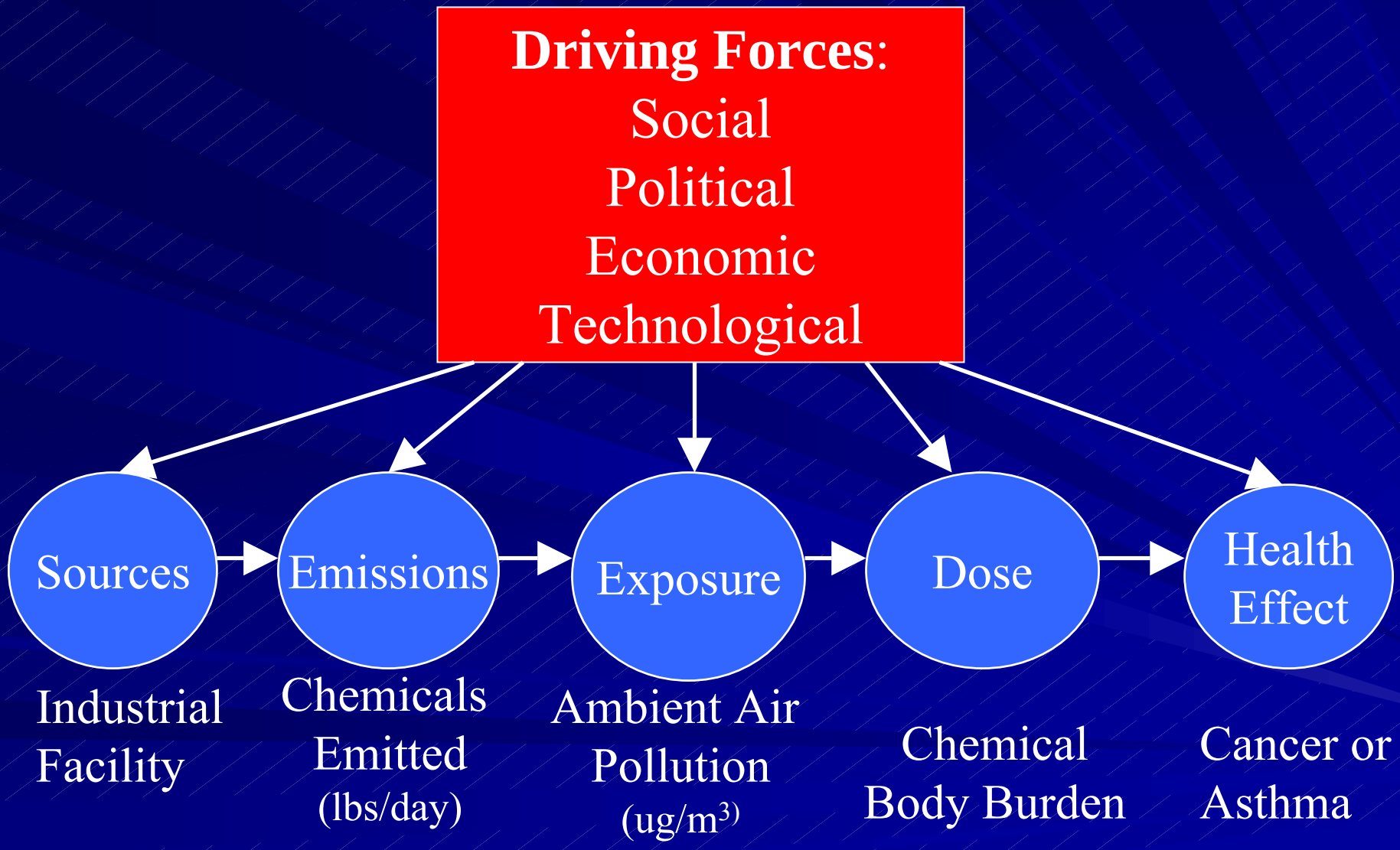
Separate But Unequal:
The relationship between residential segregation, air toxics and estimated cancer risks

Photos: David Woo, Dallas Morning News & GreenAction

The EJ Challenge of Linking Toxics to Adverse Health Outcomes



Spatially-Mediated Inequality and Community Health

- Residential Segregation

Diminish Community Capacity to Influence Regulation and Environmental Policy

- **Institutional:** Environmental Policy & Decision-Making
(e.g. siting, sanctioning activities, pollution prevention & control strategies)

- **Structural:** Regional & Economic Development and Land Use Policy
(e.g. industrial and housing development decisions, transportation planning)

Disparities in Environmental Health Stressors

- *Siting* of Environmental Hazards
- Pollution *Exposures* (through air, water and soil)
- Increased Health *Risks* (cancer, respiratory, developmental, etc.)

Health Outcome Disparities

- Premature Death Rates
- Infant Morality, Childhood Asthma, Low Birth Weight
- Decreased Lung Function & Development

U.S. EPA's National Air Toxics Assessment (NATA)

Dispersion modeling estimates long-term annual average outdoor concentrations of 33 air toxics for each census tract for 1996.

Model includes mobile and stationary emissions sources:

- Manufacturing (point and area)
  - e.g., refineries, small fabricators, chemical manufacturers
- Non-Manufacturing (point and area)
  - e.g., utilities, hospitals, dry cleaners
- Mobile (on road and off road)
  - e.g.., cars, trucks, air craft, agricultural equipment
- Pollution concentration estimates allocated to census tracts.

Estimating Cancer Risk

- Lifetime cancer risk calculated for each pollutant with toxicity information:

$$R_{ij} = C_{ij} * IUR_j$$

R_{ij} = individual lifetime cancer risk from pollutant j in census tract i.

C_{ij} = concentration of HAP j in *ug*/m^3 in census tract i.

IUR = Inhalation Unit Risk: cancer potency associated with continuous lifetime exposure to pollutant j in $(ug/m^3)^{-1}$

- Risks summed across pollutants

Key Science Policy Assumptions

- Methods based on U.S. EPA's and California's Risk Guidelines for carcinogenic risk assessment
- Air toxics classified by US EPA as known, probable or possible human carcinogens were evaluated
- Cancer potency information for pollutants compiled by US-EPA and Cal-EPA
- Assumes exposures are chronic over a lifetime
- Cancer risks are additive across pollutants

Segregation Measure: Generalized Index of Dissimilarity

Extent of segregation across several demographic groups within a metropolitan statistical area (MSA).

