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UNC - 1977 Mortality Study
September 1978

IC4

Pltf Exh

939

THE UNIVERSITY OF NORTH CAROLINA
AT
CHAPEL HILL

Occupational Health Studies Group

The University of North Carolina at Chapel Hill
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September 27, 1978

Joint URW-Firestone Occupational Health Committee

Addressees:

Dr. L. H. Ballou
Dr. Theodore Georgiadis
Mr. R.V. Hassmiller
Mr. Peter Bommarito
Mr. Louis Beliczky
Mr. Jake Miller

RECEIVED
OCT 2 1978
INDUSTRIAL HYGIENE

Gentlemen:

Enclosed is a copy of the report of the 1977 Mortality Study, I.C.-4. This study was begun by the Occupational Health Studies Group in January, 1978. This is the first application of surveillance techniques using mortality registry and population enumeration procedures. Although it was our stated intent to report in July, I feel that this report still demonstrates the timeliness with which surveillance activities can yield health information.

We were able to get data in time for this report from 42 of the 48 plants and local unions with which we work in the Joint Occupational Health Program. We expect to report further for all 48 plants later in the year.

If you need additional copies of this report, we will be pleased to provide them.

Sincerely yours,

Robert L. Harris, Jr., Ph.D.
Director

RLH:dcm

Enclosure

Identical letter and enclosure sent to all Joint Committees.

BATO/JACKSON 025905

1977 MORTALITY STUDY

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INDUSTRIAL HYGIENE
DEPARTMENT

Occupational Health Studies Group
School of Public Health
University of North Carolina
Chapel Hill, North Carolina

IC-4

SEPTEMBER, 1978

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1977 MORTALITY STUDY

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Submitted To:

The URW/Firestone, General, Goodyear and Uniroyal
Joint Occupational Health Committees

SEPTEMBER, 1978

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BATO/JACKSON 025908

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Executive Summary

Mortality studies have great value in assessing the health experience of occupational groups. Over the past several years the Occupational Health Studies Group has completed a number of studies of mortality experience among populations of workers from individual plants and local unions. These studies have dealt with deaths which occurred in past years. Most have used the 10 year interval 1964-1973.

The Occupational Health Studies Group, as part of its obligation under the Company-Union Joint Occupational Health Program, has also been developing a health surveillance system. A major part of such a system is surveillance of current mortality experience. The study described in this report is the first application of surveillance techniques to current mortality experience. The study covers 1977, the most current year of mortality experience, and it includes all of the plants and local unions in the Joint Occupational Health Program.

One objective of the study was timely reporting. Our stated intention was to report in the first six months of 1978. Although this report has been delayed beyond that time, a number of tasks which have been done will be useful in subsequent reports and will permit more rapid reporting in the future.

The University of North Carolina works with 48 plants in the Joint Occupational Health Program. Data relative to this study for six of these plants were not available during the first half of this year. As a consequence, this report is limited to analysis of data from 42 plants. Further analyses are underway and all 48 plants will be included in a subsequent report.

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A total of 1,277 deaths are known to have occurred in 1977 among the 79,500 active and retired rubber workers from the 42 plants included in this report. The relatively few deaths among women (149 deaths) do not permit extensive analysis. The overall mortality experience for the year among female workers was not markedly different from that of the general population. More detailed analysis among male workers was possible. The Standardized Mortality Ratio (SMR), which compares the mortality experience of the study population to that of men of the same ages in the general population, is used in reporting results. An SMR of 100 means that the study population and the general population had the same mortality experience. A higher value, greater than 100, means that more deaths occurred among the study population than were expected based on general population experience, and an SMR lower than 100 means fewer than expected numbers of deaths occurred among the rubber worker group.

The SMR for all causes of death in 1977 among male rubber workers in the 15-64 year age range was 73, that for retired workers in the 64-84 year age range was 106. The SMR of 73 for the active age range reflects the "healthly worker effect" which has been identified in our studies and by others with actively employed workers. The SMR of 73 for deaths from all causes in the active age range makes SMR values greater than 100 for any specific causes of death even more noteworthy than would be the case with a higher all-causes SMR.

The SMR for all forms of cancer among retired rubber workers in the study was 119. This is a statistically significant excess and is consistent with findings of several other epidemiologic studies done for past years. SMR's for a number of site specific cancers were elevated for

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this group. Particularly noteworthy is the statistically significant excess of lung cancers (SMR = 145); this is in contrast to the results of our earlier mortality studies on several individual plant populations. This finding merits further serious investigation. An excess of cancers of the lymphatic and hematopoietic systems (SMR = 135) among active workers was also found; this excess, although real, was not statistically significant at the 95 percent level of confidence. A similar excess (SMR = 130) was found for leukemia among retired workers. These latter two findings are consistent with results of past studies.

Overall and cause specific mortality experience, as was expected, varied among the individual plants. Some statistically significant excesses were observed for some causes of death in some plants. These merit further attention.

The importance of annual mortality surveys increases as times goes by and as results for successive years become available. Such surveys provide data for comparisons and for detection of trends and changes in the health of working populations. A major purpose of studies such as this is to identify plant population and disease types which need more detailed investigation with the ultimate goal being to recommend actions which remove hazards to the health of workers.

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I. INTRODUCTION AND STUDY DESIGN

The 1977 Mortality Study is an analysis of the deaths among approximately 94,000 active and retired hourly workers who were members of the United Rubber Workers Union and who during the year 1977 were employed at or retired from one of the forty-eight plants which are affiliated with the occupational health research program at the University of North Carolina.

Past cohort studies conducted by the Occupational Health Studies Group (OHSG) at the University of North Carolina have concentrated on single plants and have been retrospective in nature, reconstructing a workforce at some time in the past and then following that group of people for long periods to determine their mortality experience. The cost of such studies and the time involved prevented us from conducting similar studies for all of the plants in the industry. Yet, observations made at one plant raised questions about other similar plants. It was clearly desirable to be able to study all of the plants in the industry. Other studies done in the past have examined data from a large number of plants but have done so using a proportional analysis which again raised questions making it obvious that a more definitive study was necessary. Past studies have gone back in time and although they could give much information about the experience of workers some years back we felt that it was important to conduct a study based on the most current data available which would be more pertinent to workers today.

The OHSG has been collecting death certificates on an ongoing basis for most of the plants in this study since 1972. We have not previously enumerated the entire population of workers for the four companies.

Based on our experience it was obvious that until we established a continuous surveillance system which included enumerations of both the entire workforce and all of the deaths an industry-wide mortality study would be difficult, time consuming, and expensive. With the establishment of an efficient means of enumerating the population as part of the surveillance system this study has become possible.

The initial plan for this study was presented at the Company-Union-University scientific meetings at the OHSG in December, 1977. With the cooperation of representatives present at the meetings from the Union and from each of the four companies the study was begun in January, 1978.

The purposes of this study are:

1. To test and document the feasibility of conducting a cross-company mortality study on an ongoing basis as a part of an overall surveillance system in the industry.
2. To explore differences between the mortality experience of the rubber industry and that of a comparison population.
3. To identify differences in mortality experience between plants and processes.
4. To compare the mortality experience in 1977 with that reported earlier by the OHSG.

This study is unique. To our knowledge this is the first time that the annual mortality experience of a working population has been studied in a cohort fashion. We see it as an important contribution to the health of workers in the rubber industry to be able to conduct a study of this nature and report on it within six to nine months of the end of a year. The value of this study will increase as the study is repeated

each year permitting comparisons to be made between years and making it possible to observe trends in mortality in the rubber industry.

The study demonstrates that it is feasible to prepare an industry-wide annual mortality study within six to nine months after the end of the year, provided that most of the information which is required for the study be made available in computer readable form from corporate headquarters rather than from the individual plants. Although few companies maintain files that are specifically designed for occupational health research, almost all of the information which is required for a mortality analysis can be obtained from files which are maintained for operational purposes such as the administration of benefit programs and personnel management. With the cooperation of the participating companies, this information can be obtained quite rapidly and can be processed very easily, thus making it economically feasible to prepare an annual mortality study for the active and retired employees.

Since the major objective of the 1977 Mortality Study was to develop the data collection procedures and the data analysis programs which are required to enumerate a complete study population and to investigate the causes of death among the deceased members of that population, this report (1) summarizes the procedures which were used to collect data for the 1977 Mortality Study; (2) discusses some of the difficulties which were encountered in implementing these procedures; (3) describes the data analysis programs which were developed and (4) presents some preliminary results from an analysis of the data for 79,496 employees who worked at 42 plants. A second report, which will be completed by the end of the year, will contain more extensive analyses of the data from all 48 plants.

A mortality analysis is the first step in a comprehensive program of health surveillance. Morbidity information, environmental exposure data and personal health information are also required to monitor the health conditions in an industrial setting. The 1977 Mortality Study is the beginning of a comprehensive health surveillance system which is being developed by the OHSG for the workers in the rubber products industry. Other OHSG surveillance research projects are presently developing procedures for the collection and processing of several types of health-related information. These studies are also concerned with the development of procedures which will protect the privacy of the individuals who are included in the study population. As the results of these studies become available, they will be incorporated into future mortality studies so that the scope of the analyses can be expanded to provide a more accurate assessment of health conditions in the rubber products industry.

