Background

Air pollution accountability research evaluates the extent to which policies aimed at improving air quality produce the intended reductions in pollutant concentrations and improvements to public health. A major challenge in this research field is isolating improvements that can be attributed to the policy in question from improvements that may be due to other unrelated regulations or secular trends. This is a particular concern when policies target numerous pollutant sources, affect large geographical regions, and take several years to fully implement.

Dr. Ying-Ying Meng of the University of California, Los Angeles, and colleagues proposed to evaluate one such policy, the 2006 Emission Reduction Plan for Ports and Goods Movement in California (herein referred to as “Goods Movement Plan”). This complex set of regulations and voluntary actions targeted emissions from various marine as well as on-road and off-road vehicles used to transport traded goods into, out of, and across the entire state of California, and was implemented over several years. They assessed whether this policy resulted in reduced ambient concentrations of three air pollutants and decreased emergency healthcare utilization. To help isolate reductions attributable to this policy alone, the investigators devised exposure groupings based on proximity to goods-movement-related traffic corridors versus other traffic areas.

Approach

Meng and colleagues implemented a quasi-experimental design to study the effects of the Goods Movement Plan on air quality and health outcomes. They focused on vulnerable populations living within 10 California counties that

What this study adds

• The 2006 California Goods Movement Plan sought to decrease emissions related to the movement of goods through ports and highways via numerous mandatory and voluntary actions.
• This cohort study examined the impact of the plan on air quality and healthcare utilization among 23,000 adults with chronic health conditions who were continuously enrolled in Medi-Cal, a low income healthcare program.
• To disentangle the impact of this plan from other simultaneous emissions regulations, investigators compared changes from the pre-policy period (2004–2007) to the post-policy period (2008–2010) in three areas based on proximity to major goods movement transit routes: areas near ports and freeways with truck traffic, near freeways without truck traffic, and control areas.
• Larger improvements in nitrogen dioxide (−2.43 ppb) and fine particulate matter (−1.58 μg/m3) exposures were observed near ports and truck-permitted freeways versus control areas during the first-year post-policy compared with pre-policy years.
• Greater reductions in emergency room visits were observed among Medi-Cal beneficiaries with asthma (−170 per 1,000 beneficiaries per year) or COPD (−180 per 1,000 beneficiaries per year) who lived near ports and freeways with truck traffic versus control areas three years post-policy compared with pre-policy years.
• Results from this study demonstrated that actions to reduce emissions related to goods movement may be effective in improving local air quality levels and healthcare utilization among disadvantaged people.
contained dense urban areas and three major ports. Specifically, they studied an existing cohort of adult Medi-Cal beneficiaries (California’s Medicaid health-care program for low-income individuals) with at least one of the following chronic conditions: asthma, chronic obstructive pulmonary disease (COPD), diabetes, and heart disease. The analysis was limited to 23,000 beneficiaries with continuous Medi-Cal enrollment during the study period.

The investigators examined three air pollutants directly and indirectly targeted by the plan, including nitrogen dioxide (NO₂), fine particulate matter (PM₂.5), and ozone (O₃). Using EPA and supplemental air quality monitoring data, they first estimated annual exposure levels to these pollutants based on the home address of each beneficiary. Addresses were further assigned to three categories based on proximity to three traffic zones: (1) goods movement corridors — areas within 500 m of ports or freeways where trucks were allowed; (2) non-goods movement corridors — areas within 500 m of truck-prohibited freeways or within 300 m of freeway-connecting roads; and (3) control areas, which included all other areas away from the goods and non-goods movement corridors in the studied counties.

Meng and colleagues used these traffic zones to evaluate whether air quality and health outcomes had improved more in the areas with major truck traffic where the Goods Movement Plan was expected to have greater impacts. By comparing the three areas, they hoped to tease out the specific effects of the Goods Movement Plan compared with other regional and national regulations aimed at traffic-related pollution from cars, or that may have been due to other factors leading to reduced emissions of pollutants.

Changes in air pollutant exposure levels among those living in the three zones were compared between the pre-policy period (2004–2007) and the post-policy period (2008–2010) using difference-in-differences regression, a method commonly used for observational research on policy-related interventions to mimic experimental designs. In addition, Meng and colleagues used the difference-in-differences approach to examine subsequent changes in healthcare utilization among the Medi-Cal beneficiaries to assess whether the policy related air quality improvements were effective in improving health. They adjusted the analysis for numerous individual-level health risk factors, neighborhood-level socioeconomic factors, and census-tract-level economic indicators to account for the 2008 global recession, both at baseline and over time. Ninety-five percent confidence intervals (95% CIs) were reported. The investigators hypothesized that compared with control areas, reductions in the selected air pollutants and healthcare utilization would be greatest in goods movement corridors that were targeted by the policy actions, followed by non-goods movement corridors, which may have shown improvements due to more general statewide and national air pollution regulations.

**KEY RESULTS AND INTERPRETATION**

Compared with the pre-policy period, Meng and colleagues reported statistically significant reductions in NO₂ and PM₂.5 concentrations across all 10 counties in the post-policy period. Results from the difference-in-differences analyses showed the greatest reductions in NO₂ and PM₂.5 when comparing goods movement to control areas for all beneficiaries and among those with each chronic condition. For example, among beneficiaries with asthma, NO₂ and PM₂.5 exposures were 2.43 ppb (95% CI = −2.51, −2.34) and 1.58 μg/m³ (95% CI = −1.63, −1.52) lower, respectively, for those living in the goods movement versus control areas in the first year post-policy compared with average levels in pre-policy years. Similar, but smaller, reductions in NO₂ and PM₂.5 were observed when comparing non-goods movement to control areas, with the smallest reductions observed when comparing goods movement areas to non-goods movement areas. In contrast, O₃ concentrations demonstrated the opposite trend during the post-policy period, which is consistent with the known inverse relationship between O₃ and NO₂ concentrations. The largest changes for all three pollutants were observed in the first year of the post-policy period.

