

Health and the Urban Environment

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Air Pollution and Family Illness: I. Design for Study

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A dominant theme of human history is the consolidation of populations into ever larger social units. Acceleration of this trend in industrialized societies has concentrated 75% of the population of the United States onto 10% of the land. Although the pressures, tensions, crowding, and dirt of the urban environment are commonly stigmatized as injurious to health, astonishingly little objective evidence is available to support this belief. As measured by every vital index available our major cities are very likely the healthiest and most beneficial environments for human habitation ever developed. Despite the apparent advantages of urban populations compared to rural ones, certain features of the urban environment undoubtedly exact a toll on the health of its citizens and may indeed be direct or indirect causes of disease. Certainly the seeding of our environment with a host of new and complex chemical agents may influence health in subtle ways not immediately apparent. The most widespread

chemical agents to which city dwellers are exposed are products of the combustion of organic compounds; since this combustion is rarely complete and since chemical by-products and even substantial amounts of the fuel itself are released continually into the atmosphere, our urban populations are exposed to a constant stream of chemical agents of varying concentrations and shifting composition.

The respiratory tract contains 1,200 square feet of highly absorptive endothelium which enables it to function as an efficient mechanism for absorbing into the body various substances present in air. Absorption of harmful air pollutants has exacerbated pre-existing pulmonary disease during "acute" air pollution episodes both in the urban United States and in various European cities. Evidence for the initiation of permanent disease in previously well persons is fragmentary. To study this relationship we have undertaken a careful longitudinal study of a significant group of normal city dwellers together with simultaneous monitoring of the environment to which they are exposed. Our goal is to follow daily variations in health of a group of urban families of diverse backgrounds living in the same geographic area and to correlate these over a period of time

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with variations in the atmosphere to which they are exposed.

Study Area

Manhattan Island is the geographic center of the New York metropolitan area with its 16,000,000 inhabitants. Pollution of its air is from heating plants and incinerators of several million dwelling units, a diversified industrial complex within and outside the city, and from 4,500,000 motor vehicles registered in the area. Packed onto 22.2 square miles are 1,698,281 people representing every major racial, ethnic, and cultural group in the world. The immediate juxtaposition of rich and poor, Negro and white, tenement and substantial apartment building results in suitably small units for study which contain all the elements of the larger population.

The study area chosen was on the lower east side near the East River. Bisected by 14th St, the area includes a middle-income private housing project on the north, a tenement slum on the south, and a low-income public housing project on the east. Each of these sections is a separate census tract occupying from six to ten square blocks representing a characteristic type of urban housing.

Housing in the Study Area.—The first census tract stretching across the northern quarter of the district is composed entirely of a middle income privately owned housing project of $3\frac{1}{2}$ to $5\frac{1}{2}$ room apartments in identical 9 to 14-story buildings. The second section forms the eastern border of the study area and consists entirely of a low-income public housing project. Apartments of $2\frac{1}{2}$ to $5\frac{1}{2}$ rooms are located in 6 to 14-story brick buildings closely resembling the middle income housing project. Except for somewhat smaller rooms in the lower income project, the apartment buildings are similar in both areas and are of about the same age. Apartments in both are modern with adequate heating, lighting, and toilet facilities. Air conditioners are prohibited in both. Located almost midway between the two housing projects is a ten-square-block area of

"old-law" tenement houses, four to six story walk-up tenement apartment houses, built before modern building codes. Bathroom and toilet facilities are not always within the apartments and may be shared by several families. Although central heating is required it is often inadequate and not all apartments have hot water. Most of the buildings are dark, dirty, and in poor repair. Very few of these apartments have air conditioners and not all rooms have windows.

Rising in the geographic center of the study area is a single tall building of 16 stories. The air pollution study monitoring station is located on the top floor through the courtesy of the New York City Department of Welfare which occupies this building.

Just outside the study area on the northeast are the tall smoke stacks of a major electric power plant of the Consolidated Edison Company. The prevailing winds usually carry the effluent away from the study area. The influence of these stacks appears to be diffuse, affecting all sections of the study area to approximately equal degree. The study area totals less than half a square mile and is included in a circle with a radius of 2,000 feet centered on the air pollution monitoring station.

Population of the Study Area.—The population of Manhattan is a mixture of white and Negro, native and foreign born, and in recent years a substantial number of citizens from Puerto Rico. All these groups are represented within the project area.

