“The Role of Socioeconomic Status (SES) in Studies of Air Pollution and Health”

Jane E. Clougherty, MSc ScD

Drexel University

Dornsife School of Public Health

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Presentation Outline

- Introduction:
  - Why worry re: socioeconomic status (SES) in air pollution epidemiology??
- Measuring SES/ social processes
  - Scale of measurement
  - Exposure misclassification
- Incorporating SES into air pollution epidemiology
  - Confounding, effect modification, mediation
- Conclusions

What is Socioeconomic Status (SES)?

- "SES" refers to a myriad exposures/ pathways:
  - Health care, income, smoking, diet, education, occupational exposures, job insecurity, immunization history, indoor environments, parental stressors…
  - Aggregating & interacting over lifecourse, multi-generational (epigenetics).

- Unlike air pollution (which is physical, tangible), SES is *relational.*
  - It is an individual's *relative* standing in society.
  - Changes over time & lifecourse
    - Through actions of individual agency (e.g., gaining education)
    - Or societal shifts (e.g., changing gender norms, LGBTQ status).

How does SES affect health, across the social gradient?

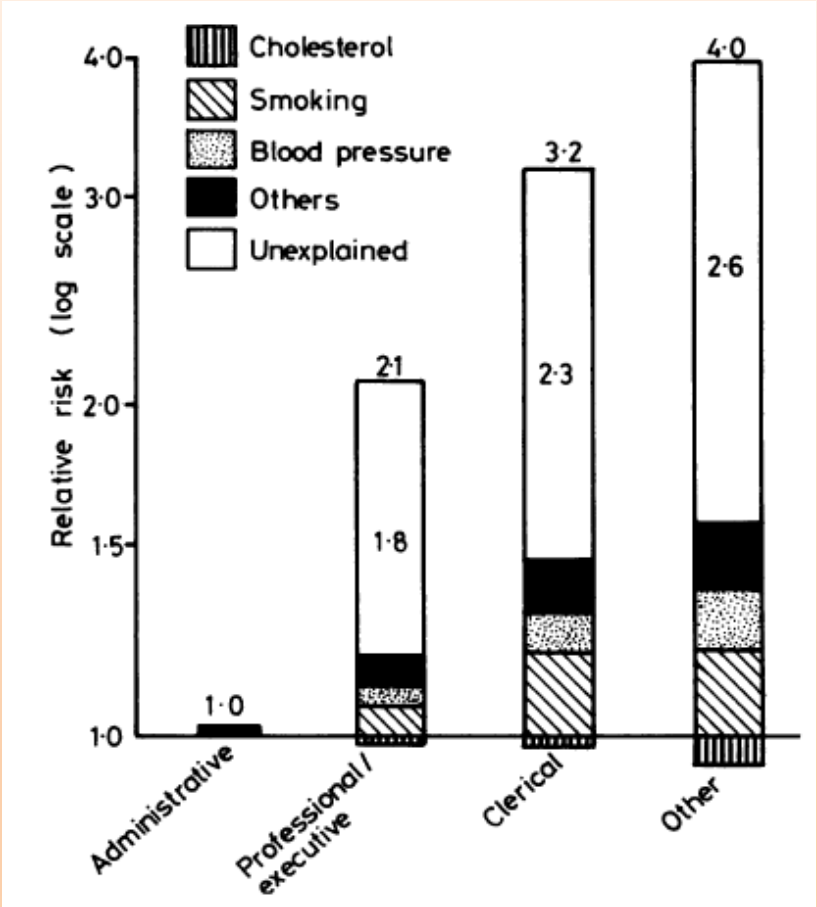


Fig. 3 *Relative risk of death from coronary heart disease according to employment grade, and proportions of differences that can be explained statistically by various risk factors.*

(Rose & Marmot, *Brit Heart J* 1981)

This ‘social gradient’ holds up across disease outcomes.

