Symptom Reporting during Recent Publicized and Unpublicized Air Pollution Episodes

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Reported symptoms of irritation during publicized and unpublicized episodes of air pollution and a control period are compared for three communities differing in air pollution exposure.

Introduction

Although many workers have attempted to study dose-response relationships of air pollution and serious health effects, few have tried to define pollution levels at which significantly harmful symptoms first appear. Studies of air pollution disasters document the frequent occurrence, during episodes, of transient eye and throat irritation, cough, chest pain or burning, shortness of breath, and increased need of medical attention.[1-5] However, these studies either lacked objective measurements of air pollution concentrations,[1-2] or showed pollution levels far above the probable threshold values for these irritative symptoms.[3-4]

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In the present study, three communities alike in socioeconomic status (middle class) but different in air pollution exposure were chosen. One hundred families in each area were telephoned during an air pollution alert accompanied by much publicity and moderate elevations of air pollution levels (publicized episode), during a period of similarly increased air pollution levels unaccompanied by publicity (unpublicized episode), and during a period of low air pollution (control period). Each family was asked about the occurrence of irritative symptoms. Our purposes were to find whether moderate elevations of air pollution levels significantly increased the reported frequency of selected symptoms, to document any study bias introduced by widespread publicity about air pollution episodes, to describe who was most affected, and to sketch their pattern of symptoms.

Methods

Area Selection

We used air pollution measurements supplied by the New York City Department of Air Resources and Suffolk

County Department of Health, the most recent available census data (1960), and current house and property values to select areas alike socioeconomically but different in long term air pollution exposure. The Westchester section of the Bronx was selected as the high pollution area, the Howard Beach section of Queens as the intermediate pollution area, and Riverhead, Long Island, as the low pollution area. As it turned out, Bronx and Queens had very similar pollution increases during the episodes studied, despite significant differences in yearly average pollution levels.

Population Selection

In earlier studies in these three areas, parents of elementary school children had returned questionnaires on chronic respiratory illness, and a random sample of 250 families per area had been further interviewed, with demographic and household census data obtained. One hundred families per area were randomly selected from the latter, well interviewed group for the present study. All subject families thus contained at least one child of elementary school age.

Selection of Periods for Phone Interviews

Calls for the publicized episode were made in late July, 1970, immediately after several days of elevated pollution levels in New York City. The New York City Department of Air Resources called an air pollution forecast, and the news media gave the forecast extensive coverage. Calls for the unpublicized episode were made in mid-August, 1970, after a similar 3-day elevation in pollution concentration unaccompanied by publicity. The control period calls were made in early September, 1970, when pollution levels had remained low for 3 days. The three callings were made within one season and at times of similar weather. This strategy made it possible to evaluate health effects both of publicity (publicized episode versus unpublicized episode) and of air pollution (episodes versus control period).

Telephone Interviews

Each subject family was asked whether any family member had experienced eye irritation, throat irritation, cough, shortness of breath, chest pain, or burning in the chest in the preceding 3 days, and whether he had to restrict activities or visit a doctor because of these symptoms. Because of a procedural error, information on coughing was collected only for the unpublicized episode and the control period.

Aerometric and Meteorological Measurements

Neighborhood measurements of total suspended particulate (TSP, 24-hr Hi-Vol samples[6]), sulfur dioxide levels (titrimetric hydrogen peroxide method, 24 1-hr samples per day[7]), temperature, humidity, wind speed and direction, and barometric pressure were obtained in all three areas. All study families lived within 1-1/2 miles of our monitoring stations. Pollen counts were available for the unpublicized episode and the control period.

Shortly after the episodes, the Community Health Effects Surveillance System (CHESS) initiated continuous monitoring of TSP and sulfur dioxide. Other pollutants, including respirable suspended particulate, nitrogen dioxide, oxidant, and trace elements, may also contribute to health problems during episodes. These are now being measured and will be a part of future reports.

