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TECHNICAL
R E P O R T



The Impact of Air Quality on Hospital Spending

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Summary

Air pollution is detrimental to human health, with adverse effects that range from restrictions in physical activity, to emergency room (ER) visits for asthma and hospitalizations for respiratory and cardiovascular causes, to premature mortality. The economic costs of such effects are substantial.

Little is known, however, about the financing of pollution-related health care. If such care imposes a significant burden on insurance companies and employers, they would have substantial stakes in improving air quality. Reduced medical spending could also benefit public programs such as Medicare and Medicaid.

The primary objective of this study was to determine pollution-related medical spending by private health insurers as well as by public purchasers such as Medicare. The study focused exclusively on hospital spending, though doctors' visits and other medical care also result from air pollution. The study did not address broader impacts of air pollution on health, which are important but better understood. (Table S.1 lists more health endpoints associated with ozone and PM_{2.5}, identified in U.S. Environmental Protection Agency [2008c], but is not exhaustive.) The cost of air quality improvement is also important, but outside our scope.

To pursue our objective, we quantified the hospital spending incurred by health care purchasers/payers from 2005 to 2007 that is attributable to California not meeting clean air standards. Millions of people were exposed to significant air pollution during this period. In addition, the state of California collects and discloses appropriate clinical and financial data on hospital care, in particular, data on spending by payers for pollution-related admissions for cardiovascular and respiratory causes, and ER visits for asthma. As the report describes in detail, we used epidemiological studies and actual pollution patterns to determine how meeting federal air quality standards would affect the number of acute health events requiring hospital care. We used actual patterns of hospital care to determine the potential reductions in care delivered at specific hospitals. Finally, we used actual spending patterns to quantify the cost, and therefore the potential spending reductions, for different types of payers.

Table S.2 summarizes our overall results. Meeting federal clean air standards would have prevented an estimated 29,808 hospital admissions and ER visits throughout California over 2005–2007. (To prevent double counting, hospital admissions are defined to include hospital encounters that began in the ER but that led to an admission.) Nearly three-quarters of the potentially prevented events are attributable to reductions in ambient levels of fine particulate matter, that is, particulate matter with an aerodynamic diameter of less than or equal to 2.5 micrometers, which we abbreviate as PM_{2.5}. The rest of the prevented events are attributable to reductions in ozone.

Failing to meet federal clean air standards cost health care purchasers/payers \$193,100,184 for hospital care alone. In other words, improved air quality would have reduced total spending

Table S.1
Known and Quantified Health Endpoints Associated with PM2.5 and Ozone

PM2.5 health effects	Premature mortality
	Chronic and acute bronchitis
	Respiratory hospital admissions
	Cardiovascular hospital admissions
	ER visits for asthma
	Heart attacks (myocardial infarction)
	Lower and upper respiratory illness
	Minor restricted-activity days
	Work loss days
	Asthma exacerbations (asthmatic population)
	Respiratory symptoms (asthmatic population)
	Infant mortality
Ozone health effects	Premature mortality: short-term exposures
	Respiratory hospital admissions
	ER visits for asthma
	Minor restricted-activity days
	School loss days
	Asthma attacks
	Acute respiratory symptoms

NOTE: Shading indicates endpoints included in this study.

Table S.2
Air Pollution–Related Hospital Events, Spending, and Hospital Charges in California over 2005–2007 Caused by Failure to Meet Federal PM2.5 and Ozone Standards, by Pollutant, Endpoint, and Population

Pollutant	Endpoint	Population	Events	Spending	Hospital Charges
Ozone	Acute bronchitis, pneumonia, or COPD admission	All ages	6,056	\$56,500,000	\$226,000,000
PM2.5	Pneumonia admission	65 and older	2,517	\$27,700,000	\$123,000,000
PM2.5	COPD admission	65 and older	652	\$5,634,450	\$24,800,000
PM2.5	COPD admission excl. asthma	Age 18–64	306	\$2,721,382	\$10,900,000
PM2.5	Asthma admission	64 and younger	940	\$5,575,469	\$20,100,000
PM2.5	Any cardiovascular admission	65 and older	3,256	\$47,700,000	\$205,000,000
PM2.5	Any cardiovascular admission	Age 18–64	1,864	\$35,100,000	\$120,000,000
Ozone	Asthma ER visit	All ages	2,027	\$1,768,883	\$5,271,011
PM2.5	Asthma ER visit	17 and younger	12,190	\$10,400,000	\$31,700,000
Total			29,808	\$193,100,184	\$766,771,011