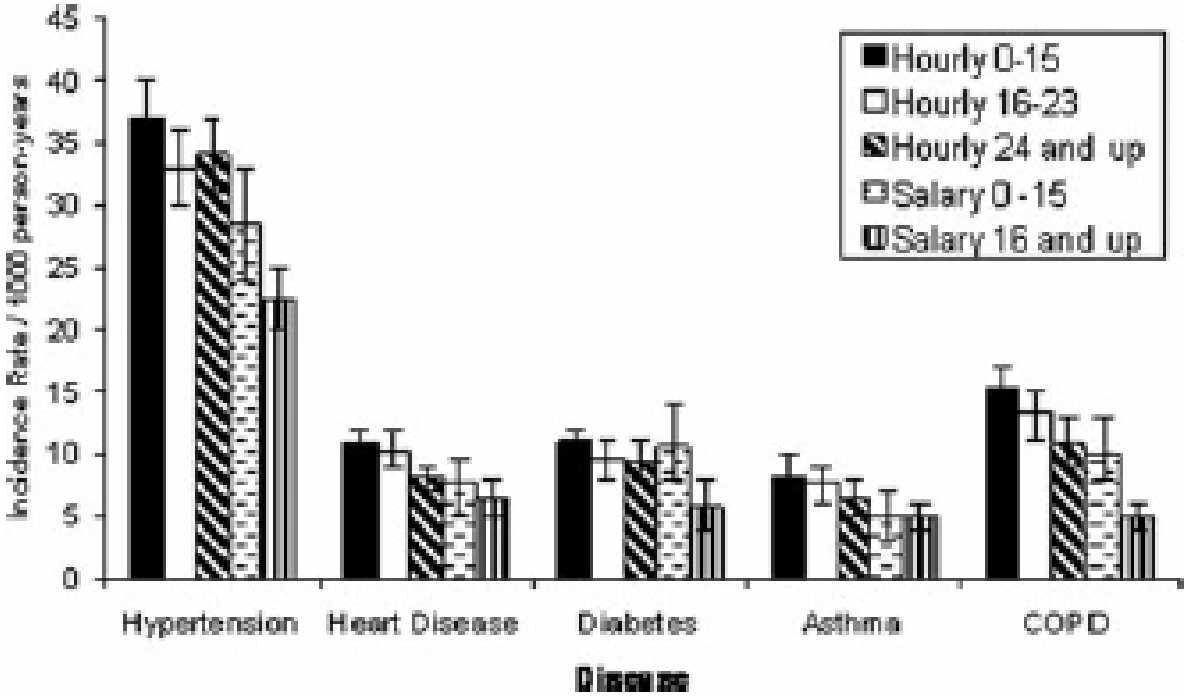


Figure 2. Male incidence rates for major chronic diseases of working-age people for each of five job grades, ranging from low-grade blue-collar (*left bars*) to highest professional/executive grade at Alcoa.

From: Clougherty JE, Souza K, Cullen MR. Work & its Role in Shaping the Social Gradient in Health, *Ann NY Acad Sci (2010) 1186: 102-124.*

Measuring SES

- Many possible SES metrics.
- Misclassification unique to each.
  - Metric needs be appropriate to population under study.
    - e.g., Income misclassifies retirees, students
    - e.g., Education misclassifies young people; generational trends
- Needs be appropriate to hypothesized pathways to health.
  - esp. for psychosocial (stress) pathways
  - e.g.: sound (physical) vs. noise (annoyance)

Hajat et al, *in preparation*

Table 1. Indicators of socioeconomic status: descriptions and issues to consider

SES indicator	Measurement	Measurement issues to consider	Citations*
Income	Captures household income as an absolute amount not as a range; account for family size to create equivalized (per capita) income measures	Varys by time and by place; subject to both short and long-term fluctuations	(Duncan and Petersen 2001)
Poverty	-Poverty threshold defined as above or below poverty line -Poverty level expressed as percentage of threshold (i.e. 100% equal to threshold; 400% is three times as high)	Varys by time and by place	(Sen et al. 2006)
Wealth	Captures different types of asset (home values, stocks/bonds, pension/retirement accounts, savings accounts etc.) and subtracts debt	Less impacted by short-term fluctuations; may be stable across generations (due to inheritance); better for older populations who no longer earn income	(Cubbin et al. 2011)
Education	Can be specified as total years of education or highest degree obtained	Varys by time (value of education has changed over time; e.g. a high school degree in 1960 creates more opportunity than a high school degree in 2010) and place (quality of education varies regionally)	(Ross and Mirowsky 1999)
Occupation	Can be specified by occupation or industry or as employment status (e.g. employed, unemployed or not in the labor force)	Downstream of income and education Occupation and industry measures do not capture people not in the labor force or those who are temporarily unemployed	(Ahonen et al. 2018)
Income inequality	Income distribution across a population, measured as a contextual (area-level) variable.	Several measures including: Gini Coefficient, Robin Hood Index, 20% share, Atkinson Index and Concentration Index. Selection of geographic unit is important (e.g., counties vs states)	(De Maio 2007)
Psychosocial stress	Many different stressors such as crime rate, residential crowding.	Often considered proxies for SES (income, poverty)	(Cohen et al. 2007)
Subjective social status	Respondent's rating of social standing relative to others	One commonly used measure shows a picture of a ladder and asks participants to place themselves on the rung where they believe they stand	(Adler et al. 2000)
Composite SES indicator	SES indices usually derived from multiple SES indicators and constructed by PCA	-May be more statistically and conceptually efficient -Useful when individual SES indictors are highly correlated -Weighted indices (using weights from PCA) is recommended -Varys by space and time	(Messer et al. 2006)

*Citations provide more information on conceptualization, measurement and mechanisms to health.

