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Research Report 205

Improvements in Air Quality and Health Outcomes Among California Medicaid Enrollees Due to Goods Movement Actions

Ying-Ying Meng et al.

Appendix 1. Phase 1 Air Quality Improvements

Appendix 2. LUR Modeling and Concentration Assessment

Appendix 3. Improvements in Air Pollution Concentrations and Health Effects

These Appendices were reviewed solely for spelling, grammar, and cross-references to the main text. They have not been formatted or fully edited by HEI. This document was reviewed by the HEI Review Committee.

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APPENDICES

Appendix 1: PHASE I AIR QUALITY IMPROVEMENTS

Assessing Air Quality Improvements using Port Authority and SCAQMD Data

The project was designed to be conducted in two phases. During Phase I of the project (9/2012-12/2014), in the fall of 2012 and spring of 2013, we deployed two new rounds of Ogawa NO_X fixed-site saturation monitors in the counties of Los Angeles and Alameda. Using previously collected Ogawa monitoring data for 2004-2005 (Alameda) and 2006-2007 (Los Angeles) and our newly collected 2012-2013 data (Alameda and Los Angeles), we have determined that improvements in air quality in GMCs are statistically significantly greater than in CTRLs after controlling for truck/vehicle kilometers traveled, cargo volume, meteorological conditions, and other factors.

Previous research suggested that we can expect to detect changes in health effects associated with air quality improvement measures when pollutant concentrations are reduced by a factor of 1.5 or greater (van Erp and Cohen 2009). From Phase I of our study, we found the annual average levels of $PM_{2.5}$ decreased from 14.5 to 9.4 µg m^{-3} between 2007 to 2010 at the Long Beach Port; $PM_{2.5}$ concentrations decreased from 13.7 to 7.1 µg m^{-3} in the source dominated Pier 300 station in the Los Angeles Port. The magnitude of reduction in $PM_{2.5}$ in neighborhoods around the Los Angeles and Long Beach Ports ranged from 1.5 to 1.7, making it highly likely that we will be able to identify improvements in common health conditions related to air pollution reduction. In addition, we used the Port of Los Angeles cargo volume and pollutant concentrations measured by the Southern California Air Quality Management District (SCAQMD) to compare trends. The purpose was to see whether decreases in air pollutant concentrations could be associated with the economic downturn, shown below by using cargo volume as an indicator. Cargo volumes were measured by twenty-foot equivalent units (TFEUs), a standardized maritime industry measurement used when counting cargo containers of varying lengths. Based on the monitoring data from SCAQMD, the mean NO_X concentrations in GMCs decreased by over half, from 67.99 ppb in 2003 to 34.75 ppb in 2012, a reduction factor of 2.0 (Figure A1-1). Mean NO_X concentrations in CTRLs decreased from 39.89 ppb in 2003 to 18.85 ppb in 2012, a reduction factor of 2.1. While Los Angeles Port cargo volume, shown at the top of the graphs below, demonstrated some fluctuations over the ten years, NO_X concentration and port cargo volume trend lines are not similar, suggesting that decreases in NO_X concentrations are not mainly related to changes in port cargo volume.

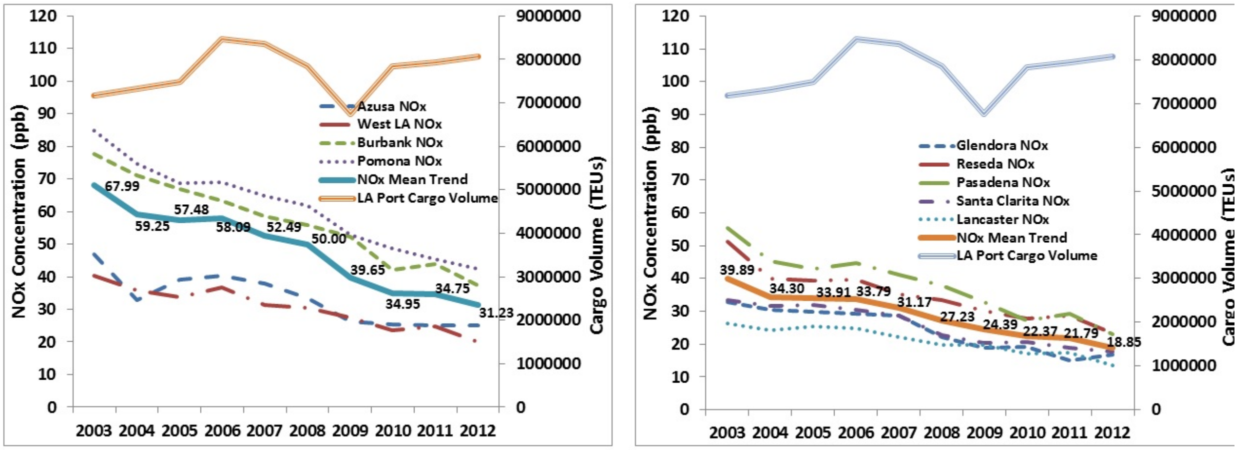

Figure A1-1. NO_X in GMC (left) vs. CTRL (right) from SCAQMD monitoring and port cargo volumes.

Similarly, NO_2, mean concentrations in GMCs steadily decreased from 30.60 ppb in 2003 to 18.72 ppb in 2012, a reduction factor of 1.6 (Figure A1-2). Mean NO_2 concentrations in CTRLs decreased from 23.78 ppb in 2003 to 13.23 ppb in 2012, a reduction factor of 1.8. Again, the shape of the Los Angeles Port cargo volume and NO_2 mean concentration trend lines are not similar, suggesting that decreases in NO_2 concentration are not mainly related to changes in port cargo volume. The air pollution reduction factors for NO_2 and NO_X ranged from 1.6 to 2.1, further indicating that it is feasible to identify possible improvements in health outcomes from the pre- to the post-policy intervention periods across domains.

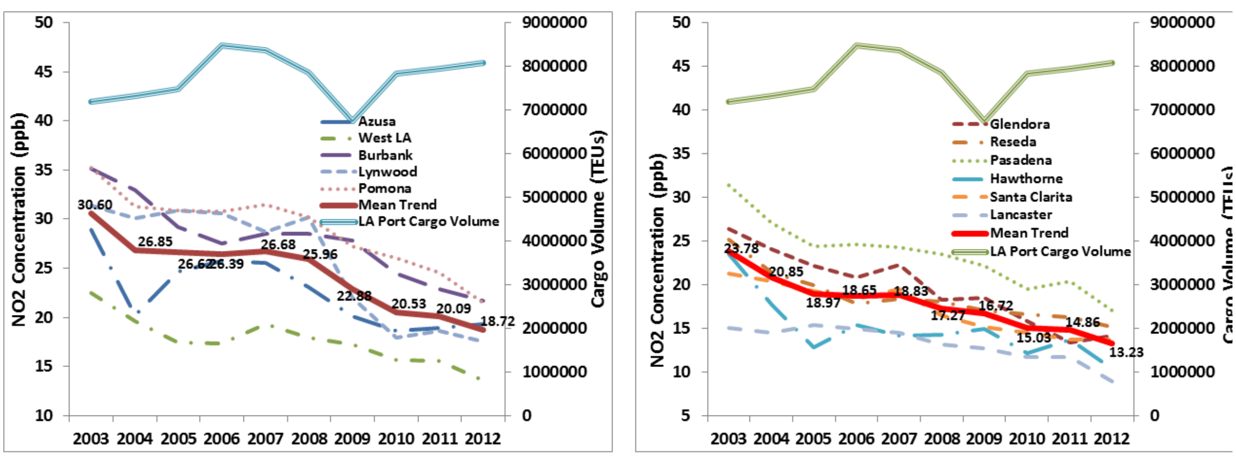

Figure A1-2. NO_2 in GMC (left) vs. CTRL (right) from SCAQMD monitoring and port cargo volumes.

Fixed Site Ogawa Saturation Monitoring Results

To address the issue of lack in the granularity of monitoring data across space and time needed to characterize the consequences of goods movement regulations from government monitoring network, we deployed our own Ogawa monitors. During Year 1 of the project (fall 2012 to spring 2013), we successfully designed and deployed two new rounds of NO_X sampling in Los Angeles and Alameda counties. For the first round of deployment in Los Angeles, Ogawa samplers were deployed at 72 sites (92 monitors) in the fall of 2012 and collected from 70 sites (90 samplers, with two samplers lost due to vandalism). Data were available from 25, 21, and 24 sites in GMC, NGMC, and CTRL areas, respectively. Of note, all Ogawa samplers co-located with government sites had effective measurements. For our second round of deployment in Los Angeles County in spring 2013, Ogawa samplers were deployed and collected at 72 sites with a total of 92 monitors. The number of sites with effective data collection was 26, 22, and 24, for GMC, NGMC, and CTRL areas, respectively, with all government co-located sites having effective measurements.

In the San Francisco Bay Area (mainly in Alameda County), we successfully deployed 60 monitors at 49 sites and retrieved all deployed monitors in fall 2012 and spring 2013, during the same periods when Ogawa monitors were deployed and collected in Los Angeles. The number of sites with effective data collection was 19, 16, and 14, for GMC, NGMC, and CTRL areas, respectively. All Ogawa monitors co-located with government sites had effective measurements.

All sites were selected from those already used for Ogawa monitoring during the pre-policy period, specifically from 198 sites in Los Angeles monitored in fall 2006 and spring 2007 and 51 sites in the San Francisco Bay (one in Contra Costa County and the others in Alameda County) in fall 2004 and spring 2005.