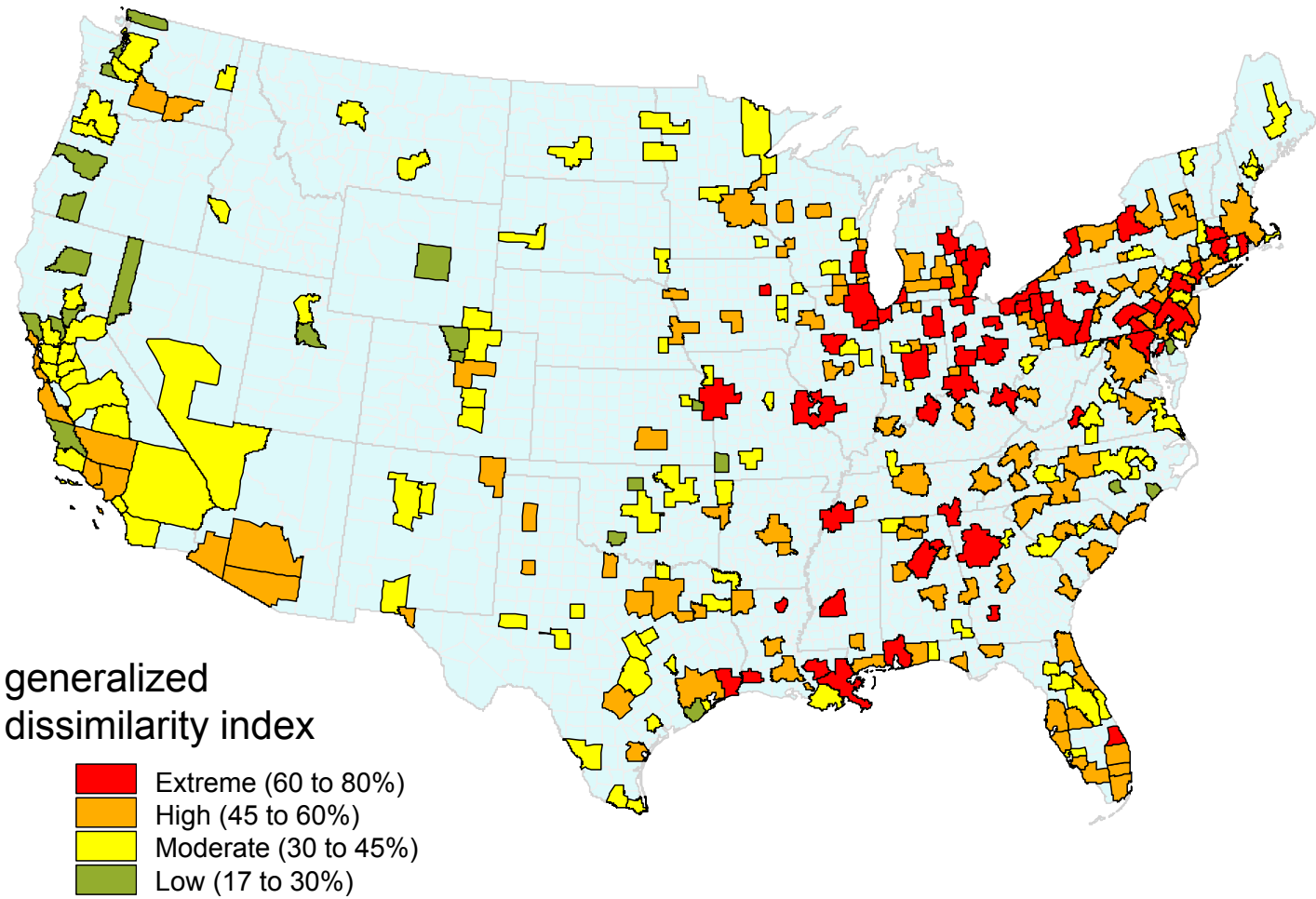
$$D_m = \frac{\frac{1}{2} \sum_i \sum_j \left| N_{ij} - E_{ij} \right|}{N \sum_j P_j (1 - P_j)}$$

- D_m = multi-racial index of dissimilarity.
- N_{ij} = number of people in racial/ethnic subgroup j in census tract i.

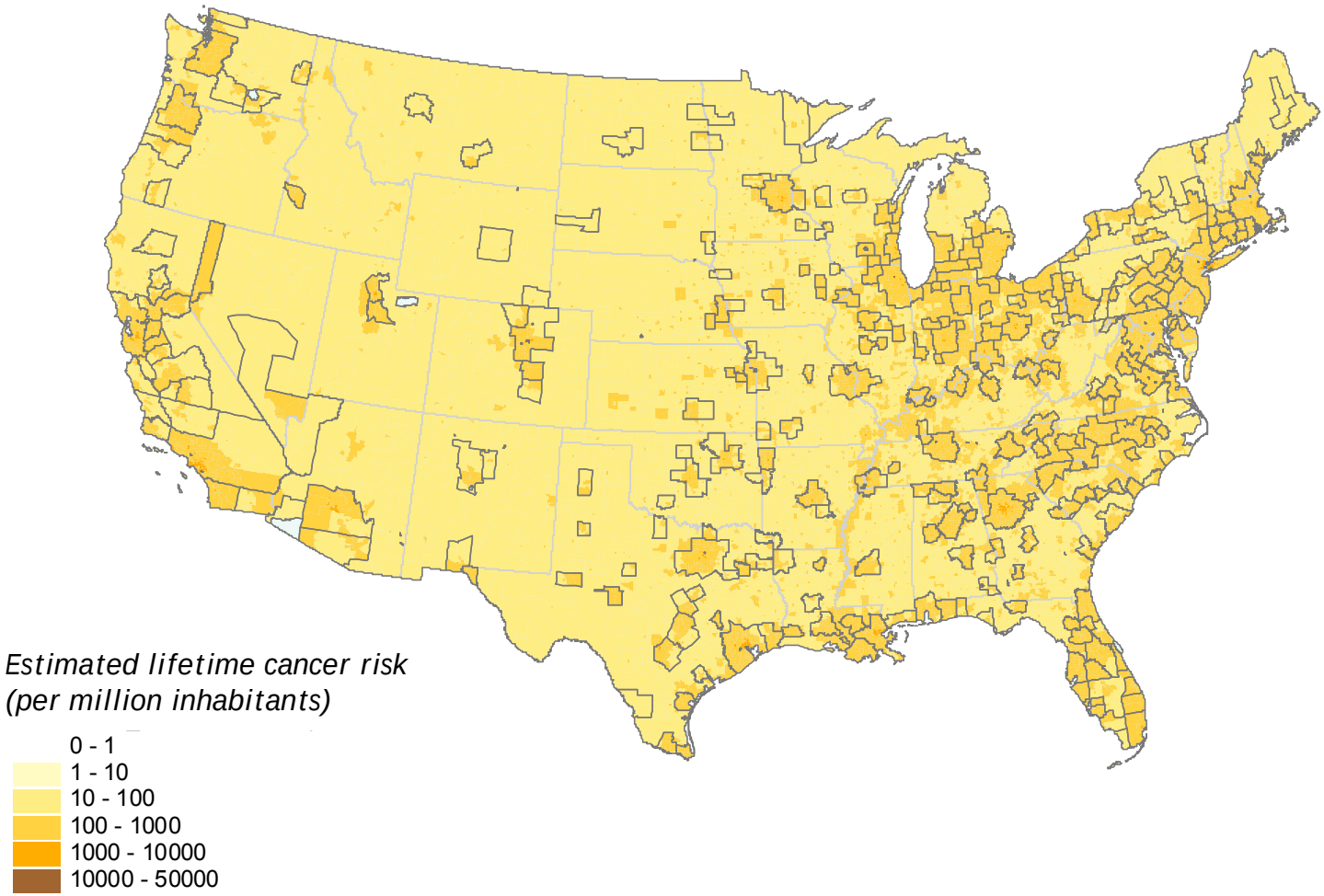
  - racial/ethnic subgroups: White, African American, Latino, Asian, Native American.