The 1977 Mortality Study is a cohort study of mortality in the rubber industry. A cohort study is a study of a group of people (the cohort or study population) who all have some characteristics in common. This study population is followed for a period of time to observe the occurrence of disease among its members. The experience of the study population is compared with the experience of some other population (often the total U.S. population) to detect what health hazards the study population may be exposed to.

For the present study the common characteristics are membership in the United Rubber Workers Union (URW) and employment in one of the plants participating in the Joint Occupational Health Program in the four companies (Firestone, General, Goodyear, and Uniroyal) in the rubber

industry. The group of people defined by these characteristics can actually be separated into two distinct cohorts. The first cohort consists of all URW members who were active employees at one of the 48 plants (listed in the appendix) at any time during the year 1977. The second cohort consists of all URW members who were retired from one of these 48 plants prior to January 1, 1977, but who were living on that date. Although the discussion which follows on data collection and preparation deals with these as a single population the analyses were done separately and the results section of this report treats them as separate groups.

The data necessary for this study were a complete enumeration of the study population including age, sex, race, and employment status on each person in the study; date of death and cause of death for each deceased person in the study; the number of people in the comparison population (in this case the U.S. population) together with the age, sex, and race distribution of this population; and the number of deaths by cause of death for each age, sex, and race group in the comparison population. The information on the study population came from records from the four companies and from death certificates obtained from the companies, their insurance carriers, and from state health departments. The number of people in the comparison population came from a publication of the Bureau of the Census,(1) and the information on deaths in the U.S. came from data generated by the National Center for Health Statistics and provided to us on computer tapes.(2) The most recent information available on deaths within the U.S. was for the year 1975 so the data for that year were used for comparison.

II. DATA COLLECTION PROCEDURES

The 1977 Mortality Study required the creation of two major data files; the Workforce Enumeration File and the Death Certificate File. These files were created separately and are maintained separately to provide a cross check on the completeness and accuracy of the information which was collected for the study. Section A below describes the procedures which were used to create the Workforce Enumeration File and Section B describes the procedures which were used to collect information for the Death Certificate File. After both files had been completed, the information from the Death Certificate File was merged with the information on the Workforce Enumeration File to create the 1977 Mortality Study File which was used to prepare the mortality analyses. The process of merging the two files is a critical step in the study procedure because any unexplained deaths which are identified at that point must be explained before the mortality analysis can be undertaken. The procedures which were used for merging the two working files to create the 1977 Mortality Study File are described in Section C. Section D describes the processing of data for the comparison population.

A. The Creation of the Workforce Enumeration File

The first step in the creation of the workforce enumeration file was the collection of information concerning all active and retired employees from each of the participating companies. We requested this information from corporate headquarters rather than from the local plants for the following reasons:

1. If the data we receive for each company were processed at one central location, the methods used to collect, code and store the information would be more likely to be consistent.
2. Computer readable data, which is much easier for us to work with, are more likely to be available from corporate headquarters.
3. The data for all the plants for each company would be sent to us in a common format with the same information being available.
4. We would work with a smaller number of computing centers, and all the data for one company would arrive at OHSG at the same time and could be copied and edited in one batch.

The strategy of obtaining the required information from a single source for each company worked quite well. We were able to obtain a single file of retired employees from each of the four participating companies; three of these files were sent to us in a computer readable form. We were also able to obtain most of the information concerning active employees from a single source for each of three companies (a few plant files were required to supplement the data received from one company), but the fourth company could only provide us with files from each of the participating plants. All information on active employees was received in a computer readable form except for the information from one plant which was provided on a computer prepared listing.

Selection of the Study Population

In January, 1978, a letter was sent to each company requesting the following information for all hourly employees who worked at one of the

participating plants during 1977 and retired employees who had previously worked at one of the participating plants and were living as of January 1, 1977.

Identifying Information

Name
Social Security Number and/or Company Identification Number

Demographic Information

Date of birth
Sex
Race

Employment Information

Plant at which the employee is currently working (if active) or the last plant at which the employee worked (if retired)
Date of initial employment and/or the continuous service date
Union Membership
Current employment status and the date this status became effective
If available, the following information was also requested:

Department in which the employee currently works
Current job assignment (code or job title)
Date and type of retirement (if retired)
Date of death (if deceased)

The responses to this request varied from company to company but generally included information on all hourly employees.

The first step in the processing of this data involved the selection of those employees who were to be included in the study population. Three basic constraints were critical to the formulation of the criteria which were used to select the study population:

1. Members of the study population had to be members of the URW Union and had to work at one of the 48 plants which are included in the OHSG contract.
2. A person was included in the study population only if the person was entitled to life insurance benefits so we could be

fairly sure that we would learn of each death through the company insurance office if the person died during 1977.

3. Data for all categories of people included had to be consistently recorded in the data files from each of the four companies which were included in the study.

The first constraint is probably not too critical to the results of this study but is does prohibit the inclusion of salaried employees, such as supervisors, who frequently work for many years as hourly employees, and who still have environmental exposures which are similar to those of the hourly employees.

The second constraint is more important because it eliminates all employees who left the companies prior to 1977 who did not receive a termination allowance or a pension. This constraint was not critical to the 1977 Mortality Study because we made no efforts to obtain information on former employees as would be done in a retrospective study. However, this constraint will become more important for the 1978 Mortality Study because we must decide if we will keep short term employees in the workforce enumeration file and attempt to obtain death certificates from sources other than the company insurance offices. We are presently analyzing the data which was collected at one pilot surveillance plant, a part of the experimental surveillance system, to guide us in the development of appropriate selection rules for the 1978 Mortality Study.

The third constraint had an important effect on the 1977 Mortality Study. Since some employees who received termination awards or deferred pensions do not qualify for life insurance and since we were not able to obtain information concerning these people from some of the companies, we decided to eliminate all of the employees in this group from the

study population even though we received a large number of death certificates for these employees. We are investigating alternative procedures which might be used so this group of employees can be included in future mortality studies.

Using these constraints, the following rules were developed to select employees for inclusion in the study population. These are illustrated in Diagram 1 in the appendix.

1. The employee had to be an hourly worker who was a member of the URW Union and who worked at one of the 48 plants which were included in the study.
2. The employee had to work at least one day during 1977 if he/she had not retired before January 1, 1977 and was not on leave for the entire year.
3. The employee had to have received a pension during 1977 if he/she had retired before January 1, 1977.
4. Employees who were on leave during 1977 were included in the population provided that they had life insurance benefits so that the company would have received a death certificate if they had died during 1977.

It should be noted that the use of these rules eliminated the following employees from the study population.

1. All employees who were on lay-off prior to January 1, 1977 and did not return to work before December 31, 1977. Because of the Union members' recall rights, there are probably very few, if any, employees in this category who will return to work at a later date. If such employees do exist, they will be picked-up in future mortality studies.

2. All employees who went on educational leave or military leave prior to January 1, 1977 and did not return to work before December 31, 1977. There is a very small number of employees in this group. These employees will be picked-up in subsequent mortality studies if, and when, they return to work.
3. All employees who terminated with a lump sum payment award or who left with a deferred vested pension prior to January 1, 1977. Employees in this category who retired during 1977 were included in the 1977 Mortality Study and will be included in all subsequent studies. We hope to be able to add all of the employees in this group, retroactively, to the workforce enumeration file for future mortality studies.
4. All salaried employees unless they transferred from hourly to salaried status during 1977. We will not be able to include these employees in future studies unless we arrange to collect the death certificates for all salaried employees and obtain agreement to extend the study to include selected employees who are not currently members of the URW Union.

Since the data for retirees and active employees were received from different sources for each company, we initially created two separate files for each company--one file for active employees and one file for retirees. These files were edited to identify missing data, duplicate records, and/or data discrepancies. Whenever data for an employee were missing or apparent discrepancies were discovered, the record was checked and corrected if necessary. For example, employees who had records which indicated that they began work before they were 14 years old (sometimes before they were born) or were still actively employed

although they were more than 65 years old, were identified and the accuracy of the recorded information was checked. Since the corporate headquarters do not have the original data files for the hourly employees, error lists had to be prepared for each plant. These lists were sent to the personnel offices at each of the plants with requests to check the original records to obtain the correct or missing information. At the time of this report we have received the missing information or corrections from all but 12 plants; eight plants have not yet responded to our requests and four plants have not yet been contacted because we received the initial information concerning the workforce at these plants very recently. Only six of the twelve plants have a significant amount of missing information, thus we were able to include 42 plants in the preliminary analyses which are included in this report.

Race information was not recorded on most of the files which were obtained from the corporate headquarters. Since race is known to be an important variable in mortality analysis, we made a special effort to obtain race information for the 1977 Mortaltiy Study. Race information which had been obtained for several plants from each company for earlier OHSG studies was transferred to the Workforce Enumeration Files for both the active and retired employees. Lists of employees for whom we did not have race information were prepared for each plant because the only source of race information is the original employee records which are stored at the plants. These lists were sent either directly to the local plants or to the corporate headquarters for forwarding to the local plants. At the time of this report, race information has been obtained for all active employees of three companies and for all retirees of one company. Since race is still missing for a large number

of employees, the preliminary mortality analyses which are included in this report do not use race as a variable. However, race information will be used in the mortality analyses which will be run at a later date.

After the active and retiree files for each company had been edited and all available correction entered, the two files for each company were merged to create a single Workforce Enumeration File for each company. Since the employees who retired in 1977 were entered in both the active and retiree files, the duplicate records for these employees had to be removed. The resulting file was later merged with the Death Certificate File to create a 1977 Mortality Study File for each company.

