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A PETROLEUM SOLVENT MORTALITY STUDY OF OKLAHOMA DRY CLEANERS

Final Report on
Project Period
01/01/86 — 03/31/88
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National Institute of Occupational
Safety and Health
Centers for Disease Control

Departments of Biostatistics and Epidemiology
and Environmental Health
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16. Abstract (Limit: 200 words) The association between exposures to the primary petroleum solvents used in commercial dry cleaning processes and various causes of death was investigated. Each commercial dry cleaning establishment in Oklahoma was classified according to the solvent or solvents in use from 1941 to 1983, based on data from the State Dry Cleaners Board. A cohort with known solvent exposures was identified. The proportionate mortality ratios (PMRs) and standardized mortality ratios (SMRs) were determined for all major causes of death. The industry in Oklahoma used a disproportionately high percentage of petroleum solvents. Owners and family members represented 29 to 42 percent of the workers. Nearly 59 percent were white males, with an average exposure of 10.5 years. No excess in overall cancer mortality was found. Significant excesses were noted for mental, psychoneurotic and personality disorders due to alcoholism; genitourinary system due to acute nephritis, chronic nephritis and renal sclerosis; bone and organ movement due to arthritis and spondylitis. An excess in cancers of the respiratory system was identified with excesses in mortality due to trachea, bronchus and lung cancer among those dying at age 65 or older. A 45 percent excess in proportionate mortality due to pancreatic cancer was found. Only on analysis of petroleum solvent exposure to white males was an excess found for kidney cancer. Moderately increased incidents of skin and bone cancer were found.

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MORTALITY STUDY OF OKLAHOMA DRY CLEANERS

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Project Period
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PURPOSE AND SCOPE

The purpose of this study is to examine the association between exposures to the primary petroleum solvents used in commercial dry cleaning plants and the distribution of causes of death by proportionate mortality ratios (PMRs) and standardized Mortality ratios (SMRs) among those exposed. The population of interest is all white males, identified as being owners and/or operators of commercial dry cleaning plants for greater than one year in the State of Oklahoma between 1941 and 1985.

The following research questions will be addressed.

1. Is there any difference in the distribution of causes of death among owners and/or operators of commercial dry cleaning plants when compared to deaths occurring in all United States white males between 1950 and 1985, matched by age group and calender period?

2. What is the influence, if any, of known petroleum solvent exposures and durations of exposure on the age and time specific distribution of causes of death by PMRs and SMRs in this population?

To achieve the research objective, the following tasks will be completed:

1. Categorize each commercial dry cleaning plant licensed in the State of Oklahoma between 1941 and 1983, by solvent use over time,

2. Identify a cohort of Oklahoma dry cleaning plant owners and/or operators with known solvent exposures and durations of exposure greater than one year, occurring between 1941 and 1985,

3. Among this cohort, determine the PMRs and SMRs for all major categories of deaths occurring between 1941-1985 to include overall cancer, and selected site-specific cancers, and

4. Estimate latency in appropriate cancer sites like renal cell carcinoma,

5. Calculate the approximate power to detect a significant excess in proportionate mortality at each of the site-specific cancer causes of death.

6. Identify high risk subgroups for future measurements of actual exposure levels, non fatal acute and chronic effects of the human kidney, and effects on reproductive outcome related to exposure to petroleum on synthetic solvents among Oklahoma dry cleaners, and

7. Prepare a final report of the findings, analyses, and recommendations resulting from the study.

MATERIALS AND METHODS

Materials

The major data resources, materials, and tools utilized in the conduct of this cancer mortality study were derived from three sources which include (a) the Oklahoma State Dry Cleaners Board, (b) the Oklahoma Association of Dry Cleaners, and (c) other sources. A listing of these resources can be found in Table 10.

The State of Oklahoma Dry Cleaners Board

The University of Oklahoma developed a strong working relationship with the Oklahoma Dry Cleaners Board beginning in 1979. The Board was very supportive of this research, and made available office space and access to all helpful data resources.

Initial and annual licence applications, 1941 - 1985.

The primary data source for the identification of dry cleaning plant owners and/or operators consists of approximately 60,000 initial and yearly renewal license applications, and transfers of ownership. These applications begin in 1941, were stored in 1-10 year groupings, and were sorted

TABLE 10

DATA RESOURCES

A. State Dry Cleaners Board

1. License Applications
2. Plant Inspections
3. Minimum Price Transcripts
4. Past Court Cases and Violations
5. Weekly Activity Reports
6. Minutes of Board Meetings
7. Industry Summaries
8. Mailing List
9. IFI Technical Bulletins
10. Special Purpose Lists and Reports
11. Current and Past Executive Secretary

B. Oklahoma Association of Dry Cleaners (OAD)

1. The OAD Bulletin
2. Membership Lists
3. Current Executive Secretary

C. Other Resources

1. The Oklahoma State Health Department Death Certificates and Limited Tapes
2. Oklahoma County Cleaners Association
3. Insurance Company Records
4. Textile Maintenance Reporter
5. Veteran's Administration - Patient Data Cards
6. Oklahoma Dry Cleaners
7. Telephone Directories (Libraries)
8. Criss-Cross and Polk Directories (Oklahoma Historical Society)
9. Newspaper Obituaries (Library)
10. Funeral Homes - Nursing Homes - Hospitals
11. Other businesses (ex Chamber of Commerce)
12. Word of Mouth - Relatives, Previous owners, Friends, and Neighbors
13. Returned Questionnaires
14. County Court House Probate Files
15. Voter Registration Tapes

alphabetically by city and business name. Six revisions of the initial application, and nine revisions of the annual renewal form have been used. Examples of each original and revised form are available at Appendices D and E. The major data items available are business name, address, name and race of owner and/or operator, previous dry cleaning experience, and solvent utilized. Of critical significance was the absence of information on date of birth, race and social security number.

Initial and annual plant inspections.

Beginning in the late 1940's, all new plants were given an initial health, safety, and fire inspection by the field man working for the State Dry Cleaners Board. The form used for inspection of petroleum solvent plants and the one for synthetic solvent plants have had few revisions, and are available at Appendix F. This data source provides for the verification of solvent used, changes in solvent category, and notes the conversion of agencies to plants. Since the early 1970's an abbreviated inspection form has been used for annual reinspections.

Minimum price transcripts, 1946 - 1976.

The proceedings of 143 minimum price hearings have been archived. A typical proceeding includes a petition signed by 75 per cent of the dry cleaners in a county, and a transcript of the public hearing in which owner name, business, and total years of dry cleaning experience of those license

holders who testified are routinely elicited. In addition, the certified mail receipts for price regulations sent to and signed by all dry cleaners within the county have been preserved.

Past court cases and violations, 1941 - 1985.

Transcripts of courtroom proceedings against individual owners have been archived and provide supplemental information regarding plant ownership and the full legal name of the owner.

Weekly activity reports, 1960 - 1985.

Summaries of businesses and owners visited and inspected by the field man on a yearly basis provide an additional source of verification of owner and/or operator name.

Minutes of the Board meetings, 1941 - 1985.

These minutes of monthly Board meeting include the approval of plans and drawings for all new plants and specify the solvent type to be used in the proposed plants.

Dry cleaning industry summaries, 1960 - 1984.

Detailed reports are available of yearly business volumes, number of plants, agencies and coin-ops, and number of family and non-family employees, by county.

Current and past mailing lists.

The current and past mailing lists maintained by the Board specify the owners, category and longevity of businesses as well as current (or past) solvent(s) in use.

IFI technical bulletins.

The yearly "Approved Solvents" bulletin, published by the IFI, helps to categorize solvents which were specified only by brand name on the licensure application.

Special purpose lists and reports.

A collection of listings of plants by solvent use (i.e. perchloroethylene) at various times to meet special administrative or legal necessities.

Executive secretary.

The executive secretary, John Dinwiddie, had worked for the Board from 1979 to 1985, and had been active in Oklahoma dry cleaning since 1925. His predecessor, Frank Olney, is a local resident who was the Executive Secretary from 1957 to 1979. Both men are invaluable resources to improve and verify the plant and name data being collected.

The Oklahoma Association of Dry Cleaners

The Oklahoma Association of Dry Cleaners (OAD) has encouraged and supported this research, making available their historical files and records, and authorizing access to insurance company data.

The OAD Bulletin.

The OAD Bulletin has been the official publication of the OAD since 1955. Approximately 93 per cent of all monthly issues have been recovered. These bulletins provide an important source of sex and race data, announce changes in

ownership, solvent use, and machinery, and routinely publishs newsworthy items of interest as well as obituaries for deaths occurring among present or past Oklahoma dry cleaners.

OAD State membership lists, 1951 - 1984.

OAD executive secretary.

The current executive secretary, Dorothy Bennett, has served in this position since 1960, and is an invaluable source of information and verification of data regarding the vital status of Oklahoma dry cleaners.

Other resources

The Oklahoma State Health Department.

The Oklahoma State Health Department is the official agency responsible for the collection and tabulation of vital statistics in Oklahoma. Notices of death are sent to the Health Department as certificates from the funeral director in charge of the disposition of the body of the deceased. They are received in the Office of Vital Records where they are numbered, sorted by county and name, and placed in permanent binders. The certificates are coded on a monthly basis by a trained nosologist. The coded items include sex, race, city and county of residence and death, and the cause of death coded according to the international classification of disease (ICD) revision in force at the time of death. These coded death certificates are key

punched and a computer tape updated monthly. Computer tapes of deaths occurring in Oklahoma by year, are available within the State Health Department for the years 1950 through 1964, and from 1975 through the present year. Machine readable death certificate data which include the cause of death are unavailable for the years 1965 through 1974. A database containing the name of the deceased, the date of death, county of death, and death certificate number is available to State Health Department Personnel in order to search for and retrieve the original copies of death certificates. This abbreviated data base is available for all deaths occurring after 1950. Copies of uncensored death tapes are available within the College of Public Health for research purposes only and include the years 1950 through 1964, and the years 1981 and 1982. It is from these death certificate abstracts on tape, or from copies of original death certificates, that the cause of death data for cohort members was obtained for use in this study.

Oklahoma County Cleaners and Dyers Association.

Newsletters and membership lists are available which reflect the membership and activities of this former county association from 1956 to 1981.

Insurance company records.

The insurance company which had been the major provider of OAD group health and life insurance was contacted and

released all death benefit claims from 1962 to 1974, all insurance claims from 1975 to 1979, and historical listings of all OAD holders of any policy type. These resources provide a valuable source of date of birth information.

Textile Maintenance Reporter, 1959 - 1983.

The Textile Maintenance Reporter is a monthly publication serving the Southwest with information and articles of interest and benefit to the dry cleaning and laundry industry. Each monthly issue contains an "In Memoriam" column which list deaths of dry cleaners occurring in Oklahoma, Texas, New Mexico or Louisiana and is supported by an extensive surveillance network of newspaper clipping services and trade associations.

Veterans Administration hospital.

Access has been granted to the patient data cards of eligible veterans who have been treated at the Oklahoma City Veteran Administration Medical Center. These cards are available on all eligible veterans treated since 1950 and contain basic demograghic data from which to determine veteran eligibility and are often annotated with the date of death for those veterans dying during their in-patient stay.

The Oklahoma Dry Cleaner.

The Oklahoma Dry Cleaner was a weekly trade newspaper published between 1947 and 1964. It emphasized news, legislation, and social events of interest to the Oklahoma dry

cleaning industry. Despite an intensive search, very few issues of this periodical have been recovered to date.

Telephone Directories.

Some people in the cohort were found in telephone directories in their last known place of business. We also used telephone directories to look up relatives, co-owners listed on licenses, and people with the same last name. The directories were also useful in contacting neighbors of people being searched for. We've also called certain businesses in that area that were at the same location for a long period of time.

Criss-Cross Directories and Polk Directories.

Located at the Health Science Center and Tulsa Libraries and the Oklahoma Historical Society. These were an excellent source of locating names of people. The Criss Cross and Polk directories provided information such as a first name (when we had only an initial) and we were able to obtain a place of employment or occupation, house address, the spouses name, the last year the person lived in that town, whether they lived in a house or apartment, and approximately when they died.

Funeral Homes.

Calling Funeral Homes was a very good source of exact dates of death of people who were suspected dead. We had received the "yellow book" which is a book of all the

Funeral Home addresses, counties and phone numbers. The Funeral Homes were called when we received information from family members or friends that a cohort members had died. All of the Funeral Homes needed an approximate year of death and most were very cooperative in searching the information needed.

Nursing Homes.

The Nursing Homes were only contacted when we received information that a particular cohort member was living in the facility. Some were cooperative in giving dates of birth. Most people in Nursing Homes were listed non-participants.

Hospitals.

Some Hospitals were called the Medical Records Department provided information on dates of death. They were helpful in looking up expired patients dates of death provided we had at least the year of death.

Word of Mouth.

The most successful method of finding people was by leads from word of mouth from relatives, previous owners, friends, and neighbors. Some were cooperative in giving information like cohort members moving from town to town, enabling us to look for them in area wide telephone listings. However, from that point contact was a little more difficult. The Funeral Home was contacted, then a

request was made and if we were lucky the death certificate was found. A lot of time was spent on the telephone contacting people and logging in information. Personal contact was better received than a phone call, but of course, an exhaustive search in this manner would be very expensive. Usually a visit was made to the local funeral homes, then the currently operating cleaners in the area. A list of unlocated persons for the N.E. quarter of the state was sent to the Oklahoma A&M College where a training school for dry cleaners was located since the early 1950's, but only four names were matched. A lot of hard to reach people were telephoned after 5:00 pm and on weekends, which was pretty productive.

County Court House Probate Files.

When all other resources were exhausted, a search of few County Court House Probate files was used. This process yielded some useful data, primarily exact date of death. This was done only in Oklahoma and Tulsa counties.

Voter Registration Tapes.

Voter registration tapes were purchased and used against the cohort list. It produced some results.

Returned Questionnaires.

Some of the information on the questionnaires that were returned was somewhat helpful. We had at times typed in information on previous drycleaner owners asking the

whereabouts. Some responded, some did not. The returned questionnaire also listed previous experience in other cities or towns which were leads to find other people.

The NIOSH life table analysis system.

The life table analysis system (LTAS) is a person-years at risk library of computer programs developed by NIOSH consisting of nine major system programs supported by eleven auxiliary programs residing with the IBM 360 computer at the Merrick Computing Center in Norman, Oklahoma. The system was specifically designed to analyze occupational cohort mortality data and can calculate standardized mortality ratios (SMR), proportionate mortality ratios (PMR), and proportionate cancer mortality ratios (PCMR).

Methods

Figure 2a shows the overall schema of the study design regarding data collection, editing and data analysis. Figure 2b illustrates the schema for follow-up of cohort. The license applications archived by the State Dry Cleaners Board were the major data resource used for the reconstruction of the Oklahoma dry cleaning industry from 1941 to 1985. License applications were sorted, coded and abstracted according to the algorithm shown in Figure 3. Two major data files were created in order to efficiently collect data regarding the solvent specific characteristics of Oklahoma dry cleaning plants, and information regarding individual

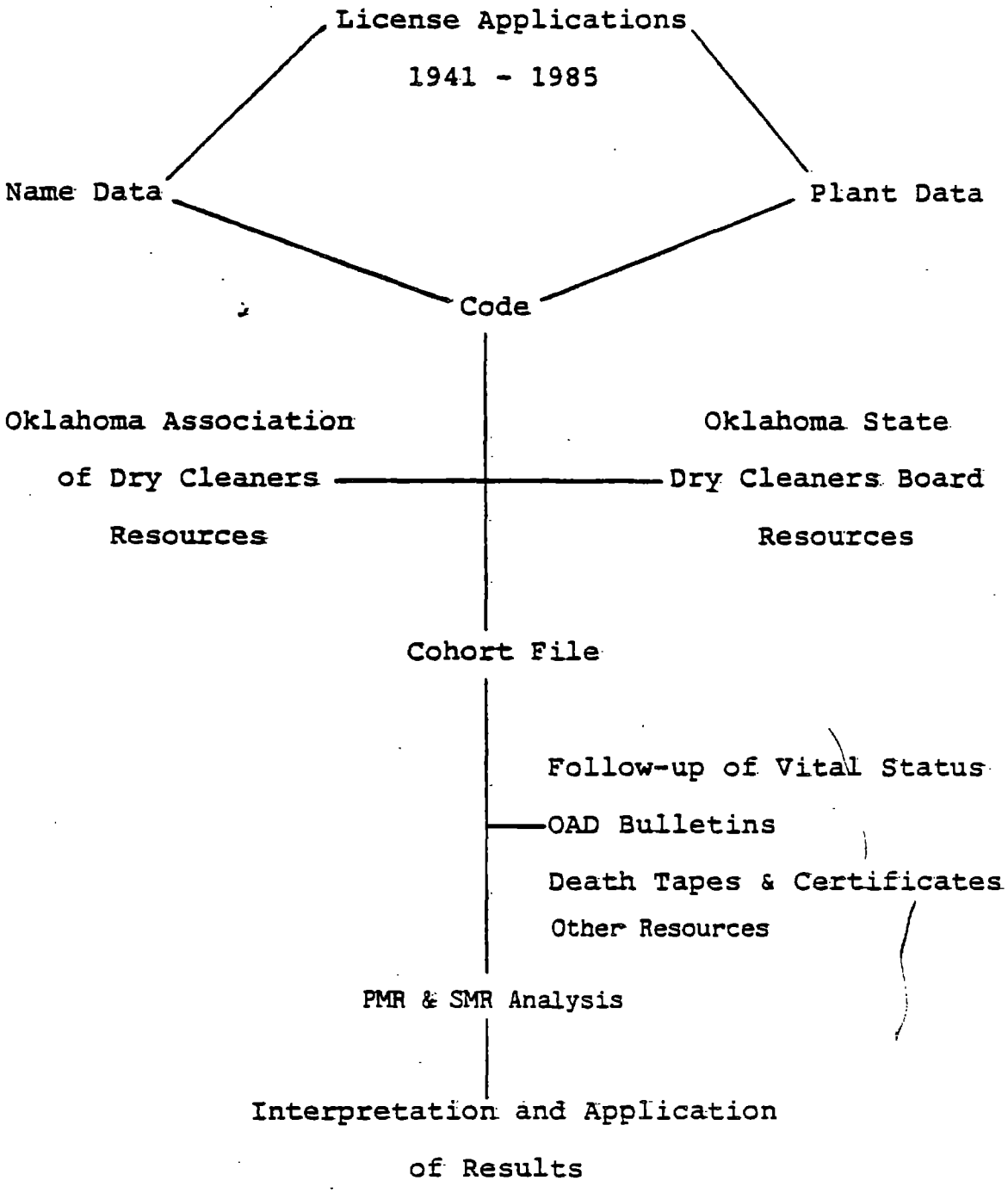


Figure 2. Outline of the Oklahoma dry cleaner mortality study.

