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A Follow-Up Study Of Mortality Among Workers At The Shell Denver Chemical Plant.

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A FOLLOW-UP STUDY OF MORTALITY AMONG WORKERS AT THE SHELL DENVER CHEMICAL PLANT

by

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A DISSERTATION

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ABSTRACT OF DISSERTATION
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Title A follow-up study of mortality among workers at the Shell Denver chemical plant

This retrospective follow-up study evaluated the mortality experience of 2,384 men and women, involved in the production of organochlorine, organophosphate and dibromochloropropane pesticides at a Shell chemical plant near Denver, Colorado. Vital status was ascertained as of January 1, 1991, for 95% of the cohort. Subjects were followed up for a median of 29 years, from 1952 to 1991. Overall and cause-specific standardized mortality ratios (SMRs) were computed using the United States ("US_SMR"), Colorado ("CO_SMR") or regional county ("R_SMR") populations for the combined and race/gender-specific cohorts, and for subgroups of white male subjects specified on the basis of payroll status (ever hourly, never hourly), broad work area and production unit.

For the total cohort, the CO_SMRs and R_SMRs for overall mortality, all cancer and heart disease were slightly elevated or as expected, whereas deficits were observed using US comparison rates. There were slight increases in hepatobiliary cancer (5/2.0; CO_SMR=249; 81-581) and

pneumonia deaths (20/13; CO_SMR=150; 92-232). White men, who formed 87% of the cohort, had a similar mortality pattern. White women had slight increases in deaths from lung cancer (3/1.2; CO_SMR=256; 53-747) and from accidents (4/1.2; CO_SMR=349; 95-893). Black men had a statistically significant excess of deaths from lymphopoietic cancer (3/0.23; CO_SMR=1318; 272-3853). There were no deaths among the black women.

Whereas the never hourly white men had fewer deaths than expected from all causes (CO_SMR=72; 58-89), the ever hourly group experienced a slight excess (CO_SMR=107; 96-119). Also, statistically significant excesses of deaths from hepatobiliary cancer (5/1.3; CO_SMR=386; 125-900) and from pneumonia (17/9.0; CO_SMR=189; 110-302) were observed among the ever hourly white men.

The hepatobiliary cancer deaths were limited to ever hourly workers in the Maintenance and Operations work areas who were hired in the 1950s. The increase was not concentrated in any particular pesticide production unit, nor was there an increase in SMRs with increasing duration of employment. Similarly, the pneumonia excess was limited to workers hired in the 1950s but was not concentrated in any work area and did not display a duration-response trend.

Abstract Approved by: Committee Chairman Elizabeth Delzell

Program Director

Date _____ Dean of Graduate School

DEDICATION

I dedicate this work to my wife, Afua Julie, my son, Kwame Ofori, and to all the staff of the Occupational Epidemiology unit, University of Alabama at Birmingham.

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LIST OF ABBREVIATIONS

CI	Confidence Interval
CNS	Central nervous system
CO_SMR	Standardized mortality ratio based on Colorado rates
DBCP	Dibromochloropropane
HWE	Healthy worker effect
NDI	National Death Index
OCMAP	Occupational Mortality Analysis Program
PY	Person-years of follow-up
R_SMR	Standardized mortality ratio based on the regional county (Adams, Arapaho, Denver, Douglas and Jefferson) rate
SES	Socio-economic status
SMR	Standardized mortality ratio
SSA	Social Security Administration
SSA-DMF	Social Security Administration Death Master File
US	United States of America
USDR	United States Death Rate (Monson's Program)
US_SMR	Standardized mortality ratio based on US rates

INTRODUCTION AND BACKGROUND

This report describes the mortality experience of employees of the Shell pesticide manufacturing facility (the Shell Denver plant) located at the Rocky Mountain Arsenal (RMA) near Denver, Colorado. The purpose of the study was to evaluate mortality patterns among the total plant work force and among subgroups of workers employed in specific work areas within the plant. The study is an update and expansion of earlier investigations of mortality among workers at the plant (1-3).

The RMA site

The RMA site was owned originally by the Unites States Army. The Army facilities had been used since 1942 to manufacture, test and/or demilitarize chemical and incendiary munitions, including nerve and mustard gases, and rocket fuels. For an unknown period in the 1940s, the Colorado Fuel and Iron Corporation manufactured chlorinated benzenes at the site. In 1946, the Julius Hyman company began production of a limited amount of pesticides, including dichloro-diphenyl-trichloroethane (DDT) and chlordane, at the site. In 1952, the Shell Oil Company purchased the Julius Hyman Company, including the pesticide manufacturing plant at the RMA site.

The RMA site is now a hazardous waste site on the National Priority List.

The Shell Denver plant

The Shell Denver plant occupied a total area of about 60 acres. It operated from 1952 to 1982, when it was closed by the Shell Oil Company. Numerous types of pesticides including organochlorines (aldrin, dieldrin), organophosphates (azodrin, vapona), planavin (nitralin) and dibromochloropropane (DBCP) were manufactured or formulated at the site. In terms of volume output, the major products were aldrin, azodrin, dieldrin and vapona. Azodrin and planavin operations, however, were more labor intensive compared to aldrin/dieldrin and all the other operations. Tables 1 and 2 list the production periods for each product and the major products, intermediates and raw materials per decade of production, respectively.

The plant work force consisted of hourly-paid employees, most of whom were production, maintenance and shipping workers; and monthly-paid (salaried) employees, most of whom were laboratory, engineering and administrative support personnel and supervisors, foremen and managers for the production, maintenance and shipping units. Worker turnover was high, particularly in the 1950s. Between about 275 and 720 Shell employees worked at the plant at any one time. The maximum work force size of 720 employees occurred in 1952.

The manufacturing process varied by product. In general, liquid raw materials arriving at the plant were emptied into storage tanks in the tank farm. They were then pumped through overhead pipes into smaller storage tanks in the production units. Solids were unloaded directly from railroad cars to storage areas in the production units. To initiate a production reaction, the production operators would pump the appropriate raw materials from the storage tanks to the reactor vessels. Solid raw materials, catalysts and other materials would be added. Operators monitored the progress of the reaction from a control room. Intermittently, the operators would open the "sampling hood" and take process samples to assess the completeness of the reaction. The samples were analyzed either in the production unit by the operators or in the laboratory. In subsequent steps in the production process, other chemicals would be added, and process intermediates would be extracted and recycled to the production lines. The final product, stripped of impurities, either would be drummed at the production unit or would be sent to central drumming for drumming and/or packaging. The packaged products would then be taken away by shippers to central stores.

Production, in general, occurred in batches. There were several production units spread throughout the facility in about 15 buildings. Almost all production units made more than one substance. Typically, several batches of a product

would be manufactured in a given unit for a period of time-up to several months. The machinery, vessels and pipes would then be cleaned and, depending on demand, another related or completely different type of product would be produced.

Exposure potential depended on the time period and area of employment. In general, exposure potential was higher in the early 1950s compared to later years. Changes in plant structure and in the production process, coupled with a much more rigorous enforcement of safety precautions, reduced exposure potential in later years.

There were few major accidents. One of the work units, the Dowtherm unit, burned down, and a chlorination reactor blew up in 1952 in the azodrin unit, killing one worker. There were no records of major fire outbreaks at the plant, and former employees could recall only a few, inconsequential fires.

Work activities associated with potentially high exposures consisted of cleaning up spills, repairing clogs and leaks and cleaning reactors during unit shut-downs or at the end of a specific batch process. Also, in early years deflaking intermediate products and drumming liquid products, in particular, were associated with potentially high exposures. Operators and drummers, by the nature of their work, were the work groups most consistently exposed to the specific chemicals and products they worked with. Maintenance personnel, especially pipefitters and instrumentmen, who

repaired clogs, major leaks and instrument failures, may have been exposed intermittently to high levels of multiple products. Also, laboratory staff may have been exposed intermittently to minimal amounts of multiple products. Utility and administrative staff were the least likely to have experienced any specific exposures.

An unknown number of Shell employees worked in the Army facilities for a period of time. There were no records identifying these persons. Also, although the Army units were distinct from the Shell facilities, it is possible that Shell employees were exposed irregularly to materials from the Army operations at the site.

Epidemiologic studies of Denver plant employees

Three major epidemiologic studies of the Denver plant workers have been conducted. Ditraglia et al., on behalf of NIOSH, conducted a mortality study of the Denver plant workers as part of an investigation of persons employed in four organochlorine pesticide manufacturing facilities (1). The cohort was limited to white men who had at least six months of employment before December 31, 1964, and included a total of 2,141 men from the four plants, 1,155 of whom were from the Shell Denver plant. These subjects were followed up through December 31, 1976. The standardized mortality ratios (SMRs) for all causes of death, all malignant neoplasms and cardiovascular disease were below the null value of 100 for subjects from each plant. There was an increase in deaths

due to pneumonia and "other respiratory diseases" for the Denver plant subcohort (SMR=212; 95% confidence interval=133-320), whereas a deficit was observed for workers at the other facilities.

Brown extended the follow-up period of the above study through December 31, 1987 (2). The investigation did not include any new subjects or any new work history information. Observed numbers of deaths from all causes and from all malignant neoplasms remained lower than or equal to the expected numbers for each plant. The SMR for pneumonia was elevated for Denver plant workers compared to US men (14 observed; SMR=173, 95-291). The increase was, however, reduced and was not statistically significant when the pneumonia rate of Denver plant workers was compared to either Colorado (SMR=136) or county (SMR=114) rates, suggesting that the apparent excess was due to confounding or to observational bias, rather than to occupational exposure.

Denver plant workers also had an increase in liver and biliary tract (hepatobiliary) cancer deaths (5 observed; SMR=393; 127-920). This association could not be interpreted as causal for several reasons. The association was of only moderate strength and was not observed at the other facilities. Furthermore, the five observed deaths comprised a heterogenous group of liver and biliary tract cancers unlikely to be of the same etiology, and there was no association between the excess of hepatobiliary cancer and

duration of employment. Exposure information was poorly assessed, and it was not clear whether the deceased cases were indeed exposed to aldrin or dieldrin, the specific pesticides suggested by Brown to be related to the excess. The extent of admixture of exposure effects with non-occupational causes of hepatobiliary cancer also was not assessed.

An increase in large intestine cancer among the Denver plant subcohort exposed to DBCP also was reported (3). This was balanced entirely by an unexplained, statistically significant deficit of the same cancer in the non-DBCP-exposed subcohort at the same facility and in the other plants as well. Such a pattern is consistent with systematic bias and/or random variation.

Lipshultz and co-workers evaluated testicular function among DBCP-exposed workers at the Denver plant and at another production facility (4). They did not find any significant difference in the median sperm count between the exposed and unexposed groups at the Denver plant. Counts for those with the most exposure time were, however, reduced in comparison to the unexposed group.

Other relevant information

DBCP, a soil fumigant nematocide, produces acute toxic injury to the testes, kidneys, intestine, liver and lymphoid organs in animals. Chronic exposure results in infertility,

testicular atrophy and stomach cancer in rats and mice (5-13). Azoospermia, infertility and testicular atrophy have been reported in persons occupationally exposed to DBCP (14-17). Ecologic analyses and case-control studies found no association between DBCP contamination of drinking water and stomach cancer (18). Nonetheless, DBCP is classified by the International Agency for Research on Cancer (IARC) as a possible carcinogen in humans (19).

Animal and experimental studies suggest that aldrin and dieldrin are carcinogenic in mice. Hepatocellular carcinoma and non-malignant hepatic tumors have been induced in mice (20,21) but not in rats (21-23). Aldrin and dieldrin also produce immunosuppression (24-26), acute renal necrosis and chronic nephritis in mice (27,28) and neuronal necrosis in the brain of rats (21). No effects on the pulmonary, gastrointestinal or hematological systems have been demonstrated (26).

In humans, reversible convulsive intoxication occurs after acute exposure to aldrin and dieldrin (29,30). There is insufficient information on the effects of chronic exposure, and no consensus has been reached on the effects of these compounds on human health. The IARC considers aldrin and dieldrin "not classifiable as to carcinogenicity" in humans (19). Several retrospective mortality studies of Dutch workers involved in the formulation and manufacture of organochlorine pesticides, including aldrin and dieldrin,

have yielded no conclusive evidence (31). Ribbens studied 232 subjects, selected from among workers at a pesticide plant in the Netherlands on the basis of high exposure to aldrin and dieldrin (31). Fewer cancers than expected were observed (9 observed/12 expected) in this cohort, and no liver cancer was found. These results do not indicate any specific carcinogenic activity of aldrin and dieldrin among manufacturing plant workers. The study size was, however, small. Other studies of the full cohort of workers at the same plant did not find any cancer excesses related to aldrin and dieldrin or any other effects on the health of the workers (29,30,32).

De Jong recently updated the Dutch studies (33). Exposure levels were estimated quantitatively. The average total intake of aldrin and dieldrin was 737 mg, with individual total intake ranging from 11 to 7,755 mg. No meaningful excess of any specific cancer, nor of any other major category of disease, was found. One liver cancer death was observed, compared to 0.6 expected.

Certain types of cancer, including Hodgkin's disease, multiple myeloma, leukemia and cancers of the brain, lung, ovary, testis and prostate, have been observed in excess numbers among farmers and farm workers (34-40). Farmers are known to be exposed to many farm chemicals in addition to organochlorines and organophosphates. No definitive study of farmers has linked any of these cancers specifically to any

of the major products (aldrin, dieldrin, endrin, vapona, azodrin) produced at the Denver plant.

Anecdotal evidence indicates that a number of heavy metals and vinyl chloride were used at the plant. Also, benzene was used as a solvent in the early 1950s. There is no information on the amounts of these chemicals used at the plant or on the number of workers with potential exposure. These chemicals are known to affect health adversely. Benzene is leukemogenic (41–45), and vinyl chloride has been linked to hepatic angiosarcomas (46).

OBJECTIVES

The specific objectives of the study were:

(1) to evaluate the overall and cause-specific mortality rates of workers at the Denver plant relative to the rates of the general populations of US, of Colorado and of nearby counties (Adams, Arapaho, Denver, Douglas and Jefferson);

(2) to determine if overall and disease-specific mortality patterns vary by subject characteristics such as age, calendar time, period of hire, duration of employment, time since hire and payroll status (ever hourly or never hourly); and

(3) to examine the relation between work areas within the plant and cause-specific mortality patterns.

METHODS

This retrospective follow-up study included 2,140 men and 244 women. The subjects were followed up from January 1, 1952, to January 1, 1991. The outcome of interest was mortality from various causes of death.

Cohort identification

The study included all subjects meeting the following eligibility criteria:

a) ever employed by Shell at the Denver plant

b) known employment dates

c) known social security number

d) known birth date.

Subjects were identified through a review of several sets of plant records and of lists compiled during previous epidemiologic investigations. Two computerized files, compiled by Dr. Patricia Buffler (the Buffler files) during a feasibility study, were used as the primary data source for initial subject identification. These files contained for each of 2,445 subjects the employee's name, the social security number, the Shell employee number, the birth date, the hire and termination dates, the payroll classification as salaried or hourly, and the DBCP exposure status.

Records from these files were verified with plant and corporate records to ensure that cohort identification was complete and that data were accurate. The following data sources were particularly useful.

Service termination records: These contained information on subject identifiers; on birth, hire and termination dates; and on first and last job title. They were available for 99% of the cohort.

Employee service records: These contained subject identifiers; birth, hire and equated dates; and sequential job changes up to 1977. They were available for 46% of the cohort.

"DBCP register": This consisted of a list of names, with information on social security number, DBCP exposure status and job title. DBCP production covered the period 1955–1976 only. The information had been compiled by a Shell industrial hygienist for the NIOSH DBCP register. In general, the criterion for inclusion in the DBCP register was a minimum of 30 person-days, not necessarily continuous, of potential DBCP exposure.

"Ergotopology sheets": These sheets had been compiled from hard copy plant records by a private consultant for Shell. They included subject identifiers, hire and termination dates and vital status information.

Errors in the Buffler files (about 1% for social security number and 5% for the birth, hire and termination

dates) were systematically identified and corrected. The corrected data set was edited for invalid entries, duplicate observations and logical inconsistencies. Three persons not previously identified in the files were added. Sixty-four persons were excluded because they were duplicate observations (N=6), they had terminated employment before 1952 and therefore had never been a Shell employee (N=15), or they did not meet the other cohort eligibility criteria (N=43).

Race information was lacking for about 11% of the cohort. On the basis of former employees' estimate of the race composition of the total work force and on the basis of the distribution of those with known race (96% white), these persons were classified as white for the purpose of data analyses.

Work histories

The available records were not sufficient for classifying all subjects by employment in specific production units or by exposure to specific substances. Instead, subjects for whom information was adequate were classified according to broad work area and production unit as described below.

Work history abstracts: For each subject, we abstracted information on sequential changes in broad work area (Production Operations ["Operations"], Maintenance, Shipping, Utilities, Laboratories, Engineering, Industrial Hygiene and

Safety, Administration) and in job title from several sources. Employee service records, the principal source of information on job changes between and within broad work areas at the plant, were available for 46% of the cohort. For the remaining 54%, work area and job changes were reconstructed using service termination sheets, seniority lists, organizational charts, monthly termination letters and employee movement registers. Appendix A briefly describes each of these sources and includes the procedures manual used for this aspect of work history reconstruction.

Production unit data: We obtained information on the number of weeks and hours per year spent in major production units (i.e., units making specific end products or intermediates, such as Aldrin/BCH/Dieldrin, Azodrin, Planavin, etc. or providing support services) by Operations, Maintenance and Shipping workers from "manning charts" and from "time sheet summaries." These two data sources, described below, differed in the time periods covered and the subjects included.

The manning charts were available for 1965-1982. They indicated the specific production unit to which a subject was assigned on a weekly basis. Most subjects with manning chart records were hourly production workers. The unit assignments of maintenance and shipping personnel or of salaried employees were indicated only occasionally. The charts contained the subject's last name and first initial only.

