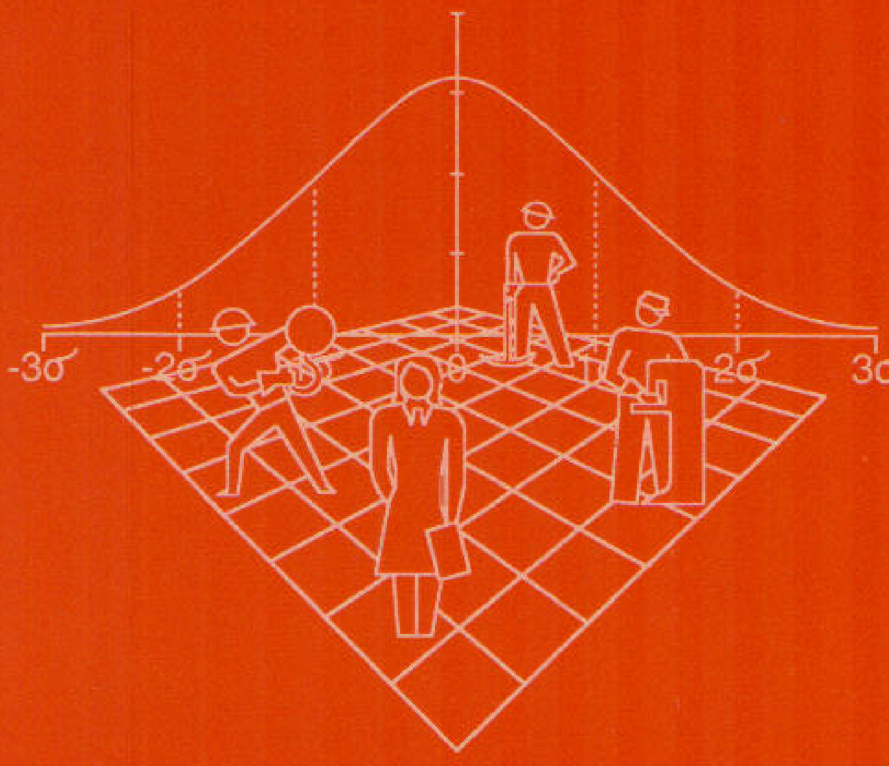
NIOSH

A Guide for the Management, Analysis, & Interpretation of

OCCUPATIONAL MORTALITY DATA



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

CDC
CENTERS FOR DISEASE CONTROL

A GUIDE FOR THE MANAGEMENT, ANALYSIS, AND INTERPRETATION OF OCCUPATIONAL MORTALITY DATA

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ABSTRACT

This report provides guidelines for state health departments interested in occupational mortality surveillance. Since 1980, the National Institute for Occupational Safety and Health (NIOSH) has promoted cooperative occupational health surveillance activities with state health departments. This report draws from our experience with the states to date, providing guidelines on data collection, data processing, analyses, and follow-up. Methods for improving data quality are described, coding procedures are discussed, and statistical measures are compared and contrasted. The report includes a lengthy reference list and a list of contact persons at NIOSH and in the state health departments. This report represents a continuing NIOSH commitment to state health departments in their efforts to promote occupational safety and health programs.

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INTRODUCTION

The incidence and prevalence of occupational disease, disability, and mortality are largely unknown. Weaknesses in systems used to measure the prevalence of occupational disease caused the National Institute for Occupational Safety and Health (NIOSH) to evaluate alternative approaches for the surveillance of occupational morbidity and mortality. Since 1980, NIOSH has promoted cooperative occupational health surveillance activities with state health departments (hereafter referred to as the "states") as one alternative to the prevailing national systems sponsored by the Department of Labor.

The following document provides a descriptive summary of various aspects of data collection, processing, analysis, and follow-up. The information is drawn from our experience with the states to date and highlights activities directed to the surveillance of occupational mortality. In principle, the framework used for mortality surveillance may apply as well to morbidity surveillance.

The document provides ample reference to professional and technical literature. Though not an annotated bibliography, we attempt to provide the reader with the literature citations necessary to understand the epidemiologic and statistical underpinnings of a surveillance activity.