- E_{ij} = expected number of people in subgroup j in census tract i, under the assumption of no segregation ($N_i * N_j / N$).
- P_j = proportion of people in subgroup j in the whole MSA population (N_j / N).

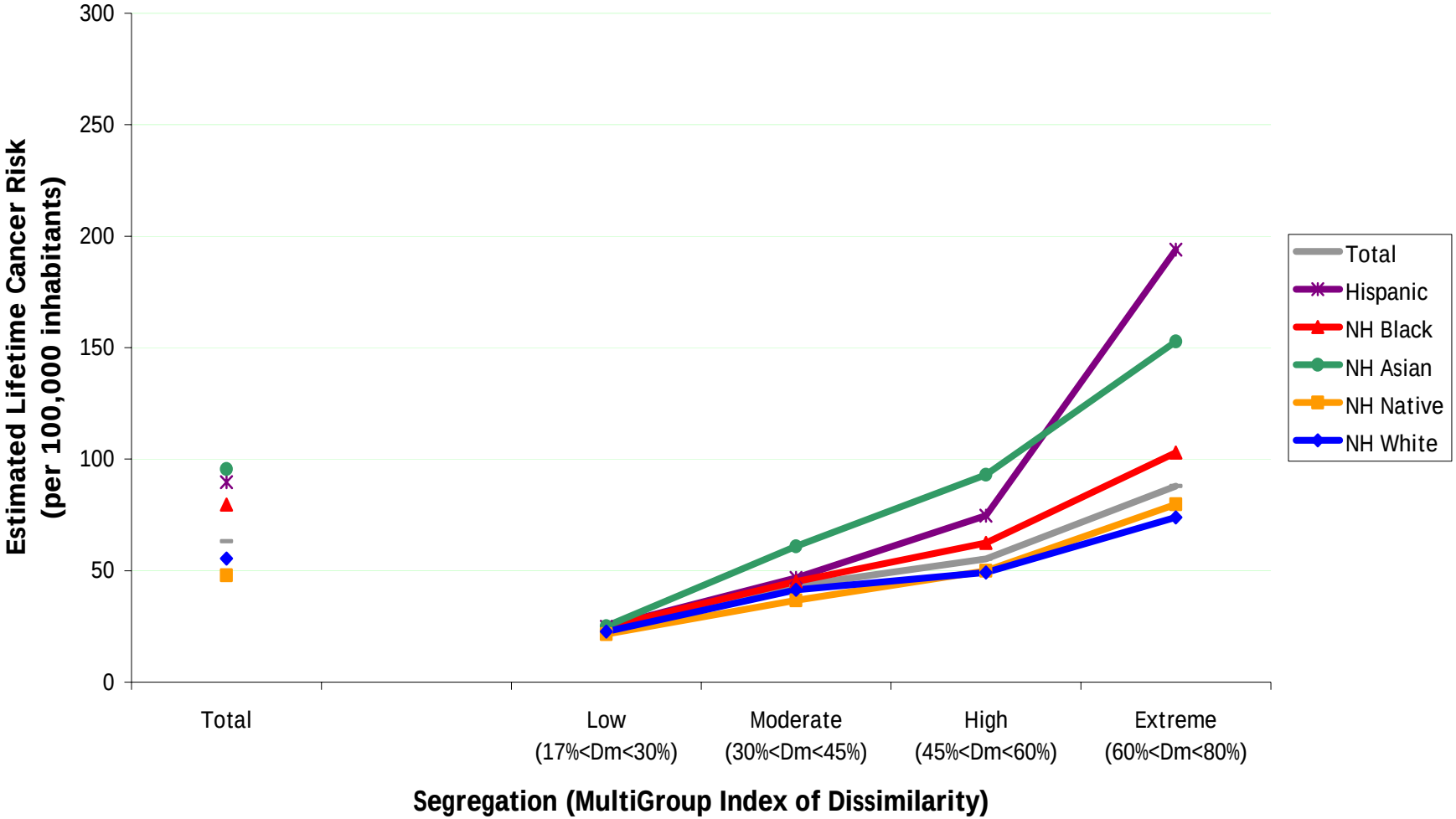
segregation (multi-racial dissimilarity index), continental United States metropolitan statistical areas



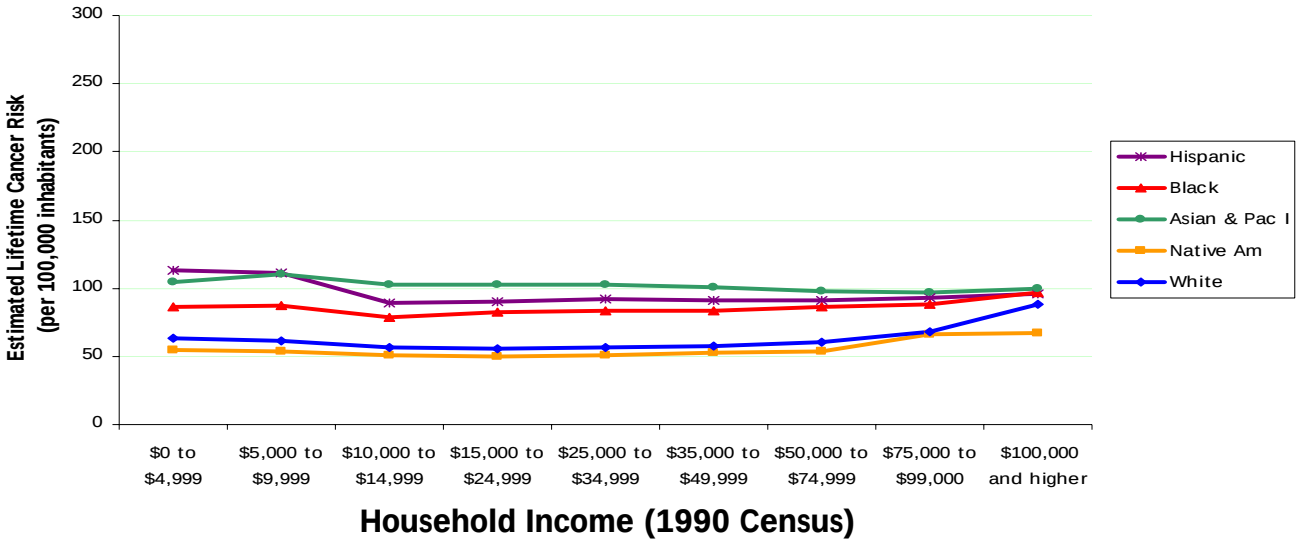
Estimated cancer risks associated with toxics exposures metropolitan statistical areas of the continental United States



