

Industrial Hygiene Survey of Metropolitan Denver

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THE OCCUPATIONAL health sections of the Colorado State Department of Public Health, the Denver Department of Health and Hospitals, the Tri-County Health Department, and the Jefferson County Health Department have been engaged in occupational health activities for a number of years. Yet, until 1965-66 no concentrated effort had ever been directed toward establishing guidelines for these activities. Instead, efforts had primarily been directed at special studies, fulfillment of requests, and the abatement of occupational health complaints in various industries.

Information was lacking on such items as (a) the specific occupational health problems which were present in the industries in the area, (b) the distribution of occupational health hazards among the plants within an industrial group, and (c) the number of employees exposed to occupational health hazards.

Data were needed on these points in order to define occupational health problems in the Denver area and to provide a basis for deter-

mining the priorities to be followed in solving them. If the correct information was obtained, it would also be possible to estimate the size and composition of the occupational health group which would be required to conduct an adequate program. Therefore, in 1965-66, the four public health agencies undertook a survey of selected plants in certain industrial categories. A scientific statistical approach was used to assure that the information collected on the plants surveyed would be representative of all plants in the industrial categories and size groups selected.

The Metropolitan Denver area comprises four counties having three health agencies—the Denver Department of Health and Hospitals, the Jefferson County Health Department, and the Tri-County Health Department (which serves Adams and Arapahoe Counties). Occupational health personnel of the three agencies receive consultation and technical assistance from the occupational health section of the Colorado State Department of Public Health.

The counties comprising Metropolitan Denver cover the following numbers of square miles: Adams, 1,246; Arapahoe, 812; Denver, 96; and Jefferson, 783. At the time of the survey, the combined population of these counties was more than 800,000.

Methodology

After assessing the available resources, we decided that some 500 establishments could be surveyed in approximately 2 weeks. To meet this schedule, however, we excluded plants em-

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ploying 250 or more persons, as these larger plants require considerable time for surveys. The self-employed and the places of business with fewer than three workers were also excluded, again to insure covering the maximum number of workers in the survey.

In each State, there is an official agency to which all businesses meeting specified criteria must send quarterly reports of their operations. In the initial application, the chief activities of the plant are described, and any fundamental changes in activities are reported if and when they occur. The business, or establishment, is assigned a numerical code based on the Bureau of the Budget's Standard Industrial Classification (S.I.C.) Manual (1). Subsequently, each establishment files a quarterly report listing, among other data, the number of employees for the given quarter. Selection of industries for the survey was made from the files of the official agency in Colorado.

The self-employed (for example, persons working on family-owned and family-run farms) are not all required to file applications under this legislation; nor are railroad enterprises or certain government agencies. Except for these groups, however, all other industries are listed in the official agency's files.

For administrative reasons, we excluded such industrial groups as banking, insurance, and real estate; Government services; and some of the establishments in the services category—primarily nonprofit organizations. Except for establishments not meeting the employee-size stipulations, all others were eligible for selection as part of the sample to be surveyed. The plants were considered in the following five broad industrial groups:

| | |
|---------------------------------|--|
| Contract construction..... | S.I.C. nos. 15-17 |
| Manufacturing | S.I.C. nos. 19-39 |
| Wholesale and retail trade..... | S.I.C. nos. 50-59 |
| Selected services..... | S.I.C. nos. 70-80, 8, 84, 88 |
| All others | all other S.I.C. numbers except 60-67, 81, 86, 89. |

The first three of these categories are complete major groups in the Bureau of the Budget's Standard Industrial Classification Code; the fourth is a partial major group; the fifth is a residual group.

The establishments meeting the employee-size limitations were subdivided into the following five groups according to the number of employees per establishment: 4-7 employees, 8-19, 20-49, 50-99, and 100-249.

The number of establishments and the corresponding number of employees were then obtained for these 25 categories, that is, for each of five size groups within each of the five industrial groups.

In the five selected industries, there were 6,717 establishments within the stipulated employee sizes, and they employed 140,269 workers. Using the total number of workers in these five industrial groups, we calculated a ratio value for each of the 25 groups of employees. Each of these values was applied to the number of establishments in the sample. The resulting figures represent the number of plants in each subgroup that would need to be surveyed to provide appropriate employee representation. This technique, termed a proportionate probability sample of employees, has been described by Hansen and co-workers (2). The method allows data in a sample to be projected to the entire universe from which the sample is selected.

