Health, Traffic, and Environmental Justice: Collaborative Research and Community Action in San Francisco, California

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Health impacts on neighborhood residents from transportation systems can be an environmental justice issue. To assess the effects of transportation planning decisions, including the construction of an intraurban freeway, on residents of the Excelsior neighborhood in southeast San Francisco, PODER (People Organizing to Demand Environmental and Economic Rights), a local grassroots environmental justice organization; the San Francisco Department of Public Health; and the University of California, Berkeley, collaborated on participatory research. We used our findings regarding traffic-related exposures and health hazards in the area to facilitate community education and action to address transportation-related health burdens on neighborhood residents. (*Am J Public Health*. 2009;99:S499–S504. doi:10.2105/AJPH.2008.148916)

TRANSPORTATION PLANNING in the 20th century resulted in environmental injustice and significant adverse health impacts.[1,2] In the 1960s, the construction of Interstate 280 (I-280) through southeast San Francisco divided the Excelsior neighborhood,[3] increased local and regional freight traffic, and precipitated diverse neighborhood health hazards mediated through effects on air quality, environmental noise, and pedestrian conditions. Today, I-280 brings almost 200 000 vehicles per day within 100 feet of the nearest residences.[4]

PODER (People Organizing to Demand Environmental and Economic Rights) is a grassroots, membership-based environmental justice organization in San Francisco. With 5 staff members and more than 400 youth and adult members, PODER organizes young people, families, and the elderly to work on local solutions to issues facing southeast San Francisco's predominantly low-income, immigrant communities and communities of color.[5] PODER uses direct action, grassroots advocacy, leadership development, and civic engagement to advocate for urban land reform, community health, youth empowerment, and immigrants' rights.

In 2006, concerned with the environmental health and justice implications of transportation planning decisions, PODER asked the San Francisco Department of Public Health (SFDPH) to collaborate on a participatory study of the impacts of building I-280 and of subsequent local traffic patterns on local residents. In response to community concerns, SFDPH has historically collaborated with community organizations and public and private agency stakeholders to assess the health impacts of land use and transportation plans and policies; the results have informed advocacy for health-promoting decisions.[6,7] PODER and SFDPH focused on I-280 and the Excelsior neighborhood after observing a stream of diesel trucks and buses on its narrow, 1-way residential streets (Figure 1). The School of Public Health at the University of California, Berkeley (UCB), which had a relationship with SFDPH, joined the collaboration in 2007. The 3 organizations undertook participatory research to understand the environmental health impacts of past transportation planning decisions on community residents; their findings have informed local policymaking to address health inequities.

PARTICIPATORY RESEARCH IN EXCELSIOR

PODER, SFDPH, and UCB first agreed on principles of collaboration. These included a focus on developing community knowledge and engaging community members; an intent to generate research that could inform actions for community change, not just serve an academic purpose; a commitment to regular communication regarding findings and their interpretation; and an intent to disseminate findings through various media after consulting with all parties. At the outset, PODER also translated community concerns to shape research goals, addressing the need to demystify the science, validate diverse knowledge sources, and draw connections that would challenge institutional paradigms.

KEY FINDINGS

- Exposure to traffic has multiple impacts on the health of community residents.
- Collaborative, community-based participatory research that combines community knowledge with scientific expertise can engage community members, public agencies, academics, and decision-makers in understanding, and taking steps to mitigate, the health impacts of transportation planning decisions.
- A comprehensive qualitative and quantitative assessment of traffic health impacts on air quality, environmental noise, and traffic hazards can support community understanding of environmental health risks and provide evidence that serves as a catalyst for reducing negative traffic-related health exposures and disparities.

The practice of health impact assessment, which seeks to comprehensively predict the health impacts of policy decisions, informed our conceptual framework.[8] Public policy decisions shape local and regional traffic patterns and subsequent traffic-related health consequences. For example, residential proximity to busy roadways results in diverse environmental health hazards. Air pollution associated with roadway proximity contributes to cancer, respiratory disease, and impaired lung development.[9] Traffic-related noise triggers community annoyance and sleep disturbance[10] and is associated with hypertension and heart disease.[11] High traffic volumes and speeds also result in increased risk of injury and death from vehicle collisions.[12] This framework informed our research questions, methods, and mitigation proposals.

