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Breathless: Schools, Air Toxics, and Environmental Justice in California

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Abstract

Recent legislation on both federal and state levels has placed the intersection between children's health and environmental justice on the forefront of public policy debate. This study looks at the intersection of air quality, children's health, and school performance in the context of environmental equity in California. Information from the U.S. EPA's National Air Toxics Assessment (NATA) is used to calculate a respiratory hazard ratio for each of California's census tracts. These ratios are then associated with a geo-coded database of the state's public schools, including school-level information on student demographics and the school's academic performance. We find that students of color are disproportionately located in schools with higher respiratory hazard ratios and also find a link between respiratory hazards and school performance, even after controlling for other factors that affect student performance. We conclude by recommending that state and community actors seek improvements in data collection, better filtration and ventilation in schools, the fuller incorporation of school-level health concerns, and the reduction of pollution at its various sources.

Center for Justice, Tolerance & Community
University of California Santa Cruz

Breathless: Schools, Air Toxics, and Environmental Justice in California

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BREATHLESS:

SCHOOLS, AIR TOXICS, AND

ENVIRONMENTAL JUSTICE IN CALIFORNIA*

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Introduction

In 1999, controversy over construction of the Belmont Learning Complex rocked Los Angeles politics. Designed to relieve severe overcrowding in a largely Latino immigrant neighborhood, the new, state-of-the-art school was sited in a former oil field with active methane gas leaks and soil contaminated with carcinogenic compounds, a fact which came to public light halfway through the construction process. When it was revealed that Los Angeles Unified School District (LAUSD) officials and developers had been aware of the underlying environmental hazards since the beginning of the project but had chosen to downplay the problem, the school board fired the incumbent superintendent and voted to halt construction of what was to slated to be the nation's costliest school.[1]

The incident fueled suspicions of environmental inequities with regard to schools, with some concerned that the environmental issues would have come to light earlier had the school not been designated for a low-income and immigrant neighborhood. This coincided with a growing concern within the state of California about both environmental justice and children's health in schools. In 1999, for example, California passed legislation mandating that environmental justice be incorporated into state planning across agencies, and initiated a process of inter-agency and community consultation that has led to one of the most far-reaching state-level efforts to understand and address demographic disparity in exposure. Part of this effort has included new attention to the proximity of

[1] For a more detailed description of the complex controversy, see Anderson (2000). The school has since been restarted, stopped, renamed, and restarted. The most recent controversies involved the discovery that the school was also located on an active fault; as a result, half-completed buildings were demolished and new set-backs were set in accordance with State law.

schools to sources of pollution, including landmark legislations pushed into being by concerned Latino legislators requiring that new schools be built at least 500 feet away from any major highway and other busy roads.[2]

The concern about children and schools reflects research as well as politics.[3] A series of studies have demonstrated that children may have distinct and higher vulnerability to environmental hazards (Bearer 1995; Crom 1994; Guzelian, Henry, and Olin 1992; Kaplan and Morris 2000; Landrigan and Garg 2002; National Research Council 1993; Parkinson 1996). Other work has demonstrated that air quality in schools, where children spend much of their day, is often problematic, partly because of ambient air quality and partly because of inadequate filtering and other systems (see Shendell, et al. 2004). A few studies have suggested that schools hosting more significant minority populations may be more likely to be facing proximity to hazards and lower quality ambient air (see Green, Smordinsky, et. al 2004, Pastor, Sadd, and Morello-Frosch 2002). Finally, one "meta-study" of the field (Wong, et al. 2004) suggests that air pollution reduction could have broad benefits for children, including reductions in school absences and hence improved academic performance.

This paper looks at the intersection of environmental justice, ambient air quality, and school performance in the state of California. Utilizing information from the U.S. Environmental Protection Agency's National Air Toxics Assessment (NATA), we calculate a respiratory hazard ratio for each of California's census tracts. We then locate each of the state's public schools within a tract and compare student demographics and

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[2] The measure, Senate Bill 352, took effect on January 1, 2004 and has exceptions for schools that utilize mitigation measures.

[3] For an overview of recent gains in science and policy see Garg and Landrigan (2002).

test scores against the hazard ratio. After examining the general pattern by race and income, we devise statistical models that attempt to control for the impact of child poverty, English skills, teacher quality, parent education, and other factors associated with school performance. Along the way, we assess one plausible link between the respiratory hazard ratio and school outcomes by examining the spatial relationship between our air toxics respiratory hazard surface and rates of asthma hospitalization in the parts of the state for which we have data.

Results indicate that students of color are disproportionately located in schools with higher respiratory hazard ratios, raising flags for policy makers and advocates. As it turns out, part of this is simply the fact that the most urban and most polluted areas are also more likely to have significant minority populations. Nonetheless, this disparate pattern generally holds even within these more urban areas, suggesting some reasons for concern about inequitable exposures. There also seems to be a relationship between respiratory hazard and school performance, even when proper controls are introduced to account for other factors associated with academic success. However, it seems that the relationship may be most pronounced in certain areas where the respiratory hazard is relatively high and there are important methodological issues regarding the appropriate scale of analysis, particularly whether the proper unit of consideration should be school districts, counties, or air basins.

The paper proceeds as follows. We first begin with a general review of the work on the schools, children's health, and environmental justice. We then turn to a description of our data and explain some geographic transformations utilized to insure compatibility of the air toxics data with the school performance data. We then show a series of cross-

tabs which describe some basic relationships to demographics and other matters, explore the relationship of our air toxic surface to recorded rates of asthma hospitalization, and finally turn to a regression analysis that first builds on a district-level analysis and scales up to consider both the state overall and select regions. We conclude by reviewing the research and drawing some implications for policy.

Literature Review

The intersection between environmental justice, children, and schools has been the subject of great interest on the part of many researchers and activists in recent years. Most environmental justice research has tended to focus on the location of hazards and potential pollution exposures relative to where people live, with a variety of controversies attached to whether the findings of disparity hold when all other factors are considered, when spatial relationships are fully taken into account, and when researchers consider the temporal dimensions of siting versus post-siting neighborhood change (see Ash and Fetter 2004, Been 1995, Been and Gupta 1997, Bowen 2001, Foreman 1998, Lester, Allen, and Hill 2001, Pastor, Sadd, and Hipp 2001, Szasz and Meuser 1997). Less attention has been paid to the environmental justice dimension of children and exposures, although the field is rapidly growing.

The issue is important, partly because increasing scientific evidence suggests that children may be more susceptible to the effects of environmental pollution than adults because of fundamental differences in their physiology, metabolism, absorption and exposure patterns (see Bearer 1995; Crom 1994; Guzelian, Henry, and Olin 1992;

Landrigan and Garg 2002; Wiley, 1991). Effects can occur very early: a variety of studies across the globe show an increased risk for a variety of adverse health effects including preterm birth, low birth weight, and birth defects given ambient air pollution levels (Bobak, 2000, Ha et al 2001, Ritz and Fei 2002, Ritz et al 2000, Ritz and Fei 1999, Wang et al. 1997) and an intriguing study by Chay and Greenstone (2003) found that increases in air pollution had a significant impact on infant mortality (particularly within the first month), with the results robust across a wide variety of specifications. Certain diseases that appear later in childhood (e.g. respiratory illnesses such as asthma) have become an increasingly significant health problem (Leikauf et al. 1995; Mannino, Homa, and Pertowski 1998; Mathieu-Nolf 2002.) and some suggest that hazardous air pollutants (HAPs) or air toxics could be aggravating these conditions (Burg and Gist 1998; Leikauf et al. 1995; Ware et al. 1993).[4]

While children are certainly affected by these threats in their home and neighborhoods, they spend much of their day at school; this school may or may not be located in the community where they live, particularly given magnet programs and cross-town busing in major urban areas. Anecdotal, epidemiologic, and exposure studies do, in fact, suggest that school children face potential short and long-term health effects from outdoor and indoor air pollutants (Balmes 1993; Gilliland et al. 1999; Guo et al. 1999; Jedrychowski and Flak 1998; National Environmental Trust 2000; Schettler, Stein, Reich, and Valenti 2000; Solomon, January 2001, Van Vliet et al. 1997), potentially hazardous facilities (Ginns and Gatrell 1996; Gomzi and Saric 1997), and pesticides (Northwest

[4] Partly because of this research, Executive Order 13045, issued in 1997, directs federal agencies to consider the particular vulnerability of children to environmental health risks. The White House. Protection of Children from Environmental Health Risks and Safety Risks. Washington, DC; 1997. Executive Order 13045.

Coalition for Alternatives to Pesticides 2000; U.S. General Accounting Office 1999).[5] That these patterns have given rise to popular concern is demonstrated in the title of a recent publication put out by one activist organization, the Center for Health, Environment and Justice, entitled *Poisoned Schools: Invisible Threats, Visible Actions* (CHEJ: 2001).

In this paper, we are primarily concerned with the situation in California. Our reasons are several. The first is simply our history of work in California and our concerns with public health policy change in the state. The second is more clearly rooted in research *per se*: regardless of the methodological debates in much of the EJ literature, particularly with regard to whether environmental disparities hold all over the U.S., most analysts have concluded that environmental inequity does seem to be present in California, particularly Southern California (Bowen 2001, Morello-Frosch, et al. 2002). A final reason is that there have also been a series of very-well done studies regarding children and environmental health in California, as well as studies documenting some existing disparities in children's environmental exposure by race in the state.

Among the most important of these California-based environmental health research efforts is a landmark study recently published in the *New England Journal of Medicine* which tracked nearly 1800 children over eight years in Southern California communities and found that air pollution can have chronic adverse impact on lung function and development.(Gauderman et al., 2004). The study also found linkages between air pollution and both asthma symptoms and the onset of asthma itself. A

[5] Many of these studies have been conducted in other countries and it is unclear whether or not their results can be meaningfully generalized to children in the United States.

detailed set of studies in the Huntington Park area of Southern California has provided further reason for concern, showing significant negative effects from pollution sources on the asthma symptoms for children aged 10-16 (Delfino, et al. 2003). A Children's Respiratory Health Study looking at more than 1,000 children in California's San Francisco Bay Area found that living and going to school near busy roads was correlated with exacerbation of asthma and chronic bronchitis (Kim, et al. 2004).[6]

Other work has suggested that such pollution exposures may not be equally distributed across ethnic groups. For example, evidence of economic and racial disparity was found in a study linking adverse pregnancy outcomes and air pollution, even after controlling for parents educational attainment, region, age, parity, and marital status (Woodruff, Parker, Kyle, and Schoendorf 2003). Green, et al. (2004) examined the proximity of California's public schools to highly trafficked roads, and found that the rates of exposure to such busy roads are much higher for students of color as well as for students learning English and students poor enough to quality for the student lunch program. In Pastor, et al. (2002), we looked at the Los Angeles Unified School District, the biggest in the state, and found that race was correlated with school proximity to a facility listed in the Toxic Release Inventory. Using an earlier version of the National Air Toxics Assessment, we also found race to be correlated with air-related cancer and respiratory risk, and showed that the correlation persists even when controls are introduced to account for neighborhood factors like land use, population density, household income, and home ownership.

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[6] In California, Ritz and Fei (2002, 2000, 1999) have also done considerable research linking adverse pregnancy outcomes to ambient air pollution, especially as related to traffic emissions.

Childhood respiratory problems of the sort that might be induced by air pollutants have also been associated directly and indirectly with lower academic performance (Fowler, Davenport, and Garg 1992; Bener, et al., 1994). In some communities, parents have complained of diminished school performance among their children due to health effects associated with outdoor and other pollution (Diette et al., 2000; Perera et al., 1999; Kaplan and Morris 2000). The issue has taken on particular salience in California since over ten percent of the state's schools are designated as overcrowded, with the majority of these located in dense urban areas where new construction to alleviate the problem is likely to occur near brownfields and in areas where local air quality is relatively poor. For example, Los Angeles County, with about twenty percent of the students in the state, has over sixty percent of the overcrowded schools, and San Francisco, with around one percent of the state's students, has more than ten percent of the overcrowded schools.[7] Given that many of the students in these schools already face economic and social challenges to their performance, adding on the potential health impacts of poor air quality seems problematic. The results offered here may add more urgency to this concern and could support the efforts of some district leaders to stress a "greener" approach to school construction and site remediation.

Data and Methods

[7] Orange and Alameda Counties, both urban concentrations, are also slightly overrepresented in the group of overcrowded schools, with all other counties in the state underrepresented. Figures generated by linking state data on overcrowding made available to us by the Public Policy Institute of California with the API data base described below. We were unable to link crowding and API data for 50 schools out of a total in our sample of over 7,000 schools.