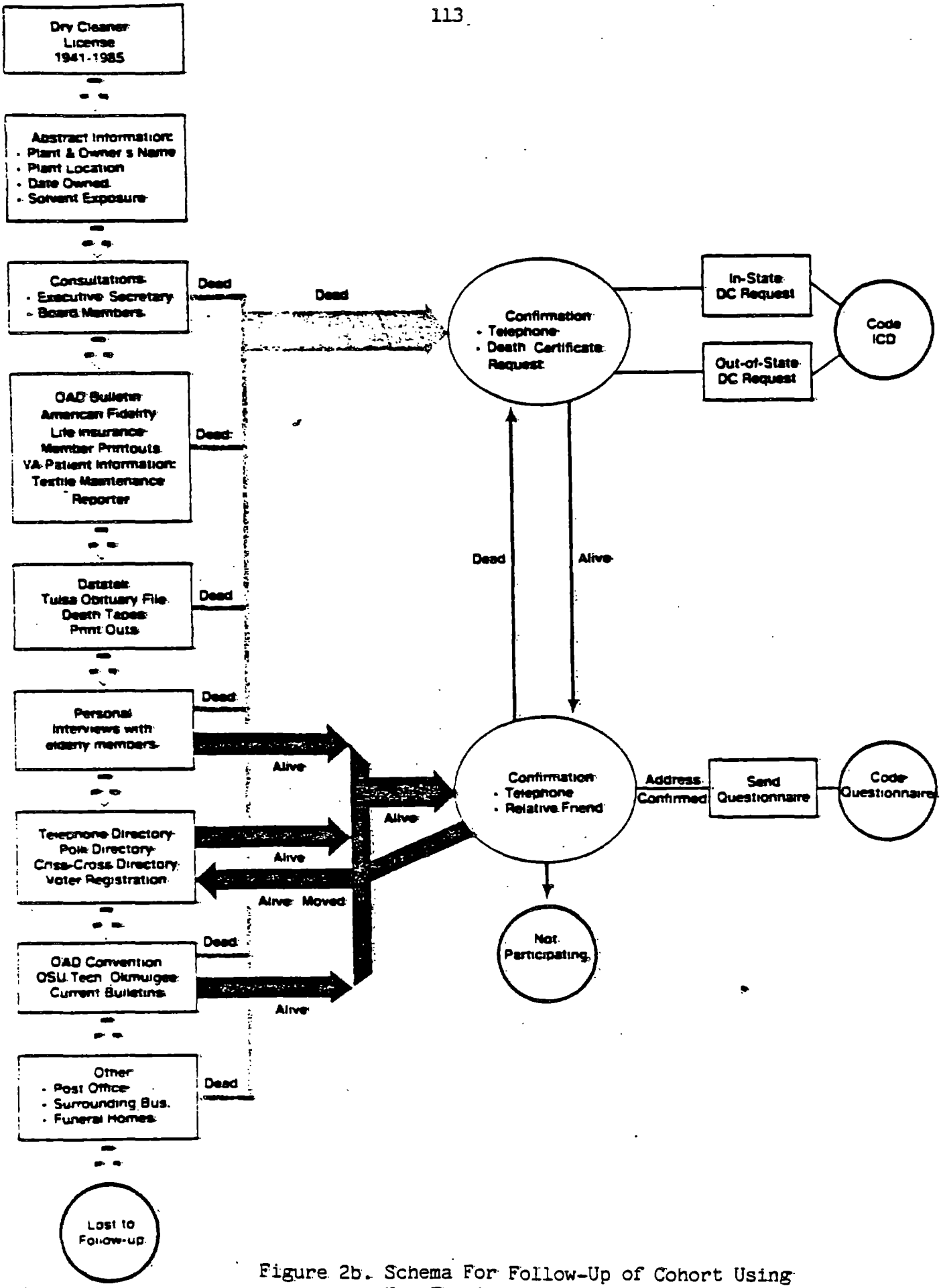


Figure 2b. Schema For Follow-Up of Cohort Using Non-Traditional Approaches

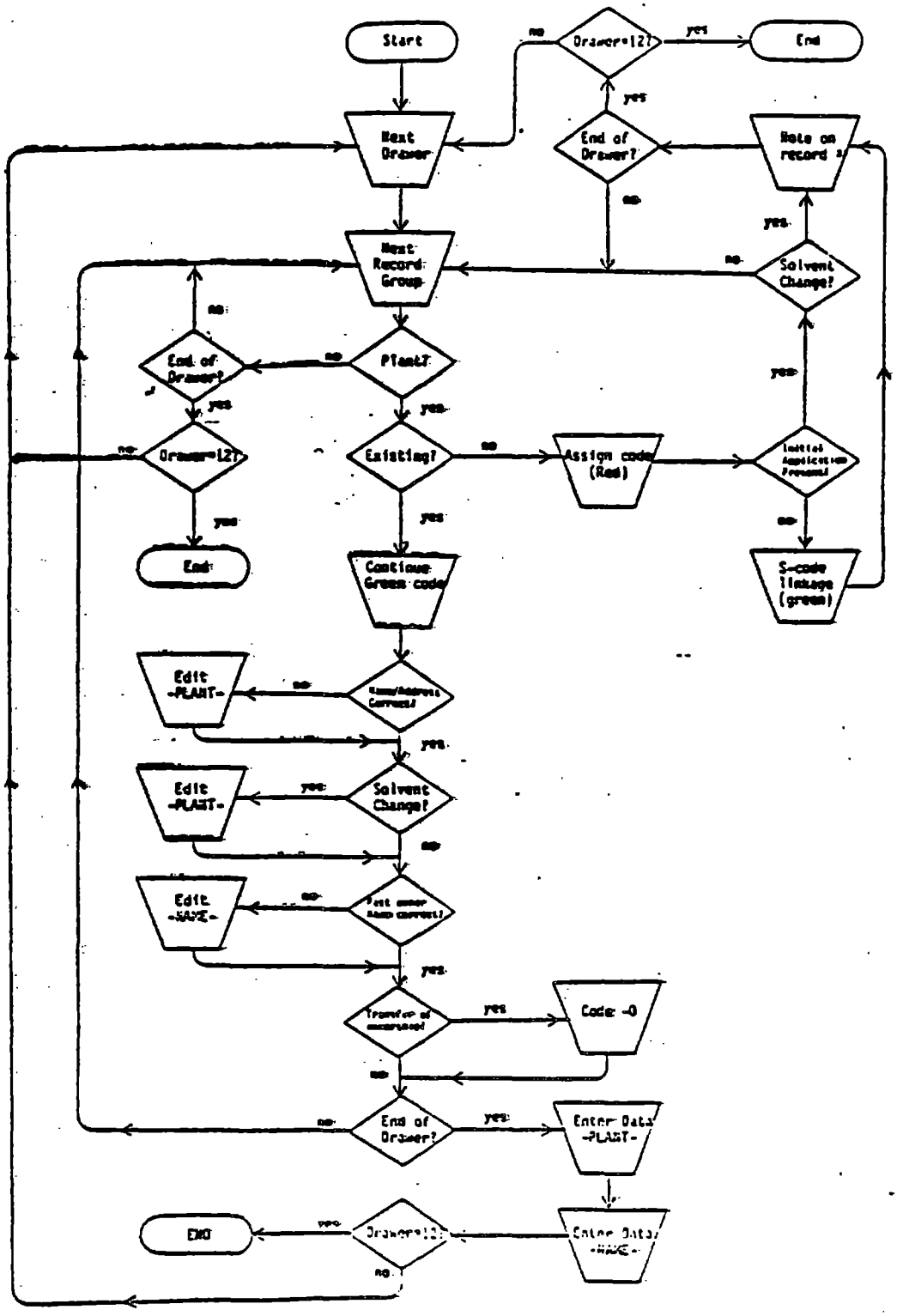


Figure 3. Algorithm for sorting, coding and data entry of dry cleaning license applications.

owners and/or operators of these solvent using dry cleaning plants. Both data files were created and managed using the Interactive Data Entry System (IDES) of the Data General M600 computer at the Research and Educational Services section of the Oklahoma University Health Science Center. The file PLANT was designed to accommodate the coding of up to four consecutive or concurrent solvent types and durations of use for each plant identified from the primary data base. The file NAME was used to collect information on individuals identified as the owner and/or operator of each solvent using dry cleaning plant. The files PLANT and NAME were linked by a shared code initially assigned to each unique solvent cleaning plant.

The File PLANT

The file PLANT was designed to contain an assigned plant code, the region in which the plant was found, the name of the plant, the address and city where it was located, and up to four solvent codes to include the start years and stop years during which that particular solvent was utilized at that plant. Nearly all plants specified the solvent to be utilized on the initial plant application. Renewal license applications did not explicitly state the solvent utilized during the years 1946 through 1965. After 1965 the class of solvent, petroleum or synthetic, was solicited. Between 1946 and 1965 the original solvent in

use for the plant was assumed to have remained unchanged, unless one of the many supplemental data sources, such as original or annual plant inspections confirmed such a change in solvent. All plants which changed name, or location were assigned a new and unique code.

The file NAME

The NAME file was designed to collect information on individual dry cleaners. Each dry cleaner was linked by PLANT code to the plant which he owned or operated, and the county in which that plant was located. Information on the first name, middle name and last name of the owner/operator as well as sex and race were collected. Ten to fifteen owners and/or operators recognized as either Hispanic or Oriental, were coded as white, and considered as such in all data analyses. Very few females or nonwhite males were identified as owners and/or operators of dry cleaning plants in Oklahoma. Those individuals completing an initial license application for a dry cleaning plant were directed to specify the number of years of prior experience within the dry cleaning industry, both in Oklahoma and elsewhere. This prior experience was used to estimate the total number of years of work experience prior to the first year of completing of a license application. Immediately following World War II and the Korean War, waivers of initial inspection fees were granted to veterans if they would supply their

prior service number. Data regarding age, social security account number, and date and cause of death were also collected. A record was created for each individual for each specific coded plant in which they were identified as being owners and/or operators. The beginning and end years of owner/operatorship were recorded. The basic assumption underlying the data collection for owners and operators is that owner/operatorship of a solvent using dry cleaning plant implies solvent exposure to the specific solvent identified as being used at that plant during that time period. Although this assumption was certainly violated at times, the nature of the Oklahoma dry cleaning industry and the preponderance of sole proprietorships allows such owner/operatorship to be a generally valid indicator of actual solvent exposure. Following the data abstraction, coding and data entry of information available from the dry cleaning license applications, the supplemental data sources were systematically reviewed and information added to, corrected or verified within the NAME and PLANT Files. Each data resource proved to be helpful in expanding the historical data base from which the solvent specific history of individual plants, and data regarding their owners and operators, was derived. The review and abstraction of these supplemental data sources provided multifaceted, overlapping, and redundant information sources in order to

accurately depict the business environment, the solvent use characteristics, and demographics of this cohort of solvent exposed dry cleaners in the State of Oklahoma.

Creation of the COHORT file

Information found in the PLANT and NAME files was merged together by shared plant code in order to create a file entitled COHORT. The COHORT file included a single record for each unique individual identified as an owner and/or operator of a solvent using dry cleaning plant between 1941 and 1985. Individuals are identified by their first name, middle name and last name, age, sex and race. The exposure histories of owner and operator were compiled over time with solvent exposure grouped into the categories of petroleum solvents, PCE, CCl_4, F113, or unknown. The durations of exposure, in years, to each of these solvent groups was recorded. Years of experience prior to the first license application was calculated and exposures were assigned to the group solvent in use at the first license application. The month, year and cause of death for deceased cohort members was recorded as well as the last two cities and counties of known residency. In order to estimate latency, a beginning year of solvent exposure was estimated using the first known year of exposure by licensure and including the known previous years of exposure. The last year of exposure was considered to be the last year for

which an individual was known to have owned or operated a solvent using plant in Oklahoma.

Recognition of deaths occurring among cohort members

The major source of reported deaths among cohort members was the OAD Bulletin and the obituaries notices routinely published in it. Other reports of death were abstracted from, license applications, minimum price transcripts, insurance company records, the Textile Maintenance Reporter, newspaper obituaries, funeral homes, probate files, next of kin and the Veteran's Administration patient data cards. Verbal reports and confirmations of written reports of death were received from executive secretaries of the State Dry Cleaner's Board and the OAD.

Oklahoma State Health Department death tapes

Coded abstracts of deaths occurring in Oklahoma between 1950 and 1964 and 1981 and 1982, available on magnetic tape, were sorted by year, sex, race and name. A binary search of these sorted files was conducted for each cohort member in the appropriate sex and race group, and in those years equal or subsequent to the last year known alive. Matches were made using a selection hierarchy of last name, first name, middle initial, age, and county of residence without regard to cause of death. Potential deaths were verified by the current or past executive secretaries of the Dry Cleaners Board and the OAD. Those potential matches to cohort mem-

bers which were unverified were considered a valid death for the purposes of the study only if no other unique name matches occurred in the death tape files.

Cause of death information

Although no data is available from Oklahoma, several studies have been published in the United States and Great Britain which assess the accuracy of cause of death certification for specific forms of cancer. For most forms of cancer, the accuracy of the cause of death statement has been found to be between 70 and 90 per cent when compared with hospital diagnoses (222), although it has been found to be somewhat lower when compared with autopsy findings (223-225).

The quality of cause of death certification presents problems for all occupational cancer mortality studies. At best, if misclassification of cause of death occurs randomly across occupations, the magnitude of any real occupation-cancer association will be diluted. However, it would not be surprising if the accuracy of cause of death certification were social class, and therefore occupation, dependent. This could be particularly true for cancer types, such as pancreatic cancer, which are difficult to diagnose. One would expect that they would be more likely to be diagnosed accurately in individuals who had better access health care and diagnostic facilities. Another problem with the use of

death certificates for occupational cancer studies is that ideally, one would want to know about all incident cancer cases, not just those whose underlying cause of death was stated to be cancer on the death certificate. Using mortality data, as opposed to incidence data, introduces potential biases with respect to differential cure rates for various types of cancer across occupations, due to unequal access to high quality medical treatment.

A related problem is the assignment of underlying cause of death in a patient with more than one major medical problem. Often, such an assignment is arbitrary. However, if the probability of assigning a cancer as opposed to another cause is the same from occupation to occupation, no bias will result from this problem. No attempt was made to utilize information on the death certificates with regard to secondary causes of death in this study.

Relationship between PMR and SMR statistics

SMR studies require that the total population at risk be followed and its endpoints ascertained for every cohort member; hence, these studies are often lengthy and expensive. When the population at risk cannot be ascertained, either because of incomplete records or lack of resources, it is sometimes possible to do a PMR study instead. In a PMR study, only deaths are ascertained, and the proportion of deaths from a specific cause in the study population is compared to the proportion expected based on some standard population, adjusted for age, race, sex and five year calendar period. The statistical significance of any departure of this ratio from 1.00 is assessed using the Mantel-Haenszel chi square test with one degree of freedom (226). A recent article by Jarvholm (227) has addressed some considerations in using mortality rates and proportions grouped by five year calender period, and recommends the future use of yearly rates and proportions to avoid an anticipated five per cent overestimation of the expected values.