Thus, some manning chart records could not be linked to other records of the cohort members. Such records, a total of four unique names and 16 weeks of work, were excluded.

The time sheet summaries covered the periods 1957-1968 and 1970-1977. The summaries were intended to include all subjects who spent at least one hour in a production unit during these time periods. The summaries were not compiled from the original time sheets by UAB staff. Rather, they were available in the form of computer printouts from Shell records. No documentation was available on procedures used to develop the printouts, and the original hard-copy time sheets from which the summaries were compiled were not available for verification of the accuracy of the data.

Three hundred sixty-one subjects (15% of the cohort) had all 3 sets of work history information; 51 (2%) had broad work area and manning chart data only; 465 (20%) had broad work area and time sheet data only; and the remaining 1,507 (63%) had broad work area data only.

Vital status ascertainment

Vital status ascertainment consisted of several steps (Figure 1). Decedents were identified primarily through a search of Shell records, the National Death Index (NDI), the Social Security Administration Death Master Files (SSA-DMF) and related national/state death data files. Shell records identified deaths that occurred mainly among active employees and pensioners. The SSA-DMF identified subjects with a death

claim filed from 1952 to 1991. The NDI identified deaths during the period 1979 through 1990. The names of all subjects not identified as deceased were submitted to the Colorado Division of Motor Vehicles (DMV) to obtain their most recent activity report (issue of a driver's license or a citation for a motor traffic offence). The names of subjects with no DMV activity date beyond 1979 and a 10% sample of subjects with an activity in or after 1979 were submitted to a credit bureau (TRW) to determine their most recent credit activity date and to identify their current address.

All subjects whose vital status remained uncertain after the credit bureau search were traced individually. UAB staff attempted to contact such subjects or their next of kin by mail and/or by phone. Also, a list of these subjects was reviewed by a group of former Shell employees to obtain further vital status information.

Death certificate retrieval and coding

We attempted to obtain a copy of the death certificate of decedents identified using the above procedures from Shell or from state bureaus of vital records. A total of 14 death certificates could not be retrieved because the subject died abroad (N=2), because the death state was unknown (N=7), or because the certificate could not be found by the appropriate state bureau of vital records (N=5). For a decedent having a death certificate, a nosologist coded the underlying cause

of death using the Ninth Revision of the International Classification of Diseases (ICD 9) and coding rules in effect at the time of death. These codes were converted to the rubric of the Eighth Revision of the International Classification of Diseases (ICD 8) for data analysis.

Data analysis

The SMR (the ratio of observed to expected number of deaths, multiplied by 100) was used as the primary measure of association in comparing the mortality experience of each race and gender subgroup of the cohort with that of the US ("US_SMRs"), Colorado ("CO_SMRs") or regional county ("R_SMRs") general population. The expected number of deaths for each cause of death was obtained by multiplying the gender-, race-, age-, calendar time-specific mortality rates of the specified comparison population by the corresponding number of person-years (PY) of follow-up of the study group and summing across all the stratifying variables. PY were accumulated starting at the beginning of the follow-up period and ending on the study's common closing date of January 1, 1991, on the date of death or on the date of loss to follow-up, whichever was earliest. For the overall cohort, follow-up began on January 1, 1952, or on the date of hire, whichever was later.

Analyses based on the status of DBCP exposure were limited to subjects who worked in 1955-1976, the period of DBCP production at the plant. Follow-up began on January 1,

1955, or on the employee's hire date, whichever was later; follow-up ended as for the general cohort. Similarly, for the broad work area analyses, follow-up began an employee's first day of work in the specific area or January 1, 1952, whichever was later, and ended as above. Separate production unit-specific analyses were done for subjects with production units specified on the basis of manning chart data and for subjects with production unit specified on the basis of time sheet summary data. For analyses based on the manning charts data, follow-up began on January 1, 1965, or on the subject's earliest date of assignment to the specified manning chart production unit, whichever was later, and ended as above. Similarly, for analyses based on time sheet summary data, follow-up began on January 1, 1957, or on the subject's earliest date of assignment to the specified time sheet production unit, whichever was later, and ended as above.

Monson's standard program (USDR) was used to compute SMRs when the comparison group was the US general population (47), and the Occupational Mortality Analysis Program (OCMAP) was used when the comparison group was the Colorado or the regional population (48). The regional population consisted of the populations of Adams, Arapaho, Denver, Douglas and Jefferson counties. In analyses using the OCMAP program, the period of observation was restricted to 1960 through 1990 for all causes and for non-cancer deaths because rates for non-cancer causes of death were not available

before 1960. For cancer deaths, the period of observation was 1952 through 1990. Similar results were obtained from the two programs in analyses using the US general population. Exact 95% confidence intervals (CIs) of the SMRs and the corresponding p-values were calculated assuming a Poisson distribution of the observed number of deaths. Mantel-Haenszel rate ratios were computed in analyses using an internal referent group (49).

RESULTS

Cohort characteristics

Of the 2,384 employees included in the study, 90% were men, and 10% were women. Eighty-seven percent were white men, 10% were white women, and 3% were black men. There were only 10 black women, less than 1% of the cohort.

About 71% of white men and 81% of black men had worked in an hourly job (table 3). Most women, however, had never been hourly (91% for white women, 70% for black women). The Denver plant was closed in 1982, so there were no active subjects as of the study end date. Seventy-nine percent of the cohort either had been laid off or had resigned their positions, 10% had been transferred to other Shell facilities, 9% had been pensioned, and 2% had died before 1982 while actively employed. As of January 1, 1991, 1,764 subjects (74%) were presumed living, and 496 (21%) were identified as deceased. The vital status of 124 subjects (5%) could not be determined. A death certificate was retrieved for 482 (97%) of the decedents.

The median age at hire of the subjects was 26 years (table 4). About 25% of cohort was hired before 1952, the year in which Shell acquired the plant. Another 25% was hired between 1952 and 1954. Most subjects were short-term

workers, with a median duration of employment of 2 years for the overall cohort. Only 33% of the cohort had worked for 5 or more years. About 48% of the cohort was followed up for at least 30 years. The cohort was relatively young, with 79% of the total PY of follow-up accrued before the 55th birthday. The distribution of whites by age and year of hire, duration of employment and years of follow-up was similar to that of the total cohort. Blacks were hired mostly in the 1960s and in the 1970s.

The payroll status distribution of white male cohort members differed by year of hire (table 5). Overall, about 71% of white men had ever worked in hourly jobs, as opposed to 29% who had always worked in salaried positions. However, among white men hired in the 1940s only 36% had been hourly, whereas 64% were never hourly.

General mortality patterns

There were systematic differences in the SMRs computed using the US population to derive the expected numbers (table 6) as compared to the SMRs based on the state rates (table 7) or regional rates (table 8). In general, the Colorado and regional rates for all causes, all cancers and heart disease were similar to one another but lower than the corresponding US rates. In contrast, the state and regional rates for non-malignant respiratory diseases were higher than the US rates. Accordingly, whereas the overall cohort had almost as many deaths from all causes combined as expected based on the

state rates (465 observed/473 expected; CO_SMR=98, 95% CI=90-108) or on regional rates (465/440; R_SMR=106, 96-116), there was a statistically significant 13% deficit of overall mortality when US rates were used to compute expected numbers. This deficit based on the US rates was present both when the entire 1952-1991 follow-up period was considered (496/569; US_SMR=87, 80-95) (table 6) and when the analysis was restricted to the period 1960-1991, covered by the state and regional rates (465/528; US_SMR=88, 80-96)(Appendix B). Subsequent descriptions of results focus on comparisons of the cohort with state, rather than regional or US, populations.

The overall cancer mortality rate of the cohort was similar to the Colorado rate (113/106; CO_SMR=106, 88-128) (table 7). There were minimal increases in deaths from lymphopoietic cancer (16/11; CO_SMR=146, 83-237) and from hepatobiliary cancer (5/2.0; CO_SMR=249, 81-581), neither of which was statistically significant. There were nearly as many deaths from lung cancer as expected based on state rates (30/32; CO_SMR=94, 63-134).

For the overall cohort, the non-malignant respiratory disease SMR was close to the null value of 100 (46/43; CO_SMR=107, 78-143). However, there was a small excess of pneumonia deaths (20/13; CO_SMR=150, 92-232).

The mortality of white men was similar to that of the total cohort. Black men experienced an increase in overall

and cancer deaths, due entirely to a statistically significant increase in deaths from lymphopoietic cancer (3/0.23; CO_SMR=1318, 272-3853). This cancer category included 2 deaths from multiple myeloma and one death from lymphosarcoma (table 9).

White women had similar numbers of observed and expected deaths from all causes combined, regardless of the comparison population (23/21; CO_SMR=111, 70-167)(tables 6-8). There was a slight increase in deaths from lung cancer (3/1.2; CO_SMR=256, 53-747) and from accidents (4/1.2; CO_SMR=349, 95-894), neither of which was statistically significant (table 7). There were no observed deaths among the 10 black women in the cohort (expected number, 0.57).

All further analyses were restricted to white male subjects. Table 10 displays mortality results for white men, with and without the assumption that the subjects lost to follow-up were alive. In general, the SMRs computed with subjects lost to follow-up being withdrawn on their work termination date were higher than the SMRs with subjects treated as alive. However, the differences were small. The true SMRs probably lie between the two sets of results.

Never hourly subjects had a statistically significant 28% deficit of overall deaths compared to Colorado white men (CO_SMR=72, 58-89) (table 11). In contrast, the ever hourly group had nearly as many deaths from all causes as expected (CO_SMR=107, 96-119) (table 12). All of the hepatobiliary

cancer deaths seen in the overall cohort occurred in the ever hourly group (5/1.3; CO_SMR=386, 125-900). Similarly, the excess of deaths from pneumonia was limited to the ever hourly group, which had a statistically significantly elevated SMR, regardless of the comparison population. The CO_SMR for pneumonia among the ever hourly group was 189 (110-302), based on 17 observed and 9.0 expected deaths.

Tables 13 and 14 display the characteristics of the hepatobiliary cancer and pneumonia decedents, respectively. The five hepatobiliary cancer cases consisted of 1 case of gall bladder cancer (confirmed by medical records), 2 confirmed cases of biliary tract cancer, 1 case of unconfirmed hepatobiliary cancer and 1 case of unconfirmed diffuse hepatoma (table 13). All five were identified previously by Brown (2,3). The 21 pneumonia decedents (table 14) were all white men. Seven pneumonia decedents were identified in the present investigation but not in the study by Brown (2,3). An increase in pneumonia deaths occurred both among subjects who were actively working or within 10 years since terminating employment (9/3.4; CO_SMR=262, 120-479) and among those with 10+ years since termination (11/9.0; CO_SMR=122, 61-129).

Subsequent analyses focused on the ever hourly white men. Tables 15 and 16 display observed/expected numbers of deaths, US_SMRs and CO_SMRs by cause of death and by four categories of employment duration (<1, 1-4, 5-9 and 10+

years). There was no consistent pattern of increasing or decreasing US_SMR or CO_SMRs across categories of employment duration for any cause of death. In general, the SMRs of men with <10 years of employment were higher than the SMRs of men who worked for 10+ years. For example, the CO_SMR for all causes was 119 (104-134) for the group with <10 years and was 84 (68-104) for the group with 10+ years. The corresponding CO_SMRs for all cancers were 111 (83-146) and 104 (67-155) respectively. However, for pneumonia an excess was present both among subjects with <10 years (CO_SMR=167, 76-316;) and among subjects with 10+ years (CO_SMR=216, 93-426). All emphysema deaths occurred among workers with less than 10 years of employment (8/3.3; CO_SMR=245, 106-484). No hepatobiliary cancer death was observed among the subgroup with 5-9 years duration of employment, whereas each of the other subgroups had more than expected deaths.

Most of the deaths among the hourly white men occurred among subjects hired before 1960 (tables 17 and 18). A statistically significant excess of hepatobiliary cancer deaths was observed in the latter subcohort (5/1.2; CO_SMR=427, 139-997). There was a statistically significant increase in pneumonia deaths among the subcohort hired before 1960 (17/8.5; CO_SMR=200, 116-320). No pneumonia death was observed among the subcohort hired after 1960 compared to 0.62 expected. The difference in the pneumonia SMRs between the subcohort hired before and after 1960 was not

statistically significant (P=0.52). Most of the deaths in the cohort occurred in or after the 1970s and 20 or more years after hire. Deaths from emphysema, unlike most of the other diseases, occurred mainly within 10-19 years after hire.

DBCP subcohort

Tables 19-21 show the employment characteristics and mortality patterns of white men classified as exposed or unexposed to DBCP, using the previously described DBCP register. Among the ever hourly subjects, the unexposed group was slightly younger, was hired in later years and worked for a shorter period of time compared to the exposed group. Both groups were followed up for a comparable period of time.

The ever hourly DBCP-exposed group had a 13% deficit of deaths from all causes when compared to the Colorado population (103/119; CO_SMR=87, 71-105) (table 21). There were almost as many observed deaths as expected among the ever hourly unexposed cohort regardless of the comparison group. Both the DBCP-exposed and the unexposed subjects had slightly more cancer deaths than expected based on the Colorado population. The DBCP-exposed cohort had only a small increase in digestive cancer deaths (9/6.6; CO_SMR=137, 63-259), due to slightly more than expected deaths from colon cancer (5/2.2; CO_SMR=226, 73-527) and from hepatobiliary cancer (2/0.47; CO_SMR=422, 51-1525). None of these

increases was statistically significant. The unexposed cohort had only 2 observed compared to 4.0 expected digestive cancer deaths. Slight increases in pneumonia deaths occurred both among the DBCP-exposed and the unexposed groups.

Broad work areas

Most white male subjects had worked in hourly positions in the Maintenance and Operations areas (tables 22 and 23). The percent of subjects who had worked in only one area was 68% for the ever hourly and 92% for the never hourly groups. The median years spent in a work area varied by payroll status, with ever hourly subjects generally having spent fewer years in each area than never hourly subjects.

Table 24 summarizes the mortality patterns of all white male ever hourly and never hourly subjects combined, by work area, and tables 25-32 present detailed results. For workers in Shipping, Laboratories, Engineering, Industrial Hygiene/Safety and Administration, the observed number of deaths from all causes was lower than the expected number derived from Colorado comparison rates. These deficits were due, in large part, to fewer than expected deaths from heart disease and from external causes. The overall mortality rates of subjects in Operations and in Maintenance were similar to the Colorado rates. However, Operations and Maintenance workers had more than expected deaths from hepatobiliary cancer and from pneumonia, as discussed later. Utilities workers had a 21% increase in deaths from all

causes, based on 47 observed versus 39 expected deaths. The increase was due to more than expected deaths from heart disease (16/12; CO_SMR=137, 79-223) and from non-malignant respiratory disease (8/4.0; CO_SMR=201, 87-397).

The increase in hepatobiliary cancer deaths seen in the overall cohort was concentrated among subjects who had worked in Maintenance (4/0.90; CO_SMR= 446, 121-1141) or in Operations (2/0.80; CO_SMR=328, 39-1171), with one decedent having worked in both work areas. The increase in hepatobiliary cancer deaths in Maintenance workers was statistically significant, whereas the increase among the Operations workers was not.

The excess of pneumonia in the overall cohort was not concentrated in any particular area. Maintenance workers, however, were the only group with a statistically significant increase in this cause of death (13/6.6; CO_SMR=197, 105-337).

Whereas 1,330 (90%) of all ever hourly workers had worked in either Maintenance or Operations, 463 (77%) of the never hourly subjects had not worked in either of these areas (tables 33 and 34). The never hourly group was, therefore, excluded from mortality analyses by mutually exclusive work area category (table 35). There was a deficit of deaths from all causes among ever hourly white men who worked in both Maintenance and Operations (58/65; CO_SMR=90, 68-116) or in Maintenance but not in Operations (162/185; CO_SMR=88,

75-102), whereas a slight excess was present among ever hourly subjects who had worked in Operations but not in Maintenance (93/89; CO_SMR=104, 84-128) and among ever hourly subjects who had never worked in Operations or in Maintenance (50/42; CO_SMR=118, 88-156). For all cancer deaths, differences between observed and expected numbers were unremarkable for all of the work area categories, with the exception of the group "ever in Operations, never in Maintenance," which had a 28% deficit of cancer mortality (15/21; CO_SMR=72, 40-119). Three of the five hepatobiliary cancer decedents had worked only in Maintenance, one had worked only in Operations, and one had worked in both areas. The SMR for pneumonia was elevated among subjects who had worked in Maintenance only (9/4.1; CO_SMR=219, 100-416), in both Maintenance and Operations (5/1.2; CO_SMR=403, 130-940), and in neither Maintenance nor Operations (2/0.88; CO_SMR=228; 26-825). The Mantel-Haenszel rate ratios for pneumonia using the ever hourly subjects who never worked in either Maintenance or Operations as the internal referent group were 1.8 (0.35-9.6) for subjects who had worked in both Maintenance and Operations, 1.0 (0.22-4.7) for subjects who had worked in Maintenance only and 0.42 (0.06-3.1) for subjects who had worked in Operations only.

Manning chart production units

Only 412 subjects (17% of the total cohort) had manning chart records. These subjects were hourly workers, most of

whom had worked in Operations during the time period covered by the manning charts. Among subjects who worked in the same time period and who did not have manning chart data, 375 (59%) were never hourly, and 260 (41%) were hourly workers in Utilities, Laboratories, Administration and Maintenance.

Subjects with manning chart records had worked in a total of 42 production units and in a median of 8 units per subject during the period 1965-1982. Of the four specific units having at least 200 subjects, Azodrin (N white men=261) was the most frequently assigned, followed by Aldrin/BCH/Dieldrin (N=221), Planavin (N=215) and Maintenance (N=205) (tables 36 and 37). There was considerable overlap in the subjects included in each group. For instance, each subject had worked in a median of 3 of the 5 most frequently assigned production-related units. Similarly only 26 (12%) of the 221 white male subjects who had worked in Aldrin/BCH/ Dieldrin had never worked in Planavin or Azodrin. Mutually exclusive manning chart production unit analyses were, therefore, not done.