Pollution Reductions Based on Ogawa Measurements

Figure A1-3 displays boxplots of the measured NO_2, NO, and NO_X concentrations for the pre-policy (left-side of a panel) and post-policy (right-side of a panel) periods for Los Angeles (first three panels) and Alameda (the fourth panel) sites, summarized by domain. In Los Angeles, the median NO_2

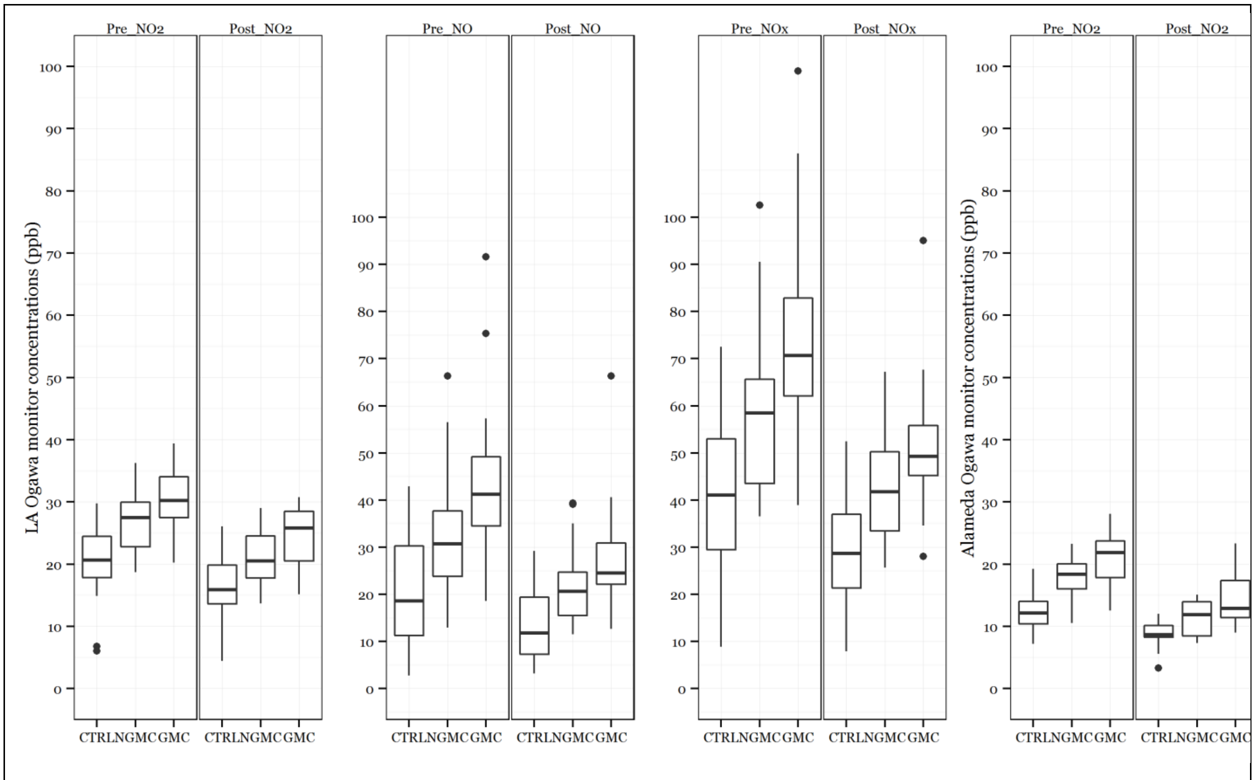

Figure A1-3. Boxplots of the measured NO_2, NO, and NO_X concentrations for the pre-policy (left-side of a panel) and post-policy (right-side of a panel) periods for Los Angeles (first three panels) and Alameda (the fourth panel), summarized by location category. (Data plots for NO and NO_x reprinted with permission from Su et al 2016. Copyright 2016 American Chemical Society.)

concentrations decreased (in ppb), from 30.24 to 25.79, from 27.47 to 20.49, and from 20.67 to 15.92 in GMC, NGMC, and CTRL areas, respectively. For the near-source pollutant NO, reductions (in ppb) were 16.63, 10.09, and 6.80 in GMC, NGMC, and CTRL areas, respectively. For NO_X, the respective reductions (in ppb) in GMC, NGMC, and CTRL areas were 21.41, 16.67, and 12.37. The range of reduction factors for NO was 1.5-1.7, with GMCs having the greatest reduction factor. For NO_X and NO_2, the reduction factors were 1.40-1.43 and 1.2-1.3, respectively. Please note, Ogawa measurements in Los Angeles for the pre-policy period were conducted in fall 2006 and spring 2007, late in the pre-policy period. We expect if measurements had been taken earlier in the pre-policy period, starting from 2003, we would have captured greater reduction factors for NO_2 and NO_X than the factor of 1.5 recommended by van Erp and Cohen (2009) (please see the air pollution trend analyses above using government continuous monitoring data). This is clearly the case for Alameda. In Alameda, the pre-policy Ogawa measures for NO_2 were taken in the fall of 2004 and spring of 2005. The post-policy Ogawa measures were taken in the fall of 2012 and spring of 2013. The median concentrations of NO_2 were reduced (in ppb), from 21.86 to 12.91, from 18.36 to 11.85, and from 12.11 to 8.64 in GMC, NGMC, and CTRL areas, respectively. The corresponding reduction factors were 1.7, 1.6, and 1.4 in GMCs, NGMCs, and CTRLs. These findings further confirm that it is feasible to identify possible improvements in health.

Agreement of Ogawa Monitoring with Co-located Government Monitoring

We colocated Ogawa monitors with government monitors for every two 2-week periods during which Ogawa saturation sampling was conducted and modeled relationships between types of monitoring (Figure A1-4). Co-located site data exist for Los Angeles and Alameda for 2004-2005 (Alameda), 2006-2007 (Los Angeles), and 2012-2013 (Alameda and Los Angeles). For NO_2, 56 colocated samples were retrieved, and for NOx, 50 were retrieved (In Alameda, Ogawa was only used to measure NO_2 in the 2004-2005 pre-policy period). Figure 4 indicates that Ogawa-measured concentrations correlated well with government-measures (R^2 = 0.87 for NO_2 and 0.90 for NO_X), with NO_2 being slightly underestimated and NOx being slightly over-estimated.

Policy Effect on Reductions of Pollutant Concentrations Based on Modeling Ogawa Monitoring

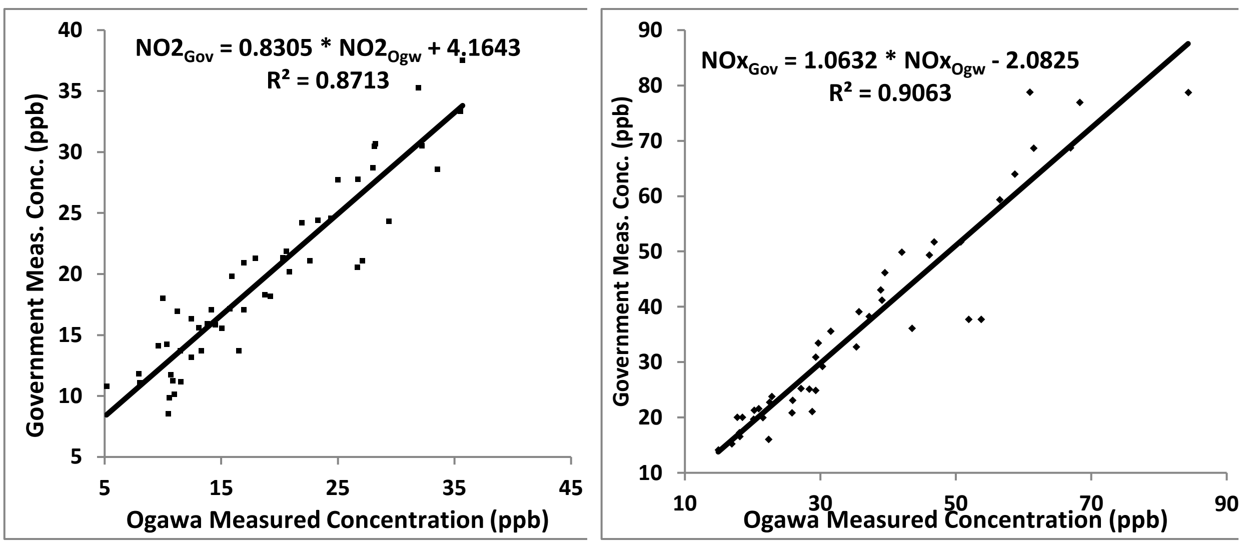

Figure A1-4. Agreement between the government monitoring and Ogawa monitoring at the co-located sites. (Reprinted with permission from Su et al 2016. Copyright 2016 American Chemical Society.)

Results

Using linear mixed models, we analyzed the difference in concentrations measured by Ogawa monitors in pre- and post-policy periods and between GMCs versus NGMCs and CTRLs. To adjust for the effects of weather and economic recession on reductions of air pollutant concentrations, we acquired data that could confound regulatory policy effects, including meteorology (e.g., precipitation, temperature, and wind speed), monthly and annual port cargo volumes from the major ports, annual average daily traffic (AADT) volumes for highways and major roadways, and AADT for truck-permitted highways and major roadways. The weighted cargo volume is calculated as follows:

$$g_{si} = \sum_{p=1}^{2} {g_{pi}}/{d_{ps}} \quad (1)$$

g_{si} is the weighted cargo volume for monitor *s* at time *i* (*i* = 2003-2012). g_{pi} is the annual total cargo volume for port *p* (*p*=1 for LA/LB and *p*=2 for Oakland) at the time period *i*. d_{ps} is the distance between port *p* and monitor *s*.

Models were developed using the following two steps:

1) We estimated the independent effects of domain and policy period on pollutant concentrations while adjusting for possible confounding factors. We treated the site as a random effect. The model we employed is shown in Eq. 2:

$$y_{si} = \beta_0 + \mathrm{d_s} + p_\mathrm{i} + \beta_1 f_\mathrm{si} + \gamma_\mathrm{s} + \varepsilon_\mathrm{si} \quad (2)$$

y_{si} is the pollutant concentration at site *s* for policy period *i*. $\mathrm{d_s}$ is the domain/location category, i.e., GMC, NGMC, or CTRL, with CTRL being the reference. p_i indicates the policy period during pollutant sampling, with the pre-policy period being the reference. $\mathrm{f_i}$ represents confounding factors that might impact the relationship between measured concentrations and policy regulation, including traffic density, cargo volume, and meteorology. β_0 is the model constant; β_1 is a vector of coefficients for possible confounding factors. γ_s is the random effect at site s and ε_si is the error term of site *s* for policy period *i*. Because the domain of a site did not change between the two policy periods, $\mathrm{d_{si}}$ was simplified in the model to $\mathrm{d_s}$. Similarly, since regulation policies were the same across all sites, $\mathrm{p_{si}}$ was simplified to $\mathrm{p_i}$. Separate models as in Eq. 2 were used to model pollutant concentrations of NO_2 and NOx.

2) We created an interaction term between domain and policy period to assess whether reductions in pollutant concentrations in GMCs from pre- to post-policy periods were greater than corresponding reductions in CTRLs. The modeling technique is described below in Eq. 3:

$$y_{si} = \beta_0 + \mathrm{d_s} + \mathrm{p_i} + \mathrm{d_s p_i} + \beta_1 \mathrm{f_{si}} + \gamma_\mathrm{s} + \varepsilon_\mathrm{si} \quad (3)$$

where $\mathrm{d_s p_i}$ is the interaction between the domain of site *s* and policy period *i*. Other variables have the same definition as in Eq 2. In the regression equations, the categorical covariates will be modeled in the usual manner as a series of dummy variables.

