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RESPIRATORY COMPLAINTS AND MEDICATION USE FOLLOWING CESSATION OF EXPOSURE TO CONSTRUCTION DUST AND DIESEL TRUCK EMISSIONS (NEVE YAKOV, JERUSALEM)

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Abstract
Objectives: The aim of the study was to assess respiratory complaints in the residents of Neve Yakov following the closure of a municipal dump, operating in the neighborhood for 3 years. **Materials and Methods:** We carried out a cross sectional survey of 250 adult residents. Exposures to sporadic dust, measurements and estimates of diesel emissions based on traffic load were assessed. **Results:** Adjusted odds ratios for respiratory symptoms in persons living in the nearest and downwind areas compared to the areas farthest from the dump site were (nearest and downwind respectively): cough OR = 3.7 (95%CI: 1.18–11.4) and OR = 2.9 (95% CI 0.79–10.9); phlegm OR = 1.9 (0.7–5.1) and OR = 2.3 (0.7–7.3); shortness of breath OR = 1.7 (0.6–4.8) and OR = 3.7 (0.9–14.6). After closing the dump, 33% of residents reported improvement in symptoms. Following closure of the dump, residual respiratory illness was observed in many residents. **Conclusion:** A substantial part of the respiratory complaints may have come from diesel emissions in addition to the ambient dust.

Key words:
Respiratory illness, Diesel, Dust

INTRODUCTION

Reports on the benefits of stopping community exposures to fixed and moving sources of air pollution are not readily available. Neve Yakov, a poor neighborhood at the extreme northern end of Jerusalem, which has many immigrant, elderly, and unemployed residents, was the location of a municipal dump for building debris between March 1993 and July 1996.

The dumpsite was an abandoned quarry situated less than 100 meters from the nearest multi-family apartment buildings. During the dump's operation, the neighborhood community center documented high concentrations of visible

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dust released into the air, mostly from the dump site, but also from uncovered bins of the diesel dump trucks which drove through the main street of the neighborhood. At the time of peak operation, it was estimated that 500 diesel dump trucks passed daily through the neighborhood. Following demonstrations and a civil lawsuit organized by the neighborhood community center, the dump was closed by the District Court in July 1996.

There are many reports on the increased prevalence of respiratory symptoms and illnesses among individuals exposed to point source of dust. Signs and symptoms include cough [1–3], wheezing [4–6], shortness of breath [4–6], conjunctivitis [2,3], rhinitis [2,3], reduced pulmonary function [6–10], increased medication use among asthmatics [5,6,8], increased respiratory-related hospitalization [7,8,11], and increased respiratory illness and mortality among smokers [4,7,12]. Diesel emissions include particulate matter, nitrogen and sulfur oxides, and can serve as carriers of allergens [13]. The agents increase risks for asthma [14–18], reduce lung function [19–21], increase allergic rhinitis [22], and now they are found to increase lung cancer risk [23–26]. Occupational health studies suggest that many victims of occupational asthma remain ill after being removed from the exposure.

This study reports the prevalence of respiratory symptoms among the adult population of Neve Yakov three to four months following the closure of the dump and simultaneous stopping of diesel traffic. It examines the degree to which proximity to the dump increased risks for symptoms of respiratory illness, the degree to which closure produced relief of symptoms, and the role of other exposures (active and passive smoking, occupational exposures). The findings are of importance in assessing combined mixed risks from point and mobile sources of air pollution and the recovery rate following the removal of exposure, both of which are not readily discussed in the literature. The case for undertaking the study basis was an exploratory set of observations from a sentinel clinic in the neighborhood, indicating an increase in the number of visits to a doctor owing to complaints of wheezing, shortness of breath, respiratory infections, and cough as well as in use of antibiotics, bronchodilators, and corticosteroids among "chesty" patients following the opening of the dump. This increase exceeded that seen in other sentinel clinics elsewhere in the City of Jerusalem.

MATERIALS AND METHODS

Study group

The study population came from three areas of the Neve Yakov neighborhood, in which we ranked exposure as high, intermediate and low. The ranking was based on estimated magnitude of exposure to dust and diesel, site visits, photographs of dispersion of dust aerosols from dump trucks, and sporadic dust measurements. The neighborhood area nearest to the dump (area A; 100–200 m) had the highest estimated exposure, the downwind area (area B; approx. 500 m from the source) intermediate and the farthest area from the dump (area C; approx. 1000 m from source) was least exposed.