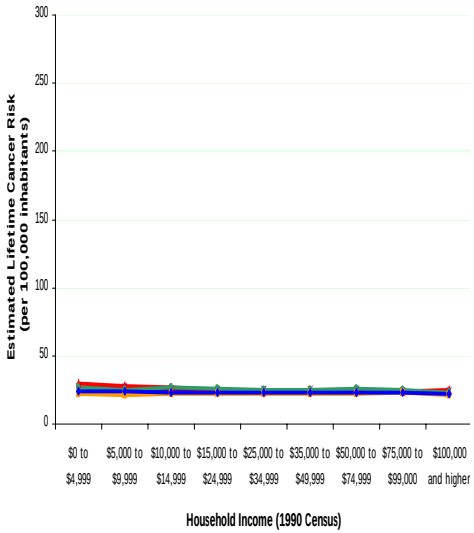
Estimated Cancer Risk From Ambient Air Toxics, by Race/Ethnicity and Segregation, Continental U. S. Metro Areas



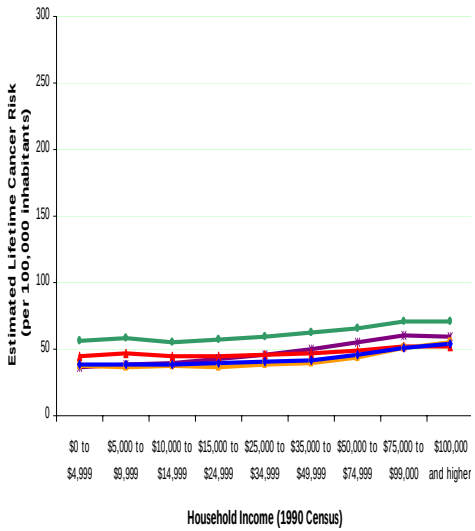
Estimated Cancer Risk From Ambient Air Toxics, by Race/Ethnicity and Household Income, Continental U. S. Metro Areas, All Segregation Levels



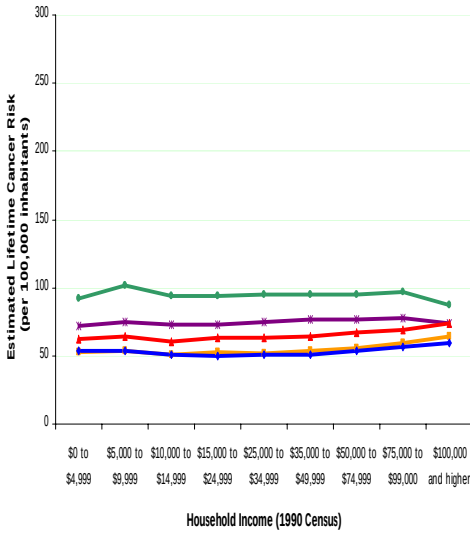
Low Segregation (17% < Dm <30%)



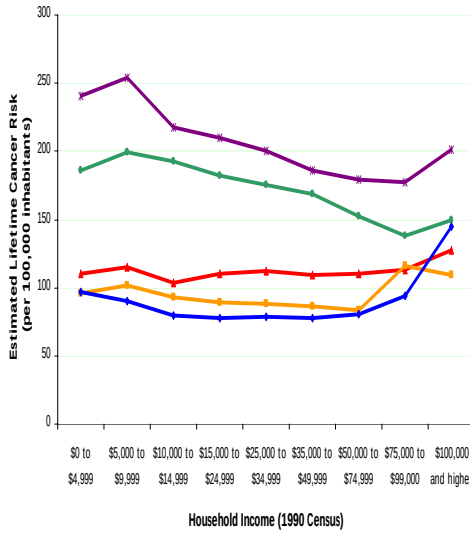
Moderately Segregated (30% <= Dm <45%)



Highly Segregated (45% <= Dm <60%)