The document also identifies state and federal resource people (see Reference section and Appendix A). Your efforts to develop and implement a successful surveillance program will require technical assistance from outside sources. The individuals and agencies noted herein should be consulted as you progress through the various stages of program development.

Finally, the document provides evidence of a continuing NIOSH commitment to state health departments in their efforts to promote occupational safety and health programs. We view this document as the first of many installments, to be followed by discussions of other NIOSH surveillance activities.

DATA COLLECTION

Most state occupational mortality surveillance activities revolve around the use of the death certificate. Information gathered from the death certificate can be easily adapted for surveillance purposes. Information about the decedent's race, sex, age, and the cause of death are routinely coded and computerized by state health department staff. Many states also code and computerize employment information from the death certificate. Most state health departments are experienced in collecting and processing the medical and basic demographic data, which follow the guidelines of the Vital Statistics Cooperative Program of the National Center for Health Statistics (NCHS). Therefore this section and the section on data processing will focus on the employment data.

The United States' recommended standard death certificate provides for information on the decedent's usual occupation ("kind of work done during most of working life, even if retired") and usual industry ("kind of business or industry"). These statements are used as a surrogate for detailed occupational history. Studies comparing "usual" industry and occupation as reported on death certificates with information on long-term workers from personnel or union records (1), or with information on the longest-held job from interview or survey data (2,3) found agreement between occupation codes from death certificates compared with the alternate source from 65% to 68% of the time. Industry codes from the two sources matched from 67% to 70% of the time. Agreement was better for men than for women. While these agreement rates are lower than might be desired for hypothesis testing, they are generally adequate for surveillance purposes.

Since 1975, improvements have been made in the quality of industry and occupation (I/O) data collected on death certificates. A study of a national sample of death certificates in 1975 showed that 9% of the occupation entries and 19% of the industry entries did not contain enough information to assign a three-digit Census code (4). Improved data collection methods have resulted in an average of 2.8% incomplete occupation entries and 2.4% incomplete industry entries among death certificates from 16 states in 1984 (Table 1).

Data collection procedures are important because they can improve the quality and completeness of the I/O data collected from death certificates. Three procedures that have been implemented in some states are: training of funeral directors to collect complete and accurate I/O information; instituting query procedures for incomplete responses for I/O; and adding company name as a separate item on the death certificate.

Information on the decedent's usual occupation and industry is obtained by the funeral director. It is important that the information is as detailed and accurate as possible. Funeral directors can be trained to collect better I/O information through the use of specially-designed courses given by state health department personnel on a periodic basis. In North Carolina, for example, a course was administered to all funeral directors in the state by state health department field personnel (5). Instructions for collecting complete I/O information were also added to the basic training program for new funeral directors in North Carolina. An educational publication, Guidelines for Reporting Occupation and Industry on Death Certificates (6), was partially funded by NIOSH and is available through NCHS. In addition, NCHS publishes a funeral director's handbook which provides additional guidelines (7).

Most state vital statistics offices have query procedures whereby funeral directors are notified if certain information on the death certificate is incomplete (e.g., name, sex, etc.). Some vital statistics offices have added industry and occupation to the list of items for which a query is issued if the response is incomplete. Responses that might be considered incomplete include "unknown," "retired," "disabled," and others. Some examples of query forms are given in Appendix B.

DATA PROCESSING

NIOSH recommends the use of the 1980 Census classification system for coding I/O entries from death certificates (8). Compared with other classification systems, the 1980 Census system is better for classifying the level of detail for industry and occupation that is typically provided by next of kin. Standardized training and quality control are available for coders using the Census system. Death certificate data coded according to the Census classification system will be compatible with similarly coded data from other states, as well as with data from the 1980 Census and national surveys. As these national data systems convert to the 1990 Census classification system, states will probably be advised to do the same.

Some states currently using the 1980 Census system have found that death certificates from previous years were coded using a different system, such as the 1970 Census system (9), the 1972 Standard Industrial Classification System (SIC) (10), or the Dictionary of Occupational Titles (11). Because these systems have limited compatibility with the 1980 Census system, it is difficult to combine data coded under the different systems. One approach is to group the data according to the coding system used, and perform separate analyses. Results from the separate analyses can usually be compared across broad I/O categories, and in some cases the detailed I/O categories are comparable from one system to another.