The mortality patterns of subjects with manning chart data were similar to the patterns of subjects who did not have such data but who worked in the plant during the same period (table 38). Both groups experienced a deficit of deaths from all causes of death and had cancer rates similar to the Colorado general population rate. Tables 39 and 40 display observed and expected numbers of deaths in the most

frequently assigned non-mutually exclusive production units. Because the numbers of deaths from specific causes in each group were small and because of the considerable overlap among the subjects in the various groups, the results were not particularly informative. However, there were no striking mortality excesses or deficits in any of the groups.

Time sheet production units

Time sheet summary records were available for 826 subjects, 35% of the overall cohort. Most subjects with time sheet records worked in the Aldrin/BCH/Dieldrin, the Nemagon (DBCP) or the Azodrin units (tables 41 and 42). Subjects without time sheet records were primarily never hourly workers or hourly workers from Utilities, Administration and Maintenance.

Subjects with time sheet records had a deficit of deaths from all causes (142/161; CO_SMR=88, 74-104), due in part to deficits of deaths from heart disease (41/45), cerebrovascular disease (2/7.4) and external causes (13/23) (table 43). The numbers of observed and expected cancer deaths were equal (33/33). However, there were slight increases in deaths from hepatobiliary cancer (2/0.62), colon cancer (7/2.9) and pneumonia (8/4.9), each of which was based on small numbers and was not statistically significant. None of these excesses was concentrated in any specific production unit (table 44). The mortality patterns of subjects without time sheet summary data were unremarkable.

DISCUSSION

This study evaluated the mortality experience of Shell chemical plant workers to determine if there were any employment-related associations with specific causes of death, particularly hepatobiliary cancer and pneumonia. Compared to the Colorado population, there were nearly as many deaths as expected from all causes, from all cancer combined and from heart disease. Lower than expected mortality rates were found for cerebrovascular disease and for external causes of death, whereas small to moderate excesses of deaths from pneumonia were observed. There were only 5 observed compared to 2.0 expected deaths from hepatobiliary cancer, a difference that was not statistically significant.

The major strengths of the study derive from its size, the use of all available work history information, the objective nature of the plant records and the use of the retrospective follow-up design. In spite of its relatively small size, the study is the largest of all the epidemiologic investigations of workers involved in the manufacture of aldrin or dieldrin (1-3, 29-33). It expands the previous NIOSH studies of the Denver cohort (1-3) and adds 31,344 PY of follow-up to the Brown study (2,3). It had sufficient

statistical power to detect moderate increases even in rare forms of cancer, such as hepatobiliary cancer, in the cohort as a whole. The use of all available work history information, in contrast to the NIOSH studies, makes it possible to draw meaningful inferences about mortality patterns by broad work area. The objective nature of plant records reduced the possibility of differential misclassification of subjects by work area. Finally, the use of a follow-up study design and inclusion of all persons meeting the eligibility criteria minimized selection bias in assembling the total cohort.

The study had several limitations. Although all subjects had some broad work area information, detailed information on production unit assignments, available only from the manning charts and time sheet summaries, was lacking for 63% of the cohort. Also, neither the manning charts nor time sheet summaries covered the period of the early 1950s, when exposure at the plant was maximal, nor did the manning chart data cover hourly subjects assigned to daily rather than weekly tasks within the production areas. The considerable overlap among subjects in each production unit, coupled with the small numbers, made it impossible to determine if excesses observed in the overall cohort were concentrated in particular production units.

The lack of information on race for 262 subjects (11% of the cohort) was another limitation of the study. All

subjects with unknown race were classified as white. If a significant number of these subjects were black, then the expected numbers of death in blacks would have been underestimated. The true SMRs for black men would be closer to the null value of 100 for estimates greater than 100 and farther away from the null for estimates under 100.

Five percent of the cohort was lost to follow-up and was withdrawn from the study on their work termination date. It could, however, be argued that most of these subjects were alive at the study closing date. The lost subjects were rather young in 1979 (median age on January 1, 1979: 51 years) and were rather unlikely to have died before that year. The combined use of the NDI and the SSA-DMF would have identified most decedents in this group who died in or after 1979 (50,51). The small differences between the two sets of SMRs with and without the assumption that subjects lost to follow-up were alive suggests that withdrawing these subjects at their work termination date did not bias the results in any appreciable way.

Another, less serious problem is the fact that death certificates were not available for 3% of deceased subjects. If one assumes that causes of death among these subjects are distributed as are the deaths with known cause, the all cancer CO_SMR increases from 106 (88-128) to 110 (91-132), the hepatobiliary cancer CO_SMR from 249 (81-581) to 258

(85-594) and the pneumonia CO_SMR from 150 (92-232) to 158 (98-243). These changes are minimal.

As in the previous studies of the Denver plant workers and in other studies of occupational groups, there was an overall deficit of deaths among the cohort members compared to the US general population. However, a favorable mortality experience (the so called healthy worker effect, HWE), was not seen in the cohort as a whole using the comparison rates of Colorado and the regional counties. The absence of a HWE may be attributable to the lack of meaningful differences in baseline health characteristics and socio-economic status (SES) of workers at the plant and the Colorado and regional general populations. It could also be argued that the lack of HWE reflects the presence of health hazards at the work place, which offset the HWE. Such an argument is, however, unpersuasive. Whereas the overall cohort did not experience a HWE, there was a 16% deficit of deaths among long-term (10+ years) hourly workers. There also was large deficit of deaths among never hourly subjects. Such a finding is not unusual and may be due to larger differences in baseline health characteristics between the never hourly group and the Colorado general population than between the ever hourly group and the general population. Similarly the lower SMRs among long-term workers compared with short-term workers may be explained in part by SES differences, by the selective retention of the most able and consequently most healthy

workers and by the health benefits derived from company health surveillance and other health programs.

White women experienced a slight excess of deaths from lung cancer and from external causes (accidents and suicides), regardless of the comparison population. Such a result is not atypical. Working women tend to have higher mortality rates from these causes than non-working women and the general population of women because of lifestyle differences. Working women tend to smoke more and are generally less risk-aversive.

The excess of hepatobiliary cancer in the overall cohort was based on five cases. All the cases were either laborers, pipefitters or operators and were hired in the 1950s. It is not known what common exposures they experienced, if any. Pipefitters and laborers generally could have had high exposures to various chemicals as they cleaned spills or repaired leaks and clogs. The magnitude of the observed hepatobiliary cancer SMR (three-fold increase among ever hourly white men), the concentration of all the cases among ever hourly workers in Maintenance and in Operations, and the median time since hire of 26 years for the cases, are consistent with a causal association. Such a causal inference is, however, weakened by a number of observed facts.

All of the excess of the hepatobiliary cancer deaths in the cohort was due to biliary duct/gall bladder cancer,

rather than to hepatocellular ("liver") cancer. Whereas Aldrin/Dieldrin are known to induce hepatocellular carcinoma in mice (20,21), there is no external evidence (experimental or epidemiologic) to support an association between pesticide exposure and biliary cancer. While the definitive cause(s) of biliary tract/gall bladder cancer remain unknown, possible etiologic factors include chronic parasitic infestations (e.g., clonorchis sinensis infestation), non-parasitic infections of the biliary tract, and gall stones (46,52,53). Parasitic infestations and other infections of the biliary tract are rare in the US and are unlikely to be occupationally related.

In spite of the doubling of the cohort size and the doubling of the expected number of hepatobiliary cancer deaths, relative to the NIOSH studies (1-3), no additional hepatobiliary cancer case was identified. Furthermore, there was no dose-response between increasing duration of employment and the SMR for hepatobiliary cancer.

The apparent increase in the hepatobiliary cancer deaths may be due to non-occupational causes or to chance. A case's spouse, who never worked at the plant herself, is known to have had liver cancer. The occurrence of two cases of hepatobiliary cancer within the same family points more towards a non-occupational cause. Also, many causes of death were examined in this cohort, and it is possible that the slightly elevated hepatobiliary cancer SMR in the overall

cohort and the statistically significant increase in the subgroup of ever hourly white men hired in the 1950s are chance results.

The pneumonia excess is difficult to explain. Several toxic fumes, including organic vapors, chlorine, bromine and oxides of sulfur and nitrogen, were generated at the plant. These are respiratory irritants and could predispose to acute respiratory infections. Also, these chemicals could act alone or synergistically with other atmospheric pollutants to impair the function of the protective cilia lining the airways, to inhibit the macrophage cells in the alveoli. Such changes could, in turn, result in an increased susceptibility to infectious airborne diseases including pneumonia (54). Although these effects tend to be acute, repetitive exposure to pulmonary irritants could lead to long-term pulmonary complications which, in turn, could predispose to pneumonia. It is, therefore, biologically plausible that the excess is due to exposures at the plant. A causal interpretation is also supported by the concentration of the excess pneumonia deaths among ever hourly white men (CO_SMR=189, 110-302) who may have had higher exposures than never hourly subjects. Furthermore, pneumonia deaths typically occur among the elderly, but in this cohort the excess was limited to subjects under 75 years of age.

The excess pneumonia deaths observed among the Shell Denver plant workers is consistent with the findings of long-term pulmonary complications, including airflow obstruction and chest symptoms (cough, chest tightness, etc.), among certain groups of pulpmill workers occupationally exposed to chlorine (55,56). However, controversy continues regarding the long-term effects of chlorine exposure, and mortality studies of pulp and paper workers have not reported any excess of deaths from pneumonia or other nonmalignant respiratory diseases (57-59).

The absence of a consistent increase in pneumonia SMRs with increasing duration of employment argues against a causal interpretation of the pneumonia excess. Furthermore, several categories of workers, including administrative workers, experienced excess deaths. Although it is possible that toxic materials released in one area could travel to other areas at the site and cause disease, the lack of a concentration of the pneumonia excess among ever hourly workers in Operations relative to other ever hourly workers detracts further from a causal interpretation. Also, workers at the Denver plant were exposed to gaseous products from the Army plants at the site, and many of the workers were employed in other industries before and after their work with Shell. It is possible that some of the excess of pneumonia observed in comparisons of the cohort with Colorado and regional populations is due to exposures experienced in other

work locations or to residual confounding by general environmental factors.

The excess of lymphopoietic cancer among black men was based on 3 observed deaths, 2 from multiple myeloma and one from lymphosarcoma. The strength of the observed association could suggest a causal explanation for the observed excess. However, one of the 2 multiple myeloma cases was a laboratory chemist, and the other was a maintenance painter/laborer. The decedent with lymphosarcoma was laboratory equipment keeper. Thus, it is rather unlikely that the 3 decedents had similar exposure patterns. The lack of an excess of lymphopoietic cancer in general or of multiple myeloma among ever hourly white men or among workers in Operations, Maintenance or Laboratories detracts further from a causal interpretation of the result among black men. Also, as previously discussed, race information was lacking for 11% of the cohort. It is possible that the PYs of follow-up of the black male cohort were underascertained, biasing the reported SMR upward. Some studies have reported an association between farm work and multiple myeloma (34-36,60). However, those investigations did not link multiple myeloma to any of the specific pesticides manufactured at the Shell Denver plant. Also, other studies have found no or only weak association between farm work and multiple myeloma (61,62).

Brown previously reported a positive association between large intestine cancer and DBCP exposure, based on 7 observed

and 2.4 expected deaths (3). We observed an increase in colon cancer deaths, of the same magnitude, among the combined group of ever hourly and never hourly DBCP-exposed white male subjects. Similar, non-independent associations were seen among subjects employed in each of the other production units (Azodrin, Planavin, Nudrin, Vapona and Aldrin/BCH/Dieldrin). Thus, it is not possible to attribute these increases to any particular chemical.

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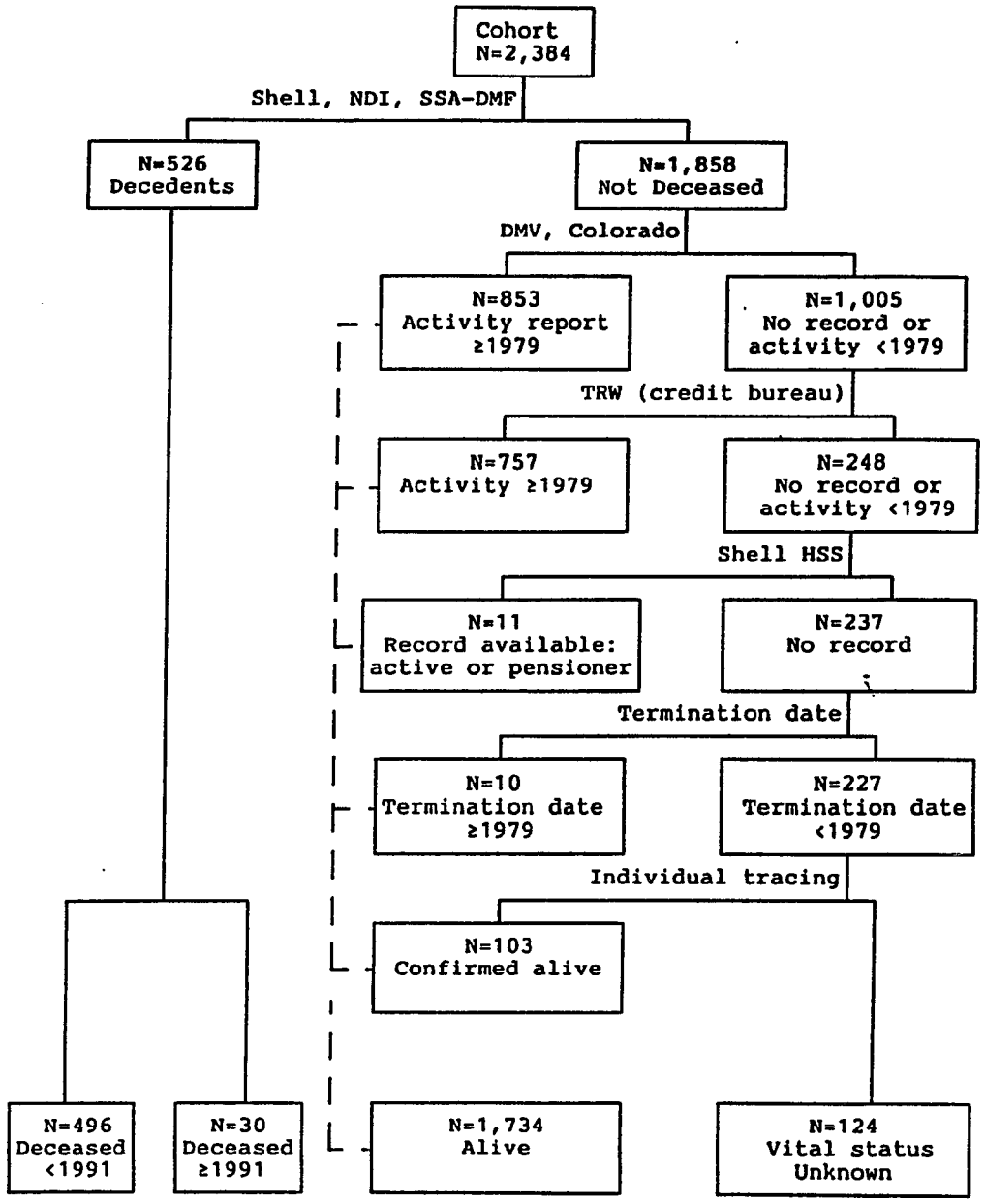

FIGURE 1. Vital Status Ascertainment

TABLE 1. Shell Denver plant historical pesticide product chronology

Date Production Initiated	Product	Date Production Ceased
1952	Aldrin	1974
	Dieldrin	1973
1953	Endrin	1965
	Chlorobromopropene	
1954	Aldrex 2	
	Aldrin 40	
	Dieldrex 15	
1955	Nemagon (DBCP)	1976
1956	Phosdrin	1973
1957	Methyl Parathion	1967
1960	Vapona	1982
1962	Bidrin	1979
	Ciodrin	1976
	Dibrom	1970
	Vapona Vaporizers (experimental)	1964
1963	Supona	1967
	Nemagon C (DBCP)	1976
1964	Ethyl Parathion	1966
1965	DDVP	1982
	Azodrin	1982
1966	Planavin	1975
1967	Akton	
	Gardona	1968
	Ciodrin PVC	
1968	Planavin 4L	1975
1969	Aldrite	1974
	Landrin	
1970	Phosdrin 4 EC	1974
	Azodrin Insecticide (3.3, 4.6, 5, etc.)	1982
	Bladex	1971
1971	Bladex 80% WP	
	Shell Poultry Spray	
	Ravap	1972
1972	Rabon 2 EC	
1973	Nudrin	1982
	Vincofos (experimental batch)	
1974	Bladex 4L	1977
1975	Nemagon EC (DBCP)	1975

TABLE 2. List of major products, intermediates and raw materials per decade of production

Period	Product	Raw materials and intermediates
1950s	Aldrin	Acetone
	Chlorine	Benzene
	Dieldrin	Bicycloheptadiene (BCH)
	Endrin	Carbon tetrachloride (CCL4)
	Methyl Parathion (MEP)	Chlorine
	Nemagon (DBCP)	Cyclopentadiene (CYCLO)
	Phosdrin	1 soldrin
		Sodium chloride
		Toluene
		Xylene
1960s	Aldrin	Acetone
	Bidrin	BCH
	Ciodrin	CCL4
	Dibrom	Chlorine
	Dieldrin	Cyclo
	Endrin	Dimethylacetoacetamide
(DMAA)		Ethyl Parathion1 Sodrin
	Gardona	Methyleben3ylace (MBAA)
	Nemagon (DBCP)	Sodium chloride
	Planavin	Sulfone
	Supona	
1970s	Aldrin	ABN
	Atrazine	Acetone
	Azodrin	BCH
	Bladex	Chloroform
	Bidrin	Chlorine
	Dieldrin	Copper sulfate
	Nemagon (DBCP)	Cyclo
	Nudrin	Dimethyldisulfide (DMMP)
	Phosdrin	DDVP
	Planavin	Sodium chloride
	Pydrin	Sulfure
	Rabon	Toluene
		Xylene
1980s	Azodrin	Chloroform
	Nudrin	Copper sulfate
	Vapona	DDMP
		DDVP
		MMAA
		Sodium chloride
		Xylene

TABLE 3. Number of subjects by payroll status, termination reason and vital status according to race and gender

	White Men		White Women		Black Men		Black Women		Total	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Number	2,072	(100)	234	(100)	68	(100)	10	(100)	2,384	(100)
Payroll status:										
Ever hourly	1,474	(71)	20	(9)	55	(81)	3	(30)	1,552	(65)
Never hourly	598	(29)	214	(91)	13	(19)	7	(70)	832	(35)
Termination reason:										
Terminated (laid off /resigned)	1,609	(78)	218	(94)	54	(79)	9	(90)	1,890	(79)
Trans. to another Shell facility	216	(10)	7	(3)	4	(6)	1	(10)	228	(10)
Pensioned/retired	206	(10)	8	(3)	7	(10)	0	(0)	221	(9)
Died while actively employed	41	(2)	1	(0)	3	(5)	0	(0)	45	(2)
Vital status:										
Presumed living*	1,531	(74)	175	(75)	48	(71)	10	(100)	1,764	(74)
Deceased	457	(22)	25	(11)	14	(20)	0	(0)	496	(21)
With death certif.	445	[97]+	23	[92]	14	[100]	-		482	[97]
Without death certif.	12	[3]	2	[8]	0	[0]	-		14	[3]
Unknown	84	(4)	34	(14)	6	(9)	0		124	(5)

* As of study closing date - January 1, 1991.
\+ Percent of total decedents.