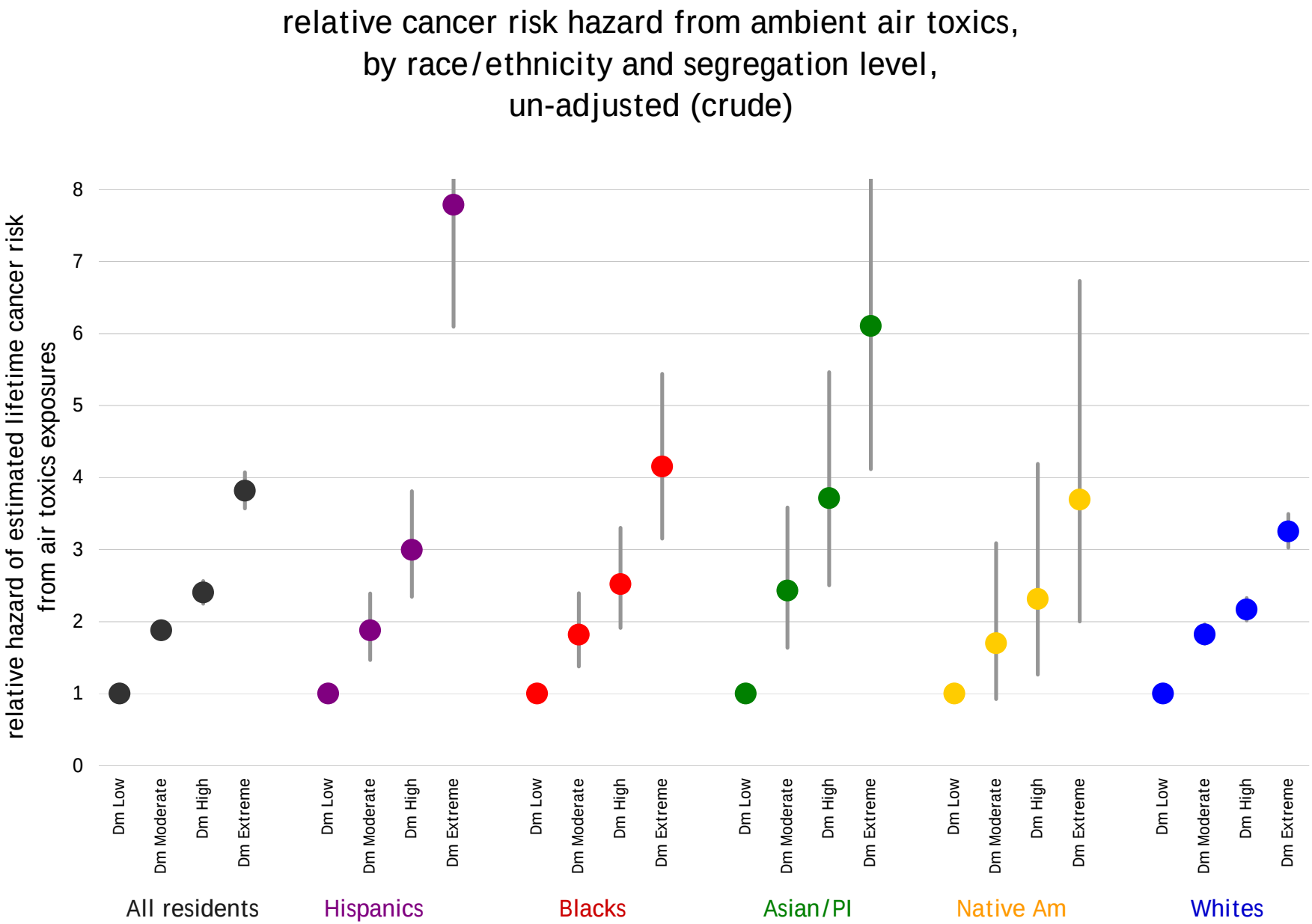


Extremely Segregated (60% <= Dm <80%)

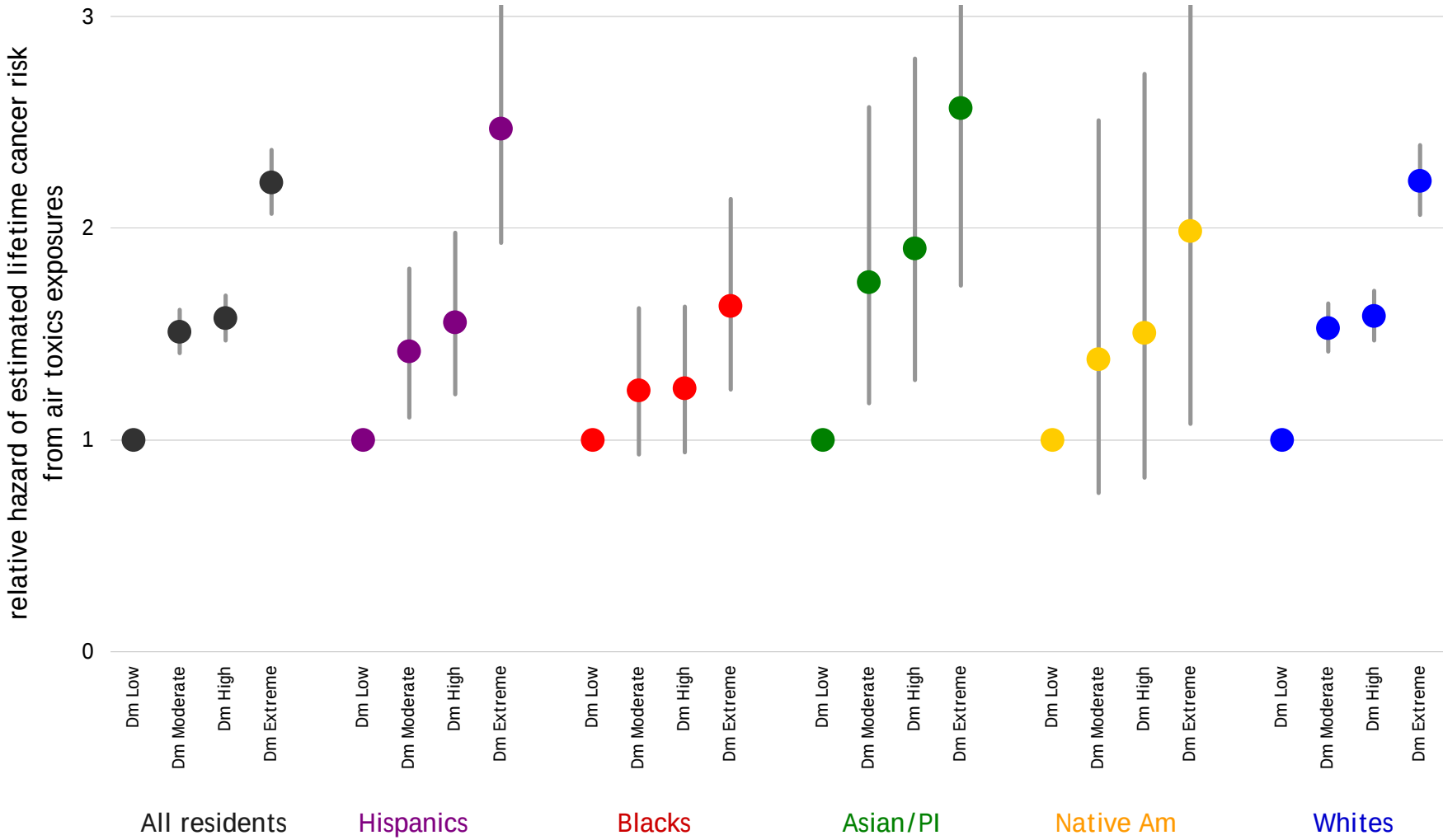


Covariates

- Segregation (MSA):
  - low (17 to 30%)
  - moderate (30 to 45%)
  - high (45 to 60%)
  - extreme (60 to 80%)
- Population Density (Tract)
- Townsend Index (Tract): sum of four z-scores /4:
  - crowding
  - unemployment
  - home ownership
  - car ownership
- Sprawl (MSA):
  - mixed use index
  - street connectivity index
- Eligible Voters (Tract)
- Average commute time (County)


relative cancer risk hazard from ambient air toxics,
by race/ethnicity and segregation level,
un-adjusted (crude)
relative hazard of estimated lifetime cancer risk
from air toxics exposures
0
1
2
3
4
5
6
7
8
Dm Low
Dm Moderate
Dm High
Dm Extreme
All residents
Hispanics
Blacks
Asian/PI
Native Am
Whites

relative cancer risk hazard from ambient air toxics,
by race/ethnicity and segregation level, adjusted for
tract density, deprivation, eligible voters, MSA sprawl & county commute



Results

- Racial segregation plays an important role in the differential distribution of air pollution exposures across diverse communities.
- Stratifying by segregation shows estimated cancer risks are higher for all demographic groups within the most segregated areas.
- Demographic disparities are higher in the more segregated areas.
- Generalized linear models show segregation modifies the relationship between cancer risk and the racial composition of tracts even after controlling for population density, material deprivation (Townsend Index), built sprawl, political empowerment, and commuting time.