The middle-income apartment project contains a relatively homogeneous group of middle to upper-middle income younger families engaged principally in professional and technical jobs. In this tract the total census for 1960 lists 22,405 persons of whom 22,315 are classified as white. Only the southern portion of this project is included in the study area.

The low income tenement section has two large population groups, the larger consisting of older foreign born or first generation white families most of whom speak English in the home. The smaller group consists of younger families of Puerto Rican back-

ground most of whom use Spanish in the home. Both groups have relatively low incomes and usually have limited formal education. The 1960 Census lists 17,496 persons in this area of whom 16,389 are white and 911 are Negro. Of this total population, 5,510 are designated as Puerto Rican, 4,094 having been born in Puerto Rico and 1,416 born of Puerto Rican parents.

The low-income public housing project has three distinct ethnic groups. Both dominant groups of the tenement area are also found here but in modern well-maintained housing. In addition to these white English-speaking families and the Spanish-speaking families from Puerto Rico, the low income housing project contains a sizeable number of native-born English-speaking Negro families. The income of all three groups is low since public housing regulations require that incomes remain below a specified level adjusted to family size to qualify for residence. The 1960 Census lists a total population for this project of 7,720 of whom 5,894 were white and 1,708 were Negro. Of these two groups, 3,177 were either born in Puerto Rico or are of Puerto Rican parentage.

From this population it was possible to draw a representative sample which would permit comparisons and conclusions as to the influence of ethnic origin, income, family size, and quality of housing in relation to health. To fulfill these study objectives, a goal of 1,000 persons in the study population was established. Since the majority of minor illnesses are known to represent family infections the study population was enrolled by family units. All members of each family selected were enrolled including all related persons living in the household. Ideally, a study population sample should represent all diverse elements present in the community. Since such representation is manifestly impossible in the heterogeneous culture of New York, certain characteristics were arbitrarily selected for study. Some of these, such as family size and composition, were included because they have been shown previously to influence illness patterns in family groups.^{1,2} Others, such as race, ethnic background, and

income level were not necessarily expected to show such correlations but were considered important parameters to include in a representative study population.

United States Census Bureau definitions of race were used. A family was classified as Puerto Rican if the head of the household was born in Puerto Rico or if Spanish was the principal language in the home. Since we wished to identify those families whose cultural patterns and family life were based on those of Puerto Rico, use of Spanish language in the home as well as place of birth were selected as major determining factors. Thus a family of Puerto Rican descent with all members born in the continental United States and using English in the home was not considered to be Puerto Rican for our purpose.

The three census tracts were chosen after a preliminary household enumeration to obtain identifying data in 2,800 households in five contiguous census tracts. Based on the population sample enumerated in these three tracts a subsample was derived to serve as the final study population. Families were divided into groups representing various ethnic and demographic characteristics. Sufficient families with each characteristic were drawn by random number to fulfill the study requirements. The resulting stratified random sample did not necessarily include persons with each desired characteristic in proportion to their numbers in the total population but did assure that each enumerated person with such a study characteristic had an equal chance of being included.

The final study population included families with children of all ages as well as some households without children. Although most of the study population was drawn from the low and middle income groups, 18 families in the "middle income" housing project sample admitted to incomes over \$10,000.

After selection of a family for participation in the study, a letter of introduction was sent, followed in a few days by a visit from an interviewer. The aim and methods of the study were fully explained and the family invited to participate. Only the fact that the

study is also concerned with air pollution was withheld from participating families to prevent unconscious coloring of responses during episodes of increased pollution.

No attempt was made to persuade reluctant families; each enrolled family understood that the interview would take up to one hour each week for one year. They were also told that they would be asked to donate blood samples and have throat cultures performed on at least two occasions during the year. The fact that all this was carried out willingly by so many families without any medical service in return is a tribute to the tact of our interviewers and the very real desire on the part of the study families to participate in medical research.

Of those families selected in the low-income tenement area, 55% agreed to take part in the study; 60% in the low-income housing project consented, but only 34% of families contacted in the middle-income housing project agreed to participate. An effort will be made to determine, at a later date, the subsequent illness experience of the families refusing to participate compared with the study population. We will also attempt to find out in what way these families differed from those which entered the study.

Cooperation of families once enrolled has been very good. Six families were dropped during the first year of study because their responses seemed unreliable. Twenty-one families were dropped when they refused to donate blood samples and an additional 32 families left the study because of lack of interest after varying periods of participation. Each of these families was replaced by an alternate family drawn at random from the same ethnic group in the same census tract.