In order to understand the relationship between local air quality, environmental justice, and academic performance, we combine several different sources of data. The first involves air quality. Annual average air toxics concentration estimates were compiled from the U.S. EPA's National Air Toxics Assessment (NATA) for 1996 (US EPA 2004), which estimates concentrations for diesel particulates and 32 of the 188 air toxics listed under the 1990 Clean Air Act Amendments.[8] To develop nationwide estimates of annual average ambient concentrations of air toxics, the Assessment System for Population Exposure Nationwide (ASPEN) model, developed and used in EPA's Cumulative Exposure Project, was employed; information on the modeling algorithm is available elsewhere (Rosenbaum, et al. 1999). The modeling approach was applied to EPA's National Toxics Inventory (NTI) which is compiled using five primary information sources including: state and local toxic air pollutant inventories, existing databases related to EPA's air toxics regulatory program, EPA's Toxic Release Inventory (TRI) database, estimates using mobile source methodology (developed by EPA's Office of Transportation and Air Quality), and emission estimates generated from emission factors and activity data. Using the emissions data as inputs, the ASPEN air dispersion model then estimates the annual average ambient concentration of each air toxic pollutant at the centroid of each census tract, after taking into account the impacts of atmospheric processes (winds, temperature, atmospheric stability, etc.) on pollutants.

We then utilized this data to calculate a respiratory hazard index associated with outdoor air toxics exposures in which we divided each pollutant concentration estimate by its corresponding Reference Concentration (RfC) to derive a hazard ratio. A reference

[8] Clean Air Act Amendments of 1990. §112 Hazardous Air Pollutants.

concentration (RfC) for chronic respiratory effects is defined as the amount of toxicant below which long-term exposure to the general population of humans, including sensitive subgroups, is not anticipated to result in any adverse effects (Dourson and Stara 1983). The actual respiratory hazard ratios for each pollutant in each census tract were calculated using the following formula:

$$HR_{ij} = C_{ij}/RfC_j$$

where HR_{ij} is the hazard ratio for pollutant j in tract i, C_{ij} is the concentration in *ug*/m^3 of pollutant j in census tract i, and RfC_j is the reference concentration for pollutant j in *u*g/m^3. An indicator of total respiratory hazard was calculated by summing together the hazard ratios for each pollutant in order to derive a total respiratory hazard index:

$$HI_i = \Sigma_j HR_{ij}$$

where HI_i is the sum of the hazard ratios for all pollutants (j) in census tract i. This measure assumes that multiple sub-threshold exposures may result in an adverse health effect.[9]

A map of the results for the state of California is show in Figure 1. Note that the areas with the highest respiratory hazard ratios are the denser urban areas of Southern California and the San Francisco Bay Area. That urban density would be associated with air toxics is to be expected: with intensive urban development comes both more emission sources and often a tendency toward stagnant air and lower dispersion. Indeed, air toxics are emitted from mobile sources such as cars and trucks, and stationary sources such as small and large industrial facilities, dry cleaners, gas stations and other facilities, all uses

[9] The methods for deriving a respiratory hazard index comply with recommendations for conducting screening-level non-cancer risk assessments for multiple pollutants under the Superfund Guidance, California's AB2588 "Hot Spots" Guidelines, and the U.S. EPA's Chemical Mixtures Guidelines.

more crowded together in urban space. However, the pattern also highlights an important fact: this data surface represents only one category of air pollutant, air toxics, which tend to concentrate at lower levels than the more ubiquitous criteria air pollutants (such as particulates and ozone). This is the reason why areas such as the San Joaquin Valley of California, now acknowledged to be among the most polluted areas in the United States in terms of particulate air pollutants, does not show up in the ranks of the areas with the highest respiratory hazard ratio. Indeed, while the heavily urbanized San Francisco, Los Angeles, Orange, Santa Clara, Alameda, and San Mateo Counties are among the top six when California's counties are ranked by the hazard ratio, the top six in terms of criteria air pollutants when ranked by days of exceedance of National Ambient Air Quality Standards (NAAQS) are Los Angeles and five more rural counties – San Bernardino, Riverside, Kern, Fresno, and Tulare.[10]

<insert Figure 1>

Why do we focus on the hazard ratio as derived from air toxics, particularly since most air pollution research on children has traditionally focused on criteria air pollutants (PM, ozone, CO, SOx, NOx)? The advantage of using modeled air toxics data is that it gives us concentration estimates for every census tract in California that hosts a school. While criteria pollutants are measured through a statewide monitoring network, these air monitors are often located far apart from each other and certain locations have no

[10] We draw the county level measure for person-days exceeding NAAQS from www.scorecard.org for the year 2002, then divide by the 2000 population as recorded in the census. While the numbers are slightly inflated given the lower population in 2000, the ranks are similar and removing the population weighting from the person-days measure moves one area (Sacramento) out of the top six and surfaces Tulare, a switch still in keeping with our notion that our own measure is biased toward urban areas. Ranking by the hazard ratio is done with the data base used in this paper; these six counties surface as the top regardless of whether we use simple averages or averages weighted by land area or population.

monitoring information. This can leave us guessing about the variations in pollutant levels that can be associated with each school site. Also, while criteria air pollutants tend to be ubiquitous and spread out across a region, air toxics tend to concentrate and create "hotspots" in certain locations, helping to highlight patterns of unequal exposures using smaller geographic units of analysis to develop a large data surface.[11] Therefore, although the large data surface associated with the air toxics data makes a large-scale geographic equity analysis possible, it implicitly lends a particular urban bias to our approach. To address this issue, we examine environmental equity patterns statewide as well as within urban counties, air basins and school districts.

Before utilizing the respiratory hazard ratio for testing, we performed a geographic transformation. As it turns out, the 1996 NATA risk surface is generated for the 1990 census tract shapes or polygons. We used standard GIS geoprocessing routines to intersect the 1990 and 2000 tract polygons, creating a single georeferenced GIS theme of polygons, each with its 1990 and 2000 tract identifier. Hazard ratios were then calculated as attributes of the 2000 tracts polygons based on the proportion of common area with 1990 tract polygons. For example, if the area of a given 2000 tract is covered entirely by a single 1990 tract, the 2000 tract receives the risk value directly from that 1990 tract; a 2000 tract which has its area 50% covered by a 1990 tract with a risk value of 2, and the remaining 50% covered by a 1990 tract with a risk value of 4 would be given an area-weighted risk value of 3. This method makes the simplifying assumption

[11] As the state's Children's Environmental Health Center notes in its most recent biennial report (CEHC 2004: 4), "The statewide ambient air-monitoring network has been most useful in assessing regional levels of air pollution in California. However, the network may not in all cases adequately represent specific locations, outdoors or indoors, where children spend time and where they are potentially exposed to harmful air pollution."

that the 1990 risk value for any given tract is homogeneously distributed within that area, but 2000 tract polygons overlay two or more 1990 tracts in a relatively small number of cases.

Because of the inherent inaccuracy of the 1990 and 2000 TIGER boundary files (vertices and tract boundaries for the two data generations sometimes do not exactly correspond geographically) it was necessary to intersect the two census polygon data sets using standard conflation routines to ensure common tract boundaries and vertices where the intent of the Census was to retain the same boundary in 1990 and 2000.[12] To allow accurate measurement of area, tract polygons from both years were projected into an equivalent map projection (Albers Equal-Area Conic) that is the standard for the state of California. We explain this resurfacing process in more detail in Pastor, Sadd, and Morello-Frosch (2004a), a paper in which we connect the NATA surface to 2000 Census demographics, while controlling for spatial clustering.

With the hazardous ratio surface prepared, we then sought to map all public schools in California. Using the names and addresses of all California schools listed by the California State Department of Education, and included in both its California Basic Educational Data System (CBEDS) and Academic Performance Index (API) for the year 2000. School location and host census tracts were determined by geocoding these addresses using Geographic Data Technology Dynamap street network and

[12] A word of caution for those who might wish to try this. In other work that transfer attributes from 1990 to 2000 tract polygons for use in a model projecting household income at the tract level, we noted that the major commercial package (Geolytics) that purports to reweight 1990 data to 2000 tracts tends to use road presence to reshape the surface and then utilizes the resulting population figures as a weight for recalculating all census data series. However, a series of cross-checks shows that a simple use of land area is often superior, at least in the Southern California case we have examined in detail (see Pastor and Scoggins 2004). Population weights are also problematic in transferring, say, household income although here we do not need to focus on the weights needed to reshape the 1990 population and housing data since the land weights are best for the air quality surface with which we are working.

correspondence files (year 2000); all addresses receiving a geocoding match score of <80% were checked for errors and rematched interactively.[13]

All school locations were linked to their respective Academic Performance Index data. Mandated by the State of California under the Public Schools Accountability Act of 1999, the API is a summary score of overall school performance based on the Stanford 9 achievement test given as part of the state's testing program; we specifically used the results for the test administered in Spring 2000. This was the second year the test was rolled up into a single school score and the scores are reportedly more reliable than in the first year (1999) when both schools and children were getting used to the new testing and data collection regimes; newer runs of the API may be even more reliable but are even further in time away from the 1996 NATA data we use to determine the hazard ratio. In order to contextualize measures of school performance, the state includes in this database a limited set of school-level variables, including student demography, a proxy for poverty, a measure of teacher quality, and other factors.[14] Since such measures have been shown in other research to have an effect on school performance, we make use of those additional variables in our regressions below, linking them to the tract-level information on the air toxics health hazard.

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[13] There are 25 California schools which we could not successfully geocode. In aggregate, these schools report 7534 students, and have a median student population of 301.

[14] Another source for school-level demographics is "California Basic Educational Data System" database (or CBEDS). This is an annual data collection program administered by the California Dept of Education Demographic Research Unit that includes basic school information as well as data on enrollment and ethnic make-up of the student population by school. The demographics from this database do not always square perfectly with the API demographics, partly because the latter records those who took the tests. We use the CBEDS numbers when simply comparing school demographics in the tables below; however, when we enter demography in a regression on the determinants of the API we utilize the figures for those who actually took the test.

As it turns out, the API data is not available for all schools. Some schools are too small to have API scores reported, while others have scores deemed suspect due to a range of issues, including a large percentage of the students excused by parents from participating, certification from the school that there were irregularities in the testing, certification from a district superintendent that the school scores do not reflect the student performance, a failure of the school to test a significant portion of students, and other issues. Some other schools do not have the demographic information reported in conjunction with the academic scores; as this is necessary later in our analysis, we exclude these schools from the beginning. We should also note that the scores of magnet programs are not reported separately when these magnets are physically part of a larger campus; in these cases, the magnet scores are averaged in with the rest of the school population.

Because we wanted to check location of schools against another emissions inventory, partly to see whether evidence of ethnic disparity was sensitive to data source, we also mapped the 2000 U.S. EPA's Toxic Release Inventory for the state, considering only TRI facilities reporting air releases (stack and fugitive emissions) in amounts greater than zero. These facilities were located by geocoding using the address ranges in the 2000 Census TIGER/Line data. Circular buffers were used to capture TIGER 2000 census tracts with boundaries falling within one mile of a facility, with attention paid to sites reporting releases of an EPA selected category priority toxics known as 33/50 chemicals (this subset of the TRI chemicals list represents EPA's priority pollutants, and most are either known or suspected carcinogens). Details on the geographic procedures and this data are available in Pastor, Sadd, and Morello-Frosch (2004b).

Results

Basic Demographics

We begin the analysis by ranking the state's schools by those above and below the median respiratory hazard ratio for all schools in the state, and then considering the racial demographics and associated family income levels for the schools above and below that break. The findings are shown in Table 1. As can be seen, those schools with above median respiratory hazard ratios are, on average, about twenty percentage points less white, with overrepresentation for Latinos, African-Americans, and Asian Pacific Islanders. Interestingly, the percent of students received a free or reduced-price lunch – a standard proxy for students living in or near poverty – is only slightly higher for the schools in the above median category. Recognizing that California's rural areas are simultaneously whiter, poorer, and have less polluted air than the rest of the state, we then turn our attention to just non-rural schools – that is, those that are urban and suburban.[15] This set of schools includes those in the urban areas within largely rural counties, such as schools in Fresno, Bakersfield, and small cities and towns in the San Joaquin Valley. We divide this set into those with respiratory hazard ratios above and below the median for that set of non-rural schools, and find a more significant presence

[15] The rural specification is not available at the whole tract level for which this and most environmental justice analyses are done but it is available at a block group level where the chain of geographic levels is such that groups may be split by jurisdiction. We calculated the "urban" area for each of the state's block groups, summed that up to the tract level, and then called a tract rural or non-rural depending on whether more than fifty percent of the calculated area was not designated as "urban." As we make clear in the text, urban in this case can also refer to suburban areas; hence, we are essentially just distinguishing between rural and non-rural areas.

of Latinos in the schools above the median respiratory hazard. We also find sharper differences in terms of the representation of poor students.[16]

<insert Table 1>

Both the table and the earlier map suggest that part of what is going on is simply the concentration of both respiratory hazards and poorer, more minority populations in particular areas of the state. Indeed, there seems to be a big difference when we look just at those counties where the respiratory hazard ratio exceeds one by an order of magnitude (that is, exceeds ten), an exceedance level that tends to be a benchmark for regulatory concern. Table 2 shows the six counties where this is the case, ranked not by the ratio itself but by the percent of schools in tracts where the assigned respiratory hazard ratio exceeds ten. As can be seen, the "big six" are San Francisco, Los Angeles, Orange, Santa Clara, Alameda, and San Mateo Counties; as it turns out, these contain nearly 95 percent of the schools where the tract-level respiratory hazard ratio exceeds an order of magnitude, and the percent of schools in such conditions drops off precipitously once we move past these to consider the remaining counties in the state that have at least 100 schools and have at least some of these schools are in tracts where the respiratory hazard ratio is above an order of magnitude.

