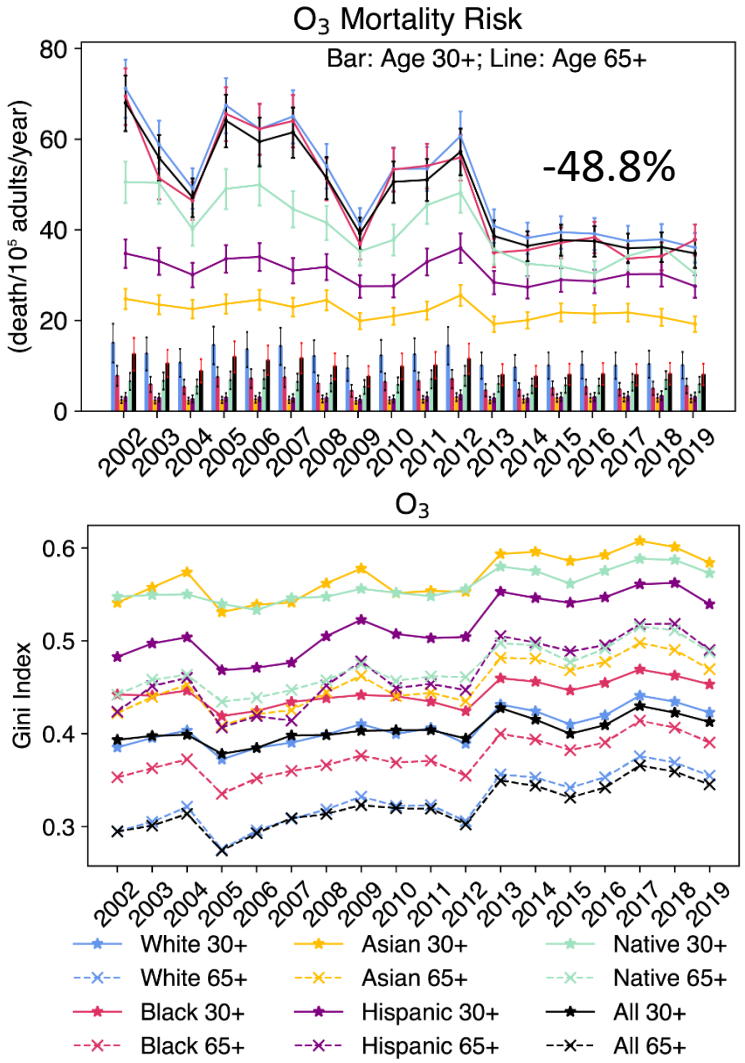
O_3 Mortality Trends of Age 30+







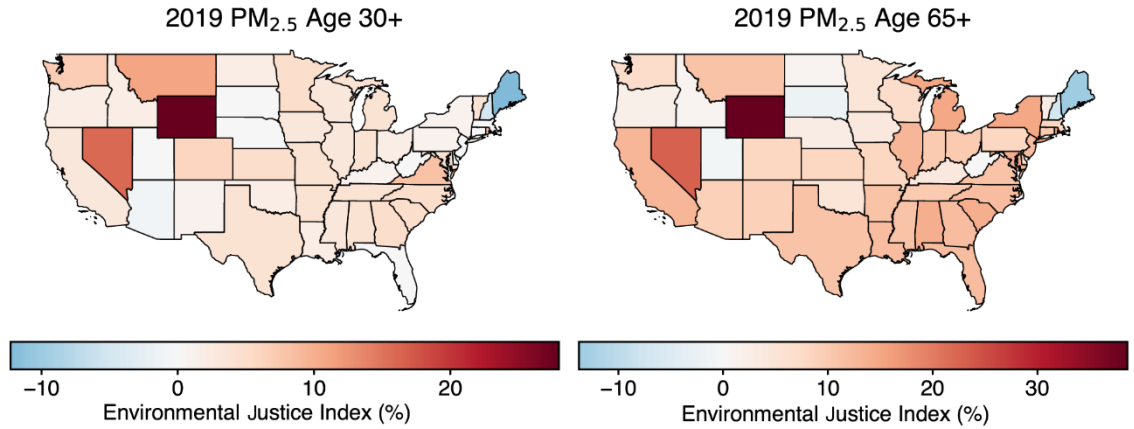


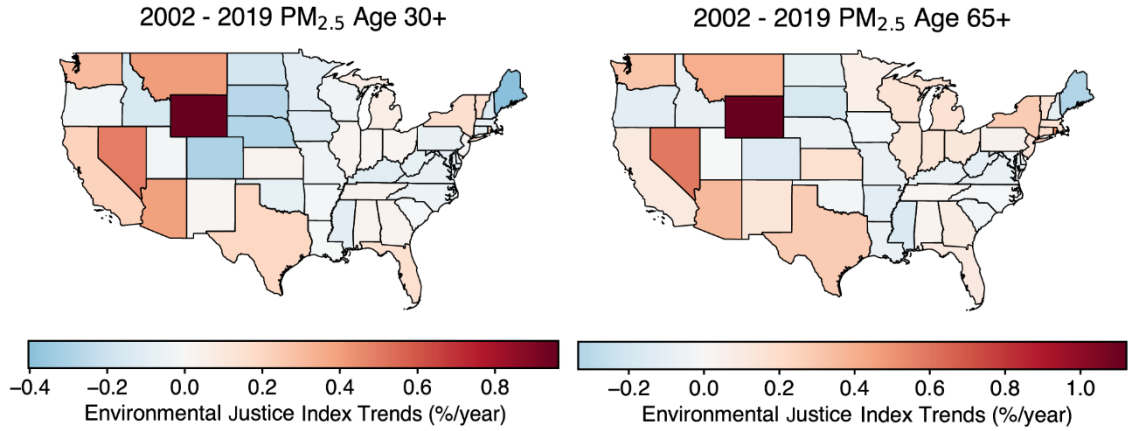


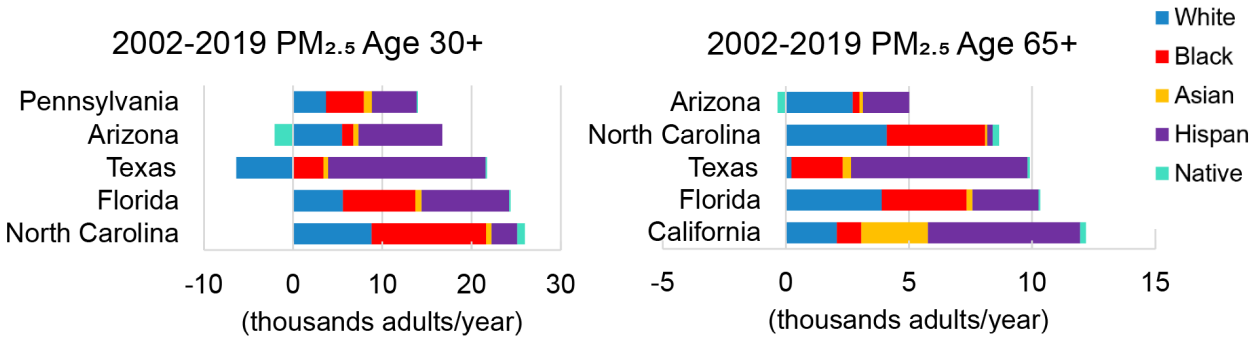
$PM_{2.5}$ Environmental Justice Trends

- 41 states with positive EJI for age 30+ in 2019
- 44 states with positive EJI for age 65+ in 2019
- 23 states with increased EJI for age 30+
- 28 states with increased EJI for age 65+
- Massachusetts, Wisconsin, Pennsylvania, Minnesota, and Connecticut with improved EJI for 30+ but degraded EJI for 65+.
- Hispanic and Black population contribute most to the increase of above-average-risk populations within HV communities, with elderly Asians in California as well.