B. Creating the Death Certificate File

Death certificate processing is an important part of any mortality study, especially if the study involves comparison among companies or comparisons with national vital statistics. Comparability is best achieved by following clearly defined processing procedures which include the coding of the cause(s) of death by a certified nosologist, an expert in determining the underlying cause of death from the information provided by the attending physician on the death certificate and in coding this information in accordance with the International Classification of Diseases.

Although the size of the 1977 Mortality Study required a few modifications and careful implementation, the procedures which were used to process the death certificates for this study are essentially the same as the procedures which have been used by OHSG personnel to process death certificates for retrospective epidemiologic studies. The major steps in this procedure are described below.

In January, 1978, a letter was sent to the medical director, or his counterpart, at each company requesting a copy of the death certificate for each hourly active employee or retiree who died in 1977. The medical directors forwarded this request either to the company insurance department or to the insurance company which underwrites the company's life insurance program.

Since OHSG receives many death certificates for other research projects, some of the requested death certificates were already on file at OHSG before the request was sent. However, most of the death certificates had to be duplicated and processed after the request was received in January. Most of these death certificates were received by the end of March but a large number of certificates were delayed for several months. We received more than 110 death certificates (almost 10% of the total number received) after July 1; the last large group was received about August 15. Although some death certificates are still outstanding, at the time of this report we had received complete death certificate information concerning about 99% of the known 1977 deaths.

In addition to death certificates, we also requested proof-of-death forms and a year-end claims listing as they were available. Although claims listings do not include information on the cause of death, and may not always be complete, they are very useful for cross-checking our records to be sure that we have received all requested death certificates. When a requested death certificate had not been received, we checked with the company to determine if they had received it. If they had not yet received it, we requested supplementary information, such as the social security number and the state in which the death occurred, so we could request a death certificate from the vital statistics office of that

state. Because of the lengthy delays involved in obtaining information from some states, we attempted to obtain as much information as possible from the companies. However, if the company did not have the death certificate, the state vital statistics office is usually the only other source of information.

Death certificates were usually received and processed in groups. Therefore, the processing procedure was designed so we could account for each certificate in a group after the processing for that group of death certificates had been completed. The steps in the processing procedure are as follows:

1. Since some companies send OHSG a copy of the death certificate for all deceased employees, the first step in processing each group of death certificates was to remove all certificates for employees who were obviously not included in the 1977 Mortality Study. All certificates for deaths which did not occur in 1977 were removed first; other certificates were removed if information provided by the company indicated that the employee was not an hourly worker, not a member of the URW Union or did not work at one of the 48 plants which were included in the study. The number of death certificates which were removed during this step was noted and the death certificates were filed for future reference or use in other OHSG studies.
2. All county, city and local death certificates were removed and replacement certificates were requested from the state office of vital statistics. It has been found that the forms issued by county or local registrars of vital events may omit some of the causes of death or list them in a different sequence than

the official state certificate does. Since these discrepancies can affect the coding of the cause of death, we use only those death certificates which are issued by the state.

3. All of the information on the remaining death certificates was checked for legibility and completeness. The information was also checked to see if it was consistent with any other information which was available from proof-of-death forms or claims listings. Minor errors, omissions or inconsistencies were corrected by using information that was available at OHSG or by contacting the corporate insurance office or the local plant at which the employee worked. If much of the information was illegible, a copy of the death certificate was requested from the state vital statistics office. If the cause of death was illegible or listed as "pending", the state vital statistics office was contacted to obtain a supplementary medical certification of the cause of death.
4. Each death certificate which was complete and legible was copied and a nosology form was attached. The certificates were counted and the group of certificates was sent to the nosologist for coding.
5. When the coded certificates were returned to OHSG, they were checked to be sure that they were all returned and that the coding was complete. If the nosologist had not been able to read the cause of death information, a new copy of the death certificate was requested from the state vital statistics office and the certificate was recycled through the processing procedure.

6. The coded death certificates were then sent to data processing to be converted into a computer readable form and entered into the death certificate file. The information on each certificate was typed on an OCR (Optical Character Recognition) typewriter and was entered into the computer file via an optical character reader. Each certificate was typed by two different operators and both copies were entered into the computer which compared them to determine if they were exactly the same. If any differences were noted, the records were printed, the differences were rectified, and both records were again entered into the computer. When no differences were detected, the information was added to a working file. When the processing for the entire batch of death certificates was completed it was added to the Death Certificate File.

7. After most of the death certificates had been received and processed, the information on the Death Certificate File was merged with the information on the Workforce Enumeration File.

Since death certificate information is available from a restricted number of sources and is not available in a computer readable form, the processing of death certificates will always be time consuming. However, the time required to process the death certificates for an annual mortality study could be substantially reduced if all of the companies would follow a few guidelines when they prepare death certificates for OHSG. We would like to suggest that the following guidelines be adopted for future studies:

1. We are aware of the fact that the copies of the death certificates which are sent to the companies are sometimes barely

legible. Our work would be greatly expedited if the copies of death certificates which are sent to OHSG are as clear as possible.

2. Checking for the completeness of death certificates is greatly expedited by the availability of a claims listing. Thus we would appreciate receiving a copy of the year-end claims listing if it is available.

3. It is useful to have the employee's pay status (hourly or salary) and plant entered on the death certificate especially if this information is not on an accompanying insurance claims listing or if a proof-of-death insurance form containing this information is not attached to the death certificate.

C. The Creation of the 1977 Mortality Analysis File

After the Workforce Enumeration File for each company was completed, it was compared with the Death Certificate File and death information was added to all matching records on the workforce file. During this process lists were made of all of the records on either file for which matching records should have existed but were not found. All of these unmatched records were then checked to determine why matching records did not exist.

All employees on the workforce file who were coded as deceased in 1977 should also have had a record on the Death Certificate File. Some did not. To determine why these death certificate records did not exist, we contacted the local plants to find out if these employees had indeed died in 1977 and were URW hourly workers. In the majority of cases the date which was recorded as the "death date" was actually a

benefit payment date and the death itself occurred prior to 1977. Since this study did not include deaths which occurred before 1977, these records were removed from the workforce enumeration file. At the time of this report, all but five deceased records on the workforce file which did not match the death certificate file have been explained and appropriate corrections made.

Since each record on the Death Certificate File represents a 1977 death, there should also have been a matching record on the Workforce Enumeration File. All death certificate records without a matching Workforce Enumeration record were listed and the cause of the discrepancy was investigated. The majority of these non-matches were for employees who left the company with a termination award prior to 1977, and who were not included in the study population for the 1977 Mortality Study. In a few cases we discovered that an employee for whom we received a death certificate did meet the criteria for inclusion in the 1977 Mortality Study but the employee's record was not included in the workforce information which we had received from the company. Apparently these records had been deleted from the company's file when pension benefits were discontinued, thus we did not receive the record when they copied the file for us in the Spring of 1978. By using some information which one company had provided for another study in 1976, we were able to identify all such deleted records for that company and to add every record which met our selection criteria to the 1977 Mortality File.

For another company, letters had to be written to the local plants to determine if the unmatched records should be added to the Workforce Enumeration File. At the time of this report, answers had not been received from all plants so there are still 23 records of 1977 deaths

for which we do not have a record on the Workforce Enumeration File. We cannot add these 23 records to the 1977 Mortality Study until we have received information from the local plants.

Because of the problems we have had in obtaining some information and removing all known errors from the information which we have received, the mortality analyses which are presented in this report are preliminary analyses which are based on approximately 85 percent of the total study population. By the time the final report is written before the end of 1978 we hope to be able to determine whether these 23 deaths should be included and we hope to have adequate data for the six plants which are excluded from this report.

D. Processing Comparison Population Data

As mentioned in the Introduction data for the U.S. population came from a publication of the Bureau of the Census. This data was key punched and double checked for accuracy by OHSG staff. The information on deaths in the U.S., however, came to us on computer tape. The file we received from the National Center for Health Statistics had about 1,900,000 records on it or one record for each death in the U.S. during the year 1975 (identification information had been removed). This massive file had to be copied and summarized by the OHSG data processing staff. The summary data from this file was then compared with the published mortality figures for 1975. The 1975 mortality data has not yet been published in the detail needed for this study so the procedure used provided us with early access to recent data.

III. ANALYSIS AND RESULTS

The mortality of the rubber workers studied was analyzed and is reported here in terms of age standardized mortality ratios (SMR's). The SMR is the ratio of the number of deaths in the study population to the number of deaths which would be expected based on the mortality experience of the comparison population. To adjust for the age distribution differences between the study population and the comparison population the numbers of expected deaths are calculated for each five year age group and these are added together to get the total number expected. Although the final formula for an SMR includes only the number of deaths observed and expected

$$\left(\text{SMR} = \frac{\text{number of deaths observed}}{\text{number of deaths expected}} \times 100\right)$$

the earlier steps in this calculation involve the computation of death rates. The SMR is uaually multiplied by 100 so that an SMR greater than 100 means that more deaths were observed in the study population than would be the case if the same death rates applied to the study population as were present in the comparison population. Conversely, an SMR less than 100 means that the study population had fewer deaths than it would have, had the same death rates applied to it as were present in the comparison population.