<insert Table 2>

There are indeed sharp differences between this six county set and the rest of the state. For the schools in the counties with the highest respiratory risk identified in Table 2, the population is 27.1 percent white and 49.9 percent poor; for the schools in the

[16] The measures in the tables are not simply averages but rather averages weighted by the relevant school population; hence, we are essentially comparing one sort of population to another.

counties with the lower respiratory risk (the ones seen in the table as well as the in the rest of the state), the student population is 46.8 percent white and 43.3 percent poor. These numbers are, of course, close to the pattern in Table 1, suggesting that it may be county location that is driving most of the statewide pattern. However, even within the six county set, we find significant differences. Table 3 shows these differences; note that we collapse the contiguous counties of San Francisco and San Mateo Counties into one area in order to be parallel to the others, each of which has a central city and some surrounding suburbs (this also raises the number of schools in that combined county set closer to the number of schools in the other counties under consideration).[17] As can be seen, within each of the county units considered, the areas with higher respiratory hazard ratios are more minority and poorer even

<insert Table 3>

Finally, we considered the pattern relative to the aforementioned TRI inventory. Schools located in a tract further than one mile from a TRI air release were 45.1 percent white while those proximate (within one mile) were 28.1 percent white. Interestingly, percent African American and Asian Pacific was roughly similar between the two sets of schools; the demographic difference between being proximate or not was almost entirely based on a larger Latino population. The schools further from the TRI sites also had about forty percent of their children receiving free or reduced price lunches; the proximate schools had fifty five percent of their students receiving free or reduced price

[17] If we look at San Francisco County separately, we find that the demographics of those schools above and below the median for the County alone are roughly similar. These numbers will become a bit clearer when we discuss the district level data below; as it turns out, San Francisco is a city, a county, and a school district. The latter is another reason why we couple San Francisco and San Mateo, so that we can be more comparable to the other counties which have multiple districts as well a central city and a suburb.

lunches. Thus, the pattern we have seen for our air toxics data is not inconsistent with that available from an alternative inventory. For the rest of the analysis, we confine our attention to the air toxics data since the connection between this and the performance scores we wish to examine may be clearer.

Test Scores

Is there a spatial pattern of health risk and air pollution with academic performance? While we focus our regression analysis on a continuous variable, the actual Academic Performance Index, in this simple initial presentation of patterns, we utilize the state rank of the school. California arranges its schools into ten deciles, with those receiving a score of ten considered to be the best performers and those receiving a score of one considered to be the weakest performers. As it turns out, those schools in the bottom half of the state in terms of the respiratory hazard ratio do have lower state ranks but as we have noted above, it might be best to focus in more tightly given the concentration of schools with higher respiratory hazard ratios in a select six county set. To get at this, we split the schools in our county groups into those in the top and those in the bottom half with regard to the respiratory hazard ratio in the county grouping under consideration (recall that we have merged San Francisco and San Mateo Counties to be consistent with the others). We then took the ranks for each of those schools and calculated a weighted average for those above and below, utilizing school population as the weights. The results are depicted in Figure 2, and show a consistent pattern in which the ranks are, on average, lower for those schools in the parts of each county where the respiratory hazard ratio is highest.

<insert Figure 2>

The school rank differences between those in the above and below categories might be termed the "gap" in school performance. Of course, many things affect that gap, including the already documented differences in demographics and income levels between schools in areas with higher and lower respiratory hazard ratios. There may also be qualities particular to certain districts, including the quality of leadership, the commitment to equitable education, the efficiency of administration, parental engagement, and other such matters. Our data set includes over 900 districts, partly because of the intense fragmentation of the California public school system; thus, for a quick and easy glance, we examine just the biggest ten districts, all of which are in major urban areas and which together account for about nineteen percent of the schools and almost twenty-three percent of the students in the state. As can be seen in Figure 3, the "gap" in the average school population-weighted state rank within these ten big districts is almost uniformly negative and often quite large – that is, schools in the half of the district with the higher respiratory hazard ratios post a significantly poorer academic performance than those in the half of the district with lower respiratory hazard ratios. The one exception is the San Francisco Unified School District, which also seems to have much less demographic variation between schools above and below the median respiratory hazard ratio for the district.

<insert Figure 3>

Of course, there are generally many other differences between those schools in the two categories of district-level respiratory risk, including the sorts of racial demographics and income characteristics noted in the tables above. These factors also

impact academic performance, something we try to control for in the multivariate regressions below. One simple way of illustrating whether the difference persists when we control for such factors is to explore the "similar schools" rank. The state determines this by assigning each school a school characteristics index based on measures such as pupil mobility, ethnicity, socioeconomic status, and English learner status, as well as percentage of teacher with full or emergency credential, average class size, and whether the school operates multitrack year-round educational programs. The school is then compared to one hundred schools, fifty below and fifty above this characteristics ranking, and the school is then given a score for its decile ranking in the group of one hundred.

For a variety of reasons, this similar schools rank measure is less satisfactory than a regression analysis – schools are being compared statewide rather than to schools in the same district, county, or air basin, the comparison group is relatively small, and the nature of the characteristics index, including the relative weights for each factor, is not made explicit through regression techniques. Still, it may be illustrative and so we show the "gap" in the similar schools rankings for the ten largest districts in Figure 4; as can be seen, eight of the ten show a negative gap (schools in the areas with the higher respiratory hazard ratio have lower similar schools rank) and San Francisco Unified now shows a negative gap (a lower score) for those schools in the areas with a higher respiratory hazard ratio. Again, we believe that a regression analysis is superior and so forego further attention to the similar schools rank.

<insert Figure 4>

We do, however, offer a final view at the raw data, this time calculating the "gap" in average school rank for those above and below the median respiratory hazard for the

counties that were not considered earlier – that is, counties where the average respiratory hazard ratio is below an order of magnitude above one. Because there are many sparsely populated counties in California with very few schools, we confine our attention to those that had at least fifty public schools in our database. As can be seen in Figure 5, the pattern is not overwhelming: there are thirteen counties in which the schools with a higher respiratory hazard ratio have lower state ranks, nine counties in which those schools with a higher respiratory hazard ratio have a higher state rank, and one case in which there is no difference between the schools with higher and lower respiratory hazard ratios. There may be something different about the areas of the state where the respiratory hazard ratio is not generally above an order of magnitude, a topic to which we return below in our regression analysis.

<insert Figure 5>

Connecting the Dots

Before we formally test the relationship between school scores and the respiratory hazard ratio, it may be useful to understand possible causal mechanisms. However, this is beyond the scope of this exploratory analysis and would require the sort of detailed epidemiological work done in other studies such as Gauderman, et al. (2004). Still, we thought it useful to explore suggestive evidence for at least one route: the notion that respiratory hazards may be associated with respiratory ailments, such as asthma (see

Delfino 2002, Delfino et al. 2002), and that this could impact student absenteeism, an association made, for example, in Silverstein, et al. (2001).[18]

To establish the plausibility of such a relationship, we first examined the association between our NATA surface and data on asthma hospitalizations for the period 1998 to 2000. The latter was made available to us by California's Community Action to Fight Asthma, an organization focused on environmental policy change who utilized hospitalization rates from the Office of Statewide Health Planning and Development (OSHPD) to calculate three-year averaged, age adjusted, asthma hospitalization rates by ZIP Code Tabulation Area (ZCTA) for selected regions of California.[19] Age-adjusted asthma hospitalization numbers and rates (per 10,000 residents) were available by ZCTA for portions of the Bay Area, the San Joaquin Valley, Los Angeles County, and San Diego and Imperial Counties, a total area that includes about two-thirds of the state's overall population. The data is pictured in Figure 6, where we classify the ZCTAs into four categories based on hospitalization rates: areas with a zero hospitalization rate (more carefully explained below), and then the remainder of the ZCTAs grouped into three categories of hospitalization rates in ascending order.

<insert Figure 6>

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[18] Shendell et al. (2004) study six school districts and twenty-five portable classrooms in Idaho and Washington and find a statistically significant relationship between CO_2 and daily attendance, even controlling for room type, socio-economic status and ethnicity, and recommend improving classroom ventilation as a practical method of reducing absenteeism. This is in the spirit of the cross-sectional analysis we conduct between respiratory hazard and academic performance and present in the next section of the text.

[19] ZIP Code Tabulation Areas are very similar and sometimes identical to the more commonly known US Postal Service ZIP Codes, but were created in the year 2000 by the US Census Bureau as a geography for tabulating data rather than for the facilitation of mail delivery. For a more detailed explanation of the difference between ZIP codes and ZCTAs see http://www.census.gov/geo/ZCTA/zcta.html.

We are seeking to investigate whether there is a correlation between our respiratory hazard ratio and the reported rates of hospitalization for asthma. To get at this, we must first took our underlying respiratory hazard data, calculated at the 1990 census tract level, and then reshaped it to fit the polygons represented by the 2000 ZIP Code Tabulation Areas, using a simply land-weighted procedure (similar to that used to shift the data surface from the 1990 tracts to the 2000 tracts). We then linked this with the asthma hospitalization rates available at the 2000 ZCTA, and found a positive and highly significant correlation between the respiratory hazard ratio and the rate of asthma hospitalization, with a Pearson correlation coefficient of 0.2973.[20]

However, it is important to realize that hospitalization is only one possible outcome for asthma; if affected individuals have better access to health care, then hospitalization is a last resort and asthma management through medication, doctors' visits, and other routes would come first.[21] While asthma prevalence would allow us to make a more direct assessment of the relationship between our respiratory hazard ratio and asthma, the hospitalization rate is a measure that is available to us.[22] In order to consider the relationship between asthma itself (as opposed to hospitalization) and our respiratory hazard ratio we must control for factors that might explain the difference

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[20] This is the unweighted correlation coefficient; a correlation coefficient in which we weight each observation by the population in the zip code (similar to the procedure we use for the regressions below) is .25161; again, this is statistically significant at the .001 level.

[21] Further, the data is based solely on hospitalization cases where asthma was listed as the *primary diagnosis* and do not include cases where asthma may have played a role but was not most immediate cause, and is therefore even more restricted to only the most acute and often poorly treated cases of asthma. For more information on the data see Data User Guideline #2 at the following URL: http://www.calasthma.org/uploads/resources/cafa_datauserguideline2_oshpd_hospitalization_vjan2004.pdf

[22] Actually, hospitalization may also be more relevant to the impact of asthma on student absenteeism since an asthma patient with proper care is less likely to miss school than one who may not be receiving the appropriate care and was in fact hospitalized for the condition.

between asthma sufferers who are hospitalized those who are not, such as income (since this might be associated with, say, better health care).

We do not have individual observations and hence we must utilize data profiles for the various Zip Code Tabulation Areas from the census. Our key socio-economic variables considered were percent of the tract population in poverty and the median value of occupied housing units, with the former intended to indirectly measure access to quality health care and the latter the quality of the housing stock (which is also likely to affect indoor air quality). We also include population density on the supposition that more crowded areas will induce more asthma, as well as ethnic-specific variables to reflect the patterns of asthma hospitalization that seem to persist by race, even after socio-economic conditions are taken into account.[23] In one of the runs below, we also include education since higher levels of education seem to be associated with lower levels of asthma hospitalizations, presumably because of more knowledge on the part of patients and/or their parents (Chen et al. 2003). Note that inclusion of these variables, several of which are also associated with higher levels of respiratory hazards in the neighborhood (see Pastor et al. 2004a) implies that a very stringent test is being put on

[23] Ray et al. (1998) conduct a similar small area analysis of asthma hospitalization, using the three-digit ZCTA; utilizing a sparse model (with ethnicity, an urban dummy variable, and median household income), they find that household income and percent African-American are the most important variables. Chen, et al. (2003) look at individual cases of asthma hospitalization and introduce area-based measures taken from the Census which include education, unemployment, family income, and population density; if we use the Chen variables, we get similar results for the air quality measure. Leaderer, et al., 2002 look at individual cases of allergen concentrations but utilize one area-based measure, population density, and a series of socioeconomic characteristics associated with individuals such as education, income, and ethnicity.

our respiratory hazard measure, given issues of collinearity which were also revealed in a correlation matrix for the independent variables.[24]

In running the actual regression, we needed to take account of the truncated nature of the data – that is, when there are fewer than five hospitalization cases per ZCTA, the actual number is not given in order to protect confidentiality.[25] This data censoring implies that an ordinary least squares regression would tend to fit the line inappropriately, and so we must use a Tobit technique. We also explored the distribution of the respiratory hazard ratio, and saw that it tended to skew dramatically for upper values; hence, we used a log-transformation of the hazard ratio when entered as an independent variable, a process that yielded a distribution far closer to normal and one consistent with the log specification utilized in the school regressions below.[26] Finally, because the zip codes are much less uniform in population than census tracts and because we are seeking

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[24] There is also collinearity between our population density measure and the respiratory hazard ratio, as might be expected.