TABLE 4. Number of subjects by selected employment characteristics, race and gender

	White Men		White Women		Black Men		Black Women		Total	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Number:	2,072	(100)	234	(100)	68	(100)	10	(0)	2,384	(100)
Age at hire (yrs):										
<20	226	(11)	29	(12)	4	(6)	1	(10)	260	(11)
20-29	1,126	(54)	131	(56)	41	(60)	6	(60)	1,304	(55)
30-39	469	(23)	59	(25)	13	(19)	3	(30)	544	(23)
40+	251	(12)	15	(7)	10	(15)	0	(0)	276	(12)
Median	26		26		27		25		26	
Year of hire:										
<1952	547	(26)	42	(18)	18	(27)	0	(0)	607	(25)
1952-1959	760	(37)	119	(51)	5	(7)	2	(20)	886	(37)
1960-1969	547	(26)	37	(16)	30	(44)	2	(20)	616	(26)
1970+	218	(11)	36	(15)	15	(22)	6	(60)	275	(12)
Median	1953		1954		1966		1973		1954	
Years worked:										
<1	684	(33)	77	(33)	14	(21)	6	(60)	781	(33)
1-4	680	(33)	111	(47)	20	(29)	3	(30)	814	(34)
5-9	324	(16)	27	(12)	12	(18)	0	(0)	363	(15)
10 or more	384	(18)	19	(8)	22	(32)	1	(10)	426	(18)
Median	2		2		5		1		2	
PY* of follow-up:										
<10	127	(6)	36	(15)	8	(12)	0	(0)	171	(7)
10-19	333	(16)	36	(15)	17	(25)	6	(60)	392	(16)
20-29	616	(30)	37	(16)	30	(44)	2	(20)	685	(29)
30-39	996	(48)	125	(54)	13	(14)	2	(20)	1,136	(48)
Median	29		32		22		18		29	
PY by age (yrs):										
<55	45,405	(78)	4,975	(81)	1,298	(85)	207	(94)	51,885	(79)
55-64	8,659	(15)	911	(15)	171	(11)	12	(6)	9,753	(15)
65+	3,885	(17)	240	(4)	59	(4)	1	(0)	4,185	(6)
Total	57,949	(100)	6,126	(100)	1,528	(100)	220	(100)	65,823	(100)

* PY, Person-years.

TABLE 5. Number of white men by year of hire and payroll status

Year of hire	Ever hourly		Never hourly		Total	
	N	(%)	N	(%)	N	(%)
1940-1949	37	(36)	67	(64)	104	(100)
1950-1959	951	(79)	252	(21)	1,203	(100)
1960-1969	329	(60)	218	(40)	547	(100)
1970-1979	157	(72)	61	(28)	218	(100)
Total	1,474	(71)	598	(29)	2,072	(100)

TABLE 6. Observed numbers of deaths and SMRs by cause of death according to race and gender, expected numbers derived from US rates

	White Men		White Women		Black Men		Black Women		Total		
	Obs	US_SMR	Obs	US_SMR	Obs	US_SMR	Obs	US_SMR	Obs/exp	US_SMR	95% CI
All causes	457	86*	25	108	14	83	0	[0.80]	496/569	87	80-95
All cancer	99	83	9	104	5	155	0	[0.19]	113/132	86	71-103
Digestive system	27	89	0	[1.60]	0	[0.94]	0	[0.04]	27/33	82	54-119
Hepatobiliary	5	212	0	[0.15]	0	[0.10]	0	[0.00]	5/2.6	196	64-458
Colon/rectum	13	97	0	[0.86]	0	[0.25]	0	[0.01]	13/14	90	48-153
Respiratory system	31	70*	3	190	0	[1.17]	0	[0.03]	34/47	72	50-101
Lung	27	64*	3	195	0	[1.10]	0	[0.03]	30/45	67	45-95
Brain and CNS	5	129	0	[0.26]	0	[0.05]	0	[0.00]	5/4.2	119	39-277
Lymphopoietic	12	100	1	[0.71]	3	1254*	0	[0.01]	16/13	123	71-200
Other cancers	24	83	5	140	2	[0.55]	0	[0.10]	31/20	155	105-220
Circulatory disease	193	78*	5	68	5	79	0	[0.26]	203/263	77	67-89
Respiratory disease	46	143*	1	[1.2]	0	[0.91]	0	[0.04]	47/34	137	101-182
Pneumonia	21	195*	0	[0.37]	0	[0.47]	0	[0.02]	21/12	180	111-275
Emphysema	8	140	0	[0.15]	0	[0.07]	0	[0.00]	8/5.9	135	58-266
Digestive disease	24	95	1	[1.2]	1	[0.98]	0	[0.06]	26/27	95	62-139
Cirrhosis of liver	13	88	0	[0.72]	0	[0.61]	0	[0.04]	13/16	80	43-137
External causes	43	72*	5	256	3	100	0	[0.10]	51/65	79	59-104
Accidents	23	59*	4	344	2	[1.5]	0	[0.05]	29/42	70	47-100
Suicide	14	98	1	[0.57]	0	[0.20]	0	[0.01]	15/16	93	52-154
Other known causes	38	93	3	169	0	[2.4]	0	[0.15]	41/45	91	65-123
Unknown	14		1		0		0		15		

Expected number is displayed in brackets when both the observed and expected numbers are less than 3.
* P<0.05.

TABLE 7. Observed numbers of deaths and SMRs by cause of death according to race and gender, expected numbers derived from Colorado rates

	White Men		White Women		Black Men		Black Women		Total		
	Obs	CO_SMR	Obs	CO_SMR	Obs	CO_SMR	Obs	CO_SMR	Obs/exp	CO_SMR	95% CI
All causes	429	97	23	111	13	123	0	[0.57]	465/473	98	90-108
All cancer	99	103	9	120	5	220	0	[0.14]	113/106	106	88-128
Digestive system	27	106	0	[1.5]	0	[0.73]	0	[0.03]	27/28	98	64-142
Hepatobiliary	5	277	0	[0.13]	0	[0.07]	0	[0.00]	5/2.0	249	81-581
Colon/rectum	13	126	0	[0.76]	0	[0.23]	0	[0.01]	13/11	115	61-196
Respiratory system	31	99	3	247	0	[0.70]	0	[0.02]	34/33	102	71-142
Lung	27	90	3	256	0	[0.67]	0	[0.02]	30/32	94	63-134
Brain and CNS	5	136	0	[0.27]	0	[0.04]	0	[0.00]	5/4.0	125	41-292
Lymphopoietic	12	110	1	[0.71]	3	1318*	0	[0.01]	16/11	146	83-237
Other cancers	24	93	5	94	2	[0.60]	0	[0.08]	31/32	97	66-138
Rheumatic and ischaemic heart disease**	126	100	3	97	2	[1.9]	0	[0.06]	131/131	100	84-120
Cerebrovascular disease	12	61	1	[1.1]	1	[0.47]	0	[0.03]	14/21	66	36-111
Respiratory disease	45	111	1	[1.6]	0	[0.78]	0	[0.03]	46/43	107	78-143
Pneumonia	20	161	0	[0.45]	0	[0.40]	0	[0.01]	20/13	150	92-232
Emphysema	8	107	0	[0.21]	0	[0.08]	0	[0.00]	8/7.8	103	45-203
Other	17	82	1	[0.90]	0	[0.30]	0	[0.02]	18/22	82	49-130
Cirrhosis of liver	13	102	0	[0.78]	0	[0.42]	0	[0.04]	13/14	93	49-158
External causes	38	62*	4	177	3	154	0	[0.10]	45/66	68	50-91
Accidents	21	58*	4	349	2	[0.84]	0	[0.05]	27/38	70	46-102
Suicide	12	66	0	[0.82]	0	[0.27]	0	[0.01]	12/19	62	32-108
Other known causes	82	99	4	91	2	[2.7]	0	[0.17]	88/90	98	78-120
Unknown	14		1		0		0		15		

Expected number is displayed in brackets when both the observed and expected numbers are less than 3.

* P<0.05.

** Hereafter referred to as heart disease.

TABLE 8. Observed numbers of deaths and SMRs by cause of death according to race and gender, expected numbers derived from regional county rates

	White Men		White Women		Black Men		Black Women		Total		
	Obs	R_SMR	Obs	R_SMR	Obs	R_SMR	Obs	R_SMR	Obs/exp	R_SMR	95% CI
All causes	429	104	23	114	13	208*	0	[0.53]	465/440	106	96-116
All cancer	99	105	9	120	5	325*	0	[0.16]	113/104	109	90-131
Digestive system	27	112	0	[1.5]	0	[0.52]	0	[0.08]	27/33	117	77-170
Hepatobiliary	5	286	0	[0.12]	0	[0.08]	0	[0.00]	5/2.0	256	83-598
Colon/rectum	13	127	0	[0.78]	0	[0.16]	0	[0.01]	13/11	116	62-198
Respiratory system	31	101	3	233	0	[0.46]	0	[0.01]	34/33	104	72-146
Lung	27	91	3	238	0	[0.44]	0	[0.01]	30/31	96	65-137
Brain and CNS	5	140	0	[0.00]	0	[0.02]	0	[0.00]	5/3.9	130	42-303
Lymphopoietic	12	113	1	[0.67]	3	2143*	0	[0.01]	15/11	140	80-227
Other cancers	24	94	5	131	2	[0.40]	0	[0.25]	31/33	94	64-134
Heart disease	126	106	3	103	2	[1.23]	0	[0.05]	131/123	107	89-127
Cerebrovascular disease	12	68	1	[1.1]	1	[0.40]	0	[0.02]	14/19	73	40-122
Respiratory disease	45	118	1	[1.6]	0	[0.41]	0	[0.02]	46/40	115	84-153
Pneumonia	20	177*	0	[0.41]	0	[0.22]	0	[0.01]	20/12	167	102-258
Emphysema	8	119	0	[0.19]	0	[0.02]	0	[0.00]	8/6.9	115	50-227
Other	17	85	1	[0.96]	0	[0.17]	0	[0.01]	18/21	86	51-135
Cirrhosis of liver	13	116	0	[0.74]	0	[0.17]	0	[0.02]	13/12	107	57-184
External causes	38	70	4	169	3	259	0	[0.14]	45/58	78	57-104
Accidents	21	70	4	348	2	[0.50]	0	[0.04]	27/32	85	56-124
Suicide	12	68	0	[0.85]	0	[0.23]	0	[0.01]	12/19	64	33-111
Other known causes	82	104	4	102	2	[1.35]	0	[0.12]	88/84	104	83-128
Unknown	14		1		0		0		15		

Expected number is displayed in brackets when both the observed and expected numbers are less than 3.
* P<0.05.

TABLE 9. Summary characteristics of black male lymphopoietic cancer decedents

Study No.	Year of Death	Race	Age at death	Cause(s) of death	Years worked	Work area & job title	Duration (weeks)	State of death
1060	1961	B	58	Lymphosarcoma	1951-1961	Laboratory	509	Colorado
						Lab Aid	6	
						Equipment keeper	503	
122	1968	B	52	Malignant myeloma	1951-1968	Maintenance	844	Colorado
				Spinal cord paralysis		Laborer	5	
						Painter	839	
860	1975	B	50	Multiple myeloma	1949-1964	Laboratory	286	New Mexico
						Scientist	132	
						Chemist	108	
						Technologist	46	

TABLE 10. Observed numbers of deaths and SMRs for all white men with subjects lost to follow-up treated as withdrawn at work termination date or treated as alive at the study closing date

	Withdrawn at termination date			Alive at study closing date		
	Obs	US_SMR	95% CI	Obs	US_SMR	95% CI
All causes	457	86	79-950	457	81	74-89
All cancers	99	83	67-101	99	77	63-94
Digestive cancers	27	89	59-130	27	84	55-122
Hepatobiliary	5	212	68-494	5	199	64-464
Colon/rectum	13	97	52-167	13	91	49-156
Respiratory system	31	70	48-99	31	66	45-93
Lung	27	64	42-93	27	60	39-87
Brain and other CNS	5	129	42-309	5	122	39-285
Lymphopoietic	12	100	52-175	12	95	49-165
Other cancers	24	83	53-124	24	74	47-110
Circulatory disease	193	78	67-89	193	73	63-84
Respiratory disease	46	143	105-191	46	133	99-178
Pneumonia	21	195	121-298	21	182	113-278
Emphysema	8	140	60-276	8	131	57-259
Digestive diseases	24	95	61-142	24	90	58-134
Cirrhosis of liver	13	88	47-150	13	83	44-142
External causes	43	72	52-97	43	69	50-93
Accidents	23	59	25-95	23	56	36-85
Suicide	14	98	53-164	14	93	51-156

Table 11

Observed and expected numbers of deaths and SMRs for selected causes among never hourly white men using US, Colorado and regional five county rates to derive the expected numbers*

	Observed	US			Colorado			Regional counties		
		Exp	US_SMR	95% CI	Exp	CO_SMR	95% CI	Exp	R_SMR	95% CI
All causes	89	136	65	52-80	123	72	58-89	116	77	62-95
All cancers	23	33	69	44-104	27	86	55-129	26	87	55-130
Digestive system	6	8.2	73	27-158	7.0	86	32-188	6.6	90	33-197
Hepatobiliary	0	0.70	0	0-566	0.51	0	0-725	0.48	0	0-772
Colon/rectum	3	3.7	82	17-240	2.8	107	22-313	2.8	105	22-308
Respiratory system	4	12	32	9-83	8.8	46	12-117	8.7	46	13-118
Lung	3	12	25	5-74	8.4	36	7-105	8.3	36	7-105
Brain & other CNS	1	1.1	92	1-510	1.0	97	2-540	1.0	98	2-545
Lymphopoietic	4	3.3	120	32-307	3.0	132	36-338	3.0	134	37-344
Heart disease	27	46	58	38-85	34	79	52-115	33	83	54-120
Cerebrovascular dis.	0	6.8	0	0-54	5.20	0	0-71	4.8	0	0-77
Respiratory disease	8	8.5	94	41-186	11	71	31-140	11	76	33-149
Pneumonia	3	2.7	110	22-321	3.3	91	19-266	3.0	100	21-292
Emphysema	0	1.5	0	0-254	1.9	0	0-190	1.8	0	0-206
Cirrhosis of liver	2	3.9	51	6-184	3.6	56	7-202	3.1	64	8-230
External causes	9	15	60	27-114	18	50	23-94	16	56	26-107
Accidents	6	9.5	63	23-138	11	56	21-123	8.9	68	25-147
Suicide	2	3.8	53	6-192	5.4	37	5-134	5.3	38	5-137

* Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancers. Adjusted rates for ICD9 were used in the computation of the expected numbers.

TABLE 12. Observed and expected numbers of deaths and SMRs for selected causes among hourly white men using US, Colorado and regional five county rates to derive the expected numbers*

	Observed	US			Colorado			Regional counties		
		Exp	US_SMR	95% CI	Exp	CO_SMR	95% CI	Exp	R_SMR	95% CI
All causes	340	353	96	86-107	318	107	96-119	297	115	103-127
All cancers	76	87	88	69-110	70	109	86-136	68	112	88-140
Digestive system	21	22	95	59-146	18	114	71-174	17	121	75-185
Hepatobiliary	5	1.7	292	94-681	1.3	386	125-900	1.3	392	127-916
Colon/rectum	10	9.7	103	49-190	7.5	134	64-246	7.4	135	65-248
Respiratory system	27	32	85	56-123	23	119	78-173	22	122	80-177
Lung	24	30	79	51-117	22	110	71-165	21	113	72-168
Brain & other CNS	4	2.8	144	39-369	2.7	151	41-386	2.5	158	43-404
Lymphopoietic	8	8.6	93	40-183	7.9	102	44-200	7.6	105	45-206
Heart disease	99	123	81	66-98	91	108	88-132	86	115	94-141
Cerebrovascular dis.	12	19	64	33-112	14	84	43-146	13	93	48-163
Respiratory disease	37	22	167	118-230	29	126	89-174	27	135	95-186
Pneumonia	17	7.4	230	134-368	9.0	189	110-302	8.3	205	119-328
Emphysema	8	4.0	200	86-393	5.5	145	63-285	4.9	162	70-320
Cirrhosis of liver	11	10	109	55-196	9.0	119	60-214	8.0	137	68-245
External causes	29	36	81	54-117	44	67	45-96	38	76	51-109
Accidents	15	23	66	37-109	26	58	33-96	21	71	40-117
Suicide	10	9.0	111	53-204	13	77	37-265	12	80	38-148

* Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancers. Adjusted rates for ICD9 were used in the computation of the expected numbers.