Data Analysis

An adaptation of Grizzle's[8] categorical analysis was chosen to separate the effects of publicity from those of air pollution. This procedure allowed each volunteer to act as his own control over time. The coding scheme used to classify an individual's reporting pattern for any one symptom over the three periods is depicted in Table 1. The first category contains volunteers who reported symptoms during both the publicized and the unpublicized episodes. The second category contains those who responded only during the publicized episode and the third category those whose response was limited to the unpublicized episode. The fourth category contains patterns which show neither air pollution nor publicity effects. Although any single symptom pattern in this category yields no useful information for this study, the individuals who report symptoms for all three periods would comprise an excellent panel for the assessment of symptom severity. The next category was indeterminate. The last category, labeled paradoxical, represents the best baseline estimate of symptom frequency.

Not all symptom patterns contained enough observations to permit the planned chi-square analyses. As a conservative approximation, volunteers reporting a symptom once were included in tests of the hypotheses separating publicity and pollution effects. This procedure ignored the experience of a substantial number of volunteers who reported symptoms during both episodes but not during the control period, thus minimizing the chance of detecting an air pollution effect. Since very few

TABLE 1—Grouping Individual Response Patterns for Any Symptom

Group Response Category	Symptom Pattern: Publicized episode	Unpublicized episode	Control period
Air pollution and publicity	Yes	Yes	No
Publicity	Yes	No	No
Air pollution	No	Yes	No
None	Yes	Yes	Yes
	No	No	No
Indeterminate	No	Yes	Yes
	Yes	No	Yes
Paradoxical	No	No	Yes

volunteers reported symptoms during one episode and the control period (less than seven for any symptom), little was lost by their exclusion.

To simplify the quantification of air pollution effects, symptom prevalence rates were standardized using the prevalence rates for the entire study population during the control period as a reference.

Results

Population Characteristics

A demographic profile of each area, which is summarized in Table 2, revealed that the low pollution area, Riverhead, had somewhat more children, more blacks, slightly less education, and a lower income than the more polluted areas. Adults in the Bronx were most likely to be smokers, and Queens families tended to move more often. However, much of this mobility proved to be internal migration.

Air Monitoring

Available air pollution levels, weather data, and pollen counts for all areas during each period are shown in Table 3. The publicized episode was characterized by elevation of pollutant concentrations in Queens and Bronx but not in Riverhead. All weather variables were about the same. Pollen counts were not available. The unpublicized episode also had increased pollution in Bronx and Queens but not in Riverhead. Weather was again similar across the areas and much like that during the publicized episode. The control period had low pollution levels in all areas. Weather was similar to the first two episodes except for a temperature decrease of about 10° F.

TABLE 2—Age, Sex, Smoking, Socioeconomic, and Migration Profile of the Study Population in Each Area

	Percentage Distribution				
	Riverhead*				
Characteristic	Black	White	Queens	Bronx	Total
Age and sex					
Adult males	15.5	18.8	20.1	22.2	19.8
Adult females	15.5	17.8	22.5	21.9	20.2
Male children	35.7	30.5	31.6	28.1	30.8
Female children	33.3	32.9	25.9	27.8	29.2
(Population)	(129)	(298)	(374)	(320)	(1121)
Adult smoking history					
Never smoked	52.5	42.2	35.2	31.9	37.4
Ex-smoker	7.5	9.2	21.4	13.5	14.7
Current smoker	40.0	48.6	43.4	54.6	47.9
(Population)	(40)	(109)	(159)	(141)	(449)
Education of head of household					
Less than H.S.	75.0	27.5	26.7	43.5	36.5
H.S. grad.	15.0	52.9	33.3	38.7	38.0
College grad. or less	10.0	13.7	29.3	16.1	19.7
Post-grad.	0.0	5.9	10.7	1.6	5.8
(Population)	(20)	(51)	(75)	(62)	(208)
Income of head of household					
$0–5,000	25.0	17.6	4.0	19.3	13.9
$5,000–12,000	70.0	52.9	48.0	58.1	54.3
$12,001+	5.0	29.4	48.0	22.6	31.7
(Population)	(20)	(51)	(75)	(62)	(208)
Residence history of head of household					
Never moved	60.0	54.9	42.7	51.5	51.4
One move in last 5 years	20.0	25.5	44.0	33.9	34.1
More than one move in last 5 years	20.0	19.6	13.3	9.7	14.4
(Population)	(20)	(51)	(75)	(62)	(208)

* Except for Riverhead, the number of blacks was too small to justify a division by race.