The linear mixed-effects modeling results with the interaction terms (based on Eq. 3) for NO_2 and NO_X are shown in Table A1-1. For NO_2, we found that being in a GMC was associated with significantly higher concentrations (than being in a CTRL area), followed by being in an NGMC. Greater precipitation and higher wind speed were found to be associated with lower NO_2 concentrations due to dispersion and sinking effects. Total vehicle miles traveled on highways and connecting roadways were positively associated with NO_2 concentrations; however, cargo volume and truck vehicle miles traveled did not significantly impact NO_2 concentrations. The spring season (rainy season) generally had lower NO_2 concentrations than the fall season, and Los Angeles sites had higher NO_2 concentrations than Alameda sites. For the interaction term, we found that reductions in NO_2 from the pre-policy to the post-policy period were significantly greater in GMCs compared to the reductions in CTRL areas after controlling for traffic, cargo volume, and meteorology. Reductions of NO_2 were also significant in NGMCs, compared to those in CTRLs.

For NO_X, we found that being in a GMC area had the greatest impact on pollutant concentrations, followed by being in an NGMC. These differences were greater than they were for NO_2. Similar to NO_2, greater precipitation and higher wind speed were associated with lower NO_X concentrations. Total vehicle miles traveled on highways and connecting roadways were positively associated with NO_X concentrations; however, cargo volume and truck vehicle miles traveled did not significantly predict NO_X concentrations. Compared to the pre-policy period NO_X, post-policy period NO_X concentrations were still statistically significantly lower. Based on the interaction term, we found that the reductions of NO_X from the pre-policy to the post-policy period were significantly greater in GMCs than corresponding reductions in CTRLs when controlling for the same factors that predict the exposures. The non-significant interaction term for NGMC and policy period, however, indicates that policy regulations did not reduce NO_X in NGMCs vs. CTRLs.

Table A1-1. Modeling the effect of policy regulations on reductions of pollutant concentrations for NO_2 and NO_X while controlling for traffic, cargo volume, meteorological conditions, season and region.§

		Coeff	S.E.	t-Val	p-Val
NO2	(Intercept)	33.059945	2.445339	13.5196	0.000
	Condition – GMC	7.570715	1.388160	5.4538	0.000
	Condition – NGMC	3.422824	1.097543	3.1186	0.002
	Policy Period – Post	-4.161154	0.452964	-9.1865	0.000
	Precipitation (In)	-2.085161	0.284733	-7.3232	0.000
	Temperature (^{O}F)	-0.067602	0.035417	-1.9088	0.056
	Wind Speed (mph)	-2.196679	0.286575	-7.6653	0.000
	Distance weighted Cargo (TEU/KM)‡	0.000004	0.000004	0.9996	0.318
	Vehicle Kilometers Traveled	0.000003	0.000001	2.2858	0.022
	Truck Kilometers Traveled	-0.000038	0.000038	-0.9981	0.318
	Season – Spring	-1.394105	0.396553	-3.5156	0.000
	County - Los Angeles	9.259356	0.711465	13.0145	0.000
	Condition - GMC * Policy Period - Post	-2.706126	0.613683	-4.4096	0.000
	Condition - NGMC * Policy Period - Post	-1.566309	0.628940	-2.4904	0.013
NO_X	(Intercept)	122.326467	15.660905	7.8109	0.000
	Condition – GMC	18.104974	5.359311	3.3782	0.001
	Condition – NGMC	5.602362	4.236699	1.3223	0.186
	Policy Period – Post	-15.318597	1.655638	-9.2524	0.000
	Precipitation (In)	-2.816964	1.047529	-2.6892	0.007
	Temperature (^{O}F)	-0.801557	0.234634	-3.4162	0.001
	Wind Speed (mph)	-7.848811	0.970618	-8.0864	0.000
	Distance weighted Cargo (TEU/KM) ‡	0.000015	0.000012	1.2204	0.222
	Vehicle Kilometers Traveled	0.000012	0.000005	2.6609	0.008
	Truck Kilometers Traveled	-0.000004	0.000141	-0.0281	0.978
	Season – Spring	0.939653	2.570465	0.3656	0.715
	County - Los Angeles	24.389814	2.907940	8.3873	0.000
	Condition - GMC * Policy Period - Post	-7.816863	2.360474	-3.3116	0.001
	Condition - NGMC * Policy Period - Post	-2.238253	2.417354	-0.9259	0.354

§ The reference group for GMC and NGMC is CTRL; the reference group for post-policy regulation period is pre-policy regulation period. Alameda is the reference group for variable County. Fall is the reference group for variable Season.

‡ TEUs were first adjusted by respective distances to the Oakland port, LA-LB ports, and Stockton port through TEUs/Km and then added up to create a single distance weighted cargo volume for each location of interest.

We also specifically investigated the policies implemented by CARB during the last ten years and found that the *2006 Emission Reduction Plan for Ports and Goods Movemen*t was the primary policy to target big polluters. In our findings, reductions of traffic-related air pollutants in GMCs were significantly greater than in other areas for the post-policy period, after controlling for traffic, cargo volume, and meteorology; thus, it is logical to conclude that these regulatory policies had a significant impact in reducing traffic-related air pollution specific to goods movement.

Policy Effect on Reductions of Pollutant Concentrations for $PM_{2.5}$, PM_{10}, and CO

As when modeling the policy effect on reductions of NO_X, we analyzed the difference in concentrations for $PM_{2.5}$, PM_{10}, and CO measured by government monitors in the pre- and post-policy time periods and between GMCs/NGMCs and CTRLs. To adjust for the effects of economic recession on reductions of air pollutant concentrations, we controlled for confounding using annual port cargo volumes from the Los Angeles/Long Beach and Oakland ports. To model the effect of policy intervention, we created an interaction between domain and policy period to assess whether reductions in pollutant concentrations in GMCs/NGMCs from the pre- to the post-policy periods were greater than corresponding reductions in CTRLs. The modeling technique is described below in Eq. 4:

$$y_{si} = \beta_0 + d_s + p_i + d_s p_i + \beta_1 g_{si} + \gamma_s + \varepsilon_{si} \quad (4)$$

y_{si} is the pollutant concentration of $PM_{2.5}$, PM_{10}, or CO at site *s* for time period *i* (*i*=2003-2012). $d_s p_i$ is the interaction between the domain *of* site *s* and policy period for time period *i*. g_{si} represents confounding from cargo and other factors. Other variables have the same definitions as those in Eqs. 2 and 3. Separate models, as in Eq. 4, were used to model reductions of pollutant concentrations for $PM_{2.5}$, PM_{10}, and CO, and the modeling results are presented in Table A1-2. We found that for PM_{10} and CO, the reductions in concentrations for GMCs are statistically significant compared to CTRLs. The reductions in pollutant concentrations for $PM_{2.5}$ in GMCs are not statistically significant compared to CTRLs; however, the reductions in NGMCs for $PM_{2.5}$ are statistically significant compared to CTRLs.

Table A1-2. Modeling the effect of policy regulations on reductions of pollutant concentrations for $PM_{2.5}$, PM_{10}, and CO while controlling for cargo volume using state-wide monitoring data.

$PM_{2.5}$ Model				
	Coeff	S.E.	t-Val	p-Val
(Intercept)	11.1652655	1.1695381	9.547	0.000
Condition – GMC	0.1278357	1.4012394	0.091	0.927
Condition – NGMC	1.6949859	1.3315093	1.273	0.203
Policy Period – Post	-1.1497838	0.3737591	-3.076	0.002
Distance weighted Cargo (TEU/KM) ‡	-0.0110555	0.2765683	-0.040	0.968
Condition - GMC * Policy Period - Post	-0.4773312	0.4488116	-1.064	0.288
Condition - NGMC * Policy Period - Post	-1.2284427	0.4277888	-2.872	0.004
PM_{10} Model				
(Intercept)	27.9029388	1.9123472	14.591	0.000
Condition – GMC	-3.5298648	2.5918667	-1.362	0.173
Condition – NGMC	-0.3765577	2.4035161	-0.157	0.875
Policy Period – Post	-5.8445447	0.7162890	-8.160	0.000
Distance weighted Cargo (TEU/KM) ‡	1.2072906	0.7808675	1.546	0.122
Condition - GMC * Policy Period - Post	2.5816391	0.9705736	2.660	0.008
Condition - NGMC * Policy Period - Post	1.7040607	0.9098229	1.873	0.061
CO Model				
(Intercept)	4.4996247	0.5069178	8.876	0.000
Condition – GMC	1.4327507	0.6515652	2.199	0.028
Condition – NGMC	0.0956803	0.5798105	0.165	0.869
Policy Period – Post	-0.7811563	0.1889287	-4.135	0.000
Distance weighted Cargo (TEU/KM) ‡	-0.0990623	0.1778022	-0.557	0.577
Condition - GMC * Policy Period - Post	-0.7875811	0.2441875	-3.225	0.001
Condition - NGMC * Policy Period - Post	-0.1127484	0.2168386	-0.520	0.603

‡ TEUs were first adjusted by respective distances to the Oakland port, LA-LB ports, and Stockton port through TE cargo volume for each location of interest.

For all the three models ($PM_{2.5}$, PM_{10}, and CO), we found that the pollutant concentrations in the post-policy period are lower than corresponding concentrations in the pre-policy period. However, compared to CTRLs, concentrations in GMCs for PM_{10} were found to have relatively lower concentrations when the statewide data were used. This is because the levels of pollutant concentrations for the three location categories could be well mixed up when statewide data are used, with some locations in GMCs having lower concentrations than other locations in CTRLs. In addition, pollutant concentrations are not measured in all years from 2003-2012. When there are more measurements in GMCs in locations with relatively low concentrations, the mean concentrations in GMCs could be smaller than the corresponding mean in CTRL. We thus modeled their concentrations separately using the four California climate regions: the coast, the mountains, the Central Valley, and the desert. For the coastal areas, we modeled their concentrations by combining data from Los Angeles and Alameda (Table A1-3), as we did for the models on NO_2 and NO_X. Table 6 shows the reductions in concentrations of NO_2 for GMCs are statistically significant compared to CTRLs. The reductions in $PM_{2.5}$ for GMCs are marginally significant compared to the reductions in CTRLs ($p = 0.10$).

Table A1-3. Modeling the effect of policy regulations on reductions of pollutant concentrations for $PM_{2.5}$, PM_{10}, and CO while controlling for cargo volume using government monitoring data for Los Angeles and Alameda counties.