Mortality rates for most diseases change over time. It is, therefore, important that the comparison population data be as close in time to the study population data as possible. As was mentioned above the most recent U.S. data available were for the year 1975. These were obtained from the Bureau of the Census and the National Center for Health Statistics. The death rates used for comparison in this study

were then calculated at the OHSG. Since the data from the National Center for Health Statistics (NCHS) were provided on computer tape they were checked for accuracy against preliminary figures published by the NCHS.

Because of the uniqueness of this study in looking at mortality for many plants during only one year a special computer program was written to analyze the data. This program is discussed briefly in the appendix.

The mortality experience of the rubber workers in this study was analyzed separately for males and females for 42 of the 48 plants in the study. The remaining six plants will be included in the final report to be released before the end of the year. These six plants have been omitted from this report because of inadequate data. It was mentioned earlier that this study is comprised of two separate populations, namely active employees and retirees. These are separated in this report by age, those under 65 being considered as active employees and those over 65 being considered as retirees. Because there are retirees under the age of 65 a further refinement of this separation will occur in future reports.

Death certificates have been located for 99 percent of the known deaths. All causes of death stated on the death certificates were coded by a qualified nosologist according to the Eighth Revision of the International Classification of Diseases Adapted for Use in the United States (ICDA).[3]

Included in this study are 48 plants ranging in size from less than 100 to over 5500 hourly workers. During the year 1977 over 65,000 people were active employees in these plants. These plants are scattered throughout 22 states. The major concentration of the plants is in the

East North Central geographic region including Ohio, Indiana, Illinois, Michigan, and Wisconsin where 20 plants are located with a total of over 23,000 actively employed hourly workers. In Ohio alone there are seven plants from all four companies employing approximately 21,000 hourly workers. In addition to the active employees there are over 25,000 retirees from these 48 plants. As mentioned above this report covers 42 of the 48 plants including 79,496 active and retired rubber workers. As can be seen from the age and sex distribution in Table 1, 79 percent of the population was in the active age range while the remaining 21 percent was at least 65 years of age. Approximately 87 percent of the actives were males and 78 percent of the retirees were males.

During 1977 a total of 1277 deaths are known to have occurred within the study population of 42 plants. Most of these occurred among retirees with 331 deaths among those under age 65. Of these 1277 deaths 1128 were among males and 149 among females.

Tables 2 through 7 of this report present SMR's for various disease categories for all 42 plants combined. Because all plants are combined for these tables many very different processes and chemical exposures are included and it should not be assumed that because an SMR is low there are no problems in the industry relative to that cause of death. Looking at large heterogeneous groups such as the rubber industry as a whole may mask specific conditions which exist in subgroups of the population.[4,5] On the other hand, a high SMR does not necessarily mean that every plant in the industry has a problem with that particular disease. At the same time a high SMR in these tables should be taken seriously. Because it is based on the experience of thousands of workers it is not likely to be a chance happening. It may either represent

a serious problem at a few plants or it may be a rather widespread problem in the industry.

The next step in the analysis is to look at individual plants to see if there are particular problems at some plants. Tables 8 through 10 present SMR's for the individual plants. In order to prevent identification of specific plants each plant was assigned a number at random and only that number appears as identification in the tables. In addition, the numbers of observed and expected deaths do not appear in Tables 8 through 10. The URW will be given a list of the plant codes and each company will be given a list identifying only its own plants.

Tables 2 through 7 show the numbers of observed and expected deaths for each cause listed. SMR's, however, have been calculated for only those causes which have at least five observed deaths because of the statistical instability of rates which are based on small numbers. While not reporting some high, but probably meaningless, SMR's, some low, but possibly meaningful SMR's will remain unreported as well. Although Tables 8 through 10 do not report numbers of observed and expected deaths the same rule applies for calculating SMR's. Dashes in the tables represent plants or diseases with fewer than five deaths as well as the six plants not included in this report.

The test of statistical significance used in this report is the χ^2 test:

$$\chi^2 = \frac{(\text{observed deaths} - \text{expected deaths})^2}{\text{expected deaths}}$$

Although SMR's are not reported for fewer than five deaths each cause of death was examined and a test for statistical significance based on the Poisson distribution was used to check the probability that what was observed was a chance occurrence. These cases are discussed later.

do not currently have death certificates were included in this category. When death certificates are obtained these deaths will be reclassified to other disease groups.

Diseases of the circulatory system account for about 54 percent of all deaths. Similarly in the U.S. general population about 55 percent of all deaths are attributed to circulatory diseases. The next most frequent cause of death was neoplasms which accounted for 23 percent of the total deaths. Because these two groups of diseases consist of several smaller disease categories of special interest they are presented in more detail in Tables 3 and 4.

As seen in Table 3 several site specific neoplasms have elevated SMR's in the study population. In the active age group, stomach cancer and neoplasms of the lymphatic and hematopoietic tissue show elevated SMR's. Within this latter group the category "other neoplasms of lymphoid tissue, polycythemia vera and myelofibrosis" had a statistically significant threefold elevation in the SMR.

Among retired men several site specific cancers had elevated mortality ratios. Interestingly, while our earlier mortality study[7] showed fewer deaths than expected due to cancer of the respiratory system for both active employees and retirees, this study shows a statistically significant elevation for lung cancer among retirees.

Table 4 presents mortality ratios for certain selected diseases of the circulatory system for males from all plants combined. In all cases fewer deaths were observed than expected among those in the active age range. Among retirees the number of observed deaths was quite close to what was expected.

In this report the results of the cause specific mortality for all plants combined and for individual plants were presented primarily for large disease groups and for a limited number of smaller groups or individual causes of death. Additional analyses for other plant combinations and for other diseases may be included in future reports.

Tables 11 through 13 present a comparison of combined plant death rates with U.S. death rates for each five year age group for total deaths, total neoplasms, and for total circulatory disease. These rates are expressed as the number of deaths per 1000 population.

The discussion which follows is by no means intended to be exhaustive but highlights some of the more noteworthy findings in these tables.

Table 2 presents the observed and expected numbers of deaths and the corresponding SMR's for males for major disease groups. The SMR for all causes combined for men age 15-64 is 73 which represents a statistically significant deficit of deaths. This is usually explained by what is known as the "healthy worker effect".[6] In other words, the fact that the study population is composed of people who are healthy enough to be working, while the comparison population, in addition to healthy workers, includes the disabled, the institutionalized, and others in ill health means that the study population should compare favorably to the comparison population. A high SMR then becomes all the more noteworthy. Statistically significant deficits also appear in the same age group for circulatory diseases; respiratory diseases; accidents, poisonings and violence; and digestive diseases. Two disease groups have statistically significant elevations in their SMR's among the retirees. These are for neoplasms and for symptoms and ill-defined conditions. The SMR for this last group is artificially inflated since some known deaths for which we

Because of the small number of deaths among females the tables for females show much less detail than those for males. Table 5 which is for all plants combined has one SMR which is statistically significant. That one is for accidents, poisonings, and violence among the active aged women. This is particularly noteworthy since five of the seven deaths in this group were suicides. These deaths were not restricted to any specific plant. It is interesting that the SMR for total deaths (ICDA 000-999) does not follow the same pattern among women as it did among men, that is, with a low SMR for those aged 15-64 and an elevated SMR for those aged 65-84. Instead, for women the two SMR's are quite similar. The SMR's for the same two age groups for circulatory disease are, likewise, quite similar to each other. Neoplasms, however, show what is a more typical pattern among men. The elevated SMR for neoplasms among retirees appears to be consistent for several specific neoplasms as shown in Table 6, specifically digestive cancer, breast cancer, and genitourinary cancer.

Although the SMR of 221 for cerebrovascular disease in Table 7 among those people over 85 years of age is statistically significant, it may not be very meaningful because of the unreliability of diagnoses for people of that age. Yet, this is something which should be kept in mind when future studies are done. Consistent results over several years are likely to be meaningful.

As mentioned above, Tables 8 and 9 give plant specific SMR's for males for select causes of death. To illustrate the earlier mentioned reference to the masking effect when large heterogeneous populations are studied notice that although the SMR of 106 for all causes among retirees is not particularly noteworthy, some individual plants do show SMR's that are quite high.

Two plants show statistically significant deficits of deaths in the age span 15-64 for total deaths (ICDA 000-999). Plant 8 has an SMR of 46 while plant 18 has an SMR of 57. For plant 18 this deficit also shows up for circulatory disease in the same age group with an SMR of 46. Although the SMR for neoplasms in the age group 65-84 at this plant is only 112, the SMR for lung cancer (ICDA 162) as seen in Table 9 is 186 which is statistically significant.

Plant 10 shows a statistically significant elevation among those age 65-84 for deaths due to neoplasms with an SMR of 222. Plant 33 had three times the number of total deaths expected among the retired. This SMR of 302 was not attributable to any specific cause, however. The elevation due to circulatory disease in plant 36 (SMR of 208) is largely due to cerebrovascular disease (notice the SMR of 452 in Table 9) although deaths due to ischemic heart disease were also elevated. This particular plant is being investigated further because 82 percent of all deaths in the plant were due to circulatory disease. The SMR of 186 for neoplasms among retirees at plant 41 is statistically significant. Similarly, Table 9 shows an elevated SMR of 226 for lung cancer in the same age group for this plant. Plant 47 has consistently high SMR's for myocardial infarction for both age groups 15-64 and 65-84. Both of the SMR's (283 and 231) are statistically significant. Plant 48 has three SMR's for the age group 65-84 which are statistically significant. These are for total deaths (SMR = 132), neoplasms (SMR = 172), and myocardial infarction (SMR = 198). Although the SMR of 240 for circulatory disease among those people over 85 years of age is statistically significant, as mentioned above, this is something to be watched in future studies, but it may not be important because of diagnostic unre-

liability. Only five plants had enough female deaths to report plant specific SMR's. These are shown in Table 10. Although not statistically significant, the elevated SMR's for total deaths in the 15-64 year old age group in plants 18 and 39, the SMR of 132 for total deaths among retirees at plant 26, and the SMR of 153 for neoplasms among retirees in plant 32 should be noted and checked for consistency in later studies.