From the total number of establishments within each of the 25 groups, we then chose the particular establishments to be surveyed, using a random selection technique. This sample, 500 establishments, was next randomly divided into two equal parts within each size-industry category.

One of the sets of 250 establishments was further randomly divided into five comparable size-industry subgroups of 50 establishments each. Five industrial hygienists who were considered to have comparable experience were assigned these subgroups for survey and were not free to make any exchanges whatsoever. This procedure was followed so that an evaluation could be made of the comparability of the judgments of five experienced men who were using the same criteria to assess conditions. With this procedure we could estimate the amount of confidence which could be placed in the information to be collected by the surveys.

The remaining 250 establishments were further randomly subdivided into five industrial groups and again subdivided into five sub-

groups by employee size. In some instances, however, two or three surveyors might work on a given group of 50 establishments. If a local man, for example, drew a plant with which he was very familiar, he was instructed to exchange it for one not known to him. Also, if a man had only one establishment extremely far from the others allotted to him, he was free to make an exchange.

Since we expected some of the selected establishments to be out of business by the time the survey actually began, a group of plants was selected for substitution. As it was impossible to obtain an absolutely up-to-date list of establishments, our results represent a random sample of the establishments in operation on the date of the list we used in selecting the sample.

Published standards applying to this type of survey were limited; experience in conducting such a survey was also lacking. Therefore, we had to formulate written procedures and instructions that would assure as much uniformity of judgment as possible. The staff of the Public Health Service's Occupational Health Field Station at Salt Lake City prepared these criteria, using information available from official agencies or data the staff had developed on the basis of their own experience. After these instructions were discussed in several training sessions, a final set was prepared for each surveyor to use in the field.

In addition to evaluating hazards in the actual workplace, we considered it desirable to try to assess the provision of health-related services for employees by the industries of the type and size selected. A questionnaire was prepared to collect data for the various groups which had planned the survey. Questions framed to elicit the desired information were pretested, and necessary changes were made; finally, instructions for the survey were prepared. Before beginning the survey, we held a training session with the surveyors. Also, after the first days of surveying, we held another session to discuss any problems in connection with the questions or use of the questionnaire.

As expected, some of the 500 plants that were originally selected had gone out of business by the time the survey began; others were found to be only administrative offices of a business. For example, a construction company with a home

office in Denver, but with actual construction going on in another State, did not fit the criteria for the survey. No replacements within the specific industry-size category were available for 38 of such plants. This lack left 462 plants with approximately 20,000 employees for survey. Industrial hygienists from the several health departments and the Occupational Health Field Station interviewed some representatives from management in each of these plants. The hygienists observed conditions and evaluated employees' exposure to toxic chemicals or harmful physical conditions, the use or nonuse of control procedures, and the adequacy of controls.

Results from Questionnaires

In general, the interviews conducted by the staffs of the health department and the field station confirmed our previous impression that some employers were not aware of the occupational health hazards in their workplaces and had not taken suitable preventive measures to protect the workers' health. Many employers did not know of the resources and services of the various government occupational health agencies.

The surveyors reported that potential hazards were present in three-fourths of the plants visited. Two-thirds of the persons interviewed in these establishments "thought" that they had no hazards. Additionally, in some instances where the plant management was aware of the existence of certain hazards, others had been overlooked.

The answers to various survey questions indicated that some of the employers had never heard of, or even thought about, occupational health and occupation-related illness. In short, few of them were able to recognize a health hazard in the workplace or to foresee its possible consequences. Only one employer in four said that, in introducing a new process or material at work, he had consulted or would have consulted someone in advance about the possible health hazards.

In this group of small-sized and medium-sized plants, the use of professional medical and related help was relatively rare. For example, only 28 percent of the employers' representatives whom we interviewed reported that a physician "advises or assists . . . in any way." This

percentage, moreover, includes representatives of plants which had only an informal arrangement for emergency service.

A safety committee was reported in only 25 percent of the establishments with 50 or more employees. Representatives of small establishments were not asked this question.

Only one establishment in four offered employees any health education material. More than half of the management representatives said, however, that such material—or more of it—would be useful to them. Interest in receiving health material was greatest among those already distributing it.

Arrangements for early detection of disease and disability and for prompt treatment were generally inadequate. About half of the establishments reported that they kept records of all employee absences due to illness. About one employer in three was reported to have made arrangements for employees to obtain chest X-rays—a valuable screening device for tuberculosis, emphysema, and other cardiopulmonary conditions.