$PM_{2.5}$ Model				
	Coeff	S.E.	t-Val	p-Val
(Intercept)	11.1784166	2.4049881	4.648	0.000
Condition – GMC	6.1504905	2.9368492	2.094	0.036
Condition – NGMC	-1.0329615	2.2923530	-0.451	0.652
Policy Period – Post	-3.2940452	0.5949208	-5.537	0.000
Distance weighted Cargo (TEU/KM) ‡	-1.0178663	0.3005073	-3.387	0.001
County - Los Angeles	5.1158031	2.2731253	2.251	0.024
Condition - GMC * Policy Period – Post	-1.3350879	0.8134997	-1.641	0.101
Condition - NGMC * Policy Period - Post	0.4576244	0.7388198	0.619	0.536
PM_{10} Model				
(Intercept)	21.4241582	2.1557230	9.938	0.000
Condition – GMC	3.9171608	4.0295330	0.972	0.331
Condition – NGMC	-3.1684557	2.4179380	-1.310	0.190
Policy Period – Post	-1.7814477	1.3270550	-1.342	0.179
Distance weighted Cargo (TEU/KM) ‡	0.0910951	0.4306860	0.212	0.832

County - Los Angeles	10.5608631	2.1010060	5.027	0.000
Condition - GMC * Policy Period – Post	-5.3913847	1.7756410	-3.036	0.002
Condition - NGMC * Policy Period - Post	-1.3888416	1.5450940	-0.899	0.369
CO Model				
(Intercept)	4.8705279	0.9693180	5.025	0.000
Condition – GMC	2.4819446	1.2957760	1.915	0.055
Condition – NGMC	-0.8732379	1.0223238	-0.854	0.393
Policy Period – Post	-1.4389203	0.3393024	-4.241	0.000
Distance weighted Cargo (TEU/KM) ‡	-0.2786949	0.2076159	-1.342	0.179
County - Los Angeles	0.9228763	0.9377739	0.984	0.325
Condition - GMC * Policy Period – Post	-0.9218610	0.4582721	-2.012	0.044
Condition - NGMC * Policy Period - Post	0.4919791	0.4082064	1.205	0.228

‡ TEUs were first adjusted by respective distances to the Oakland port, LA-LB ports, and Stockton port through TEUs/Km and then added up to create a single distance weighted cargo volume for each location of interest.

Note: On some statewide models, the coefficient Condition – GMC is negative. However, it is consistent that the mean pollutant concentrations are always lower in the post-policy period (negative sign in coefficients). When we limited our study regions to Los Angeles and Alameda, we found that the coefficient Condition – GMC is positive, indicating concentrations in GMCs are higher than in CTRLs. Separate pollutant surfaces will be created using separate modeling results for each of the four climate regions.

Appendix 2: LUR Modeling and Concentration Assessment

The location categories including GMC, NGMC, and CTRL across California are displayed in Figure A2-1.

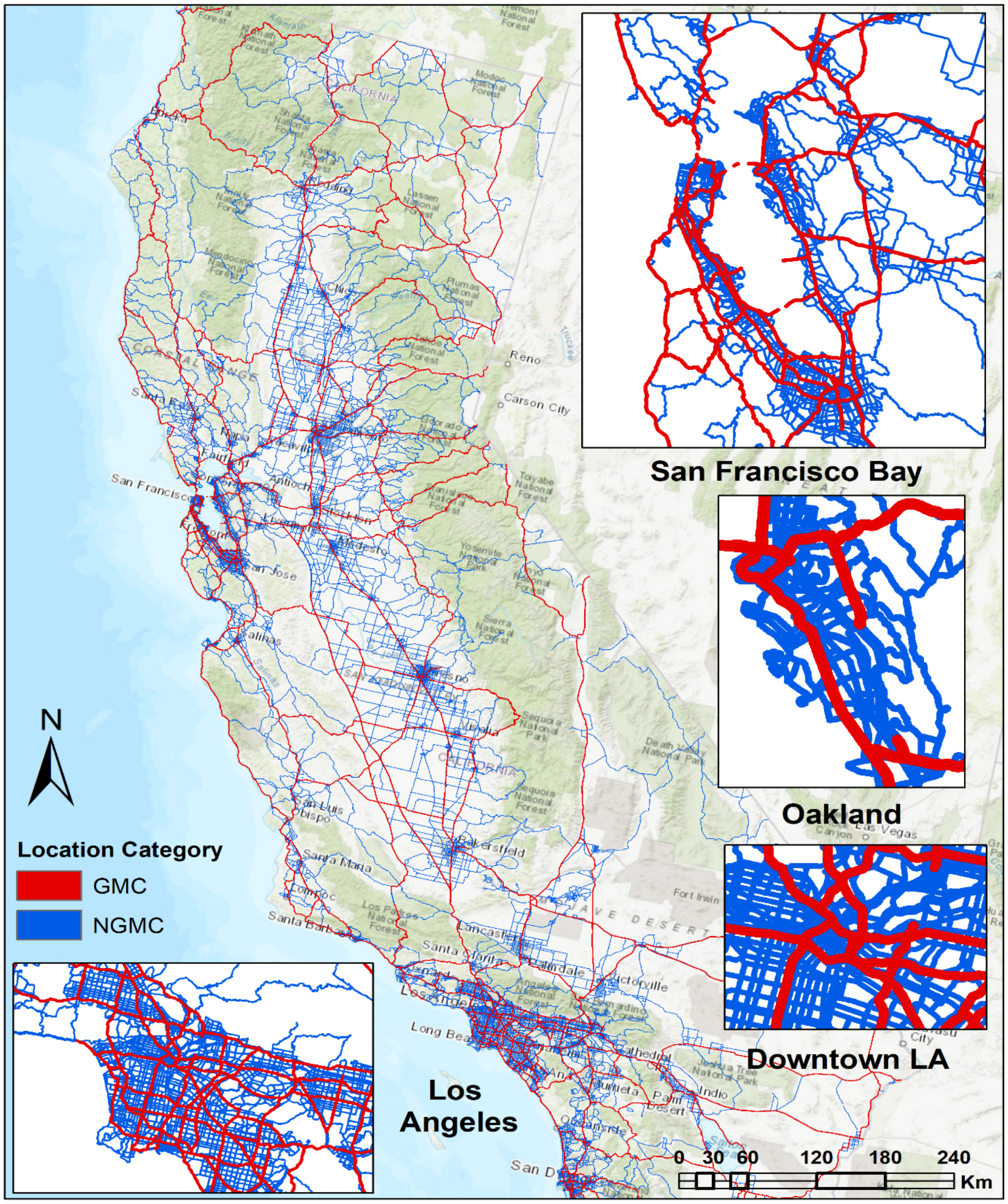

Figure A2-1. The spatial distribution of the study domains, including GMC, NGMC, and CTRL (unmasked for CTRL). The study domains are mutually exclusive, and one location can only be in GMC, NGMC, or in CTRL. (From Su et al. 2020; licensed under CC-BY-NC-ND 4.0.)

Acquisition and processing of LUR predictors

We acquired and processed related data for the development of LUR models across California and they included both buffered and non-buffered data sources. The non-buffered data sources included:

Digital elevation model (DEM) – in meters: We acquired the national elevation dataset for California from the U.S. Geological Survey (USGS) (http://nationalmap.gov and http://seamless.usgs.gov) for 2011. The data included 45 1/3 arc-second (approx. 10 meters) raster DEM and were mosaicked into a single DEM raster for the entire state.

Distance to coast – in meters: The California shoreline was derived from The National Assessment of Shoreline Change: A GIS Compilation of Vector Cliff Edges and Associated Cliff Erosion Data for the California Coast (http://pubs.usgs.gov/of/2007/1112). These data are integrated into the Geographic Information System (GIS) mapping tool to produce a geographic view of topographical changes in California's coastline over time. The most recent view was created using data collected between 1998-2002.

Distance to roadways – in meters: We used Business Analysts 2010 Street Carto map layer provided by the Environmental Systems Research Institute (ESRI in Redlands, CA) to derive the distance to the nearest highway (defined as feature class classification or FCC A1 and A2), to the nearest major roadway (FCC A3) and to the nearest local roadway (FCC A4).

Distance weighted cargo volume – TEU/Km: We acquired monthly and annual cargos for the Oakland, Los Angeles (LA), and Long Beach (LB) ports from corresponding port authorities for 2003–2012 periods. The boundary layer of the three ports was acquired from Caltrans (California Department of Transportation) for 2011. We used TEU statistics for the cargo volumes in the three ports. TEUs are twenty-foot equivalent units, a standardized maritime industry measurement used when counting cargo containers of varying lengths. Because of the adjacency of LA and LB ports, we merged monthly and annual cargos and corresponding spatial boundaries and treated them as a single LA-LB port complex. TEUs were first adjusted by corresponding distances to the Oakland and LA-LB ports through TEUs/Km and then added up to create a single distance weighted cargo volume for each location of interest for each year from 2004 to 2010.

Location category – unitless: By using Business Analysts 2010 and the port boundary layer, we first separated the entire California roadway system into three parts: the first part includes locations within 500 m of FCC A1 or A2, or within 500 m of any of the three ports (i.e., goods movement corridors); the second part includes locations not encompassed in the first part and is within 300 m of FCC A3 (i.e., non-goods movement corridors); the third part includes locations not encompassed in the first and second parts (i.e., control areas). We then first enhanced the above location categories by reclassifying the first part with truck usage restrictions (see http://www.dot.ca.gov/hq/traffops/engineering/trucks/routes/restrict-list.htm) to non-goods movement corridors.

Locational data – in meters (Alberts projection): Because we suspected there might be a spatial trend in levels of pollutant concentrations, we used latitude and longitude information as potential covariates for prediction.

Meteorological data: We acquired daily meteorological data from the California Irrigation Management Information System (CIMIS) for the 2003-2012 periods for the entire State. CIMIS includes 167 active weather stations across the state from 2003-2012. The daily temperature and wind speed data were aggregated to monthly and annual means. Spatial interpolation algorithm inverse distance weighting was used to create statewide monthly and annual surfaces in temperature and wind speed. The monthly and annual temperatures and wind speeds for each government and Ogawa monitor were then estimated for use as covariates for LUR modeling.

For the buffered data, buffer distances of 50 m to 2000 m, with an incremental unit of 50 m, were created and the statistics within a specified buffer distance were calculated separately for each location of interest. They included:

Land use data – in hectares (ha): We acquired land cover data for the entire state of California from the U.S. Geological Survey (USGS) for 2006 and 2011. The National Land Cover Database (NLCD) is a 16-class land cover classification scheme that has been applied consistently across the conterminous United States at a spatial resolution of 30 meters. We were interested in the combined classes that either act as a sink (reduces levels of pollution), a source (contributes to air pollution) or a non-source (lack of emission and reduction), including (1) Veg1: natural vegetation including forest (41, 42 and 43, see coding in Appendix 1), shrubland (51 and 52) and herbaceous (71, 72, 73 and 74); (2) Veg2: all vegetation including Veg1 plus developed open space (21); (3) NE1: natural environments including all the land cover types other than developed low intensity (22), medium intensity (23), high intensity (24) and water (11 open water and 12 perennial ice/snow); (4) NE2: natural environments including all the land cover types other than developed low intensity (22), medium intensity (23), and high Intensity (24); (5) DHi: developed high intensity (24) land cover.