[25] We specifically set the rate to 1.92 hospitalizations per 10,000 people, the minimum rate among ZCTAs for which there were five or more hospitalizations. Note that the rate of 1.92 probably understates, on average, the true rates for ZCTAs with less than 5 asthma hospitalizations overall because many of these areas have such small populations that even one hospitalization could translate into a very high rate per 10,000. When we ran the regression with the dependent variable figured as a number instead of a rate and implemented appropriate left-censoring, setting all of the unknown (less than five) values to five, we got essentially the same results shown in Table 4 with a slightly lower level of significance attached to our respiratory risk variable, and a much less significant result (.107) for population density (not surprising since we had to also include the number of people in the zip code as a control). We think the rate approach is more appropriate and when we tried filling in unknown asthma hospitalization rates with values higher than 1.92 and ran the Tobit model, we obtained higher levels of significance for our respiratory risk variable as we did for most other variables on the right side of the regression. Given the data, the approach we take to left-censoring is designed to work least favorably in our direction, entirely appropriate in this sort of test.

[26] We first multiplied the respiratory hazard ratio by 10 in order to insure that every observation would be above one so that we could avoid creating negative values. A linear specification of the hazard ratio performed quite similarly, with significance falling slightly: for our full model in column two of Table 4, in the log specification, the significance level is .009, and in the linear specification, it is .0132.

to discover the relationship in the general society, we ran all regressions weighted by the zip code population.[27]

The results are presented in three columns in Table 4. In the first, we enter only the socio-economic variables; all are significant and appropriately signed.[28] In the second, we include the ethnicity variables as in Ray et al. (1998); as might be expected, the coefficient values fall for the socio-economic variables once the highly correlated factor of race is taken into account, and the African American presence, as the literature suggests, is highly associated with asthma hospitalizations. Still, the important news for this effort is that all variables are significant and the respiratory hazard ratio is positively and significantly associated with the hospitalization ratio, even after we have controlled for the other measures. The last column introduces an education measure, the percent of residents older than 25 with at least a B.A.; this reduces the significance level for the percent Latino and for house values, presumably because of correlation, but the respiratory hazard ratio remains significant at the .01 level. There may be a plausible connection between our NATA surface and the asthma symptoms many associate with lesser school performance.

<insert Table 4>

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[27] Weights were normalized so that the total equaled the number of observations. The population of the tracts for which we had hospitalization data was 22,164,915 out of a total California population of 33,871,648. For five of the zip codes for which we had hospitalization data, we lacked poverty data (because the population was either too small or, in two cases, consisted entirely of group quarters populations (entirely institutionalized in one zip code and mostly in another). For nine zip codes, we lacked data on housing values. Dropping all 14 of these observations caused us to lose 10,674 people, less than one-tenth of one percent of the total.

[28] The actual test statistics are Chi-squared and the significance levels are figured from those. However, we calculate a pseudo-T statistic by dividing the coefficient by the standard error as this might be more familiar to readers and more consistent with the regression reporting later in the paper.

Assessing School Performance

The final part of our analysis seeks to understand whether there is an association between our respiratory hazard ratio and a school's academic performance index. This requires, of course, a general understanding of what produces school scores in the first place and, in designing our model, we looked at the thriving literature on education production functions (see, for example, Hanushek 1992 and Krueger 1999). Of course, much of that research has been done at the individual level and the regressions below are in the tradition of those studies that focus instead on aggregate school performance (Fowler and Walberg 1991; Bickel and Howley 2000). However, as Bickley and Howley note, such school-level studies are increasingly common because of the way in which states and school districts have focused on schools as the unit of accountability and the state of California, in its similar schools ranking system, does seem to suggest what socioeconomic factors (such as percent poor students and English learners its policymakers believe drive academic performance at the school level.[29]

The basic regression to be tested involves analyzing a school's performance index, or API score, as a function of the respiratory hazard ratios as well as a series of now standard measures, including the percent of children receiving free school lunches (see Krueger 1999), the percent of teachers with emergency credentials (a proxy for teaching quality),[30] the percent of students just learning English,[31] and a measure of

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[29] See also Powers (2001) who uses the API in regressions on student performance in the San Diego School District. While her regressions are specified slightly differently and her focus is more on the impacts of teacher quality, the pattern of results is not dissimilar from what we obtain for the non-environmental variables in this study.

[30] See Darling-Hammond (2000) for a discussion of the results on teacher quality and student performance.

student mobility (the number of students who are new to the school that year) on the grounds that continual changes in school registration could produce lower performance.[32] We also introduced a measure of school size; the research on whether school size has an impact on academic performance is reviewed in Fowler (1995) and the general pattern suggests a negative effect, with the general notion being that smaller schools can more easily offer students individual attention.[33]

The statistical literature on student performance also suggests that parents' educational background matters greatly (see Hanushek 1992). Unfortunately, this is imperfectly collected in the state – in 2000, the median school had eighty-seven percent of parents reporting their education level but around 15 percent of schools receive less than a fifty percent report back. Still, we know the measure is important theoretically and as we see below the results are robust to its inclusion, with shifts in the coefficients for other variables sensibly reflecting the impact of including parental education. We specifically utilize as our measure the percent of parents lacking a high school degree, with the expectation that this will negatively affect school performance.[34] We also

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[31]English proficiency impacts the overall Academic Performance Index scores, which are not adjusted for this variable. The underlying exams used to calculate the API are administered in English due to the passage in California of a 1998 statewide initiative that limits bilingual instruction and testing.

[32] The API database's measure of mobility excludes students who are new to the district and thus focuses more on intra-district transfers. This present measurement problems in areas where a significant number of students are immigrants and may be very recent arrivals, but there is little that can be done given the data limitations.

[33] Interestingly, class size, the subject of recent heated debate between a series of researchers and policy makers (see Hanushek 2000; Krueger 2000), does not have a significant impact on the school score in our regressions; while we tested to find this out, we drop it from the regressions presented here because of the insignificance.

[34] California also has a continuous variable which is the average of parents' education level, with this being the average of parent responses where 1 is assigned to not being a high school graduate, 2 to being a high school graduate, 3 to some college, 4 to a college graduate, and 5 to completing graduate school. This variable, while descriptive is problematic in that it is not clear that the numbers have real meaning – is the change in parental effectiveness from being a high school drop out to having completed high school, the

introduced a dummy-variable for whether the school has a year-round or traditional academic calendar, because of the argument some have made that this diminishes school performance.[35] Finally, we introduce variables indicating the percent Latino, African American, and Asian in the school, on the grounds that this will pick up some unexplained differences in performance (see Krueger 1999).[36] Both the dependent (the academic performance index) and all non-dummy variables are entered as natural logs, both to reflect diminishing returns and for reasons of standardization (as in epidemiological work).[37]

Before we begin the analysis, however, we should consider the appropriate scale for the analysis. Note that we are collecting and testing data for schools that can be considered in the context of the school district, the county, or air basin. Each of these levels may have a very specific impact associated with it, with the two most theoretically relevant being district and air basin: schools may systematically differ in their

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same as going from college graduation to a graduate degree? For this reason (and also because it gives us a percent like our other variables, we utilize the measure for parents lacking a high school degree.

[35] While many proponents of year-round education have argued that there is a positive effect, presumably because shorter breaks between sessions facilitate retention, the evidence is actually mixed (Naylor 2001, Campbell 1994) and Weaver (1992) notes that when year-round programs are adopted solely to alleviate overcrowding, education improvement is not significant. In face, many year-round schools in urban areas have adopted this calendar because of overcrowding; as a result, this variable may be actually picking up older, rundown facilities and more at-risk students, and thus may not be an indictment of the calendar *per se*. If that is so, one positive outcome for the regression analysis is that we are separating out some of the other broader "environmental" factors from our more strictly construed measures of environmental air quality. Interestingly, a dummy variable for whether the school is deemed critically overcrowded by the state of California, another measure of general facility conditions, does not have a significant impact on school performance, at least in a full multivariate analysis.

[36] Readers will note that we are essentially entering all variables that the state uses in constructing its similar schools analysis. The exception is that we do not use class size but school size (as indicated in a footnote, class size is not significant) and that we include parents' education in light of the stress in the education literature on the importance of this factor.

[37] In addition, log values were more normally distributed. In order to prevent missing values, we added to all percent values the sum of 1.01 (so that we never log anything below one or equal to zero). We also multiplied the hazard ratio by 10 to avoid the same problem. We take a similar approach to specification in Pastor et al. (2004c).

performance depending on the quality of the district while, as the earlier discussion indicated, the baseline level of our measure of air quality systematically differs by air basin.

We decided to begin the analysis by temporarily foregoing the issue of how to control for scale in such a large sample – technically, at what level we should model fixed and random effects – by focusing in a single district, the Los Angeles Unified School District (LAUSD). LAUSD also has the virtue of being the largest in the state (with approximately twelve percent of the students in the state) and perhaps the vice (although a virtue for our analysis) of being in one of the parts of the state where the county-level respiratory hazard ratio exceeds an order of magnitude. A depiction of the respiratory hazard ratio and school scores for LAUSD is shown in the map in Figure 7; as can be seen, there is a visual correlation between scores and the respiratory hazards but sorting out all the other factors driving those scores requires multivariate analysis.

<insert Figure 7>

A panel of regression results is shown in Table 5; all regressions were weighted by the number of students. We start with a specification that includes the usual key variables associated with school performance, percent of poorer students, percent learning English, percent teachers with an emergency credential, the degree of mobility in the school, school size, and a dummy for having a year-round calendar; we find a negative and significant coefficient for all these variables as well as a reasonable fit (as measured by the R^2). Our second column introduces the measure for parents' education level; we do this separately because this measure is slightly less reliable given that not all

parents respond to questions about their education level.[38] As can be seen, the measure is statistically significant, as we would expect, the fit of the regression improves, and several other variables which may have been correlated with parental education (such as percent students poor enough to receive free or reduced price lunch) see their coefficients decline. The third specification introduces the demographics of the student body, with Latinos and African Americans associated with lower scores (even controlling for all the other schools measures) and the Asian Pacific presence contributing to higher scores. Note also the interactions: in particular, the coefficient and t-statistic for the percent poorer students decline, suggesting that race was one of the factors "buried" in the poverty measure, and the coefficient and t-statistic for teachers with an emergency credential also declines, again pointing to the fact that such teachers are more likely to be in highly minority schools (now being controlled by the direct introduction of demographics).

<insert Table 5>

The fourth and fifth columns introduce the respiratory hazard ratio, first without the student racial demographics and then with those demographics. As can be seen, it is negative and statistically significant in both although the coefficient is halved when we introduce the demographics – given the racial pattern of exposure to hazardous air documented earlier, this is to be expected and the important thing is that the effect persists at a statistically significant level. The fit of the regression is satisfactory at .831.

[38] The other issues is that some schools do not have recorded levels of parent education. To maintain comparability with the first column, the regression there only includes schools with the parent education variable even though we do not enter the variable itself; if we were to expand the sample to include those schools lacking the variable, the pattern would be the same and so we impose the constraint so that we can more clearly see the effect of the variable and not the effect of changing sample size when we introduce the parent education measure.

To explore the implications for size effects, we took the coefficients from regression in the fifth column and conducted a series of simulations in which we sequentially shifted the value of each variable from the 75th percentile of its distribution to its median (i.e., from being in the middle of the half of the schools with the highest percent English learners to being in the exact middle of the whole distribution). The logic for this rather than utilizing percentage increases in each variable is that this would allow us to better take account of the underlying distribution of the independent variables.[39]

While we experimented with all the variables, several are not likely to come about through school- or district-level policy: reducing students on free lunch, lowering student mobility, altering student racial demographics, reducing school size, and increasing parent education levels can all improve scores but the major influences on these variables are often well beyond the control of school administrators.[40] On the other hand, the model suggests that moving from the 75th percentile to the median for percent English learners (which might be accomplished by more effective language transition programs) would yield about a modest 2.35 percent increase in test scores; this slightly less than twice what we would expect to see from the same relative improvement (from the 75th

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[39] Another way to take account of the underlying distribution could be to vary each variable by its standard deviations. However, several of the variables are quite skewed: for example, the percent parents without a high school degree averaged 30 percent in the LAUSD sample but had a standard deviation of 21 points because of skewness of the data. The skewness and standard deviation problem is even worse for Asians and African American who both have a lower average presence but are quite concentrated in certain schools. For these reasons, we decided to instead vary from the 75th to the 50th, as indicated in the text.