Based on a hypothesis that the expected proportion of persons with symptoms would be 0.20 ($\rho 1$) in area A, and 0.10 ($\rho 2$) in areas B and C, we calculated a minimum sample size (n = 157 persons per area) based on the following criteria: $\alpha = 0.05$, $\beta = 0.20$; $1\text{-}\beta = 0.80$, $\rho 2 = 0.10$ [27].

We randomly selected 3 buildings in the nearest area, 5 in the downwind area, and 5 buildings in the farthest area. In November 1996, 526 adults, aged 16 years and more, living in those buildings were requested to complete a questionnaire. Two trained interviewers collected the completed questionnaires and interviewed residents who were unable to complete the questionnaire because of language difficulties or physical disabilities. In total, we received responses from 250 residents: of the nearest (n = 99), downwind (n = 97), and farthest (n = 54) areas.

Exposure Data

The dump site itself served as a point source for dust exposure from May 1993 to July 1996. The depth of the dump site was 80 m, width 300 m and length 600 m ($14.4 \cdot 10^6$ m^3). The debris contained earth, cement, metals and plastics hauled from building and demolition sites. Truck beds were open, dust was freely dispersed during hauling and dumping, and there was no rinsing or washing down of truck beds following disposal.

Measurements of dust levels were provided by the Union for Environmental Protection, a non-profit organization. Measurements of mean dust levels were collected by a high volume sampler (<100 um) placed on rooftops of selected buildings. The sites were 3 buildings in the nearest area A, 1 building in area B, and 1 building in area C. Sixteen measurements (a three-hour sample) were carried out on seven different days (20 May and 13 June 1996), between 10:00 and 17:30, two to three months prior to the closure of the dump. Composition of the dust was determined by spectroanalysis.

The average daily traffic volumes of diesel trucks progressively rose: 20 trucks/day from May 1993 to July 1993 (74 working days); 50 trucks/day from August to December 1993 (123 working days); 100 trucks/day from January to June 1994 (121 working days); 300 trucks/day from July to November 1994 (123 working days); and 450 trucks/day from December 1994 to June 1996 (439 working days).

We estimated diesel emissions from daily dump truck traffic volume, distance traveled per truck within Neve Yakov (approximately 2 km), and reported emissions per kilometer traveled at a speed of 50 kph, an estimated travel speed. The reported emissions at 50 kph were as follows: carbon monoxide (CO), 2.90 mg/km; hydrocarbons (HC), 1.85 mg/km; and nitrous oxides (NOx), 13.52 mg/km [28].

Questionnaire

We used the American Thoracic Society standard questionnaire (ATSQ). In order to target data on the frequency of symptoms at the time of interview and four preceding months we added the element of time to some questions. All other aspects of the ATSQ questionnaire were not modified. The questionnaire included questions on personal status (age, gender, ethnicity, country of birth, date of immigration, level of education, religion, marital status), housing status (apartment size, number of persons residing in the household and domestic fuel use), occupational and environmental exposures, personal smoking histories, symptoms (frequency and severity of cough, phlegm, wheezing and shortness of breath), medications use for respiratory conditions – an indicator of morbidity, and personal medical histories.

Questionnaire validation

We evaluated the validity of the questionnaire for assessing respiratory problems by examining medical records of a small randomly selected subgroup of cases and controls. Cases (n = 10) were persons reporting two or more respiratory symptoms and controls were those reporting the absence of respiratory symptoms (n = 12).

Nine of ten individuals who reported respiratory symptoms in the interview had visited their doctor between May 1993 and July 1996 for respiratory complaints. Of the nine persons, eight (88.9%) had 2 or more visits with their local physician. During the same period, of the twelve controls, three (25%) had visited a physician for such complaints, but of these, only one (11.1%) had two or more visits ($p < 0.01$; χ^2-test). The most frequent diagnoses in the nine individuals were sinusitis, asthma, and bronchitis.

Bias

To assess selection bias, we used a brief questionnaire to collect information on age, gender, presence of respiratory conditions in non-respondent adults residing in the apartment for at least one year and compared the results with those from respondents. Of the 276 non-respondents, there were 99 males (52.4%) and 90 females (47.6%), and mean age of non-respondents was 44.6 years (range 18–86; area A = 39.9 years; area B = 25.4 years; area C = 34.8 years). The majority of respondents reported being symptom free with little differences between the areas.