Positive EJI for disproportion risks towards vulnerable communities







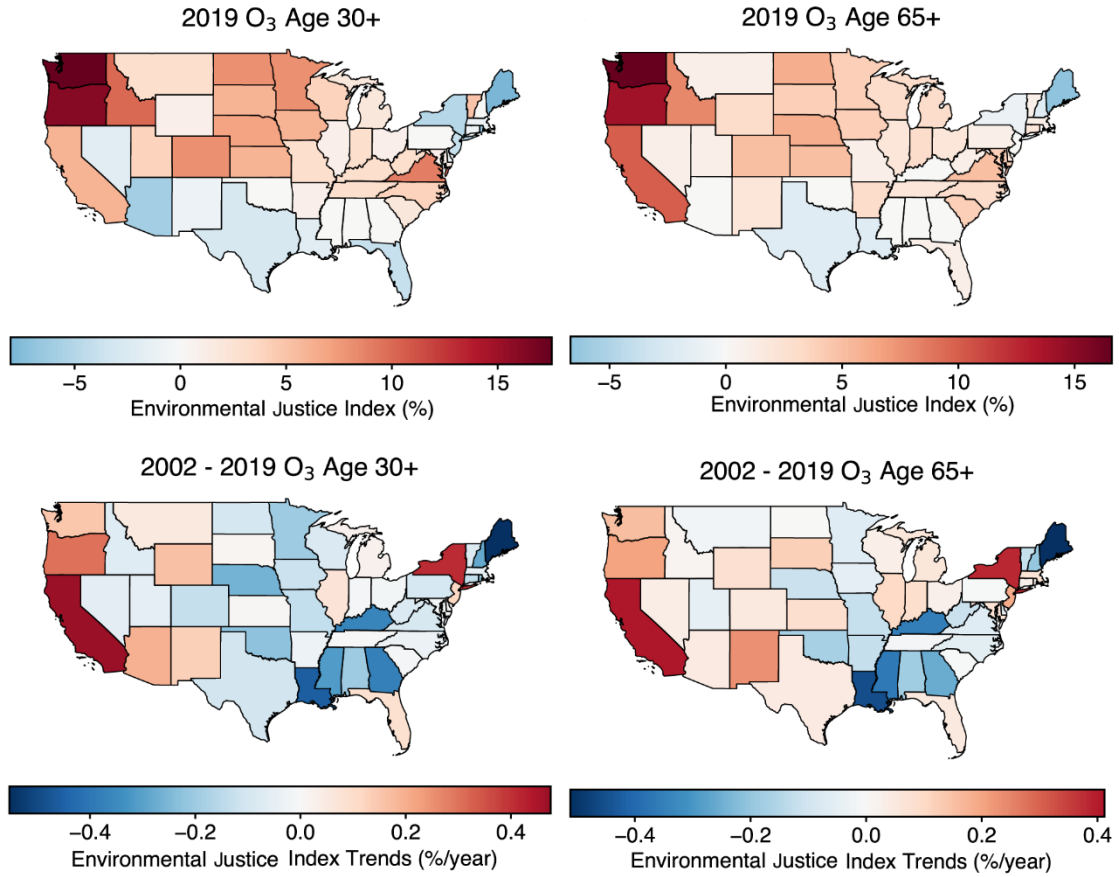
Positive trend for degraded EJ level

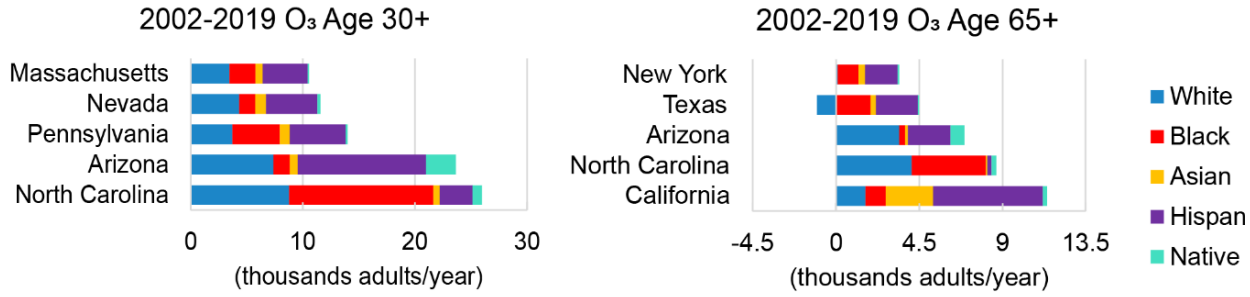
RESULTS ARE PRELIMINARY

O_3 Environmental Justice Trends

- 34 states with positive EJI for age 30+ in 2019
- 38 states with positive EJI for age 65+ in 2019
- 18 states with increased EJI for age 30+
- 26 states with increased EJI for age 65+
- Montana, Delaware, and Tennessee with improved EJI for 65+ but degraded EJI for 30+.
- Hispanic and Black population contribute most to the increase of above-average-risk populations within HV communities.