TABLE 13. Summary characteristics of hepatobiliary cancer decedents

Study No.	Year of Death	Race	Age at death	Cause(s) of death	Years worked	Work area & job title	Duration (weeks)	State of death
2196	1970	W	56	Carcinoma, common bile duct	1951-1952	Maintenance Laborer Pipefitter	56 27 29	Colorado
2265	1972	W	63	Hepatoma diffuse Hepatic and renal failure	1951-1952	Maintenance Pipefitter	28 28	Colorado
1925	1977	W	71	Cancer gall bladder	1951-1968	Operations Operator Maintenance Gen. helper Laborer Welder	798 798 74 42 30 2	Colorado
1797	1982	W	85	Biliary tract cancer	1952-1962	Maintenance Janitor Laborer	547 276 271	Colorado
1723	1984	W	56	Widely metastatic hepatobiliary carcinoma	1951-1953	Maintenance Laborer Pipefitter	56 27 29	California

TABLE 14. Summary characteristics of pneumonia decedents

Study No.	Year of Death	Race	Age at death	Cause(s) of death	Years worked	Work area & job title	Duration (weeks)	State of death
1234	1958	W	52	Lobar pneumonia	1950-1958	Maintenance Laborer Pipefitter	386 18 369	Colorado
1588	1961	W	51	Bronchopneumonia Chronic peptic ulcer of jejunum	1951-1954	Operations Operator	184 184	Colorado
1053	1962	W	65	Bronchopneumonia	1951-1954	Maintenance Carpenter Painter	138 46 92	Colorado
2072	1964	W	46	Lobar pneumonia	1952-1954	Maintenance Gen. helper Pipefitter	81 55 26	Colorado
564	1966	W	69	Acute broncophneumonia Prostate adenocarcinoma Pulmonary emphysema	1951-1960	Utilities Water tender	459 459	S. Dakota

Table 14. (continued)

Study No.	Year of Death	Race	Age at death	Cause(s) of death	Years worked	Work area & job title	Duration (weeks)	State of death
95	1970	W	59	Bronchopneumonia Emphysema	1952-1968	Operations	2	Colorado
						Laborer	1	
						Operator	1	
						Maintenance	734	
						Gen. helper	21	
						Laborer	178	
						Pipefitter	535	
						Shipping	6	
						Shipper	6	
						Laboratory	2	
						Equip. keeper	2	
585	1970	W	58	Interstitial pneumonia Pulmonary edema Arteriosclerotic heart ds.	1950-1970	Maintenance	978	Colorado
						Laborer	8	
						Painter	970	
1064	1971	W	38	Lobar pneumonia	1952-1953	Maintenance	17	Colorado
						Laborer	17	
346	1972	W	74	Pneumonia Arteriosclerosis Squamous cell ca - metastatic	1950-1963	Utilities	681	Colorado
						Engineer	681	

Table 14. (continued)

Study No.	Year of Death	Race	Age at death	Cause(s) of death	Years worked	Work area & job title	Duration (weeks)	State of death
1812	1972	W	46	Lobar pneumonia	1950-1970	Operations	243	Colorado
						Operator	243	
						Maintenance	766	
						Gen. helper	63	
						Pipefitter	228	
						Toolroom keeper	475	
						Laboratory	2	
						Equipment keeper	2	
						Administration	8	
						Stockhandler	8	
						Purchasing	2	
						Salvageman	2	
811	1973	W	59	Pneumonia Bullous emphysema	1947-1952	Administration	308	Colorado
						Salesman	308	
1133	1973	W	75	Recurrent pneumonia Chronic Pulmonary congestion Acute renal necrosis, (status - post hip procedure)	1951-1963	Maintenance	617	Colorado
						Welder	617	
1907	1976	W	68	Pneumonia Preleukemia	1951-1970	Operations	130	Colorado
						Laborer	9	
						Operator	121	

Table 14. (continued)

Study No.	Year of Death	Race	Age at death	Cause(s) of death	Years worked	Work area & job title	Duration (weeks)	State of death
1973	1976	W	70	Pneumonia	1951-1952	Maintenance Carpenter Laborer	66 34 32	Colorado
1206	1977	W	50	Pneumonia Coronary artery disease History of ventricular arrhythmia	1948-1969	Operations Operator	1073 1073	Colorado
973	1980	W	73	Lobar pneumonia Arteriosclerotic cardiovascular and renal disease; nephrosclerosis	1951-1952	Operations Laborer Maintenance Mechanic	20 20 41 41	Colorado
415	1985	W	74	Pneumonia Parkinson's disease	1950-1952	Maintenance Electrician	121 121	Colorado
212	1988	W	81	Aspiration pneumonia Diabetes mellitus	1952-1967	Operations Operator Maintenance Mechanic Pipefitter	60 60 736 17 719	Colorado
2028	1988	W	81	Pneumonia	1952-1953	Administration Superintendent	86 86	Virginia

Table 14. (continued)

Study No.	Year of Death	Race	Age at death	Cause(s) of death	Years worked	Work area & job title	Duration (weeks)	State of death
936	1990	W	66	Pneumonia	1990-1955	Maintenance Gen helper Laborer	42 24 18	New Mexico
1111	1990	W	68	Pneumonia Severe cardiomyopathy	1949-1955	Laboratory Chemist	327 327	Louisiana

TABLE 15. Observed/expected numbers of deaths and SMRs by duration of employment among ever hourly white men, expected numbers derived from US rates*

Cause of death	Years worked	Obs/exp	US_SMR	95% CI
All causes	<1	101/108	93	76-113
	1-4	112/103	109	90-131
	5-9	58/52	111	85-144
	10+	92/121	76	61-93
All cancers	<1	23/25	90	57-135
	1-4	17/22	77	45-124
	5-9	12/11	110	57-191
	10+	24/28	85	54-127
Hepatobiliary	<1	1/0.47	212	3-1181
	1-4	2/0.46	439	49-1585
	5-9	0/0.23	0	0-1620
	10+	2/0.56	357	40-1288
Colon/rectum	<1	3/2.6	114	24-33
	1-4	1/2.5	40	1-223
	5-9	1/1.3	79	2-442
	10+	5/3.3	152	49-354
Lung	<1	9/9.5	95	43-181
	1-4	4/7.4	54	15-139
	5-9	4/3.6	110	30-282
	10+	7/10	70	28-145
Heart disease	<1	27/34	79	52-115
	1-4	36/35	104	73-144
	5-9	16/18	87	50-142
	10+	30/45	67	45-96
Cerebrovascular disease	<1	6/4.1	147	54-320
	1-4	5/5.8	87	28-202
	5-9	0/3.1	0	0-118
	10+	2/7.4	27	3-97
Respiratory disease	<1	7/5.5	128	51-263
	1-4	14/5.8	242	132-406
	5-9	7/3.1	228	92-471
	10+	10/9.0	111	53-205
Pneumonia	<1	2/1.7	116	13-419
	1-4	6/2.0	295	108-642
	5-9	2/1.1	177	20-638
	10+	8/3.0	268	115-527
Emphysema	<1	3/0.88	340	68-994
	1-4	4/1.1	375	101-959
	5-9	1/0.60	166	2-926
	10+	0/1.7	0	0-220
Cirrhosis of liver	<1	5/3.8	133	43-309
	1-4	2/2.8	71	8-255
	5-9	3/1.4	213	43-621
	10+	1/2.7	37	0-205

* Period of observations is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancers.

TABLE 16. Observed/expected numbers of deaths and SMRs by duration of employment among ever hourly white men, expected numbers derived from Colorado rates*

Cause of death	Years worked	Obs/exp	CO_SMR	95% CI
All causes	<1	96/90	106	86-130
	1-4	99/78	126	103-154
	5-9	53/41	131	98-171
	10+	92/109	84	68-104
All cancers	<1	23/20	114	72-171
	1-4	17/18	96	56-154
	5-9	12/8.8	137	71-239
	10+	24/23	104	67-155
Hepatobiliary	<1	1/0.36	275	7-1533
	1-4	2/0.36	623	75-2252
	5-9	0/0.16	0	0-2370
	10+	2/0.46	438	53-1584
Colon/rectum	<1	3/2.0	150	31-438
	1-4	1/1.9	52	1-293
	5-9	1/0.96	104	3-580
	10+	5/2.6	192	62-449
Lung	<1	9/6.5	138	63-262
	1-4	4/5.2	76	21-195
	5-9	4/2.6	156	43-400
	10+	7/7.3	96	39-197
Heart disease	<1	25/24	103	67-153
	1-4	30/22	136	92-194
	5-9	14/12	119	65-199
	10+	30/33	91	61-130
Cerebrovascular disease	<1	6/2.9	209	77-455
	1-4	4/3.7	109	30-280
	5-9	0/2.1	0	0-174
	10+	2/5.7	35	4-127
Respiratory disease	<1	7/6.6	106	43-218
	1-4	14/6.8	205	112-344
	5-9	6/3.7	162	60-353
	10+	10/12	82	39-151
Pneumonia	<1	2/1.9	106	13-381
	1-4	6/2.2	270	99-588
	5-9	1/1.3	77	2-427
	10+	8/3.7	216	93-426
Emphysema	<1	3/1.1	280	58-819
	1-4	4/1.4	297	81-759
	5-9	1/0.76	131	3-730
	10+	0/2.3	0	0-157
Cirrhosis of liver	<1	5/3.4	149	48-348
	1-4	2/2.3	87	11-316
	5-9	3/1.1	269	56-786
	10+	1/2.5	41	1-227

* Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancers.

TABLE 17. Observed/expected numbers of deaths for selected causes among ever hourly white men according to period of hire and of death and years since hire, expected numbers derived from US rates

	All causes Obs/exp	All cancers Obs/exp	Hepato-biliary ca Obs/exp	Pneumonia Obs/exp	Emphysema Obs/exp
Period of hire:					
<1950	12/20	3/4.4	0/0.09	1/0.45	0/0.27
1950-1959	320/321	63/73	5/1.5*	17/6.9*	8/3.7
1960-1969	29/34	9/7.4	0/0.13	0/0.47	0/0.17
1970+	2/9.1*	1/1.9	0/0.03	0/0.12	0/0.04
Period of death:					
1952-1959	23/31	1/4.7	0/0.14	1/0.52	0/0.21
1960-1969	68/69	10/12	0/0.27	4/1.3	4/1.0*
1970-1979	128/108	26/23	3/0.34*	9/2.1*	2/1.4
1980+	144/176	39/47	2/0.97	4/3.9	2/1.6
Years since hire:					
<10	25/52	3/7.9	0/0.19	1/0.84	0/0.33
10-19	96/91	17/18	1/0.34	7/1.7	6/1.2
20-29	125/117	28/28	2/0.48	7/2.2	0/1.4
30+	107/124	28/33	2/0.70	3/3.1	2/1.3

* $P<0.05$.

TABLE 18. Observed/expected numbers of deaths for selected causes among ever hourly white men according to period of hire and of death and years since hire, expected numbers derived from Colorado rates +

	All causes Obs/exp	All cancers Obs/exp	Hepato-biliary ca Obs/exp	Pneumonia Obs/exp	Emphysema Obs/exp
Period of hire:					
<1950	11/16	3/3.6	0/0.07	1/0.51	0/0.36
1950-1959	298/264*	63/59	5/1.1*	16/8.0*	8/4.9
1960-1969	29/30	9/5.7	0/0.10	0/0.50	0/0.18
1970+	2/8*	1/1.4	0/0.03	0/0.12	0/0.04
Period of death:					
1952-1959	--- +	1/3.9	0/0.06	--- +	--- +
1960-1969	68/66	10/9.8	0/0.11	4/2.2	4/1.7
1970-1979	128/98*	26/18	3/0.35*	9/2.6*	2/1.9
1980+	144/154	39/38	2/0.78	4/4.3	2/2.0
Years since hire:					
<10	13/21	3/6.5	0/0.09	0/0.48	0/0.21
10-19	95/84	17/14	1/0.21	7/2.5	6/1.9*
20-29	125/104	28/22	2/0.40	7/2.7*	0/1.9
30+	107/110	28/27	2/0.60	3/3.5	2/1.6

+ Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancers.
* P<0.05.

TABLES 19. Number of white men by selected employment characteristics according to DBCP exposure

	DBCP exposed						DBCP unexposed					
	Ever hourly		Never hourly		Total		Ever hourly		Never hourly		Total	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Number	469	(100)	35	(100)	504	(100)	481	(100)	438	(100)	919	(100)
Vital status:												
Alive	351	(75)	32	(91)	383	(76)	372	(77)	380	(87)	752	(82)
Deceased	105	(22)	3	(9)	108	(21)	88	(18)	48	(11)	136	(15)
Unknown	13	(3)	0	(0)	13	(3)	21	(5)	10	(2)	31	(3)
Age at hire*:												
<20	24	(5)	0	(0)	24	(5)	59	(15)	12	(3)	81	(9)
20 - 29	236	(50)	17	(49)	253	(50)	242	(50)	289	(66)	531	(58)
30 - 39	107	(23)	17	(49)	124	(25)	107	(22)	94	(21)	201	(22)
40+	102	(22)	1	(2)	103	(20)	63	(13)	43	(10)	106	(11)
Median	28		30		28		26		26		26	
Year of hire*:												
<60	268	(57)	18	(51)	286	(57)	221	(46)	188	(43)	409	(44)
60 - 69	156	(33)	9	(26)	165	(33)	173	(36)	209	(48)	382	(42)
70 - 76	45	(10)	8	(23)	53	(10)	87	(18)	41	(9)	128	(14)
Median	1955		1955		1955		1962		1963		1963	
Years worked++:												
<1	41	(9)	1	(3)	42	(8)	205	(42)	125	(28)	330	(36)
1 - 4	155	(33)	9	(26)	164	(33)	164	(34)	209	(48)	373	(41)
5 - 10	105	(22)	4	(11)	109	(22)	56	(12)	65	(15)	121	(13)
10+	168	(36)	21	(60)	189	(37)	56	(12)	39	(9)	95	(10)
Median	6		15		7		1		2		2	
PY of follow-up:												
<10	18	(4)	0	(0)	18	(4)	21	(4)	8	(2)	29	(3)
10 - 19	27	(6)	0	(0)	27	(6)	34	(7)	16	(4)	50	(5)
20 - 29	47	(10)	2	(6)	47	(9)	28	(6)	15	(3)	43	(5)
30+	377	(80)	33	(94)	410	(81)	398	(83)	399	(91)	797	(87)
Median	36		36		36		36		36		36	

* Hire date was set to 1955, the start year of DBCP production, for all persons employed in the Denver cohort before 1955.
++ Years worked at the plant during the period 1955-1976.

TABLE 20. Observed/expected numbers of deaths and SMRs among ever hourly white men according to DBCP exposure, expected numbers derived from US rates

	Ever exposed			Never exposed		
	Obs/exp	US_SMR	95% CI	Obs/exp	US_SMR	95% CI
All causes	105/138	76	62-92	88/87	101	81-124
All cancers	28/31	91	60-131	16/20	81	46-132
Digestive system	9/7.9	114	52-217	2/4.8	41	5-149
Stomach	1/1.2	82	1-454	1/0.74	134	2-747
Colon	5/2.8	180	58-419	0/1.7	0	0-217
Rectum	0/0.74	0	0-499	1/0.44	228	3-1270
Hepatobiliary	2/0.61	328	37-1184	0/0.38	0	0-975
Respiratory system	9/11	80	37-152	6/7.3	82	30-179
Lung	7/11	65	26-135	6/7.0	86	31-187
Brain and CNS	1/0.92	109	1-605	1/0.70	144	2-800
Lymphopoietic	2/3.0	66	7-240	2/205	98	11-352
Circulatory disease	35/67	52	36-73	46/39	118	86-157
Respiratory disease	14/9.1	154	84-258	6/4.9	122	44-265
Pneumonia	8/3.1	255	110-502	3/1.7	181	36-528
Emphysema	1/1.7	60	1-335	0/0.87	0	0-420
External causes	11/13	82	41-147	8/12	66	28-129
Accidents	7/8.7	81	32-166	4/7.8	51	14-131
Suicide	3/3.3	91	18-267	3/2.9	103	21-302

TABLE 21. Observed/expected number of deaths and SMRs among ever hourly white men according to DBCP exposure, expected numbers derived from Colorado rates

	Ever exposed			Never exposed		
	Obs/exp	CO_SMR	95% CI	Obs/exp	CO_SMR	95% CI
All causes	103/119	87	71-105	79/75	105	83-131
All cancers	28/25	112	75-162	16/16	102	58-166
Digestive system	9/6.6	137	63-259	2/4.0	50	6-179
Stomach	1/1.1	92	2-510	1/0.66	150	4-838
Colon	5/2.2	226	73-527	0/1.4	0	0-274
Rectum	0/0.50	0	0-735	1/0.29	339	9-1889
Hepatobiliary	2/0.47	422	51-1525	0/0.29	0	0-1283
Respiratory system	9/8.1	112	51-212	6/5.1	119	44-258
Lung	7/7.7	91	37-188	6/4.8	124	46-270
Brain and CNS	1/0.88	114	3-634	1/0.68	147	4-820
Lymphopoietic	2/2.8	72	9-261	2/1.9	107	13-388
Heart disease	25/34	73	47-108	29/20.2	144	96-206
Cerebrovascular disease	0/5.7	0	0-64	4/3.0	132	36-338
Respiratory disease	13/12	110	58-188	6/6.2	97	36-211
Pneumonia	7/3.8	184	74-380	3/1.9	155	32-454
Emphysema	1/2.2	45	1-250	0/1.1	0	0-326
External causes	11/14.7	75	37-134	6/13	45	17-98
Accidents	7/8.8	80	32-164	3/7.9	38	8-111
Suicide	3/4.3	69	14-203	2/3.9	51	6-184

TABLE 22. Number of white men ever employed in each work area by payroll status within the area

Work area*	Ever hourly N	Ever hourly (%)+	Never hourly N	Never hourly (%)	Total N	Total (%)
Operations	739	(86)	112	(14)	851	(100)
Maintenance	885	(96)	41	(4)	926	(100)
Shipping	105	(78)	29	(22)	134	(100)
Utilities	135	(88)	18	(12)	153	(100)
Laboratories	35	(9)	342	(91)	377	(100)
Engineering	0	(0)	117	(100)	117	(100)
Industrial Hygiene/ Safety	6	(6)	100	(94)	106	(100)
Administration	58	(28)	148	(72)	206	(100)

* The classification of subjects by work area is not mutually exclusive.