The 1980 Census classification system contains 503 unique occupation codes and 231 unique industry codes. An instruction manual is available for coder training (12), emphasizing the adaptation of the Census system for death certificates. Basic and advanced training courses are offered by NIOSH and NCHS for state coders (13). As of May 1989, coders from 43 state and territorial health departments have been trained in I/O coding (figure 1).

Quality control assistance for I/O coding is provided by NIOSH and NCHS to several states (14). Some states perform their own quality control. Typically, quality control for I/O coding consists of having a second coder perform a blind recode of a sample of death certificates. Then the two sets of codes are compared for differences. NIOSH has developed a computer program which compares the codes and prints any differences (15). This program could also be used by states desiring to do their own quality control. A third, more experienced, coder adjudicates the differences to determine which coder made the error. Error rates and lists of common errors are given to the coders to provide ongoing feedback.

Most experienced coders can be expected to have an error rate of 5% or less. Some examples of common errors are shown in Appendix C. Any errors detected during quality control should be corrected on the state's computerized death certificate file. If the error rate for a particular batch exceeds 7%, the entire batch should be recoded and corrected on the computer file. If the error rate is between 5% and 7%, the errors should be reviewed with the coder(s) so that corrective action can be taken with future batches.

Most data items used in occupational mortality surveillance undergo standard editing procedures under the NCHS Vital Statistics Cooperative Program (16). In addition, NIOSH has developed an I/O edit program which will check for invalid I/O codes and inconsistent combinations of I/O codes (17). This program is based on information provided by the Census Bureau on inconsistent code combinations (Appendix D). All errors detected during editing should be resolved by referring back to the death certificate. Additional queries may be necessary to obtain complete information. Certificates with incomplete information on age, race, sex, or cause of death must be excluded from analyses. Certificates with incomplete information on occupation or industry may or may not be excluded from analyses, depending on the type of analysis.

Certain I/O codes can be imputed when one code is known (usually occupation) and the other code (usually industry) is either missing or "retired". The Census Bureau provides a list of codes that fall into this category (Appendix E). Since the Census imputation list was developed for use with the 1980 U.S. Census, the suggested imputations may not always be appropriate for I/O data gathered from state death certificates. We have developed a method at NIOSH for adapting the Census list for use with death certificate data. This method is described in Appendix E, along with some examples.

ANALYSIS

Methods for Screening the data

In most occupational mortality surveillance systems, it is desirable to screen the data periodically to identify trends or to generate new hypotheses about associations between occupation and disease. Various methods have been used by NIOSH and state health departments to screen the data. Several surveillance reports have been published by the states (18-28). Each state must make decisions about the study population, the exposure and disease categories, types of adjustment, and the statistics used. These topics will be discussed below in more detail.

Study Population

Most states must combine data from several years to increase the size of the study population to permit meaningful analysis. The number of years combined varies from state to state. For example, Washington combined data for the years 1950-1979 to obtain a total of 429,926 white male deaths (26). Pennsylvania, on the other hand, combined only three years of data to obtain over 150,000 deaths for white males (22).

Some states include only resident deaths occurring in-state. Other states include non-resident deaths and/or deaths occurring out-of-state. NIOSH often combines resident, in-state deaths from several states into geographic regions for analysis purposes. States might also consider combining data with neighboring states in order to increase the size of the study population.

Analyses are usually restricted to persons over age 15 or 20, and a few states further restrict their data with an upper age limit of 65 or 75. Restrictions on age have the effect of eliminating retired persons from the analysis. Such restrictions also may effectively eliminate certain chronic diseases from the analysis. There are several reasons for setting an upper age limit: (1) the quality of the I/O data on death certificates for retired persons is thought by some researchers to be poor (29); (2) there may be a desire to focus on premature death; or (3) the statistic used in the analysis (e.g. standardized mortality ratio) may require employment data to estimate the denominator, or population at risk, and employment data are limited for persons over age 65. NIOSH performs separate analyses for persons in different age groups (e.g. 18-64, 65+), so that results for the different age groups can be compared.

Separate analyses are usually performed according to race and sex. If the non-white population is too small to perform a separate analysis, some states drop minorities from the analysis, while some combine minorities with the white population. For example, Washington state, with only 3% non-white deaths, excludes non-whites from their analyses (26). In upstate New York (excluding New York City), where 7% of the deaths occur among non-whites, data are combined for whites and non-whites (21).