Positive EJI for disproportion risks towards vulnerable communities

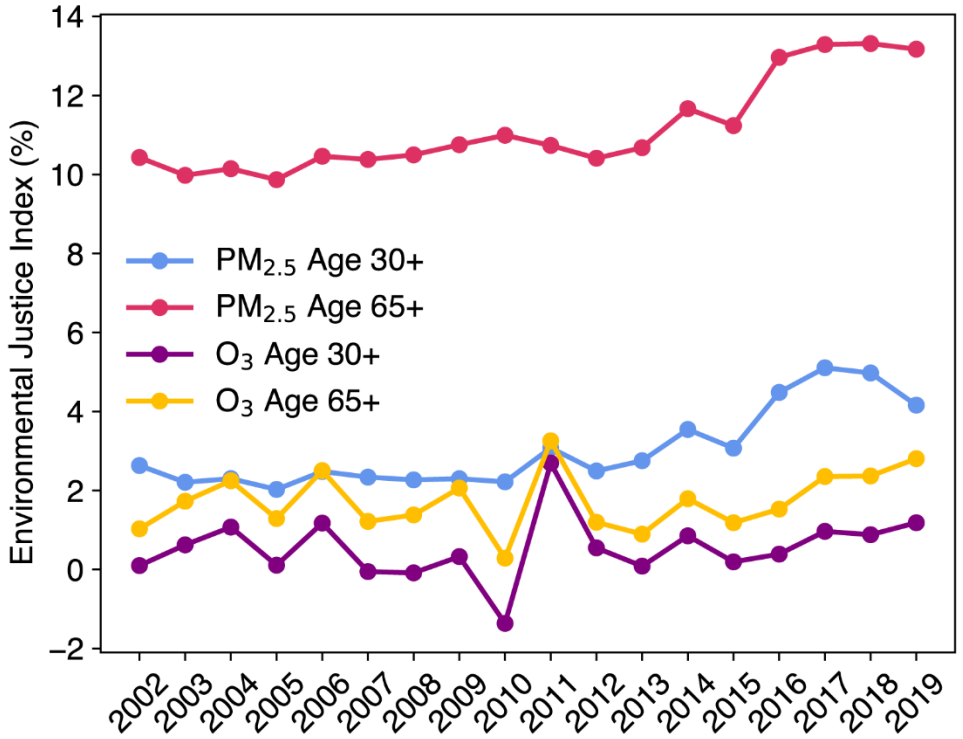




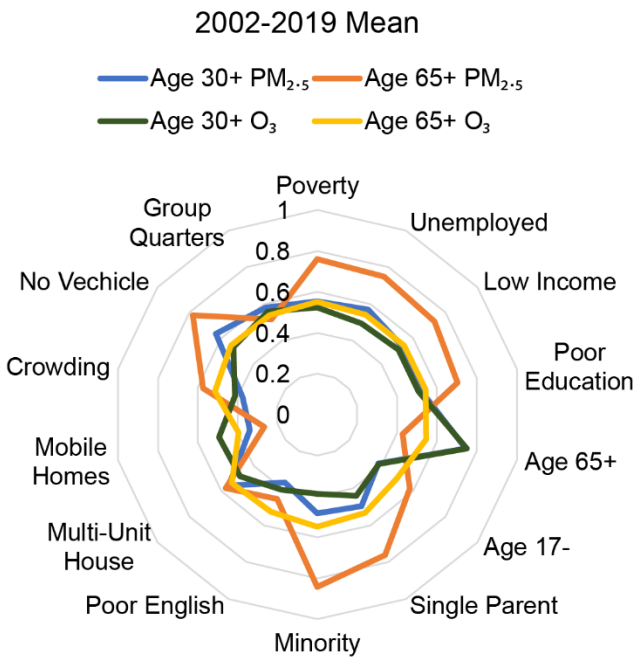
Positive trend for degraded EJ level

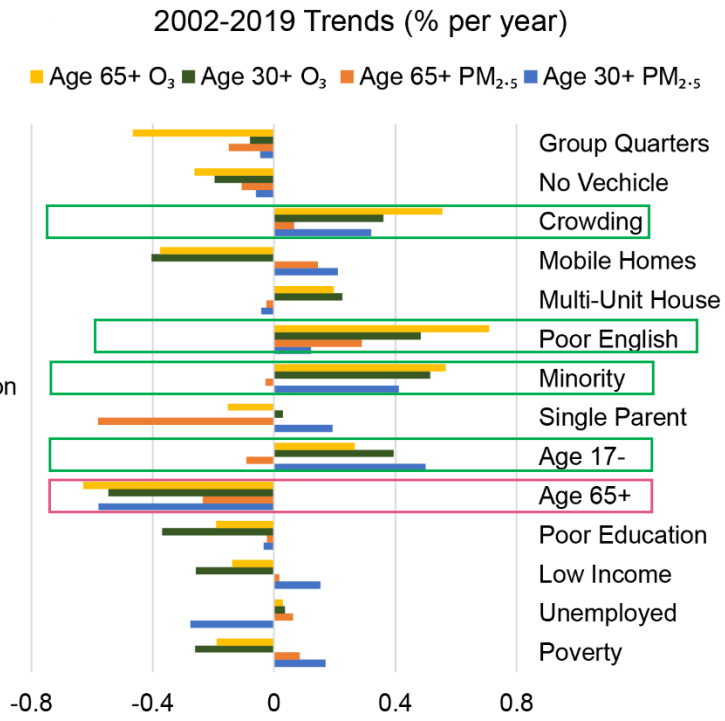
Social-Economic status of top 10% mortality risks Communities

- In the national level, EJI are increasing for $PM_{2.5}$-related mortality while remaining relatively constant for O_3-related mortality.



- Fourteen socioeconomic factors of communities with the top 10% mortality risks (e.g., high-risk) are analyzed for different pollutants and age groups.
- High-risk communities are increasing in Crowding, Poor English, Minors and Minority levels.





Conclusion

- Significant air quality improvements were achieved between 2002 and 2019, particularly for $PM_{2.5}$.
  - For O_3, more improvement occurred in eastern regions of the US.
- The disproportionate burden of air pollution-associated health risk is increasing for HV communities, especially for $PM_{2.5}$.
- Elderly populations (age 65+) experience higher health risks and inequality.
- It is important to develop race and ethnicity specific health risk functions, e.g., Black populations have 3X higher mortality risks due to $PM_{2.5}$ among the elderly groups.
- Minority groups experience most of the increase in above-average-risk populations within HV communities.
- Elderly ratio is the most important factor for high-risk communities of age 30+, while minority is the most important factor for high-risk communities of age 65+.
- Our environmental justice index can capture and assess the equitableness of air pollution health risk distributions. It can help policymakers to better evaluate the progressiveness of environmental mitigation policies in improving environmental justice.

Thank you!

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Questions?