The total number of subjects is 1,474 for the ever hourly groups and 598 for the never hourly groups.

\+ Percent of total white men who ever worked in the specified area.

TABLE 23. Number of subjects, median years worked and median start year by non-mutually exclusive work area

Work area	Number	Median years worked		Median start year	
		At plant	In unit	At plant	In unit
Operations					
Ever hourly	739	3.3	2.0	1954	1954
Never hourly	112	5.7	1.9	1953	1955
Total	851	3.9	2.0	1954	1954
Maintenance					
Ever hourly	885	1.6	0.5	1953	1953
Never hourly	41	6.0	2.0	1951	1952
Total	926	1.8	0.6	1953	1953
Shipping					
Ever hourly	105	4.8	0.3	1959	1961
Never hourly	29	17	0.9	1954	1965
Total	134	5.6	0.4	1956	1962
Utilities					
Ever hourly	135	6.1	4.6	1954	1960
Never hourly	18	21	5.6	1951	1970
Total	153	6.7	4.6	1952	1961
Laboratories					
Ever hourly	35	7.1	0.2	1952	1954
Never hourly	342	2.4	1.9	1959	1959
Total	377	2.5	1.7	1957	1959
Engineering					
Ever hourly	0	-	-	-	-
Never hourly	117	3.6	2.3	1965	1967
Total	117	3.6	2.3	1965	1967
Indus Hygiene/Safety					
Ever hourly	6	10	0.3	1952	1963
Never hourly	100	17	0.3	1953	1963
Total	106	17	0.3	1953	1963
Administration					
Ever hourly	58	14	1.0	1958	1963
Never hourly	148	5.0	2.9	1953	1954
Total	206	6.5	2.7	1953	1956

TABLE 24. Observed/expected numbers of deaths and SMRs for selected causes among ever hourly and never hourly white men, combined, by work area

	Operations	Maintenance	Shipping	Utilities	Laboratories	Engineering	Industrial Hyg/Safety	Administration
All causes								
Obs/exp	161/151	222/221	20/23	47/39	44/68	14/20	20/25	50/57
CO_SMR	107	101	88	121	70	70	79	88
95% CI	91-125	88-115	54-136	89-161	51-93	38-117	48-122	65-116
All cancers								
Obs/exp	37/33	52/48	6/4.9	8/8.5	15/14	5/4.5	5/6.1	11/13
CO_SMR	111	108	122	94	111	111	82	88
95% CI	78-153	81-142	45-266	41-185	62-183	36-260	27-192	44-157
Hepatobiliary cancer								
Obs/exp	2/0.61	4/0.90	0/0.09	0/0.16	0/0.25	0/0.09	0/0.12	0/0.24
CO_SMR	328	446	0	0	0	0	0	0
95% CI	39-1171	121-1141	0-4082	0-2285	0-1467	0-4270	0-3093	0-1530
Heart disease								
Obs/exp	44/42	63/63	5/6.2	16/12	12/17	4/6.5	11/7.5	15/17
CO_SMR	105	99	80	137	71	62	148	90
95% CI	76-141	76-127	26-188	79-223	36-123	17-158	74-264	50-149
Pneumonia								
Obs/exp	7/3.8	13/6.6	1/0.54	2/1.3	4/1.5	0/0.45	0/0.61	4/1.7
CO_SMR	186	197	185	154	265	0	0	234
95% CI	75-383	105-337	5-1027	19-570	72-679	0-285	0-603	64-600
External causes								
Obs/exp	17/24	20/29	2/3.8	3/4.1	4/11	0/3.2	0/2.8	4/6.3
CO_SMR	72	70	52	74	36	0	0	63
95% CI	42-115	43-107	6-189	15-215	10-91	0-116	0-132	17-161

* Period of observation is 1960-1990 for all causes and non-cancers and 1952-1990 for cancer deaths.

TABLE 25. Observed numbers of deaths and SMRs among 851 white men ever in Operations, using US rates or Colorado comparison rates

	US comparison			Colorado comparison*		
	Obs	US_SMR	95% CI	Obs	CO_SMR	95% CI
All causes	171	95	81-110	161	107	91-125
All cancers	37	89	62-122	37	111	78-153
Digestive cancers	11	107	53-192	11	128	64-229
Hepatobiliary	2	[0.80]	28-903	2	[0.61]	39-1171
Colon/rectum	6	133	49-290	6	172	63-375
Respiratory system	9	57	26-108	9	81	37-155
Lung	8	53	23-105	8	76	33-149
Brain and other CNS	2	[1.5]	15-498	2	[1.4]	17-518
Lymphopoietic	3	71	14-207	3	78	16-229
Heart disease	49	82	61-108	44	105	76-141
Cerebrovascular disease	4	48	13-123	4	68	19-173
Respiratory disease	15	148	83-244	15	119	67-196
Pneumonia	7	211	85-435	7	186	75-383
Emphysema	2	[1.8]	13-410	2	[2.3]	11-321
Cirrhosis of liver	4	71	19-182	4	81	22-208
External causes	20	88	53-135	17	72	42-115
Accidents	12	81	42-141	12	87	45-151
Suicide	6	109	40-237	4	56	15-143

* Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancer deaths.
Expected number is displayed in brackets when both the observed and the expected numbers are less than 3.

TABLE 26. Observed numbers of deaths and SMRs among 926 white men ever in Maintenance, using US rates or Colorado comparison rates

	US comparison			Colorado comparison*		
	Obs	US_SMR	95% CI	Obs	CO_SMR	95% CI
All causes	235	89	78-101	222	101	88-115
All cancers	52	87	65-115	52	108	81-142
Digestive cancers	14	92	50-155	14	110	60-185
Hepatobiliary	4	338	91-866	4	446	121-1141
Colon/rectum	7	104	42-215	7	135	54-277
Respiratory system	19	87	53-136	19	122	74-191
Lung	15	72	40-119	15	101	57-167
Brain and other CNS	1	[1.9]	1-301	1	[1.8]	1-316
Lymphopoietic	5	85	27-199	5	93	30-216
Heart disease	70	76	59-96	63	99	76-127
Cerebrovascular disease	7	49	19-100	6	59	22-128
Respiratory disease	24	144	92-214	23	108	69-162
Pneumonia	14	247	135-415	13	197	105-337
Emphysema	5	164	53-383	5	124	40-289
Cirrhosis of liver	9	127	58-240	9	148	68-281
External causes	21	76	47-116	20	70	43-107
Accidents	10	55	26-100	9	53	24-100
Suicide	8	120	52-237	8	95	41-186

* Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancer deaths.
Expected number is displayed in brackets when both the observed and the expected number are less than 3.

TABLE 27. Observed numbers of deaths and SMRs among 134 white men ever in Shipping, using US rates or Colorado comparison rates

	US comparison			Colorado comparison*		
	Obs	US_SMR	95% CI	Obs	CO_SMR	95% CI
All causes	21	78	48-119	20	88	54-136
All cancers	6	97	36-212	6	122	45-266
Digestive cancers	2	[1.5]	15-468	2	[1.3]	19-563
Hepatobiliary	0	[0.12]	0-3033	0	[0.09]	0-4082
Colon/rectum	1	[0.67]	4-832	1	[0.52]	5-1071
Respiratory system	2	[2.3]	10-315	2	[1.6]	15-454
Lung	2	[2.2]	10-330	2	[1.5]	16-475
Brain and other CNS	0	[0.21]	0-1747	0	[0.21]	0-1794
Lymphopoietic	1	[0.63]	2-885	1	[0.58]	4-961
Heart disease	5	56	18-130	5	80	26-188
Cerebrovascular disease	0	[1.3]	0-281	0	[0.92]	0-402
Respiratory disease	1	[1.5]	1-365	1	[1.9]	1-287
Pneumonia	1	[0.48]	3-1161	1	[0.54]	5-1024
Emphysema	0	[0.30]	0-1217	0	[0.41]	0-908
Cirrhosis of liver	0	[0.81]	0-455	0	[0.71]	0-520
External causes	2	56	6-202	2	52	6-189
Accidents	2	[2.3]	10-313	2	[2.3]	11-320
Suicide	0	[0.85]	0-433	0	[1.1]	0-328

* Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancer deaths.
Expected number is displayed in brackets when both the observed and the expected number are less than 3.

TABLE 28. Observed numbers of deaths and SMRs among 153 white men ever in Utilities, using US rates or Colorado comparison rates

	US comparison			Colorado comparison*		
	Obs	US_SMR	95% CI	Obs	CO_SMR	95% CI
All causes	49	103	76-136	47	121	89-161
All cancers	8	76	33-150	8	94	41-185
Digestive cancers	0	[2.8]	0-131	0	[2.3]	0-158
Hepatobiliary	0	[0.22]	0-1672	0	[0.16]	0-2285
Colon/rectum	0	[1.2]	0-300	0	[0.95]	0-388
Respiratory system	4	108	29-276	4	148	40-380
Lung	4	113	30-290	4	156	42-399
Brain and other CNS	1	[0.29]	5-1937	1	[0.27]	9-2073
Lymphopoietic	0	[0.99]	0-372	0	[0.92]	0-403
Heart disease	16	93	53-152	16	137	79-223
Cerebrovascular disease	2	65	7-236	2	[2.1]	12-344
Respiratory disease	8	256	110-504	8	201	87-397
Pneumonia	2	[1.1]	21-266	2	[1.3]	19-570
Emphysema	1	[0.60]	2-926	1	[0.80]	3-693
Cirrhosis of liver	0	[1.1]	0-329	0	[0.92]	0-402
External causes	4	102	27-260	3	74	15-215
Accidents	2	[2.6]	9-281	1	[2.4]	1-229
Suicide	1	[0.99]	1-564	1	[1.2]	2-455

* Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancer deaths.
Expected number is displayed in brackets when both the observed and the expected numbers are less than 3.

TABLE 29. Observed numbers of deaths and SMRs among 377 white men ever in Laboratories, using US rates or Colorado comparison rates

	US comparison			Colorado comparison*		
	Obs	US_SMR	95% CI	Obs	CO_SMR	95% CI
All causes	45	60	44-81	44	70	51-93
All cancers	15	88	49-145	15	111	62-183
Digestive cancers	4	96	26-246	4	114	31-293
Hepatobiliary	0	[0.33]	0-1126	0	[0.25]	0-1467
Colon/rectum	3	164	34-482	3	213	44-622
Respiratory system	3	47	9-137	3	68	14-198
Lung	3	49	10-144	3	71	15-207
Brain and other CNS	1	[0.62]	2-903	1	[0.59]	4-942
Lymphopoietic	1	[1.8]	1-313	1	[1.6]	2-349
Heart disease	13	48	26-82	12	71	36-123
Cerebrovascular disease	0	0	0-107	0	[2.5]	0-149
Respiratory disease	4	99	27-255	4	80	22-205
Pneumonia	4	302	81-772	4	265	72-679
Emphysema	0	[0.68]	0-538	0	[0.87]	0-426
Cirrhosis of liver	0	[2.4]	0-156	0	[2.1]	0-178
External causes	4	38	10-97	4	36	10-91
Accidents	3	44	9-128	3	45	9-133
Suicide	1	[2.5]	1-222	1	30	1-167

* Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancer deaths.
Expected number is displayed in brackets when both the observed and the expected numbers are less than 3.

TABLE 30. Observed numbers of deaths and SMRs among 117 white men ever in Engineering, using US rates or Colorado comparison rates

	US comparison			Colorado comparison*		
	Obs	US_SMR	95% CI	Obs	CO_SMR	95% CI
All causes	14	60	33-101	14	70	38-117
All cancers	5	89	29-208	5	111	36-260
Digestive cancers	1	[1.4]	1-407	1	[1.2]	2-482
Hepatobiliary	0	[0.11]	0-3394	0	[0.09]	0-4270
Colon/rectum	1	[0.60]	4-929	1	[0.47]	5-1185
Respiratory system	1	[2.2]	1-257	1	[1.5]	2-362
Lung	1	[2.1]	1-268	1	[1.5]	2-379
Brain and other CNS	0	[0.19]	0-1919	0	[0.18]	0-2081
Lymphopoietic	2	[0.56]	40-1289	2	[0.50]	48-1443
Heart disease	4	52	14-133	4	62	17-158
Cerebrovascular disease	0	[0.09]	0-372	0	[0.71]	0-523
Respiratory disease	1	[1.4]	1-407	1	[1.8]	1-317
Pneumonia	0	[0.40]	0-919	0	[0.45]	0-825
Emphysema	0	[0.24]	0-1550	0	[0.31]	0-1204
Cirrhosis of liver	1	[0.71]	2-779	1	[0.62]	4-894
External causes	0	[2.9]	0-126	0	[3.2]	0-116
Accidents	0	[0.94]	0-392	0	[1.8]	0-201
Suicide	0	[0.73]	0-504	0	[0.97]	0-381

* Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancer deaths.
Expected number is displayed in brackets when both the observed and the expected numbers are less than 3.

TABLE 31. Observed numbers of deaths and SMRs among 106 white men ever in Industrial Hygiene/Safety, using US rates or Colorado comparison rates

	US comparison			Colorado comparison*		
	Obs	US_SMR	95% CI	Obs	CO_SMR	95% CI
All causes	22	74	47-113	20	79	48-122
All cancers	5	66	21-154	5	82	27-192
Digestive cancers	3	163	33-475	3	191	39-558
Hepatobiliary	0	[0.14]	0-2532	0	[0.12]	0-3093
Colon/rectum	1	[0.82]	3-679	1	[0.64]	4-871
Respiratory system	0	0	0-121	0	[2.2]	0-170
Lung	0	[2.9]	0-127	0	[2.1]	0-177
Brain and other CNS	0	[0.23]	0-1575	0	[0.22]	0-1682
Lymphopoietic	2	[0.69]	32-1044	2	[0.62]	39-1170
Heart disease	12	117	60-204	11	148	74-264
Cerebrovascular disease	0	[1.3]	0-268	0	[0.93]	0-397
Respiratory disease	0	[1.8]	0-199	0	[2.4]	0-156
Pneumonia	0	[0.54]	0-678	0	[0.61]	0-603
Emphysema	0	[0.30]	0-1220	0	]0.38]	0-979
Cirrhosis of liver	1	[0.91]	1-610	1	[0.80]	3-699
External causes	1	[2.5]	1-224	0	[2.8]	0-132
Accidents	1	[1.6]	0-355	0	[1.6]	0-230
Suicide	1	[0.67]	0-548	0	[0.90]	0-408

* Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancer deaths.
Expected number is displayed in brackets when both the observed and the expected numbers are less than 3.

TABLE 32. Observed numbers of deaths and SMRs among 206 white men ever in Administration, using US rates or Colorado comparison rates

	US comparison			Colorado comparison*		
	Obs	US_SMR	95% CI	Obs	CO_SMR	95% CI
All causes	53	79	59-104	50	88	65-116
All cancers	11	71	36-127	11	88	44-157
Digestive cancers	2	51	6-183	2	60	7-217
Hepatobiliary	0	[0.31]	0-12	0	[0.24]	0-1530
Colon/rectum	1	[1.8]	1-310	1	[1.4]	2-398
Respiratory system	3	52	11-153	3	73	15-212
Lung	3	55	11-161	3	76	16-222
Brain and other CNS	1	[0.45]	3-1241	1	[0.42]	6-1325
Lymphopoietic	1	[1.5]	1-380	1	[1.3]	2-419
Heart disease	15	63	35-104	15	90	50-149
Cerebrovascular disease	0	0	0-97	0	[2.7]	0-136
Respiratory disease	8	182	78-358	8	140	61-277
Pneumonia	4	274	74-702	4	234	64-600
Emphysema	0	[0.79]	0-466	0	[1.1]	0-353
Cirrhosis of liver	1	[1.7]	1-324	1	[1.5]	2-377
External causes	4	68	18-173	4	63	17-161
Accidents	3	78	16-229	3	80	16-233
Suicide	0	[1.5]	0-247	0	[1.9]	0-192

* Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancer deaths.
Expected number is displayed in brackets when both the observed and the expected numbers are less than 3.