[40] Strictly speaking, this is not true since either forced bussing or choice programs could alter student demographics in certain schools. However, since the same students would simply be at other schools, we suspect that this would just be a shuffling of scores rather than the sort of policy-induced improvement contemplated in the subsequent paragraph. Another change is to shift from year-round calendars but this is a "lumpy" jump – either the school is on such a calendar or it is not – and so moving from the 75th to the 50th percentile has little meaning in this context.

percentile to the median) in either the share of teachers with emergency credentials (which might be achieved through incentives for more qualified teachers and improved teaching training) or in the respiratory hazard ratio (perhaps through emissions source reduction, careful consideration of air quality when siting new schools, and other strategies discussed below).

While the improvements might seem modest, the reader should recall that given the nature of the regression technique, the estimates offered here essentially describe how to shift ranks within the cross-section of schools in any particular year. As it turns out, changes in academic performance year-to-year are usually driven not so much by changes in the underlying variables as by gains in efficiency – schools figure out how to achieve better results with the same resources. Still, the cross-sectional estimates do provide some direction as to where to focus resources and environmental improvement might be one part of a much larger package for school reform.

What happens when we scale up the analysis statewide? Table 6 presents several statistical cuts on the issues, each of which involves taking account of effects that might be specific to either the district the school is in or the air basin in which the district resides; to get a sense of the air basins in California, see Figure 8. Technically, we implement a mixed effects regression procedure where we assume that the impacts of variables of interest (such as the respiratory hazard ratio or percent students on free lunch) are the same across all districts; thus, we let the intercept vary for each district to reflect any specific effects associated with that district. When we couple air basins and districts, we implement this as a nested set of effects – essentially, the intercept is varying dependent on both the air basin and the district. Because the fixed effect procedure is

essentially looking at the variance within districts, we set a minimum number of schools per district for inclusion in the sample when we use district controls; we chose five because this let us include slightly over 90 percent of the students in the state in the fullest regression.[41] When we introduce controls just for air basins or counties, we are under no such constraint; this explains why the number of observations in the third column is higher than that in the first column.

<insert Figure 8 and Table 6>

The first column in Table 6 offers a broad overview of the state, with controls entered for each district. Note that we enter a new variable in this regression and the others in this table: an identifier for whether a school is suburban (since there seems to be some evidence that such schools exhibit higher performance than schools in either central cities or rural areas).[42] As can be seen, all variables are signed as expected and significant at the .01 level; the explanatory power, as given by a pseudo R-squared calculated directly from the regression residuals, is nearly ninety percent. Our second column continues with controls for districts, but this time focuses on the top ten districts depicted in an earlier graph. As can be seen, all variables are signed as expected and significant at the .01 level, although the respiratory hazard ratio, as in the statewide sample, has one of the lower t-scores.

The third column introduces controls for the air basin location. As in the other specification, all variables are signed as expected and significant. Column four reflects

[41] Setting a higher minimum of 10 schools in a district would cover approximately 75 percent of the students in the state; since the results are quite similar we stick with the lower minimum and higher coverage.

[42] A school is tagged as suburban if it is in a area of the state designated as urban but not in one of the following central cities: Bakersfield, Fresno, Long Beach, Los Angeles, Oakland, Riverside, Sacramento, San Bernardino, San Diego, San Francisco, San Jose, and Santa Ana.

what is likely to be the most sensible specification: controls are introduced for both districts (to capture impacts of the district itself) and air basins (to insure that we are looking at the relationships within air basins for reasons discussed earlier).[43] Note that the psuedo R-squared is quite high. Second, while nearly all coefficients are lower than in our full specification for LAUSD, the pattern is quite similar and the significant levels are much higher (not surprising in light of the much higher sample size). Further tests show that the regressions are relatively robust. Dividing the state into air basins of generally highest concern for reason of air quality (San Francisco Bay, South Coast, and the San Joaquin Valley) and the rest of the state, and utilizing the district controls, we find that the regression is stable in both subsets, with the respiratory hazard ratio having a larger impact in the largest air basins than in the rest of the state but both exhibiting a statistically significant impact.

We also decided to run the regressions for the counties where the respiratory hazard ratio exceeds 10. One of those runs is shown in the last column of Table 6, utilizing controls for the counties; all variables are signed appropriately and significant.[44] When we utilize controls for both county and district; the respiratory hazard ratio is significant and all other variables remain appropriately signed and significant (although the percent poor students declines in significance to .05 level). We also ran a regression for the counties where the respiratory hazard ratio is less than an order of magnitude but there are at least fifty schools in the county (that is, the sample in Figure 5). Utilizing

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[43] Another specification involved entering the log of the value of the respiratory hazard ratio relative to the average hazard ratio for all schools in that basin, a strategy that may better control for the basin-level effect on schools scores. This yielded a strong and significant negative coefficient and all other variables behaved as expected.

[44] The county control again collapses San Francisco and San Mateo Counties.

controls for both counties and districts, we find that the results seem to parallel the simple comparisons in Figure 5: the respiratory hazard measure is negatively signed but posts an anemic t-score of -.600. Given that the counties are rather small, we tried instead to utilize air basins as the control in addition to districts; in that run, the respiratory hazard measure was negative with a t-score of 1.966 which is significant at the .05 level. It seems that the effects of the respiratory hazard ratio might be more pronounced in the areas with higher respiratory hazards, a possible avenue for future research.

Conclusions and Implications

Across the country, politicians, parents, and business leaders are talking about the need to improve our country's educational system in order to better compete in today's global economy. Special attention has been paid to those students who have often been left behind: poor students, minority students, and English learners. Much needs to be done to help both students and communities achieve their full potential. While most of the needed and perhaps more critical interventions will focus on issues of teacher quality, after-school programming, parental engagement, and extra resources, this paper suggests that attention to environmental quality at and around schools might be a relevant part of the mix.

Utilizing one measure of air quality, based on respiratory hazards associated with ambient air toxics, we mapped the state of California and compared the demographics of those schools whose proximate air quality was above and below the median for various school sets; the general pattern is that minority and lower-income students generally seem

to go to schools with lower air quality within the state and their respective counties. We then examined school-level academic scores and found that these were often lower in areas with higher respiratory hazards, perhaps reflecting effects on health, absenteeism and other factors that might affect school performance. To get at these more formally, we conducted multivariate regression analysis in which we controlled for other factors that might impact schools scores: examining this with controls for district and air basin, and sometime county, we find that there is a statistically significant negative impact. We also find that the effect seems to be stronger in the larger air basins (San Francisco Bay, South Coast, and the San Joaquin Valley) and in counties where the baseline respiratory hazard ratio exceeds one by an order of magnitude.

The result provided here might seem to suggest a need to avoid such areas in our school-attending and school-building future. Yet things are not so simple. It turns out that the denser and more polluted areas are where the need for new schools may be the greatest.[45] Seventeen percent of public school students in California are in what the state terms "critically overcrowded" schools – but the problem is severely racialized with only 5 percent of white students in critically overcrowded schools versus one in four African American and Latino students. Overcrowding is particularly serious in the Los Angeles Unified School District where almost 80 percent of students are in critically overcrowded schools (see Pastor and Reed 2004). As a result, some students are forced into long bus rides to other schools in the district, exposing them to diesel exhaust and the burdens that

[45] Moreover, building outside these areas simply encourages further sprawl which has its own costs in terms of environmental and economic sustainability. See Wolch, et al. (2004).

impose extraordinarily elevated cancer risks (see Solomon, et al. 2001; see also Fitz, et al. 2003; Wargo and Brown 2002.).

Thus, building will occur in our older urban areas and the challenge is to make the schools as environmentally friendly as possible. Indeed, building new permanent classroom to high standards may be an important part of the solution. Crowding has led to an excessive use of portable classrooms: a study by the California Air Resources Board and the California Department of Health Services (2003) reported that just under one-third of all K-12 classrooms were portable in 2000-01 and suggested that while environmental problems were frequently found in both portable and traditional classrooms, indoor air quality issues seem to be of particular concern in portables, partly because noisy ventilation systems are sometimes turned off by teachers seeking a quieter classroom (see CARB/CDHS 2003). Two recent California studies have also found higher levels of VOCs, including aldehydes, in portable classrooms (Hodgsen et al, 2001; Schendell et al. 2004); given the fact that VOC emissions have been linked to adverse respiratory outcomes among children, this warrants special concern (Meggs 1993, Norback 1995).Both improving portable systems and getting new construction moving are key.

Nor is air quality the only environmental issue for new and existing schools. Pesticide use at schools have also been a concern; while this is an evident issue for schools in rural areas, urban and suburban schools often have significant green space and so the state maintains a voluntary Integrated Pest Management Program. Brownfield concerns are also present. Because the state is building schools in older urban areas, many of which have also hosted industrial uses, the state's Department of Toxic

Substances Control (DTSC) has been busy reviewing proposals for new school construction with an eye toward appropriate remediation or removal of tainted soil as necessary. However, the DTSC acknowledges that there are also issues for existing schools that may unknowingly be near hazardous locations (Oudiz, Booze, and Pollack 2003).

Fortunately, the state of California and several districts do seem to be taking a lead. Under 1999, the state established a Children's Environmental Health Center under the state's Environmental Protection Agency, and this has become a central point for children's issues, including those at school. The Los Angeles Unified School District passed a landmark Integrated Pest Management (IPM) policy in 1999 that has enabled the district to stop using some highly toxic pesticides and to cut down overall pesticide use from 136 different chemicals to only 36. LAUSD has also stopped broadcast spraying and the use of pesticide bombs which greatly increase the risk of children's exposures. The district's policy is now being used as a model for schools in California and across the country.

Based on our own work, we would specifically recommend four main threads for policy. The first is simply to improve the data with which we are able to assess air quality. Better localized measures of criteria pollutants, many of which have been implicated in more detailed epidemiological studies, would make the assessment of both environmental equity and the impact on learning more feasible. This would involve more extensive and reliable air monitoring, better modeling of air dispersion, and better GIS techniques to take advantage of local geological and meteorological information in interpolation. Several efforts in California are headed in this direction, including a new

Environmental Health Tracking Program which has emerged from the recommendations of an Expert Working Group (www.catracking.com)

The second, based on the connection between outdoor and indoor air (Sexton, et al. 2004), is to establish better ventilation and filtration strategies, with particular target schools being those where data surfaces, such as the one used here, suggest that there may be higher need. We note that the state of California has established laws that prevent new schools from being built within 500 feet of busy roads but has not established a program to go back and assess those schools that currently fall within these no-build zones in order to assess the need for site remediation re air quality. The U.S. EPA has offered a new set of "Tools for Schools" concerned about indoor air quality, which includes significant details about ventilation and other strategies [see http://www.epa.gov/iaq/schools/]. Along these same lines, it is important to speed progress on cleaner school buses and, recognizing the harmful effects of diesel emissions, the state of California has recently passed useful regulations to limit bus idling near schools.

The third policy area involves building an understanding of the need to incorporate health concerns at school. Thompson, et al. (2002: 8) note that increased responsibility for raising test scores has led some school officials to be reluctant about venturing into health tracking (for example, of students with asthma), particularly when fiscal constraints are leading to a cutback in school nursing staffs. However, California's ratio of students to nurses is more than three times the level recommended by the National Association of School Nurses and this paper suggests that environmental health

and academic performance may be interrelated, offering new reasons to include this in the arsenal of strategies for school improvement.

Finally, our main policy goal should remain source reduction. There is a substantive amount of evidence pointing the positive health effects in mobile and point source reduction and Wong, et al. (2004) provide a useful assessment of the impact of general air pollution reduction on children's health, suggesting enormous savings in health and other costs.[46, 47] In some sense, children are a barometer: improving air quality with kids in mind is likely to improve air quality for everyone, much like targeting environmental justice communities is less likely to spread existing pollution evenly (given resistance in higher-income communities) and more likely to reduce the presence of "hot spots" that drive up regional averages. Better ventilation, site remediation, health monitoring, and other measures are useful stopgap measures for schools; the prize remains an environment in which risks are minimized and children's health, learning, and development are valued and supported by all aspects of public policy.

Achieving this goal will require new alliances and new collaborations. Agencies and stakeholders that have not always worked together will need to find common ground, building on promising practices and experimenting with innovative strategies. Children's

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[46] One classic study is Friedman et al. (2001) which looked at the effects of an extensive traffic reduction program put in place during the 1996 Summer Olympic Games in Atlanta Georgia: there was a 41.6% decrease in acute care asthma events and a prolonged reduction in ozone (Friedman et al. 2001). In Utah Valley the closure and subsequent reopening of a steel mill during an extended strike resulted in significant PM reductions and decreased hospitalization. (Pope, 1996; Pope, 1991), with Ransom and Pope (1995) estimating excess hospitalization costs from mill operation at 2 million dollars a year and increased mortality at 40 million dollars a year (Ransom & Pope, 1995). Ransom and Pope (1992) also found that school absenteeism was about 25 percent higher during mill operations.