Limitations

- Ambient air concentrations are not reflective of personal exposures and do not include indoor exposures.
- Concentration estimates from 1996 that may have changed significantly over time.
- Several pollutants could not be included in this analysis due to limited cancer toxicity data.
- Dispersion model underestimates concentrations of certain pollutants.
- Potential for mis-interpretation of ecological risk as individual risk

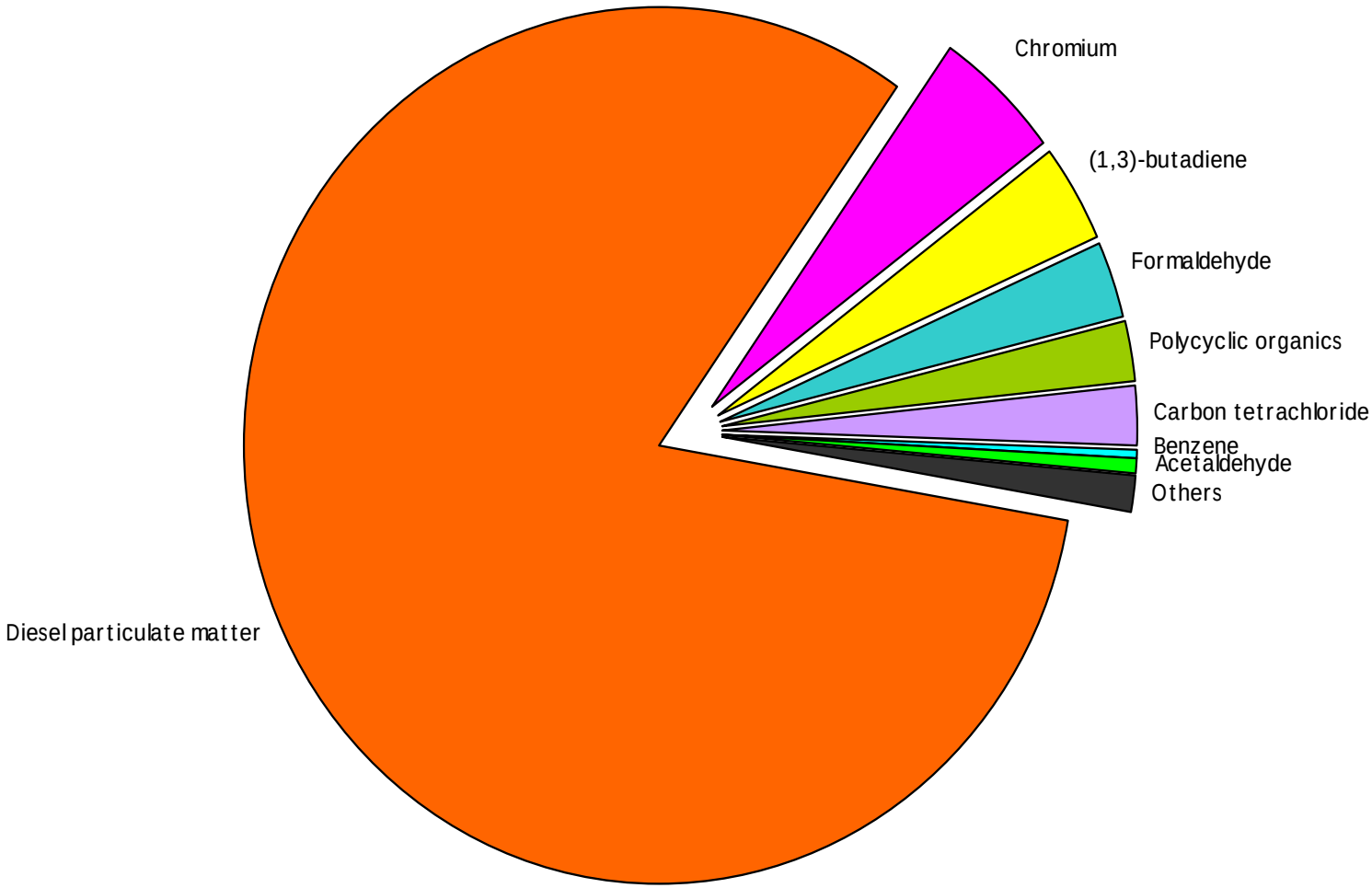
Conclusions

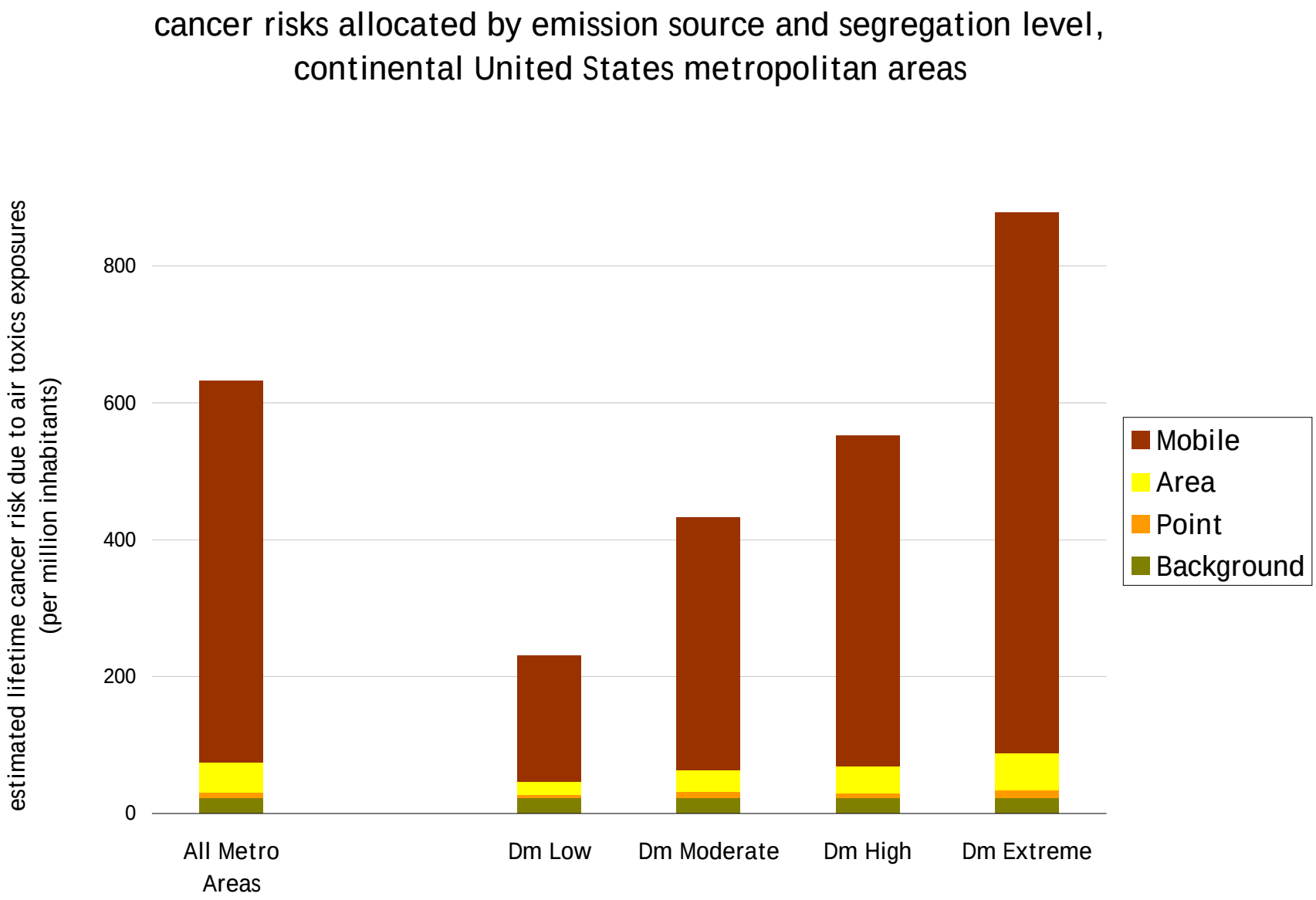
- Segregation appears to increase exposure to carcinogenic ambient air toxics for all racial/ethnic groups.
- Disparities widen with increasing segregation
- Regulatory efforts should examine how zoning, land use patterns, suburbanization and transportation development affect pollution streams and the distribution of associated risks among communities of color and the poor.
