

An Application of the Sentinel Health Event (Occupational) Concept to Death Certificates

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Abstract: This article describes a computer-based application of the Sentinel Health Event (Occupational) [SHE(O)] concept, developed in conjunction with five states, to monitor deaths which are occupationally related. The states have coded their state death certificate files for industry and occupation, using the decedent's usual occupation and industry as reported on the death certificate. From these files, the SHE(O) computer program selects deaths which are likely to be work-related, based on a previously published SHE(O) list of 50 disease rubrics and associated industries and occupations. The computer program matches the SHE(O) list with the recorded industry, occupation, and underlying cause of death.

The program has been tested using 1984 death certificate data from Maine, upstate New York (excluding New York City), North Carolina, Pennsylvania, and Rhode Island. Approximately 1 to 2 per cent of all deaths were selected by the program, with lung cancer and coal workers' pneumoconiosis being the most frequent cause of death. The SHE(O) program may be useful for identifying deaths which are potentially occupationally related, but its utility and its application to death certificates needs further evaluation before recommending widespread use. Limitations are discussed, as well as plans for improving the application of the SHE(O) concept to death certificates. (*Am J Public Health* 1987; 77:1310-1314.)

Introduction

One of the mandates of the National Institute for Occupational Safety and Health (NIOSH) is the surveillance of occupational disease, disability, and mortality. In 1980, we started a program entitled Surveillance Cooperative Agreements between NIOSH and States (SCANS) in an effort to decentralize and broaden the NIOSH surveillance program. Six states have participated in the SCANS program: Maine, upstate New York (excluding New York City), North Carolina, Pennsylvania, Rhode Island, and Utah. One activity undertaken with the states is the evaluation of the utility of the Sentinel Health Event¹ concept for surveillance of occupationally related disease, disability, and mortality. The purpose of this article is to describe a computer-based application of the Sentinel Health Event concept, developed for the SCANS program.

The Sentinel Health Event concept, first described by Rutstein, *et al.* in 1976,¹ was applied to occupational diseases with the publication of a list of Sentinel Health Events (Occupational) [SHE(O)] in 1983.² Rutstein and his colleagues at NIOSH 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." The SHE(O) list is intended to be used as a tool to aid in screening data for potential SHE(O)s. Individual cases should then be examined more closely to verify that the event is occupationally related.

One use of the SHE(O) list is to aid reporting and follow-up of occupationally related disease, and several states have expressed an interest in using occupational sentinel health events as the basis for occupational disease reporting with subsequent investigatory follow-up. The follow-up might take the form of education or prevention efforts, or epidemiologic or industrial hygiene studies. Re-

searchers in Rhode Island are conducting a study to determine the feasibility of hospital-based SHE(O) reporting, using hospital discharge records.

Another application of the SHE(O) concept under evaluation with the states is the use of the SHE(O) list to monitor deaths that may be occupationally related. The first step in the monitoring process is to identify death certificates matching the criteria on the SHE(O) list. We have developed a computer program for this purpose, and have tested the program with quarterly data tapes received from five of the SCANS states. In this article, we describe the computer program and present some of the results of its use with the SCANS data. We discuss some of the next steps necessary to verify that the deaths selected by the program are actual SHE(O)s. Limitations and plans for improving the method are also discussed.

Methods

Three separate activities contribute to the SCANS/SHE(O) program: 1) coding of industry and occupation (I/O) entries from death certificates; 2) assigning I/O codes to industries and occupations noted in the SHE(O) article; and 3) developing computer software to select potential SHE(O)s from the state death certificate files.