Although SMR's were not reported when there were fewer than five observed deaths yet each SMR was examined and tested for statistical significance. Statistically significant elevations in SMR's with fewer than five deaths appear in Tables 8 through 10 as (***). In each of these cases there was more than one death but less than five. These appear in Table 9 for lung cancer among actives at plant 33 and in Table 10 for all causes and circulatory diseases among retirees at plant 8 and for neoplasms among retirees at plant 26. Although these are based on few deaths they should be noted for further observation.

As can be seen in Table 11 the death rates for all causes combined is lower in the rubber industry than in the U.S. population for all ages up through age 64, although the differences are not statistically significant through age 49. After age 65 the rubber industry rates are higher than the U.S. rates for some age groups and lower for others. The comparison of the rates in Table 12 for circulatory diseases does not show any pattern with the rubber industry having higher rates than the U.S. for some age groups and lower rates for others. Table 13 which is for neoplasms shows a statistically significant difference in the rates for age group 70-74. In this case the rubber industry has a higher death rate than the U.S. population.

IV. SUMMARY AND CONCLUSION

The principal purpose of the 1977 Mortality Study has been to demonstrate the feasibility of conducting a mortality study on an annual basis as part of a health surveillance system and at the same time to report on that study within a reasonable amount of time. This has been accomplished. Some of the problems encountered in this first study of this type, such as obtaining race data, will be avoided in subsequent studies because the data will not need to be collected again for the vast majority of the population.

As mentioned before, the importance of an annual mortality study increases as time goes by because it provides valuable data for comparison and for observing trends or changes in the health of working populations over time. The function of studies such as this is to indicate what plants and disease groups particularly need further investigation with the ultimate goal being to recommend actions which remove hazards to the health of workers.

A final report on this study will be prepared by the end of 1978 which will include all 48 plants as well as further analyses of the 42 plants included here. Additional checks will be made on the quality of the data presented here, for example, checking for additional death certificates, checking on the correct identification of people for whom we have death certificates but who are not part of this report, and checking the accuracy of the nosology coding although samples of records checked in the past have indicated a high degree of accuracy. As mentioned earlier this study is in reality made up of two separate populations: actives and retirees. All 1977 actives, regardless of how long

they worked in a plant, were included in the study. Because a minimum length of service is required for retirement, the retirees all had to have at least ten years of service in a plant. This gives the two groups quite different exposure characteristics. For this reason we hope to continue the analysis of this data by looking at actives and retirees separately. This report separated on age (prior to 65 and 65+) which approximates the active/retiree separation, but because many people retire prior to reaching age 65 this is not as precise as we would like.

Other analyses planned for the next report will include length of service and race, neither of these variables being ready for use at this time. We also plan to group plants according to products to see if there are problems which are common to plants of one type. Individual company analyses will be done for the next report, as well. The final report on this study will also include analyses using other methods of standardizing for age. Instead of using only the U.S. population for comparison, populations based on smaller geographical areas may be used and the total rubber industry may be used as a comparison for specific companies or plants.

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TABLES

NOTE: In Tables 2-7 which follow, the number of observed and expected deaths for "all causes", "all neoplasms" and "all circulatory" which appears at the bottom of each table may not equal the sum of the observed and expected deaths for the individual diseases listed in the table. This is because the disease groups are not always mutually exclusive and because the bottom line may include more diseases than are listed in the tables.

TABLE 1

Distribution of Population and Deaths by Age and Sex

Age	Population			Deaths		
	Males	Females	Total	Males	Females	Total
15-19	510	87	597	0	1	1
20-24	5433	640	6073	10	1	11
25-29	8148	725	8873	9	0	9
30-34	7989	745	8734	8	1	9
35-39	5844	684	6528	8	1	9
40-44	4440	581	5021	11	1	12
45-49	4414	710	5124	24	1	25
50-54	5765	1006	6771	33	5	38
55-59	6182	1479	7661	74	10	84
60-64	5871	1544	7415	119	14	133
65-69	4697	1367	6064	180	23	203
70-74	3674	1108	4782	217	29	246
75-79	2482	669	3151	183	26	209
80-84	1487	375	1862	158	19	177
85+	704	136	840	94	17	111
Total	67640	11856	79496	1128	149	1277

TABLE 2

OBSERVED AND EXPECTED DEATHS AND SMR's FOR MAJOR DISEASE CATEGORIES
AMONG MALES FOR ALL PLANTS COMBINED

Cause of Death	ICDA Codes	Observed			Expected			SMR's		
		15-64	65-84	85+	15-64	65-84	85+	15-64	65-84	85+
Circulatory Diseases	390-458	137	411	58	174.80	401.65	67.10	78**	102	86
Neoplasms	140-239	74	175	13	89.27	147.56	11.23	83	119*	116
Respiratory Diseases	460-519	8	57	8	19.65	57.88	8.38	41**	98	95
Accidents, Poisonings, Violence	800-999	42	18	4	65.49	20.15	2.44	64**	89	--
Digestive Diseases	520-577	13	26	2	24.23	20.15	2.07	54*	129	--
Endocrine, Nutritional Diseases	240-279	5	17	2	6.88	13.05	1.59	73	130	--
Symptoms, Ill-defined Conditions	780-796	6	15	2	7.82	8.05	1.27	77	186*	--
Nervous System Diseases	320-389	5	5	0	3.80	4.63	0.32	132	108	--
Genitourinary Diseases	580-629	3	6	1	3.53	10.59	2.28	--	57	--
Infective Diseases	000-139	0	5	0	3.28	4.69	0.58	--	107	--
Blood, Blood-forming Organ Diseases	280-289	1	2	1	0.86	1.56	0.26	--	--	--
Congenital Anomalies	740-759	1	0	2	0.93	0.31	0.03	--	--	--
Mental Disorders	290-315	1	0	1	4.59	1.99	0.25	--	--	--
Musculo-Skeletal Diseases	710-738	0	1	0	0.78	1.10	0.13	--	--	--
All Causes Combined	000-999	296	738	94	406.15	693.97	98.01	73**	106	96

Note: The SMR's for Symptoms and Ill-defined Conditions are artificially inflated because missing death certificates for known deaths are included in this category temporarily until death certificates can be obtained and the deaths reclassified to another disease category.

* = Statistically significant at the 0.05 level of significance.
** = Statistically significant at the 0.01 level of significance.

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TABLE 3

OBSERVED AND EXPECTED DEATHS AND SMR's FOR NEOPLASMS
AMONG MALES FOR ALL PLANTS COMBINED

Cause of Death	ICDA Codes	Observed			Expected			SMR's		
		15-64	65-84	85+	15-64	65-84	85+	15-64	65-84	85+
Buccal Cavity, Pharynx	140-149	1	5	1	3.27	3.41	0.23	--	147	--
Digestive Organs, Peritoneum	150-159	18	48	5	21.52	41.14	3.44	84	117	145
Esophagus	150	3	4	1	2.88	3.34	0.19	--	--	--
Stomach	151	5	8	0	3.51	7.03	0.68	142	114	--
Large Intestine	153	6	19	2	6.79	15.11	1.35	88	126	--
Rectum	154	2	6	1	1.97	4.31	0.45	--	139	--
Liver	155	0	1	0	0.79	1.10	0.05	--	--	--
Pancreas	157	2	7	0	4.61	8.21	0.53	--	85	--
Peritoneum	158	0	2	0	0.20	0.25	0.01	--	--	--
Unspecified Digestive	159	0	1	1	0.11	0.29	0.04	--	--	--
Respiratory System	160-163	27	66	2	35.39	46.65	1.62	76	141**	--
Larynx	161	0	2	0	1.48	1.84	0.08	--	--	--
Trachea, Bronchus, Lung	162	25	64	2	33.41	44.23	1.50	75	145**	--
Other, Unspecified Respiratory	163	2	0	0	0.28	0.34	0.01	--	--	--
Bone, Skin, Breast	170-174	2	1	0	2.72	2.53	0.29	--	--	--
Genitourinary Organs	180-189	6	32	1	7.60	28.54	3.64	79	112	--
Prostate	185	4	19	1	2.94	19.37	2.73	--	98	--
Bladder	188	1	9	0	1.71	6.01	0.72	--	150	--
Other, Unspecified Urinary	189	1	4	0	2.31	2.88	0.16	--	--	--
Other, Unspecified Sites	190-199	8	11	2	9.17	11.61	0.82	87	95	--
Brain, Nervous System	191-192	2	1	0	3.05	1.82	0.03	--	--	--
Lymphatic, Hematopoietic	200-209	11	9	2	8.42	12.28	1.05	131	73	--
Lymphosarcoma	200	2	0	0	1.63	1.92	0.12	--	--	--
Multiple Myeloma	203	2	1	1	1.19	2.22	0.15	--	--	--
Leukemia	204-207	2	7	1	3.11	5.37	0.60	--	130	--
Lymphatic Leukemia	204	1	3	0	0.71	1.72	0.25	--	--	--
Myeloid Leukemia	205	0	4	1	1.70	2.27	0.21	--	--	--
Monocytic Leukemia	206	1	0	0	0.08	0.19	0.02	--	--	--
Other Lymphoid, Polycythemia Vera, Myelofibrosis	202,8,9	5	1	0	1.48	2.21	0.16	338**	--	--
Benign Neoplasms	210-228	0	1	0	0.40	0.41	0.04	--	--	--
Unspecified Neoplasms	230-239	1	2	0	0.79	0.97	0.11	--	--	--
All Neoplasms	140-239	74	175	13	89.27	147.56	11.23	83	119*	116

* = Statistically significant at the 0.05 level of significance.
** = Statistically significant at the 0.01 level of significance.