A PMR cannot indicate the risk of death from any specific cause, but can detect any excess or deficit in the proportion of deaths from that cause. Since the sum of the proportion of deaths from each cause must equal one, a large deficit from a single cause of death will produce an excess from other causes. Competing risks of death can create an

artificially high PMR for a particular cause due to any large deficit from one cause. It has recently been shown that if the overall SMR from a study population is significantly less than 100, each cause specific PMR will be biased upward by the amount of the differential (228, 229). Conversely, if the SMR exceeds 100, each PMR will be biased downward.

The cause specific PMR approximates the cause specific SMR if the overall SMR is equal to 1.00, that is, the mortality rates are similar in the study and comparison groups.

$$PMR(\text{Cause i}) = SMR(\text{Cause i}) \times \frac{1}{SMR\ (\text{All causes})}$$

If the overall SMR is known or can reasonably estimated, the PMR can be multiplied by this factor to approximate the cause specific SMR. However, if the overall SMR varies with age, this equation cannot be used for PMRs summed over all ages. It is known that SMRs usually vary across age bands and decrease with age (230). The SMR could be approximated for each age band using the cause specific PMR from the same age bands, but the overall SMRs by age group are not usually estimable.

Wong and Decoufle (229) have suggested the use of a set of causes of death that will have similar rates in the working population and the general population. Cancer mortality rates have this property, due to the long latency period for

most cancers, and the fact that workers are not likely to be screened from employment for cancers. The type of PMR study where only cancer deaths are included is known as a proportionate cancer mortality ratio (PCMR) study. In this kind of study, the observed and expected deaths from any given cancer site are compared in a manner comparable to a PMR study. However, if the study population has an excess cancer risk from all sites, that is, an overall cancer specific SMR greater than 1.00, the site specific PCMRs will be biased downward. It cannot be assumed that the cancer SMRs will be constant across age bands or that the PCMR will closely approximate the actual site specific SMR. In most cases, however, PCMRs will generally be less biased than PMR statistics.

The NIOSH life table analysis system

The LTAS death rate/proportion subsystem uses external files in order to calculate expected death statistics for SMR, PMR, and PCMR studies. These files contain either estimated death rates or estimated death proportions for the United States population for 89 NIOSH cause of death categories, by sex, race, age group, and calendar period.

Each year, data on all individual deaths in the United States is made available by The National Center for Health Statistics (NCHS). This data contains the sex, race, age and cause of death for each person who died during the year. The causes of death contained in this data are categorized

according to a schedule established by the World Health Organization (WHO) (241). Because this schedule is quite large (nearly 2,000 different causes of death are recognized) it has been transformed into a NIOSH schedule which recognizes up to 89 causes of death and which retains the same categories for all years. Both schedules are periodically revised to keep them representative of current medical knowledge.

Using the NIOSH schedule found in Appendix G (231), the death categories in the records from the NCHS are converted from WHO categories to NIOSH categories. The records are then totaled for five-year periods, producing a summary of individual deaths for each NIOSH cause of death within each sex, race and age category. This five-year total is then divided by the number of people alive in the United States during the same period, by sex, race and age. The live population figure is estimated by interpolating between end-of-decade Census Bureau population estimates to find the population at the midpoint of the five year period in question and then multiplying the five-year midpoint by five. The result of this division is the average rate of death during the five-year period for each NIOSH cause of death within each sex, race and age category.

The expected death proportions are calculated by dividing the number of deaths due to a specific cause in any sex, race, age and calendar period combination by the total num-

ber of deaths for that combination.

Poisson hypothesis test and confidence limits.

LTAS performs hypothesis testing under the assumption that the observed number of events is distributed as a Poisson variable. The LTAS additionally gives confidence limits based upon the Poisson distribution. The user may specify whether the hypothesis testing is to be one-sided or two-sided. When one-sided is specified, only ratios in excess of 1.00 are tested, and 90 per cent confidence limits are calculated. When two-sided is specified, all ratios are tested and 95 per cent confidence limits are calculated. For six or more observed deaths, the Byar approximations to the exact test of confidence limits for a Poisson variable are used (232). The approximations agree very closely with Miettinen's exact methods and the Biometricka tables of Poisson limits (233). The accuracy of the approximate confidence limits for six observed deaths, for example, is within 0.5% of the exact limits, with the approximation being somewhat conservative.

To determine statistical significance for less than six deaths, the LTAS uses a table of values of observed and expected deaths which are taken from the Biometrika Tables for Statisticians. To determine the confidence limits for the ratios, the LTAS uses a built-in table of exact confidence limits factors. These factors are divided into the ratios to derive the confidence limits (234) and can be

found in Appendix I with the tables of significance for less than six deaths.

Sample size in occupational mortality studies

In 1980 the OSHA published its general policy for the identification and regulation of carcinogens (235). It was stated that "non-positive human studies," i.e., those in which a risk following exposure to a substance was not found, would be considered in a review of the evidence only if they met several criteria. One of these stipulated that:

> "the group of exposed subjects [should have been] large enough for an increase in cancer incidence of 50% above that in unexposed controls to have been detected at any of the predicted sites."

Essentially, the OSHA criterion refers to the statistical power of significance tests. Power can be increased by increasing the sample size. However, in an observational study, such as one examining occupational mortality, the sample size is usually fixed. It is possible in these circumstances, given certain information, to estimate the power of the significance test.

The significance test in the analysis of a mortality study usually compares the observed number of deaths from some cause (or causes) with the expected number. The expected number E is that which would have occurred if the mortality pattern were the same as that in a control group, based on absolute rates in a follow-up (SMR) study or the proportion of all deaths due to the cause of interest in a

proportionate mortality study. Allowance is also made for factors such as age and calendar period to achieve "standardization." The ratio of observed to expected numbers (O/E) represents the relative risk of acquiring the disease for exposed, as compared with nonexposed, persons.

Given the expected number of deaths, it is possible to calculate the power of the significance test when the true relative risk is some specified value; in the OSHA criterion the increase of 50 per cent in the incidence represents a relative risk of 1.5.

Power analysis

In order to assess whether the negative results obtained for the site specific cancers of interest in this study indicate a true lack of risk, a statistical power analysis was performed for those sites. That is, given the expected number of deaths generated for these sites, what is the probability of detecting a significant excess risk of a given magnitude and alpha level? To be consistent with the policy of the OSHA, a nonpositive human study would be considered evidence for lack of a carcinogenic risk only if the probability of detecting a 50 per cent increase in risk for exposed subjects is large (235). Statistical power is the probability of not overlooking an excess risk, i.e., of not making a Type II statistical error. A brief review of Type I and Type II errors follows.

Type I errors.

If the true state of nature is the null hypothesis (no increase in risk), then a Type I error is wrongly rejecting the null hypothesis and declaring that there is an increase in risk. The probability of a Type I error is known as alpha, or more commonly, the "level of significance." When an investigator finds an excess and declares it "significant at the 0.05 level," he or she is stating that there is less than a five per cent chance of having made a Type I error.

Type II errors.

Type II errors are less familiar but, nevertheless, very important (13). When the true state of nature is the alternative hypothesis (increased risk), the research goal is to detect it (i.e., reject the null hypothesis). If an exposure is harmful with a relative risk of R, then not rejecting the null hypothesis (i.e., wrongly accepting the exposure as harmless) is called a Type II error. The probability of a Type II error is usually denoted beta ( ). Conversely, the probability of correctly rejecting the null hypothesis and therefore of detecting the excess risk is called power and is equal to 1 - B. Thus, power quantifies the ability of a particular study to detect an excess risk that truly exists. It is intuitively clear that with a fixed amount of data there is a greater likelihood of detecting a large excess risk. Similarly, an increase in the amount of data increases the chance of observing a given

risk and increases power.

To calculate power for a given number of expected deaths, we can apply a Poisson formula for any specified risk level we want to detect, using a given alpha level (236). If the expected number of deaths is large, we can use a formula based on the standard normal distribution to approximate exact power probabilities (237). The power formula given by Armitage (240) for the Poisson distribution is based on the following terms:

E = Number of expected deaths

R = True relative risk

E_1 = R x E, the number of relative expected deaths

c = the smallest number of deaths that is significantly increased, where:

$$\text{Power} = 1 - \beta = 1 - \sum_{i=0}^{c-1} \frac{e^{-E_1} E_1^{\,i}}{i!}$$

The approximate power $(1-\beta)$ to detect a relative risk R at the alpha level of significance can also be calculated from the following formula which uses the fact that the square root transformation stabilizes the variance of the Poisson distribution where:

E = Number of expected deaths

R = Ratio of observed to expected deaths

$$Z_{(1-\beta)} = Z_{\alpha} - 2(\sqrt{RE} - \sqrt{E})$$

Here Z_α denotes the upper 100_α percentile of the standard normal distribution and E the expected number of cancer deaths based on general population rates. This approximation agrees well with exact power calculations based on Poisson probabilities made by Cutler (238) and Molina (239). When the discreteness of the exact test based upon Poisson probabilities is accounted for, the approximate and exact power curves are virtually identical.

RESULTS AND DISCUSSION

The Oklahoma Dry Cleaning Industry

Figures 4 - 8 are based on yearly data compiled by the Oklahoma State Dry Cleaners Board beginning in 1960. Figure 4 depicts the yearly gross volume, in constant 1983 dollars, of dry cleaning done in the State of Oklahoma between 1960 and 1983, for plants, agencies, and coin-ops. The business trend for dry cleaning in Oklahoma paralleled that of the entire nation, with a peak in dollar volume occurring in 1966 - 67, followed by a rapid decline lasting until 1975. Since 1975, the industry in Oklahoma has shown a steady yearly growth in dollar volumes which, by 1983, approached the 1966 - 67 peak.

Figure 5 displays the total employment in the Oklahoma dry cleaning industry between 1960 and 1984. Owners and family members have represented between 29 and 42 per cent of the total workforce. Employment totals specific for plants, agencies and coin-ops are not currently available.

Figure 6 displays the number of total licenses (new licenses, license renewals, and transfers of ownership)

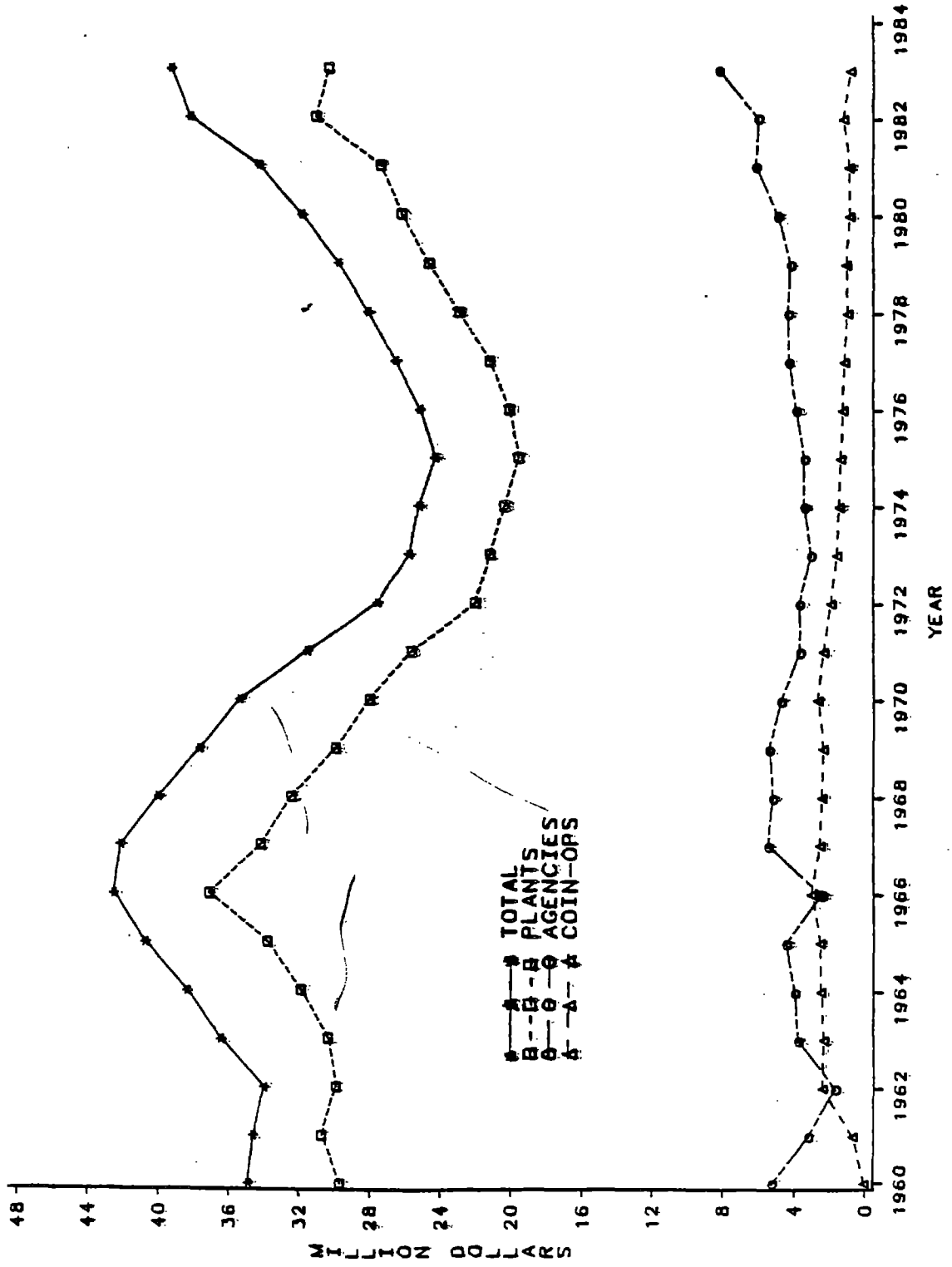
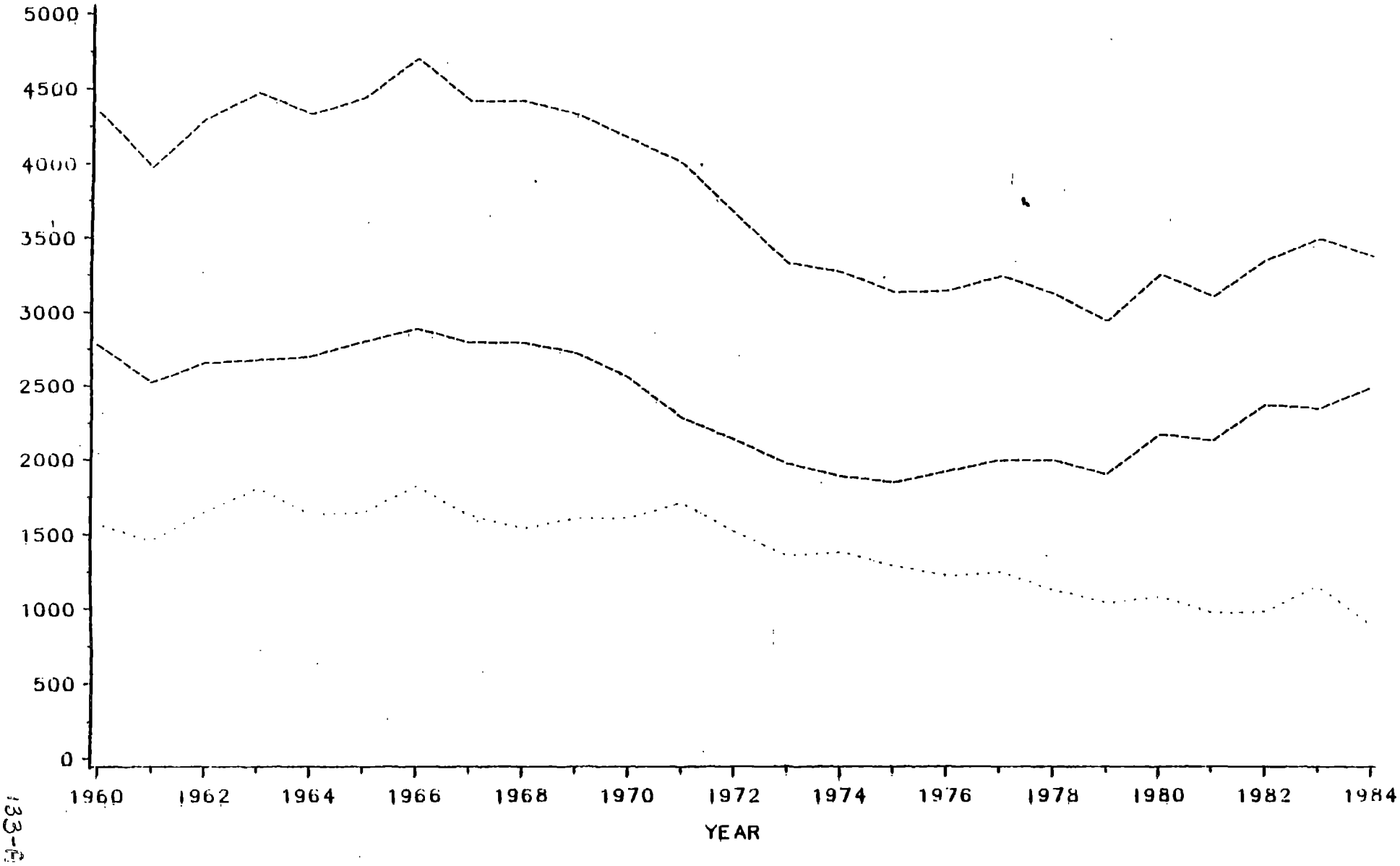


Figure 4. Yearly dry cleaning volumes, the State of Oklahoma, in constant 1983 dollars.