Table 1 describes the methods we chose to study traffic and its health effects. We drew on PODER's experience with community assessment and education, SFDPH and UCB's technical capacity, and community members' expertise and experiences. PODER recruited members and Excelsior community volunteers to conduct community surveys, traffic counts, and photo documentation, supporting and engaging community members as researchers (e.g., in traffic counting) and experts (e.g., in surveying). SFDPH and UCB's preexisting collaboration had developed analytic models to relate local traffic to air quality and environmental noise[10,14] and estimate indirect health impacts, and SFDPH had developed a pedestrian environmental quality assessment metric.[13] We applied these tools to the project area. A historical analysis of community sociodemographics before and after freeway construction provided context for our understanding of traffic exposures; census, hospital, mortality, and vehicle collision data helped us understand community demographics, exposures, and health outcomes.

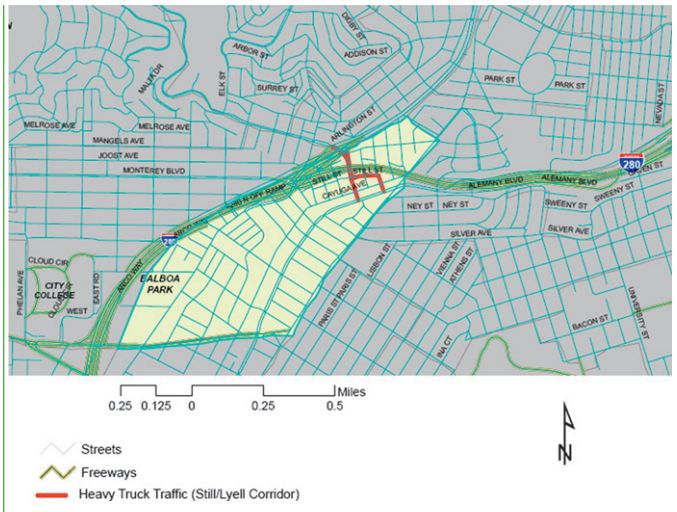

FIGURE 1—Excelsior project area map, including key traffic routes: 2000 census tract boundary.

Our methods and analytic approach supported our collaboration's principles of community engagement and education. For example, PODER members and residents conducted traffic counts, data that were required by our air quality exposure model. Collective review and interpretation of the model parameters and outputs increased the transparency of the analytic methods, supporting PODER's ability to translate air quality findings to residents and decision-makers. Geographic information system mapping of spatial analyses facilitated interpretation of the findings.

Key findings produced by each of our methods are shown in Table 2. Our conceptual framework influenced the design of our community survey, which included questions about air pollution, noise, and pedestrian hazards and about potential mitigations. The responses supported this comprehensive assessment of traffic's health effects. Community traffic counts showed that trucks and buses accounted for more than 10% of local traffic. Air quality and noise modeling and monitoring provided evidence that traffic contributed significantly to environmental hazards in the Excelsior neighborhood. These impacts are alarming, especially because the population, largely composed of families with children, immigrants, and people of color, increased after I-280's construction at a much faster rate than in surrounding areas further from freeway traffic. We also found that leading causes of death in the project zip code were illnesses associated with increased exposure to traffic and traffic-related air pollutants and noise,[22–24] including heart disease, lung cancer, and traffic collisions.