I/O coding of death certificates is a major component of mortality surveillance programs in the states. Death certificates in the SCANS states conform to the US recommended standard format, which includes entries for "usual occupation" and "kind of business or industry." State coders assign industry and occupation codes, using the 1980 census classification system.³ The 1980 census codes were chosen over other I/O coding schemes because standard training courses and training materials are available; uniform coding procedures ensure consistency among coders and states; and the codes are compatible with codes used in the 1980 Census of Population, allowing linkage of death certificate data with census data.⁴

Since 1981, I/O coding training and quality control programs have been instituted through the collaborative efforts of NIOSH, the National Center for Health Statistics, and the Bureau of the Census. Quality control support entails the recoding of a sample of death certificates. The coders receive feedback on error rates and the types of coding errors.

The SCANS states provide NIOSH with quarterly data tapes containing underlying cause of death (coded according

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TABLE 1—Number and Per Cent of Deaths due to SHE(O) Rubrics, Ages 18 and Over, by State, 1984

State	All Deaths		Qualified SHE(O) Rubrics				Inherent SHE(O) Rubrics	
			Total		I/O Match			
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Maine	10,314	100	1,010	9.8	82	0.8	8	0.1
New York	43,085	100	5,997	13.9	589	1.4	52	0.1
North Carolina	49,585	100	4,930	9.9	368	0.7	29	0.1
Pennsylvania	119,396	100	12,017	10.1	1,297	1.1	694	0.6
Rhode Island	9,381	100	978	10.4	81	0.9	11	0.1
Total	231,761	100	24,932	10.8	2,417	1.0	794	0.3

NOTE: Tables are based on provisional state data made available to NIOSH before final year-end editing.
NOTE: New York State data are for ages 18–74.

to the 9th revision of the International Classification of Disease (ICD)⁵, I/O codes, and other routine death certificate information. For preliminary testing of the SHE(O) program, we used 1984 data from five SCANS states: Maine, upstate New York, North Carolina, Pennsylvania, and Rhode Island.

The computer program selects potential SHE(O)s from the state data files by matching information from the state files with information on the SHE(O) list. In its published form, the SHE(O) list provides: one or more ICD codes (9th revision) for each of 50 disease rubrics, or categories, classified as occupational sentinel health events; one or more occupational hazards associated with the disease; examples of industries and occupations where the hazards may occur; and references from the medical literature about the disease/hazard associations. It should be noted that the published SHE(O) list does not include specific entries for occupational injuries and poisoning, but rather provides a reminder that these are also considered to be sentinel events. SCANS mortality surveillance efforts thus far have focused primarily on disease. Hence, the SCANS SHE(O) program is restricted to the 50 published disease rubrics.

There are two types of SHE(O) rubrics in the SHE(O) list: 1) inherently occupational SHE(O)s, such as mesothelioma and the pneumoconioses, which are known to be occupationally related (called "inherent SHE(O)s" in this article); and 2) non-inherently occupational SHE(O)s, such as lung cancer or renal failure, which may not always be caused by occupational exposures (called "qualified SHE(O)s" in this article). A death attributed to an inherent SHE(O) rubric should be considered a potential SHE(O) based on the ICD code for the cause of death, regardless of the decedent's usual occupation and industry. A death attributed to a qualified SHE(O) rubric should be regarded as a potential SHE(O) only if an appropriate industry or occupation is noted on the death certificate, in addition to the ICD code for the cause of death.

A first step in facilitating linkage with the quarterly death tapes was to assign codes to the industries and occupations linked to the qualified SHE(O) rubrics. We are assigning I/O codes for these rubrics in two phases. In the first phase, we assigned 1980 census I/O codes to the industries and occupations given in the previously published list. Standard census coding conventions were used to assign the codes. In a few instances the hazards were used to aid the assignment of I/O codes, but only to the extent that this additional information could be used within the framework of census coding guidelines. Most of the examples given in the SHE(O)

list are in terms of industries where exposure might occur. Thus, most of the assigned codes are industry codes, with relatively few occupation codes. The first phase of code assignment has been completed, and the results are presented in this paper. In the second phase, exposure databases developed at NIOSH^{6,7} will be used to identify additional industries and occupations with potential exposure to the hazards mentioned on the SHE(O) list.