To minimize the response bias, we formulated the questions on symptoms at the times of completing the survey and 4 months prior to the survey without reference to the date when the dump was closed.

Statistical analysis

We used SPSS 8.0 analysis programs for the statistical analysis. Chi-square test was used to analyze categorical variables. We fitted a multivariable logistic regression model, including all the potential predictors to estimate adjusted ORs for respiratory symptoms of persons living in areas A and B compared to those residing in area C. The following variables were included as possible confounders in the multivariate model: age, gender, area, occupation,

domestic use of natural gas, overerowding, smoking, passive smoking, and marital status. We also calculated attributable fractions for cough, shortness of breath and phlegm based on comparison of risks in the highest (area A) and lowest exposure (area C) groups. A two-tailed p-value less than 0.05 was considered statistically significant.

RESULTS

Demographic Data

Table 1 presents socio-demographic data for areas A, B and C.

We had an overall response rate of 47.5% (250 out of 526). Respondents from areas A and B reported lower incomes than those from area C. The downwind area comprised almost entirely an ultra-orthodox religious community characterized by the lower mean age, low divorce rate, larger families and overcrowded households, absence of risky occupations and low rates of reported smoking compared to the populations of two other areas.

Of the 250 respondents, 59 were born in Israel (23.6%); 96 in Eastern Europe (38.4%; mostly the former Soviet Union;, 56 in North or South America (22.4%); 20 in other parts of Europe (8.0%); and 19 in Africa or Asia

Table 1. The Neve Yakov residential dump site, 1996: Demographics

Category (No. of respondents)	Area A	Area B	Area C	Total*
Total number of residents in Neve Yakov	850**	5000**	5000**	22000***
Total number of residents in the study	209	167	150	526
Total number of respondents	99 (47.4%)	97 (58.1%)	54 (36%)	250 (47.5%)
Mean Age (n = 242)	46.5 (r = 17–85)	38.4 (r = 16–69)	49.2 (r = 17–86)	43.9 (r = 16–86)
Gender (n = 249)				
Male	44 (44.4%)	45 (46.9%)	25 (46.3%)	114 (45.8%)
Female	55 (55.6%)	51 (53.1%)	29 (53.7%)	135 (54.2%)
Marital satus (n = 249)				
Married	42 (42.9%)	45 (46.4%)	23 (42.6%)	110 (44.2%)
Single	45 (45.9%)	52 (53.6%)	23 (42.6%)	120 (48.2%)
Divorced or widowed	11 (11.2%)	0 (0%)	8 (14.8%)	19 (7.6%)
Education (n = 229)				
≤12 years	44 (49.4%)	38 (41.8%)	33 (67.3%)	115 (50.2%)
13–16 years	39 (43.8%)	48 (52.7%)	16 (32.7%)	103 (45.0%)
17+ years	6 (6.7%)	5 (5.5%)	0 (0%)	11 (4.8%)
Overcrowd (n = 183)				
≤15 m^2/person	33 (42.9%)	53 (76.8%)	3 (8.1%)	89 (48.6%)
16+ m^2/person	44 (57.1%)	16 (23.2%)	34 (91.9%)	94 (51.4%)
Occupation (n = 242)				
Risky	10 (10.3%)	0 (0%)	3 (6.0%)	13 (5.4%)
Use of bottled gas (n = 237)	5 (5.3%)	12 (13.2%)	2 (3.8%)	19 (8.0%)
Use of natural gas (n = 237)	75 (79.8%)	70 (76.9%)	46 (88.5%)	191(80.6%)
Smoking (n = 247)	27 (27.6%)	4 (4.2%)	13 (24.5%)	44 (17.8%)
Passive smoking (n = 247)	48 (49.0%)	4 (4.2%)	21 (39.6%)	73 (29.6%)

* Omissions on specific questions from respondents are subtracted from the denominator (n = 250).
** Approximate numbers provided by community center representatives.
*** Total population of entire neighborhood of Neve Yakov from Jerusalem census, 1996.

(7.6%). The majority of respondents immigrated to Israel after 1986 (n = 111; 44.4%), and only 16.4% of them (n = 41) had arrived in Israel before 1975.