DRY CLEANING EMPLOYMENT
THE STATE OF OKLAHOMA
1960 - 1984



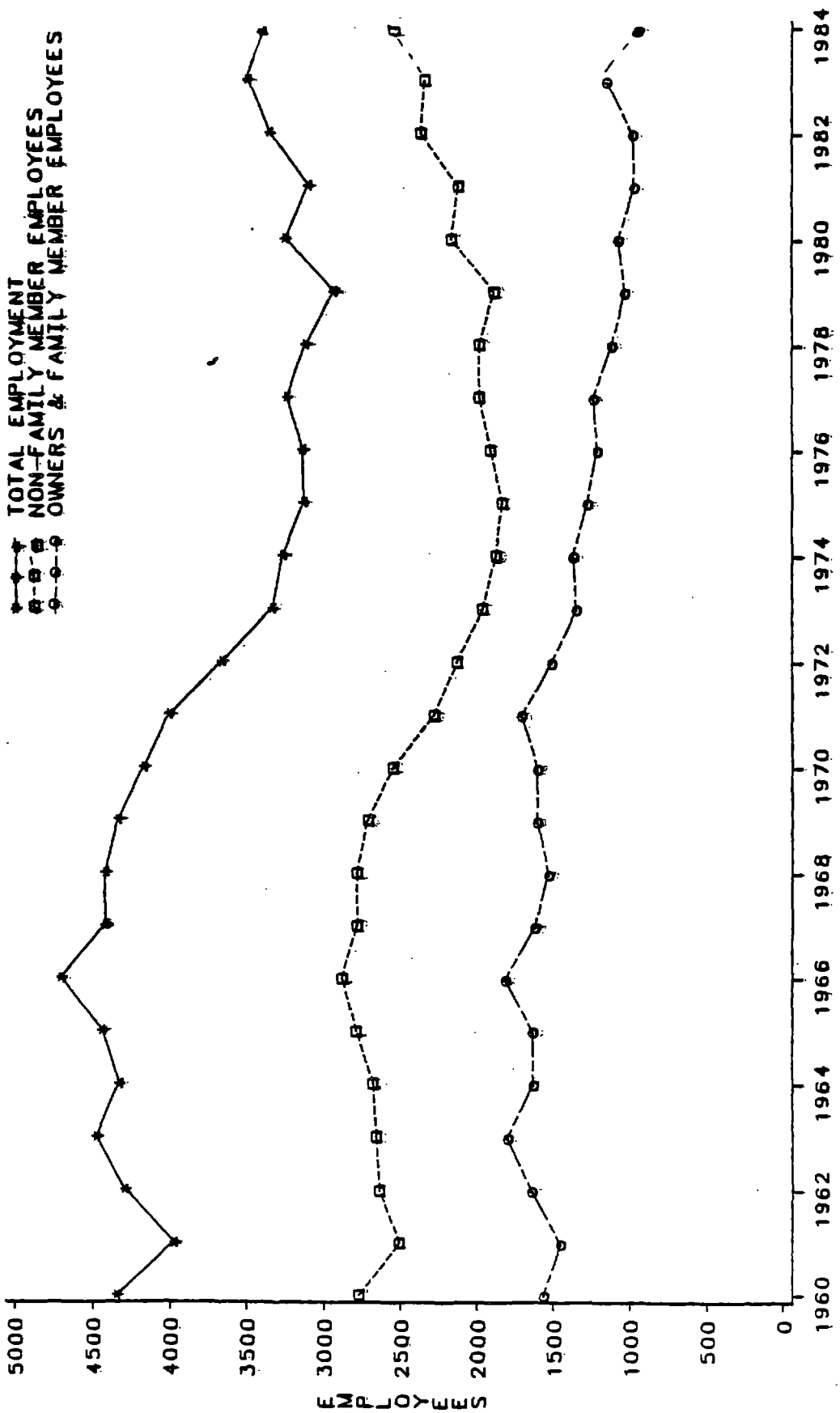
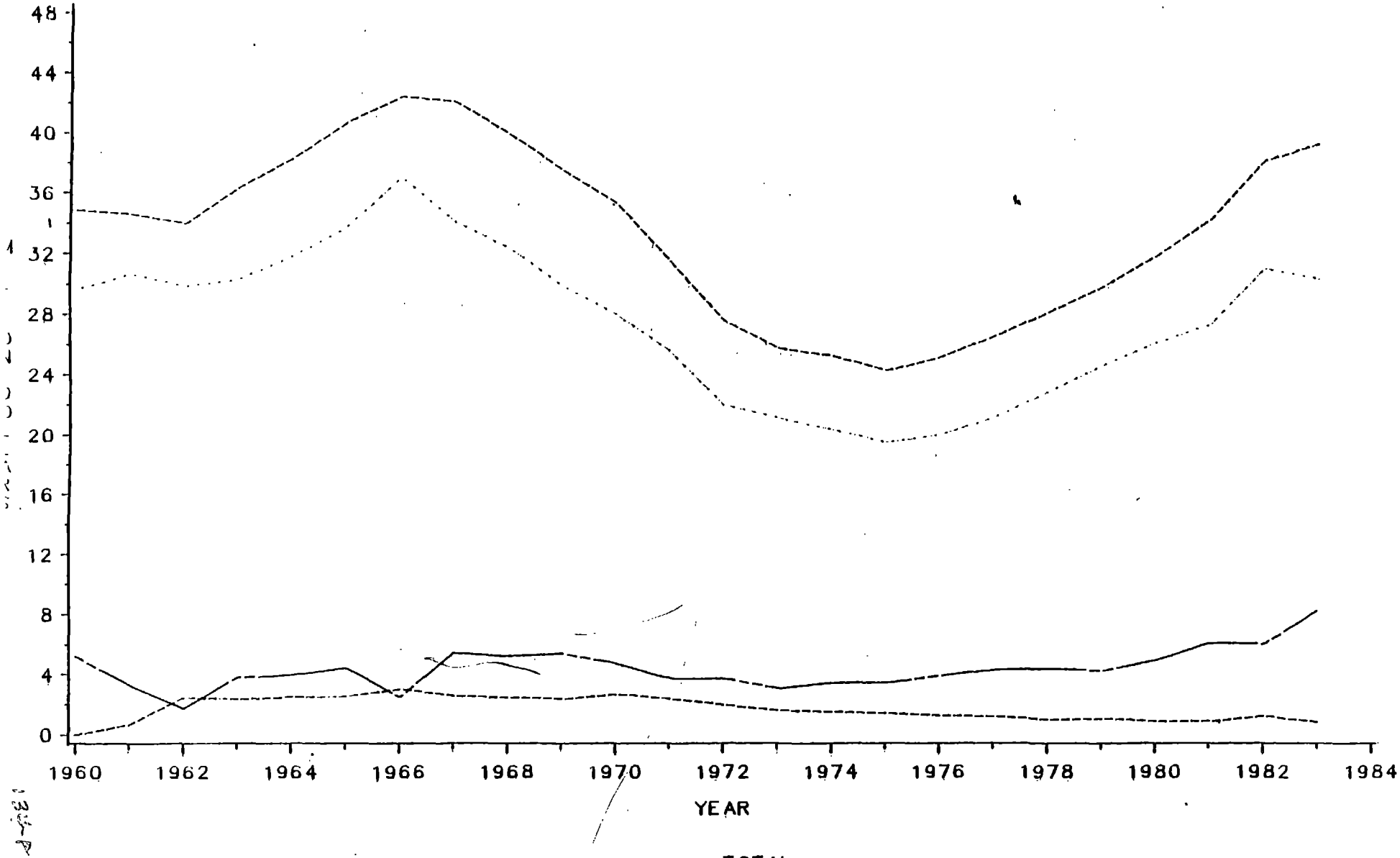


Figure 5. Dry cleaning employment, the State of Oklahoma, 1960-1984.

YEARLY DRY CLEANING VOLUMES
THE STATE OF OKLAHOMA
IN CONSTANT DOLLARS (1983)



issued for plants, agencies and coin-ops for each year between 1960 and 1984. A gradual decline in plant licenses issued since 1966 has occurred. This decline appears to be unrelated to the more dramatic decline in dry cleaning dollar volume between 1966 and 1975, and the substantial improvement in dollar volume following 1975. Since 1982, fewer plants have been doing larger volumes of cleaning, in part through an expansion in the number of agencies licensed.

The number and solvent use characteristics of all plants licensed in Oklahoma between 1941 and 1985 are depicted in Figure 7. Prior to 1948, nearly all plants in Oklahoma used some form of petroleum solvent. An expected decline in all plants, related to World War II, occurred between 1942 and 1945 which was followed by a rapid expansion in the number of solvent using plants from 1945 to 1950. The total number of plants remained fairly constant at approximately 800 until 1962 when a steep, steady decline brought the number to about 400 by 1978. Since 1978 this number has been very stable. PCE was introduced in 1948 and slowly grew in popularity until it accounted for roughly 200 active plants. The number of PCE plants remained stable despite the rapid decline of petroleum plants, reflecting an emphasis on synthetic solvent replacements, or new plant purchases, with the attrition from the industry of much older petroleum plants. The date reveals that by 1985, more than 50 per

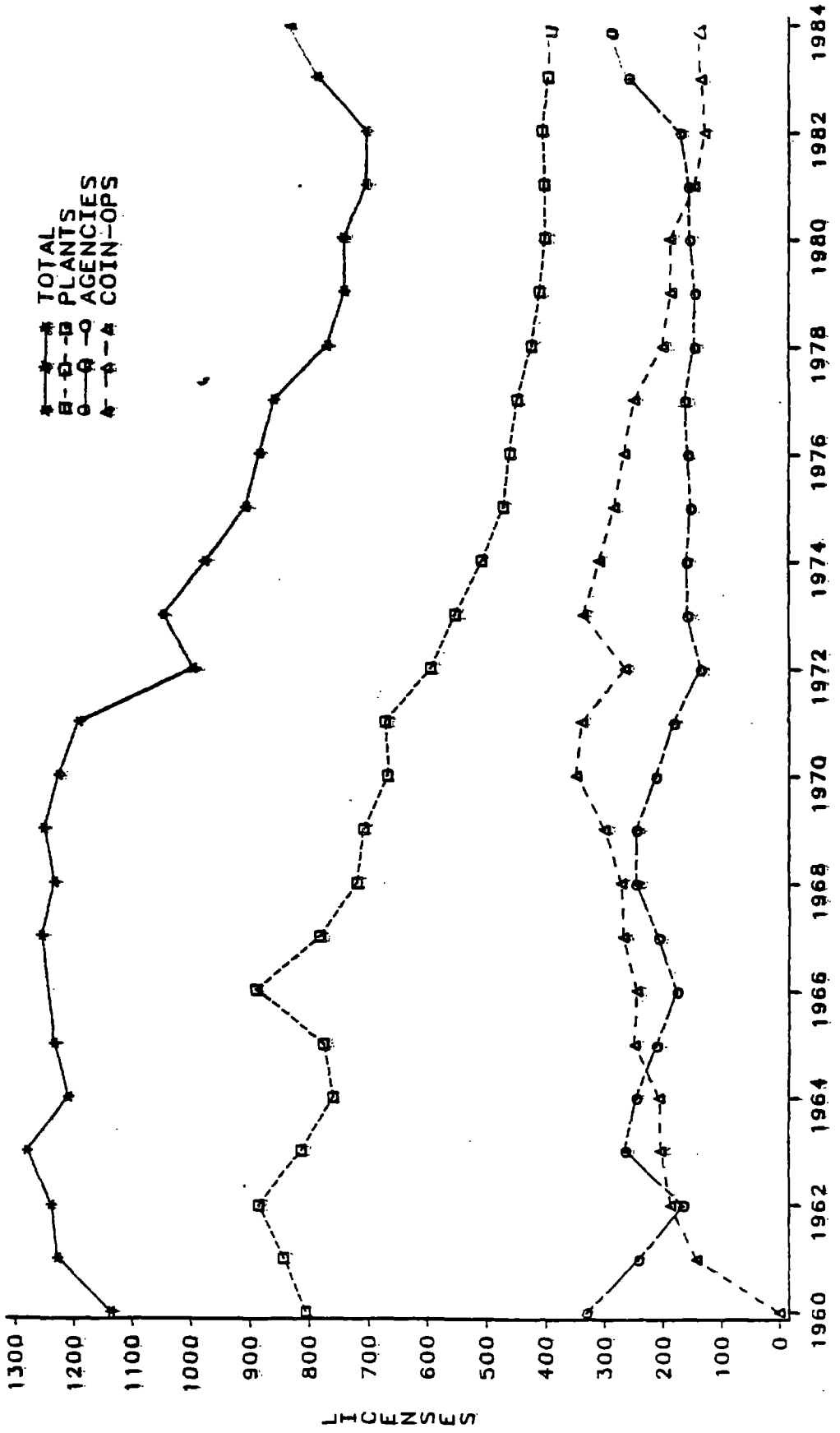
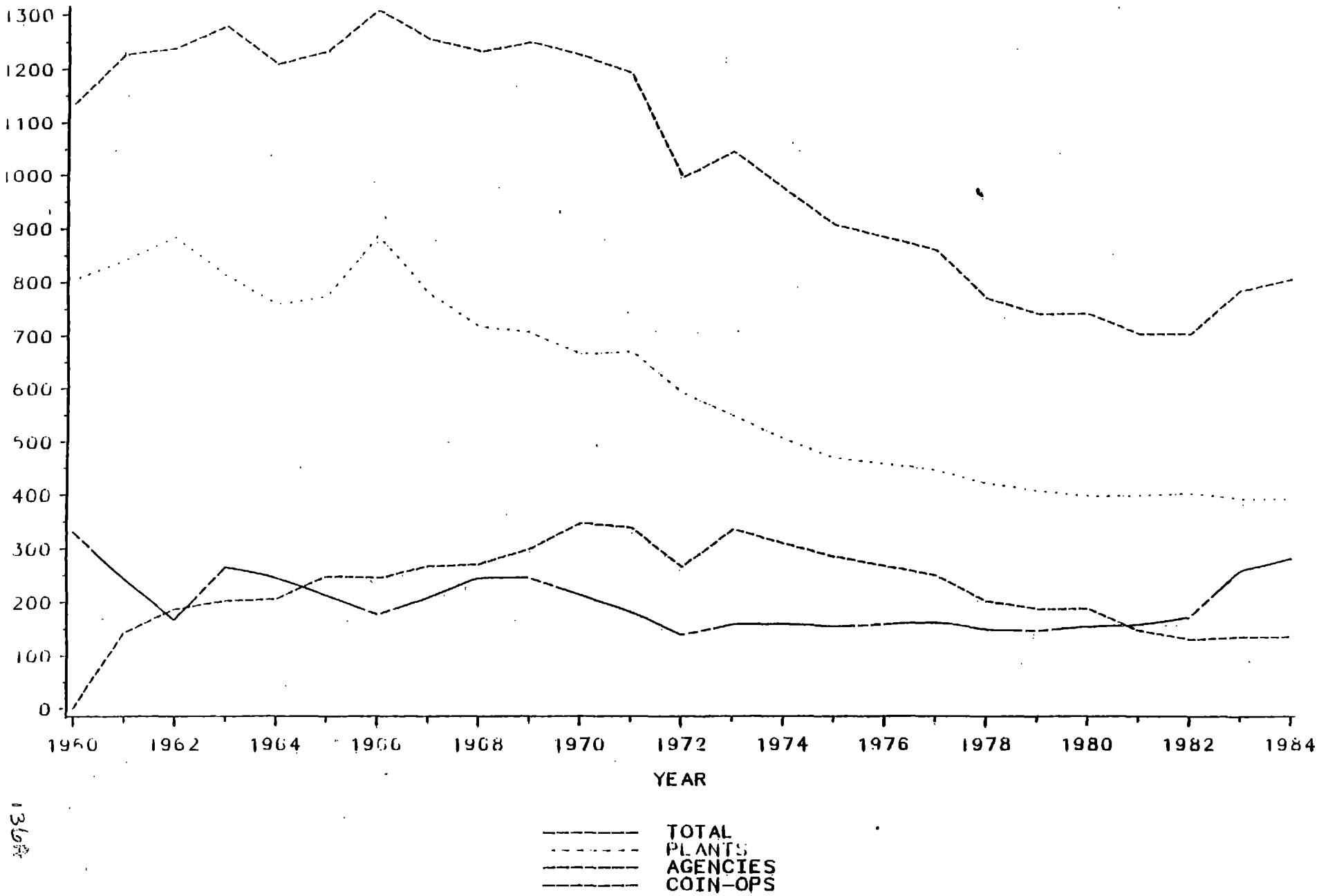


Figure 6. Dry cleaning licenses, the State of Oklahoma, 1960-1984.