Disease and Exposure Categories

Most states combine the specific, cause-of-death codes into broader categories for analysis purposes. The frequencies of the specific causes of death, the size of the dataset, and the change in disease rates over time are the primary factors to be considered in selecting cause-of-death categories. Usually, several broad categories, such as "all cancers" or "all heart disease," are analyzed, as well as those detailed categories having an adequate sample size (see **Statistical Inference**, below). Diseases with similar etiologies can be combined to provide the frequencies needed. Diseases whose patterns have changed differentially over time should probably not be combined. Appendix F lists the detailed cause-of-death categories used by NIOSH for the analysis of large data sets. Appendix G shows a shorter list used with smaller data sets.

Separate analyses are usually performed for occupation and for industry. The 1980 Bureau of the Census coding system is set up so that similar occupations and similar industries are grouped together. Broad occupation or industry groups can be formed by collapsing the appropriate contiguous detailed categories. Other methods for grouping occupation and industry include defining different categories for males and females (because of different employment patterns), and combining industry with occupation. Appendix H shows detailed groupings of occupations and industries used by NIOSH for large datasets. Appendix I shows broader groupings used with smaller datasets.

Additional effort is required to define categories of occupations or industries which are homogeneous with respect to exposure. One approach is to use information from a job exposure matrix (JEM) to define I/O categories (30). The typical JEM is a computerized database containing information on workplace hazards (e.g., chemical exposures) and the occupations and industries where exposure to those hazards may occur. Attempts to use JEMs to define I/O categories have met with varying levels of success (30-34), and more work needs to be done in this area. NIOSH has developed a JEM using data from the National Occupational Hazard Survey (35). The NIOSH JEM can be made available to the states by contacting the appropriate NIOSH staff member listed in the reference section (35).

Adjustment factors

Statistical adjustment is an analytic method used to take into account differences between the occupation group under study and the comparison group with respect to certain factors that may be related to disease. Age is the most commonly used factor for adjustment, but some states also adjust for other factors like race or year of death. The way in which the adjustment is calculated depends on the statistic used to estimate risk (see **Estimates of Risk**, below). Adjustment can be made indirectly for factors not reported on the death certificate, such as tobacco use, by using an external source of information on the distribution of the factor according to occupation and/or industry (27, 36-38).

Another way to account for differences between occupation and comparison groups with respect to important risk factors is to perform separate analyses for different risk categories. For example, separate analyses might be performed for the subset of all white collar or all blue collar workers, as a way of comparing each occupation or industry to other workers in similar social classes.

Estimates of Risk

The typical screening analysis produces an estimate of risk for each I/O category with respect to each cause of death category. The three most commonly used estimates of risk for occupational mortality surveillance are the Standardized Mortality Ratio (SMR), the Proportionate Mortality Ratio (PMR), and the Standardized Mortality Odds Ratio (SMOR) (figure 2). A PMR or SMR greater than 100, or an SMOR greater than 1.0, indicates an excess risk, while a PMR/SMR less than 100, or an SMOR less than 1.0, indicates a decreased risk of disease for the occupation under study. A number of papers compare the different methods (39-44). This document will provide a brief description of each method, highlighting the advantages and disadvantages with respect to the other methods.

Standardized Mortality Ratio (SMR)

The SMR is the ratio of the number of observed deaths for a particular cause in an occupation or industry group to the expected number of deaths based on the mortality rate for that cause in a standard population (40). For purposes of occupational mortality surveillance, the entire population usually serves as the standard population, and the indirect method of standardization is used (40). To compute SMRs the population at risk must be known, that is the number of individuals in the population in each occupation and industry group by age, sex, race and any other variable for which it is necessary to adjust. For death certificate studies in the United States, this information is usually obtained from the decennial Censuses, which provide information on current industry and occupation for a 20% sample of the population.

While the SMR is statistically a better estimator of the relative risk than the other methods (39), the application of the methodology has met with limited success in the United States. This is explained partly by the difficulty in obtaining detailed and accurate data on the population at risk. Census data provide a measure of the current occupation and industry of the population surveyed, while death certificates request the usual occupation and industry for decedents. This can result in misclassification of the population at risk (40, 45). Furthermore, Census data are obtained every 10 years, which leads to the problem of obtaining estimates for inter-censal years.