For the pre-policy period (2004-2007) we used NLCD2006 data for land cover information and for the post-policy period (2008-2010) we used NLCD2011 data for land cover classification. We assume relative stability of land cover types, respectively, for the pre- and post-policy intervention periods. Buffer distances of 50 m to 2000 m, with an incremental unit of 50 m, were created and the total acreage (in ha) of each land cover type within a specified buffer distance was calculated separately for each location of interest.

Traffic data – in Vehicle Kilometers Traveled (VKT): In assigning measured postmile traffic data (AADT) in a year to the highway roadways in California, we used the 2016 highway network provided by Caltrans as a reference road network. We assumed that the highway road network remained largely unchanged throughout the study period. The following procedures were used to assign AADT data to the California highway network.

Step 1: The postmile traffic data provided by Caltrans include route, county, district, and postmile data, in addition to the measured traffic data. The reference highway network data include route, county, district, and beginning and ending postmiles for each roadway segment. A postmile traffic data was assigned to a reference roadway segment if (1) the two are in the same route, county and district, and (2) the postmile of the measured traffic data is between the roadway segment's beginning and ending postmiles. A roadway segment could include multiple postmile traffic data records for a single year.

Step 2: For years 2010-2015, Caltrans also includes spatial point data (in ArcGIS shapefile) for postmile traffic data. We did not use the spatial information from the postmile traffic to assign traffic counts to the reference road network spatially because the Caltrans road network was found in some cases to not be accurate (sometimes several hundred meters deviation from real roadways). The geolocation information of the postmile traffic data, however, was found to be accurate (on the accurate road network provided by the ESRI Business Analysts for 2012). After postmile traffic data assignment in Step 1, we used the spatial information to assign remaining postmile traffic data that were not successfully applied in Step 1 to the reference roadway segments. Specifically, we buffered all the road network segments by 50 m, and a postmile traffic data point (from the remaining ones) within a 50 m buffered road network segment was assigned to that road network segment.

All the highway roadway segments that were assigned postmile traffic data from Step 1 and 2 were merged into a single dataset and the mean traffic volume for each roadway segment was calculated.

Step 3: All the roadway segments without postmile traffic data being assigned were further assigned based on corresponding closest roadway segments (based on the distance between roadway segment middle points) that were assigned traffic from Step 1 and 2 using the following criteria: both roadway segments belong to the same route, county, and district.

Step 4: All the remaining roadway segments without postmile traffic being assigned were further assigned based on corresponding closest roadway segment (based on the distance between roadway segment middle points) that were assigned traffic from Step 1, 2 and 3 using the following criterion: both roadway segments belong to the same route.

Similar procedures were used to assign annual postmile truck traffic data to the California highway segments using the postmile truck traffic data and the California highway truck road network data. We used the California highway truck road network for 2015 as a reference highway truck road network for data assignments. Through these steps, all the Caltrans highway road networks are assigned annual traffic counts for years 2004-2010.

The Caltrans highway network vehicle (AADT) and truck traffic data (AADTT) were then used to calculate vehicle (VKT) and truck kilometers traveled (TKT) at buffer distances from 50 m to 2000 m, with an incremental unit of 50 m separately for total vehicle and truck traffic for each location of interest. The VKT and TKT were estimated for individual years 2004-2010.

Acquisition and processing of air pollution data

We acquired air pollution data from both the government's continuous air quality monitoring and our saturation monitoring. They included:

Criteria pollutant NO_2, $PM_{2.5}$, and Ozone data: Criteria pollutants included those collected by U.S. EPA. They included annual summary data for the state of California for years 2004-2012 (https://aqsdr1.epa.gov/aqsweb/aqstmp/airdata/download_files.html#Annual) and our focus was on NO_2, $PM_{2.5}$, and ozone.

Ogawa saturation monitoring data: We have collected Ogawa data for both pre- and post-policy intervention periods for the San Francisco Bay and the LA regions. Table A1-1 displays the date of data collection, pollutants measured, and effective sample sizes. To enable us to merge the Ogawa data with the government monitoring data, all the Ogawa data were corrected based on the government monitoring data through collocated sites. Because of differences in vehicle emissions and urban structures, especially for highway roadways, the NO_2 and NO_X data collected through Ogawa were corrected separately for policy periods and regions. We found the agreement (correlation coefficient) for measured pollutant concentrations at the same 14-day period between the collocated government and Ogawa monitors ranged from 0.69 to 0.98 (Table A2-1), indicating the overall representativeness of using Ogawa monitors for NO_2 and NO_X monitoring. After consulting with the experts in the Research Triangle Park (North Carolina, USA), the company responsible for providing us the Ogawa samplers and the analysis of the sampled data, we concluded that the reasons for some discrepancy between government monitoring and our Ogawa monitoring were partly because the Ogawa data were calibrated based on the latest lab results, but the government data were rarely calibrated. We also investigated the number of effective hours of data collection for every government site during the same period when an Ogawa monitor was collocated. We found the number of hours for government monitors ranged from 34 hours to the full range of 14 days. Even though we removed those government monitoring stations with the number of effective hours of measurement being less than 200 in our effort to calibrate the measured Ogawa data, the missing hours might also have contributed to the discrepancy between the two data sources. In some situations, because of our inability to gain access to the exact location of a government monitoring station, the Ogawa samplers were placed on the gate to the building on which the government monitoring station was placed on top. This might also have contributed to the discrepancy between the two data sources.

We further averaged NO_2 and NO_X concentrations for the dry and wet seasons to represent annual concentrations measured at those saturation monitoring sites. This procedure is valid given that measurements for each policy period in each region were selected after reviewing historical long-term government monitoring data with the goal that these two 2-week monitoring would allow us to estimate long-term average concentrations most accurately. Our research did show that the average of dry and wet season concentrations in a sampling period was close to the annual concentrations measured at those sites (Su et al. 2016).

Table A2-1. Historical Ogawa samplings conducted in California and agreement with collocated government sites

Region	Policy Period	Year	Month	Pollutants	Sample size	Collocated sites	Correlation coefficient
Alameda	Pre-policy	2004	November	NO_2	51	3	0.88
		2005	May	NO_2	48	3	0.72
	Post-policy	2012	October	NO_2	49	4	0.93
				NO_X	49	4	0.98
		2013	March	NO_2	49	4	0.69
				NO_X	49	4	0.94
Los Angeles	Pre-policy	2006	September	NO_2	198	10	0.90
				NO_X	198	10	0.94
		2007	February	NO_2	195	12	0.81
				NO_X	195	12	0.97
	Post-policy	2012	October	NO_2	70	12	0.91
				NO_X	70	12	0.92
		2013	March	NO_2	72	8	0.90
				NO_X	72	8	0.88

LUR modeling distance decay curves and surfaces for NO_2

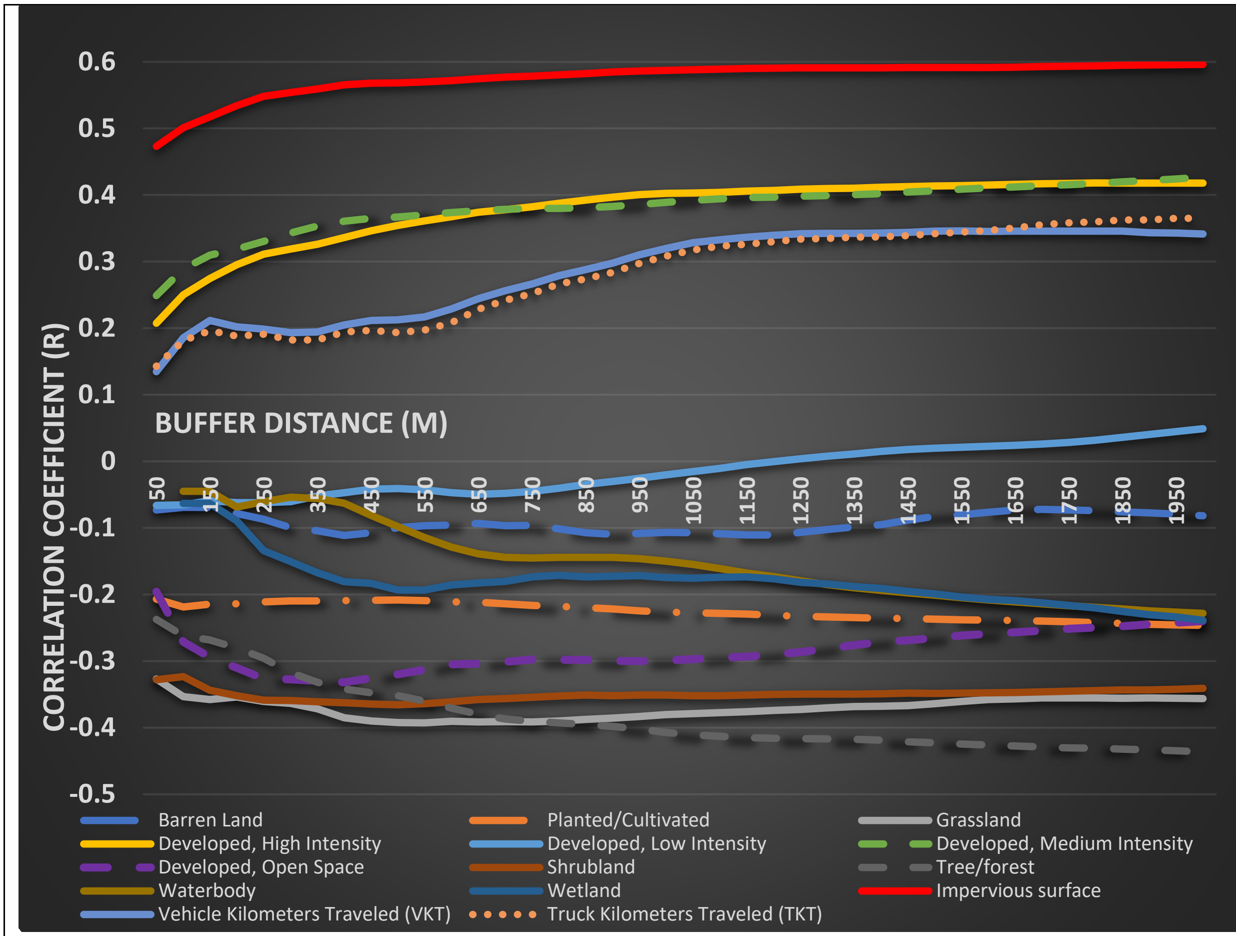

Figure A2-2. The distance curve of correlation with NO_2 for potential predictors in the LUR modeling process. (From Su et al. 2020; licensed under CC-BY-NC-ND 4.0.)