Codes from the quarterly death tapes are matched with SAS (Statistical Analysis System) software⁸ against the SHE(O) ICD and I/O codes. The SAS program produces a data file, a listing of the potential SHE(O) deaths, and several summary tables. Users familiar with the SAS language can add their own tabulations to those produced by the program. Graphics, including maps, can be generated easily.

We have tested the program using the 1984 data provided by the SCANS states. Highlights of the SCANS results are presented below.

Results

Maine, North Carolina, Pennsylvania, and Rhode Island provide data for all persons dying at age 18 and older, while upstate New York provides data for persons dying between the ages of 18 to 74. Table 1 displays, by state: the total number of deaths; the total number and per cent of deaths attributed to the qualified SHE(O) ICD rubrics, regardless of an industry or occupation match; the number and per cent of qualified SHE(O) deaths with I/O matches; and the number and per cent of deaths due to the inherent SHE(O) rubrics.

The qualified SHE(O) ICD rubrics comprise about 10 per cent of all causes of death among persons dying at age 18 and over. The per cent is slightly higher in upstate New York (13.9 per cent), for persons aged 18 to 74. Qualified SHE(O) deaths with an I/O match comprise about 1 per cent of all deaths. The inherent SHE(O) rubrics comprise fewer than 1 per cent of all deaths, with the largest percentage in Pennsylvania.

Table 2 displays the per cent distribution of selected demographic factors for all deaths, all deaths due to qualified SHE(O) rubrics (regardless of I/O), qualified SHE(O) deaths with I/O matches, and inherent SHE(O) deaths. Most death certificates reported on the SCANS quarterly tapes are for White persons (89.0 per cent), aged 65 and over (68.9 per cent), with slightly more males than females (53.6 per cent compared with 46.5 per cent). In contrast, deaths attributed to the qualified SHE(O) ICD rubrics, regardless of I/O, account for a greater proportion of male deaths and a greater proportion of deaths under age 65. The proportion of male

TABLE 2—Per Cent Distribution of Demographic Factors, SCANS States, Ages 18 and Over, 1984

Demographic Factor	All Deaths	Qualified SHE(O)s		Inherent SHE(O)s
		Total	I/O Match	
Race				
White	89.0	89.2	89.8	97.7
Black	10.6	10.5	10.0	2.3
Other	0.4	0.3	0.2	0.0
Sex				
Male	53.6	65.4	94.9	93.1
Female	46.5	34.6	5.1	6.9
Age (years)				
18–64	31.1	41.3	43.2	14.6
65 & over	68.9	58.7	56.8	85.4

NOTE: Per cents may not always add to 100 because of rounding.

NOTE: Tables are based on provisional state data made available to NIOSH before final year-end editing.

NOTE: New York State data are for ages 18–74.

deaths is even greater among deaths due to qualified SHE(O) rubrics with a matching I/O (94.9 per cent), while a matching I/O does not have an effect on the age distribution.

Table 3 displays the number and per cent of deaths due to inherent SHE(O) rubrics, according to the underlying cause of death: nearly three-fourths are due to coal workers' pneumoconiosis (CWP). Of the 577 CWP deaths, 575 occurred in Pennsylvania. The second most frequent inherent SHE(O) rubric is malignant neoplasm of peritoneum and pleura (mesothelioma), which comprises 16.8 per cent of the deaths due to inherent SHE(O) rubrics in the five states in 1984. Other inherent SHE(O) rubrics seen in the SCANS states are silicosis (3.9 per cent), asbestosis (3.0 per cent), unspecified pneumoconiosis (2.5 per cent), and byssinosis, malignant neoplasm of the scrotum, and extrinsic allergic alveolitis, each accounting for 0.4 per cent of the deaths due to inherent SHE(O) rubrics.