As each family completes its initial year in the study it is offered the option of remaining for a second year. An indication of the interest of our families is the fact that of the first group of 47 families finishing a full year, 40 elected to continue for a second year. As the interview staff has been expanded more families have been added so that at the end of 1963 the total study popu-

lation numbered 942. All those persons have agreed to continue throughout 1964 so that simultaneous rather than sequential observations will be possible on the total population.

The Questionnaire

The basic aim of the study was to follow the daily incidence of symptoms in a large segment of a normal population. The questionnaire was selected as the most suitable tool for this task. Aside from the fact that questionnaires are easy to use and cheap, we feel that minor and subtle variations in health are most likely to be uncovered in reports of affected persons rather than through physical examination or function studies.

One respondent in each family answers the questionnaire for the entire family each week. Exactly the same wording is used for each question and the entire questionnaire is asked at each interview even if the respondent denies any change in health during the week. The questions concern only the seven days immediately preceding the interview. If an interview is delayed, only the immediately preceding seven days are recorded. No attempt is made to recall symptoms for more than seven days since we assume that recall for many minor symptoms is probably not reliable for more than a week.

Although it seems logical that the physiologic response to atmospheric pollutants should be observed most readily in the respiratory tract it is possible that effects are also expressed in other symptoms. One of these effects may be to alter the state of general well-being which may not be reflected in specific symptoms. To determine such subtle effects a series of questions on general well-being was developed. Although all answers are subjective, the questions were tested extensively in a pilot population in many forms and the current 114 questions appear to be meaningful to the study population.

The questionnaire contains eight categories: (1) general well-being; (2) fever, headache, and eye symptoms; (3) gastrointestinal symptoms; (4) acute respiratory symptoms; (5) miscellaneous (including asthma, other chronic respiratory symptoms,

and home accidents); (6) other health complaints; (7) sources of health care; and (8) indices of disability.

Since the population is a cross section of normal urban dwellers it contains persons with a variety of chronic symptoms which affect their responses to certain questions. To evaluate the daily changes in the symptoms of such persons, certain additional questions relating to their disabilities were included. The number of questions asked may vary from person to person depending on chronic conditions but will be the same for each person from week to week. The variation is dependent upon age and sex as well as the presence of chronic illnesses.

The questionnaire in addition to respiratory illness deals with a variety of subjects such as home accidents, sources of health care, and degree of disability.

In constructing the present form of each question the questionnaire was revised many times. Between each revision it was tested in a pilot population. Questions were changed or rejected if they were not clearly understood, were ambiguous, or caused difficulties in recording.

In addition to the individual weekly questionnaire, a base line questionnaire designed to elicit basic health and demographic background on each study member was administered once to each participant. This base line questionnaire has three different forms to make it appropriate for preschool children (0-4 years), school-age children (5-14 years), and adults (15+ years). The questions concern age, sex, ethnic background, places of past residence, and for relevant age groups, smoking and drinking habits, marital status, previous marital history, number of times moved, type of employment and resulting occupational exposure, number of past jobs, income, details of present housing, past illnesses, immunization status, a review of symptoms, and certain attitude questions about health.

Except for children this base line questionnaire is asked directly of the person it concerns. It is asked after the respondent has been in the study at least four weeks and

if familiar with the questionnaire and the interviewer who asks it.

The British Medical Research Council questionnaire on respiratory symptoms was incorporated bodily into the adult base line questionnaire for comparison with the numerous other studies that have utilized this questionnaire to determine the prevalence of bronchitis in various populations. The number of questions varies from 190 for an adult to 85 for a child and may involve more than one interview for completion.

The Interview

To insure the full and correct completion of the questionnaires questions are always asked by a trained interviewer; questionnaires are never handled nor filled out by the respondent. In most cases the mother is the respondent. Although only one person serves as respondent, all members of the family have agreed to participate in the study and the other household members assume the obligation of keeping the respondent informed of symptoms as they appear. Since the respondent is identified on each questionnaire it is possible to determine whether his responses differ in degree and kind for himself compared with his reports for others in the family.

An individual questionnaire can be completed in ten minutes if there are no symptoms to report but may require 20 minutes if an illness has occurred. The total length of an interview depends, of course, on the number of persons in the household and the resulting number of questionnaires to be completed. The base line questionnaire, unlike the weekly illness questionnaire, is always administered personally to every adult over age 15. Mothers usually assist with children below this age.