on hospital care by \$193,100,184 in total. Table S.3 reports cost by type of payer. Medicare, the federal program that primarily covers the elderly, spent \$103,600,000 on air pollution–related hospital care during 2005–2007. Medicaid (Medi-Cal in California), the federal-state program that covers low-income people, spent \$27,292,199. Private health insurers (that is, third-party payers) spent about \$55,879,780 on hospital care.

These results suggest that the stakeholders of public programs may benefit substantially from meeting federal clean air standards. Private health insurers and employers (who contribute to employee health insurance premiums) may also have sizable stakes in improved air quality.

We also determined the impact of poor air quality at specific hospitals. Five hospitals are presented here as “case studies”: Riverside Community Hospital, St. Agnes Medical Center, St. Francis Medical Center, Stanford University Hospital, and University of California–Davis Medical Center.

These case studies are a diverse group. We reviewed and qualitatively selected hospitals according to the following criteria: the scale of potential prevented events and spending reductions; geographic region; and payer and patient mix.

Figure S.1 shows the number of events by patient zip code. These events are concentrated in the San Joaquin Valley and South Coast air basins. St. Agnes is located in the former, while Riverside Community and St. Francis are located in the latter. PM_{2.5} and ozone levels in these areas substantially exceed federal standards. A sizable number of events originate in and near Sacramento, where the UC Davis Medical Center is located.

Stanford University Hospital is located in the San Francisco metropolitan area. Moreover, as Table S.4 shows, private insurers were expected to pay most of the bill for 46% of Stanford University Hospital’s patients, versus 31% for California as a whole. At the other extreme, private payers paid for only 14% of patients at St. Francis. Medi-Cal paid for 59% of patients, compared with a state average of 22%. Among the case study hospitals, the Medicare share was highest at St. Agnes (50%) and lowest at St. Francis (21%).