Space limitations prohibit a detailed listing here of the results for the qualified SHE(O) rubrics (available on request to author). The qualified SHE(O) rubrics responsible for the largest proportions of deaths, regardless of I/O, are malignant neoplasm of the trachea, bronchus, and lung (60.0 per cent), hepatitis B (8.1 per cent), acute or chronic renal failure (8.0 per cent), bladder cancer (4.6 per cent), malignant neoplasm

TABLE 3—Number and Per Cent of Inherent SHE(O)s, According to Underlying Cause of Death

Underlying Cause of Death (ICD)	Number	Per Cent
Malignant neoplasm of peritoneum and pleura (mesothelioma) (158, 163)	133	16.8
Malignant neoplasm of scrotum (187.7, 187.9)	3	0.4
Extrinsic allergic alveolitis (495)	3	0.4
Coal workers' pneumoconiosis (500)	577	72.7
Asbestosis (501)	24	3.0
Silicosis and talcosis (502)	31	3.9
Byssinosis (504)	3	0.4
Pneumoconiosis, unspecified (505)	20	2.5
Total	794	100.0

NOTE: Per cents may not always add to 100 because of rounding.

NOTE: Tables are based on provisional state data made available to NIOSH before final year-end editing.

NOTE: New York State data are for ages 18–74.

of the kidney and other and unspecified urinary organs (4.2 per cent), malignant neoplasm of the liver and soft tissue of the abdomen or unspecified site (hemangiosarcoma of the liver) (4.0 per cent), myeloid leukemia (3.7 per cent), lymphoid leukemia (1.9 per cent), malignant neoplasm of the larynx (1.8 per cent), and extrinsic asthma (1.4 per cent). Each of the remaining qualified SHE(O) rubrics accounts for fewer than 1 per cent of the deaths in this category.

The percentage of I/O matches is 9.7 per cent for all deaths due to the qualified SHE(O) rubrics. However, the percentage of matches varies according to cause of death. The SHE(O) rubrics with the highest percentages of I/O matches are those associated with occupations and industries where asbestos exposure might occur. The per cent of lung cancer deaths with I/O matches is the highest (14.5 per cent), followed by 11.1 per cent matches for malignant neoplasm of the larynx. The percentage of I/O matches among deaths due to extrinsic asthma is 6.7 per cent, compared with 3.3 per cent for malignant neoplasm of the kidney, 3.0 per cent for renal failure, and 2.6 per cent for hepatitis B.

The actual number of potential SHE(O)s for each qualified SHE(O) rubric is a function of the total number of deaths due to the ICD rubric, and the percentage of I/O matches for that rubric. Overall, the qualified SHE(O) rubrics account for 24,932 deaths in the SCANS states in 1984 (see Table 1), while only 2,417 of these have I/O matches. Most of the qualified SHE(O) deaths with I/O matches are due to lung cancer (89.7 per cent), which accounts for the greatest overall number of deaths and also has the largest percentage of I/O matches. Renal failure accounts for 2.5 per cent of the qualified SHE(O) deaths with I/O matches, followed by hepatitis B (2.2 per cent), malignant neoplasm of the larynx (2.1 per cent), malignant neoplasm of the kidney (1.4 per cent), and extrinsic asthma (1.0 per cent). Each of the remaining qualified SHE(O) rubrics accounts for fewer than 1 per cent of all qualified SHE(O) deaths with I/O matches.