DRY CLEANING LICENSES
THE STATE OF OKLAHOMA
1960 - 1984



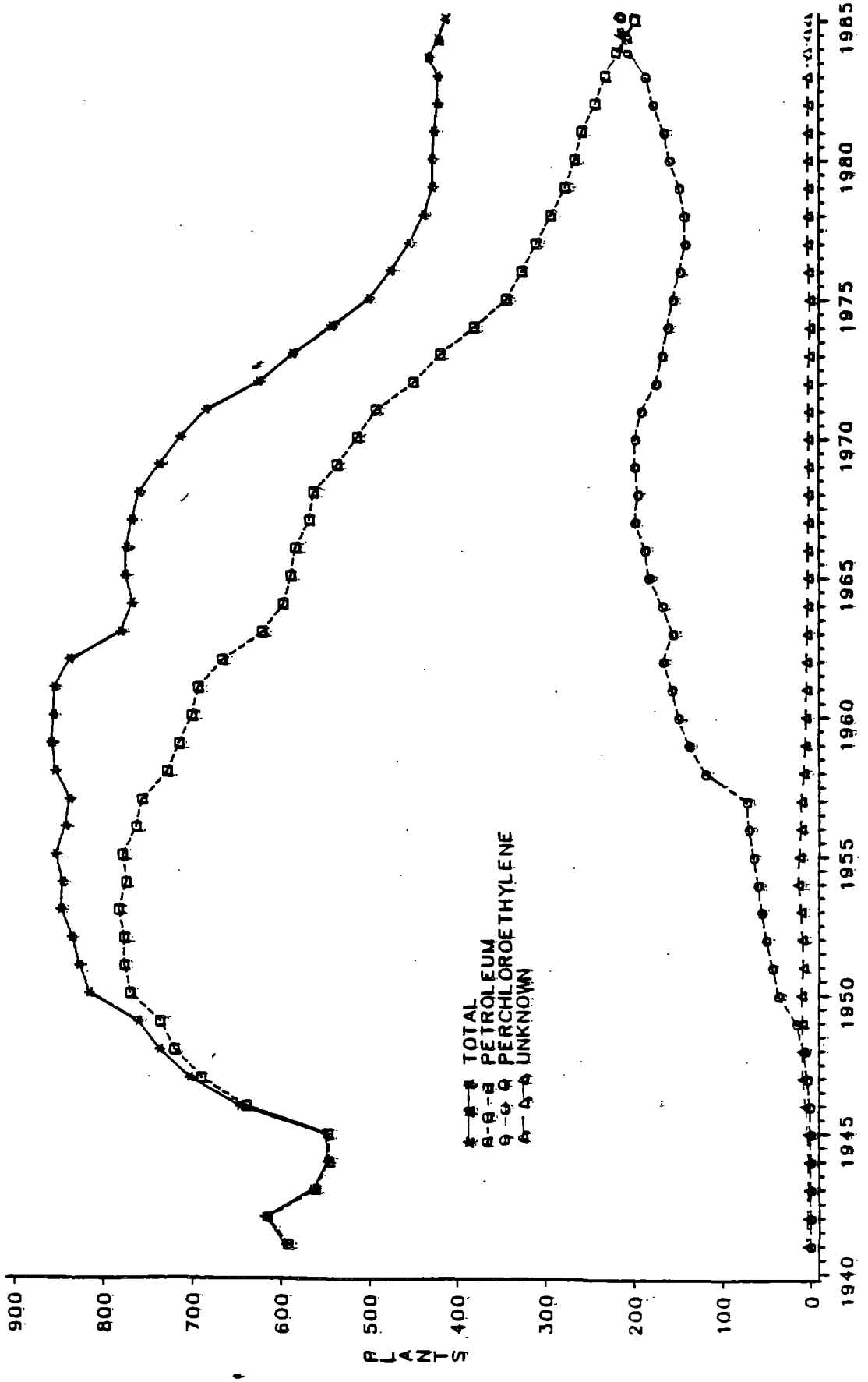
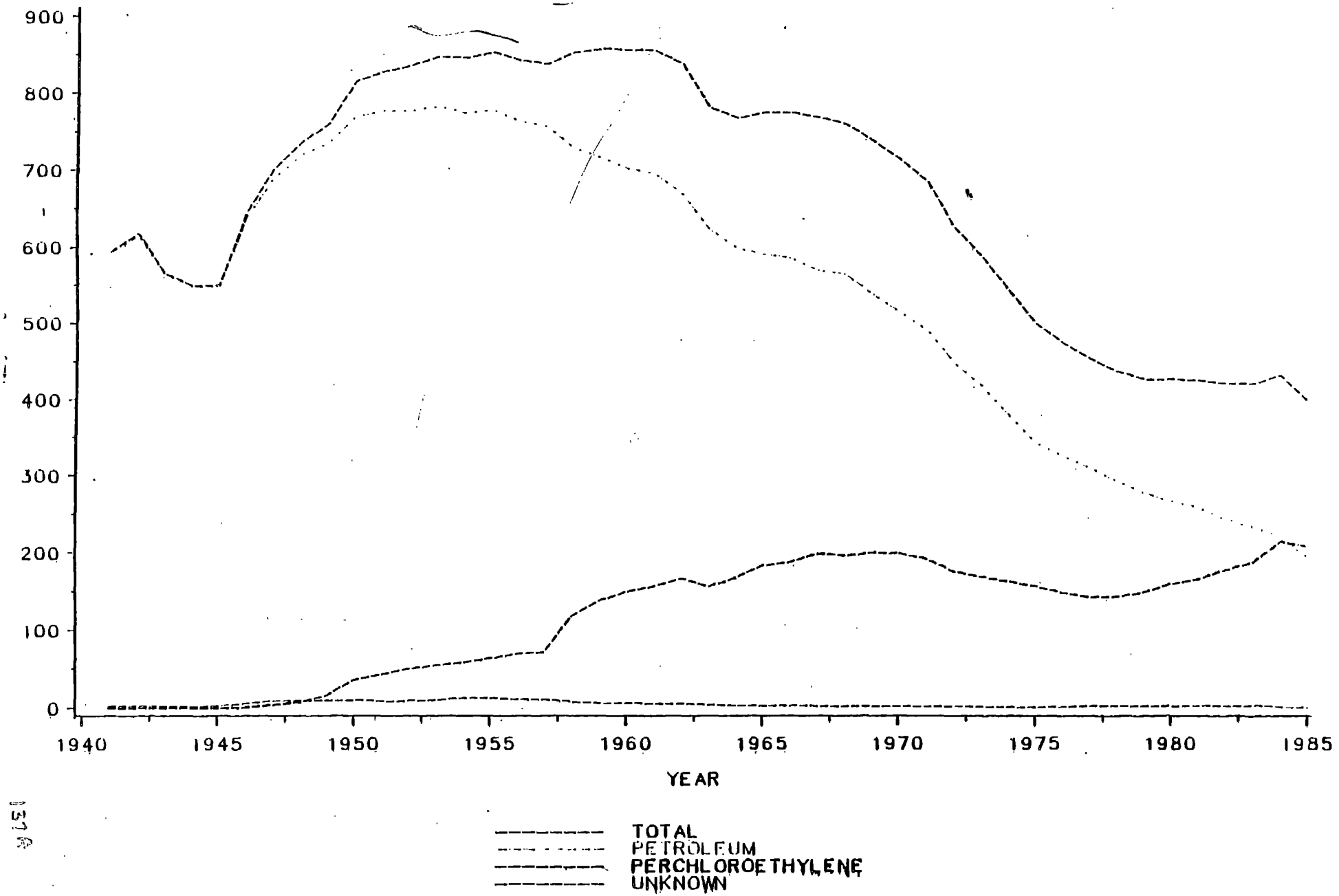


Figure 7. Oklahoma dry cleaning plants, by solvent category, 1941-1985.

OKLAHOMA DRY CLEANING PLANTS
BY SOLVENT CATEGORY
1941 - 1985



cent of all plants in Oklahoma were using PCE. Figure 7 also shows the near absence of plants with "unknown" solvent usage, due to the adequacy of the licensure data base to identify specific solvent usage, and the attention to completeness in submitting the license applications required by the Oklahoma State Dry Cleaners Board.

Table 11 gives a detailed account of the total number and solvent use characteristics of plants existing in Oklahoma between 1941 and 1985, having a unique name and address. Due to those circumstances where an existing plant changed only its name, or an owner relocated an existing plant, the total number of plants may be slightly overestimated. Plants have been categorized by solvent group; petroleum, synthetic, or unknown, and by the specific solvent recorded on the license application. The specific solvent in use was requested on all applications prior to 1965, but subsequent to that the applicant was directed to check either "petroleum" or "synthetic" as the solvent in use. A review of all initial plant inspections since 1941, and yearly inspections (only available since 1975), contributed to the extremely low percentage of plants with unknown solvent use characteristics. Each plant contributed one plant-year to each solvent category for each year, or partial year of operation. The few plants which used two or more different solvents concurrently tend to produce a small overestimation of the actual total number of plant-years

TABLE 11

SOLVENT USE CHARACTERISTICS OF ALL OKLAHOMA DRY CLEANING PLANTS LICENSED BETWEEN 1941 and 1983

Solvent Group	Specific Solvent	Total Plants	% of Total	Plant-Years	% of Years
Petroleum	Stoddard 105°F	907	37.76	14,020	47.44
	Stoddard 140°F	85	3.54	1,246	4.22
	Stoddard 125°F	8	0.33	65	0.22
	White Gas	6	0.25	12	0.04
	Tractor Gas	1	0.04	1	0.00
	Motor Fuel	1	0.04	1	0.00
	Unspecified	809	33.68	9,035	30.57
Synthetic	PCE	522	21.72	4,581	15.50
	CCl_4	19	0.79	196	0.66
	Triclene	2	0.08	6	0.02
	Panoclene	1	0.04	2	0.01
	F-113	1	0.04	1	0.00
	Unspecified	29	1.21	274	0.93
Unknown	Unspecified	12	0.50	113	0.41
Petroleum	All	1,817	75.61	24,380	82.47
Synthetic	All	574	23.88	5,060	17.12
Unknown	All	12	0.50	113	0.41
All	All	2,403	100.00	29,553	100.00

under study. In 1985, less than 10 per cent of all plants utilized more than one specific solvent, and concurrent, multiple solvent use appears to be a very recent occurrence in the Oklahoma dry cleaning industry.

Petroleum solvents were used in over 75 per cent of all plants, and account for 82.5 per cent of the 29,553 plant-years under surveillance. Most, if not all unspecified petroleum solvent was Stoddard 105 ^{o}F. The handful of plants which specified tractor gas, motor fuel, or white gas did so during 1941 to 1945 when periodic shortages of Stoddard solvent occurred. A total of 1,817 petroleum solvent using plants were identified which were in operation for 24,380 plant-years (an average of 13.4 years).

Figure 8 depicts the number of owners and/or operators of solvent using dry cleaning plants in Oklahoma between 1941 and 1983. As can be expected, the distribution of owners and operators by solvent category is highly correlated to the distribution of plants shown in Figure 7.

Table 12 gives the sex and race characteristics of all owners and/or operators of solvent using, Oklahoma dry cleaning plants between 1941 and 1985. Nearly 80 per cent of the 3,315 members of this cohort were white males, and account for 44,383 exposure-years, or 86 per cent of the total 51,565 exposure-years. White females comprise 18 per cent of the total members of the cohort. Unless specifically identified on a license application, the females who were

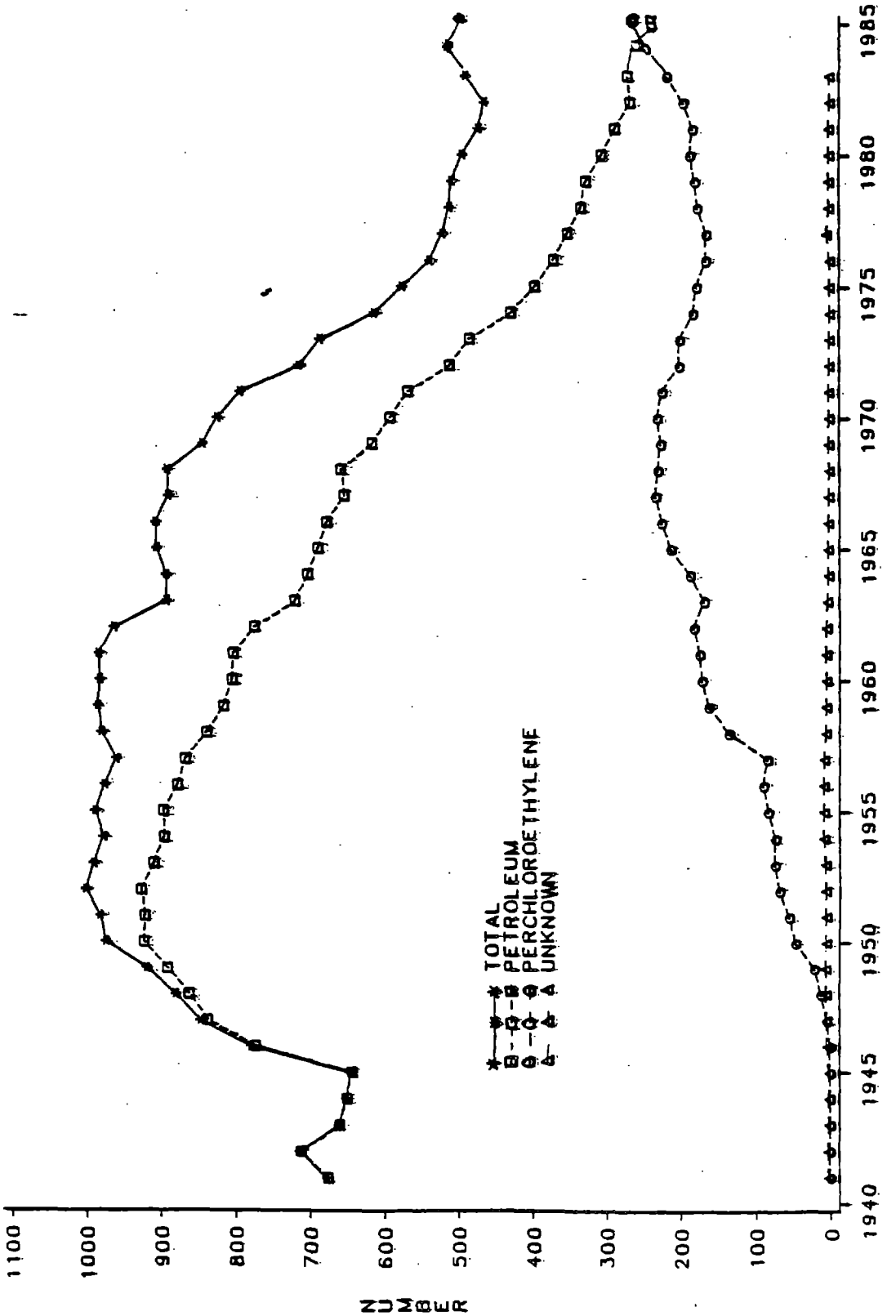
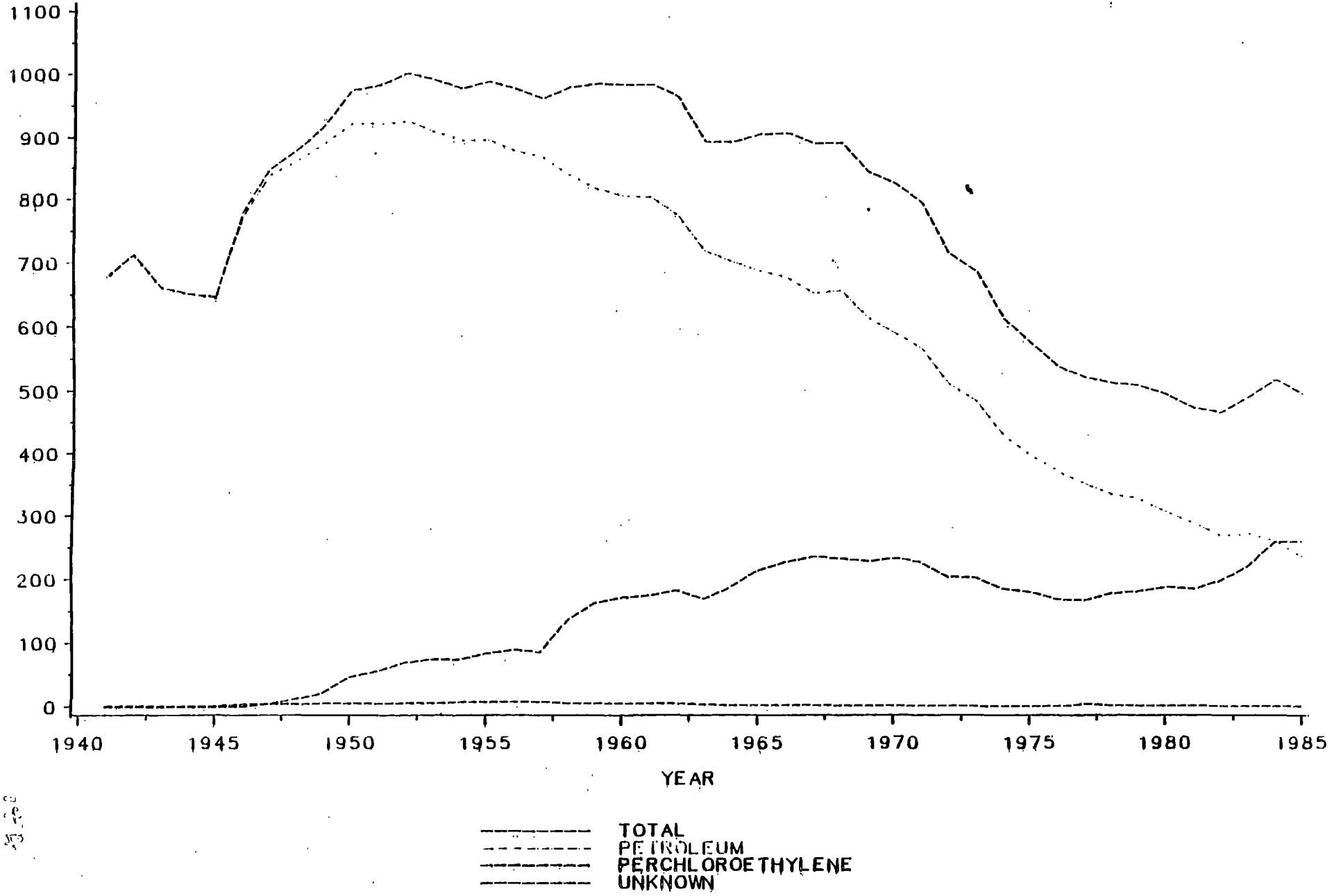


Figure 8. Oklahoma dry cleaners, by solvent category, 1941-1985.