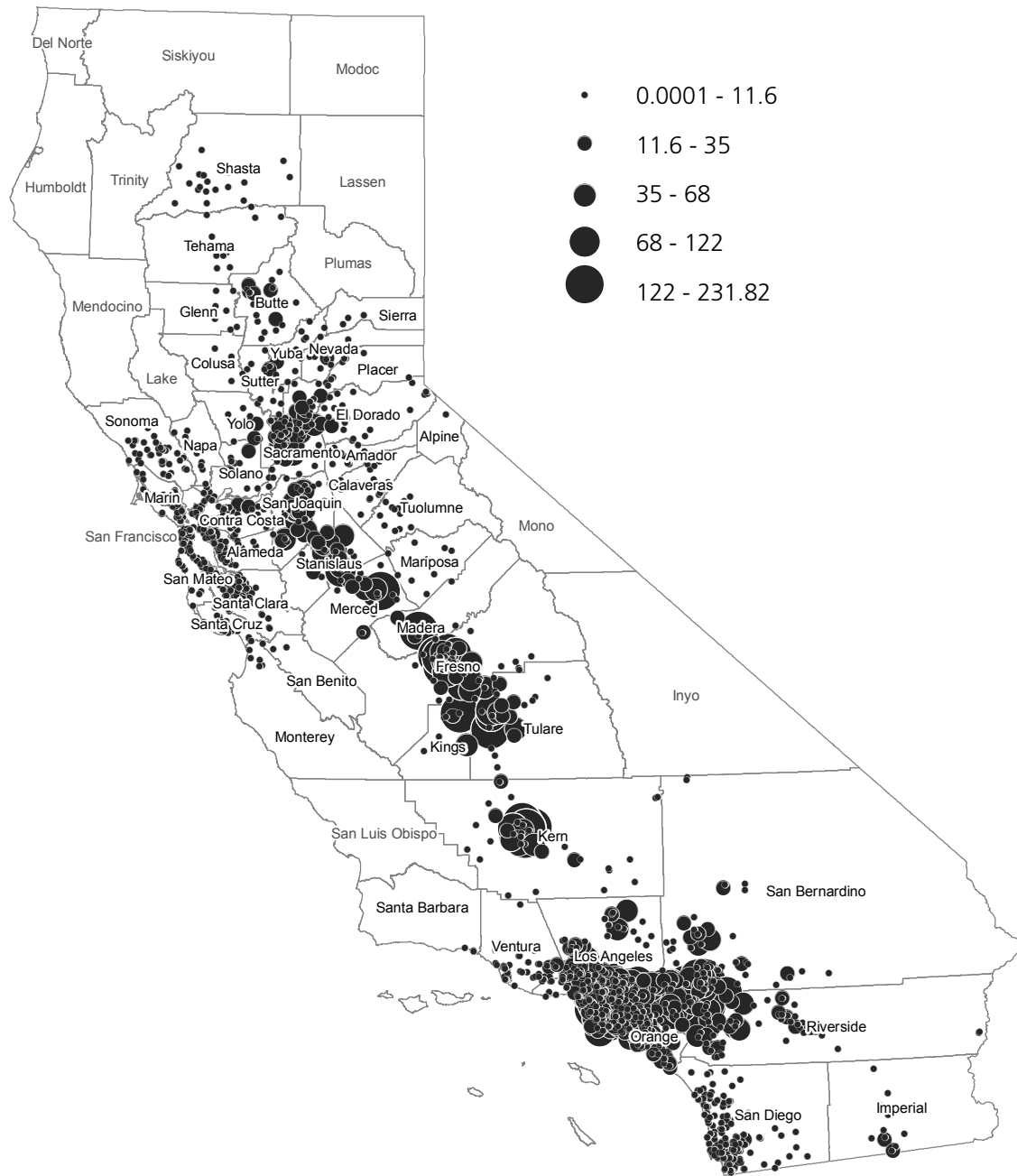
The racial composition of patients varied substantially across hospitals. Slightly more than three-quarters of patients were white at Stanford University Hospital, compared with 2% at St. Francis. African-Americans were 20% of the patient population at St. Francis, compared with

Table S.3
Events, Spending, and Hospital Charges in California over 2005–2007 Caused by Failure to Meet Federal PM_{2.5} and Ozone Standards, by Payer Type

Payer	Reduction in Events	% of Total Event Reduction	Reduction in Spending	% of Total Spending Reduction	Reduction in Hospital Charges
Medicare	9,247	31.02	\$103,600,000	53.60	\$463,000,000
Medi-Cal	8,982	30.13	\$27,292,199	14.14	\$126,000,000
County indigent	335	1.12	\$1,071,967	0.55	\$7,612,133
Total public	18,564	62.28	\$131,964,166	68.29	\$596,612,133
Total private third-party	9,029	30.29	\$55,879,780	28.90	\$149,954,889
Total all other	2,216	7.43	\$5,443,008	2.82	\$20,919,389

NOTE: Medi-Cal is the name for California’s Medicaid program.

Figure S.1
Pollution-Related Hospital Events throughout California over 2005–2007, by Patient Zip Code



a statewide average of 7%. The proportion of Hispanic patients was well above average at St. Francis (77%) and at Riverside Community Hospital (38%).

The economic status of patients also varied widely. Statewide, 15% of patients have incomes below the federal poverty level. But at St. Francis, more than one-quarter of patients were poor; at Stanford University Hospital, fewer than 10% of patients were poor.

