

Outbreak of Acute Eye Irritation Associated With Air Pollution

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AT 9:30 a.m., September 18, 1963, the director (W. R. E.) of the division of epidemiology, Erie County (N.Y.) Department of Health, received a report of a number of cases of severe eye irritation among employees of a small wholesale distributor of window and door frames located in the south-central industrial area of Buffalo. The reporting source stated that at 8:30 a.m. men working on a warehouse loading platform complained of smarting eyes and that symptoms had progressed to severe burning and tearing in the ensuing hour. Heavy smog was noted in the vicinity. The health department subsequently received a num-

ber of calls reporting similar conditions in the central and southeastern parts of Buffalo. These reports suggested the occurrence of an outbreak of illness associated with air pollution, and an investigation was immediately undertaken.

Two investigators (R. A. P. and J. H. S.) arrived at the scene of the initial complaint at 11 a.m. Shortly after, one investigator noted slight smarting of his eyes, while the other experienced nasal congestion. The smog had largely cleared, however, and the workers originally affected were no longer complaining of eye irritation. Examination of these workers' eyes at this time revealed no conjunctival injection.

A company spokesman stated that at 8:30 a.m. warehouse workers complained of eye irritation. By 9:30 a.m. the irritation had become so severe that all outdoor workers gathered inside the buildings for relief. By this time, indoor workers were also complaining. The complaints peaked at 10 a.m. but had largely disappeared by 10:30 a.m. In all, 27 workers were affected. Only office personnel in an enclosed area on the first floor were not affected. Several men who had worked in the area for up to 18 years could not remember a similar episode.

Severe burning of the eyes associated with marked reddening and tearing was the most frequently reported complaint. In some persons, the symptom complex included coughing and burning of the nose and throat. In others, the burning sensation in the nose and throat was associated with a "sharp biting taste like acid." Many stated that a "sharp, stinging, sulfurous

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odor" had been present. Workers also reported that during the episode smoke from a small fire in a field behind the warehouse had collected near the ground rather than rising and dispersing in the usual manner. Moreover, from 8:00 to 10:30 a.m., the flare of an oil refinery 1½ miles distant could not be seen. The company workers reported that they could not remember any previous morning without precipitation or fog on which the flare was not visible.

A number of witnesses in the area reported that on the morning of the outbreak truck drivers pulled to the roadside and sought refuge in local diners because they experienced excessive tearing and burning of the eyes. Two area schools reported severe eye irritation among students and teachers. Management representatives of several large industrial plants in the area were queried but denied that their plants had produced any unusual amount or type of pollutant or that their workers had experienced any symptoms during the time of the outbreak.

The foregoing sequence of events strongly suggested the occurrence of an outbreak of symptoms related to air pollution. The extent of the outbreak and its epidemiologic characteristics could not, however, be assessed from the selected information obtained from the wholesale firm or from telephone complaints. These sources had only reported the type and intensity of symptoms and that complaints were not localized in one area of the city. For a more comprehensive understanding of the episode, a survey of a random sample of the population was needed. Although it would have been desirable to draw a geographically stratified sample, available resources permitted only a limited effort. It was decided, therefore, to sample only the residential population nearest the area where the original complaints had arisen.

Method of Study

A list of 123 households, located within an area approximately one-half mile in radius and immediately southeast of the wholesale distributor of window and door frames, was obtained from the Buffalo city directory. Sixty-five of these households were randomly selected for the survey. Successful contacts were made

Table 1. Number affected and attack rates of at-risk populations according to age and sex

Age group and sex	Number at risk	Number affected ¹	Attack rate (percent)
Less than 20 years.....	62	12	19
Male.....	26	7	27
Female.....	36	5	14
20 years and older.....	76	9	12
Male.....	21	3	14
Female.....	55	6	11
All ages.....	138	21	15
Male.....	47	10	21
Female.....	91	11	12

¹ Experienced either burning or tearing eyes or burning nose, mouth, or throat.

with 56 (86 percent). Four households could not be contacted, dwellings of two were vacant, and three refused to provide information. The survey was accomplished by telephoning and home visiting during the week following the outbreak. Most contacts were made the first and second day after the episode.