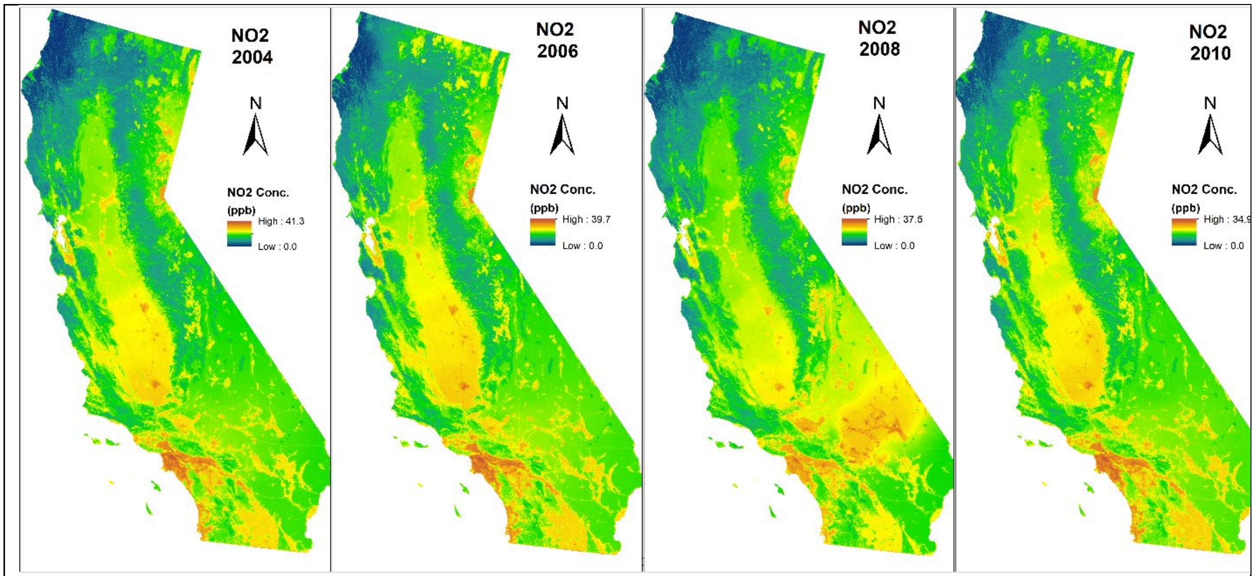

Figure A2-3. Selected years of predicted NO_2 surfaces across California.

LUR modeling distance decay curves and surfaces for $PM_{2.5}$

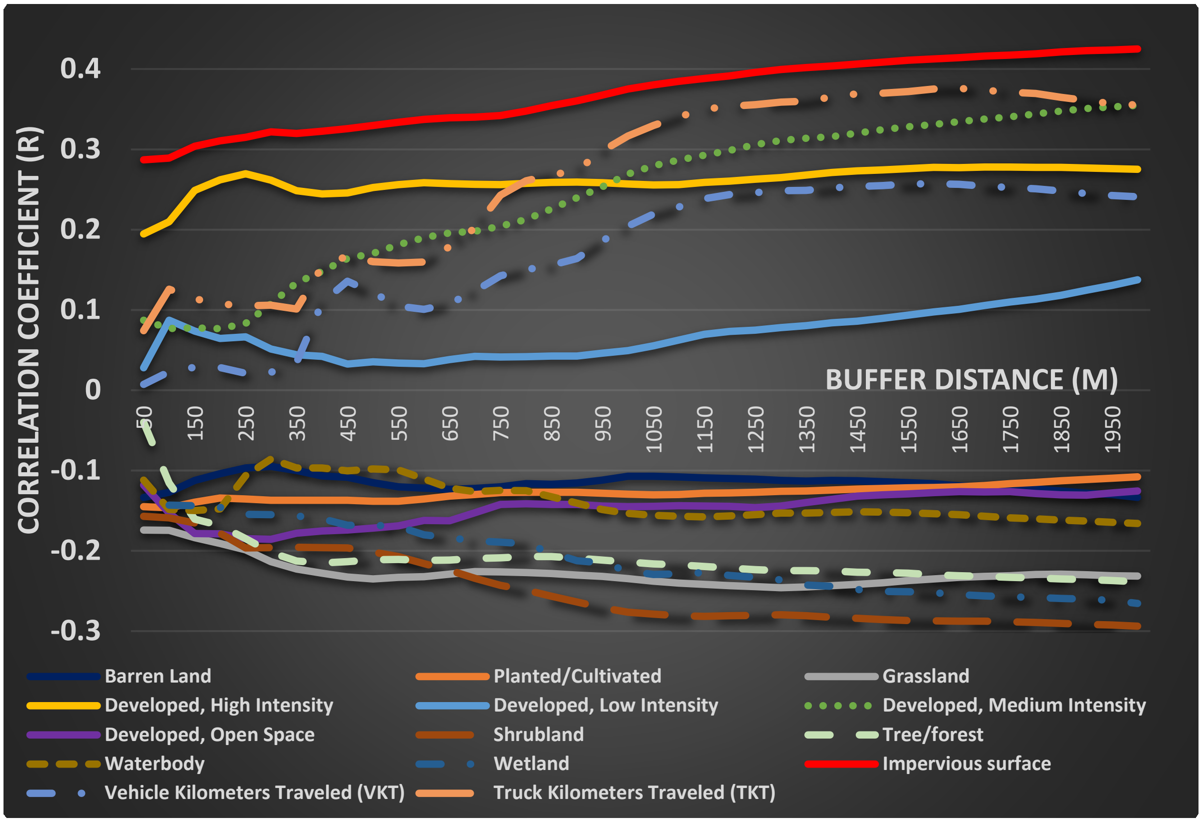

Figure A2-4. The distance curve of correlation with $PM_{2.5}$ for potential predictors in the LUR modeling process.

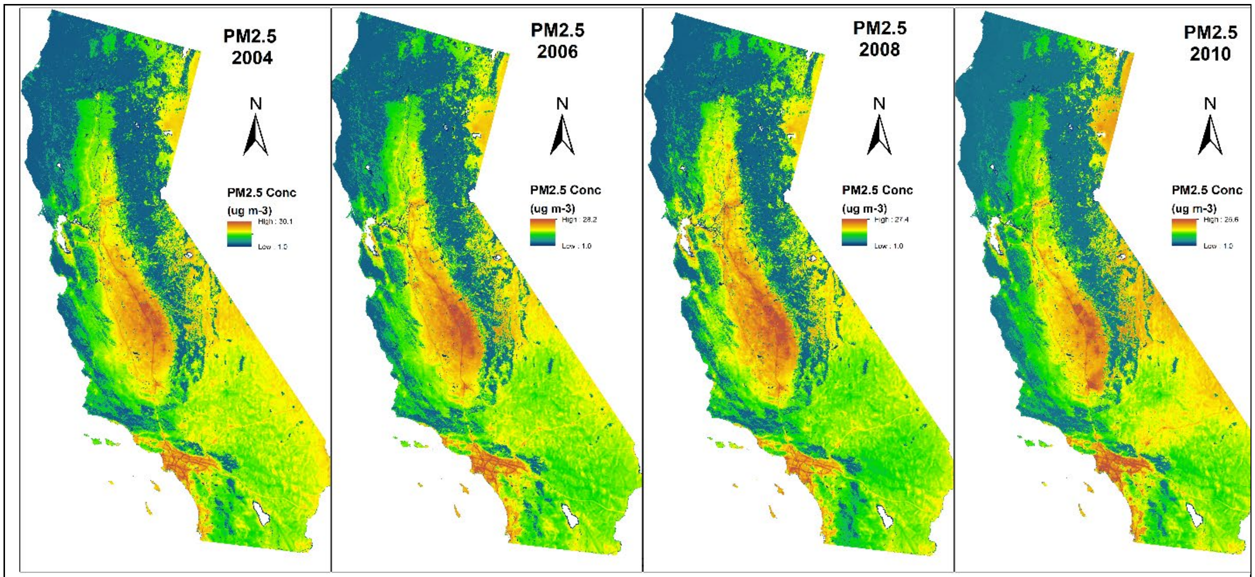

Figure A2-5. Selected years of predicted $PM_{2.5}$ surfaces across California.

Appendix 3: Improvements in Air Pollution Concentrations and Health Effects Air Pollution Concentration Reductions

We observed significant reductions in pollutant concentrations for enrollees living in 10 counties based on the pre- and post-policy averages for NO_2 and $PM_{2.5}$ using the annual air pollution surfaces developed for years 2004-2010. Table A3-1 displays average NO_2 and $PM_{2.5}$ concentration levels among study subjects for the pre-policy and post-policy periods summarized by domain. The average NO_2 concentrations decreased (in ppb), from 24.0 to 19.3, from 22.4 to 18.7, and from 20.1 to 17.3 for those living in GMC, NGMC, and CTRL areas, respectively. The enrollees living in GMCs for NO_2 experienced the greatest reductions in concentration. Their levels approached those of NGMCs and CTRLS in the post-policy periods.