Figures S.2 through S.11 show the number of air pollution–related events at each of the five case-study hospitals:

Table S.4
Characteristics of Case Study Hospitals, 2005–2007

Hospital	Riverside Community Hospital	St. Agnes Medical Center	St. Francis Medical Center	Stanford University Hospital	UC Davis Medical Center	All California Hospitals
Summary information						
City	Riverside	Fresno	Lynwood	Stanford	Sacramento	—
County	Riverside	Fresno	Los Angeles	Santa Clara	Sacramento	—
Annual discharges	18,903	24,396	22,841	22,788	29,282	7,248
Staffed beds	345	406	384	454	550	175
Teaching hospital	No	No	No	Yes	Yes	—
Discharges, by payer (%)						
Private third-party	37	30	14	46	35	31
Medicare	36	50	21	38	24	37
Medi-Cal	22	18	59	9	29	22
Other	5	2	7	7	13	10
Patient race/ethnicity (%)						
White	51	72	2	78	50	62
Black	7	4	20	5	12	7
Hispanic	38	21	77	7	18	24
Asian or Pacific Islander	1	3	0	10	5	5
American Indian	0	0	0	0	0	0
Other	3	0	1	0	15	2
Patient economic status, by income as percentage of Federal Poverty Level						
0–100% FPL	15	20	27	9	16	15
> 100% FPL	85	80	73	91	84	85

NOTES: Medi-Cal is the name for California's Medicaid program. See Table 4.4 for detailed payer types. Racial groupings include non-Hispanic persons of single race.

At **Riverside Community Hospital**, 329 hospital admissions and ER visits would have been prevented had federal standards for PM_{2.5} and ozone been met during 2005–2007 (Figure S.2). Private health insurers paid most of the bill for almost half (149) of these patients. Medicare was the next most frequent payer for these preventable events. Overall, spending was \$2,015,880 (Figure S.3). Medicare spent about \$1,140,060, as these patients were relatively likely to have costly hospital stays, rather than ER visits. Private insurers spent \$708,700.

At **St. Agnes Medical Center** in Fresno, failing to meet federal air standards had even greater effects: 384 hospital admissions/ER visits occurred (Figure S.4) and \$2,976,936 was spent (Figure S.5). More than half of these events (208), totaling \$1,913,116, were paid for primarily by Medicare, consistent with its above-average importance at this hospital.

At **St. Francis Medical Center** in Lynnwood (south of Los Angeles), 295 hospital admissions and ER visits occurred (Figure. S.6). Medi-Cal was the primary payer for more than half of these events (156). The next most frequent payer, Medicare, had one-third as many events (51). Nevertheless, Medicare spent \$716,979, partly because Medi-Cal tends to pay less for hospital care. For example, Medi-Cal spent \$9,482 on average for pneumonia admissions for those 65 and older, compared with \$10,882 for Medicare. Overall, failing to meet clean air standards led to \$1,220,595 in spending at St. Francis (Figure. S.7).

At **Stanford University Hospital**, 30 hospital admissions and ER visits occurred (Figure S.8), costing \$534,855 (Figure. S.9). Figure S.1 shows that fewer events occurred in the San Francisco metro area than in other parts of the state.

At **UC Davis Medical Center** in Sacramento, our final case study, 182 events occurred (Figure. S.10), and spending totaled \$1,882,412 (Figure S.11). Medi-Cal was the most frequent payer (81) for these preventable events, while Medicare would have experienced the largest spending reduction (\$855,499).

These case studies underscore that health care payers could enjoy substantial reductions in hospital spending from improved air quality. The payers who benefit the most vary substantially across hospitals and communities.

Figure S.2
Air Pollution–Related Hospital Events at Riverside Community Hospital over 2005–2007, by Payer