Although most establishments (82 percent) had some sort of first aid equipment or supplies, some had only “a bottle of aspirin and a package of band-aids.” Only one-third reported having an employee with first aid training. Thus, even though first aid supplies were usually on hand, an untrained person often administered them. In more than half of the plants the first aid equipment was rated as “poor.”

Results of Plant Inspections

Inspections of the plants revealed that exposures to hazardous agents and materials were common, averaging about 30 exposures per establishment. Industrial hygiene controls of these exposures were absent or inadequate in more than one-third of these situations. Almost 25 percent of the plants had hazards which the industrial hygienist adjudged serious enough to warrant immediate attention.

The estimated population at risk was sizable. About 30 percent of the study population, or almost 43,000 workers, were employed in establishments which were rated “high priority,” that is, the surveyors judged the composite picture of hazards in these establishments to be serious enough to require a visit within 1 year.

We estimated that more than 1,400 plants of the size range studied would require occupational health services within the year following our inspection. About three-fourths of the employees in these high-priority establishments worked in manufacturing or trade.

Multiple, mixed, and unidentified chemical exposures were frequent. All the establishments which were rated as high priority had chemical hazards; in three-fourths of these, a physical hazard was also present. In nine of 10 high-priority establishments, the employees were exposed to hazardous gases, vapors, fumes, and mists. Noxious and pneumoconiosis-producing dusts were present in 42 percent of the high-priority establishments, and significant skin irritants were found in 66 percent. Employees in more than half of the high-priority manufacturing plants were exposed to chemicals which could not be identified by labels on containers or dispensers. In more than two-thirds of the high-priority establishments, employees were potentially exposed to six or more different chemical agents.

One index by which to judge industrial hygiene conditions in plants is the number of inadequately controlled chemical exposures per 100 employees. We have termed this relationship an “inadequacy ratio.” For the high-priority establishments surveyed, this ratio was 55 per 100; for all other establishments, it was 14 per 100.

An interesting observation was the frequency with which certain health hazards occurred. Carbon monoxide was detected in 37 percent of the plants, oxides of nitrogen in 21 percent, ozone in 16 percent, Stoddard solvent vapors in 16 percent, unidentified solvent vapors in 8 percent, lead fumes in 5 percent, silicosis-producing dust in 4 percent, and vapors from epoxy resins in 3 percent.

Intercomparison of Surveyors

The design of the survey provided for five subgroups of 50 plants, selected so as to be similar in the industries represented and in size. One of these groups was assigned to each of five experienced industrial hygienists for survey. The frequency with which each surveyor assigned high-priority ratings to the plants in his group was examined to estimate the consistency of

judgment between surveyors. The plant ratings assigned by the several surveyors are compared in the following table.

| <i>Surveyor</i> | <i>Percent given high-priority rating</i> | |
|---------------------------------|---|-------------------|
| | <i>Manufacturing plants</i> | <i>All plants</i> |
| 1----- | ¹ 90 | 35 |
| 2----- | 50 | 22 |
| 3----- | 78 | 35 |
| 4----- | ² 22 | ² 4 |
| 5----- | 63 | 30 |
| Average of other surveyors----- | 49 | 23 |
| Average of all surveyors-- | 54 | 25 |

¹ $P < 0.01$.

² $P < 0.05$.

Only one of the surveyors appeared to deviate markedly from the general pattern in rating the plants. There are several possible explanations. Despite the effort to make each subgroup comparable in composition, there may have been actual differences among them. It is more likely, however, that the criteria for the ratings were not sufficiently specific or inclusive and that the period of training of the surveyors in their use was not sufficient.

Recommendations

After assessing the information obtained from our survey of manufacturing plants, wholesale and retail trade establishments, and construction firms, we used it in formulating an industrial hygiene surveillance program, including staffing requirements. Service and transportation establishments were included in our survey, but the results revealed that exposure to industrial hazards of employees in these groups was infrequent and unpredictable. Therefore, routine evaluations of such establishments—with the possible exception of selected service groups such as automobile repair shops, garages, and drycleaners—did not appear to be warranted.

Inspection of the forms completed in the survey showed that the plants could be categorized as high, intermediate, and low in occupational health hazards. According to our definitions, firms with a high-risk rating exhibited one or more industrial hygiene hazards requiring immediate attention, an annual survey, or both.