Table A3-1. Average NO_2, $PM_{2.5}$, and O_3 Levels among by Study Domain by Year

		NO_2 (ppb)			$PM_{2.5}$ (μg m^{-3})			O3 (ppb)		
		GMC	NGMC	CTRL	GMC	NGMC	CTRL	GMC	NGMC	CTRL
Baseline year	2005	24.0	22.4	20.1	13.9	12.9	12.3	43.8	45.5	50.8
	2006	23.7	22.0	19.6	13.9	12.9	12.3	45.3	47.0	52.0
	2007	22.8	21.1	18.9	13.8	12.9	12.4	44.3	46.0	51.4
Project year	2008	20.7	20.0	19.0	14.2	13.4	12.9	44.5	46.3	51.3
	2009	20.4	19.7	18.6	12.5	11.6	11.0	45.3	47.0	51.6
	2010	19.3	18.7	17.3	11.8	10.9	10.4	44.5	46.2	50.8
Percentage change (2005 vs. 2010)		-19.58%	-16.52%	-13.93%	-15.11%	-15.50%	-15.45%	1.60 %	1.54%	0.00%

Table A3-2. Difference-in-Differences Estimates for Ozone (ppb) between GMCs and CTRLs, GMCs and NGMCs; NGMCs and CTRLs

	GMCs and CTRLs		GMCS and NGMCs		NGMCs and CTRLs	
	DiD (95% CI)[a]	P-value	DiD (95% CI)[a]	P-value	DiD (95% CI)[a]	P-value
All Patients						
Post 3rd Year[b]	0.59 (0.53,0.64)	<0.01	0.01 (-0.03,0.06)	0.60	0.58 (0.53,0.62)	<0.01
Post 2nd Year[b]	0.59 (0.53,0.64)	<0.01	0.00 (-0.04,0.05)	0.84	0.58 (0.54,0.63)	<0.01
Post 1st Year[b]	0.08 (0.02,0.14)	<0.01	-0.09 (-0.14,-0.05)	<0.01	0.17 (0.13,0.22)	<0.01
Asthma Patients						
Post 3rd Year[b]	0.60 (0.50,0.69)	<0.01	-0.01 (-0.09,0.06)	0.75	0.61 (0.53,0.69)	<0.01
Post 2nd Year[b]	0.57 (0.48,0.66)	<0.01	-0.01 (-0.09,0.07)	0.76	0.58 (0.50,0.66)	<0.01
Post 1st Year[b]	-0.01 (-0.10,0.09)	<0.01	-0.16 (-0.23,-0.08)	<0.01	0.15 (0.07,0.23)	<0.01
COPD Patients						
Post 3rd Year[b]	0.73 (0.63,0.82)	<0.01	0.06 (-0.01,0.14)	0.11	0.66 (0.58,0.75)	<0.01
Post 2nd Year[b]	0.56 (0.46,0.65)	<0.01	0.00 (-0.08,0.07)	0.97	0.56 (0.48,0.64)	<0.01
Post 1st Year[b]	0.12 (0.03,0.22)	<0.01	-0.11 (-0.18,-0.03)	<0.01	0.23 (0.15,0.31)	<0.01
Diabetes Patients						
Post 3rd Year[b]	0.52 (0.45,0.59)	<0.01	0.02 (-0.04,0.08)	0.45	0.50 (0.43,0.56)	<0.01
Post 2nd Year[b]	0.60 (0.52,0.67)	<0.01	0.01 (-0.05,0.07)	0.81	0.59 (0.53,0.65)	<0.01
Post 1st Year[b]	0.07 (-0.01,0.14)	0.07	-0.10 (-0.16,-0.04)	<0.01	0.17 (0.11,0.23)	<0.01
Heart Disease Patients						
Post 3rd Year[b]	0.54 (0.45,0.63)	<0.01	0.04 (-0.03,0.11)	0.31	0.51 (0.43,0.58)	<0.01
Post 2nd Year[b]	0.46 (0.37,0.55)	<0.01	-0.01 (-0.08,0.06)	0.72	0.47 (0.40,0.55)	<0.01
Post 1st Year[b]	0.12 (0.03,0.21)	0.01	-0.08 (-0.16,-0.01)	0.02	0.20 (0.13,0.28)	<0.01

[a] The model adjusted for age groups, sex, race/ethnicity, language speaking, number of comorbidities in baseline years, the county, year-specific smoking, depression, number of doctor visits, and CDPS scores, plus census track-level SVI variables: percent of unemployed (age 16+), persons below poverty estimates, minority, and households with no vehicle available.

[b] Numbers are difference-in-differences (DiD) estimates comparing changes between corridors each post-policy year vs. the baseline years (3 years before the implementation of GM actions. Post- 3rd Year denotes the policy effect three years after GM actions. 95% CI entries refer to 95% confidence intervals.

Health Effects Results

Table A3-3. Percent Change for ER Visits between GMCs and CTRLs

	Percent Change (%)	95% Confidence Intervals
Patients with Asthma		
Third year effect	-14.8	(-24.0, -4.4)
Second year effect	-11.8	(-21.4, -1.1)
First year effect	-7.8	(-17.8, 3.3)
Patients with COPD		
Third year effect	-11.8	(-21.2, -1.2)
Second year effect	-6.9	(-16.9, 4.3)
First year effect	-5.5	(-15.5, 5.7)

Notes: Numbers are percent changes comparing the number of ER visits between GMCs and CTRLs before and after the GM Actions. Third-year effect denotes the policy effect three years after GM actions.

Table A3-4. DiD Estimates for ER Visits with Additional Control for Air Pollutants (NO_2, $PM_{2.5}$, and O_3) between GMCs and CTRLs, GMCs and NGMCs; NGMCs and CTRLs						
	GMCs and CTRLs		GMCS and NGMCs		NGMCs and CTRLs	
	DiD (95% CI)[a]	P-value	DiD (95% CI)[a]	P-value	DiD (95% CI)[a]	P-value
All Patients						
Post 3rd Year[b]	-0.02 (-0.08,0.04)	0.53	0.02 (-0.03,0.08)	0.40	-0.04 (-0.09,0.01)	0.10
Post 2nd Year[b]	-0.04 (-0.10,0.02)	0.16	-0.04 (-0.09,0.02)	0.18	0.00 (-0.05,0.05)	0.88
Post 1st Year[b]	-0.02 (-0.08,0.05)	0.62	-0.01 (-0.06,0.04)	0.72	0.00 (-0.05,0.05)	0.86
Asthma Patients						
Post 3rd Year[b]	-0.17 (-0.29,-0.05)	0.01	0.00 (-0.11,0.10)	0.95	-0.16 (-0.26,-0.06)	<0.01
Post 2nd Year[b]	-0.17 (-0.29,-0.06)	<0.01	-0.06 (-0.17,0.04)	0.22	-0.11 (-0.20,-0.01)	0.03
Post 1st Year[b]	-0.09 (-0.21,0.03)	0.13	-0.05 (-0.16,0.05)	0.32	-0.04 (-0.14,0.06)	0.45
COPD Patients						
Post 3rd Year[b]	-0.18 (-0.30,-0.05)	0.01	-0.08 (-0.19,0.03)	0.14	-0.10 (-0.20,0.01)	0.08
Post 2nd Year[b]	-0.13 (-0.25,0.00)	0.04	-0.06 (-0.17,0.04)	0.25	-0.06 (-0.17,0.04)	0.23
Post 1st Year[b]	-0.08 (-0.21,0.05)	0.21	-0.05 (-0.15,0.06)	0.38	-0.03 (-0.14,0.07)	0.52
Diabetes Patients						
Post 3rd Year[b]	-0.02 (-0.10,0.06)	0.61	0.04 (-0.03,0.10)	0.28	-0.05 (-0.12,0.01)	0.09
Post 2nd Year[b]	-0.01 (-0.08,0.07)	0.81	-0.04 (-0.11,0.02)	0.20	0.04 (-0.02,0.10)	0.24
Post 1st Year[b]	0.02 (-0.06,0.09)	0.67	-0.02 (-0.08,0.05)	0.57	0.03 (-0.03,0.10)	0.27
Heart Disease Patients						
Post 3rd Year[b]	-0.01 (-0.12,-0.10)	0.88	0.00 (-0.09,0.09)	0.95	0.00 (-0.09,0.08)	0.96
Post 2nd Year[b]	-0.06 (-0.16,0.05)	0.29	-0.05 (-0.14,0.04)	0.24	0.00 (-0.08,0.08)	0.94
Post 1st Year[b]	0.00 (-0.11,-0.10)	0.96	-0.02 (-0.11,0.07)	0.69	0.02 (-0.06,0.11)	0.59

[a] The model adjusted for age groups, sex, race/ethnicity, language speaking, number of comorbidities in baseline years, the county, year-specific smoking, depression, number of doctor visits, and CDPS scores, plus census track-level SVI variables: percent of unemployed (age 16+), persons below poverty estimates, minority, and households with no vehicle available. **In addition, the model controlled for** NO_2, $PM_{2.5}$, and O_3.

[b] Numbers are difference-in-differences (DiD) estimates comparing changes between corridors each post-policy year vs. the baseline years (3 years before the implementation of GM actions. Post- 3rd Year denotes the policy effect three years after GM actions. 95% CI entries refer to 95% confidence intervals.

Table A3-5. Difference-in-Differences Estimates with Lag of CDPS between GMCs and CTRLs for ER Visits and Hospitalizations

	ER Admissions		Hospitalizations	
	DiD (95% CI)[a]	P-Value	DiD (95% CI)[a]	P-Value
All Patients				
Post 3rd Year	-0.03 (-0.10,0.04)	0.40	0.00 (-0.03,0.03)	0.95
Post 2nd Year	-0.06 (-0.12,0.01)	0.10	-0.02 (-0.06,0.01)	0.14
Post 1st Year	-0.03 (-0.09,0.04)	0.41	0.00 (-0.03,0.03)	0.99
Asthma Patients				
Post 3rd Year	-0.17 (-0.30,-0.04)	0.01	-0.02 (-0.08,0.04)	0.49
Post 2nd Year	-0.18 (-0.31,-0.05)	0.01	-0.06 (-0.12,0.00)	0.04
Post 1st Year	-0.09 (-0.22,0.03)	0.15	0.00 (-0.05,0.06)	0.93
COPD Patients				
Post 3rd Year	-0.18 (-0.32,-0.04)	0.01	0.01 (-0.06,0.08)	0.76
Post 2nd Year	-0.13 (-0.27,0.00)	0.06	-0.03 (-0.09,0.04)	0.44
Post 1st Year	-0.09 (-0.23,0.05)	0.21	0.00 (-0.07,0.06)	0.89
Diabetes Patients				
Post 3rd Year	-0.04 (-0.12,0.04)	0.35	0.01 (-0.03,0.06)	0.61
Post 2nd Year	-0.04 (-0.12,0.04)	0.37	-0.02 (-0.06,0.02)	0.37
Post 1st Year	-0.02 (-0.11,0.06)	0.58	0.01 (-0.03,0.05)	0.65
Heart Disease				
Post 3rd Year	-0.03 (-0.15,0.09)	0.66	-0.01 (-0.07,0.05)	0.75
Post 2nd Year	-0.09 (-0.20,0.03)	0.15	-0.02 (-0.09,0.04)	0.46
Post 1st Year	-0.05 (-0.17,0.06)	0.37	-0.01 (-0.07,0.05)	0.69

Table A3-6. Parallel Trends Assumption for ER Visits in Pre-Policy Period

	Patients with Asthma	Patients with COPD
$\lambda: GMC$	0.3647***	0.2978***
	(0.0739)	(0.0740)
β_2: t=2	-0.0153	-0.0038
	(0.0532)	(0.0536)
β_3: t=3	0.0777	0.0335
	(0.0529)	(0.0538)
γ_2: GMC * (t=2)	-0.0070	0.0188
	(0.0707)	(0.0699)

γ_3: GMC * (t=3)	-0.0803	-0.0698
	(0.0707)	(0.0703)
Constant	-1.2058***	-1.1086***
	(0.0581)	(0.0590)
Observations	11,154	11,181
Number of groups	3,718	3,727

Notes: Estimates are from a multilevel model with a negative binomial distribution and log link function. The first baseline year (t=1) was the reference group. In parentheses are standard errors. *** p<0.01.