TABLE 3—Air Pollution and Weather during the Three Study Periods, Distributed by Area*

Measurement	Riverhead Publicized episode	Riverhead Unpublicized episode	Riverhead Control	Queens Publicized episode	Queens Unpublicized episode	Queens Control	Bronx Publicized episode	Bronx Unpublicized episode	Bronx Control
Pollution levels									
Sulfur dioxide (ppm)	0.03	0.01	0.02	0.12	0.11	0.04	0.14	0.15	0.04
TSP sulfate fraction (μg/cu m)	—	—	—	7.6	—	6.6	8.5	12.3	5.8
Total suspended particulates (μg/cu m)	26	44	36	145	165	55	240	180	50
Soiling index (cohs)	—	—	—	0.4	0.4	0.2	1.8	2.3	0.9
Pollen count	—	1	14	—	1	14	—	1	14
Weather									
Maximum temperature (° F)	79	77	64	81	80	67	81	83	67
Maximum relative humidity (%)	84	79	82	80	73	70	73	63	70
Average barometric pressure (cm Hg)	29.9	29.9	30.0	29.9	30.1	30.1	29.9	30.0	30.1
Average wind speed (m/hr)	7.5	9.3	8.7	10.7	11.9	11.1	10.5	11.0	11.4

* Oxidants and nitrogen dioxide were not measured in the study neighborhood, but a Manhattan station reported peak hourly oxidant levels of 0.07 and 0.11 ppm during the two episodes. Peak 24-hr nitrogen dioxide levels of 0.20 and 0.10 ppm were also reported during the episodes. During the control period, peak hourly oxidant levels of 0.03 ppm were reported, but no nitrogen dioxide measurements were available.

TABLE 4—Reported Frequency of Selected Symptoms during the Control Period, Distributed by Age Group, Sex, and Smoking History

Symptom	Male adults Smoker (N = 119)	Male adults Nonsmoker (N = 103)	Female adults Smoker (N = 96)	Female adults Nonsmoker (N = 131)	Children (N = 672)
	Percentage Reporting Symptoms				
Eye discomfort	5.0	1.0	5.2	7.6	4.9
Throat discomfort	5.0	1.9	9.4	3.8	5.5
Cough	3.4	2.9	3.1	4.6	4.9
Shortness of breath	0.8	0.0	5.2	0.7	1.8
Chest burning	0.8	0.0	1.0	0.0	0.3
Chest pain	0.8	0.0	1.0	0.0	0.4
Restricted activity	0.8	0.0	2.1	0.7	2.7
Medical visits	1.7	0.0	2.1	0.0	1.2

Symptom Reporting during the Control Period

Age, sex, smoking status, and respondent bias might all exert significant impacts upon the prevalence of irritation symptoms. Thus, symptom prevalence rates for adult females, the usual questionnaire respondents, and adult males were computed for smokers and nonsmokers. All other persons under 21 were grouped together and called children. Then, symptom prevalence rates of all groups for the control period were compared in an effort to separate the effects of the aforementioned sociological variables from those of publicity and air pollution as shown in Table 4.

Children tended to have symptom prevalence rates intermediate between the higher rates of adult smokers and the lower rates of adult nonsmokers. Evidence for either a sex difference or a respondent bias was reflected in generally higher female rates that were most marked in the case of throat irritation and shortness of breath. However, other analyses failed to reveal any sex difference in symptom rates among children. Prevalence rates were also partitioned by race, and no ethnic differences were observed in the limited number of blacks, who were almost all residents of Riverhead.

Effect of Pollution, Publicity, and Area

When the average of both episode rates was compared to that of the control period, all symptoms except cough were significantly increased during the pollution episodes (Table 5). When the publicized and unpublicized episodes were similarly compared, no significant differences were observed for any symptom. Symptom reporting was significantly more frequent in Queens (intermediate pollution area) than in the Bronx (high pollution area), and both were higher than Riverhead (low pollution area).