Required timelines for community-based action efforts

TABLE 1—Collaborative Research on Traffic, Health, and Environmental Justice: San Francisco, CA, 2006–2008

Method	Description	Project Leader[a]
Air quality modeling	We evaluated roadway-related air quality issues with traffic volume data from the county transportation agency's model (SF-CHAMP)[b] and specific local traffic counts and truck and bus percentages collected by PODER volunteers, known emissions for San Francisco County vehicles (EMFAC2007)[c], and the US Environmental Protection Agency recommended dispersion model (CAL3QHCR)[d] for the traffic associated with I-280 and local streets. The model creates contour maps of annual exposure level for PM 2.5 in excess of the ambient exposure level and associated with the location. These exposure data are then used to calculate the expected health effects associated with PM 2.5 roadway exposure.	SFDPH
Community photography	Community residents took pictures of factors in their daily community environment that affected their health.	PODER
Community surveys	PODER members conducted door-to-door surveys in Spanish and English over 7 census blocks. The completion rate was greater than 35% (52/146 occupied housing units per US Census 2000 data).	PODER
Noise modeling	SFDPH evaluated traffic noise exposure with traffic volume data from SF-CHAMP and noise-level modeling software (SoundPLAN).[e] The model included 3-dimensional buildings and topology.	SFDPH
Noise monitoring	Noise monitoring and dosimetry was conducted at 3 sites by PODER youth interns from a local high school.	SFDPH
Oral histories	PODER members interviewed community residents to learn about their personal stories, experiences, struggles, and successes in the neighborhood.	PODER
Pedestrian environmental quality assessment	We worked with students in an undergraduate environmental justice class at the University of California, Berkeley, to assess the quality of the pedestrian environment in a pilot application of the Pedestrian Environmental Quality Index.[f,13]	SFDPH
Secondary data analysis	We used existing community, hospitalization, emergency room, mortality, and motor vehicle collision data to describe health outcomes in the project area and compare them with other city neighborhoods.	SFDPH
Traffic counting	PODER members worked in teams, standing on street corners in the residential project area to conduct traffic counts during the morning and afternoon peak periods. Members counted cars, trucks, and buses separately on tally sheets.	PODER
US Census analysis	We analyzed historical US Census data to consider how overall population and number of households, median incomes, median house values, and percentages of Whites, children, and homeowners in the population differed in 1960, 1980, and 2000. We compared the trends for 5 different areas: the PODER Excelsior study community, areas 0.5 km north of the freeway, areas 0.5 km south of the freeway, and north and south areas slightly farther than 0.5 km away from the freeway.	UCB

Note. SF-CHAMP=San Francisco County Chained Activity Modeling Process; PODER=People Organizing to Demand Environmental and Economic Rights; EMFAC2007=emission factors 2007 model; CAL3QHCR=Caline 3 air quality dispersion model with advanced features for including hourly meteorological data; PM=particulate matter; SFDPH=San Francisco Department of Public Health, Environmental Health Section, Program on Health, Equity and Sustainability; UCB=University of California, Berkley, School of Public Health, Environmental Health Sciences.

[a]Data analysis and interpretation were collaborative. Information on project leaders is included to aid other organizations interested in replicating this model.

[b]SF-CHAMP is a transportation forecasting model developed by the San Francisco County Transportation Authority for use in various land use and transportation planning applications (Model documentation is available at: http://www.sfcta.org).

[c]This model was developed by the California Air Resources Board and is used to calculate emission rates from all motor vehicles operating on highways, freeways, and local roads in California. EMFAC2007 is the most recent version (Software and additional information is available at: http://www.arb.ca.gov/msei/onroad/latest_version.htm).

[d]CAL3QHCR is an air dispersion modeling software package for predicting air quality impacts of pollutants near roadways, developed by Scientific Software Group. Sandy, UT. (Additional information is available at: http://www.scisoftware.com/products/calroadsview_overview/calroadsview_overview.html).

[e]SoundPLAN LLC. Shelton, WA. (Additional information is available at: http://www.soundplan.com).