Twenty two (8.8%) respondents reported occupations in industries suspected of potential respiratory health hazards (exposures to dust, gas, vapor or mist); 13 (5.2%) worked in occupations assessed by the respondents as potentially hazardous to their airways. Twelve (28.6%) smokers reported smoking more than one pack a day (>20 cigarettes). Of the 44 smokers, 27 (61.3%) lived in area A.

Exposure: air samples, estimated truck emissions and duration

The dump site was located at the northwest corner of Neve Yakov.

Generally, the wind direction was northwest to southeast – from the nearest area towards the downwind area (Wind Rose Analysis; Jerusalem Municipality, 1996).

Table 2. Neve Yakov residential dump stie, 1996: Analysis * of particulate air matter

Metal, mineral, compound	Air concentration (mg/m^3)
Calcium	63.23
Titanium	0.126
Copper	0.052
Magnesium	1.11
Iron	2.52
Silicon	0.52
Nickel	0.018
Vanadium	0.022
Manganese	0.047
Cobalt	0.015
Lithium	0.001
Natrium	14.8
Strontium	0.013
Graphite	8.29
Phosphorous	0.22
Clay	2.00
Chloride	3.11
Bromide	0.007
Nitrates	12.88
Phosphates	0.019
Sulfates	27.08

* Air analysis was performed by the Union for Environmental Protection. Mean time weighted dust levels of 16 three-hour samples taken between 20 May and 13 June 1996. Samples were taken on the roof of building 21 on Neve Yakov Blvd (area A).

Time weighted dust levels of mean particulate air matter were 600 mg/m^3 in May and 450 mg/m^3 in September 1995, based on a three-hour sampling period. The mean time weighted dust level of samples taken between 20 May and 13 June 1996 (16 air samples) was 517 mg/m^3 (Israeli standard: 300 mg/m^3). Results of the particulate air matter composition are shown in Table 2. Only air levels for sulfates exceeded Israeli standards for air quality (Sulfates: 25 mg/m^3).

The average daily traffic volumes of diesel trucks progressively rose during the period of dump operation. Total estimated truck travel through the neighborhood from May 1993 to June 1996 was 508 360 vehicle kilometers. Estimated cumulative emissions (metric tons) in Neve Yakov during a three-year period was as follows: CO – 0.9 tons of, HC – 0.6 tons and Nox – 4.3 tons [28].

The majority of respondents (n = 186; 74.4%) resided in Neve Yakov for the whole three-year period of exposure, 28 (11.2%) for two years and 28 (11.2%) for one year or less.

Respiratory complaints and medications use at time of study

The prevalence of cough, phlegm, and shortness of breath was more frequently reported by the residents of area A (Table 3). Whereas wheezing was more common among those living in area C (p = 0.05). More than one symptom was reported by 115 (46.0%) respondents.

The use of medications reported in the interview was lower than the prevalence of reported symptoms. The use of antibiotics, antitussives and antihistamines was highest in respondents living in area A (Table 4). However, the use of bronchodilators and systemic steroids was highest in area B with the highest prevalence of asthma (n = 15, 75%).

Personal medical history: past medical complaints

The illnesses reported most frequently by respondents were: sinusitis (n = 57, 22.8%), bronchitis (n = 49, 19.6%) and eye irritation (n = 44, 17.6%). Eighteen (40.9%) respondents with eye irritation reported the appearance

Table 3. Neve Yakov residential dump site, November 1996*: Respiratory complaints at the time of the study

Symptom	Area A	Area B	Area C	Total	P-value**
Cough	35 (35.5%)	18 (18.8%)	10 (18.5%)	63 (25.3%)	0.01
Phlegm	26 (32.5%)	22 (22.9%)	10 (18.5%)	58 (25.2%)	0.1
Shortness of breath	26 (26.8%)	15 (15.6%)	10 (18.5%)	51 (20.6%)	0.1
Wheezing	11 (11.1%)	11 (11.5%)	13 (24.1%)	35 (14.1%)	0.05
One symptom or more	55 (55.6%)	36 (37.1%)	24 (44.4%)	115 (46.0%)	0.03

* Dump was opened in May 1993 and closed in November 1996.
** Chi-square test.