TABLE 33. Number of white men by history of mutually exclusive employment in Operations and Maintenance

Production unit	Ever hourly N	Ever hourly (%)	Never hourly N	Never hourly (%)	Total N	Total (%)
In both Operations, and Maintenance	305	(20)	7	(1)	312	(15)
Ever in Operations, never in Maintenance	441	(30)	98	(16)	539	(26)
Ever in Maintenance, never in Operations	584	(40)	30	(5)	614	(30)
Never in Operations, or Maintenance	144	(10)	463	(78)	607	(29)
Total	1,474	(100)	598	(100)	2,072	(100)

TABLE 34. Number of white men, median years worked and median start year by mutually exclusive production unit

Production unit	Number	Median years worked		Median start year	
		At plant	In unit	At plant	In unit
In both Operations and Maintenance					
Hourly	305	5.3	4.6 [2.2 (OP)*] [0.40 (MT)*]	1959	1959 [1960 (OP)] [1960 (MT)]
Never hourly	7	17	6.5 [6.0 (OP)] [0.33 (MT)]	1953	1954 [1954 (OP)] [1955 (MT)]
Total	312	5.5	4.7 [2.3 (OP)] [0.4 (MT)]	1959	1959 [1960 (OP)] [1960 (MT)]
Ever in Operations, never in Maintenance					
Hourly	441	2.2	1.8	1953	1953
Never hourly	98	5.5	1.8	1953	1955
Total	539	3.2	1.8	1953	1953
Ever in Maintenance, never in Operations					
Hourly	584	0.96	0.65	1952	1952
Never hourly	30	4.4	2.6	1950	1950
Total	614	1.1	0.70	1952	1952
Never in Operations or Maintenance					
Hourly	144	4.0	-	1953	-
Never hourly	463	2.2	-	1960	-
Total	607	2.4	-	1957	-

* OP = Operations
MT = Maintenance

TABLE 35. Observed/expected numbers of deaths and SMRs for selected causes among ever hourly white men according to mutually exclusive production unit categories

	In both Operations and Maintenance			Ever in Operations never in Maintenance			Ever in Maintenance never in Operations			Never in Operations or Maintenance		
	Obs/exp	CO_SMR	95% CI	Obs/exp	CO_SMR	95% CI	Obs/exp	CO_SMR	95% CI	Obs/exp	CO_SMR	95% CI
All causes	58/65	90	68-116	93/89	104	84-128	162/185	88	75-102	50/42	118	88-156
All cancers	14/15	94	51-158	15/21	72	40-119	37/41	90	63-123	10/9.2	108	52-199
Hepatobiliary	1/0.28	351	5-1955	1/0.40	250	3-1392	3/0.83	362	73-1057	0/0.19	0	0-1916
Colon/rectal	2/1.6	125	15-452	3/2.2	136	28-399	5/4.7	106	35-248	0/1.1	0	0-335
Pneumonia	5/1.2	403	130-940	2/1.6	124	14-446	9/4.1	219	100-416	2/0.88	228	26-825
Emphysema	0/0.66	0	0-554	2/0.85	234	26-847	5/2.2	228	74-532	1/0.50	202	3-1121

TABLE 36. Number of subjects by manning chart production unit, race and gender

Production unit	White men N	White men (%)	White women N	White women (%)	Black men N	Black men (%)	Black women N	Black women (%)	Total N	Total (%)
All units	371	(90)	12	(3)	27	(7)	2	(0)	412	(100)
Azodrin	261	(89)	8	(3)	21	(7)	2	(1)	292	(100)
Aldrin/BCH/ Dieldrin	221	(92)	0	(0)	18	(8)	0	(0)	239	(100)
Planavin	215	(93)	3	(1)	14	(6)	0	(0)	232	(100)
Vapona	118	(91)	1	(1)	9	(7)	2	(1)	130	(100)
Nudrin	114	(85)	7	(5)	11	(8)	2	(2)	134	(100)
Nemagon	69	(92)	0	(0)	6	(8)	0	(0)	75	(100)
Maintenance	205	(89)	7	(3)	17	(7)	1	(1)	230	(100)
Shipping	166	(86)	7	(4)	17	(9)	2	(1)	192	(100)
Drumming	166	(91)	0	(0)	16	(9)	0	(0)	182	(100)
Effluent treatment	95	(89)	3	(3)	9	(8)	0	(0)	107	(100)
Other units	345	(90)	11	(3)	25	(6)	2	(1)	383	(100)

TABLE 37. Number of white men, median weeks worked, median start year and median age at hire by non-mutually exclusive manning chart production unit

Production unit	Number	Median weeks worked		Median start year		Median age at hire	
		At plant	In unit*	At plant	In unit*	At plant	In unit*
All units	371	325	167	1966	1966	27	31
Azodrin	261	415	23	1966	1968	28	32
Aldrin/BCH/Dieldrin	221	463	17	1965	1967	27	34
Planavin	215	432	27	1966	1967	27	33
Vapona	118	422	7	1966	1967	27	33
Nudrin	114	486	39	1972	1974	28	37
Nemagon	69	762	10	1965	1968	27	37
Maintenance	205	487	11	1966	1969	28	36
Shipping	166	464	5	1967	1975	28	35
Drumming	166	423	6	1966	1968	28	34
Effluent treatment	95	540	9	1967	1976	29	40
Other units	345	332	27	1966	1976	27	40

* All production unit data cover time period 1965-1982 only.

TABLE 38. Observed/expected numbers of deaths and SMRs among hourly white men employed during 1965-1982, according to whether they had manning chart records

	Subjects with manning chart records (N=359)			Subjects without manning chart records (N=247)		
	Obs/exp	CO_SMR	95% CI	Obs/exp	CO_SMR	95% CI
All causes	37/43	86	61-119	54/61	89	67-116
All cancers	10/9.1	109	53-201	16/13	124	71-202
Digestive cancers	5/2.3	218	71-509	1/3.7	30	1-166
Hepatobiliary	1/0.17	574	14-3200	0/0.26	0	0-1403
Colon	3/0.78	384	79-1122	1/1.2	85	2-473
Rectum	0/0.15	0	0-2455	0/0.25	0	0-1504
Lung cancer	2/3.0	68	8-245	6/4.1	146	54-318
Brain and CNS	1/0.43	237	6-1302	0/0.40	0	0-918
Lymphopoietic system	0/1.1	0	0-351	1/1.3	75	2-415
Heart disease	13/11	119	63-203	16/17.32	92	53-150
Cerebrovascular disease	0/1.3	0	0-276	0/2.8	0	0-130
Respiratory disease	1/3.1	32	1-178	8/6.6	121	52-239
Pneumonia	1/0.86	116	3-647	3/1.8	167	34-487
Emphysema	0/0.47	0	0-786	0/1.2	0	0-305
External causes	4/8.5	47	13-120	4/6.8	59	16-151
Accidents	3/4.9	61	13-179	1/4.1	25	1-137
Suicide	1/2.6	38	1-211	1/2.0	50	1-276
Other known causes	9/10	90	41-171	10/14	69	33-127
Unknown	0			0		

TABLE 39. Observed/expected numbers of deaths* among white men with a manning chart record of employment in Azodrin, Aldrin/BCH/Dieldrin (ALBD), Planavin, Vapona, Nudrin and Nemagon production units in the period 1965-1982

	Azodrin	ALBD	Planavin	Vapona	Nudrin	Nemagon
All causes	30/32	28/32	23/28	11/14	11/11	7/12
All cancers	9/7.0	7/7.0	6/6.3	2/3.1	5/2.6	1/2.7
Digestive cancers	5/1.8	4/1.8	3/1.6	2/0.77	3/0.65	1/0.69
Hepatobiliary	1/0.14	1/0.13	0/0.12	0/0.06	0/0.05	0/0.05
Colon	3/0.61	2/0.60	3/0.54	2/0.26	2/0.22	1/0.24
Rectum	0/0.12	0/0.12	0/0.10	0/0.05	0/0.04	0/0.05
Lung	2/2.3	1/2.3	1/2.1	1/1.0	0/0.86	0/0.90
Brain and CNS	1/0.32	0/0.31	0/0.29	1/0.15	0/0.11	0/0.11
Lymphopoietic	0/0.79	0/0.78	0/0.70	0/0.35	0/0.27	0/0.29
Heart disease	8/8.5	8/8.4	8/7.4	3/3.6	4/2.9	3/3.3
Cerebrovascular disease	0/1.1	0/1.1	0/0.88	0/0.41	0/0.35	0/0.44
Respiratory disease	1/2.5	1/2.5	1/2.1	0/0.98	0/0.89	0/1.1
Pneumonia	1/0.67	1/0.67	1/0.55	0/0.26	0/0.21	0/0.28
Emphysema	0/0.37	0/0.39	0/0.31	0/0.14	0/0.13	0/0.16
External causes	4/5.9	4/5.5	3/5.2	2/2.7	0/1.8	0/1.7
Accidents	3/3.4	3/3.2	3/3.0	2/1.5	0/1.0	1/0.98
Suicide	1/1.9	1/1.7	0/1.6	0/0.85	0/0.61	0/0.55
Other known causes	8/7.0	8/7.5	5/6.1	4/3.2	2/2.5	2/2.8
Unknown causes	0	0	0	0	0	0

* Expected numbers were derived using Colorado rates.

TABLE 40. Observed/expected numbers of deaths among white men with a manning chart record of employment in Maintenance, Shipping, Drumming, Effluent Treatment or Other production units in the period 1965-1982*

	Maintenance	Shipping	Drumming	DET	Other
All causes	23/27	19/19	17/22	10/12	34/42
All cancers	9/6.2	7/4.2	6/4.9	3/2.8	10/8.7
Digestive cancers	4/1.6	3/1.1	3/1.3	1/0.70	5/2.2
Hepatobiliary	0/0.12	0/0.08	0/0.10	0/0.06	1/0.17
Colon	3/0.54	2/0.37	2/0.43	1/0.24	3/0.75
Rectum	0/0.10	0/0.07	0/0.08	0/0.05	0/0.14
Lung	2/2.1	1/1.4	0/1.6	1/0.93	2/2.8
Brain and CNS	1/0.25	1/0.18	1/0.21	1/0.11	1/0.41
Lymphopoietic	0/0.65	0/0.45	0/0.54	0/0.28	0/1.0
Heart disease	6/7.4	6/5.0	4/6.0	5/3.2	11/11
Cerebrovascular disease	0/0.92	0/0.62	0/0.75	0/0.39	0/1.3
Respiratory disease	1/2.3	0/1.5	0/1.8	0/1.0	1/3.1
Pneumonia	1/0.58	0/0.39	0/0.47	0/0.24	1/0.83
Emphysema	0/0.34	0/0.22	0/0.27	0/0.15	0/0.45
External causes	2/4.3	2/3.0	2/3.6	0/1.6	4/8.1
Accidents	2/2.4	2/1.7	2/2.1	0/0.90	3/4.7
Suicide	0/1.4	0/0.99	0/1.2	0/0.55	1/2.5
Other known causes	5/5.9	4/4.7	5/5.0	2/3.0	8/9.8
Unknown causes	0	0	0	0	0

* Expected numbers were derived using Colorado rates.

TABLE 41. Number of subjects by time sheet production unit, race and gender

Units	White men		White women		Black men		Black women		Total	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
All units	776	(94)	9	(1)	39	(5)	2	(0)	826	(100)
Azodrin	406	(91)	9	(2)	30	(7)	2	(0)	447	(100)
Aldrin/BCH/ Dieldrin	696	(95)	3	(1)	32	(4)	0	(0)	731	(100)
Planavin	348	(92)	3	(1)	25	(7)	0	(0)	376	(100)
Vapona	376	(94)	3	(1)	22	(5)	0	(0)	401	(100)
Nudrin	161	(87)	7	(4)	14	(8)	2	(1)	184	(100)
Nemagon	458	(95)	2	(0)	24	(5)	0	(0)	484	(100)
All others	708	(94)	7	(1)	35	(5)	1	(0)	751	(100)

TABLE 42. Number of white men, median weeks worked, median start year and median age at hire by non-mutually exclusive time sheet production unit

Production unit	Number	Median weeks worked		Median start year		Median age at hire	
		In plant	At unit*	In plant	At unit*	In plant	At unit*
All units	776	304	61	1960	1961	26	28
Azodrin	406	435	17	1965	1966	27	31
Aldrin/BCH/Dieldrin	696	312	14	1959	1960	26	28
Planavin	348	493	16	1965	1966	28	34
Vapona	376	520	3	1962	1963	27	31
Nudrin	161	565	17	1967	1973	29	39
Nemagon	458	434	1.3	1959	1960	26	29
All others	708	324	19	1960	1960	26	28

* All production unit data cover time period 1957-1977 only.

TABLE 43. Observed/expected numbers of deaths and SMRs among white men, ever hourly and never hourly combined, employed during 1965-1982, according to whether they had time sheet summary data*

	Subjects with time sheet summary data (N=776)			Subjects without time sheet summary data (N=552)		
	Obs/exp	CO_SMR	95% CI	Obs/exp	CO_SMR	95% CI
All causes	142/161	88	74-104	70/97	73	57-92
All cancers	33/33	100	69-141	22/20	109	69-166
Digestive cancers	11/8.6	128	64-229	5/5.2	96	31-225
Hepatobiliary	2/0.62	321	39-1160	0/0.38	0	0-960
Colon	7/2.9	240	97-495	2/1.8	114	14-411
Rectum	2/0.64	313	38-1130	1/0.38	266	7-1480
Lung cancer	6/10	59	22-129	6/6.3	96	35-208
Brain and CNS	1/1.2	80	2-448	1/0.81	123	3-689
Lymphopoietic system	3/3.7	80	17-235	3/2.3	129	27-378
Heart disease	41/45	91	66-124	22/26	84	52-127
Cerebrovascular disease	2/7.4	27	3-98	1/3.9	26	1-142
Respiratory disease	17/15	112	65-179	3/8.4	36	7-104
Pneumonia	8/4.9	164	71-323	1/2.5	40	1-225
Emphysema	1/2.8	36	1-201	0/1.5	0	0-251
Cirrhosis of liver	4/4.4	91	25-232	0/2.9	0	0-128
External causes	13/23	56	30-96	9/16	56	25-105
Accidents	9/14	65	30-123	6/9.6	63	23-137
Suicide	3/6.8	44	9-129	2/4.8	42	5-151
Other known causes	28/33.2	84	50-122	11/20	55	28-99
Unknown	4			2		

* Expected numbers based on Colorado rates.

TABLE 44. Observed/expected numbers of deaths* among all white men ever worked in Azodrin, Aldrin/BCH/Dieldrin (ALBD), Planavin, Vapona, Nudrin and Nemagon time sheet production units in the period 1965-1982

	Azodrin	ALBD	Planavin	Vapona	Nudrin	Nemagon
All causes	58/71	136/148	54/62	73/85	16/22	95/105
All cancers	16/15	32/31	16/13	21/17	7/5.2	25/22
Digestive cancers	5/3.8	11/8.0	5/3.5	7/4.5	4/1.3	8/5.7
Hepatobiliary	0/.29	2/0.58	0/0.27	1/0.34	0/0.09	1/0.42
Colon	5/1.3**	7/2.7**	5/1.2**	6/1.6**	3/0.46**	6/1.9**
Rectum	2/0.27	2/0.59	2/0.24	1/0.33	0/0.09	0/0.43
Respiratory system	4/5.0	8/9.9	4/4.6	5/5.7	2/1.9	7/7.0
Lung	4/4.8	6/9.5	4/4.4	5/5.4	2/1.8	6/6.7
Brain and CNS	1/0.57	1/1.2	1/0.51	0/0.61	1/0.20	1/0.78
Lymphopoietic	1/1.6	3/3.5	1/1.5	1/1.9	0/0.53	2/2.4
Heart disease	15/19	37/42	14/17	19/24	6/6	23/30
Cerebrovascular disease	0/2.9	2/6.7	0/2.4	0/4.0	0/0.73	0/5.0
Respiratory disease	7/6.6	17/14	7/5.7	10/8.5	0/1.9	13/10
Pneumonia	3/1.9	8/4.4	4/1.5	5/2.7	0/0.44	5/3.3
Emphysema	0/1.1	1/2.6	0/1.0	1/1.6	0/0.29	1/1.9
Cirrhosis of liver	0/2.0	4/4.1	0/1.8	2/2.2	0/0.69	2/2.8
External causes	5/11	13/21	4/8.8	6/11	1/3.0	11/14
Accidents	3/6.2	9/13	3/5.1	6/6.6	1/1.7	7/8.2
Suicide	1/3.2	3/6.2	0/6.2	0/3.3	0/1.0	3/4.1
Other known causes	15/14.5	27/29.2	13/13.3	15/18.3	2/4.5	19/21
Unknown causes	0	4	0	0	0	2

* Expected numbers were derived using Colorado rates.
** $P<0.05$.

APPENDIX A.

PROCEDURES MANUAL FOR ABSTRACTING GENERAL WORK HISTORY INFORMATION

GENERAL INFORMATION

This is a manual for abstracting general work history information from the personnel record (hard copy) using a specifically designed abstract form (Work History Abstract Form).

SOURCE OF WORK HISTORY INFORMATION

There may be more than one source of information on Denver Plant employees. Reference is made to these documents to reconstruct or enhance an employee's work history. Inspect the document carefully for its date and write this date on any specific page used for the particular employee and copy the document for the employee file.

Familiarization with the different personnel records and their formats is recommended. Carefully note any comments regarding the subject's termination or re-classification. The personnel records and related personnel documents should be searched in the following order:

1. Use "Employee Service Record" if available;
2. else, use "Termination Sheet";
3. else, use "Organization Chart" (1952-82) or
4. "Seniority List" (1952-78 and 1980-82) and/or
5. "Employee Movement Register"
   (hourly and staff, 1976-83) or
6. "Monthly Termination Letter" (1955-1978)
   as appropriate.

FORM FOR ABSTRACTING WORK HISTORY

LABEL:

A pre-printed LABEL for each subject is affixed on the Work History Abstract Form. The label has identifying information from the cohort file. Line 1 has the last name, first name and middle initial. Line 2 has the social security number. Lines 3 and 4 have the hire date and termination date respectively.

WORK HISTORY ABSTRACT FORM:

Fill-in the page number, 4 items of job-specific information abstracted from the data of the personnel records and the job title dictionary, and the TERMINATION REASON. Make sure the personnel records match both the name and SSN on the abstract form.