[f]Results are being analyzed at the time of writing. Upon completion, findings will be posted online.[13]

TABLE 2—Key Issues, Findings, and Methods for Collaborative Research on Traffic, Health, and Environmental Justice: San Francisco, CA, 2006–2008

Issue	Findings[a]	Methods[b]
Traffic	The ratio of trucks and buses to overall traffic in areas where families live and children play exceeded 10%. At the corner of Still and Lyell streets, > 107 medium and big trucks passed in 1 hour.	Traffic counting
	Of the 18 city bus routes serving southeastern San Francisco, 83% were diesel bus lines and 17% were electric lines.	Personal contact, SFMTA
	Project-area residents documented the following negative health effects of traffic in their community: idling trucks, garbage and debris, air and noise pollution, freeway noise, traffic congestion, concentration of gas stations, and parked commuter cars.	Community photography
Air quality	Community survey participants reported smelling car, truck, or bus exhaust on their block in the past 6 months at least weekly (41%), daily (25%), or in the past 6 months (46%).[c]	Community surveying[d]
	Forty-four percent of respondents reported smelling car, truck, or bus exhaust in the places where they go to school, go to work, play in parks, or go elsewhere in their daily routine.	Community surveying[d]
	In the Excelsior neighborhood, 23% of residents live within 500 feet of busy roadways ($\geq$ 100 000 vehicles/day), a significant source of air pollution; the citywide figure is 4%.	Secondary data analysis[e]
	More than 20% of respondents reported smelling car, truck, or bus exhaust in their homes in the past 6 months.	Community surveying[d]
	Roadway and freeway traffic modeling found PM 2.5 exposures 0.2–0.4 ug/m^3 greater than ambient levels. These elevated levels are associated with significant increased risk of heart, lung, and circulatory diseases for nearby families.[15]	Air quality modeling[f]
	Community traffic counts showed that truck traffic on Lyell and Still Streets was the greatest contributor to PM 2.5 exposure on those streets.	Air quality modeling,[f] traffic counting
Environmental noise	Neighborhood noise levels were in excess of those that the San Francisco General Plan deemed acceptable for new residential construction.	Noise modeling and monitoring[f]
	The project site was highly affected by noise in excess of 70 Ldn, which can increase blood pressure, elevate cortisol level, increase stress responses and associated heart disease, and cause annoyance, sleep disturbance, and reduced learning in children.	Noise modeling and monitoring[f]
	More than 35% of respondents reported that traffic noise from city buses, trucks, I-280, and neighborhood traffic interfered with the sleep of people in their household. An additional 37% reported the noise used to disturb their sleep, but they'd gotten used to it.	Community surveying[d]
	Areas at the end of Cayuga near I-280 had noise levels in excess of 70 Leq, attributable almost exclusively to freeway traffic.	Noise modeling and monitoring[f]
Pedestrian hazards	Twenty-seven percent of respondents reported that either a household member or neighbor had been hit by a vehicle while walking in the neighborhood.	Community surveying[d]
	In 2001–2005 in the project area, 55 motor vehicle collisions with pedestrians resulted in pedestrian injury or death. Only 15 of the 176 San Francisco census tracts had more such incidents in the same period (range = 0–191 collisions).	Secondary data analysis[g]
	Of respondents with children, 57% reported that neighborhood traffic dangers affected their willingness to let their children walk or play outside.	Community surveying[d]
Community demographics	From 1960 to 2000, the percentage of White persons living in the areas close to the freeway went from 98% to 39%.	US Census analysis[h]
	The proportion of foreign-born persons in the Excelsior area was 52% (37% citywide); the largest groups were from Mexico, El Salvador, China, Philippines, Nicaragua, and Guatemala.	US Census analysis[h]
	From 1960 to 2000, the number of children living in the project area and in areas close to the freeway dramatically increased.	US Census analysis[h]
	Two thirds of respondents were immigrants; >75% spoke a language other than English at home.	Community surveying[d]
	From 1960 to 2000, the population in the southeastern part of the city became more concentrated, particularly in neighborhoods closer to the freeway.	US Census analysis[h]
	I-280 became a barrier, or color line, because the dynamics on opposite sides of the freeway were very different.	US Census analysis[h]
Community health outcomes	In 2006, the neighborhood had the highest number of emergency department visits for asthma of all San Francisco neighborhoods (n = 266).	Secondary data analysis[i]
	According to 2000–2001 death data, the top neighborhood causes of death and illness were ischemic heart disease, stroke, lung cancer and other cancers, and chronic obstructive pulmonary disease, all of which are associated with increased risk from long-term exposure to air pollution as well as noise. Traffic collisions were among the top 10 causes of death and injury.[c]	Secondary data analysis[j]
	The neighborhood had the highest overall number of asthma hospitalizations of all San Francisco neighborhoods (538 hospitalizations with asthma as the principal diagnosis from 2001 to 2006).[c]	Secondary data analysis[i]
Community solutions	Almost 50% of respondents reported that reducing the number of trucks passing through their neighborhood would improve the community's health "a lot."[k]	Community surveying[d]
	Sixty-nine percent of respondents reported that ensuring their children have safe routes to and from school would improve the community's health "a lot." Among families with children, 82% felt that safe routes to and from school would improve the community's health "a lot."[k]	Community surveying[d]
	More than 75% of respondents reported that having nonpolluting buses would improve the community's health "a lot." Among those who reported smelling exhaust on their block in the past 6 months, 83% believed that having nonpolluting buses would improve the community's health "a lot."[k]	Community surveying[d]
	More than 50% of respondents reported that improving access to health care services would improve the community's health "a lot."[k]	Community surveying[d]
	More than 50% of respondents reported that building a sound wall next to the freeway would improve the community's health "a lot."[k]	Community surveying[d]