[47] A recent report released by the American Academy of Pediatrics summarizes current research and regulation and provides clear health-based policy recommendations to address the growing issue of ambient air pollution and childrens health (American Academy of Pediatrics, 2004)

advocates, public health officials, educators, and parents will have to nurture a groundswell of public concern for environmental health. And environmental justice advocates will need to stress children's health as central to their struggle for equity, recognizing that inequality must be addressed not only across race and class but also across generations.

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Figure 1.

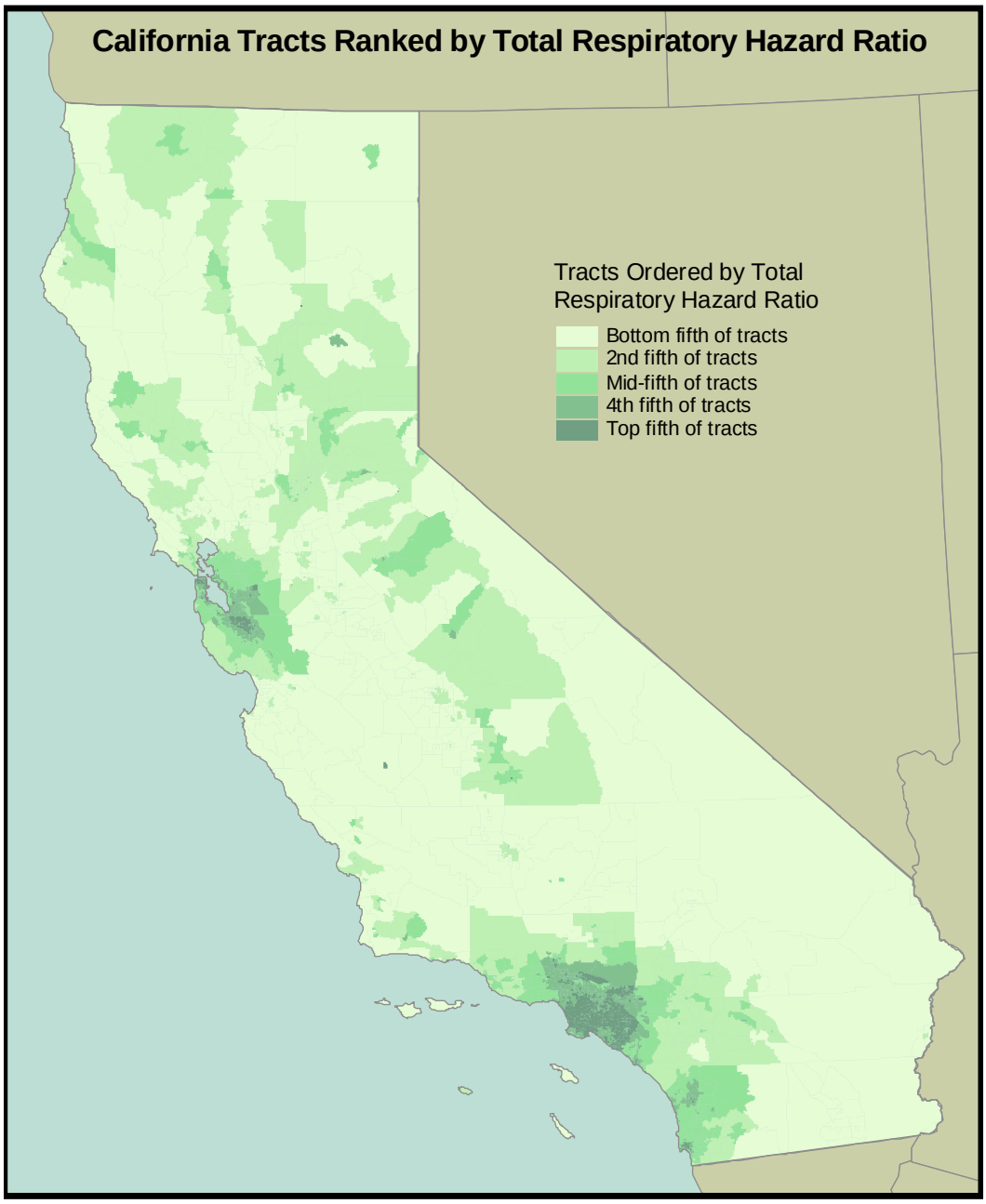
California Tracts Ranked by Total Respiratory Hazard Ratio
Tracts Ordered by Total Respiratory Hazard Ratio
Bottom fifth of tracts
2nd fifth of tracts
Mid-fifth of tracts
4th fifth of tracts
Top fifth of tracts

Table 1

Schools Ranked by Respiratory Hazard Ratio, California

	% white	% Latino	% Black	% Asian Pacific	% Other	% free or reduced lunch
Below Median	48.1	34.2	7.3	7.9	2.6	43.2
Above Median	29.7	45.4	9.0	14.3	1.6	48.8

California's Non-Rural Schools Ranked by Respiratory Hazard Ratio

	% white	% Latino	% Black	% Asian Pacific	% Other	% free or reduced lunch
Below Median	45.2	34.4	8.7	9.7	2.1	42.3
Above Median	25.1	49.1	9.2	15.1	1.5	52.4

Table 2

County Average Respiratory Hazard Ratio and Schools in Tracts
with Hazard Ratios Above an Order of Magnitude

County	County Respiratory Hazard Ratio	Number of Schools	% of Schools in Tracts Where Respiratory Hazard Ratio Exceeds an Order of Magnitude
San Francisco	18.7	106	99.1%
Los Angeles	17.2	1552	90.7%
Orange	17.9	516	90.5%
Santa Clara	13.0	332	72.3%
Alameda	11.1	292	63.4%
San Mateo	10.7	157	50.3%
San Diego	8.3	508	15.0%
San Bernardino	6.6	396	14.1%
Riverside	5.8	307	5.2%
Ventura	6.3	167	2.4%
Fresno	3.1	232	2.2%

Table 3

Schools Ranked Within County Sets for Counties Where Respiratory Hazard Ratio Exceeds an Order of Magnitude

	% white	% Latino	% Black	% Asian Pacific	% Other	% free or reduced lunch
ALAMEDA						
Below Median	35.4	16.7	23.1	21.2	3.6	28.2
Above Median	31.5	24.3	16.2	24.8	3.1	34.4
LOS ANGELES						
Below Median	27.2	50.6	9.1	11.9	1.1	54.1
Above Median	13.2	62.1	13.2	10.4	1.1	67.7
ORANGE						
Below Median	49.2	32.3	1.8	15.7	1.1	32.7
Above Median	37.5	46.3	2.1	13.1	0.9	41.7
SAN FRANCISCO / SAN MATEO						
Below Median	41.8	24.8	4.6	25.5	3.3	20.1
Above Median	14.9	25.1	14.3	36.1	9.6	46.4
SANTA CLARA						
Below Median	46.6	23.8	3.1	24.4	2.1	18.2
Above Median	23.2	38.8	4.3	32.5	1.2	37.4

Figure 2.

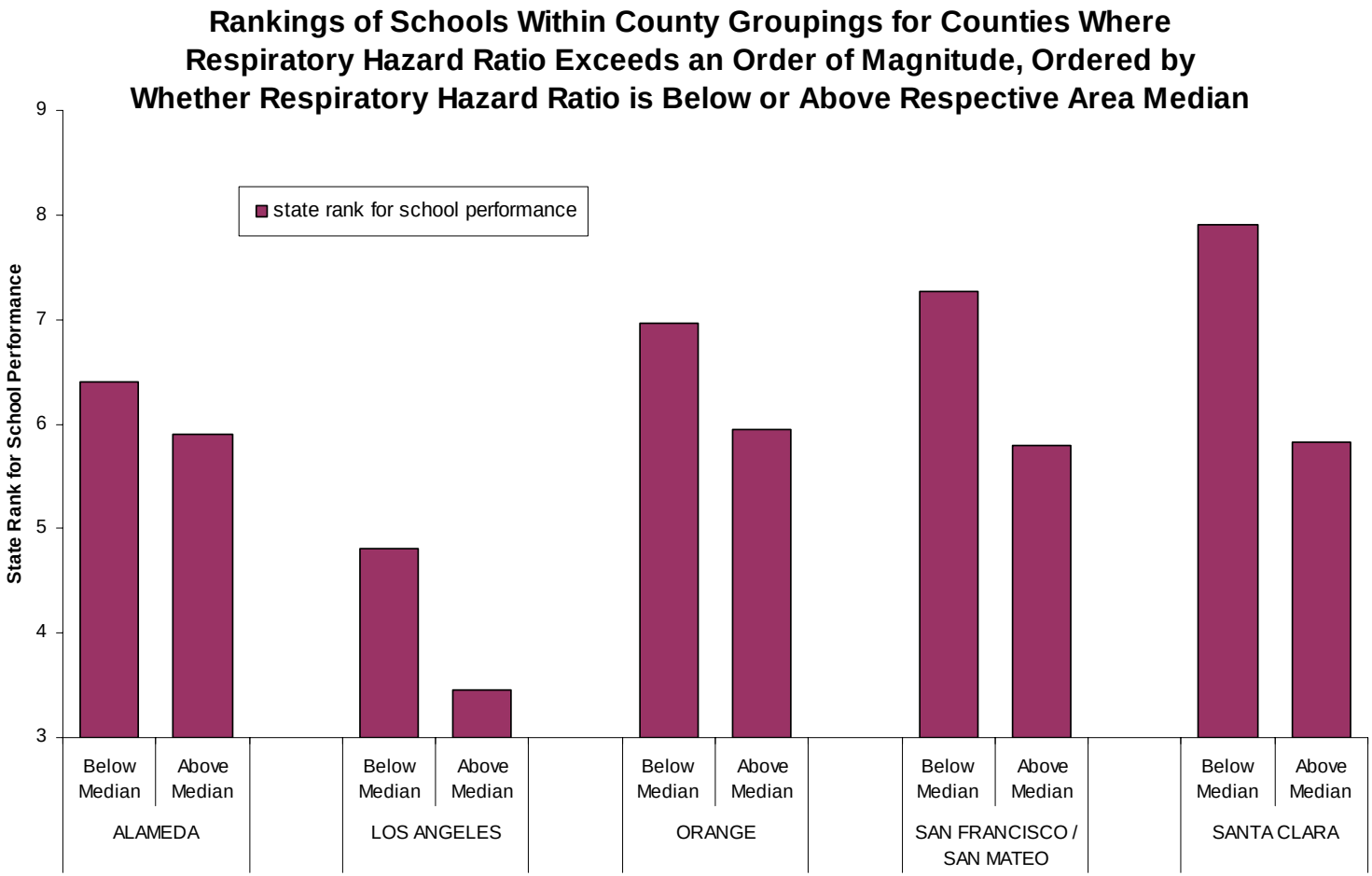
Rankings of Schools Within County Groupings for Counties Where Respiratory Hazard Ratio Exceeds an Order of Magnitude, Ordered by Whether Respiratory Hazard Ratio is Below or Above Respective Area Median
state rank for school performance
State Rank for School Performance
9
8
7
6
5
4
3
Below Median
Above Median
ALAMEDA
LOS ANGELES
ORANGE
SAN FRANCISCO / SAN MATEO
SANTA CLARA

Figure 3.