Critical Role of Scale in Measuring SES/ Social Variables

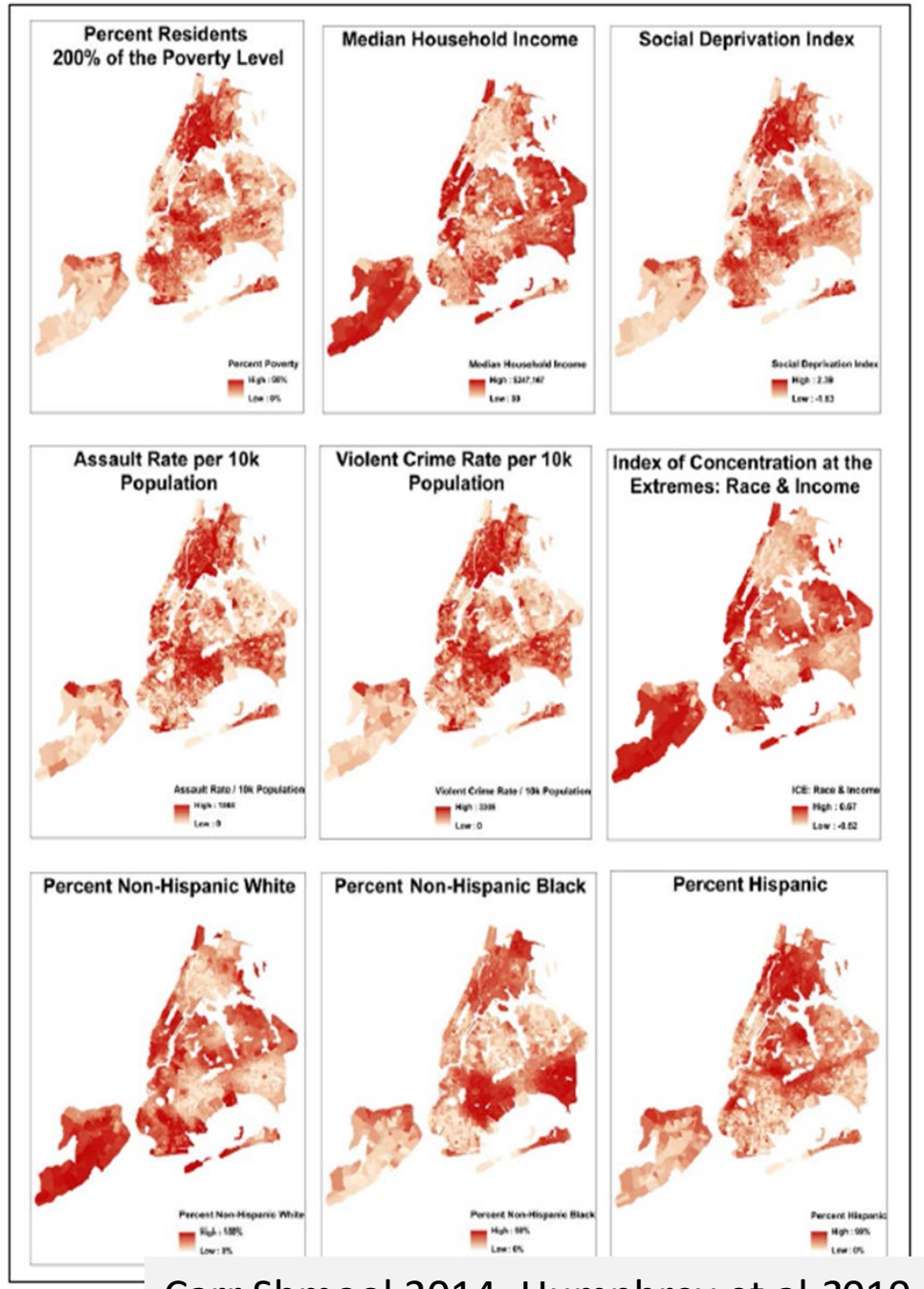
- Community- & Individual-level SES are different:
  - Avoid using one to proxy for other, as possible.

  – Community-level processes
    - (e.g., school district, resources, crime, culture) = *context*
  – vs. Individual characteristics
    - (e.g., individual income, job strain, social support) = *composition*

Community-level SES Metrics

Stressor Construct	Indicator and Administrative Scale	Data Source and Date
Crime & Violence	Murder and non-negligent manslaughter per 10,000 (PP)	NYPD (FY 2009)
	Felonious Assault per 10,000 (PP)	NYPD (FY 2009)
	Robbery per 10,000 (PP)	NYPD (FY 2009)
	Burglary per 10,000 (PP)	NYPD (FY 2009)
	Felony Larceny thefts per 10,000 (PP)	NYPD (FY 2011)
	% Perceptions of Neighborhood Safety (self-report) (UHF)	DOHMH CHS (2010)
Mental and General Health Status	% Depression diagnosis ever (self-report) (UHF)	DOHMH CHS (2009)
	% Mental health treatment in past year (self-report) (UHF)	DOHMH CHS (2009)
	% Fair or Poor general health (self-report) (UHF)	DOHMH CHS (2009)
Physical/Built Environment	% Small parks not acceptably clean (CD)	NYC Parks (FY 2009)
	% Sidewalks not acceptably clean (CD)	MOoO (FY 2009)
	Serious housing violations per 1,000 Rental Units (CD)	HPD (2009)
	Air Quality complaints per 10,000 residents (CD)	DEP (FY2009)
	% Residential Crowding (>1 occupant/room) (USCBG)	US Census ACS (2005-09)
Access to Healthcare	% With no type of insurance coverage (self-report) (UHF)	DOHMH CHS (2009)
	% Went without needed medical care (self-report) (UHF)	DOHMH CHS (2009)
	% Without a personal care provider (self-report) (UHF)	DOHMH CHS (2009)
	Public Health Insurance enrollment per 10,000 (CD)	MOO (FY 2009)
Noise disruption	% Frequent noise disruption (3+ times/wk over 3 months) (self-report) (UHF)	DOHMH CHS (2009)
	% Noise disruption, by noise sources (i.e. neighbors, traffic) (self-report) (UHF)	DOHMH CHS (2009)
Childhood-specific stressors	% Students in schools exceeding capacity (SD)	NYC DOE (SY 2006-07)
	% School buildings in good to fair condition (SD)	NYC DOE (SY 2006-07)
	% Average daily student attendance (SD)	NYC DOE (SY 2008-09)
	Substantiated cases of Child Abuse/Neglect per 10,000 (CD)	NYC ACS (2008)
Socioeconomic Position (SEP)	% Living below 200% federal poverty line (USCBG)	US Census ACS (2005-09)
	% Delayed rent or mortgage payment in past year (self-report) (UHF)	DOHMH CHS (2009)
	Food Stamp program enrollment per 10,000 (CD)	MOO (FY 2009)
	% Less than high school education (self-report) (UHF)	DOHMH CHS (2009)
	% Unemployed for less than 1 year (USCT)	US Census ACS (2005-09)

Figure 3: Spatial distribution in census-tract-level social covariates across NYC.