The types of industry and occupation codes assigned for the potential SHE(O)s can be illustrated by looking at the matching records for the two largest SHE(O) rubrics: lung cancer and CWP. Most of the lung cancer deaths with I/O matches are selected on the basis of a matching industry code. This is because the published SHE(O) article provides many more examples of industries linked to lung cancer, compared with the number of occupations linked to lung cancer. The industry occurring most often is the construction industry (56.9 per cent of all lung cancer deaths with I/O matches), followed by blast furnaces, steelworks, rolling and finishing mills (24.6 per cent); pulp, paper, and paperboard mills (4.4 per cent); industrial and miscellaneous chemicals (3.5 per cent); and other miscellaneous industries (10.6 per cent). The occupations listed most often for the same set of lung cancer death certificates, most of which are selected on the basis of their industry codes, are construction trades (34.2 per cent), machine operators and assemblers (16.8 per cent), laborers and helpers (15.8 per cent), transportation and material moving occupations (7.8 per cent), managerial and professional specialty occupations (7.8 per cent), precision production occupations (6.0 per cent), technical, sales, and administrative support occupations (3.6 per cent), and other miscellaneous occupations (8.0 per cent).

Since CWP is an inherent SHE(O) rubric, an I/O match is not required by the SHE(O) program. Ideally the I/Os reported on CWP death certificates would correspond to the I/Os which are associated with CWP. While the disease occurs almost exclusively among mine workers in the coal

industry,² the SCANS data show that other occupations and industries are reported on death certificates. Among the 577 deaths due to CWP, the industry reported most often on the death certificate is coal mining (80.2 per cent), followed by various manufacturing industries (6.6 per cent), transportation, communication, and other public utilities (3.1 per cent), construction (2.6 per cent), wholesale and retail trade (2.4 per cent), public administration (1.2 per cent), and other miscellaneous industries (3.9 per cent).

The most frequent occupation listed on CWP death certificates is mining machine operator (69.3 per cent), followed by other types of machine operators, fabricators, and laborers (14.6 per cent), executive, administrative, and managerial occupations (3.3 per cent), service occupations (2.8 per cent), technical, sales, and administrative support occupations (2.4 per cent), precision production occupations (2.3 per cent), construction trades (1.9 per cent), mechanics and repairers (1.0 per cent), and other miscellaneous occupations (2.4 per cent).

Discussion

The SHE(O) selection program may provide NIOSH and state health departments with a useful tool for monitoring selected cause of death rubrics which are occupationally related. As the test results show, the number of deaths which would be targeted for review [all inherent SHE(O) deaths and qualified SHE(O) deaths with I/O matches] represents only 1 or 2 per cent of all deaths.

The utility of the SHE(O) program and its application to death certificates needs further evaluation before widespread use can be recommended, however. First, the ability of the program to detect actual SHE(O)s must be evaluated. For example, it might be useful to review the selected death certificates to determine whether the deaths are true SHE(O)s, and also to review all death certificates for the SHE(O) rubrics, regardless of I/O, to determine whether some true SHE(O)s are missed by the program. Information from other sources, such as follow-back surveys, cancer registries, or hospital discharge records, could also be used to confirm the SHE(O) deaths.

Second, it is unclear whether the use of the SHE(O) program for monitoring death certificates will have any impact on the prevention of occupational disease. Death certificates, compared with other disease reporting systems such as workers' compensation data or hospital discharge data, do not provide the best opportunities for follow-up and early intervention. Many work-related diseases, such as cancer, have long latency periods, and by the time a death occurs the chances of identifying and preventing further exposures may be rather slight. Restricting the death certificate review to deaths occurring at younger ages may lend greater success to follow-up and prevention efforts. The question of utility for prevention purposes can be resolved only by field testing.

The application of the SHE(O) concept to death certificates has other limitations. The occupation and industry entries on death certificates are for "usual" occupation and industry, and therefore may not always reflect a complete employment history. Studies comparing occupation and industry entries on death certificates with personnel or union records,⁹ interview data or survey data,^{10,11} and city directory data¹⁰ found agreement between occupation codes from death certificates compared with the alternate source from 65 to 68 per cent of the time. Industry codes from the two

sources matched from 67 to 78 per cent of the time. Agreement was better for men than for women.