OKLAHOMA DRY CLEANERS
BY SOLVENT CATEGORY
1941 - 1985



wives of owners and/or operators were, for the most part, not included as cohort members despite their equal potential for solvent exposure in the many small, husband and wife operated dry cleaning shops which characterized the industry in this state.

Table 13 shows the distribution of single and multiple solvent exposures by the sex and race of the cohort members. Nearly 59 per cent of the entire cohort were white males, and 12 per cent were white females who were exposed only to petroleum solvents. White males exposed only to PCE comprise 12 per cent of the cohort, and white females with PCE solvent exposure, 4 per cent. The remaining 13 per cent of the cohort is made up of all sex and race groups exposed to some combination of petroleum, synthetic and/or unknown solvent exposures.

Table 14 displays the distribution of 1150 deaths occurring among the cohort members between the years 1950 and 1985, categorized by sex, race and solvent exposures. A total of 998 (87 per cent) of all cohort deaths occurred among white males. Among the white males deaths, 831 were exposed only to petroleum solvents and comprise over 72 per cent of the deaths known to have occurred. These 831 petroleum solvent exposed white males will be the major focus of the solvent and duration of exposure specific mortality analyses.

TABLE 12

SEX AND RACE CHARACTERISTICS OF OWNERS AND OPERATORS OF OKLAHOMA DRY CLEANING PLANTS LICENSED BETWEEN 1941 and 1985

Sex	Race	Number	% of Number	Exposure-Years	% of Years
Male	White	2,654	80.06	44,383	86.07
Male	Black	48	1.45	1,000	1.93
Female	White	605	18.25	6,038	11.71
Female	Black	8	0.24	144	0.28
All	All	3,315	100.00	51,565	100.00

TABLE 13

DISTRIBUTION OF OKLAHOMA DRY CLEANING PLANT OWNERS AND OPERATORS, BY RACE, SEX, AND SOLVENT EXPOSURE(S)

Race/ Sex	Solvent Exposure(s)												
	Petroleum						Synthetic					Unknown	Total
	Pet	Pet PCE	Pet CCl_4	Pet Unk	Pet PCE CCl_4	Pet PCE Unk	PCE	PCE CCl_4	PCE Unk	CCl_4	F113		
White Males	1939	259	15	6	5	6	406	0	1	12	0	5	2654
White Females	410	44	4	2	1	1	136	1	0	5	0	1	605
Black Males	39	5	0	0	0	0	4	0	0	0	0	0	48
Black Females	7	1	0	0	0	0	0	0	0	0	0	0	8
Total	2395	309	19	8	6	7	546	1	1	17	0	6	3315

TABLE 14

DISTRIBUTION OF DEATHS, BY RACE, SEX, AND SOLVENT EXPOSURE(S)

Race/ Sex	Solvent Exposure(s)								
	Petroleum					Synthetic			
	Pet	Pet PCE	Pet PCE CCl_4	Pet PCE Unk	Pet CCl_4	PCE	CCl_4	Unknown	Total
White Males	831	72	3	2	6	78	5	1	998
White Females	106	7	1	0	1	12	1	0	128
Black Males	21	0	0	0	0	1	0	0	22
Black Females	1	1	0	0	0	0	0	0	2
Total	959	80	4	2	7	91	6	1	1150

Table 14a

Cohort of Oklahoma Dry Cleaners 1941-1985

Follow-up Summary

Total Cohort Members	3946	
Cohort Members with less than one year of exposure	631	
Cohort members followed-up	3315	100%
Cohort members known to be alive	1554	47%
known alive with date of birth	(1330)	(40%)
known alive without date of birth	(224)	(7%)
Cohort members known to be dead	1365	41%
known dead with certificate of death	(1150)	(35%)
known dead without certificate of death	(215)	(6%)
Lost to follow-up	396	12%

Mortality Analyses

Proportionate mortality analyses for three groups, defined by sex, race, and solvent exposure(s) will be presented. The first of these analyses will consider the 1150 deaths occurring among all sex and race groups regardless of solvent exposure (group I). In order to assess the influence of sex and race groups other than white males, a second analysis will be presented of 998 white males with any solvent exposure (group II). The most detailed analysis to be presented will be of the 831 white males who were exposed only to petroleum solvents (group III). Mortality analyses of small and very specific subgroups of potential interest include deaths occurring among white females and an analysis of deaths among white males with any PCE exposure. A summary of these analyses will be available on request.

All sex and race groups, all solvents

This initial analysis represents a composite of all sex and race groups regardless of solvent exposure and consists of 1150 deaths: 998 white males, 128 white females, 2 black females and 22 black males. Table 15 presents the distribution of total deaths by age group, and five year calendar period between 1940 and 1985. One death was identified for cohort members less than 30 years of age. Proportionately fewer deaths identified between the period of 1965 to 1974 can be explained in part by the lack of access to machine readable death certificate information.

TABLE 15

DISTRIBUTION OF DEATHS BY AGE GROUP AND CALENDER PERIOD

Age Group	Calender Period								
	1940 -49	1950 -54	1955 -59	1960 -64	1965 -69	1970 -74	1975 -79	1980 -87	Total
20-24	0	1	0	0	0	0	0	0	1
25-29	0	0	0	0	0	0	0	0	0
30-34	3	1	1	2	0	0	0	0	7
35-39	2	1	1	2	2	0	0	0	8
40-44	0	2	4	7	2	1	1	2	19
45-49	4	8	8	7	5	4	2	5	43
50-54	4	9	11	7	12	3	9	10	65
55-59	5	9	14	16	22	11	15	22	114
60-64	5	15	26	26	27	15	17	25	156
65-69	5	5	9	41	24	31	26	52	193
70-74	4	7	12	23	22	19	41	50	178
75-79	0	4	8	18	14	30	38	56	168
80-84	0	3	7	16	11	17	21	43	115
85+	0	3	1	11	2	6	19	39	81
Total	36	68	99	176	143	137	189	304	1148

Table 16 presents the distribution of total deaths by latency and by years of solvent exposure. Latency is defined as the number of years from the estimated first solvent exposure to the year of death. Nearly 68 per cent of the deceased cohort members had solvent exposures in excess of ten years; 29 per cent had solvent exposures in excess of 30 years.

The observed and expected deaths, proportionate mortality ratios, and 95 per cent confidence limits (95% CL) for 18 major categories of death are displayed in Table 17. Significantly elevated PMRs were found for the major category of death, mental, psychoneurotic and personality disorders due primarily to alcoholism and the genito-urinary system due to acute and chronic nephritis. Heart disease represents the largest category of cause of death, with 527 deaths observed, and 524.03 expected, giving a PMR of 0.96 (95% CL = 0.88 - 1.05). The PMR for all malignant neoplasms was 1.04 with 236 deaths observed and 226.7 expected (95% CL = 0.91 - 1.18).

Table 18 shows a more detailed analysis of the observed and expected cancer deaths. While the overall proportionate mortality due to cancer was not significantly elevated, a substantial excess in pancreatic cancer (19 deaths observed, PMR = 1.50, 95% CL = 0.91 - 2.35) and cancers of the respiratory system (78 observed, PMR = 1.17, 95% CL = 0.93

TABLE 16

DISTRIBUTION OF DEATHS, BY YEARS OF LATENCY AND YEARS OF EXPOSURE

	Years of Exposure							
Years of Latency	1-4	5-9	10-14	15-19	20-24	25-29	30+	Total
1-4	36							36
5-9	32	33						65
10-14	33	23	38					94
15-19	30	21	24	27				102
20-24	34	26	21	15	31			127
25-29	21	14	15	16	12	33		111
30+	37	27	44	35	51	85	334	613
Total	223	144	142	93	94	118	334	1148

TABLE 17

OBSERVED AND EXPECTED DEATHS, PMRS, AND 95% CL
FOR MAJOR CAUSES OF DEATH

Cause of Death	OBS	EXP	PMR	95% CL
All Causes	1148	1147.97	1.00	0.07- 0.19
Tuberculosis	7	7.40	0.81	0.30- 1.77
All Malignant Neoplasms	236	226.68	1.04	0.91- 1.18
Diabetes Mellitus	12	18.06	0.66	0.34- 1.16
Diseases of the Blood and Blood Forming Organs	3	3.51	0.85	0.18- 2.50
Mental, Psychoneurotic and Personality Disorders	10	3.79	2.63*	1.26- 4.86
Nervous System	109	105.7	1.03	0.85- 1.24
Circulatory System	527	524.03	0.96	0.88- 1.05
Respiratory System	77	71.77	1.09	0.85- 1.34
Digestive System	22	32.77	0.67	0.42- 1.02
Genito-Urinary System	25	13.74	1.81*	1.18- 2.69
Bone and Organs of Movement	4	1.18	1.38	0.92- 8.65
Unknown Causes	10	11.56	0.86	0.41- 1.59
Accidents	43	42.8	1.00	0.73- 1.35
Violence	18	17.80	1.01	0.60- 1.50
Other Causes and Blank ICD	44	41.41	1.06	0.91- 1.18

*$p < 0.05$

- 1.47) were noted. PMRs in excess are shown for kidney cancer (1.8), skin cancer (2.42*), and malignant neoplasms of bone, only skin cancer was statistically significant. Stomach cancer does show a statistically significant deficit with 4 deaths observed versus 13.2 expected, yielding a PMR of 0.30.

Table 19 shows the distribution of observed and expected cancer deaths by age group. Significant elevation in PMRs for cancer deaths are shown to occur in 75-79 age group.

Table 20 depicts the distribution of observed cancer deaths and PMRs by latency and years of exposure. No trend can be seen by years of latency. When the PMRs for all malignant neoplasms deaths are related to years of exposure, however, a small peak in cancer proportionate mortality (PMR = 1.40) can be seen with 15-19 years of exposure. In fact, among those with exposures greater than 30 years the PMR for all malignant neoplasms is only 0.92.

Mortality analyses for white males

All solvent exposures.

By analyzing only white males, the relative contribution to the overall proportionate mortality made by females and black males can be indirectly assessed. Table 21 presents the distribution of 997 deaths by age group and five year calendar period between 1940 and 1985.

TABLE 18

OBSERVED AND EXPECTED DEATHS, PMRS, AND 95% CL FOR SELECTED CANCER SITES

Cancer Site	OBS	EXP	PMR	95% CL
Buccal Cavity & Pharynx	6	6.39	0.93	0.34- 2.05
Digestive Organs	60	69.05	0.86	0.66- 1.12
Esophagus	5	5.03	0.99	0.32- 2.32
Stomach	4	13.19	0.30**	0.08- 0.78
Intestine Except Rectum	17	23.41	0.72	0.42- 1.16
Rectum	6	7.61	0.78	0.29- 1.72
Biliary Passages & Liver	3	4.16	0.72	0.15- 2.11
Liver Not Specified	4	2.04	1.96	0.53- 5.02
Pancreas	19	12.63	1.50	0.91- 2.35
Peritoneum & Other	2	0.97	2.05	0.25- 7.41
Respiratory System	78	66.29	1.17	0.93- 1.47
Larynx	4	3.04	1.31	0.36- 3.36
Trachea, Bronchus, & Lung	73	62.53	1.16	0.92- 1.47
Other Respiratory	1	0.72	1.38	0.04- 7.72
Breast	7	5.78	1.21	0.49- 2.50
Female Genital Organs	3	4.05	0.74	0.15- 2.16
Other Parts of Uterus	1	1.05	0.95	0.02- 5.30
Prostate	18	18.59	0.96	0.57- 1.53
Urinary Organs	16	12.76	1.25	0.72- 2.04
Kidney	9	5.00	1.80	0.82- 3.42
Bladder & Other	7	7.77	0.90	0.36- 1.86
Other & Unspecified Sites	31	23.86	1.29	0.88- 1.84
Skin	8	3.30	2.42*	1.04- 4.78
Brain	6	4.94	1.21	0.44- 2.65
Bone	3	1.01	2.98	0.62- 8.73
Unspecified Sites (minor)	12	13.16	0.91	0.47- 1.59
Lymphatic & Hematopoietic	17	19.23	0.88	0.51- 1.42
Lympho-Reticulosarcoma	5	5.74	0.87	0.28- 2.03
Hodgkin's Disease	2	1.64	1.22	0.15- 4.41
Leukemia & Aleukemia	5	8.49	0.58	0.19- 1.38
Other	5	3.36	1.48	0.48- 3.48

*p < 0.05 **p < 0.01

TABLE 19

OBSERVED AND EXPECTED DEATHS AND PMRS
FOR ALL MALIGNANT NEOPLASMS, BY AGE GROUP

Age Group	Observed	Expected	PMR
30-34	1	0.71	1.40
35-39	2	1.23	1.58
40-44	4	3.02	1.32
45-49	8	7.86	1.01
50-54	10	13.73	0.72
55-59	26	26.37	0.98
60-64	34	35.79	0.94
65-69	48	44.32	1.08
70-74	37	37.60	0.98
75-79	45	31.02	1.45*
80-84	11	16.84	0.65
85+	10	8.10	1.23
Total	236	226.68	1.04

TABLE 20

OBSERVED DEATHS AND PMRS FOR ALL MALIGNANT NEOPLASMS, BY YEARS OF LATENCY AND YEARS OF EXPOSURE

Years of Latency		Years of Exposure							
		1-4	5-9	10-14	15-19	20-24	25-29	30+	Total
1-4	OBS	7							7
	PMR	0.92							0.92
5-9	OBS	10	8						18
	PMR	1.49	1.34						1.42
10-14	OBS	9	6	8					23
	PMR	1.22	1.25	1.01					1.15
15-19	OBS	5	2	6	6				19
	PMR	0.82	0.43	1.25	1.22				0.93
20-24	OBS	9	7	5	4	2			27
	PMR	1.24	1.26	1.17	1.38	0.31			1.02
25-29	OBS	3	2	4	5	2	5		21
	PMR	0.67	0.76	1.35	1.56	0.78	0.76		0.94
30+	OBS	5	5	9	10	15	19	58	121
	PMR	0.64	0.85	1.05	1.46	1.58	1.15	0.92	1.02
Total	OBS	48	30	32	25	19	24	58	236
	PMR	1.02	1.02	1.12	1.40	1.03	1.04	0.92	1.04

TABLE 21

DISTRIBUTION OF DEATHS OCCURRING AMONG WHITE MALES, BY AGE GROUP AND CALENDER PERIOD

Age Group	Calender Period									
	1940 -49	1950 -54	1955 -59	1960 -64	1965 -69	1970 -74	1975 -79	1980 -84	1985	Total
20-24	0	1	0	0	0	0	0	0	0	1
25-29	0	0	0	0	0	0	0	0	0	0
30-34	3	1	1	2	0	0	0	0	0	7
35-39	2	1	1	2	0	0	0	0	0	6
40-44	0	2	4	7	2	1	0	2	0	18
45-49	4	8	7	6	5	3	1	5	0	39
50-54	4	8	10	7	11	3	8	8	0	59
55-59	5	9	14	15	20	11	12	18	0	104
60-64	4	14	24	22	26	14	16	19	0	139
65-69	5	4	9	38	20	27	22	45	0	170
70-74	4	7	12	17	19	18	35	43	0	155
75-79	0	4	7	18	14	25	36	48	0	152
80-84	0	3	3	14	8	14	16	32	0	90
85+	0	3	0	8	2	3	15	26	0	57
TOTAL	31	65	92	156	127	119	161	246	0	997

Table 22 presents the distribution of the 997 white male deaths by latency and by years of solvent exposure. Approximately 71 per cent of all white males had solvent exposures in excess of ten years; 31 per cent had solvent exposures in excess of 30 years.