Carr Shmool 2014; Humphrey et al 2019

Spatial scale & exposure misclassification

- Different scales of resolution often used for pollution vs. SES:
  - Day- and residence-specific spatio-temporal pollution
  - vs. annual-average census-tract SES indictor.

- Or, different patterns in actual (true) exposures:
  - = "Uncertain Geographic Context" (Kwan 2012).
    - e.g., pollution decays rapidly within 50-200m of roadway;
    - vs. Some social variables vary by community (e.g., school district).

Using SES/ Social indicators in Environmental Epidemiology

1) Confounding
2) Effect modification
3) AP as mediator of SES effects on health.

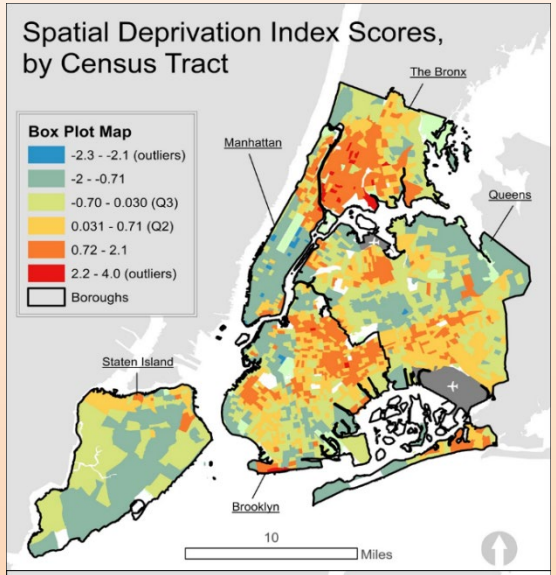
Confounding: Spatial Correlation

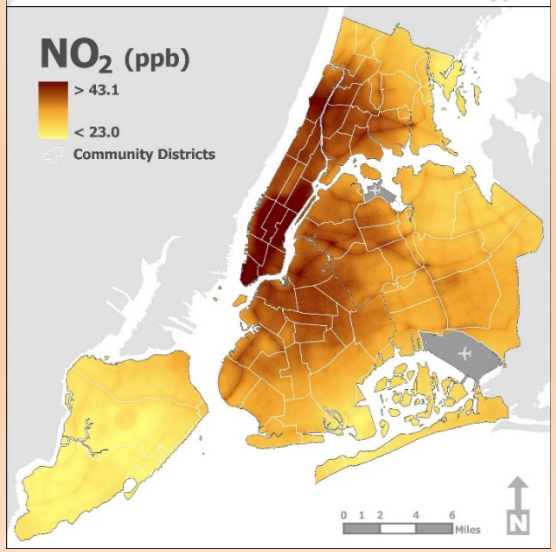
Pollution exposures often clustered in lower-SES communities (Graves 1998).

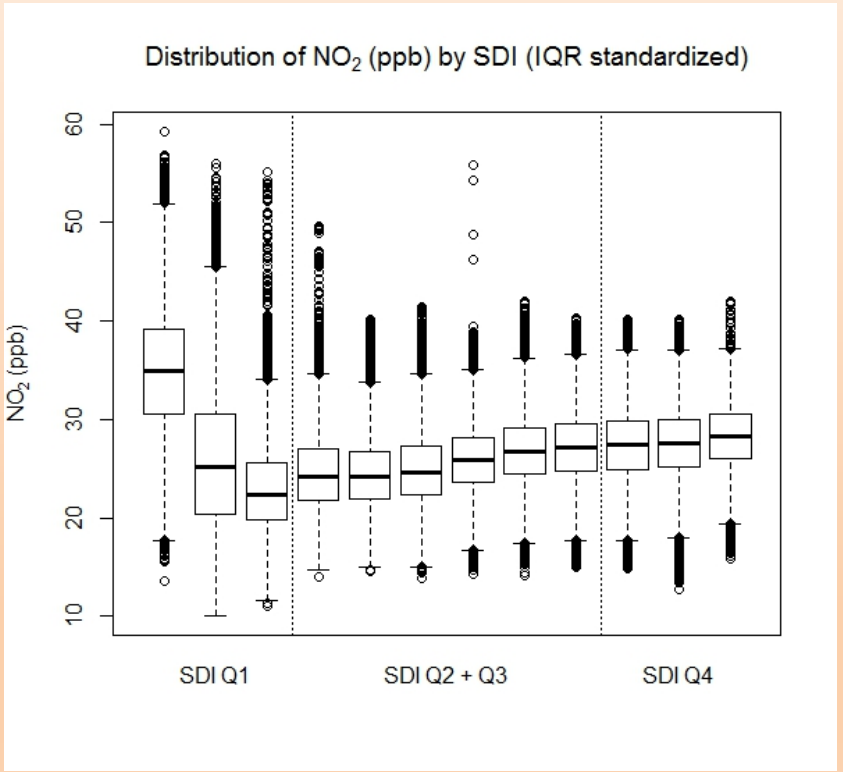
On average, lower-SES communities experience higher (primary) pollution exposures (Clark et al, 2014).

Some air pollution sources (e.g., traffic) inherently confounded by chronic stressors (e.g., noise).

But, (non-linear) joint distributions can complicate adjustment/ interpretability.