TABLE 5—Effects of Publicity and Air Pollution upon Symptom Frequency

Symptom	Both Episodes vs. Control χ^2 *	Both Episodes vs. Control p†	Publicized vs. Unpublicized Episodes χ^2	Publicized vs. Unpublicized Episodes p
Eye discomfort	18.5	0.000	0.5	NS
Throat discomfort	14.9	0.000	0.4	NS
Cough	2.7	NS‡	—	—
Shortness of breath	27.1	0.000	0.2	NS
Chest burning	4.8	0.027	3.6	NS
Chest pain	7.8	0.005	2.3	NS
Restricted activity	4.6	0.03	0.1	NS
Medical visits	5.5	0.018	0.3	NS

* All χ^2 have 1 degree of freedom.
† NS denotes not significant at the p = 0.05 level.
‡ Contrast limited to unpublicized episode and control period.

Groups Most Affected

Symptom reporting for Queens and Bronx was pooled, as was that for both pollution episodes. Rates were then standardized using the prevalence rates for the entire study population during the control period. Standardized rates were computed for age, sex, smoking, and area-specific groupings. These are shown in Tables 6 to 8.

Symptom prevalence in the clean area, Riverhead, was lower than that in the polluted areas during both the control period and the episodes. Chest burning was greatly increased in all exposed groups during the episodes. Consistent but less impressive increases in cough, chest pain, shortness of breath, and restricted activity occurred in all exposed groups. Eye discomfort was increased only in adults. The first effect of smoking on symptom prevalence, readily apparent during the control period, was almost obscured by the pollution episodes. In other words, the relative increase in irritation symptoms during the pollution episodes among nonsmokers was greater than that for exposed smokers. Children were somewhat less affected than adults.

Discussion

In the two areas showing variation in air pollution levels, reports by adults of eye irritation, shortness of breath, chest pain or burning, and restricted activity were significantly increased during air pollution episodes. It is unlikely that weather conditions contributed significantly to these variations, since subjects in a nearby area with no change in air pollution levels during the study showed no

TABLE 6—Irritation Symptom Prevalence among Females Distributed by Area, Episode, and Smoking Status

	Reported Symptom Ratios								
	Adult female smokers				Adult female nonsmokers				
	Bronx and Queens (N = 64)		Riverhead (N = 32)		Bronx and Queens (N = 90)		Riverhead (N = 41)		
Symptom	Pooled episodes	Control	Pooled episodes	Control	Pooled episodes	Control	Pooled episodes	Control	Standard Prevalence Rate* (%)
Eye discomfort	3.2	1.5	0.9	0.0	4.0	1.7	0.7	1.0	(5.1)
Throat discomfort	2.5	2.4	0.6	0.6	2.3	0.8	1.4	0.5	(5.3)
Cough	2.5	1.1	0.7	0.0	1.8	1.3	0.0	0.5	(4.4)
Shortness of breath	14.2	4.6	1.8	0.0	6.5	0.6	2.9	0.3	(1.7)
Chest burning	9.8	4.0	0.0	0.0	9.8	0.0	6.0	0.0	(0.4)
Chest pain	13.8	4.0	4.0	0.0	1.5	0.0	3.0	0.0	(0.4)
Restricted activity	5.8	1.6	0.0	0.0	4.7	0.6	0.0	0.6	(2.0)
Medical visit	3.5	2.8	0.0	0.0	2.5	0.0	0.0	0.0	(1.1)

* Based upon symptom frequency among the total study population (N = 1121) during the control period.

TABLE 7—Irritation Symptom Prevalence Ratios among Males Distributed by Area, Episode, and Smoking Status