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TABLE 4

OBSERVED AND EXPECTED DEATHS AND SMR's FOR CIRCULATORY DISEASE
AMONG MALES FOR ALL PLANTS COMBINED

Cause of Death	ICDA Codes	Observed			Expected			SMR's		
		15-64	65-84	85+	15-64	65-84	85+	15-64	65-84	85+
Chronic Rheumatic Heart Disease	393-398	3	2	0	3.10	3.46	0.20	--	--	--
Hypertensive Disease	400-404	1	5	1	2.29	5.77	1.25	--	87	--
Ischemic Heart Disease	410-413	103	294	41	131.38	274.36	41.64	78*	107	98
Acute Myocardial Infarction	410	62	152	12	87.98	148.48	14.34	70**	102	84
Cerebrovascular Disease	430-438	14	70	10	18.17	71.15	14.79	77	98	68
All Circulatory Diseases	390-458	137	411	58	174.80	401.65	67.10	78**	102	86

* = Statistically significant at the 0.05 level of significance.

** = Statistically significant at the 0.01 level of significance.

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TABLE 5

OBSERVED AND EXPECTED DEATHS AND SMR's FOR MAJOR DISEASE CATEGORIES
AMONG FEMALES FOR ALL PLANTS COMBINED

Cause of Death	ICDA Codes	Observed			Expected			SMR's		
		15-64	65-84	85+	15-64	65-84	85+	15-64	65-84	85+
Circulatory Diseases	390-458	11	53	12	15.60	67.68	10.85	71	78	111
Neoplasms	140-239	10	27	2	15.08	22.42	1.17	66	120	--
Respiratory Diseases	460-519	3	3	1	1.91	5.05	0.82	--	--	--
Accidents, Violence, etc.	800-999	7	3	0	3.02	2.52	0.30	232*	--	--
Digestive Diseases	520-577	2	2	0	2.55	3.21	0.31	--	--	--
Endocrine, Nutritional Diseases	240-279	1	2	0	1.39	3.95	0.29	--	--	--
Symptoms, Ill-defined Conditions	780-796	1	3	0	0.68	1.17	0.18	--	--	--
Nervous System Diseases	320-389	0	0	0	--	--	--	--	--	--
Genitourinary Diseases	580-629	0	2	1	0.57	1.64	0.20	--	--	--
Infective Diseases	000-139	0	1	0	0.41	0.72	0.07	--	--	--
Blood, Blood-forming Organs	280-289	0	0	0	--	--	--	--	--	--
Congenital Anomalies	740-759	0	1	0	0.12	0.08	0.00	--	--	--
Mental Disorders	290-315	0	0	0	--	--	--	--	--	--
Musculoskeletal Diseases	710-738	0	0	1	0.25	0.42	0.02	--	--	--
Complications of Pregnancy	630-678	0	0	0	--	--	--	--	--	--
All Causes	000-999	35	97	17	42.60	110.36	14.40	82	88	118

* = Statistically significant at the 0.05 level of significance.

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TABLE 6

OBSERVED AND EXPECTED DEATHS AND SMR's FOR NEOPLASMS
AMONG FEMALES FOR ALL PLANTS COMBINED

Cause of Death	ICDA Codes	Observed			Expected			SMR's		
		15-64	64-84	85+	15-64	65-84	85+	15-64	65-84	85+
Digestive Organs, Peritoneum	150-159	1	9	0	3.20	7.39	0.46	--	122	--
Esophagus	150	0	1	0	0.18	0.24	0.02	--	--	--
Stomach	151	0	1	0	0.37	0.93	0.07	--	--	--
Large Intestine	153	0	4	0	1.39	3.35	0.22	--	--	--
Rectum	154	0	1	0	0.30	0.67	0.05	--	--	--
Gallbladder	156	0	1	0	0.16	0.47	0.02	--	--	--
Pancreas	157	1	1	0	0.65	1.45	0.07	--	--	--
Respiratory System	160-163	3	0	1	2.35	2.29	0.07	--	--	--
Trachea, Bronchus, Lung	162	3	0	1	2.25	2.18	0.07	--	--	--
Bone, Skin, Breast	170-174	4	6	1	3.84	3.96	0.20	--	152	--
Breast	174	4	6	1	3.53	3.56	0.16	--	169	--
Genitourinary Organs	180-189	0	5	0	2.63	3.69	0.17	--	136	--
Genital Organs	180-184	0	4	0	2.29	2.83	0.12	--	--	--
Cervic Uteri	180	0	1	0	0.62	0.53	0.02	--	--	--
Ovary, Fallopian Tube	183	0	3	0	1.15	1.28	0.05	--	--	--
Other Unspecified Urinary	189	0	1	0	0.21	0.41	0.02	--	--	--
Other, Unspecified Sites	190-199	2	3	0	1.47	2.39	0.13	--	--	--
Brain, Nervous System	191-192	1	0	0	0.43	0.36	0.00	--	--	--
Lymphatic, Hematopoietic	200-209,	0	3	0	1.12	2.13	0.10	--	--	--
Lymphosarcoma	200	0	1	0	0.23	0.38	0.02	--	--	--
Multiple Myeloma	203	0	1	0	0.20	0.41	0.02	--	--	--
Other Lymphoid, Polycythemia Vera Myelofibrosis	202,8-9	0	1	0	0.19	0.46	0.02	--	--	--
Benign Neoplasms	210-228	0	1	0	0.08	0.10	0.00	--	--	--
All Neoplasms	140-239	10	27	2	15.08	22.42	1.17	66	120	--

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TABLE 7

OBSERVED AND EXPECTED DEATHS AND SMR's FOR CIRCULATORY DISEASE
AMONG FEMALES FOR ALL PLANTS COMBINED

Cause of Death	ICDA Codes	Observed			Expected			SMR's		
		15-64	65-84	85+	15-64	65-84	85+	15-64	65-84	85+
Chronic Rheumatic Heart Disease	393-398	1	0	0	0.62	1.00	0.05	--	--	--
Hypertensive Disease	400-404	0	2	0	0.36	1.38	0.22	--	--	--
Ischemic Heart Disease	410-413	6	35	5	9.31	42.28	6.40	64	83	78
Acute Myocardial Infarction	410	3	22	1	5.64	20.23	1.86	--	109	--
Cerebrovascular Disease	430-438	3	10	6	3.10	15.61	2.72	--	64	221*
All Circulatory Diseases	390-458	12	53	12	15.60	67.68	10.85	77	78	111

* = Statistically significant at the 0.05 level of significance.

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TABLE 8

SMR's BY PLANT FOR MALES FOR SELECTED MAJOR DISEASE CATEGORIES

Plant	All Causes (000-999)			Circulatory (390-458)			Neoplasms (140-239)			Accidents (800-999)		
	15-64	65-84	85+	15-64	65-84	85+	15-64	65-84	85+	15-64	65-84	85+
1	72	109	--	95	93	--	--	122	--	--	--	--
2	--	--	--	--	--	--	--	--	--	--	--	--
3	101	--	--	--	--	--	--	--	--	--	--	--
4	76	100	--	--	98	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--	--	--	--
7	--	--	--	--	--	--	--	--	--	--	--	--
8	46**	118	--	77	104	--	--	--	--	--	--	--
9	--	79	--	--	--	--	--	--	--	--	--	--
10	139	91	--	151	--	--	--	222*	--	--	--	--
11	--	190	--	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--	--
13	--	--	--	--	--	--	--	--	--	--	--	--
14	--	--	--	--	--	--	--	--	--	--	--	--
15	--	--	--	--	--	--	--	--	--	--	--	--
16	--	--	--	--	--	--	--	--	--	--	--	--
17	--	--	--	--	--	--	--	--	--	--	--	--
18	57**	101	109	46**	97	98	97	112	109	--	--	--
19	--	--	--	--	--	--	--	--	--	--	--	--
20	--	--	--	--	--	--	--	--	--	--	--	--
21	94	--	--	--	--	--	--	--	--	--	--	--
22	--	--	--	--	--	--	--	--	--	--	--	--
23	79	71	178	--	70	--	--	--	--	--	--	--
24	73	135	--	--	114	--	166	130	--	--	--	--
25	--	--	--	--	--	--	--	--	--	--	--	--
26	118	108	--	130	145	--	--	--	--	--	--	--
27	--	--	--	--	--	--	--	--	--	--	--	--
28	--	--	--	--	--	--	--	--	--	--	--	--
29	--	--	--	--	--	--	--	--	--	--	--	--
30	--	--	--	--	--	--	--	--	--	--	--	--
31	--	--	--	--	--	--	--	--	--	--	--	--
32	107	91	--	145	95	--	--	--	--	--	--	--
33	--	302**	--	--	--	--	--	--	--	--	--	--
34	--	--	--	--	--	--	--	--	--	--	--	--
35	--	--	--	--	--	--	--	--	--	--	--	--
36	70	139	--	--	208**	--	--	--	--	--	--	--
37	--	--	--	--	--	--	--	--	--	--	--	--
38	--	--	--	--	--	--	--	--	--	--	--	--
39	67	81	--	--	69	--	--	96	--	--	--	--
40	--	--	--	--	--	--	--	--	--	--	--	--
41	86	117	--	56	82	--	94	186*	--	181	--	--
42	--	--	--	--	--	--	--	--	--	--	--	--
43	72	107	86	64	102	77	73	106	--	--	188	--
44	--	--	--	--	--	--	--	--	--	--	--	--
45	--	--	--	--	--	--	--	--	--	--	--	--
46	--	--	--	--	--	--	--	--	--	--	--	--
47	100	130	--	159	129	--	--	--	--	--	--	--
48	86	132**	165	90	138*	240**	--	172**	--	211	--	--
All Plants	73**	106	96	78**	102	86	83	119*	116	64**	89	--