Investigators reported statistically significantly greater improvements in health outcomes for Medi-Cal beneficiaries suffering from respiratory-related chronic conditions who were living in goods movement and non-goods movement corridors when compared with control areas. For example, the number of emergency visits among the 8,636 beneficiaries with asthma (Statement Figure) and 8,900 beneficiaries with COPD was reduced by 170 (95% CI = −290, −50) and 180 (95% CI = −300, −50) visits per 1,000 beneficiaries per year, respectively, in the
ports and freeways permitting trucks. They generally agreed with the investigators that there were greater reductions in NO\textsubscript{2} and PM\textsubscript{2.5} levels during the post-policy period in goods movement areas compared with control areas. They also agreed that the post-policy reductions in air pollution subsequently were associated with lower emergency healthcare utilization among Medi-Cal beneficiaries with respiratory-related chronic conditions. Smaller reductions were observed when comparing non-goods movement with control areas, and the smallest reductions were observed when comparing goods movement with non-goods movement areas. Overall, the Committee found the study results to be useful and clearly presented, and they considered them to be of particular interest to policymakers who are planning goods movement policy interventions in other jurisdictions. However, the Committee thought that the investigators’ stated conclusions were too strong because the changes in health outcomes could not be definitively linked to the Goods Movement Plan since various other air pollution regulations and economic changes that happened during the same time frame could have also contributed to improvements.

The Committee noted several strengths of this study, including a robust study design that mimics a randomized trial, the use of unique datasets linking detailed air quality measurements with a large longitudinal Medi-Cal claims dataset, and exposure assessment at the individual home address level. Of note, this study targeted people who may be more vulnerable to the health effects of air pollution, a population that is often inadequately included in many other studies. The Committee also appreciated the inclusion of an intermediate non-goods movement area. This allowed the investigators to attempt to tease out the effects attributable to the Goods Movement Plan from the effects of other regional and national regulations involving vehicle emissions that would impact both the goods movement and non-goods movement corridors, but which were expected to affect the control areas to a much smaller extent. The three different traffic zones also allowed investigators to compare changes by approximate distance from goods movement traffic. In fact, the difference-in-differences results comparing these three zones were suggestive of a gradation in responses, with goods movement corridors showing the greatest improvement in air quality and healthcare utilization, a smaller improvement shown for non-goods movement corridors, and minimal or no improvement in control areas.

**HEI REVIEW COMMITTEE EVALUATION**

In its independent evaluation of the study, the HEI Review Committee appreciated that this study used a quasi-experimental design to assess the effectiveness of the 2006 California Goods Movement Plan on air pollution and health outcomes near major goods movement areas compared with control in the third year following the goods movement policy actions. Post-policy reductions in emergency room visits among all beneficiaries and among beneficiaries with either diabetes or heart disease were not significantly different for goods movement and nongoods movement corridors when compared with controls, however. There were also no significant differences in emergency visits (for all causes, asthma, COPD, diabetes, or heart disease) among any of the beneficiary groups living in goods movement compared with non-goods movement corridors. Investigators reported that the difference-in-differences estimates for hospitalizations showed a downward trend in the post-policy period but were not significantly different for those living in goods and non-goods movement corridors versus controls.

**Statement Figure. Average number of emergency room visits among Medi-Cal beneficiaries with asthma before and after policy implementation in 2007.** Reductions were greater for goods movement corridors compared with control areas and were related to reductions in exposure to NO\textsubscript{2}. The counterfactual line shows the expected trend if the Goods Movement Plan had not been implemented. (Adapted from Figure 5 in Investigators’ Report.)
However, the Committee noted several limitations. First, the exclusion of beneficiaries without continuous Medi-Cal enrollment greatly reduced the sample size. Although this was necessary to ensure individuals were followed throughout the study period, the investigators did not characterize demographic differences between those excluded and the study cohort in their Investigators’ Report. Therefore, it is unclear whether findings from this study generalize to all Medi-Cal beneficiaries with chronic conditions. It is also unknown whether external secular trends, such as the 2006 diesel fuel standard change or the 2008 global economic recession may have affected the results for the goods movement, non-goods movement, and control areas differentially. Although investigators attempted to control for the 2008 recession in their statistical analysis of pollutant exposures, this information could not all be included in the health effect models. Finally, the Goods Movement Plan included many rules that took time to implement. Thus, if the Goods Movement Plan were largely responsible for air quality improvements, the Committee would have expected NO₂ and PM₂.₅ improvements to accumulate over time. However, results showed the greatest improvements during the first-year post-policy period, with incrementally smaller improvements in the second and third years. The Committee would have preferred a more detailed interpretation of these results.

Overall, this study provided evidence that regulatory actions to limit emissions from goods-movement related traffic may decrease emergency care utilization among disadvantaged people who live nearby, in particular among those who suffer from respiratory-related chronic conditions. Further research is needed to understand whether continued improvements are seen during the decade(s) following the start of the implementation of the Goods Movement Plan in 2006, given that it takes many years to implement such an ambitious program and that vehicle turnover is generally slow. It will also be useful to evaluate whether similar improvements are observed elsewhere when goods movement actions are implemented, targeting ports and other major distribution hubs. The most difficult and pressing challenge remains to disentangle the effects of individual regulations. Although it is useful to study the effectiveness of a broad program of regulations, such as the Goods Movement Plan, governing authorities would ultimately like to know which of the individual actions has been most effective.