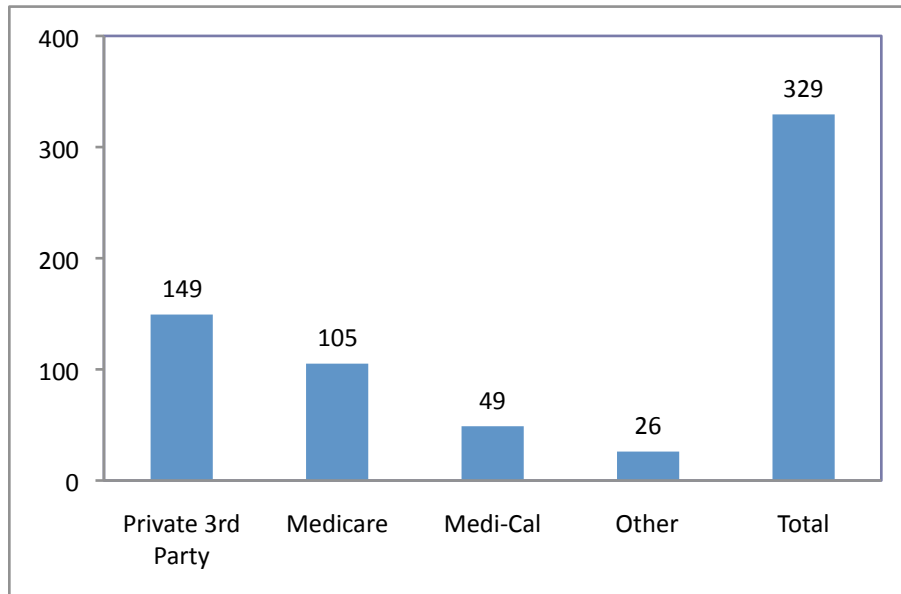


Figure S.3
Air Pollution–Related Hospital Spending at Riverside Community Hospital over 2005–2007, by Payer

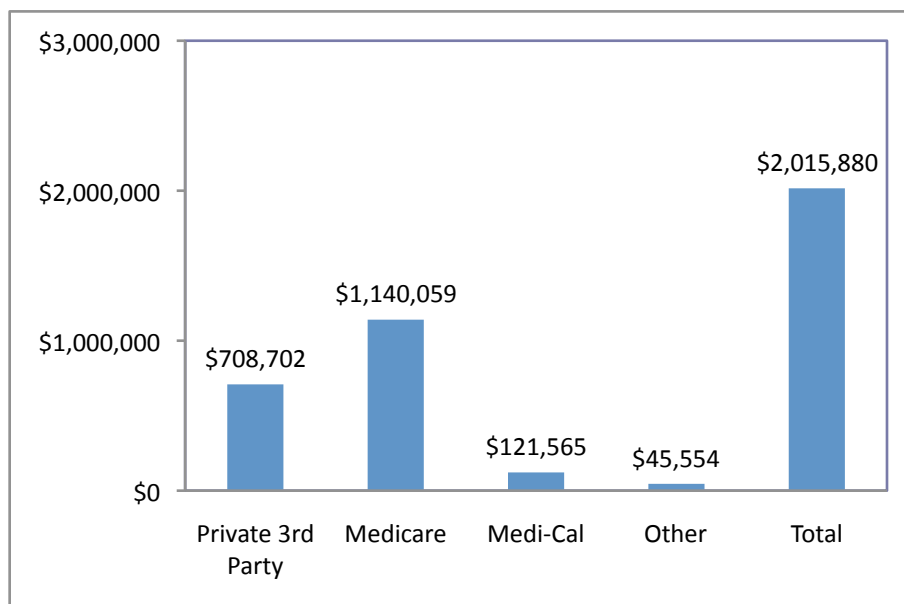


Figure S.4
Air Pollution–Related Hospital Events at St. Agnes Medical Center over 2005–2007, by Payer