* = Statistically significant at the 0.05 level of significance.

** = Statistically significant at the 0.01 level of significance.

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TABLE 9

SMR's BY PLANT FOR MALES FOR SELECTED CAUSES OF DEATH

Plant	Acute Myocardial Infarc. (410)			Cerebrovascular Disease (430-438)			Cancer: Trachea, Bronchus, Lung (162)		
	15-64	65-84	85+	15-64	65-84	85+	15-64	65-84	85+
1	105	73	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--
7	--	--	--	--	--	--	--	--	--
8	113	--	--	--	--	--	--	--	--
9	--	--	--	--	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--
13	--	--	--	--	--	--	--	--	--
14	--	--	--	--	--	--	--	--	--
15	--	--	--	--	--	--	--	--	--
16	--	--	--	--	--	--	--	--	--
17	--	--	--	--	--	--	--	--	--
18	--	102	--	--	87	115	--	186**	--
19	--	--	--	--	--	--	--	--	--
20	--	--	--	--	--	--	--	--	--
21	--	--	--	--	--	--	--	--	--
22	--	--	--	--	--	--	--	--	--
23	--	--	--	--	--	--	--	--	--
24	--	81	--	--	--	--	--	--	--
25	--	--	--	--	--	--	--	--	--
26	--	96	--	--	--	--	--	--	--
27	--	--	--	--	--	--	--	--	--
28	--	--	--	--	--	--	--	--	--
29	--	--	--	--	--	--	--	--	--
30	--	--	--	--	--	--	--	--	--
31	--	--	--	--	--	--	--	--	--
32	--	--	--	--	--	--	--	--	--
33	--	--	--	--	--	--	(***)	--	--
34	--	--	--	--	--	--	--	--	--
35	--	--	--	--	--	--	--	--	--
36	--	--	--	--	452**	--	--	--	--
37	--	--	--	--	--	--	--	--	--
38	--	--	--	--	--	--	--	--	--
39	--	--	--	--	--	--	--	--	--
40	--	--	--	--	--	--	--	--	--
41	--	--	--	--	--	--	--	226*	--
42	--	--	--	--	--	--	--	--	--
43	73	87	--	--	127	--	--	127	--
44	--	--	--	--	--	--	--	--	--
45	--	--	--	--	--	--	--	--	--
46	--	--	--	--	--	--	--	--	--
47	283**	231**	--	--	--	--	--	--	--
48	--	198**	--	--	112	--	--	145	--
All Plants	70**	102	84	77	98	68	75	145**	--

* = Statistically significant at the 0.05 level of significance.

** = Statistically significant at the 0.01 level of significance.

*** = Statistically significant at the 0.05 level of significance. SMR not reported because of less than five deaths.

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TABLE 10

SMR's BY PLANT FOR FEMALES FOR SELECTED MAJOR DISEASE CATEGORIES

Plant	All Causes (000-999) 15-64	65-84	85+	Circulatory (390-458) 15-64	65-84	85+	Neoplasms (140-239) 15-64	65-84	85+	Accidents (800-999) 15-64	64-85	85+
1	--	--	--	--	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--	--	--	--
7	--	--	--	--	--	--	--	--	--	--	--	--
8	--	(***)	--	--	(***)	--	--	--	--	--	--	--
9	--	--	--	--	--	--	--	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--	--
13	--	--	--	--	--	--	--	--	--	--	--	--
14	--	--	--	--	--	--	--	--	--	--	--	--
15	--	--	--	--	--	--	--	--	--	--	--	--
16	--	--	--	--	--	--	--	--	--	--	--	--
17	--	--	--	--	--	--	--	--	--	--	--	--
18	157	102	121	--	82	133	--	114	--	--	--	--
19	--	--	--	--	--	--	--	--	--	--	--	--
20	--	--	--	--	--	--	--	--	--	--	--	--
21	--	--	--	--	--	--	--	--	--	--	--	--
22	--	--	--	--	--	--	--	--	--	--	--	--
23	--	--	--	--	--	--	--	--	--	--	--	--
24	--	--	--	--	--	--	--	--	--	--	--	--
25	--	--	--	--	--	--	--	--	--	--	--	--
26	--	132	--	--	--	--	--	(***)	--	--	--	--
27	--	--	--	--	--	--	--	--	--	--	--	--
28	--	--	--	--	--	--	--	--	--	--	--	--
29	--	--	--	--	--	--	--	--	--	--	--	--
30	--	--	--	--	--	--	--	--	--	--	--	--
31	--	--	--	--	--	--	--	--	--	--	--	--
32	71	77	--	--	--	--	--	153	--	--	--	--
33	--	--	--	--	--	--	--	--	--	--	--	--
34	--	--	--	--	--	--	--	--	--	--	--	--
35	--	--	--	--	--	--	--	--	--	--	--	--
36	--	--	--	--	--	--	--	--	--	--	--	--
37	--	--	--	--	--	--	--	--	--	--	--	--
38	--	--	--	--	--	--	--	--	--	--	--	--
39	126	87	--	--	97	--	--	--	--	--	--	--
40	--	--	--	--	--	--	--	--	--	--	--	--
41	--	--	--	--	--	--	--	--	--	--	--	--
42	--	--	--	--	--	--	--	--	--	--	--	--
43	--	79	--	--	92	--	--	--	--	--	--	--
44	--	--	--	--	--	--	--	--	--	--	--	--
45	--	--	--	--	--	--	--	--	--	--	--	--
46	--	--	--	--	--	--	--	--	--	--	--	--
47	--	--	--	--	--	--	--	--	--	--	--	--
48	--	--	--	--	--	--	--	--	--	--	--	--
All Plants	82	88	118	71	78	111	66	120	--	232*	--	--

*** = Statistically significant at the 0.05 level of significance. SMR not reported because of less than five deaths.

* = Statistically significant at the 0.05 level of significance.

TABLE 11

COMPARISON OF MORTALITY RATES BETWEEN RUBBER INDUSTRY (ALL PLANTS COMBINED) AND U.S. POPULATION FOR ALL CAUSES OF DEATH AMONG MALES

Age	Study Population		Deaths Per 1000 Population	
	Person Years	No. of Deaths	Rubber Mortality Rate	U.S. Mortality Rate
15-19	426.1	0	0	1.473
20-24	4849.9	10	2.062	2.094
25-29	7608.7	9	1.183	1.999
30-34	7429.6	8	1.077	2.058
35-39	5357.8	8	1.493	2.765
40-44	4278.9	11	2.571	4.191
45-49	4398.5	24	5.456	6.670
50-54	5824.1	33	5.666	10.439 **
55-59	6065.4	74	12.200	16.151 *
60-64	5712.8	119	20,830	25.216 *
65-69	4507.3	180	39.935	36.373
70-74	3433.5	217	63.201	55.602
75-79	2299.4	183	79.586	82.589
80-84	1287.0	158	122.766	115.933
85+	557.7	94	168.549	175.726

Note: Calculation of person-years is explained in the appendix.

* = Statistically significant difference at the 0.05 level of significance.
** = Statistically significant difference at the 0.01 level of significance.

TABLE 12

COMPARISON OF MORTALITY RATES BETWEEN RUBBER INDUSTRY
(ALL PLANTS COMBINED) AND U.S. POPULATION
FOR ALL CIRCULATORY DEATHS AMONG MALES

	Study Population		Deaths Per 1000 Population	
Age	Person Years	No. of Deaths	Rubber Mortality Rate	U.S. Mortality Rate
15-19	426.1	0	0	0.043
20-24	4849.9	1	0.206	0.066
25-29	7608.7	1	0.131	0.117
30-34	7429.6	2	0.269	0.244
35-39	5357.8	1	0.187	0.623
40-44	4278.9	2	0.467	1.422
45-49	4398.5	15	3.410	2.746
50-54	5824.1	14	2.403	4.830 **
55-59	6065.4	40	6.595	7.971
60-64	5712.8	61	10.678	12.916
65-69	4507.3	90	19.968	19.432
70-74	3433.5	115	33.494	31.223
75-79	2299.4	108	46.969	48.987
80-84	1287.0	98	76.146	73.204
85+	557.7	58	103.999	120.295

Note: Calculation of person years is explained in the appendix.