Inadequate denominator data can lead to several problems. The misclassification in the denominator resulting from the lack of data on the usual occupation and industry of the population at risk causes systematic errors. The underestimation of the number in an occupation group results in inflated SMRs, while overestimation causes deflated SMRs. Since the number of persons employed falls rapidly after age 64, data on occupation and industry for persons over age 64 are unavailable through the Census. Deaths occurring in persons over 64 cannot be analyzed using the Census data, which means the loss of over half the deaths.

Surveillance studies using SMRs have been done in California (18), Rhode Island (23), Great Britain (40), and the United States (46). North Carolina recently published results of a study in which a variation of the SMR, with direct adjustment, was used (28).

Proportionate Mortality Ratio (PMR)

The PMR compares the observed number of deaths for a particular cause in an occupation or industry group with the expected number of deaths from that cause, based on the proportion of all deaths due to that cause in a standard population (40). The standard population usually used in occupational mortality surveillance studies is the total population of decedents in the study. The PMR uses the indirect method of standardization (40).

The PMR analysis is the easiest of the three, which is its main advantage. Data on the population at risk are not required. The computer programming is relatively simple for two reasons. First, each specific occupation or industry is usually compared to the total population rather than to "all other occupations" or to some group of "non-exposed" occupations. Second, the standard population usually includes all causes of death rather than a set of auxiliary causes specific to each cause being analyzed.

The PMR method requires the assumption that the all-cause, or total, mortality rate is the same for both the exposure group (i.e., occupation) under study and the comparison group (i.e., the all-cause SMR=100) (39). If the all-cause SMR for an industry or occupation is greater than 100, the PMRs tend to underestimate the true risk. That is, they may not detect all real associations. If the all-cause SMR is less than 100, the PMRs tend to overestimate the true risk and may produce "false positives."

Another problem is that the PMR for each particular cause of death is dependent on the PMRs for the other causes in a particular occupation or industry. This can be especially important if the occupation under study has relatively high or relatively low mortality due to some common cause. If the PMR for the common cause of death is high, the PMRs for other causes are artificially deflated. Conversely, if the PMR for the common cause is low, the PMRs for other causes are artificially inflated.

One way to avoid the problem of PMRs being influenced by PMRs for common causes is to exclude the common causes from the analysis (40, 47). For example, McDowall (47) found that male administrators and managers had a PMR for cancer of the pancreas of 129, and a PMR for ischemic heart disease, a common cause of death, of 120. When the deaths were reanalyzed excluding the ischemic heart disease deaths, the PMR for cancer of the pancreas increased to 145. The high PMR for ischemic heart disease was effectively reducing the PMR for cancer of the pancreas.

Most of the published state-based surveillance studies have used PMRs (20-26). NIOSH has developed a PMR computer program designed for surveillance studies (48).

Standardized Mortality Odds Ratio (SMOR)

The SMOR has been suggested as an alternative to the PMR when denominator data are not available (41). The SMOR is the ratio of the mortality odds between the occupation of interest and a non-exposed comparison group. The mortality odds for the cause of interest is computed relative to a comparison group of auxiliary causes. The SMOR is adjusted by using the indirect method of standardization. The SMOR differs from the Mantel-Haenszel Odds Ratio (MHOR) in the method of weighting (49). Unlike the MHOR, the SMOR does not require the assumption of homogeneous odds ratios across the strata (49). The SMOR, however, requires larger frequencies in each stratum (i.e., few counts under 5) compared to the MHOR (49).

Compared to the PMR, the SMOR requires the more easily satisfied assumption that the mortality rate for the auxiliary causes of death is the same for the occupation under study as for the comparison group (41). This can usually be achieved by selecting auxiliary causes that are not related, either directly or indirectly, to an occupational exposure. For example, in a study of cancer risks in the optical manufacturing industry by Wang, et al., cardiovascular disease was chosen as the auxiliary cause, because it was not thought to be related to the types of exposures present in the optical manufacturing industry or in the comparison industries (50).

Because the auxiliary causes may change for each comparison, the computer programming necessary for a large series of comparisons can be very complex. The SMOR is a useful method of analysis when examining a small number of occupations and causes of death. Death certificate surveillance studies using SMORs have been described by Dubrow and Wegman (27) and by Wang, et. al. (50).