Carr Shmool et al., *Am J Epidemiol 2015*

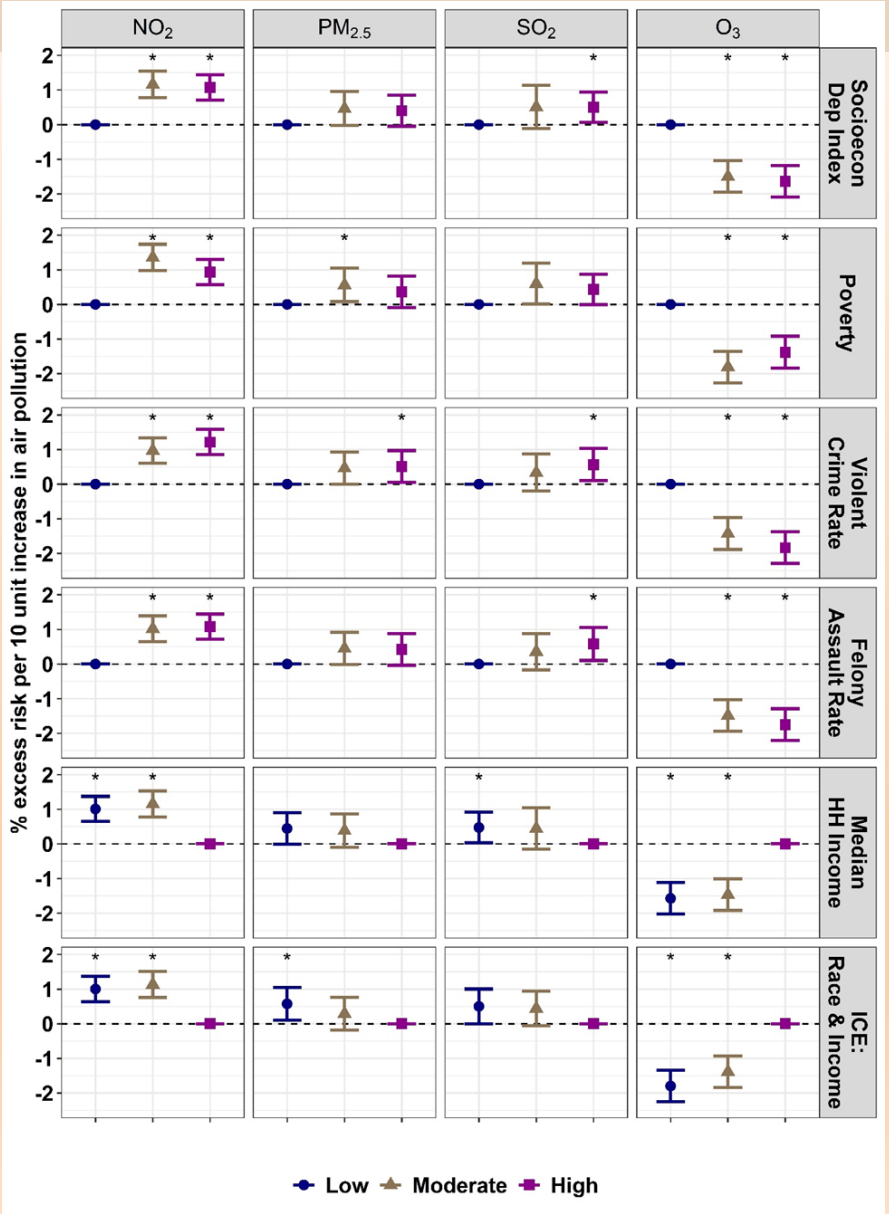
NO_2 map authorship: Grant Pezeshki, NYCCAS Team, New York City Department of Health and Mental Hygiene

Effect Modification: AP-CVD associations by SES

Studies report stronger AP health effects among lower-SES populations (Jerrett et al, 2004; Hicken et al., 2016).

We observed stronger (primary) pollution-CVD relationships in communities of higher stressor exposures in NYC.

**Elucidating susceptibility identifies opportunities to cost-effectively target AP interventions, to optimize benefits.*



Clougherty et al, *HEI Res Rep, under review*

Or, is pollution one way in which SES 'gets under the skin"??

Requires **mediation** analysis/ decomposition analysis:

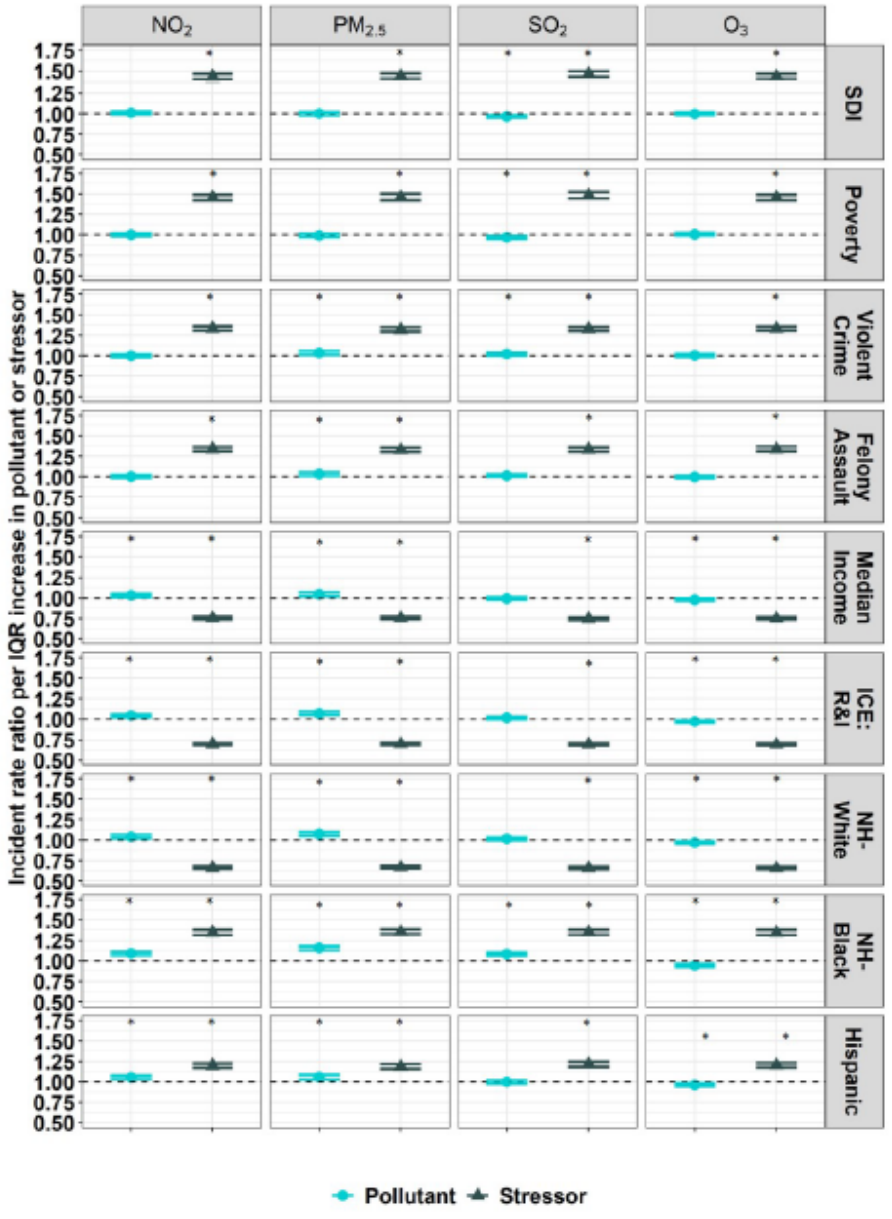
SES -> pollution -> health

Mutually-adjusted negative binomial ecologic models.

Compared pollution & SES effects at same spatial & temporal scale (annual-average census tract).

Clougherty et al, *HEI Res Rep, under review*

Figure 4: Mutually-adjusted negative binomial ecologic models for each pollutant- stressor combination vs. census tract CVD rate (n = 1,981). Each model includes only one pollutant and one social stressor. Incidence rate ratios (IRRs) represent the change in community CVD event rates per 1-IQR change in each covariate, shown with 95% confidence intervals. Asterisks indicate statistical significance after false discovery rate adjustment. ICE:R&I = index of concentration at the extremes: race & income; SDI = social deprivation index.



Conclusions I

- SES is complicated.
  - A *relational* construct among individuals – varies across space, time, culture.
- SES may confound or modify air pollution effects on health
  - Or, mediation: Pollution may be one way SES "gets into the body."
- Urge attention to:
  - Thoughtful measurement of SES
    - Appropriate to the population under study.
    - Specific to hypothesized pathway(s).
  - Issues of scale/ differential misclassification for air pollution & SES.

Conclusions II

- The path forward:
  - Elucidating components (stressors) within SES.
    - Varying roles in confounding/ modifying effects of air pollution on health.
  - Multiple-modifier models:
    - Simultaneous modification by multiple (correlated) susceptibility factors.
  - Mediated-modifier models
    - To identify specific components (stressors) explaining modification by SES.
    - *To quantify that portion of the (large) SES effect on health which may be attributable to pollution.*

Acknowledgments

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Health Effects Institute (HEI) 15-2: Social Susceptibility to Multiple Air Pollutants in CVD

EPA-G2009-STAR-E-2: Community Stressors and Susceptibility to Air Pollution in Urban Asthma (Clougherty)

NIH 1 R21 ES021429-01: Children's Health and Vulnerability to Heat and Ozone in New York City (Sheffield/ Clougherty)

NIH 1R01HL114536-01: Validating GIS-based methods to address spatial uncertainty in clinical trials (Clougherty/ Holguin)

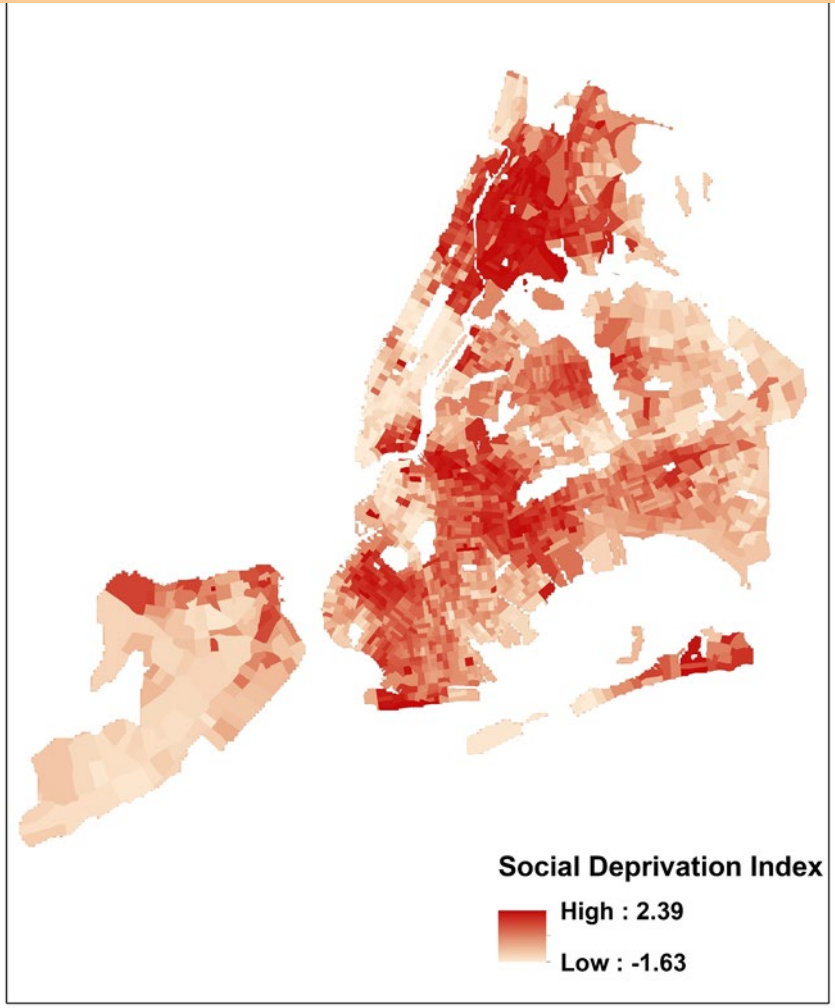
NIH 5 R01 ES19955-3: Air Pollution and Pregnancy Outcomes in NYC (Savitz)