DOCUMENTATION:

Document all records used for each subject in the person's folder. Make copies of any support documents, such as seniority lists, organization charts, employee movement register and/or monthly termination letters used and add them to the employee's file.

GENERAL INSTRUCTIONS FOR ABSTRACTING WORK HISTORIES

Information on "Start date" is obtained and entered from a personnel record. Other information ("Department" and "Exact Job Title") is obtained from the personnel record but entered exactly as it appears in the Shell Denver Job Title Dictionary by looking up the department and exact job title

in the dictionary. This is necessary to avoid differences in spelling and abbreviations that occur in various personnel records. No punctuation is used in the abbreviations of titles or departments.

1. If there is a personnel folder, but there is no abstract form for the person, give the personnel folder to the Project Coordinator (PC) so that a form can be prepared.
2. If there is an abstract form for a person, but there is no personnel folder, give the abstract form to PC.
3. Compare the name and the dates on the I.D. label to the personnel records to ensure an employee match and to flag any unusual end and start dates.
4. Scan the assignment locations on the Employee Service Record before beginning, as only jobs held in Denver are to be entered.
5. If after searching all available sources of work history information, there is no work history for a subject, enter the following codes:

   "Start date": 99/99/99

   "Exact job title": No WH

   Give both the abstract form and the personnel folder to the PC.
6. The Work History Abstract Form has ten lines for 10 job assignments. If a person has held more

than 10 jobs, continue the abstracting on a second page of the form, numbering it accordingly and recording the employee's name and SSN in the upper right hand corner.

7. If there is a GAP between two consecutive jobs held, the gap shall be recorded as a part of the work history by entering the following values:

"Start date":	One day after the end date of previous job.
"Exact Job Title":	"Laid-off" unless otherwise specified.
"Department":	Blank.
"S or H":	Blank.

8. If there is a GAP between the end date of the last job held and the termination date, the gap shall be recorded as a part of the work history by entering the following values:

"Start date":	One day after the end date of the last job.
"Exact Job Title":	"Leave of Absence" or "Laid-off," unless otherwise specified.

9. Enter the subject's job termination as part of the job history abstraction by entering the following values:

"Start date":	One day after the end date of the previous job, (the start of the termination period).
"Exact Job Title":	"Terminated," irrespective of the termination reason.

"Department": Blank.

"S or H": Blank.

10. If there is no job title for any point in the employee's work history, enter "unknown" for exact job title.

11. Fill in the appropriate code for the termination reason for all subjects. If the employee transferred to a location other than Denver, write the city or plant name on the line, Termination Reason, along with the termination code.

12. If any relevant information is illegible, bring it to the attention of the PC.

SPECIFIC INSTRUCTIONS FOR DATA ABSTRACTING WORK HISTORY

ABSTRACT FORM

Work History Items	Instructions
1. "Page No.":	Enter "1" for the first page. For subsequent pages, enter "2","3", etc.

Note: ENTER JOBS HELD IN DENVER ONLY

2. "Start date":

a. Enter the actual date, using month/day/year (MM/DD/YY).

b. Omit the leading 19 from the year.

c. Assign "99" to each unknown component of either date (including instances in which there is no WH information).

d. Check to identify and verify any gaps between two consecutive jobs. Record confirmed gaps (i.e., lay-offs, leaves of absence, time-off between summer employment periods) as part of the work history, as instructed in General Instructions, item 7.

3. "Department":

a. Identify the name of the department/subunit from the personnel record.

b. Find the corresponding department in the Shell Denver Job Title Dictionary.

c. Enter the name of the department/subunit as it appears on the Job Title Dictionary. If two job assignments (titles) appear listed with the same date, refer this discrepancy to the PC. Should titles, Operator No. 1 and Operator No. 2, appear with the same date, enter the title as Operator No. 1 with the referenced date, omitting No. 2 from the history.

d. If no information is available, follow the instructions below:

1). Check the Job Titles Dictionary to determine if the job title indicates a specific department/subunit.

2). If the specific location is still unknown, assign the non-specific code.

4. "Exact Job Title":

   a. Identify the literal job title as it appears on the personnel record.

   b. Enter the job title **exactly** as it appears in the job title dictionary.

5. "S or H":

   a. Enter "S" for salaried jobs, and H" for hourly jobs. Hourly jobs are indicated as "O" and salaried jobs as "S" on the Employment Service Record.

6. "Termination Reason":

   a. Enter the code corresponding to why the subject ceased working in the Shell Denver Plant.

      T = Terminated ("laid-off," "quit," military leave from which employee does not return, etc.)

      D = Died while active

      P = Retired/Pensioned

      TR = Transferred to another Shell facility. With this code, write the destination (city or plant site) to which the employee was sent after leaving Denver.

      "Unknown" is not allowed as a termination reason.

7. "Abstractor":

   Enter the initials of the abstractor when the work history has been completed.

SHELL DENVER PROJECT WORK HISTORY ABSTRACT FORM

Page No. _____ Abstractor: _____

Termination Reason: _____ I. D. Label Here

START DATE MM/DD/YY	DEPARTMENT	JOB TITLE	H or S

HOW TO USE THE PERSONNEL RECORDS

EMPLOYEE SERVICE RECORD

1. Locate "Employee Service Record." If none, move to "Termination Sheet."

2. From the "Employee Service Record," identify the following data from the ESR Columns:

"Start date":	See 'Effective Date' for each specific job title.
"Department":	See 'Department'.
"Exact Job Title":	See 'Occupational Classification.'
"S or H":	See 'S or O' for pay status of Salaried or Hourly. Where S is indicated, code "S". Where O is indicated, code "H".

3. Compare the end date of each job with the start date of the following job.

   A. Is there any overlap in the time frames of the two job assignments? If so, an error has been made. Re-examine ESR details for correctness, and if necessary, verify against "Employee Movement Register" for appropriate periods to clarify and remove overlap errors.

   B. Are there any time gaps in job assignments? Verify end dates and start dates against "Employee Movement Register". Record gaps in employment in the work history as shown in General Instructions, item 7, page 102.

C. When end dates and start dates of jobs and employment gaps (lay-offs) are contiguous, continue to next step.

4. Locate the "Termination Sheet".

A. Compare the end date of the last job listed on the ESR to the termination date on the "Termination Sheet."

1). If they agree, also compare the last job title on the ESR to the job title/position held upon termination, according to the "Termination Sheet." If they also agree, END the work history.

2). If ending job titles/positions disagree, or if end-date of last job and termination date disagree, refer to the "Employee Movement Register" of the earlier date listed on the ESR. Locate the job-end date for the last job title and any further reference to subsequent job title or transfer. When the subsequent job title ends, compare this end date with termination sheet's date of termination and position held upon termination. When agreement has been found, END the work history.

TERMINATION SHEET

If there is no "Employee Service Record," abstraction may begin with the "Termination Sheet". If there is no "Termination Sheet" for the subject, proceed to the "Organization Chart" of the year of hire and follow the specific instructions on page 112.

The "Termination Sheet" is divided into two sections by a double line. Above the double line are the employee's job details at termination. Below double line are two sections:

(1). The employee's job details at hire, and

(2). Remarks are found at the bottom of the form and should be read carefully for explanation of exceptional circumstances of termination. A gap at the end of the work history, where the end date of the last job and the termination date are not matched, should be verified with the "Employee Movement Register" and then recorded as "Leave of Absence", detailed in General Instructions, item 7, page 102.

1. STEPS FOR ABSTRACTING FROM "TERMINATION SHEET":

A. Refer to the HIRE DATE information below double line and identify the following:

"Start Date": First (earliest) Hire date

"Department": Department name

"Exact Job Title": Position

B. Is there more than one date of hire?

1). If NO, and there is ONE HIRE DATE, COMPARE job title/position at time of hire and termination.

a). If the job titles agree:

Enter the date of termination on the cover sheet of the Work History Abstract Form as the "Start date" of the termination period. Complete the Abstract Form and END the abstraction.

b). If job titles/positions disagree:

The subject was reclassified or reassigned to a subsequent job(s) before terminating and "Start date" of the subsequent job(s) need to be searched.

c). Searching service period(s) spanning three or more years:

Refer to "Organization Chart" of year of hire and locate subject by name and job title. Should the "Chart" reflect title/position only, the "Seniority List" can be consulted for employee name by job title/position. Scan forward until subject name is omitted from original position. The year of omission less one year should be searched in

"Employee Movement Register" or "Monthly Termination List" to identify "Start date" of subsequent assignment and the new job title and/or department.

d). Searching service period(s) of less than three years:

"Start date" can be searched directly in the "Employee Movement Register" or the "Monthly Termination List". Beginning with subject's initial hire date, scan "Movement Register" for the end date of the first hire position and "Start date" of the subsequent assignment. Then, check "Movement Register" at date of termination to verify that this corresponds to subject's Termination date". Continue until both the job title and department agree AND the end date of the job matches the date of termination.

2). If YES, and there are MULTIPLE HIRE DATES:

a). Review "Employee Movement Register" or the "Monthly Termination List" for the end date of the first assignment.

b). Is this end date earlier than the next Hire Date?

If NO: An error is indicated. Recheck dates.

If YES: The "End date" of the first job and the next Hire date are not continuous, so record the GAP as instructed in General Instructions, Item 7, page 102.

c). Enter SECOND hire date and locate Job title and Department in "Movement Register" at this date verifying title and department.

d). Start date of job termination period should be one day after the Date of Termination; also, job titles should agree. Confirm agreement and then, complete Work History Abstract Form and END the abstraction.

ORGANIZATION CHART

The "Organization Chart" is a six-month report which is helpful in tracking job-titles by departments, as well as in verifying employee names assigned to these positions. The list is useful mainly for salaried (staff) positions. The lower level positions (mainly hourly) in the department hierarchy reflect job titles only. The "Seniority List" covers the hourly employees and must be used as a supplement to the Organization Chart.

1. STEPS FOR ABSTRACTING FROM THE ORGANIZATION CHART:

A. Locate the Organization Chart for the period immediately <u>following</u> the Hire date. Is the NAME found on the "Chart"?

1). <u>If YES,</u> and NAME is on "Chart", identify the following:

"Exact Job Title"

"Department"

"Start date": Enter the hire date

a). Identify the next "Organization Chart" and search for name. If job title and name are present, repeat process until a change or omission is evident.

b). When Job Title/Position changes, locate "Employee Movement Register" for the time span between the differing Charts. Search for details of reclassification or termination.

c). When the Job Title/Position of service <u>agrees</u> with Job Title/Position at termination date, enter one day after the termination date as the "Start Date" for the termination period.

d). When both Job Title/Position and end date of the job assignment <u>agree</u> with the same at termination, END the

abstraction and complete the Work History Abstract Form.

2). If NO, the NAME is not found on the "Chart":

a). If Job Title only is found, go to section on "Seniority List" and follow instructions.

b). If Job Title is NOT found on "Organization Chart," record name and SSN on "Problem Review List" for further investigation or referral to PC.

SENIORITY LIST

The "Seniority List" is a monthly list of hourly paid employees only. It is available from 1952 through 1978 and 1980 through 1982. The "List" is organized by Job Title and Department.

1. STEPS FOR ABSTRACTING WORK HISTORY FROM "SENIORITY LIST"

A. When subject has known job title and/or when the subject is known to be an hourly employee with a known hire date, locate the Seniority List for the period following the hire date and search for NAME of employee.

1). If name is NOT FOUND under the known job title, record the name and SSN of the subject on the "Problem Review List" for later investigation or referral to PC.

2). If the name is FOUND on "Seniority List":

a). Enter on the Work History Abstract Form:

"Start date"

"Department"

"Exact Job Title"

b). Go to the next "Seniority List"; search for name under SAME Job title.

(1). When the name appears with SAME Job title, continue tracing by going to next later "Seniority List."

(2). When the name appears under a DIFFERENT Job Title, enter this information as a new job assignment on the Work History Abstract Form as above in 2). a).

(3). When the name is NOT FOUND on the subsequent "Seniority List," COMPARE the subject's termination date to the date of the failed "Seniority List." Is termination date later than this List?

(a). <u>If YES</u>:

Go to "Employment Movement Register" or "Monthly Termination List" corresponding to date of

"Seniority List" and search for end date.

(b). If NO:

Enter the Termination date as the End date.

B. If the name is not located on any "Seniority List", record the name and SSN on the "Problem Review List" for further investigation or referral to the PC.

EMPLOYEE MOVEMENT REGISTER

The "Employee Movement Register" is a monthly list of changes in job assignments. Two separate lists are available, one for hourly-paid employees and one for salaried employees. They both cover from 1976-1982 only. Each job change and the effective dates are recorded by Job Title/Position and Department, listing both "From" information and "To" information. This personnel record is a helpful supplement to a work history search from the "Termination Sheet" and the "Organization Chart" or the "Seniority List".

MONTHLY TERMINATION LETTER

Terminations for both hourly-paid and salaried employees are listed on the "Monthly Termination Letter". The available records cover from 1955 through 1978. Date of termination and termination reason are indicated, as well as initial hire date. No interim reclassification from one job

assignment to another is included. Interim changes must be identified from the "Employee Movement Register" (above). This personnel record is a supplement to the other personnel documents referenced herein.

Appendix B.

US_SMR COMPUTED WITH PERIOD OF OBSERVATION RESTRICTED TO 1960-1990 FOR ALL CAUSES AND NON-CANCER DEATHS AND 1952-1990 FOR CANCER DEATHS

TABLE B1. Observed numbers of deaths and SMRs by cause of death according to race and gender, expected numbers derived from US rates**

	White Men		White Women		Black Men		Black Women		Total		
	Obs	US_SMR	Obs	US_SMR	Obs	US_SMR	Obs	US_SMR	Obs/exp	US_SMR	95% CI
All causes	429	88*	23	104	13	85	0	[0.76]	465/528	88	80-96
All cancer	99	83	9	104	5	155	0	[0.19]	113/132	86	71-103
Digestive system	27	89	0	[1.60]	0	[0.94]	0	[0.04]	27/33	82	54-119
Hepatobiliary	5	212	0	[0.15]	0	[0.10]	0	[0.00]	5/2.6	196	64-458
Colon/rectum	13	97	0	[0.86]	0	[0.25]	0	[0.01]	13/14	90	48-153
Respiratory system	31	70*	3	190	0	[1.17]	0	[0.03]	34/47	72	50-101
Lung	27	64*	3	195	0	[1.10]	0	[0.03]	30/45	67	45-95
Brain and CNS	5	129	0	[0.26]	0	[0.05]	0	[0.00]	5/4.2	119	39-277
Lymphopoietic	12	100	1	[0.71]	3	1254*	0	[0.01]	16/13	123	71-200
Other cancers	24	83	5	140	2	[0.55]	0	[0.10]	31/20	155	105-220
Rheumatic ischaemic heart disease	126	75	3	69	2	65	0	[0.11]	131/176	74	62-88
Cerebrovascular dis.	12	47*	1	[1.3]	1	[1.03]	0	[0.06]	14/28	50	27-84
Respiratory disease	45	147*	1	[1.2]	0	[0.82]	0	[0.03]	46/33	141	103-188
Pneumonia	20	198*	0	[0.35]	0	[0.42]	0	[0.02]	20/11	184	112-284
Emphysema	8	147	0	[0.15]	0	[0.07]	0	[0.00]	8/5.7	140	60-276
Other	17	113	1	[0.66]	0	[0.35]	0	[0.01]	18/16.0	112	67-178
Cirrhosis of liver	13	93	0	[0.69]	0	[0.59]	0	[0.04]	13/15	85	45-145
External causes	38	75	4	228	3	113	0	[0.09]	45/55	81	59-109
Accidents	21	65	4	390	2	[1.31]	0	[0.04]	27/35	78	51-114
Suicide	12	94	0	[0.53]	0	[0.19]	0	[0.01]	12/14	87	46-155

Expected number is displayed in brackets when both the observed and expected numbers are less than 3.

* $P<0.05$.

** Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancer deaths.

TABLE B2. Observed and expected numbers of deaths and SMRs for the total cohort using US, Colorado and regional five county rates to derive the expected numbers*

	Observed	US			Colorado			Regional counties		
		Exp	US_SMR	95% CI	Exp	CO_SMR	95% CI	Exp	R_SMR	95% CI
All causes	465	528	88	80-96	473	98	90-108	440	75	60-92
All cancers	113	132	86	71-103	106	106	88-128	104	85	54-128
Digestive system	27	33	82	54-119	28	98	64-142	33	81	30-176
Hepatobiliary	5	2.6	196	64-458	2.0	249	81-581	2.0	0	0-753
Colon/rectum	13	14	90	48-153	11	115	61-196	11	103	21-307
Respiratory system	34	47	72	50-101	33	102	71-142	33	44	12-113
Lung	30	45	67	45-95	32	94	63-134	31	35	7-101
Brain & other CNS	5	4.2	119	39-277	4.0	125	41-292	3.9	100	3-557
Lymphopoietic	16	13	123	71-200	11	146	83-237	11	134	37-344
Other cancers	31	20	155	105-220	32	97	66-138	33	94	64-134
Heart disease	131	176	74	62-88	131	100	84-120	123	107	89-127
Cerebrovascular dis.	14	28	50	27-84	21	66	36-111	19	73	40-122
Respiratory disease	46	33	141	103-188	43	107	78-143	40	115	84-153
Pneumonia	20	11	184	112-284	13	150	92-232	12	167	102-258
Emphysema	8	5.7	140	60-276	7.8	103	45-203	6.9	115	50-227
Other	18	16	112	67-178	22	82	49-130	21	90	54-140
Cirrhosis of liver	13	15	85	45-145	14	93	49-158	12	107	57-184
External causes	45	55	81	59-109	66	68	50-91	58	78	57-104
Accidents	27	35	78	51-114	38	70	46-102	32	85	56-124
Suicide	12	14	87	46-155	19	62	32-108	19	64	33-111

** Period of observation is 1960-1990 for all causes and non-cancer deaths and 1952-1990 for cancers.
* P<0.05.

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