** = Statistically significant difference at the 0.01 level of significance.

TABLE 13

COMPARISON OF MORTALITY RATES BETWEEN RUBBER INDUSTRY
(ALL PLANTS COMBINED) AND U.S. POPULATION
FOR ALL NEOPLASMS AMONG MALES

Age	Study Population		Deaths Per 1000 Population	
	Person Years	No. of Deaths	Rubber Mortality Rate	U.S. Mortality Rate
15-19	426.1	0	0	0.074
20-24	4849.9	1	0.206	0.096
25-29	7608.7	1	0.131	0.130
30-34	7429.6	0	0	0.188
35-39	5357.8	1	0.187	0.323
40-44	4278.9	4	0.935	0.655
45-49	4398.5	6	1.364	1.356
50-54	5824.1	10	1.717	2.437
55-59	6065.4	18	2.968	4.055
60-64	5712.8	33	5.777	6.493
65-69	4507.3	50	8.752	9.112
70-74	3433.5	60	17.475	12.834 *
75-79	2299.4	36	15.656	16.408
80-84	1287.0	29	22.533	19.183
85+	557.7	13	23.310	20.124

Note: Calculation of person-years is explained in the appendix.

* = Statistically significant difference at the 0.05 level of significance.

APPENDIX I

LIST OF INDIVIDUAL PLANTS

FIRESTONE

Akron
Albany
Bloomington
Decatur
Des Moines
Los Angeles
Memphis
Noblesville
Pottstown
Russellville
Salinas

GENERAL

Akron
Mayfield
Waco

GOODYEAR

Akron
Conshohocken
Cumberland
Danville
Freeport
Gadsden
Jackson
Lincoln
Los Angeles
Madisonville
Marysville
New Bedford
North Chicago
St. Mary's
Sun Prairie
Topeka

GOODYEAR (continued)

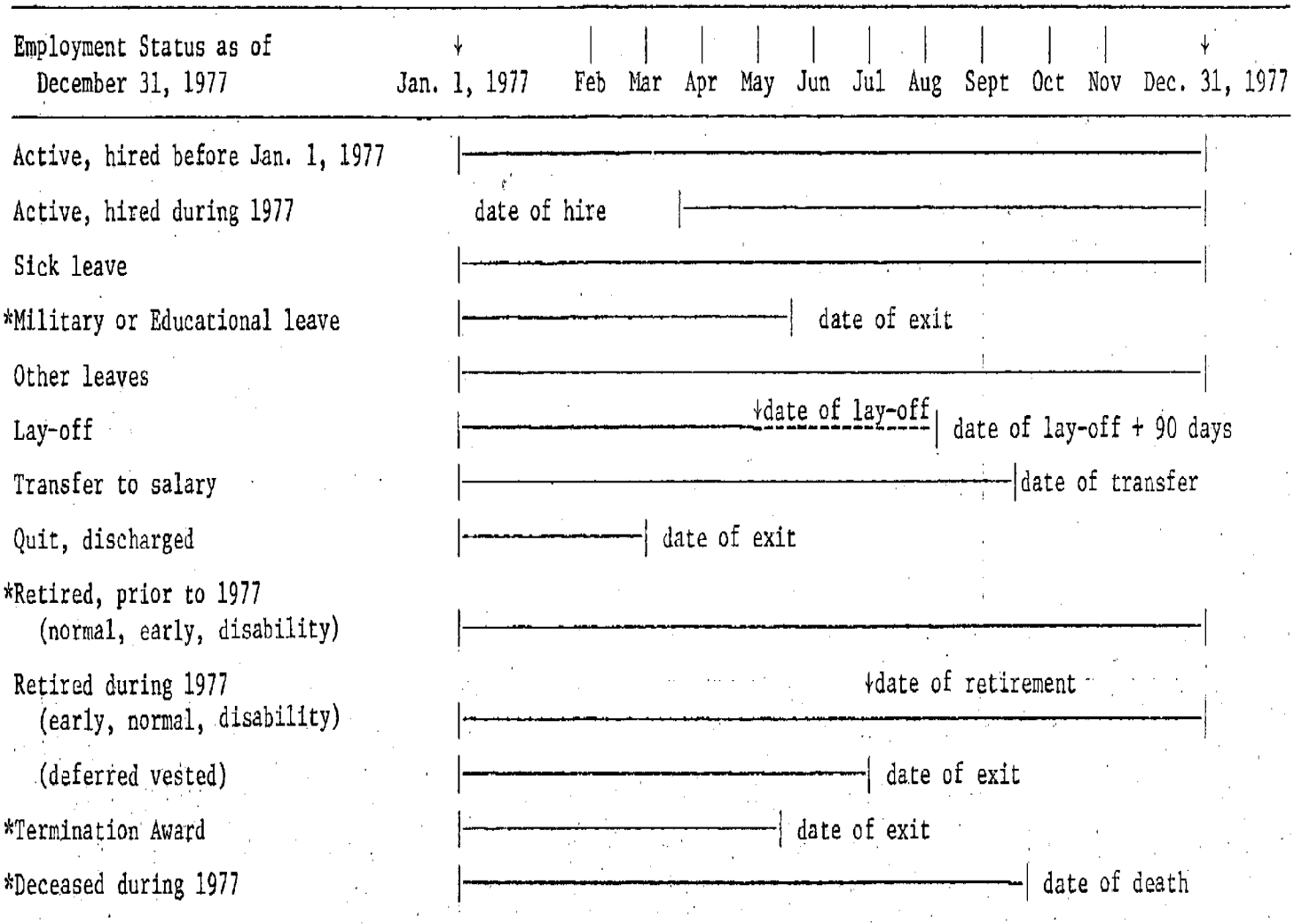
Tyler
Union City
Windsor

UNIROYAL

Chicago
Chicopee
Detroit
Eau Claire
Los Angeles
Masland
Mishawaka
Naugatuck Chem. & Syn.
Naugatuck Footwear
Opelika
Painesville
Port Clinton Coated Fabrics
Port Clinton Industrial Products
Scotts Bluff
Washington

APPENDIX II

DIAGRAM 1: TYPES OF EMPLOYEES INCLUDED IN THE STUDY POPULATION



*Employees who (1) began a military or educational leave before 1/1/77, (2) retired before 1/1/77 with deferred vested benefits but received no benefits in 1977, (3) received a termination award before 1/1/77 or (4) died before 1/1/77, were not included in the 1977 Mortality Study population.

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APPENDIX III

Data Analysis Program

Past mortality studies done at the OHSG have identified study populations at given points of time and then have followed these populations for a number of years (usually ten). This study has some unique features in that it is for only one year and people can enter the study at different times and can leave the study as well. Diagram 1 illustrates the categories of people who enter or leave during the year 1977. Because of these differences from past studies a new computer program was written to analyze the data.

Basic to a cohort mortality study is the population from which the deaths occur. The death rates in the comparison population are applied to this study population to determine the number of expected deaths. Yet when people enter and leave the study population it is difficult to determine exactly how many people are in the study population at any one time or even during an entire year. Including people for a whole year who either entered or left during the year results in overestimating the population and consequently overestimating the number of expected deaths and underestimating the SMR. An illustration may be helpful. Suppose that a person is hired on February 1, 1977 and quits on June 1, 1977. If he died after June 1 there is a good chance that we will never learn of his death. If his death cannot be included in the study then neither should he be included in the underlying study population. Yet, if he had died on May 25, 1977 his death would be recorded on company files, we would learn of it, and we would get a copy of the death certificate. It becomes clear then that he should be included in the study population

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for that portion of the year during which he worked and for which his death will be recorded in company records or in other words, for that portion for which he qualifies for life insurance. The concept of the person year was used to account for the number of people in the study population. Person years are the number of years (in this case, a fraction of a year) which a person contributes to the study population.

The task of the computer program is to calculate for each person that fraction of a year that he contributes to the total person years of the population. This is made more complex by virtue of the fact that expected deaths are calculated separately for each age/sex/race group so that the person years must be accumulated separately for each of these groups. The program that was written looks at each individual record. If a person was hired before January 1, 1977 and was still working on December 31, 1977 the program adds one person year to the appropriate age/sex/race category. If, however, a person was hired during the year or left other than for retirement or leave of absence the program calculates the fraction of the year he was eligible for life insurance and that fraction of a person year is added to the appropriate group. This entire process is complicated further by the fact that each person has a birthday during the year so that the person years of any individual may be divided between two different age groups. The end result is a population which has been broken down into 60 different age/sex/race groups with the appropriate number of person years in each group.

After the study population has been processed the expected number of deaths can be calculated. The number of deaths in each age/sex/race/disease group in the comparison population are read into the computer. These numbers are divided by the corresponding age/sex/race population

figures to get the comparison population death rates. These rates (for each age/sex/race/disease group) are multiplied by the study population figures to get the number of expected deaths for each age/sex/race/disease group. There were 78 different disease groups studied for this report resulting in a total of 4680 possible age/sex/race/disease groups.

Finally, the deaths in the study population are tabulated according to the same age/sex/race/disease groups. The SMR's can then be calculated for any combination of these groups by summing the observed and expected deaths across groups and then dividing the sum of the observed by the sum of the expected.