CRDF Faculty Development Award 2011: Developing a GIS-based survey instrument to examine multiple exposures in neighborhood health research (Clougherty)

UCSUR Manners Faculty Development Award 2011: A novel geospatial modeling technique to predict individual-level chronic stress in urban communities (Clougherty)

Measuring SES: Composite metrics

Candidate SEP variables (n = 20) *Source: US Census American Communities Survey (2005-2009)*	***PCA first-component solution***	
	Spatially-Stratified	***City-wide***
Education (among adults aged > 25)		
% < High School		
% BA or more	X	
Employment (among adult labor force, aged 20-64)		
% unemployed	X	X
% males in labor force		
% females in labor force		
Housing		
% renter occupied (among occupied units)		
% vacant housing units (among total housing units)		
% crowded (> 1 occupant per room, among occupied housing units)	X	X
Occupation (among full-time, year-round civilian employed population)		
% adults in management or professional occupations	X	
Income		
% households in poverty (< 200% Federal Poverty Line)	X	
% Families w/ annual income < $35,000 (2009 inflation-adjusted)		
% female householders with children aged < 18		
% households w/ public assistance income	X	
% households w/ Food Stamp benefits (in past 12 months)		
Median household income (in the past 12 months)		
% renter or owner housing costs in excess of 30% household income (in past 12 months)		X
Racial composition		
% African American (non-Hispanic)		X
% non-white (calculated as inverse of non-Hispanic white population)	X	
% Hispanic		
Language		
% speak English less than "very well" (among pop > 5 years old who speak a language other than English at home)		



Humphrey et al 2019

Identifying a meaningful "neighborhood"