Data concerning the members of each household were obtained from any adult respondent who claimed knowledge of the health status of the household members. The data collected included age, sex, symptomatology, and location of the person's activities during the outbreak. A person was considered affected if, while "at risk," he experienced burning or tearing of the eyes or burning of the nose, mouth, or throat. "At risk" was defined as being within an 8-block radius of home between 8:30 and 10:30 a.m. on the morning of September 18, 1963. This definition of time period and area of activity (derived from the experience of the workers of the wholesale firm) made querying more specific and, hopefully, more reliable.

Climatologic data were obtained from the U.S. Weather Bureau station at the Buffalo International Airport, 7 miles northeast of the sampled area. Radiosonde observations taken at the airport were obtained from the National Weather Records Center in Asheville, N.C. The New York State Air Pollution Control Board supplied the synoptic meteorology. A series of 24-hour suspended-particulate measurements was obtained from the daily air

sampling station of a network maintained jointly by the Erie County Department of Health and the New York State Department of Health.

Results

The 56 surveyed households had a total population of 198 persons, of whom 138 were at risk. The attack rates of the at-risk population according to age and sex are shown in table 1. The overall attack rate was 15 percent. All but one of the persons affected experienced the common symptom of burning eyes. Among those less than 20 years of age, the attack rate was 19 percent; among those 20 years and older, it was 12 percent. Males had a higher attack rate (21 percent) than females (12 percent). This difference was most pronounced for those less than 20 years of age (27 percent males, 14 percent females) but was not remarkable among those 20 years and older (14 percent males, 11 percent females).

Since, at the wholesale company, the symptoms reported by those working outdoors differed markedly in severity from the symptoms of those working inside, the effect of outdoor exposure was assessed (table 2). A 10-minute breakpoint revealed impressive differences. The overall attack rate was 48 percent for those exposed outdoors 10 minutes or more and 2 percent for those outdoors less than 10 minutes. This difference in the indoor-outdoor attack rate applied equally to males and females in

both age groups. Thus when the attack rates for the two age groupings were compared, taking outdoor exposure into account, differences based on age alone disappeared. Differences in attack rates according to sex, however, did not appreciably change.

The 24-hour suspended-particulate values from the daily sampling station 2 miles north of the survey area showed a steady increase from 40 $\mu\text{g./m.}^3$ on September 12-13 to 129 $\mu\text{g./m.}^3$ September 17-18. (Twenty-four-hour sampling is maintained from 1 p.m. to 1 p.m.) The higher value was recorded for the sample that included the suspended particulates collected during the morning of the pollution episode. The value for September 18-19, which was recorded for the sample that included particulates collected during the afternoon and evening of the day of the episode, was 174 $\mu\text{g./m.}^3$ and represents the highest value of the series. Further analysis reveals that this value lies at the 90th percentile in a 2-year distribution of summer values.

Monthly values for sulfur dioxide and dust-fall were available from eight sampling stations but could not be specifically analyzed for the period of the air pollution episode. Nor was a portable air-sampling apparatus readily available for spot analyses in specific areas in which illness had been reported during the acute episode.

Review of meteorologic data for the period of the episode revealed that the stagnant air-

Table 2. Number affected and attack rates of at-risk population according to age, sex, and duration of time outdoors

Age group and sex	Outdoors less than 10 minutes			Outdoors 10 minutes or more		
	Number at risk	Number affected	Attack rate (percent)	Number at risk	Number affected	Attack rate (percent)
Less than 20 years.....	39	1	3	23	11	48
Male.....	15	1	7	11	6	54
Female.....	24	0	0	12	5	42
20 years or older.....	57	1	2	17	8	47
Male.....	15	0	0	6	3	50
Female ¹	42	1	2	11	5	45
All ages.....	96	2	2	40	19	48
Male.....	30	1	3	17	9	53
Female ¹	66	1	1	23	10	43