Table 4. Neve Yakov residential dump site, 1996: Medication use

Medication use*	Area A	Area B	Area C
Antibiotics	12 (16.7%**)	6 (6.3%)	2 (3.9%)
Antitussive	13 (18.1%)	2 (2.1%)	3 (5.9%)
Antihistamines	6 (11.3%)	6 (6.3%)	0 (0%)
Bronchodilators	4 (5.6%)	11 (11.5%)	2 (3.9%)
Systemic Steroids	1 (1.4%)	3 (3.1%)	0 (0%)

* Number of respondents to questions regarding use of medications was n = 219.
** Prevalence of medication use (%) among total number of respondents in a corresponding area.

of this symptom after the opening of the dump. Of the 18 respondents, six (33%) persons reported the onset of asthma after opening of the dump.

The rates for self-reported asthma and sinusitis ($p < 0.01$), bronchitis ($p < 0.05$) and hay fever ($p < 0.05$) were highest in the respondents from area B.

Odds ratios: symptoms and exposures

Adjusted odds ratios for reported symptoms in areas A and B, respectively were as follows: cough OR = 3.7 (95% CI: 1.18–11.4) and OR = 2.9 (95% CI: 0.79–10.9); phlegm OR = 1.9 (0.7–5.1) and OR = 2.3 (0.7–7.3); shortness of breath OR = 1.7 (0.6–4.8) and OR = 3.7 (0.9–14.6).

The crude odds ratios for symptoms among smokers were cough OR = 2.15 ($p = 0.02$) and the presence of one or more symptom OR = 2.33 ($p = 0.01$). Persons with exposure to environmental tobacco smoke (ETS) complained of respiratory symptoms twice as frequently as those not exposed.

Risk for cough was strongly associated with occupational exposure to hazardous gasses or dusts OR = 6.3 (95% CI: 1.51–28.4; $p = 0.02$), active smoking OR = 2.9 (95% CI: 0.7–11.7; $p = 0.1$), and domestic use of natural gas OR = 2.3 (95% CI: 0.8–6.7; $p = 0.1$). The association between overcrowded households and cough was weakly negative OR = 0.6 (0.3–1.2; $p = 0.3$).

Calculations of attributable fraction (AF) based on comparison of risks in the interviewed residents in the areas of the highest and lowest exposures indicated that 47.9% of reported cough was attributable to exposure from the dump site combined with truck emissions. For phlegm and shortness of breath, the AFs based on the comparison of the highest and lowest exposures were 43.1% and 30.9%, respectively. The population attributable fractions for risks among persons living in areas A and B compared to those living in area C were: 26.9% for cough, 26.6% for phlegm and 10.2% for shortness of breath. But, as indicated above, smoking and occupation accounted for the remaining increase in the risk.

Changes in reported symptoms: three months following the dump closure

Two thirds of the respondents continued to experience complaints following the closure of the dump. The remaining 33% of those with respiratory symptoms reported to be less ill three to four months when the dump stopped to operate. The following proportions of respondents reported improvements in individual respiratory symptoms after closing the dump: cough – 31.7%; phlegm – 32.7%; shortness of breath – 19.1%; and wheezing – 31.4% (Table 5).

Discussion

The residents of Neve Yakov were at risk of community exposure to large volumes of dust and diesel emissions.

Table 5. Neve Yakov residential dump site, November 1996: Change in respiratory symptoms four months after closing of the dump

Symptoms	Area A	Area B	Area C	P-value*
Cough				0.19
Better	8 (24.2%)	8 (47.1%)	3 (30%)	
Worse	3 (9.1%)	3 (17.6%)	0 (0%)	
Same	22 (66.7%)	6 (35.3%)	7 (70%)	
Phlegm				0.28
Better	9 (37.5%)	4 (21.1%)	4 (44.4%)	
Worse	0 (0%)	2 (10.5%)	0 (0%)	
Same	15 (62.5%)	13 (68.4%)	5 (55.6%)	
Shortness of Breath				0.08
Better	2 (8.7%)	5 (35.7%)	2 (20%)	
Worse	8 (34.8%)	0 (0%)	3 (30%)	
Same	13 (56.5%)	9 (64.3%)	5 (50%)	
Wheezing				0.02
Better	2 (18.2%)	7 (63.6%)	2 (15.4%)	
Worse	1 (9.1%)	0 (0%)	4 (30.8%)	
Same	8 (72.7%)	4 (36.4%)	7 (53.8%)	

* P-value was calculated using Chi-square statistic.