Gaps in School Ranks for Ten Largest Districts, with Two Groups Set by Whether Respiratory Hazard Ratio is Above or Below Median for District

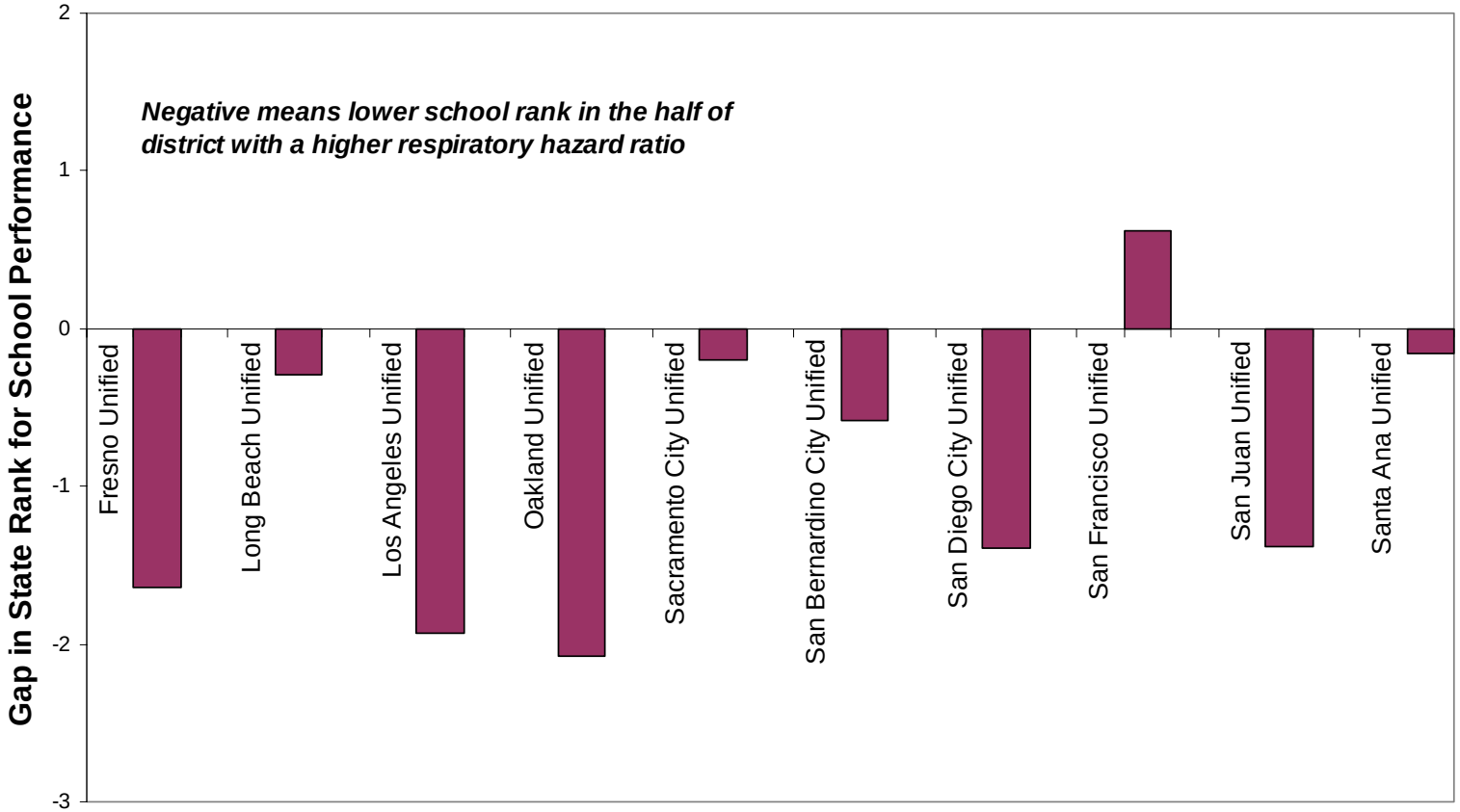

Figure 4.

Gaps in Similar School Ranks for Ten Largest Districts, with Two Groups Set by Whether Respiratory Hazard Ratio is Above or Below Median for District

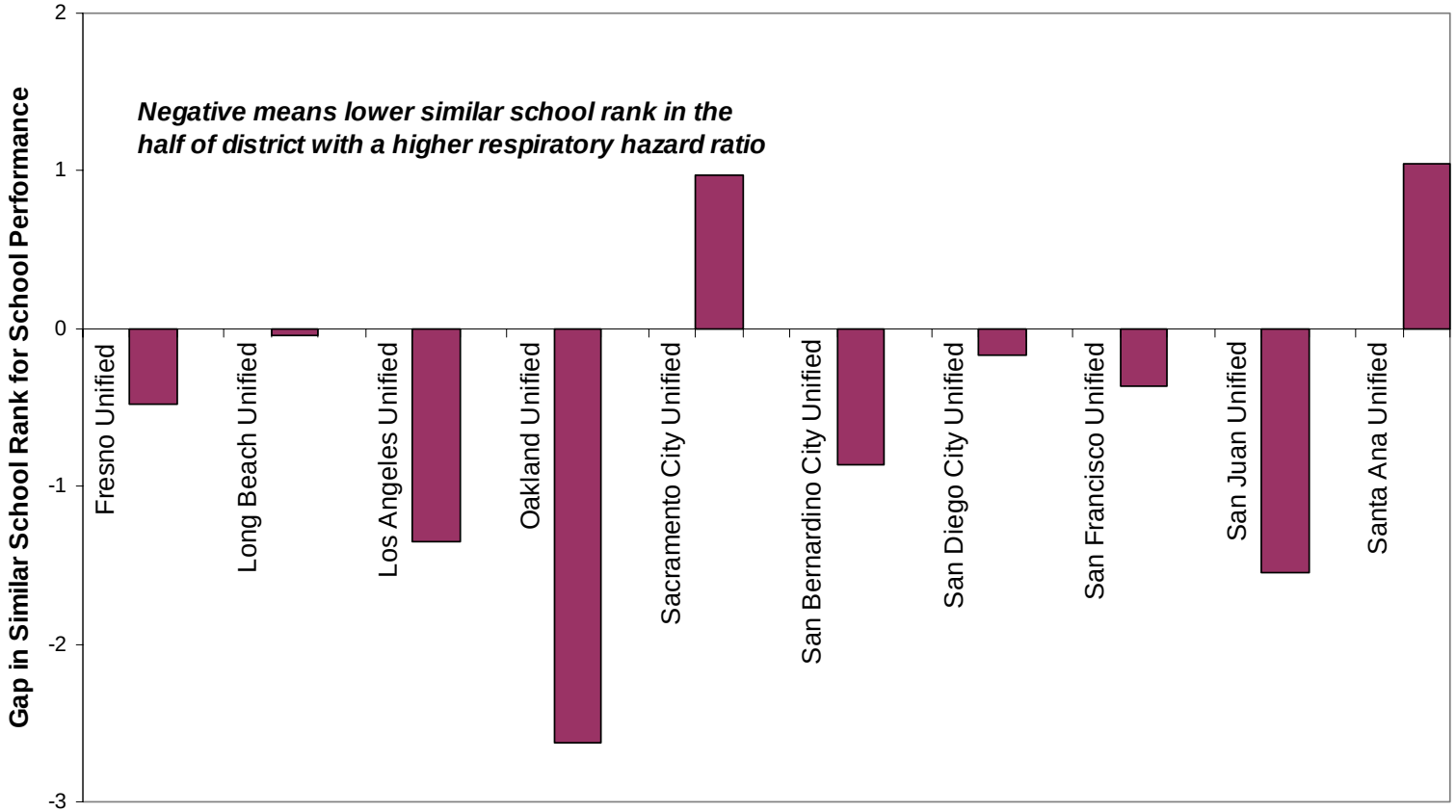

Figure 5.

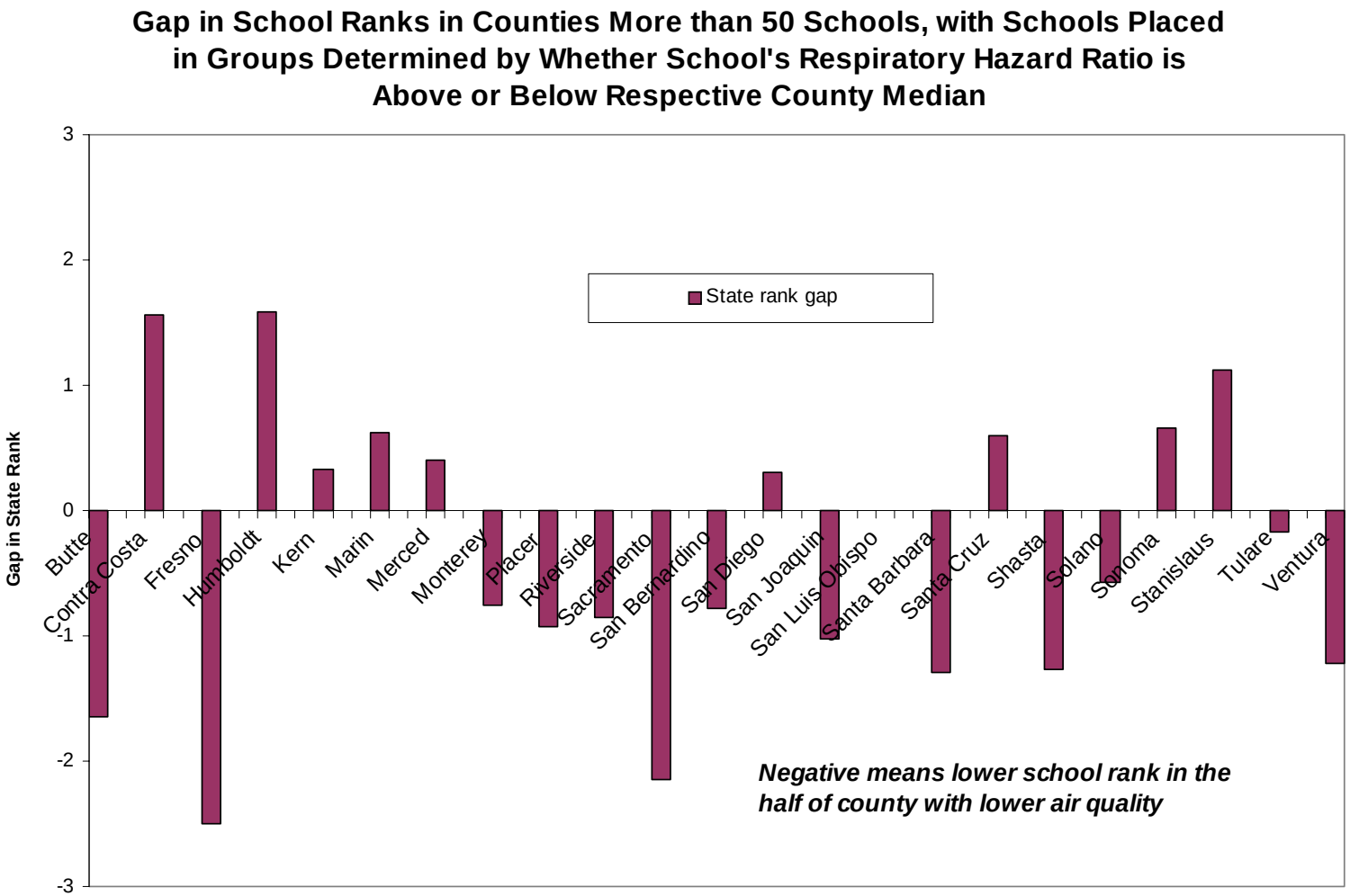
Gap in School Ranks in Counties More than 50 Schools, with Schools Placed in Groups Determined by Whether School's Respiratory Hazard Ratio is Above or Below Respective County Median
Gap in State Rank
3
2
1
0
-1
-2
-3
State rank gap
Butte
Contra Costa
Fresno
Humboldt
Kern
Marin
Merced
Monterey
Placer
Riverside
Sacramento
San Bernardino
San Diego
San Joaquin
San Luis Obispo
Santa Barbara
Santa Cruz
Shasta
Solano
Sonoma
Stanislaus
Tulare
Ventura
Negative means lower school rank in the half of county with lower air quality

Figure 6.

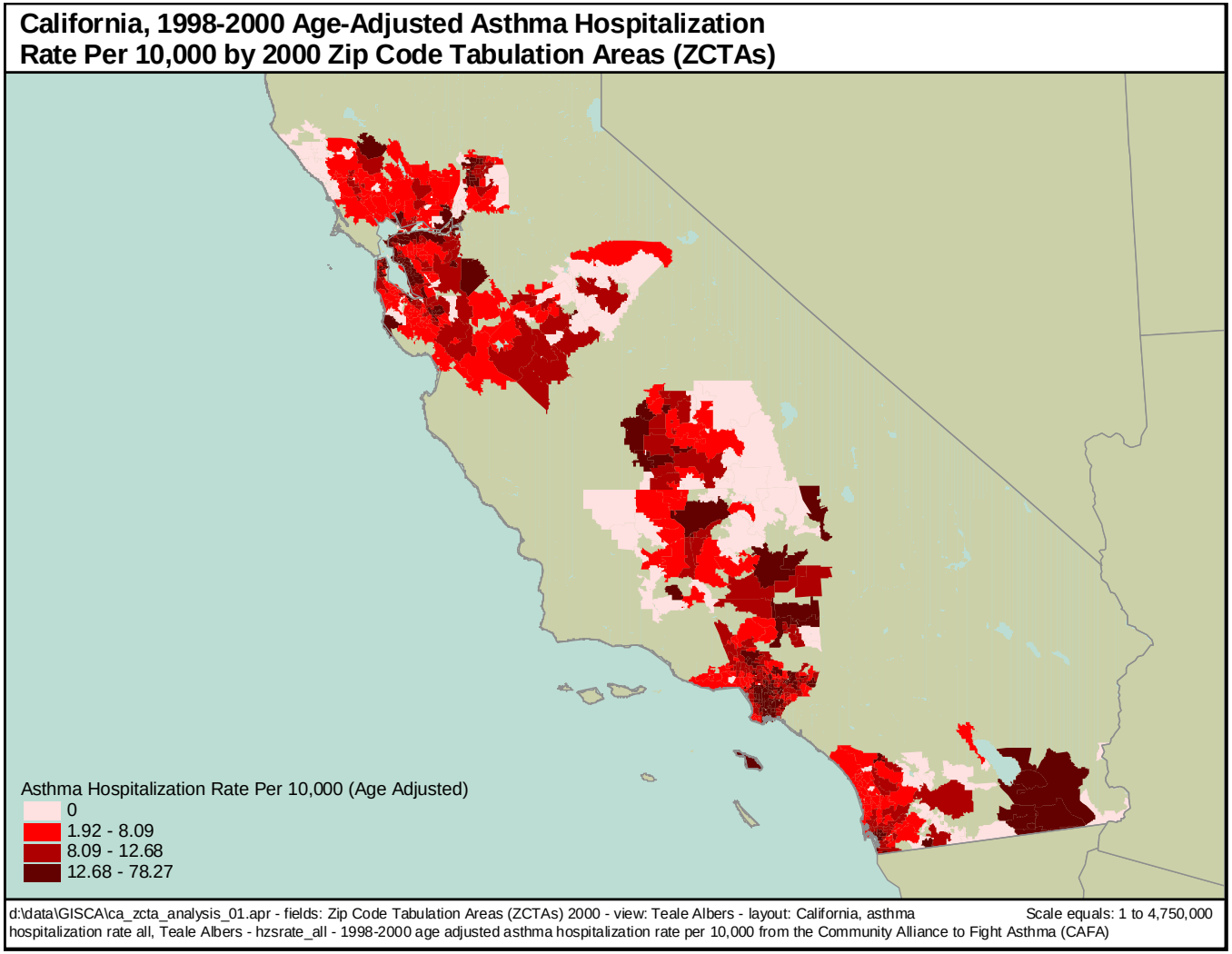
California, 1998-2000 Age-Adjusted Asthma Hospitalization
Rate Per 10,000 by 2000 Zip Code Tabulation Areas (ZCTAs)
Asthma Hospitalization Rate Per 10,000 (Age Adjusted)
0
1.92 - 8.09
8.09 - 12.68
12.68 - 78.27
d:\data\GISCA\ca_zcta_analysis_01.apr - fields: Zip Code Tabulation Areas (ZCTAs) 2000 - view: Teale Albers - layout: California, asthma hospitalization rate all, Teale Albers - hzsrate_all - 1998-2000 age adjusted asthma hospitalization rate per 10,000 from the Community Alliance to Fight Asthma (CAFA)
Scale equals: 1 to 4,750,000