Interviewers.—Previous experience in interviewing was found to be a disadvantage for interviewers since most of such persons had preconceived ideas on the conduct of an interview. A medical background also disqualified an applicant since the tendency to interpret symptoms or to prompt a respondent seemed difficult to control. Because of

the large number of Spanish-speaking families in the study population fluency in both English and Spanish was essential for most interviewers.

Young people without previous interview experience but with at least a high school education were used. Both males and females were equally well accepted by the study population. The initial three interviewers were expanded to a full-time field staff of 18 persons, most of whom have completed at least two years of college.

Since interviewers were deliberately selected without previous interviewing or medical experience it was necessary to establish a training program which included orientation to the project, techniques for establishing and maintaining contact with emphasis on ethics and the confidential nature of medical information, a limited amount of theory on interviewing techniques, and intensive drill in the use of our questionnaires.

Evaluation of performance and retraining are conducted by several methods. Visits to the families are made periodically by the field supervisor, some with the interviewer and some alone. The quality of interviewing is evaluated by these visits, by a review of completed questionnaires, and by regular weekly error checks. A separate questionnaire was designed to elicit the respondents' reactions to the study and to the interviewers. The greatest danger seems to be that familiarity with the questions breeds carelessness, particularly in recording. A continuing training program has been developed to help overcome this and a manual has been written for guidance in recording. In our study an interviewer can carry a case load of 20 to 30 families containing from 85 to 100 persons.

Laboratory Studies

Since detailed medical information is regularly obtained from the study population a serum bank for correlative antibody studies was felt to be of great value. Blood samples as well as cultures of nasopharyngeal flora are obtained at least twice each year from

each study participant. Since many in the study group are children a pediatric resident physician is included in the team visiting the home for these bleedings. The value of such a serum bank associated with detailed current information on illness is obvious.

Environmental Measurements

To monitor the atmosphere to which the study population is exposed, a weather and air pollution monitoring station was established in the center of the study area. Although the laboratory is on the top floor of a 16-story building, air sampling lines extend down the south wall to the 3rd, 6th, and 10th, as well as the 16th floors. These intake ports allow sampling of the air at various levels above the street to provide a vertical profile of air pollution.

Meteorological equipment includes Aerovane, temperature differential recorder, hygrothermograph, pyrlieliograph, and rain gauge. The Aerovane measures wind direction and wind speed, and records both on a strip chart. The transmitter is mounted on a mast above the roof peak of the building.

Temperature difference equipment is designed to measure small temperature differences between one point and other points in the atmosphere, employing the principle of the resistance thermometer for precision. Shields were mounted on window brackets of the 3rd, 6th, 10th, and 16th floors.

The hygrothermograph measures and records the temperature and humidity of the atmosphere operating with a hair hygrometer and a Bourdon tube temperature element.

The pyrlieliograph is designed to measure and record solar radiation using the principle of the by-metallic strip. It is mounted on the parapet of the roof at the 16th floor level.

The rain gauge measures rain and snowfall by weighing the catch and recording the accumulation in inches of rain. Supporting climatological data including temperature, wind speed, and direction, psychrometric information, sky cover, and radiosonde readings are obtained from United States Weather Bureau stations at Central Park, LaGuardia, and Kennedy Airports.

The monitoring station is also equipped to measure the following pollutants: sulfur dioxide, total hydrocarbons, carbon monoxide, total oxidants, nitrogen dioxide, total sulfation, and particulate density. Equipment is on hand for mobile station monitoring of particulate density, total sulfation and ozone (oxidants). We can also sample gases by impingement apparatus, analyze gases by a laboratory constructed gas train system, and analyze organic gases using gas chromatography.

This monitoring station has been designated as a station of the United States Public Health Service Continuous Air Monitoring Program. The recorders are equipped with slidewire attachments and digital converters for data read-out on each instrument.

To determine the relationship of air pollution measured at the centrally located main monitoring station to that portion of the pop-

ulation living on the periphery of the study area, a satellite monitoring station was established on a roof of the low-income housing project 2,000 feet from the main station. This substation is located at the edge of the study area at the same height as the main station. In addition to the main station and the substation, mobile units are planned to make further comparisons between the findings at the central station and the remainder of the study area.

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