Note. SFMTA=San Francisco Municipal Transportation Agency; PM=particulate matter; Ldn=day–night average sound level; I-280=Interstate 280; Leq=equivalent constant decibel levels; respondents=participants in a community survey.

[a]The geographic area analyzed varied with different research methods and was largely determined by the availability of aggregrated secondary data and project resources.

[b]Methods are described in Table 1.

[c]Finding cited in San Francisco Board of Supervisors. Resolution 081397[16]

[d]Community surveying targeted a 7-census block area proximate to the truck corridor (Figure 1). The completion rate was greater than 35% (52/146 occupied housing units in US Census 2000 data).

[e]Data are for the Excelsior Planning Neighborhood and were obtained from the Healthy Development Measurement Tool, a comprehensive evaluation metric to consider health needs in urban development developed by the San Francisco Department of Public Health.[17]

[f]The modeled area included the location of the freeway as well as the 1-way truck and traffic feeder routes for the Still–Lyell corridor and I-280 underpass (Figure 1).

[g]Data are for the census tract detailed in Figure 1. Pedestrian injury collision data obtained from the California Highway Patrol, Accident Investigation Unit, Statewide Integrated Traffic Records System.[18]

[h]Data are for the census tract detailed in Figure 1. Data for 1960 to 2000 obtained from Minnesota Population Center, National Historical Geographic Information System.[19]

[i]Data are for the Excelsior community zip code, 94112. Asthma hospitalization and emergency room data by resident zip code for San Francisco obtained by request California Breathing, a program in the California Department of Public Health's Environmental Health Investigations Branch.[20] Although differences between neighborhoods in population size and age composition do not allow for direct comparison, 2000 US Census data show that more than 12% of the city's asthma hospitalizations and 11% of asthma emergency room visits involved residents of this neighborhood (but only ~9% of all city residents).

[j]Data are for the Excelsior community zip code, 94112. These data were accessed from the San Francisco Burden of Disease and Injury Web site.[21]

[k]Community survey response options for these questions were "a lot," "a little," and "not at all."

(months) relative to health research (years) created an early challenge. The partnership created a key findings document (from which Table 2 was adapted) and incorporated findings as they emerged to resolve this tension, agreeing that partners could disseminate findings to external stakeholders with all collaborators' approval.

TRANSLATING RESEARCH TO ACTION

Our retrospective health impact assessment of I-280's construction on current transportation and health conditions created an opportunity to connect community knowledge, scientific research, and community action. PODER leaders used the key findings to create popular education activities to disseminate the message that health is dependent on the environment where we live and to demystify scientific information about pollution and health. Activities included workshops and training involving youth and adult community members, skits at community movie nights in the park, and a pamphlet containing community stories, comic art, and research findings. Media events at City Hall also educated residents and policymakers about traffic's health effects and the need for action. These activities allowed members to disseminate findings to audiences in diverse contexts.