- Future research should how relationship between health outcomes and air pollution may be influenced by segregation.

Examining Links Between Segregation, Environmental Inequality

- Health literature points to persistent association between segregation and mortality/morbidity
  - (e.g. infant mortality)
- Suggests spatially-mediated power distributions across racial and economic lines
- Segregation may shape disparities in pollutant exposures across demographic groups.
- Spatially-mediated differences in environmental regulation and land use policy may also impact community environmental health.

pollutant-specific contributions to cancer risk weighting (national average)



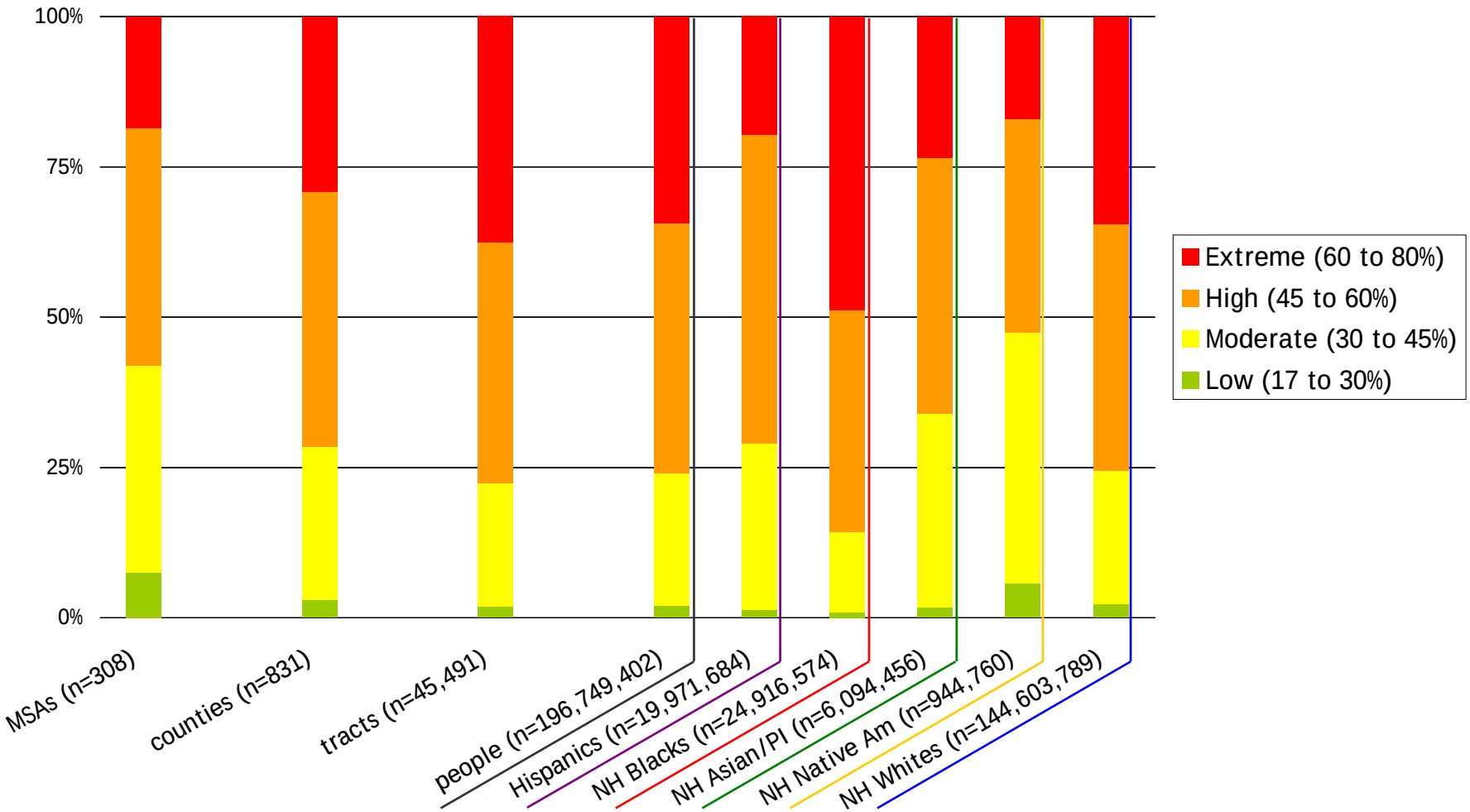

cancer risks allocated by emission source and segregation level, continental United States metropolitan areas
estimated lifetime cancer risk due to air toxics exposures (per million inhabitants)
800
600
400
200
0
All Metro Areas
Dm Low
Dm Moderate
Dm High
Dm Extreme
Mobile
Area
Point
Background