Statistical Inference

Various methods can be used to determine whether the risk ratio is statistically significantly greater than or less than unity. For PMRs and SMRs, most states use the Mantel-Haenszel adjusted chi-square (51) (or an exact test based on the Poisson distribution (52)) for comparing an observed number to its expected value. For the SMOR, inference is usually based on the Mantel-Haenszel Odds Ratio (MHOR) (51), including various methods which have been derived for estimating the variance and confidence intervals of the MHOR (53-57).

To assure the validity of the chi-square and other statistics, most states require some minimum number of observed or expected deaths for each combination of occupation or industry and cause of death. The usual method is to require a minimum of five expected deaths (58). Mantel and Fleiss have developed a statistical method for determining the minimum expected cell size for the Mantel-Haenszel chi-square (59). Otherwise, the choice of an appropriate minimum appears to be somewhat arbitrary.

In most surveillance studies, an alpha of .05 is used to construct a two-sided test for significance. Even though many estimates are being tested simultaneously, few states use statistical methods to compensate for multiple comparisons. Most states use the alpha level as a tool for narrowing the focus to a small number of PMRs, SMRs, or SMORs that should be followed-up with more rigorous epidemiologic and statistical evaluation.

Interpreting Results

Given the many PMRs, SMRs, or SMORs that are produced in a surveillance study, additional tools are needed to aid in interpretation. The analyst would like to focus on those associations that are most likely to be cause-effect relationships and to disregard those that are probably spurious associations.

One useful approach, outlined by Hill (60), suggests a number of areas that should be considered:

(1) the strength of the association - a risk ratio of 10 to 1 is more difficult to attribute to some confounder than a ratio of 2 to 1;

(2) consistency - do the results agree with other studies;

(3) specificity - is the result limited to a specific disease in specific workers, with no associations with other diseases;

(4) the relationship in time - for example, is the disease a result of something in the work environment, or are persons who are prone to the disease more likely to engage in that type of work;

(5) presence of a biological gradient, or dose-response curve;

(6) biological plausibility;

(7) coherence - does the result conflict with known facts of the natural history and biology of the disease;

(8) experimental evidence - do preventive measures affect the association over time; and

(9) analogy - have the results been found in other occupations with similar exposures.

NIOSH has used these principles to evaluate and interpret results from PMR studies of data from several states (61, 62).

NIOSH has developed or is developing various tools that can aid in interpreting results. These can be made available to the states by contacting the appropriate NIOSH staff member listed in the reference section. The NIOSH Job Exposure Matrix can be used to link occupational codes with hazardous agents to which persons in those occupations are likely to be exposed (35). In addition, NIOSH maintains a comprehensive bibliographic database called NIOSHTIC, which emphasizes the occupational safety and health literature (63). A third database maintained by NIOSH, called RTECS (Registry of Toxic Effects of Chemical Substances), provides basic information on the known toxic and biological effects of chemical substances (64, 65). A computer-based retrieval system for results from occupational mortality surveillance studies is in the early stages of development (66). When completed, this system will facilitate access to and comparison of the results of the various studies.

Follow-up Studies

Follow-up studies are usually done to investigate further a finding or hypothesis generated by the initial PMR/SMR/SMOR analysis. The purpose of the follow-up study is to try to validate the original finding using the same data in a refined analysis or by analyzing new data or both. The follow-up study is usually designed after the initial hypothesis has been evaluated together with the results of other surveillance studies or other research findings, if available.

There are several kinds of follow-up studies. Some of these are described below, including refined PMR analyses, case-control studies, and geographic or trend analyses. Validation procedures for industry and occupation codes are also discussed.

Validation Procedures

To increase the precision of follow-up studies using death certificates, it may be useful to perform further editing of the data, particularly the industry and occupation codes. Systematic coding errors can sometimes lead to spurious associations. Several steps can be taken to test the accuracy of the I/O coding. Listing occupations within industries may make evident systematic coding errors. If an occupation has been frequently coded within an industry where it would not be expected (for example, underwriters coded to some industry other than insurance), either the industry or the occupation may be coded incorrectly. This is likely to happen with a large company that could have more than one industry code.