	Reported Symptom Ratios								
	Adult male smokers				Adult male nonsmokers				
	Bronx and Queens (N = 82)		Riverhead (N = 37)		Bronx and Queens (N = 64)		Riverhead (N = 39)		
Symptom	Pooled episodes	Control	Pooled episodes	Control	Pooled episodes	Control	Pooled episodes	Control	Standard Prevalence Rate* (%)
Eye discomfort	2.4	1.4	0.3	0.0	1.2	0.3	0.9	0.0	(5.1)
Throat discomfort	1.4	1.4	0.3	0.0	1.5	0.0	0.6	0.6	(5.3)
Chest burning	4.5	3.0	0.0	0.0	5.8	0.0	0.0	0.0	(0.4)
Chest pain	6.0	3.0	0.0	0.0	4.0	0.0	4.0	0.0	(0.4)
Cough	1.9	1.1	0.7	0.0	1.1	0.4	0.7	0.0	(4.4)
Shortness of breath	4.6	0.7	0.8	0.0	3.2	0.0	1.8	0.0	(1.7)
Restricted activity	1.8	0.6	0.0	0.0	2.0	0.0	0.0	0.0	(2.0)
Visited a physician	1.6	2.2	0.0	0.0	0.0	0.0	0.0	0.0	(1.1)

* Based upon symptom frequency among the total study population (N = 1121) during the control period.

TABLE 8—Irritation Symptom Prevalence among Children, Distributed by Area and Episode

	Reported Symptom Ratios				
	Bronx and Queens (N = 394)		Riverhead (N = 278)		
Symptom	Pooled episodes	Control	Pooled episodes	Control	Standard Prevalence Rate* (%)
Eye discomfort	1.6	1.5	0.1	0.1	(5.1)
Throat discomfort	1.7	1.3	0.5	0.7	(5.3)
Cough	2.5	1.7	0.7	0.3	(4.4)
Shortness of breath	1.1	1.5	0.3	0.4	(1.7)
Chest burning	4.0	1.2	0.0	0.0	(0.4)
Chest pain	1.8	0.5	0.5	1.8	(0.4)
Medical visit	2.5	1.2	0.6	1.0	(1.1)

* Based upon symptom frequency among the total study population (N = 1121) during the control period.

substantial symptom variation. For all symptoms and within each study area, reported illness during New York City's widely publicized pollution episode was not significantly greater than during the unpublicized pollution episode. The symptom pattern in New York families differed from patterns reported during the Birmingham episode study in that eye irritation, but not throat irritation, during the Birmingham episode was increased.

For several symptoms, adult females reported higher rates than either adult males or young females. This has been observed in other studies[9,10] including the Birmingham episode study, with no clear explanation given. One hypothesis is that these differences are the result of a study design in which information for the entire family is given by the housewife. Since she knows her own symptoms first hand and may not notice or be told of those of her husband or children, a spurious symptom difference may be reported. Such observation errors might have been avoided by notifying a panel that a study call was coming in the near future, and asking for close observation of symptoms in all family members, but this would have required setting the dates of the study in advance, rather than following pollution levels and beginning interviews when pollution and weather conditions allowed for similar weather and contrasting pollution and publicity effects.

Children reported less symptom variation with air pollution variation than did adults. This has also been reported before,[11,12] most recently in the Birmingham episode study. For example, children in the Birmingham study reported no increase in restricted activity during the episode, whereas adults reported greatly increased restricted activity.

Black-white differences in symptom rates were generally insignificant in the New York area, but this was not the case in Birmingham. Birmingham blacks reported fewer symptoms than whites even though residing in a more polluted area. A sociological difference between these two groups in regard, for example, to illness reporting or behavior might be proffered as an explanation for this phenomenon.

Unlike previous workers and our own Birmingham study,[13-15] we found only a weak association between a positive smoking history and increased shortness of breath in males in New York, possibly because the periods of observation were short or because wives underestimated their spouse's symptoms. We did find that the increase in symptom reporting during both New York episodes was greater, relatively speaking, among nonsmokers than among smokers, confirming a finding of the Birmingham report.

The other major work thus far on irritative symptoms and air pollution is the series of studies by McCarroll and associates, in which interviewers gathered health data weekly on about 2000 subjects living in a small section of New York City.[16-19] They found no increase in eye irritation, rhinorrhea, diarrhea, or home accidents during two episodes in which 24-hr sulfur dioxide averages reached 0.25 and 0.50 ppm, respectively. During a third episode, when the peak 24-hr average sulfur dioxide level was about 0.70 ppm, they found significant increases in rhinitis, cold, cough, pharyngitis, eye irritation, and headache.