Table A3-7. Percent Change on ER Visits with Full Interactions between GMCs and Year Dummy Variables

	Percent Change %	95% Confidence Intervals
Patients with Asthma		
Third year effect	-17.2	(-28.0, -4.7)
Second year effect	-14.3	(-25.6, -1.4)
First year effect	-10.4	(-22.1, 3.1)
Patients with COPD		
Third year effect	-13.8	(-24.9, -1.1)
Second year effect	-9.1	(-20.8, 4.4)
First year effect	-7.7	(-19.5, 5.9)

Note: Estimates are from a multilevel model including full interactions between GMCs and Year Dummy variables with a negative binomial distribution and log link function.

Table A3-8. Descriptive Statistics (Weighted Sample) after Propensity Score Matching (Baseline Year)

	All		Asthma		COPD	
	GMCs	CTRLs	GMCs	CTRLs	GMCs	CTRLs
Female	0.64	0.64	0.71	0.69	0.62	0.6
English	0.33	0.34	0.39	0.41	0.4	0.4
Age categories						
21-45	0.17	0.17	0.23	0.24	0.16	0.17
46-55	0.33	0.33	0.36	0.36	0.36	0.35

56+	0.49	0.5	0.41	0.4	0.48	0.47
Race/ethnicity						
White	0.38	0.38	0.36	0.36	0.47	0.42
African American	0.13	0.18	0.16	0.21	0.16	0.2
Asian/Pacific Island	0.23	0.18	0.24	0.18	0.15	0.13
Latino	0.12	0.15	0.1	0.14	0.1	0.13
Other or Unknown	0.14	0.11	0.14	0.1	0.12	0.11
Number of comorbidities in 2005-2007						
0	0.51	0.51	0.28	0.27	0.14	0.18
1 or 2	0.46	0.46	0.63	0.64	0.76	0.74
3+	0.03	0.03	0.09	0.09	0.09	0.09
Smoking in 2005	0.03	0.04	0.04	0.05	0.06	0.07
Depression in 2005	0.11	0.12	0.12	0.13	0.13	0.14
Number of doctor visits in 2005	5.84	6.43	6.33	6.98	6.23	7.12
Log (CDPS score)	0.001	-0.014	0.005	-0.027	0.1	0.09
% of unemployed (16+)	11.18	10.42	11.5	1.07	11.08	10.6
% of persons below poverty	23.2	18.18	24.3	18.95	23.12	18.37
% of minority	70.14	64.31	70.86	64.52	68.86	63.67
% of households without vehicle	16.92	8.88	16.98	9.04	17.07	9.21
N	5,232	4,768	1,931	1,787	2,047	1,680

Table A3-9. Difference-in-Differences Estimates for Hospitalizations; GMCs and CTRLs, GMCs and NGMCs; NGMCs and CTRLs

	GMCs and CTRLs		GMCS and NGMCs		NGMCs and CTRLs	
	DiD (95% CI)[a]	P-value	DiD (95% CI)[a]	P-value	DiD (95% CI)[a]	P-value
All Patients						
Post 3rd Year[b]	0.00 (-0.03,0.03)	0.95	-0.01 (-0.04,0.01)	0.34	0.01 (-0.01,0.04)	0.28
Post 2nd Year[b]	-0.03 (-0.06,0.00)	0.06	-0.01 (-0.03,0.01)	0.43	-0.02 (-0.04,0.01)	0.14
Post 1st Year[b]	-0.01 (-0.04,0.02)	0.53	0.00 (-0.03,0.02)	0.83	-0.01 (-0.03,0.01)	0.46
Asthma Patients						
Post 3rd Year[b]	0.00 (-0.06,0.05)	0.94	-0.01 (-0.05,0.04)	0.75	0.01 (-0.03,0.05)	0.70
Post 2nd Year[b]	-0.04 (-0.08,0.01)	0.17	0.00 (-0.05,0.04)	0.86	-0.03 (-0.07,0.01)	0.15
Post 1st Year[b]	0.00 (-0.05,0.05)	0.99	-0.01 (-0.05,0.03)	0.73	0.00 (-0.04,0.04)	0.84
COPD Patients						
Post 3rd Year[b]	-0.01 (-0.07,0.05)	0.80	-0.01 (-0.06,0.03)	0.55	0.01 (-0.04,0.06)	0.75
Post 2nd Year[b]	-0.04 (-0.09,0.02)	0.19	-0.01 (-0.05,0.04)	0.82	-0.03 (-0.08,0.01)	0.16
Post 1st Year[b]	-0.01 (-0.06,0.04)	0.72	-0.04 (-0.09,0.00)	0.05	0.03 (-0.01,0.08)	0.13
Diabetes Patients						
Post 3rd Year[b]	0.02 (-0.02,0.06)	0.36	-0.02 (-0.06,0.01)	0.16	0.04 (0.01,0.07)	0.01
Post 2nd Year[b]	-0.02 (-0.06,0.02)	0.34	-0.01 (-0.05,0.02)	0.46	0.00 (-0.04,0.03)	0.83
Post 1st Year[b]	0.01 (-0.03,0.05)	0.62	0.00 (-0.03,0.03)	0.93	0.00 (-0.03,0.03)	0.84
Heart Disease Patients						
Post 3rd Year[b]	-0.02 (-0.08,0.03)	0.47	-0.06 (-0.10,-0.01)	0.02	0.04 (-0.01,0.08)	0.09
Post 2nd Year[b]	-0.04 (-0.09,0.01)	0.15	-0.04 (-0.08, 0.01)	0.12	0.00 (-0.05,0.04)	0.92
Post 1st Year[b]	-0.03 (-0.09,0.02)	0.24	-0.05 (-0.10,-0.01)	0.03	0.01 (-0.03,0.06)	0.56

[a] The model adjusted for age groups, sex, race/ethnicity, language speaking, number of comorbidities in baseline years, the county, year-specific smoking, depression, number of doctor visits, and CDPS scores, plus census track-level SVI variables: percent of unemployed (age 16+), persons below poverty estimates, minority, and households with no vehicle available.

[b] Numbers are difference-in-differences (DiD) estimates comparing changes between corridors each post-policy year vs. the baseline years (3 years before the implementation of GM actions. Post- 3rd Year denotes the policy effect three years after GM actions. 95% CI entries refer to 95% confidence intervals.

Table A3-10. DiD Estimates for Hospitalizations with Additional Control for Air Pollutants (NO_2, $PM_{2.5}$, and O_3) between GMCs and CTRLs, GMCs and NGMCs; NGMCs and CTRLs

	GMCs and CTRLs		GMCS and NGMCs		NGMCs and CTRLs	
	DiD (95% CI)[a]	P-value	DiD (95% CI)[a]	P-value	DiD (95% CI)[a]	P-value
All Patients						
Post 3rd Year[b]	0.00 (-0.03,0.03)	1.00	-0.01 (-0.04,0.01)	0.34	0.01 (-0.01,0.04)	0.31
Post 2nd Year[b]	-0.03 (-0.06,0.00)	0.05	-0.01 (-0.03,0.01)	0.43	-0.02 (-0.04,0.01)	0.13
Post 1st Year[b]	-0.01 (-0.04,0.02)	0.55	0.00 (-0.03,0.02)	0.85	-0.01 (-0.03,0.01)	0.46
Asthma Patients						
Post 3rd Year[b]	0.00 (-0.06,0.05)	0.88	-0.01 (-0.05,0.04)	0.74	0.01 (-0.04,0.05)	0.77
Post 2nd Year[b]	-0.04 (-0.08,0.01)	0.17	0.00 (-0.05,0.04)	0.86	-0.03 (-0.07,0.01)	0.15
Post 1st Year[b]	0.00 (-0.05,0.05)	0.93	-0.01 (-0.05,0.04)	0.74	0.01 (-0.03,0.05)	0.80
COPD Patients						
Post 3rd Year[b]	-0.01 (-0.07,0.05)	0.75	-0.01 (-0.06,0.03)	0.55	0.00 (-0.04,0.05)	0.84
Post 2nd Year[b]	-0.04 (-0.09,0.02)	0.17	-0.01 (-0.05,0.04)	0.82	-0.04 (-0.08,0.01)	0.14
Post 1st Year[b]	-0.01 (-0.06,0.04)	0.74	-0.04 (-0.09,0.00)	0.05	0.03 (-0.01,0.08)	0.13
Diabetes Patients						
Post 3rd Year[b]	0.02 (-0.02,0.06)	0.40	-0.02 (-0.06,0.01)	0.17	0.04 (0.01,0.07)	0.01
Post 2nd Year[b]	-0.02 (-0.06,0.02)	0.31	-0.01 (-0.04,0.02)	0.47	0.00 (-0.04,0.03)	0.79
Post 1st Year[b]	0.01 (-0.03,0.05)	0.58	0.00 (-0.03,0.03)	0.91	0.00 (-0.03,0.03)	0.87
Heart Disease Patients						
Post 3rd Year[b]	-0.02 (-0.08,0.03)	0.46	-0.06 (-0.10,-0.01)	0.02	0.04 (-0.01,0.08)	0.10
Post 2nd Year[b]	-0.04 (-0.09,0.01)	0.14	-0.04 (-0.08,0.01)	0.12	0.00 (-0.05,0.04)	0.93
Post 1st Year[b]	-0.03 (-0.09,0.02)	0.24	-0.05 (-0.10,-0.01)	0.03	0.02 (-0.03,0.06)	0.51

[a] The model adjusted for age groups, sex, race/ethnicity, language speaking, number of comorbidities in baseline years, the county, year-specific smoking, depression, number of doctor visits, and CDPS scores, plus census track-level SVI variables: percent of unemployed (age 16+), persons below poverty estimates, minority, and households with no vehicle available.

[b] Numbers are difference-in-differences (DiD) estimates comparing changes between corridors each post-policy year vs. the baseline years (3 years before the implementation of GM actions. Post- 3rd Year denotes the policy effect three years after GM actions. 95% CI entries refer to 95% confidence intervals.