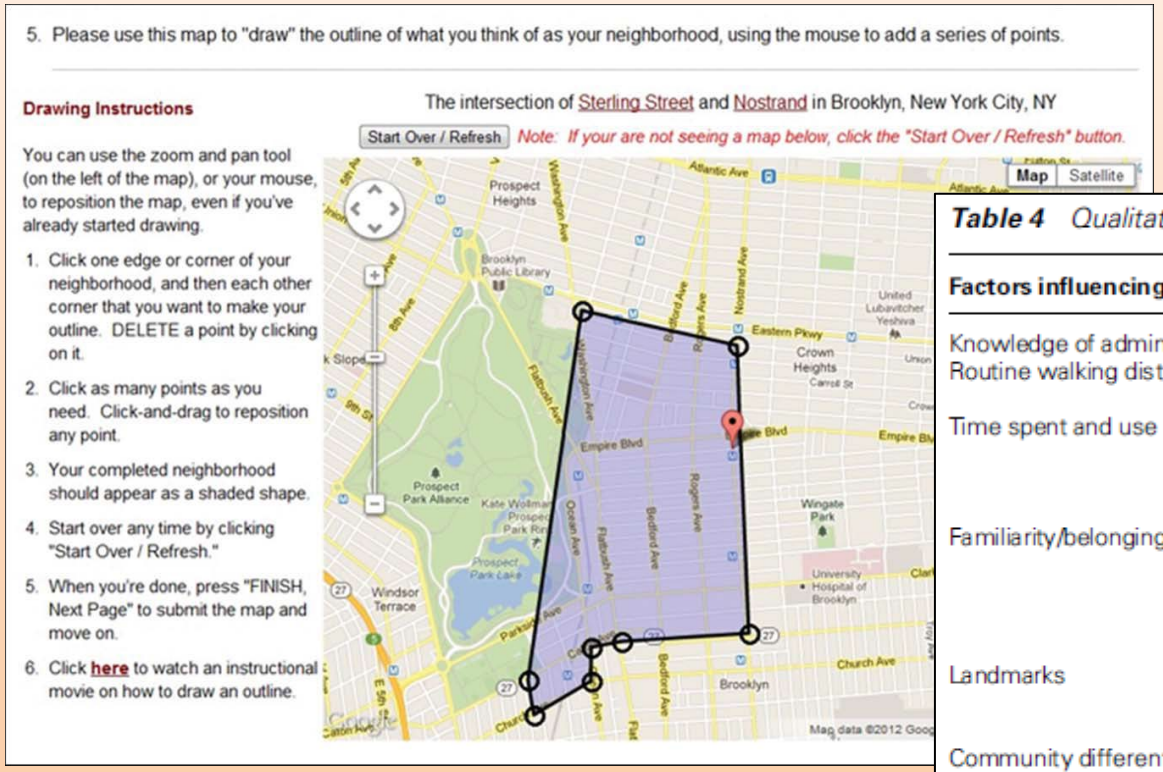


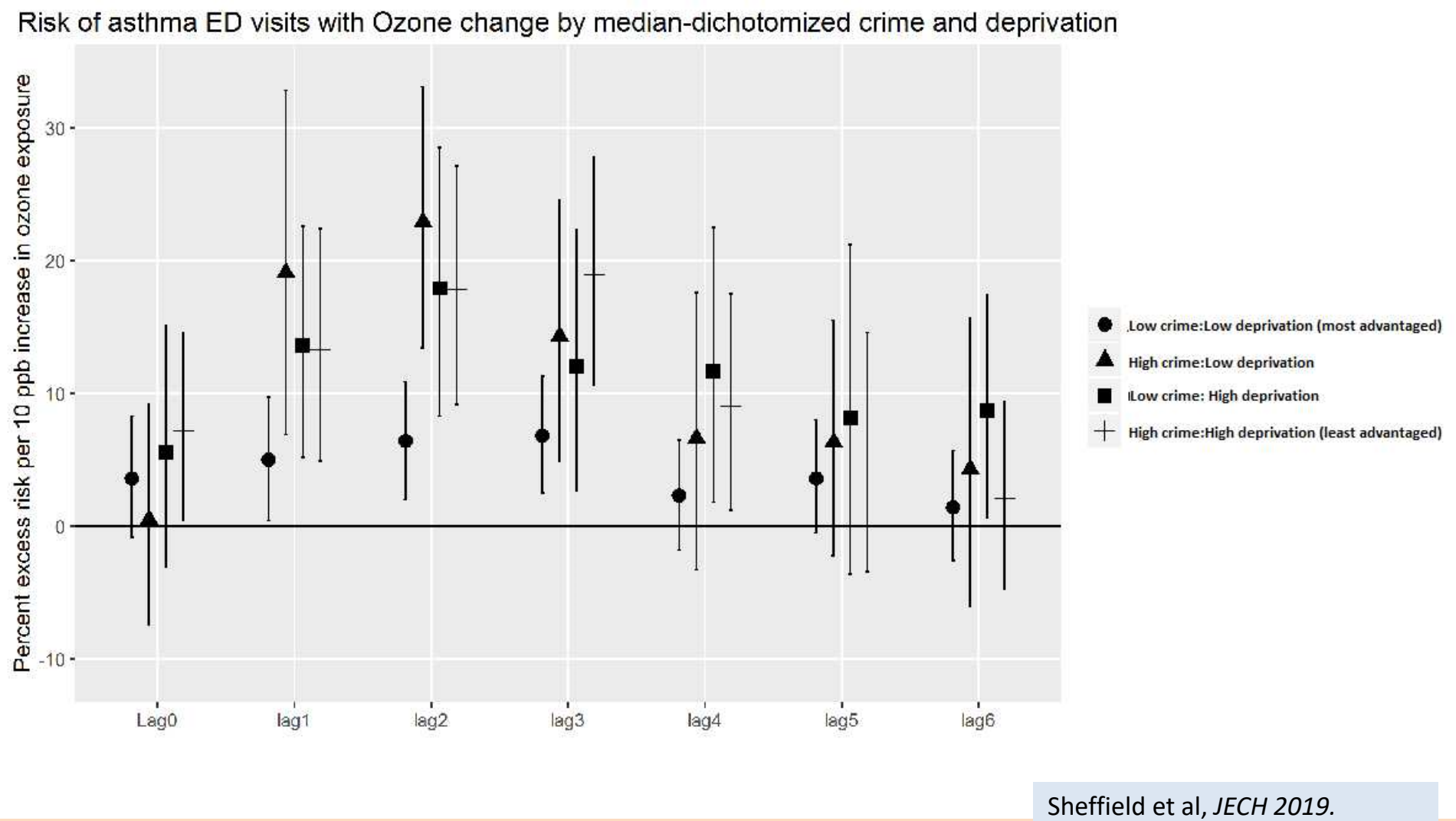
Table 4 *Qualitative factors influencing neighborhood delineation*

Factors influencing neighborhood delineation	Quotations and examples[a]
Knowledge of administrative or political boundaries	Neighborhood association boundaries; real estate divisions; street signs (Pittsburgh)
Routine walking distance	Area I "cover on foot" (Pittsburgh) "Daily walking route" (New York)
Time spent and use	Leisure walking; dog walking; "Area I utilize" (Pittsburgh) "Stores where I stop" (New York) "Work, shop, and play" (New York)
Familiarity/belonging	Area where people feel comfortable; "Feel houses in the area are the same" (Pittsburgh) "I know most people" (New York) "Feel at home" (New York) "Where I could offer welcome and help to someone visiting" (New York)
Landmarks	Major streets, parks, natural boundaries, and rivers; "Railroad tracks" (Pittsburgh) "Cemetery is a major break" (Pittsburgh)
Community differentiation	"Point where I would feel I would be in a different neighborhood" (Pittsburgh) "I tried to stay outside of the adjacent neighborhood" (Pittsburgh) "Where one ends and the other begins" (New York) "Change in spirit in surrounding areas" (New York)
Socioeconomic characteristics (New York only)	Race, class, and ethnic borders; e.g., "Where the buildings start to get more expensive"
Transportation (New York only)	Subway stops

[a]Unquoted examples represent reasons stated in both cities, unless specifically noted.

Shmool et al, *Professional Geographer*, 2018.

Multiple modifiers: Violent crime & material deprivation



Sheffield et al, *JECH 2019.*