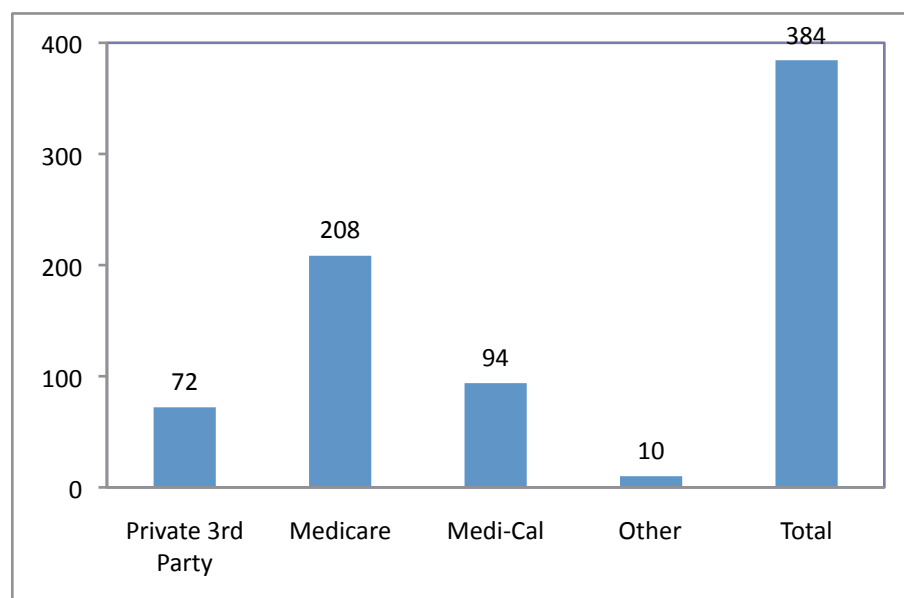


Figure S.5
Air Pollution–Related Hospital Spending at St. Agnes Medical Center over 2005–2007, by Payer

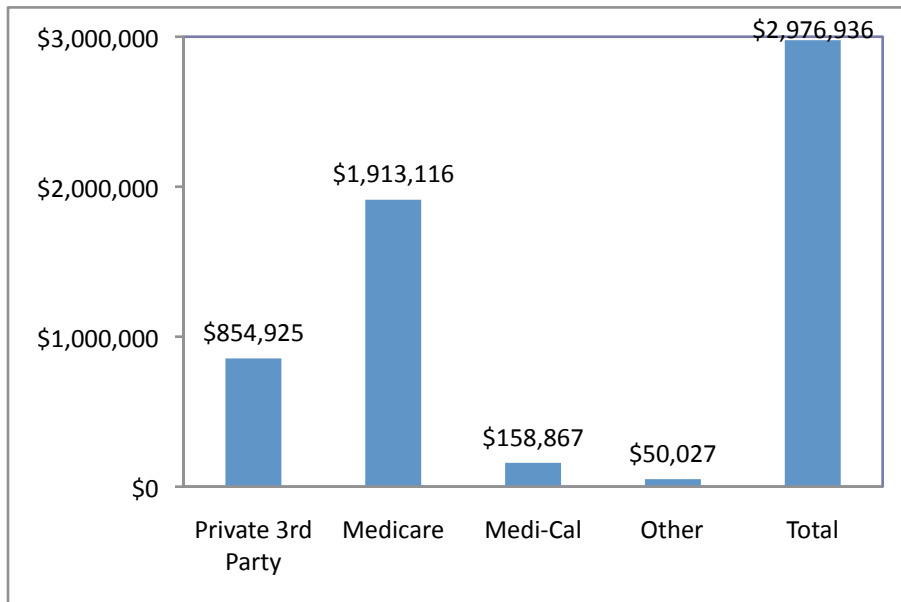


Figure S.6
Air Pollution–Related Hospital Events at St. Francis Medical Center over 2005–2007, by Payer

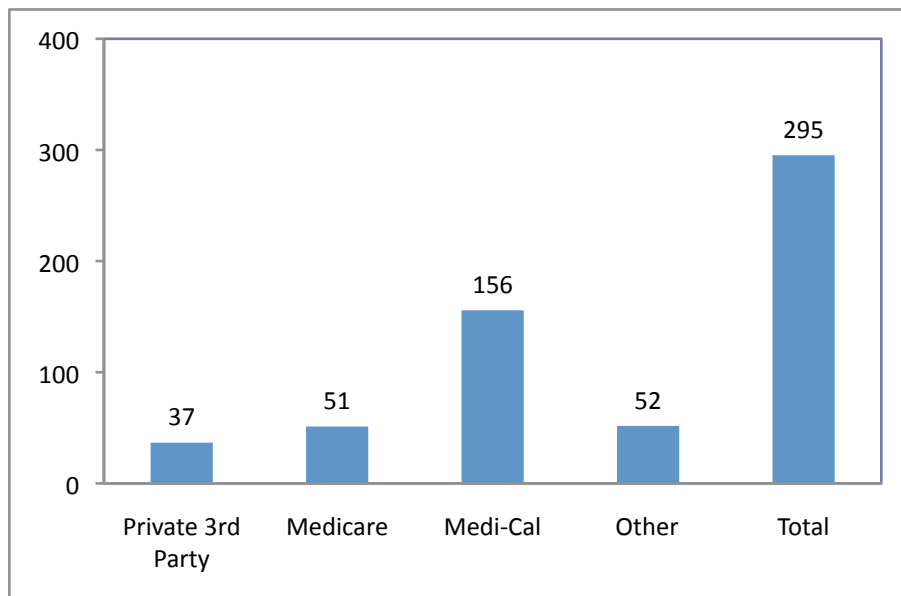


Figure S.7
Air Pollution–Related Hospital Spending at St. Francis Medical Center over 2005–2007, by Payer