Segregation Measure: Generalized Index of Dissimilarity

$$D_m = \frac{\frac{1}{2} \sum_i \sum_j \left| N_{ij} - E_{ij} \right|}{N \sum_j P_j (1 - P_j)}$$

- Numerator sums number of people who would have to move from one census tract to another to attain an equivalent racial/ethnic balance in every census tract within an MSA.
- The denominator represents the maximum possible value of the numerator if each racial/ethnic group were completely segregated from one another in separate neighborhoods.
- The index varies from 0 (no segregation) to 1 (completely segregated).

proportion of MSA's, counties, tracts, and people (by race/ethnicity), by MSA segregation level (multi-racial dissimilarity index)



Southern California Collaborative for Environmental Justice:

Connecting Research to Action

EDUCATION

Who's Minding the Air at Your Child's School?

By RACHEL MORELLO-FROSCH, MANUEL PASTOR and CARLOS PORRAS

SANTA CRUZ—Both President George W. Bush and Gov. Gray Davis want schools to meet tougher standards, to be accountable to parents and to improve student performance. But enhancing education requires going beyond the basics of testing, teacher training and curriculum reform. A study we conducted in the Los Angeles Unified School District suggests that a school's environment can impair learning.

For a decade, researchers have raised concerns about the rise in learning disabilities among children in the U.S. Approximately 12 million children suffer from learning, developmental or behavioral problems; the number of students enrolled in special-education programs has increased nearly 200% over the last 20 years. Soaring rates of childhood asthma, especially among inner-city youth, have been linked to school absenteeism and diminished learning capacity. Increasingly, scientists and regulators see environmental pollution as a potential cause.

Many studies have investigated the short-term effects of dirty air—eye irritation, coughing and chest tightness—on the health of adults. New research suggests that polluted air may also have long-term adverse effects on kids. Researchers looking at the Los Angeles Basin, for example, recently concluded that air pollutants commonly found in smog can significantly impair lung growth and function in children.

JENNIFER HEWITSON/For The Times

Most studies on the health of children's environments focus on conditions in their neighborhoods. Yet, children can also encounter hazards at their schools. True, a majority of students in Los Angeles live and attend school in the same neighborhoods, but a significant number of them cross town on an army of buses to attend magnet schools or simply because their neighborhood schools are overcrowded; many white middle-class students attend private schools far from their homes.

There have been dramatic examples of environmental hazards located near some Southern California schools. Many parents of students at Suva Elementary and Intermediate schools in Bell Gardens blamed chrome-plating plants nearby for a cluster of cancer cases among students and teachers. While health officials and researchers could not demonstrate a causal link, community and parental pressure forced cleanups at the two sites. Last week, similar pressure forced the LAUSD to promise removal of arsenic-tainted soil at Park Avenue Elementary in Cudahy.

Cases like Suva and Park, where more than 95% of the students are Latino, have reinforced concerns that pollution and its effects may not be an equal-opportunity problem. If environmental risks are disproportionately concentrated at minority schools, and their effects spread beyond health to include student achievement, then they are another obstacle in the path of children who already face barriers of poverty, neighborhood instability and underperforming schools.

To explore these questions, we recently examined the distribution of potential environmental risks among schoolchildren in LAUSD. The local environmental conditions of each school was mapped. A school's racial composition, test scores, teacher experience and other variables were determined so patterns could be revealed. The results were striking.

Using air-toxicity models developed by the Environmental Protection Agency, we estimated cancer and respiratory risks associated with pollution sources near each school. The fifth of the schools with the cleanest air were nearly 30% Anglo (in a school district that is less than 15% white), while the fifth with the most polluted air were 92% minority.

This disparity could simply be a function of other factors. For example, heavily minority schools tend to be located in older industrial areas. We therefore tried to control for factors usually associated with pollution: population density, the percentage of land zoned for industrial use, income levels and home ownership (often a sign of both political power and resident commitment to the neighborhood). Nevertheless, the racial make-up of the student body still played a significant role in predicting the environmental risks associated with a school.

Is this correlation simply a reflection of neighborhood demographics? After all, previous research indicates that Southern California's most hazardous air pollutants, as well as its toxic storage and disposal facilities, are disproportionately concentrated in minority communities. To account for this, we reanalyzed our data to determine if a school was more or less minority than would have been predicted from the neighborhood in which it was situated. As it turns out the racial disparity persisted, with significantly higher cancer and respiratory risks from hazardous air pollutants in the schools with more minority students than would have been expected, given local demographics.

Do these persistent health dispariti among Los Angeles schoolchildren har other effects? We examined the rel tionship between respiratory risks a school achievement, as measured by t Academic Performance Index. Even a ter accounting for the poverty levels the students, their English languag proficiency, the percentage of teache with emergency credentials, the educ tions of parents and other standard pr dictors of academic achievement, a pollution had a negative and statist cally significant effect on test scores.

The causal chain and biologic mechanisms involved remain unclea and detailed epidemiological work necessary. But the apparent connectio between pollution and impaired learnin is troubling, given that many minorit and low-income students already fac academic challenges. Why put one mo barrier in their way?

The LAUSD is slated to build 86 ne schools in the next five years. With lan scarce in the densely populated inne city, the district will have to consider a eas once used for industrial uses. Whil tradeoffs may be necessary, the result of our study, coupled with the contro versies generated by the siting of th Belmont Learning Complex and a ne South Gate high school, suggest tha any proposed school location and co struction plan take into account the vu nerability of children to environmenta hazards.

When we see a pattern in which env ronmental hazards are disproportion ately affecting minority children' health and academic performance, w must ask: Who's minding the kids?

Rachel Morello-Frosch is an assistant professor of health education at San Francisco State University. Manuel Pastor is director of the Center for Justice, Tolerance and Community at UC Santa Cruz. Carlos Porras is executive director of Communities for a Better Environment.

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