Table 23 depicts the observed and expected deaths, PMRs, and 95 per cent confidence limits for selected categories of causes of death occurring among 997 white males. Only the major categories of mental, psychoneurotic and personality disorders due to alcoholism and genito-urinary system due to acute and chronic nephritis shows a significant elevation of the PMR. The PMR for all malignant neoplasms was 1.05 with 206 deaths observed and 194.7 expected (95% CL = 0.92 - 1.21).

Table 25 shows a more detailed analysis of the observed and expected cancer deaths occurring among white males. While the overall proportionate cancer mortality was not significantly elevated in this cohort subgroup, a significant excess in malignant neoplasms of the pancreas (18 deaths observed, PMR = 1.65, 95% CL = 0.98 - 2.61) and of the respiratory system (76 observed, PMR = 1.22, 95% CL = 0.96 - 1.53) continue to be recognized. PMRs in excess of 2.00 are shown for kidney cancer, skin cancer, and a

TABLE 22

DISTRIBUTION OF DEATHS OCCURRING AMONG WHITE MALES, BY YEARS OF LATENCY AND YEARS OF EXPOSURE

	Years of Exposure							
Years of Latency	1-4	5-9	10-14	15-19	20-24	25-29	30+	Total
1-4	25							25
5-9	29	31						60
10-14	22	19	33					74
15-19	26	15	22	26				89
20-24	26	20	17	13	29			105
25-29	15	8	13	14	12	29		91
30+	31	24	37	31	43	78	309	553
Total	174	117	122	84	84	107	309	997

TABLE 23

OBSERVED AND EXPECTED DEATHS, PMRs, AND 95% CL
FOR MAJOR CAUSES OF DEATH OCCURRING AMONG WHITE MALES

Cause of Death	OBS	EXP	PMR	95% CL
All Causes	997	996.98	1.00	0.94- 0.06
Tuberculosis	6	6.91	0.86	0.32- 1.89
All Malignant Neoplasms	206	194.72	1.05	0.92- 1.21
Benign & Unspecified Neoplasms of the Brain	1	1.39	0.71	0.02- 3.99
Diabetes Mellitus	10	14.38	0.69	0.33- 1.28
Diseases of the Blood and Blood Forming Organs	3	2.94	1.01	0.21- 2.98
Mental, Psychoneurotic and Personality Disorders	8	3.40	2.35*	1.01- 4.64
Nervous System	92	85.94	1.07	0.86- 1.31
Circulatory System	450	479.90	0.93	0.85- 1.03
Respiratory System	69	64.53	1.06	0.83- 1.35
Digestive System	22	29.31	0.75	0.47- 1.14
Genito-Urinary System	21	11.92	1.76*	1.09- 2.69
Diseases of the Skin	0	0.81	0.00	0.00- 0.00
Bone and Organs of Movement	4	0.91	4.41	1.20-11.28
Unknown Causes	8	9.81	0.81	0.35- 1.61
Accidents	39	38.65	1.00	0.72- 1.38
Violence	17	16.43	1.03	0.60- 1.59
Other Causes and Blank	41	35.033	1.17	0.84- 1.59

*p < 0.05

single case of male breast cancer, but none were statistically significant. Stomach cancer does show a significant deficit with four deaths observed versus 11.7 expected, yielding a PMR of 0.34.

Table 26 shows the distribution of observed and expected cancer deaths by age group. A significant elevation in PMRs for cancer deaths are shown to occur only in the age groups 75-79. No excess were found among those deaths occurring under age 65.

Table 27 depicts the distribution of observed cancer deaths and PMRs by latency and years of exposure. The peak in cancer proportionate mortality (PMR = 1.30 to 1.40) can be seen with the latency periods between 5 and 14 years. When the PMRs for all malignant neoplasms deaths are related to years of exposure, there remains a small peak in 15-19 years of exposure. Among those with exposures greater than 30 years the PMR for all malignant neoplasms is 0.90.

Only petroleum solvent exposures

This group of 831 petroleum solvent exposed white male dry cleaners presents the best opportunity to date to judge the influence of petroleum solvent exposures on the distribution of causes of death. Although smaller numbers give less power to detect significant differences, similari-

TABLE 25

OBSERVED AND EXPECTED DEATHS, PMRs, AND 95% CL
FOR SELECTED CANCER SITES OCCURRING AMONG WHITE MALES

Cancer Site	OBS	EXP	PMR	95% CL
Buccal Cavity & Pharynx	6	5.89	1.01	0.37- 2.22
Digestive Organs	54	59.22	0.91	0.69- 1.19
Esophagus	4	4.55	0.87	0.24- 2.25
Stomach	4	11.71	0.34*	0.09- 0.87
Intestine Except Rectum	15	19.37	0.77	0.43- 1.28
Rectum	5	6.71	0.74	0.24- 1.74
Biliary Passages & Liver	3	3.40	0.88	0.18- 2.58
Liver Not Specified	3	1.75	1.71	0.35- 5.00
Pancreas	18	10.91	1.65	0.98- 2.61
Peritoneum & Other	2	0.82	2.43	0.29- 8.79
Respiratory System	76	62.10	1.22	0.96- 1.53
Larynx	4	2.90	1.37	0.38- 3.53
Trachea, Bronchus, & Lung	71	58.55	1.21	0.95- 1.53
Other Respiratory	1	0.65	1.54	0.04- 8.61
Breast	1	0.28	3.46	0.09-19.27
Prostate	17	17.91	0.94	0.55- 1.52
Urinary Organs	16	11.66	1.37	0.78- 2.23
Kidney	9	4.49	2.00	0.91- 3.80
Bladder & Other	7	7.17	0.97	0.39- 2.01
Other & Unspecified Sites	25	20.34	1.22	0.80- 1.81
Skin	7	2.91	2.40	0.96- 4.95
Bone	3	0.88	3.39	0.70- 9.92
Unspecified Sites (minor)	9	11.03	0.81	0.37- 1.55
Lymphatic & Hematopoietic	11	16.65	0.66	0.33- 1.18
Lympho-Reticulosarcoma	4	4.89	0.81	0.22- 2.09
Hodgkin's Disease	1	1.46	0.68	0.02- 3.80
Leukemia & Aleukemia	3	7.46	0.40	0.08- 1.18
Other	3	2.84	1.05	0.22- 3.09

*p < 0.05

TABLE 26

OBSERVED AND EXPECTED DEATHS, AND PMRS FOR ALL MALIGNANT NEOPLASMS OCCURRING AMONG WHITE MALES, BY AGE GROUP

Age Group	Observed	Expected	PMR
30-34	1	0.71	1.40
35-39	0	0.67	0.00
40-44	3	2.65	1.13
45-49	7	6.51	1.07
50-54	10	11.75	0.85
55-59	23	22.75	1.01
60-64	27	30.84	0.87
65-69	45	38.21	1.17
70-74	34	32.59	1.04
75-79	40	28.20	1.41*
80-84	9	13.60	0.66
85+	7	6.17	1.13
Total	206	194.72	1.05

* $p < 0.05$

TABLE 27

OBSERVED DEATHS AND PMRS FOR ALL MALIGNANT NEOPLASMS OCCURRING AMONG WHITE MALES, BY YEARS OF LATENCY AND YEARS OF EXPOSURE

		Years of Exposure							
Years of Latency		1-4	5-9	10-14	15-19	20-24	25-29	30+	Total
1-4	OBS	3							3
	PMR	0.73							0.73
5-9	OBS	8	7						15
	PMR	1.35	1.25						1.30
10-14	OBS	8	5	7					20
	PMR	1.86	1.36	1.11					1.40
15-19	OBS	3	1	6	6				16
	PMR	0.60	0.32	1.39	1.26				0.93
20-24	OBS	8	5	3	4	2			22
	PMR	1.50	1.27	0.87	1.51	0.32			1.04
25-29	OBS	2	1	3	5	2	5		18
	PMR	0.59	0.63	1.13	1.74	0.78	0.87		0.96
30+	OBS	4	5	8	9	14	19	53	112
	PMR	0.60	0.92	1.06	1.41	1.65	1.26	0.90	1.03
Total	OBS	36	24	27	24	18	24	53	206
	PMR	1.03	1.03	1.11	1.44	1.07	1.15	0.90	1.05

ties and differences between this subset and either all cohort deaths or deaths among all white males with any solvent exposures can contribute greatly to assessing the true sex and race specific influence of petroleum solvent exposures in the absence of confounding by synthetic solvent exposures. Table 28 shows the distribution of total deaths by age and five year calendar period for these petroleum solvent exposed white males.

Table 29 shows the distribution of total deaths by latency and years of solvent exposure. Over 72 per cent of this subset of white males were exposed to petroleum solvents for greater than 10 years, with nearly 32 per cent being exposed for 30 years or more.

Table 30 depicts the observed and expected deaths, PMRs, and 95 per cent confidence limits for selected categories of causes of death occurring among 831 white males with only petroleum solvent exposures. A total of 166 deaths due to cancer of all sites was observed, with 159.7 expected, yielding a PMR of 1.03 (95% CL = 0.89 - 1.21). Significant excesses in three major noncancer cause of death categories were found: mental, psychoneurotic and personality disorders which was due primarily to the subcategory, alcoholism, genito-urinary, and disease of bone and organ movements, arthritis.

Table 31 shows a more detailed analysis of observed and expected deaths, PMRs, and 95 per cent confidence limits for

TABLE 28

DISTRIBUTION OF DEATHS OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES, BY AGE GROUP AND CALENDER PERIOD

	Calender Period									
Age Group	1940 -44	1945 -49	1950 -54	1955 -59	1960 -64	1965 -69	1970 -74	1975 -79	1980 -84	Total
20-24	0	0	1	0	0	0	0	0	0	1
25-29	0	0	0	0	0	0	0	0	0	0
30-34	0	3	1	0	1	0	0	0	0	5
35-39	1	1	1	1	1	0	0	0	0	5
40-44	0	0	2	2	6	1	0	0	0	11
45-49	2	2	7	7	4	4	3	0	5	34
50-54	1	3	7	9	6	10	3	5	3	47
65-69	2	3	3	9	33	18	21	20	32	141
70-74	1	3	7	11	16	17	15	28	32	130
75-79	0	0	4	6	17	14	22	32	37	132
80-84	0	0	3	2	14	8	14	15	28	84
85+	0	0	3	0	7	2	3	15	21	51
Total	8	22	60	77	136	110	101	133	184	831

TABLE 29

DISTRIBUTION OF DEATHS OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES, BY YEARS OF LATENCY AND YEARS OF EXPOSURE

	Years of Exposure							
Years of Latency	1-4	5-9	10-14	15-19	20-24	25-29	30+	Total
1-4	15							15
5-9	23	26						49
10-14	16	16	23					55
15-19	20	11	18	20				69
20-24	20	15	13	8	22			78
25-29	13	7	12	11	10	24		77
30+	29	22	34	28	41	70	264	488
Total	136	97	100	67	73	94	264	831

TABLE 30

OBSERVED AND EXPECTED DEATHS, PMRS, AND 95% CL FOR MAJOR CAUSES OF DEATH OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES

CAUSE OF DEATH	OBS	EXP	PMR	95% CL
All Causes	831	830.98	1.00	0.93- 1.07
Tuberculosis	4	6.11	0.65	0.18- 1.67
All Malignant Neoplasms	166	159.66	1.03	0.89- 1.21
Benign & Unspecified Neoplasms of the Brain	0	1.13	0.00	0.00- 0.00
Diabetes Mellitus	9	12.00	0.74	0.34- 1.42
Diseases of the Blood and Blood Forming Organs	3	2.45	1.22	0.25- 3.58
Mental, Psychoneurotic and Personality Disorders	7	2.69	2.60*	1.04- 5.37
Nervous System	85	73.80	1.15	0.92- 1.42
Circulatory System	372	401.99	0.92	0.83- 1.02
Respiratory System	60	53.98	1.11	0.85- 1.43
Digestive System	18	23.86	0.75	0.45- 1.19
Genito-Urinary System	17	10.33	1.64	0.96- 2.63
Diseases of the Skin	0	0.67	0.00	0.00- 0.00
Bone and Organs of Movement	4	0.75	5.30	1.45-13.56
Unknown Causes	7	7.99	0.87	0.35- 1.80
Accidents	34	31.43	1.08	0.75- 1.51
Violence	15	12.99	1.15	0.65- 1.90
Other Causes and Blank ICD	30	29.12	1.03	0.89- 1.21

* $p < 0.05$

selected causes of cancer death. Respiratory system cancer was elevated with 60 observed versus 49.81 expected, yielding a PMR of 1.20 (95% CL = 0.92 - 1.55). Stomach cancer was significantly decreased (three deaths observed, PMR = 0.30, 95% CL = 0.06 - 0.88). Pancreatic cancer remains high (13 deaths observed, PMR = 1.45, 95% CL = 0.77 - 2.48) but not statistically significant. Singular deaths due to bone and skin cancer give PMRs in excess of 3.00 when compared to relatively small expected values. It is interesting to note that the excess in kidney cancer has been reduced when only petroleum solvent exposed white males are considered. The reduction of the subset from 998 white males with any solvent exposure to 831 with only petroleum solvent exposure reduces the PMR for kidney cancer to 1.64. The elimination of 167 white males exposed to synthetic solvents or synthetic and petroleum solvent combinations resulted in the loss of three cases of kidney cancer from the analysis. One of these three cases was in the only white male exposed exclusively to CCl_4, with 13 years of exposure. The second was in a white male with 11 years of exposure to PCE. And the third had 11 years of exposure to petroleum solvents and 17 years of exposure to PCE. Pharyngeal cancer appears to be moderately elevated with 4 observed deaths versus 2.0 expected yielding a PMR of 1.88 (95% CL = 0.51 - 4.81).

TABLE 31

OBSERVED AND EXPECTED DEATHS, PMRs, AND 95% CL FOR SELECTED CANCER SITES OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES

Cancer Site	OBS	EXP	PMR	95% CL
Buccal Cavity & Pharynx	6	4.80	1.24	0.46- 2.72
Digestive Organs	41	49.27	0.83	0.60- 1.13
Esophagus	4	3.71	1.07	0.29- 2.75
Stomach	3	9.94	0.30*	0.06- 0.88
Intestine Except Rectum	10	16.03	0.62	0.30- 1.15
Rectum	5	5.63	0.88	0.29- 2.07
Biliary Passages & Liver	2	2.82	0.70	0.09- 2.56
Liver Not Specified	2	1.47	1.36	0.17- 4.91
Pancreas	13	8.96	1.45	0.77- 2.48
Peritoneum & Other	2	0.69	2.90	0.35-10.50
Respiratory System	60	49.81	1.20	0.92- 1.55
Larynx	3	2.37	1.26	0.26- 3.70
Trachea, Bronchus & Lung	56	46.91	1.19	0.90- 1.55
Other Respiratory	1	0.53	1.90	0.05-10.58
Breast	1	0.24	4.20	0.11-23.34
Prostate	14	15.81	0.88	0.48- 1.49
Urinary Organs	13	9.67	1.34	0.72- 2.29
Kidney	6	3.65	2.03	0.66- 4.74
Bladder & Other	7	6.02	1.16	0.47- 2.39
Other & Unspecified Sites	23	16.49	1.39	0.88- 2.09
Skin	6	2.35	2.55	0.93- 5.56
Brain	3	3.40	0.87	0.18- 2.57
Bone	3	0.73	4.11	0.85-12.02
Unspecified Sites (minor)	9	9.03	0.99	0.45- 1.89
Lymphatic & Hematopoietic	8	13.58	0.58	0.25- 1.16
Lympho-Reticulosarcoma	3	3.93	0.76	1.16- 2.22
Hodgkin's Disease	1	1.16	0.85	0.02- 4.71
Leukemia & Aleukemia	2	6.16	0.32	0.04- 1.17
Other	2	2.31	0.86	0.11- 3.12

*p < 0.05

Table 32 presents the observed and expected deaths and PMRs by age group for deaths due to all malignant neoplasms, and selected site specific cancers occurring among 831 white males exposed only to petroleum solvents. A significant excess in the PMR for all malignant neoplasms occurred at age group75-79 (36 observed, 24 expected and PMR = 1.48). A total of 54 cancer deaths were observed for ages 30 - 64, with 58.73 expected (PMR = 0.92). The two deaths caused by cancer of the biliary passages and liver both occurred in age group 55 - 59, yielding an elevated PMR of 6.43 at that age group. Cancer of the pancreas showed a nonsignificantly elevated PMR at each age group over 45 - 49, except for age groups 55 - 64 and 70 - 74. All excesses in cancer of the trachea, bronchus, and lung occurred at age 45 - 49 and age 65 and older. Three of the six observed kidney cancer deaths occurred at ages 75 - 79 and yielded a significant ($p < 0.05$) excess and a PMR at 6.45. One observed bladder cancer death occurred at ages 40 - 44 which, when compared to an expected value of 0.02 yielded a significant PMR of 51.54.

Table 33 depicts the distribution of 166 cancer deaths occurring among white males exposed only to petroleum solvents and PMRs by years of latency and years of exposure. No clear trends can be seen which relate years of exposure to petroleum solvents to proportionate mortality due to cancer.