If it is possible to retrieve the death certificates, a sample of the certificates of interest could be recoded and the accuracy of the coding evaluated. If the quality is poor, all certificates of interest could be recoded. Also, if there is a high percentage of "not elsewhere classified" types of occupation or industry codes, it might be desirable to have these recoded. Special codes could be added, if necessary, to classify the occupations and industries more specifically than possible within the Census coding system. For instance, Rhode Island added more specific codes for the jewelry industry and its occupations (23).

Refined PMR Analyses

More refined PMR analyses using death certificates can be done for groups of particular interest, if sample size permits. This could be a first follow-up to hypotheses generated by the initial analysis. Preferably the data would be further edited as described above. More detailed information on the industry, occupation, cause of death, or other factors might be retrieved from the death certificates to further refine the analysis.

There are several ways in which the initial analysis could be revised to learn more about the potential association. Examples of refinements over the initial analysis include blue collar- or white collar-specific analyses or occupation within industry analyses. If the occupation or industry group of interest has a cause of death with a particularly high or low rate, which could affect the PMRs of other causes of death, the PMR analysis could be repeated with this cause of death removed. An example of this would be pneumoconiosis in coal miners. Studies by Dubrow and others, showing some of these methods, are listed in the reference section (67-71).

Case-Control Studies

Death certificate-based case-control studies are an intermediate step between the general mortality surveillance and field investigations to evaluate the relative risks. Death certificate statements, regarding occupation and industry of decedents who died from a specific cause of interest, can be compared to those of a control group who died of other selected causes or all other causes. Variables in the case-control study that might be used for matching or adjustment are sex, race, age, or county of residence. Initial hypotheses substantiated by such analyses would be prime candidates for further study. See the reference section for studies of this type (72-75).

Geographic or Trend Analyses

Other follow-up studies may include geographic or trend analyses. Trends in causes of death may vary by geographic locale or over time. If the data range over several years or contain rates or ratios at the county level, a trend analysis may be done as a follow-up study. The purpose of trend analysis is to assess variation in rates over time or place. Mortality rates or other statistics may be compared across counties and over time. Not all causes will lend themselves to this type of analysis, because the smaller geographic areas and shorter time frames lead to small numbers of deaths. Trend analyses may be especially useful for describing a new hypothesis or excess cause of death. This additional information can help in the design of a more detailed study. Some examples of geographic and trend analyses are listed in the reference section (25, 76-78).

Applying the SHE(O) method to death certificates

Occupational mortality data can be used to monitor occupational sentinel health events, or SHE(O)s. Rutstein et. al. published a list of SHE(O) disease rubrics, or categories, in 1983 (79). They defined a SHE(O) as "a disease, disability, or untimely death which is occupationally related and whose occurrence may: (1) provide the impetus for epidemiologic or industrial hygiene studies; or (2) serve as a warning signal that materials substitution, engineering control, personal protection, or medical care may be required".

Several states are using the SHE(O) list to aid reporting and follow-up of occupationally-related disease (80). The SHE(O) list can also be used as a framework for monitoring deaths that may be occupationally related (19, 81-82). There are two types of SHE(O)s in the list: (1) inherently occupational SHE(O)s, such as coalworkers' pneumoconiosis, which are known to be occupationally related; and (2) non-inherently occupational SHE(O)s, such as lung cancer, which may not always be caused by occupational exposures. The first type can be identified by the ICD code for the cause of death, while the second type is identified by the ICD code and the associated industry or occupation.

NIOSH has developed a computer program which can be used to identify death certificates matching the criteria on the SHE(O) list (83). Certificates flagged by the program can then be reviewed to see if some type of follow-up is warranted. Other uses of the SHE(O) list include: (1) a way to focus the review of results from the screening analysis; and (2) monitoring trends in occupational mortality over time and space.

SUMMARY

This report has presented an overview of a variety of methods, particularly in the area of data analysis. The reader should consult the references given for more detailed discussions of these methods. In most cases, there is no right or wrong technique. The availability of resources, professional expertise, and state commitment to occupational mortality surveillance will vary from state to state and will dictate, to some extent, the methods used. For states planning to begin a program of occupational mortality surveillance, consultation with NIOSH and state contact persons can be helpful in narrowing the focus and providing some direction to program development.