Plants labeled “intermediate” exhibited potential health hazards, but at the time of the investigation these hazards appeared to be under control. We decided that such establishments should be visited biennially. Low-risk plants had possible hazards of a lower order which might require an occasional reappraisal.

We estimated the man-hours which would be required to conduct an evaluation of the occupational health hazards in the various industrial and size categories. Using these estimates and the numbers of plants in each risk group, we calculated that about 2,500 plant surveys, requiring about 4,500 man-hours, should be made each year. With a maximum of 220 working days available in a year, six industrial hygienists allotting about 50 percent of their time to fieldwork would be required. (The details of this and similar calculations can be obtained from the Occupational Health Field Station, Box 8137, Salt Lake City, Utah 84108.) The supporting staff should include two chemists, a stenographer, and a clerk-typist.

Our calculations do not provide an estimate of the staff needed for a total program; they only indicate staff requirements for monitoring workers in the universe from which the sample was drawn. Followup studies and consultations, occupational disease investigations, emergency visits in response to requests, and other occupational health services would increase staff requirements. Our results do not provide data from which to estimate these needs.

Conclusions

The results of our survey point up the large amount of work that needs to be done to correct the numerous hazardous and unsatisfactory conditions found in many plants in the Metropolitan Denver area. They indicate where these conditions are and how an organized surveillance program can be planned.

The programs of the government occupational health units must be expanded and strengthened if the benefits of known procedures for controlling exposures to toxic materials are to be made generally available to workers in the Metropolitan Denver area. An estimated 2,500 plant visits per year would be necessary to provide minimum occupational health services to the estimated 6,700 plants of

the types and sizes which were represented in our survey. The immediate aim would be to serve the estimated 40,000 workers in high-priority plants and to deal with the estimated 80,000 inadequately controlled exposures in Metropolitan Denver.

Summary

Limitations on staff and budget have forced the State and local occupational health units operating in the Metropolitan Denver area to restrict their activities to investigating a potpourri of high-risk situations and to responding to specific requests for assistance in studying occupational health problems. To define the occupational health problems in the area and provide a basis for determining the priorities to be followed in solving them, a survey of selected plants was undertaken. Five hundred plants were chosen from selected industrial categories and employee-size groups. Proportionate probability sampling was used so that the results of the survey could be projected to all the plants in the categories and sizes from which the sample was drawn.

Carefully defined criteria were prepared to guide the surveyors in evaluating environmental conditions. The results of a test of the com-

parability of the ratings assigned to plants by the surveyors showed good agreement.

Exposures to hazardous agents or materials averaged about 30 per plant; industrial hygiene controls were absent or inadequate for about one-third of these exposures. The survey showed that about 30 percent of the study population (some 43,000 workers) were employed in plants which the surveyors judged to be in the high-risk category. About three-fourths of the employees in the high-priority establishments worked in manufacturing or trade.

The staffs of the governmental occupational health units in the Metropolitan Denver area should make about 2,500 plant visits a year to give minimum occupational health services to the 6,700 plants represented in the study.

REFERENCES

- (1) Standard Industrial Classification Manual. Technical Committee on Industrial Classification, Office of Statistical Standards, in cooperation with the Executive Office of the President and the Bureau of the Budget. U.S. Government Printing Office, Washington, D.C., 1957.
- (2) Hansen, M. H., Hurwitz, W. N., and Madow, W. G.: Sample survey methods and theory. Vol. 1, Methods and application. John Wiley & Sons, Inc., New York, 1953.

Smallpox Vaccination Requirements Modified

Smallpox vaccination procedures for travelers entering the United States have been modified by the Public Health Service.

The Foreign Quarantine Program of the National Communicable Disease Center in Atlanta, Ga., will continue—with certain countries exempted—to require a valid vaccination certificate (showing vaccination within 3 years) of all persons arriving in the country, but will rely more upon public cooperation in the future. Previously, all persons entering the United States without valid vaccination certificates were subject to smallpox vaccination at the port of entry.

The new procedure will be to vaccinate only those travelers without valid certificates who have, within the past 14 days, visited a country where smallpox is present or who have been exposed to a smallpox patient somewhere en route. Persons without these certificates, but considered at low risk of having been exposed, will be referred to their physicians or health departments for vaccination.

The worldwide smallpox situation is extremely variable because of the volume and speed of international travel. Persons involved in international travel should maintain their state of immunity and keep certificates valid by being revaccinated every 3 years.