Unlike freeway traffic, which is regulated by the state, local street traffic is under the purview of the local transportation agency, the San Francisco Municipal Transportation Agency (SFMTA), and can be regulated to address concerns about local health impacts. Community action thus focused on local policymakers, emphasizing health effects from the high volumes of diesel buses and trucks channeled along residential streets on their way to and from I-280 (Table 2).

With the evidence provided by our research, PODER mobilized community members to attend a SFMTA public hearing to demand action to reduce pollution and protect community health, such as deploying hybrid electric buses and creating a truck route network to keep trucks off residential streets.[25] Community members subsequently presented to SFMTA staff the southeast community bus lines they identified as of greatest concern for community exposure to pollution. SFMTA confirmed that hybrid buses are being deployed more often on those bus lines relative to the citywide system; however, they did not adopt a formal policy for priority deployment.

PODER youth and adult leaders lobbied the San Francisco Board of Supervisors to draft and adopt a resolution urging the SFMTA and SFDPH to consider health and environmental justice in transportation policymaking. At a Board committee hearing, PODER members and staff, SFDPH, community residents, and a key community ally, the Chinese Progressive Association, testified about the need to reduce the adverse health impacts of local truck traffic on southeast communities.[26] On November 25, 2008,[27] the Board unanimously passed Resolution 081397:

> [U]rging the Municipal Transportation Agency and the Department of Public Health to collaborate and create health protective truck route planning in Southeast Neighborhoods. Encouraging cooperation between DPH and SFMTA and the local community in identifying and correcting health and safety related issues associated with truck traffic. Urging DPH to create a truck related exposure map identifying areas of significant exposure to air quality, noise and traffic hazards. Urging SFMTA to create a mitigation plan to address the impacts of local truck traffic on residential communities of southeast San Francisco that protects community health and provides efficient routes for commercial vehicle traffic.[16]

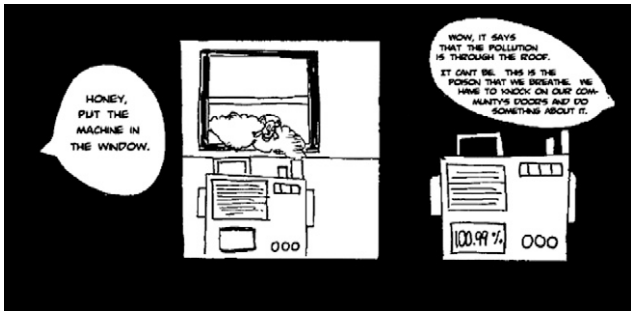

Image 1—Artwork by Ceci Baeza.

Image 2—PODER members translated their technical research experience into everyday language and creative expression about the community's real and perceived exposures with representations reflected in popular education materials including collages as well as comic art.

The resolution cites key participatory research findings (Table 2), among other community conditions and traffic-related health impacts. The resolution also reflects critical city political support for collaboration between the community, SFDPH, and SFMTA to expand the analysis of truck traffic's impact on residents'

health. One legislator invited city agencies and community stakeholders, including PODER, to meet in January 2009 to coordinate their response.

CONCLUSIONS

Our participatory research suggests the need for increased attention of public health agencies and environmental justice organizations to transportation planning. In an established urban residential neighborhood, the combination of a freeway and busy thoroughfares resulted in disproportionate, traffic-related health and environmental burdens. Although reversing such infrastructure decisions may not be feasible, our case study shows that participatory research can engage local public health and community partners in policy-relevant research that can inform solutions to transportation-related health hazards. Over time, we hope decision-makers will recognize that transportation decisions have multiple health impacts and will identify and avoid such disproportionately shared risks. ■

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Contributors

M. Wier coordinated the research project and conducted analyses. C. Sciammas led the community data collection, analyses, and research translation. E. Seto conducted data analyses and contributed to study design. R. Bhatia supervised and provided guidance to SFDPH researchers. T. Rivard originated the study and conducted data analyses. All authors contributed to writing the article, led by M. Wier and R. Bhatia.

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Human Participant Protections

This article describes a study carried out by community volunteers whose activities were not subject to protocol approval.

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