Investigation of Association between Environmental and Socioeconomic Factors and Preterm Birth in California

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Background

Preterm birth (PTB), defined birth before 37 weeks of gestation, is a significant cause of newborn morbidity and mortality, resulting in tremendous individual suffering and societal economic burden. Relationships have been identified between PTB and environmental/chemical exposures, and social factors. However, fewer studies evaluate the joint effects of environmental exposure and social factors upon PTB.

Research Objectives

- 1. Investigate associations between environmental exposures and PTB;
- 2. Examine potential effects of environmental justice indicators, data that emphasize certain aspects or trends in the environment^{1,} upon preterm birth;



3. Understand geographic variability of preterm birth and environmental exposures in California.

Data & Variables

1. The California Communities Environmental Health Screening Tool (CalEnviroScreen) Version 3.0 Data²

CalEPA 🚫 OFHHA CalEnviro	Pollution Burden	Population Characteristics	
California Environmental Protection Agency CalEnviroScreen: - Helps California identify the most	Exposures - Ozone Concentrations - PM2.5 Concentrations	Sensitive Populations - Asthma Emergency Department Visits	
environmentally burdened and disadvantaged communities. - Inform policies, programs and activities within	 Diesel PM Emissions Drinking Water Contaminants Pesticide Use Toxic Releases from Facilities Traffic Density 	- Cardiovascular Disease (Emergency Department visits for Heart Attacks) - Low Birth Weight Infants	
the California EPA. Limitations	Environmental Effects	Socioeconomic Factors	
 Not definitive in estimating individual exposure levels Not cover all pollutants 	 Cleanup Sites Groundwater Threats Hazardous Waste Impaired Water Bodies Solid Waste Sites and Facilities 	 Educational Attainment Housing Burdened Low Income Households Linguistic Isolation Poverty Unemployment 	

8035 census tracts, 80+ variables (including drinking water contaminants variables, details in Table 1)

Figure 1. Categories of Variables in CalEnviroScreen 3.0 (Adapted from CalEnviroScreen 3.0 Report²) **Table 1. Variable Definitions**

Facilities

Variable Name	Description
Ozone	Amount of daily maximum 8 hour Ozone concentration
PM2.5	Annual mean PM 2.5 concentrations
Diesel PM	Diesel PM emissions from on-road and non-road sources
Pesticides	Total pounds of selected active pesticide ingredients (filtered for hazard and volatility) used in production-agriculture per square mile in the census tract
Tox. Release	Toxicity-weighted concentrations of modeled chemical releases to air from facility emissions and off-site incineration (from RSEI)
Traffic	Traffic density, in vehicle-kilometers per hour per road length, within 150 meters of the census tract boundary
Cleanup Sites	Cleanup sites, sum of weighted EnviroStor cleanup sites within buffered distances to populated blocks of census tracts
Groundwater Threats	Groundwater threats, sum of weighted GeoTracker leaking underground storage tank sites within buffered distances to populated blocks of census tracts
Haz. Waste	Sum of weighted hazardous waste facilities and large quantity generators within buffered distances to populated blocks of census tracts
Imp. Water Bodies	Impaired water bodies, sum of number of pollutants across all impaired water bodies within buffered distances to populated blocks of census tracts
Solid Waste	Sum of weighted solid waste sites and facilities (SWIS) within buffered distances to populated blocks of census tracts
Linguistic Isolation	Percent limited English speaking households
Poverty	Percent of population living below two times the federal poverty level
Unemployment	Percent of the population over the age of 16 that is unemployed and eligible for the labor force
Housing Burden	Percent housing burdened low income households
Arsenic	Arsenic average (ppb)
Cadmium	Cadmium average (ppb)
DBCP	1,2-dibromo-3-chloropropane average (ppb)
HexChrom	Hexavalent chromium average (ppb)
Lead	Lead average (ppb)
Nitrate	Nitrate (as NO ₃) average (ppm)
Perchlorate	Perchlorate average (ppb)
TCE	Trichloroethylene average (ppb)
ТНМ	Total trihalomethane average (ppb)
Uranium	Uranium average (PCI/L)
MCL Violations	The total number of Maximum Contaminant Level (MCL) violations for any chemical by system from 2008 to 2012 population weighted to the census tract
TCR Violations	Total coliform rule violations by system from 2008 to 2012 population weighted to the census tract
	A violation was indicated by these codes:

Figure 4. Heatmap of County-averaged Contaminants Exposure Levels in California

Table 3.	Logistic	GLM	Output	from	Experime	ent E

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Code 21 - MCL, Acute (TCR) Code 22 - MCL, Monthly (TCR)

2. Office of Statewide Health Planning and Development Patient Discharge (OSHPD) Data (2009-2012) - 1.8 million birth records, 6.5k unique census tract IDs

OSHPD - Variables: maternal demographics (e.g. race/ethnicity, gender, age, nationality), socioeconomic factor (e.g. education, insurance coverage), birth record (e.g. term vs. preterm, Office of Statewide Health Planning and Development gestational age), maternal medical information.

Methods

Data Merging & Matching

We matched the OSHPD birth records with the CalEnviroScreen 3.0 data based on coded geographic information (i.e. census tract). If a census tract identifier for a birth record was not available, we used zip code level information as surrogate. All data merging & matching was performed using statistical software RStudio Version 1.0.136 (RStudio, Inc., Boston, MA, 2016).



Figure 3. Unmatched Census Tracts Labels

Statistical Analysis

We used logistic regression to evaluate the relationship between environmental pollutant data, social factors and preterm birth (<37 weeks). We estimated the relationship between pollutant variables (individually and all together) and preterm birth while accounting for potential confounders including maternal race/ethnicity, maternal age, maternal education and mom's insurance coverage type (private insurance or not).

For certain contaminants of interest, we also performed county-wise Student's t-test comparing their mean concentrations (preterm birth vs. term birth). Logistic regression models were fitted for each county using the particular contaminant variable of interest adjusted by confounding variables.

Note: Peach colored rows indicate statistically significant pollutant variables with association directions we expected.

CalEnviroScreen 3.0 Drinking Water Contaminant - Arsenic



Figure 5. Correlation Plot of Contaminant Variables in the Matched Data

Logistic Regression Model for each county

Preterm Birth Category = Arsenic + Race + Maternal Age + Maternal Education + Private Insurance

Comparison based on arithmetic means (PTB vs. TB)



Area Weighting Method Updated Matched(74%)

OSHPD

Interpolation based on Zipcode

Final Merged data (99%)

Figure 2. Data Matching Procedure

Initial Matched (40%)

CES 3.0

Except Placer, San Benito and Santa Cruz, most of the counties w/ empty labels and zero matched records are rural counties, including: Alpine, Amador, Calaveras, Colusa, Inyo, Lake, Lassen, Mendocino, Modoc, Mono, Plumas, Shasta, Sierra, Siskiyou, Tehama, Trinity

ArcGIS Mapping

We also generated maps for contaminant variables of interest in order to evaluate the geographic variability of certain environmental pollution across California.

Results

Logistic Regression Models

A. Preterm Birth Category ~ Summary variable + Demographic

Table 2. Logistic GLM Output from Experiment A

	p value	IQR	OR for IQR
Pollution Burden	0.0007	17.2946	0.9812
Pop Characteristic	<0.0001	31.14474	1.1649
Drinking Water Score	<0.0001	392.05	1.0400

B. Preterm Birth Category ~ Pollution Burden (PB) + Drinking Water Contaminants (DW) + Socio-economic Factors (SES) + Demographic variables

Summary variable: Pollution Burden, Population Characteristic, DW

PB: Ozone, PM_{2.5}, Diesel PM, Pesticides, Toxic Release, Traffic, Cleanup Sites, Ground Water Threats,

Hazardous Waste, Impaired Water Bodies, Solid Waste

SES: Linguistic Isolation, Poverty, Unemployment, Private Insurance

DW: Arsenic, Cadmium, DBCP, Lead, Nitrate, Perchlorate, PCE, TCE, THM, Uranium, TCP, MCL Violations, TCR Violations

Demographic: Race, Maternal Age, Maternal Education

Figure 6. Figure 6. Arsenic Levels for Term Birth vs. Preterm Birth for **Selected Counties**

Figure 7. Spatial Distribution of Arsenic Levels (ppb) in Drinking Water in California

Discussion:

- CalEnviroScreen data was useful in providing environmental and social information for identifying exposure-outcome associations;
- Certain drinking water contaminants such as Arsenic and Nitrate were found to be associated with preterm birth;
- Association between preterm birth and certain pollutants varied for different counties;
- 4. Urbanization level of a county modified the above-mentioned associations.

Key References:

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