In the present study, certain symptom rates were increased when sulfur dioxide levels exceeded 0.11 ppm and suspended particulate levels exceeded 145 μg per cu m for the 3-day average. These levels are not infrequent in New York City. For the winter of December, 1970—February, 1971, 24-hr sulfur dioxide averages at the 38 stations run by the New York City Department of Air Resources were greater than 0.10 ppm 19 per cent of the time.[20] Suspended particulate readings during the same period exceeded 120 μg per cu m 39 per cent of the time; three stations averaged 140 μg per cu m or more. In Birmingham, striking increases in irritation symptoms were noted when residential particulate levels averaged 180 to 220 μg per cu m over a 5-day period even though sulfur dioxide levels averaged less than 0.01 ppm.

The contribution of other factors in geneses of these irritation syndromes must be considered. Such factors include pollutants other than suspended particulates and sulfur dioxide, intercurrent infectious disease, and sociocultural differences in symptom recognition and reporting. Photochemical oxidant air pollution is associated with eye irritation when peak hourly values exceed 0.10 ppm.[21] Peak oxidant values of this magnitude were recorded during the unpublicized episode but not during the publicized episode. Eye irritation was, however, significantly increased during both New York episodes. A role for oxidants in the irritation or aggravation of irritation symptoms could be explained by the combined irritation effect of several pollutants. One need not involve an additive or synergistic hypothesis because an alternate explanation is available. The air monitoring methods used for oxidants and sulfur dioxide during the New York episodes are subject to interactive interferences which might cause spuriously low readings.[22,23] Furthermore, vandalism and urban congestion necessitated location of air monitoring stations atop buildings, and these stations may well have registered lower readings than ground level stations.

The New York episode study contains an internal inconsistency that may have resulted from intercurrent infectious disease or sociocultural differences. During the publicized episode, particulate air pollution was distinctly higher in the Bronx than in Queens, while irritation symptoms were somewhat higher in Queens. Increased environmental awareness in the Queens study neighborhood or unusual pollutants associated with nearby Kennedy Airport could have both played roles in this apparent paradoxical effect.

Conclusion

During the summer of 1970, New York City experienced a well publicized period of moderately elevated air pollution, an unpublicized period of similarly elevated pollutant levels, and a period of low pollution. A telephone survey of irritative symptoms showed no significant differences between the publicized and the unpublicized episodes, but significant increases in eye irritation, throat irritation, chest discomfort, shortness of breath, restricted activity, and medical visits in adults during the two high pollution episodes. A low pollution control area showed no significant symptom-rate variation with time.

Although eye irritation, shortness of breath, chest pain or burning, and restriction of activity may not be life threatening per se, their frequent occurrence cannot help but affect adversely the quality of life to those exposed. The data indicate that irritative symptoms may significantly increase when sulfur dioxide levels exceed 0.11 ppm and suspended particulate levels exceed 145 μg per cu m for several days. However, the possible confounding effects of other air pollutants, intercurrent infectious disease, and sociocultural differences could not be quantitated.

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The Harvard Industrial Hygiene Workshop, Evaluation and Control of Occupational Hazards, is a short course designed for engineers and others with a technical background who are beginning a career in occupational health protection with little prior training or work experience. The objective is to prepare the beginner to perform occupational health field duties with reliability, accuracy, and confidence. The course content will emphasize practice in the use of proven field inspection and measurement techniques. It will provide an understanding of the physiological effects of exposure to toxic materials and physical stress in industry and will cover basic principles of occupational health protection. The curriculum is appropriate for those in industry, governmental agencies, and casualty insurance carriers.

Mornings will be devoted to classroom lectures and demonstrations and afternoons to field procedures in a laboratory and pilot plant setting. Because the afternoon practice sessions are central to this course, the size of the class must be limited to the first 20 applicants.

The course will be presented at the Harvard School of Public Health July 15—19. Applications with fee should be received by June 17. Application or inquiries should be sent to Melvin W. First, ScD, Dept. of Environmental Health Sciences, Harvard School of Public Health, 665 Huntington Ave., Boston, MA 02115. The fee for registration is $375.