Many persons were exposed to environmental smoke in their homes and also to an array of unspecified agents in their work environment.

There was a much higher prevalence of respiratory complaints among people living in areas A and B compared to the residents of area C. Our findings confirmed the observation made during the medical records-based pilot study, mentioned above, suggesting an increase in respiratory illnesses among sentinel residents with increasing truck traffic and dumping.

The findings presented here suggest a gradient of risks for respiratory illness associated with proximity to combined exposures from a point source, dust from construction debris, and a more widespread exposure to diesel exhaust. We were unable to assign a relative weight to the role of the two separate exposures played in producing the described respiratory problems. But the risks were associated not only with exposure to particulates from the debris and from diesel emissions, but also from smoking and occupational sources. Details on the occupational sources were not readily available.

Respondents living in the closest vicinity of the dump had a higher frequency of symptoms indicating irritation, e.g., cough, eye irritation and use of antitussives and antihistamines. By contrast, among respondents from the downwind area a higher prevalence of chronic-type illnesses and infections, e.g., asthma, bronchitis, shortness of breath and more extensive use of bronchodilators, or steroids were observed. These differences in illness patterns suggest that individuals from area A were more exposed to dust, and thus experienced irritation and allergic effects in eyes, nasal passages and upper airways, whereas in residents of area B exposures to smaller particulates and gasses from diesel fumes, which penetrate deeper into the airways, predominated. In both groups, it is plausible to expect that exposures to air pollutants interacted with preexisting susceptibility in those with allergic or asthmatic type responses [29].

The fact that two third of the persons with respiratory complaints were still ill several months after closure of the dump suggests that 1) there were other causes (e.g., prior illness, smoking, occupational exposures) of their complaints, or 2) they were experiencing residual and possibly irreversible effects of exposure to dust, or 3) both. Such a residual impairment has been seen in persons with occupational asthma after cessation of exposure [30], and provides a plausible explanation for the persistence of illness in our study group.

At the same time, higher remission of rates in respondents in area B may have resulted from a lower proportion of smokers and individuals with occupational exposures.

Limitations. The major limitation of our study is that the obtained exposure data were constricted. Ambient air measurements did not separate particles by size of more or less than 10 microns. Yet, our estimates for diesel emissions were based on traffic load, a recognized tool in epidemiologic studies [19]. The high estimates of traffic load suggest that diesel exhaust from dump trucks combined with exposure to dust as well as downwind from the main road posed a hazard to residents living in area A. Diesel emissions were higher as a result of acceleration, deceleration and engine idling, all of which increase exhaust emissions.

The overall low response rate combined with a lower response rate in area A may have biased the findings. Residents of areas A and B reported a higher awareness of the activities going on at the dump site. However, the possibility that exposed residents were more prone to recall respiratory symptoms is substantially discounted by the high degree of agreement between interview data and physicians reports.

Our findings indicate that proximity to the dust and diesel exhaust in the area A and area B groups is suggested to increase the susceptibility of these groups to respiratory disease [31–36]. Low socioeconomic status, a recognized indicator of increased risks for respiratory illness [37], usually includes increased exposures to air pollution, smoking and adverse occupational factors, all of which were present in our study groups. More recent findings suggest that polycyclic aromatic hydrocarbons in the particulates of diesel exhaust are themselves capable of inducing IgE, and thus, could cause, and not only trigger, allergic responses [38].

CONCLUSIONS

This study reports the adverse effects of combined exposure to a point source of dust from construction debris and from diesel emissions in a low-income neighborhood. This study was unique in that it provides an opportunity for testing the effects of the cessation of these exposures. After the closure of the dump and stopping the traffic of diesel trucks, most residents remained ill for four months after closure, particularly those living in the area nearest to the dump. Despite the reported health improvement in some residents, a large group of subjects remained ill four months after closure and another group reported a worsening of preexisting respiratory complaints. The study distinguished subgroups with specific risks of combined exposures to smoking, occupational hazards, and residential exposure. Our findings show that to prevent short-term health risks from air pollution in high-risk neighborhoods, a comprehensive approach to all sources of air pollution is needed, although one should be aware that residual aftereffects persist in many instances.

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