¹ Two women in the 20 or older age group were not included because of missing information.

mass which dominated the weather over Buffalo on September 18 was an extensive but moderately weak anticyclone, which had arrived on the 13th from Canada. Winds had slowed to about 7 mph on the 13th and stayed at that speed or less until the 18th, when they reached a low average of 4 mph. They were variable in direction but had definite easterly components. This low wind velocity contrasted markedly with the average 11-mph wind normally seen in Buffalo in September.

Visibility records also revealed a consistent and steady decrease from a maximum daytime visibility of 15 miles on the 14th to about 8 miles on the 18th and 19th, a decrease indicating the gradual accumulation of pollutants in the air. Temperatures throughout the period ranged from highs in the mid-seventies to lows in the mid-forties.

A trend toward increasing diurnal fluctuation in temperature was evident, reflecting the increasing effect of local radiation. Radiosonde observations at the Buffalo airport, made daily at 7 a.m. and 7 p.m. e.s.t., revealed that temperature inversions between the earth's surface and the 450-meter level occurred each morning from the 14th through the 19th and on the 17th and 18th were quite strong. The temperature at the surface on the 17th was 7.7° C. lower than that 450 meters above and on the 18th, 7.2° C. lower.

The meteorologic conditions which dominated Buffalo September 13-18 began changing late on the morning of the 18th. Winds increased and began mixing and dispersing the airmass over the city. Finally, on the 19th, the stagnating anticyclone which had dominated the airmass assumed its own circulation, and its center moved southward from Buffalo, destroying the meteorologic conditions favorable to air pollution. Late on the same day, an active cold front passed through Buffalo bringing an influx of cooler, drier air, some precipitation, and a new dominant airmass.

Discussion

Brief consideration of the quality and extent of the data collected is in order. The investigation was limited in scope. No effort was made to ascertain whether mortality was af-

ected by the hypothesized air pollution incident. The sample was not large enough to reveal effects on chronically ill persons, nor were efforts made to evaluate this possibility by examining trends in hospital admissions. In the sample household survey, selection of a single informant to provide information on all household members may have resulted in under-enumeration of symptoms.

Available air pollution data proved to be inadequate. No air sampling for specific eye irritants could be performed in the area of Buffalo where the complaints arose. Also, monthly sampling station values for sulfur dioxide or dustfall could not be analyzed specifically for the period of the pollution episode. Finally, it should be noted that discussion of the air pollution and meteorologic occurrences is speculative and their association with the outbreak of eye irritation circumstantial.

That air pollution can precipitate acute illnesses such as asthma, pulmonary edema, and cardiovascular collapse is now well documented (1-6). Causation of serious chronic disorders, such as bronchial asthma and chronic bronchitis, however, is less well supported (7-10), and while irritating, mild acute effects, particularly ophthalmic, have been reported frequently in connection with air pollution (11), rates of occurrence of these subjective complaints have not been adequately recorded (12).

The Buffalo study documents an outbreak of acute eye irritation associated with air pollution and reports attack rates. The most striking finding was that outdoor exposure of 10 minutes or more greatly increased illness rates. It would appear from this observation that closed structures afford substantial protection from the effects of airborne irritants, at least if the period of exposure is limited in duration.

Further consideration of the protective effect of closed shelters revealed that little information is available concerning the relative quality of indoor and outdoor air. This is particularly true of the relative rates of change in pollution levels (13). It seems reasonable to assume, however, that while the concentration of pollutants reached indoors may be much smaller than that outdoors, the low indoor ventilation rate results in increased exposure time (14). Therefore, indoor dosage may equal outdoor dosage

unless significant adsorption of pollutants occurs during ventilation or unless ventilation is increased after outdoor pollution has dispersed. Thus a closed indoor shelter may not afford the same degree of protection against the chronic effects of gaseous pollutants as that observed for the acute effects.