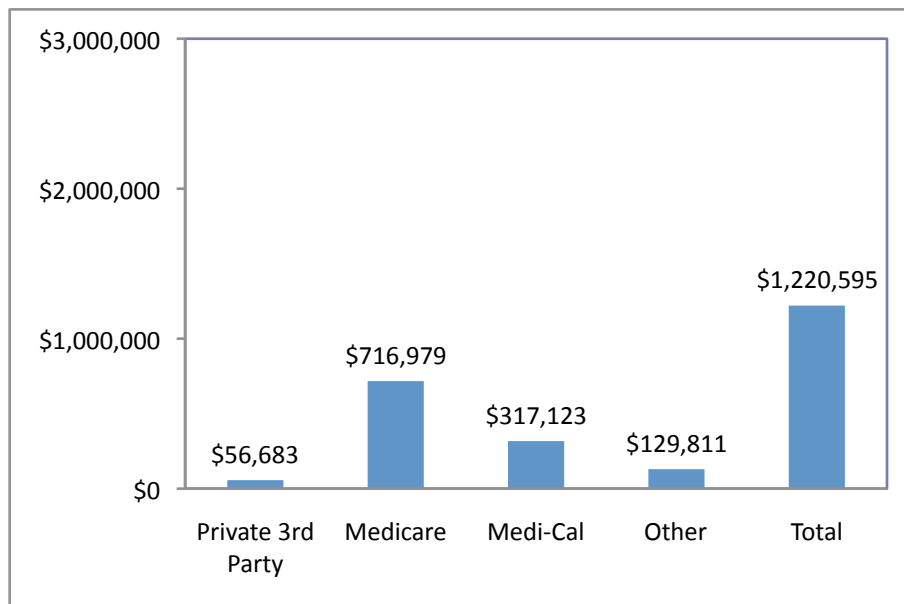


Figure S.8
Air Pollution–Related Hospital Events at Stanford University Hospital over 2005–2007, by Payer

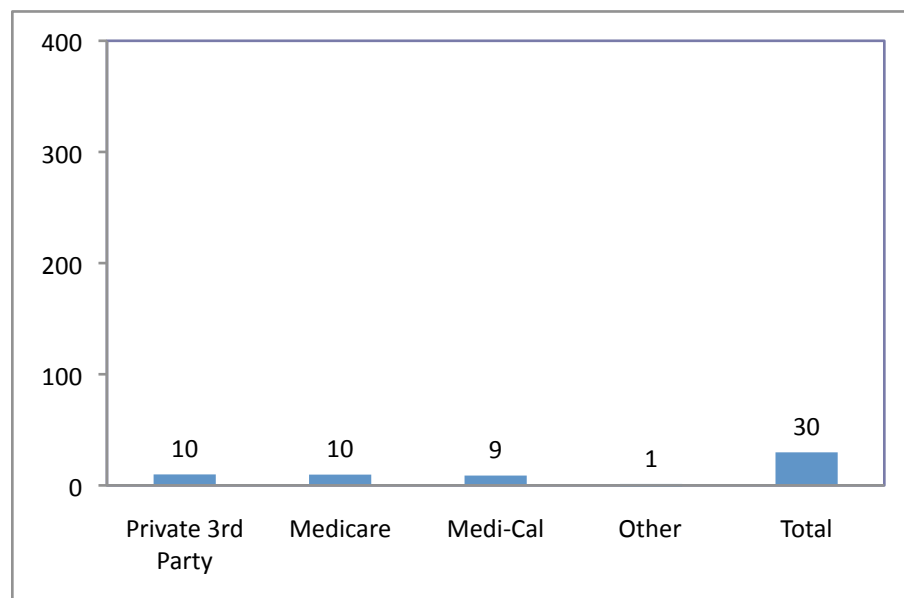


Figure S.9
Air Pollution–Related Hospital Spending at Stanford University Hospital over 2005–2007, by Payer