In addition, occupation and industry entries on death certificates are sometimes incomplete or missing. A study of a national sample of death certificates in 1975 showed that 9 per cent of the occupation entries and 19 per cent of the industry entries did not contain enough information to assign a three-digit Census code.¹² The 1984 SCANS data show that some improvements have been made. The per cent of occupation entries coded as "unknown" or "retired" ranged from 1.5 per cent in Maine and New York to 5.2 per cent in Pennsylvania. The per cent of "unknown" or "retired" codes for industry ranged from 1.8 per cent in New York to 6.2 per cent in Pennsylvania. These improvements may be due in part to increased efforts by the SCANS states and other states to collect more complete and accurate information on occupation and industry.

Some states are beginning to collect additional job information on the death certificate, such as both usual and current occupation. In upstate New York, the name and locality of the firm or company are collected in addition to usual occupation and industry. Other states, including some of the SCANS states, have begun to educate funeral home directors and other information providers in the importance of providing complete, accurate, and specific occupation information on death certificates.

In April 1984, North Carolina began a series of educational workshops for funeral home directors across the state. Training materials were developed using a recent National Center for Health Statistics publication, *Guidelines for Reporting Occupation and Industry on Death Certificates*,¹³ which was funded in part by NIOSH. The workshops were combined with intensive follow-up efforts and additional quality control measures and query procedures. North Carolina researchers are monitoring the I/O reporting by funeral directors to evaluate the effect of the training workshops and query procedures.

In addition to its potential use in prevention efforts, the SHE(O) list may also be a useful tool for monitoring trends in occupational mortality. National mortality statistics are being used to monitor trends in deaths due to some of the inherently occupational diseases, such as the pneumoconioses and mesothelioma.¹⁴ These diseases can be monitored without the use of a SHE(O) selection program, because the diagnosis alone suggests that the death was occupationally related. The use of age-at-death, multiple cause data, and denominator data to enhance the national trend statistics is being explored. Once the SHE(O) program and its application to death certificates have been evaluated, states with access to coded industry and occupation data from their death certificates may wish to use the SHE(O) program to monitor trends for SHE(O) rubrics which are not inherently occupational.

Several enhancements are planned for the SHE(O) list and its application to death certificates:

- The authors of the SHE(O) list are developing a first "revision", which will include additional occupational hazard/disease associations that have been documented since the first list was published. In addition, parental employment will be added to the US standard fetal death certificate in 1989, which may facilitate the inclusion of specific reproductive effects.
- A more complete and accurate list of I/O codes is being developed based on potential exposure data from two surveys conducted by NIOSH researchers. These sur-

veys—the National Occupational Hazard Survey⁶ and the National Occupational Exposure Survey⁷—were conducted in 1972–74 and 1981–83, respectively. The purpose of the surveys was to determine the potential for worker exposure to chemical and physical agents by identifying those agents present in the work area. The survey databases include census I/O codes for the workers covered by the surveys, and can be used to identify industries and occupations with potential exposure to the hazards on the SHE(O) list.

• For states with computerized multiple cause of death data, we are exploring search strategies which will incorporate these additional data.

The SHE(O) program will continue to be updated as improvements are made to the SHE(O) list and to the methods for its application to death certificates. We hope that potential users will begin to apply some of the methods described here, in order to further evaluate the utility of the program.*

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*The SHE(O) program, and a list of the ICD, industry, and occupation codes it uses, is available to all interested parties. Please address requests to Ms. Lalich, and include tape specifications and a blank tape.

Johns Hopkins Announces Annual Meeting and Alumni Reunion

The Johns Hopkins School of Hygiene and Public Health, Society of Alumni, has announced its annual meeting and scientific symposium will be held November 7–8, 1987. The theme for the symposia is "Hard Choices in Public Health: AIDS, Aging, Biotechnology." Various perspectives will be presented, including ethics, research, economic, policy, legislative, and consumer. Continuing Education Units have been applied for.

The two-day enclave will feature departmental reunions. Alumni, friends, family and colleagues are invited to attend. For information, contact:

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