Analysis of the 24-hour particulates collected by the daily sampling station revealed that a steady increase in values occurred during the 6 days before the episode. Although the value for the day of the episode was in the 90th percentile in a 2-year distribution of summer values, equally high or higher values have occurred without episodes of illness associated with air pollution.

Additional investigation revealed that a stagnating anticyclone associated with five strong nocturnal inversions dominated meteorologic conditions for 6 days before the episode and on the day of the episode. As in past air pollution incidents (1-4), existence of such strong inversions and the length of time in which conditions favorable to their development prevailed might be considered an adequate explanation for occurrence of this acute air pollution episode. This is not, however, the case. Twenty-nine inversions equally as strong as those observed during this episode were recorded in a 2-year period between May 1, 1961, and April 30, 1963. Five of these inversions occurred during the summer and early fall. Nor are long strings of consecutive nocturnal inversions rare. During the same 2 years, there were 15 instances of 5 or more consecutive nocturnal inversions and 7 instances of 8 or more. Four of the longer periods of consecutive inversions occurred during the season in which the described episode occurred.

There are, however, at least two ways in which nocturnal inversions may affect the accumulation of pollutants, and the concentrations which reach the population may vary from one inversion period to another. One way is by the simple nocturnal accumulation of pollutants between the surface and the base of an inversion. Another, not necessarily exclusive, is the accumulation of pollutants in a layer within the inversion but above the surface. Inversion conditions were known to have existed both between the surface and 30 meters and between 30 and

450 meters. Under these conditions, in calms or very light winds such as existed at the time of the episode, there could have been little or no mixing of factory emissions downward until thermal turbulence after sunrise caused an especially concentrated layer of pollutants to descend abruptly to ground level by Hewson fumigation (15). The suddenness of the episode suggests the latter may have occurred.

In past years, air pollution events were often studied several months after they occurred. Today, the changing patterns of pollution make it important that such events be studied as soon as they occur so that more detailed and valid firsthand information can be gathered concerning both the immediate effect on the population and the meteorologic and the manmade air pollution factors related to the event. Surveillance of acute episodes, however, need not necessarily depend on establishment of an elaborate air pollution measuring system. A periodic inventory of emissions combined with air sampling in geographic areas where characteristic symptoms arise and the evaluation of meteorologic conditions as reported by the U.S. Weather Bureau would provide useful information in periods of illness associated with air pollution.

Summary

An outbreak of acute, severe eye irritation in Buffalo, N.Y., occurred on September 18, 1963. In a random sample of the residential population of the industrial neighborhood where the initial complaints arose, the attack rate was 15 percent. The rate was 48 percent for persons exposed outdoors 10 minutes or more and only 2 percent for those remaining outdoors less than 10 minutes.

A stagnating anticyclone associated with five consecutive nocturnal inversions dominated meteorologic conditions in Buffalo for 6 days before the episode. Twenty-nine equally strong inversions and 15 instances of 5 or more consecutive nocturnal inversions had occurred, however, during the previous 2 years without evidence of illness associated with air pollution. It was hypothesized that on the morning of the episode a Hewson fumigation brought a concentrated layer of irritating pollutants abruptly to ground level, causing the eye irritation.

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National Clearinghouse on Smoking and Health

The newly established Clearinghouse on Smoking and Health, supported by a Congressional appropriation of \$2 million for the first year of operation, will undertake new functions as well as continuing current behavioral research in smoking and health.

The Clearinghouse will collect and distribute available materials on smoking and health, consult with Government agencies and voluntary and professional organizations, conduct studies in the behavioral areas on how to help people resist pressures to smoke or continue smoking, and develop two community "laboratories" where public education and communication will be tested on large population groups.

Dr. Daniel Horn, a pioneer in establishing the link between cigarette smoking and disease and former director of program evaluation for the American Cancer Society, will direct the information, education, and research programs of the new unit within the Public Health Service.