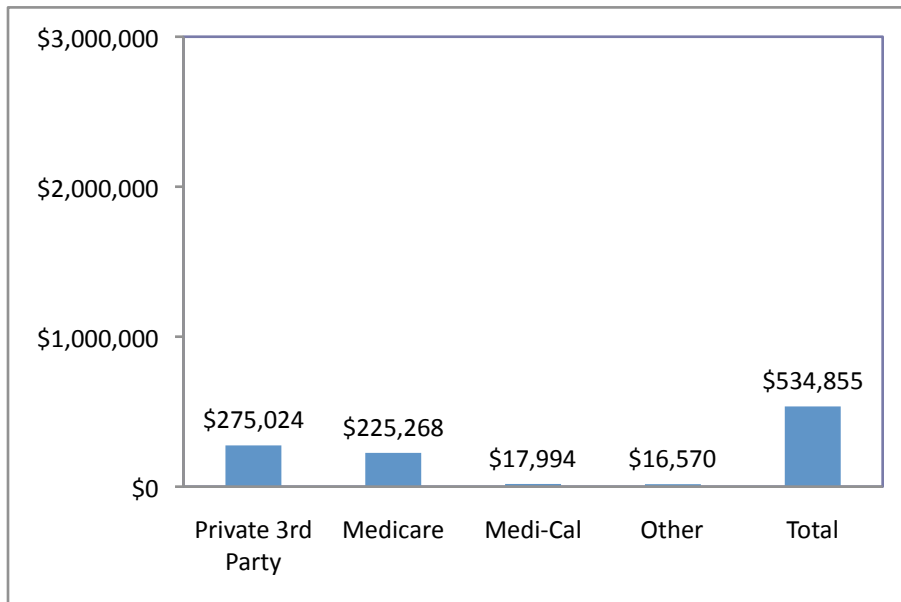


Figure S.10
Air Pollution–Related Hospital Events at UC Davis Medical Center over 2005–2007, by Payer

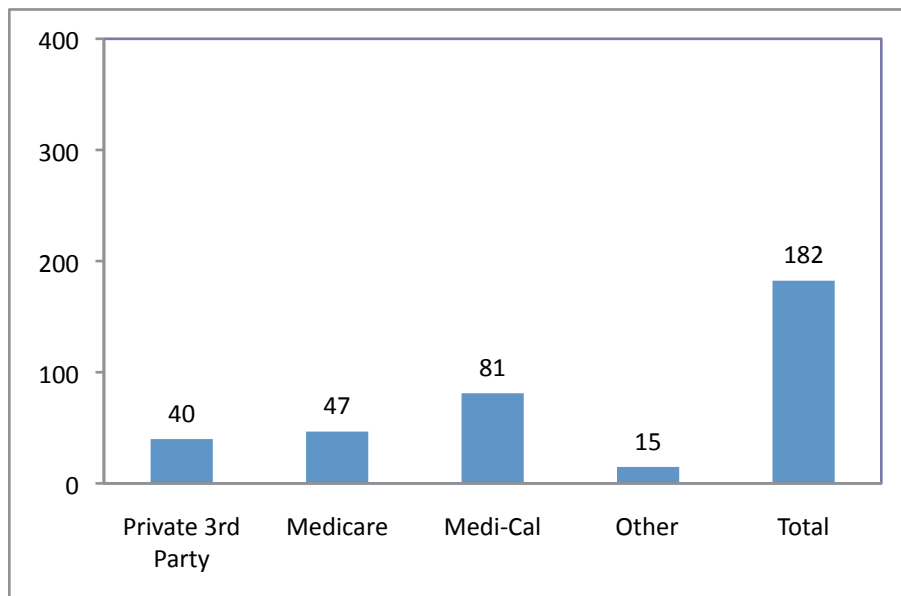


Figure S.11
Air Pollution–Related Hospital Spending at UC Davis Medical Center over 2005–2007, by Payer