Table 4.

Tobit Regressions on Asthma Hospitalization Rate by Zip Code Tablulation Area

Dependent Variable - Asthma Hospitalization Rate per 10,000 (age-adjusted)

Explanatory Variables	Coeff.	Psuedo-T	sig.	Coeff.	Psuedo-T	sig.	Coeff.	Psuedo-T	sig.
Intercept	2.946	*(2.32)*	**	4.465	*(4.69)*	***	5.497	*(5.56)*	***
log of respiratory hazard ratio	1.769	*(6.31)*	***	0.592	*(2.60)*	***	0.765	*(3.31)*	***
population density	0.444	*(2.52)*	**	0.451	*(3.37)*	***	0.405	*(3.04)*	***
poverty rate	24.623	*(9.38)*	***	8.255	*(3.37)*	***	8.436	*(3.47)*	***
median house value	-2.213	*-(8.31)*	***	-1.146	*-(5.14)*	***	-0.458	*-(1.55)*	#
percent Latino				4.436	*(4.63)*	***	2.042	*(1.75)*	*
percent African American				35.562	*(24.22)*	***	34.230	*(22.74)*	***
pecent Asian Pacific				3.566	*(2.97)*	***	3.330	*(2.79)*	***
percent w/ B.A. or better							-6.612	*-(3.51)*	***
Number of observations	799			799			799		

*** = significant at .01 level; ** = significant at .05 level;
* = significant at .10 level; # = significant at .20 level

Figure 7.

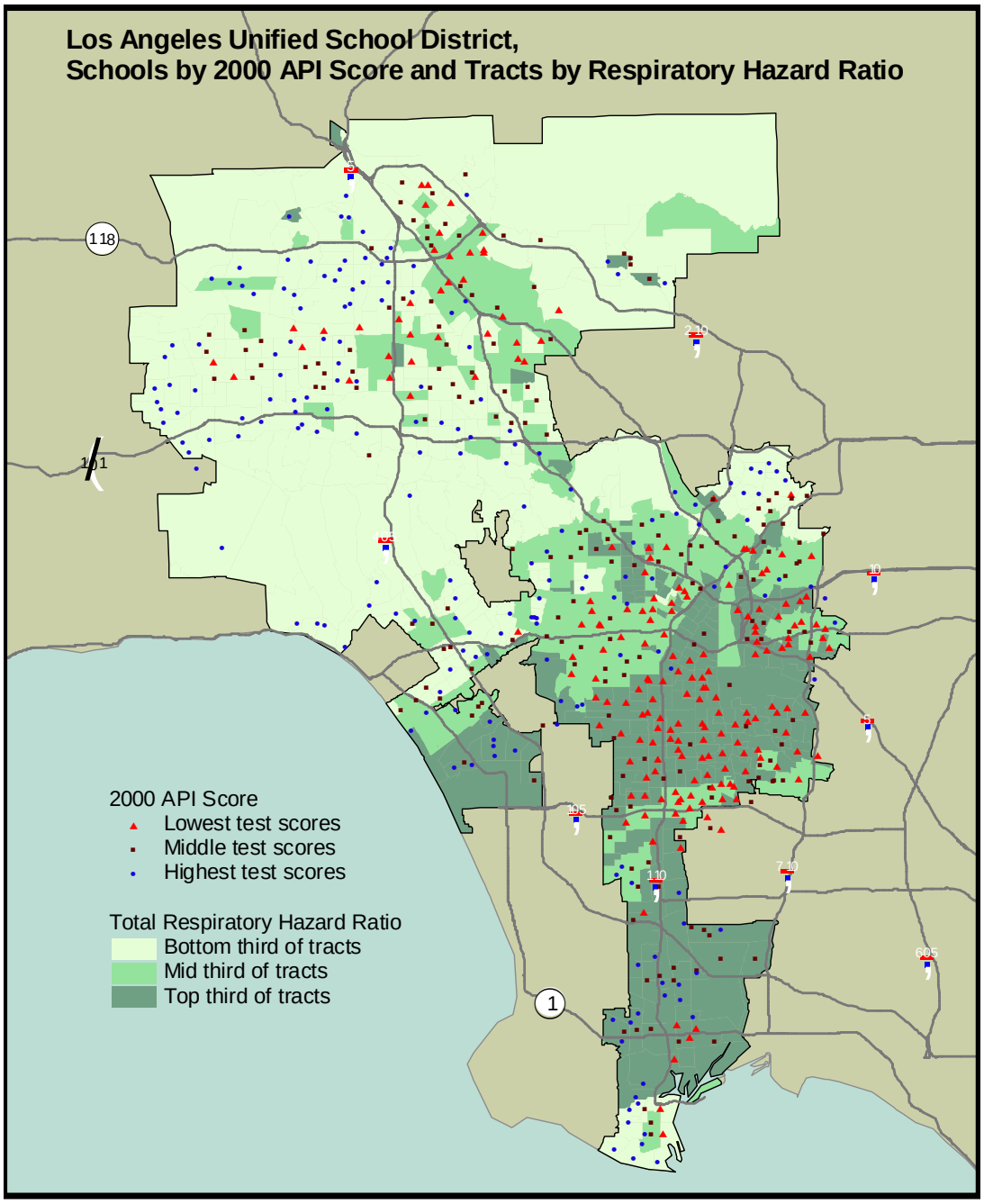
Los Angeles Unified School District,
Schools by 2000 API Score and Tracts by Respiratory Hazard Ratio
2000 API Score
Lowest test scores
Middle test scores
Highest test scores
Total Respiratory Hazard Ratio
Bottom third of tracts
Mid third of tracts
Top third of tracts

Table 5.

Academic Performance Index as a Function of School Variables and Respiratory Hazard Ratio
(Los Angeles Unified School District)

	Base regression			*Base regression, with parents' educational level*			*Base regression, with race*			*Regression with respiratory hazard ratio*			*Regression with respiratory hazard ratio, and race variables*		
Variables	coefficient	*T-stat*		coefficient	*T-stat*		coefficient	*T-stat*		coefficient	*T-stat*		coefficient	*T-stat*	
students on free lunch	-0.151	*-9.59*	***	-0.129	*-8.20*	***	-0.078	*-5.66*	***	-0.099	*-6.32*	***	-0.060	*-4.32*	***
students learning English	-0.049	*-4.87*	***	-0.029	*-2.76*	***	-0.048	*-4.64*	***	-0.044	*-4.25*	***	-0.055	*-5.41*	***
teachers w/ emergency credential	-0.105	*-8.56*	***	-0.104	*-8.74*	***	-0.052	*-5.19*	***	-0.094	*-8.21*	***	-0.049	*-5.01*	***
student mobility	-0.059	*-4.80*	***	-0.062	*-5.23*	***	-0.030	*-2.91*	***	-0.067	*-5.92*	***	-0.034	*-3.46*	***
school size	-0.074	*-10.45*	***	-0.058	*-7.82*	***	-0.057	*-8.93*	***	-0.060	*-8.38*	***	-0.058	*-9.21*	***
year-round school	-0.067	*-5.91*	***	-0.065	*-5.87*	***	-0.033	*-3.50*	***	-0.051	*-4.76*	***	-0.026	*-2.88*	***
parents w/o high school degree				-0.040	*-5.64*	***	-0.029	*-4.77*	***	-0.039	*-5.76*	***	-0.028	*-4.82*	***
percent Latino							-0.042	*-2.49*	**				-0.046	*-2.79*	***
percent African American							-0.031	*-7.04*	***				-0.030	*-7.11*	***
percent Asian Pacific							0.060	*14.65*	***				0.056	*13.77*	***
respiratory hazard ratio										-0.122	*-7.03*	***	-0.079	*-5.49*	***
Adjusted R-squared	0.704			0.720			0.821			0.743			0.831		
number of observations	537			537			537			537			537		

*** significant at the .01 level; ** significant at the .05 level; * significant at the .10 level; # significant at the .20 level

Figure 8.
California Air Basins

Table 6.

Academic Performance Index as a Function of School Variables and Tract Respiratory Hazard Ratio
(state of California, utilizing controls for specific factors in school districts and air basins)

	All of state, controlling for district (districts with more than five schools)			*Biggest ten districts, controlling for district*			*All of state, controlling for location in air basin*			*All of state, controlling for air basin and district (districts with more than five schools)*			*Six County Set, controlling for county location*		
Variables	coefficient	*T-stat*		coefficient	*T-stat*		coefficient	*T-stat*		coefficient	*T-stat*		coefficient	*T-stat*	
students on free lunch	-0.027	*-8.75*	***	-0.056	*-6.57*	***	-0.035	*-14.25*	***	-0.024	*-7.61*	***	-0.019	*-4.87*	***
students learning English	-0.046	*-18.32*	***	-0.064	*-10.02*	***	-0.040	*-19.25*	***	-0.046	*-18.63*	***	-0.043	*-13.56*	***
teachers w/ emergency credential	-0.021	*-13.16*	***	-0.035	*-7.88*	***	-0.024	*-17.23*	***	-0.021	*-13.54*	***	-0.021	*-9.34*	***
student mobility	-0.018	*-7.29*	***	-0.035	*-5.85*	***	-0.015	*-7.01*	***	-0.018	*-7.39*	***	-0.023	*-6.25*	***
school size	-0.053	*-25.08*	***	-0.063	*-15.21*	***	-0.052	*-26.22*	***	-0.053	*-25.33*	***	-0.056	*-19.61*	***
year-round school	-0.022	*-6.30*	***	-0.027	*-3.87*	***	-0.012	*-3.69*	***	-0.021	*-6.13*	***	-0.020	*-3.84*	***
parents w/o high school degree	-0.038	*-18.15*	***	-0.035	*-7.72*	***	-0.043	*-21.21*	***	-0.036	*-17.21*	***	-0.034	*-11.73*	***
percent Latino	-0.036	*-9.28*	***	-0.046	*-5.55*	***	-0.028	*-8.94*	***	-0.043	*-11.10*	***	-0.049	*-10.68*	***
percent African American	-0.024	*-13.61*	***	-0.035	*-10.51*	***	-0.023	*-16.88*	***	-0.025	*-14.14*	***	-0.019	*-9.34*	***
percent Asian Pacific	0.053	*30.85*	***	0.052	*17.00*	***	0.049	*34.16*	***	0.052	*30.28*	***	0.057	*28.73*	***
suburban	0.023	*7.38*	***	0.022	*3.28*	***	0.020	*8.21*	***	0.021	*6.95*	***	0.033	*7.98*	***
respiratory hazard ratio	-0.009	*-2.60*	***	-0.037	*-3.75*	***	-0.014	*-5.73*	***	-0.023	*-5.65*	***	-0.027	*-5.80*	***
Psuedo R-squared	0.863			0.833			0.796			0.864			0.841		
number of observations	5694			1271			6535			5694			2802		

*** significant at the .01 level; ** significant at the .05 level; * significant at the .10 level; # significant at the .20 level