TABLE 32

OBSERVED AND EXPECTED DEATHS AND PMRS FOR ALL CANCERS AND SELECTED SITE-SPECIFIC CANCERS OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES, BY AGE GROUP

All Cancers

Age	OBS	EXP	PMR
30-34	0	0.47	0.00
35-39	0	0.54	0.00
40-44	2	1.58	1.26
45-49	7	5.64	1.24
50-54	8	9.07	0.88
55-59	15	17.66	0.84
60-64	22	23.77	0.92
65-69	35	31.42	1.11
70-74	26	27.0	0.96
75-79	36	24.31	1.48*
80-84	8	12.63	0.63
85+	7	5.50	1.27
Total	166	159.66	1.03

Intestine except Rectum

Age	OBS	EXP	PMR
30-34	0	0.12	0.00
35-39	0	0.05	0.00
40-44	0	0.12	0.00
45-49	0	0.45	0.00
50-54	0	0.71	0.00
55-59	0	1.47	0.00
60-64	1	2.12	0.47
65-69	1	3.05	1.32
70-74	4	2.89	1.38
75-79	3	2.82	1.06
80-84	0	1.59	0.00
85+	1	0.72	1.39
Total	10	16.03	0.62

Buccal Cavity & Pharynx

Age	OBS	EXP	PMR
30-34	0	0.01	0.00
35-39	0	0.01	0.00
40-44	0	0.05	0.00
45-49	0	0.22	0.00
50-54	0	0.39	0.00
55-59	0	0.71	0.00
60-64	0	0.84	0.00
65-69	3	0.95	3.16
70-74	0	0.68	0.00
75-79	2	0.53	3.75
80-84	1	0.27	3.69
85+	0	0.12	0.00
Total	6	4.80	1.24

Biliary Passages & Liver

Age	OBS	EXP	PMR
30-34	0	0.00	0.00
35-39	0	0.00	0.00
40-44	0	0.02	0.00
45-49	0	0.09	0.00
50-54	0	0.15	0.00
55-59	2	0.31	6.43
60-64	0	0.43	0.00
65-69	0	0.58	0.00
70-74	0	0.51	0.00
75-79	0	0.42	0.00
80-84	0	0.21	0.00
85+	0	0.08	0.00
Total	2	2.82	0.70

*$p < 0.05$

TABLE 32 Continued

Pancreas			
Age	OBS	EXP	PMR
30-34	0	0.01	0.00
35-39	0	0.02	0.00
40-44	0	0.08	0.00
45-49	1	0.31	3.26
50-54	1	0.51	1.95
55-59	1	0.01	0.98
60-64	1	1.38	0.72
65-69	3	1.81	1.65
70-74	0	0.52	0.00
75-79	3	1.35	2.21
80-84	2	0.69	2.91
85+	1	0.27	3.72
Total	13	8.96	1.45

Larynx			
Age	OBS	EXP	PMR
30-34	0	0.00	0.00
35-39	0	0.00	0.00
40-44	0	0.02	0.00
45-49	0	0.09	0.00
50-54	0	0.17	0.00
55-59	1	0.34	2.95
60-64	1	0.43	2.29
65-69	0	0.49	0.00
70-74	1	0.37	2.73
75-79	0	0.28	0.00
80-84	0	0.13	0.00
85+	0	0.05	0.00
Total	3	2.37	1.26

Trachea, Bronchus & Lung			
Age	OBS	EXP	PMR
30-34	0	0.04	0.00
35-39	0	0.06	0.00
40-44	0	0.38	0.00
45-49	4	1.69	2.35
50-54	2	2.99	0.66
55-59	3	6.15	0.48
60-64	4	7.99	0.50
65-69	17	10.50	1.62
70-74	13	7.92	1.63
75-79	9	6.11	1.47
80-84	3	2.34	1.28
85+	1	0.71	1.40
Total	56	46.90	1.19

Prostate			
Age	OBS	EXP	PMR

*p < 0.05

TABLE 32 Continued

Kidney				Bladder & Other Urinary			
Age	OBS	EXP	PMR	Age	OBS	EXP	PMR
30-34	0	0.01	0.00	30-34	0	0.00	0.00
35-39	0	0.01	0.00	35-39	0	0.00	0.00
40-44	0	0.05	0.00	40-44	1	0.02	51.54*
45-49	0	0.18	0.00	45-49	0	0.10	0.00
50-54	0	0.27	0.00	50-54	0	0.20	0.00
55-59	0	0.50	0.00	55-59	0	0.45	0.00
60-64	2	0.59	3.36	60-64	0	0.74	0.00
65-69	0	0.73	0.00	65-69	1	1.17	0.89
70-74	1	0.56	1.79	70-74	1	1.14	0.87
75-79	3	0.47	6.45*	75-79	2	1.18	1.68
80-84	0	0.21	0.00	80-84	0	0.71	0.00
85+	0	0.08	0.00	85+	2	0.36	5.62
Total	6	3.65	1.64	Total	7	6.02	1.16

*p < 0.05

TABLE 33

OBSERVED DEATHS AND PMRS FOR ALL MALIGNANT NEOPLASMS OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES, BY YEARS OF LATENCY AND YEARS OF EXPOSURE

Years of Latency		Years of Exposure							
		1-4	5-9	10-14	15-19	20-24	25-29	30+	Total
1-4	OBS	1							1
	PMR	0.44							0.44
5-9	OBS	8	5						13
	PMR	1.76	1.10						1.43
10-14	OBS	5	4	3					12
	PMR	1.70	1.28	0.68					1.15
15-19	OBS	1	1	5	4				11
	PMR	0.27	0.44	1.43	1.12				0.85
20-24	OBS	7	5	2	2	1			17
	PMR	1.75	1.72	0.76	1.33	0.23			1.11
25-29	OBS	2	1	2	4	2	3		14
	PMR	0.67	0.76	0.82	1.88	0.95	0.65		0.90
30+	OBS	4	5	8	8	12	17	44	98
	PMR	0.64	1.01	1.14	1.40	1.50	1.27	0.89	1.03
Total	OBS	28	21	20	18	15	20	44	166
	PMR	1.05	1.10	1.00	1.39	1.04	1.11	0.89	1.03

Table 34 depicts the distribution of 13 pancreatic cancer deaths and PMRs by years of latency and years of exposure. Consistent elevations in PMRs are seen for all categories of exposure between 5 - 29 years. No pancreatic cancer deaths occurred with less than 20 years of latency and eight of thirteen cases occurred after 30 years of latency.

Table 35 depicts the distribution of 56 trachea, bronchus, and lung cancer deaths and PMRs by years of latency and years of exposure. Six deaths occurred among those white males with petroleum solvent exposures of less than five years. No clear pattern of increasing proportionate mortality related to increasing exposure can be seen. However, a statistically significant PMR (I.42, $p < .05$) was observed for 39 of 56 cases whose latency exceeded 30 years. Three of six kidney cancer deaths shown in Table 36 occurred in white males with greater than 25 years of exposure to petroleum solvents with about 30 years of latency. All the PMRs were elevated.

Table 37 displays the distribution of seven bladder cancer deaths and PMRs by years of latency and years of exposure. Of these seven deaths, two each occurred after 1 - 4 and 5 - 9 years of exposure. A highly significant excess is noted for the three deaths occurring with 20 - 24 years of latency.

TABLE 34

OBSERVED DEATHS AND PMRS FOR PANCREATIC CANCER OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES, BY YEARS OF LATENCY AND YEARS OF EXPOSURE

Years of Latency		Years of Exposure							
		1-4	5-9	10-14	15-19	20-24	25-29	30+	Total
1-4	OBS	0							0
	PMR	0.00							0.00
5-9	OBS	0	0						0
	PMR	0.00	0.00						0.00
10-14	OBS	0	0	0					0
	PMR	0.00	0.00	0.00					0.00
15-19	OBS	0	0	0	0				0
	PMR	0.00	0.00	0.00	0.00				0.00
20-24	OBS	0	0	1	1	0			2
	PMR	0.00	0.00	6.92	11.57	0.00			2.32
25-29	OBS	0	0	2	0	0	1		3
	PMR	0.00	0.00	14.61*	0.00	0.00	3.86		3.44
30+	OBS	0	1	1	0	2	2	2	8
	PMR	0.00	3.68	2.57	0.00	4.49	2.66	0.72	1.51
Total	OBS	0	1	4	1	2	3	2	13
	PMR	0.00	0.94	3.55	1.40	2.49	2.97	0.72	1.75

*$p < 0.05$

TABLE 35

OBSERVED DEATHS AND PMRS FOR TRACHEA, BRONCHUS, AND LUNG CANCER OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES, BY YEARS OF LATENCY AND YEARS OF EXPOSURE

Years of Latency		Years of Exposure							
		1-4	5-9	10-14	15-19	20-24	25-29	30+	Total
1-4	OBS	0							0
	PMR	0.00							0.00
5-9	OBS	2	0						2
	PMR	1.49	0.00						0.77
10-14	OBS	1	1	0					2
	PMR	1.19	1.00	0.00					0.65
15-19	OBS	0	0	2	3				5
	PMR	0.00	0.00	2.01	2.73				1.30
20-24	OBS	2	1	0	0	0			3
	PMR	1.58	1.11	0.00	0.00	0.00			0.64
25-29	OBS	1	0	0	2	0	2		5
	PMR	0.94	0.00	0.00	3.24	0.00	1.30		1.01
30+	OBS	0	1	4	4	5	5	20	39
	PMR	0.00	0.59	1.79	2.23	1.17	1.30	1.49	1.42*
Total	OBS	6	3	6	9	5	7	20	56
	PMR	0.74	0.50	0.98	2.28*	1.17	1.33	1.49	1.19

* $p < 0.05$

TABLE 36

OBSERVED DEATHS AND PMRS FOR KIDNEY CANCER OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES, BY YEARS OF LATENCY AND YEARS OF EXPOSURE

		Years of Exposure							
Years of Latency		1-4	5-9	10-14	15-19	20-24	25-29	30+	Total
1-4	OBS	0							0
	PMR	0.00							0.00
5-9	OBS	1	0						1
	PMR	9.04	0.00						4.39
10-14	OBS	0	0	1					1
	PMR	0.00	0.00	9.25					3.77
15-19	OBS	0	0	0	0				0
	PMR	0.00	0.00	0.00	0.00				0.00
20-24	OBS	0	0	0	0	0			0
	PMR	0.00	0.00	0.00	0.00	0.00			0.00
25-29	OBS	0	0	0	1	0	0		1
	PMR	0.00	0.00	0.00	20.08	0.00	0.00		2.61
30+	OBS	0	0	0	0	0	1	2	3
	PMR	0.00	0.00	0.00	0.00	0.00	3.55	1.89	1.48
Total	OBS	1	0	1	1	0	1	2	6
	PMR	1.60	0.00	2.16	3.22	0.00	2.49	1.89	1.64

TABLE 37

OBSERVED DEATHS AND PMRS FOR BLADDER AND OTHER URINARY CANCER OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES, BY YEARS OF LATENCY AND YEARS OF EXPOSURE

		Years of Exposure							
Years of Latency		1-4	5-9	10-14	15-19	20-24	25-29	30+	Total
1-4	OBS	1							1
	PMR	14.08							14.08
5-9	OBS	0	0						0
	PMR	0.00	0.00						0.00
10-14	OBS	0	0	0					0
	PMR	0.00	0.00	0.00					0.00
15-19	OBS	0	0	0	0				0
	PMR	0.00	0.00	0.00	0.00				0.00
20-24	OBS	1	1	0	0	1			3
	PMR	7.09	11.73	0.00	0.00	6.70			5.89*
25-29	OBS	0	0	0	0	0	0		0
	PMR	0.00	0.00	0.00	0.00	0.00	0.00		0.00
30+	OBS	0	1	0	0	0	1	1	3
	PMR	0.00	5.56	0.00	0.00	0.00	1.75	0.48	0.77
Total	OBS	2	2	0	0	1	1	1	7
	PMR	2.20	3.25	0.00	0.00	1.81	1.39	0.48	1.16

*p < 0.05

Table 38 compares the PMRs for each major cancer site among the cohort subsets of a) group I, all solvent exposures among all sex and race groups, b) group II, all solvent exposures among white males only, and c) group III only white males exposed to only petroleum solvents. Despite the relatively small numbers of deaths for most site specific cancers, the reported PMRs for each group have remained relatively stable. Slight reductions in the value of the PMRs for kidney cancer, and genito-urinary system are most notable. The reduction in PMR from 1.80 to 1.64 for kidney cancer and 1.8 to 1.64 for genito-urinary system for white males with only petroleum solvents would appear to infer that petroleum solvent exposure in conjunction with some degree of synthetic solvent exposure may increase risk of kidney disease while exposure only to petroleum solvents carries some risk. This finding is consistent with the analysis done by Brown and Kaplan (25), in which an excess in kidney and bladder cancer found in dry cleaning workers with at least one year of PCE exposure, was also eliminated when workers with only PCE were analyzed. Any excess in genitourinary cancer deaths occurred in that portion of the cohort with PCE and petroleum solvent exposures. Petroleum solvents may in fact act as nephrotoxic and initiators of kidney cancer with PCE being a promoter of carcinogenesis at the same site. One kidney cancer death was found among the 36 deaths occurring in white males exposed to both petroleum solvents and PCE.

TABLE 38

COMPARISON OF PMRS FOR SELECTED CANCER AND NON-CANCER SITES BY COHORT, GROUP, BASED ON SEX, RACE, AND SOLVENT EXPOSURE

Group:	I	II	III
Sex / Race:	All	MW	MW
Solvent Exposure:	All	All	PET
Total Deaths:	1150	998	831
Cancer Site	**PMR**	**PMR**	**PMR**
All Malignant Neoplasms	1.04	1.05	1.03
Digestive Organs	0.86	0.91	0.83
Esophagus	0.99	0.87	1.07
Stomach	0.30*	0.34*	0.30*
Intestine Except Rectum	0.72	0.77	0.60
Rectum	0.78	0.74	0.88
Biliary Passages & Liver	0.72	0.88	1.20
Pancreas	1.50	1.65	1.45
Respiratory System	1.17	1.22	1.20
Larynx	1.31	1.37	1.26
Trachea, Bronchus, & Lung	1.16	1.21	1.19
Other Respiratory	1.38	1.54	1.90
Prostate	0.96	0.94	0.91
Urinary Organs	1.25	1.37	1.34
Kidney	1.80	2.00	1.64
Bladder & Other	0.90	0.97	1.16
Other & Unspecified Sites	1.29	1.22	1.39
Skin	2.42*	2.40	2.55
Brain	1.21	0.92	0.87
Bone	2.98	3.39	4.11
Unspecified Sites (minor)	0.91	0.81	0.99
Lymphatic & Hematopoietic	0.88	0.66	0.58
Lympho-Reticulosarcoma	0.87	0.81	0.76
Hodgkin's Disease	1.22	0.68	0.85
Leukemia & Aleukemia	0.58	0.40	0.32
Other Neoplasms	1.48	1.05	0.86
Mental, Psychoneurotic and Personality Disorders	2.63*	2.35*	2.60*
Alcoholism	2.73	2.55	2.73
Genito-Urinary System	1.81**	1.76*	1.64
Acute Nephritis	3.95	4.63	5.52
Chronic Nephritis and Renal Sclerosis	2.78**	2.41*	2.11

*p < 0.05 **p < 0.01

Power Analyses

Estimated power for selected cancer sites at varying levels of relative risk are presented for groups I, II, and III in tables 39 to 41 respectively. As the total number of observed deaths in each group decreased, the power to detect a statistical significance in proportionate mortality also decreased in a predictable manner for each site specific cancer. The ability to detect a true risk of 1.5 in overall proportionate mortality due to cancer was nearly a certainty. For a true relative risk of 2.0, power was adequate (> .80) for the general category of digestive organs and for lung cancer. At relative risks of 3.0, power was adequate to detect excesses or deficits in stomach, intestine, rectum, pancreas, prostate, and urinary bladder cancer, leukemia & aleukemia, and in the general category of lymphtic and hematopoietic cancers. At a true relative risk of 4.0, cancers of the buccal cavity and pharynx, esophagus, kidney, and lympho-reticulosarcoma were adequately detectable. The power to adequately detect a true relative risk of 4.0 was lacking for some rare site specific cancers to include the the liver, peritoneum, larynx, male breast, skin, bone, and Hodgkin's disease.

Restrictions in Interpreting the Results

The results presented here should be interpreted with caution, and used as a basis for further studies. This caution is predicated on the following reasons.

TABLE 39

ESTIMATED POWER FOR OBSERVED AND EXPECTED DEATHS FOR SELECTED CANCER SITES AT VARYING LEVELS OF RELATIVE RISK

Cancer Site	OBS	EXP	Relative Risk			
			1.5	2.0	3.0	4.0
All Cancer Sites	117	109.54	.99			
Buccal Cavity & Pharynx	0	3.28	.20	.44	.84	.98
Digestive Organs	29	34.65	.84	.99		
Esophagus	1	2.51	.17	.37	.75	.94
Stomach	2	7.37	.33	.73	.99	
Intestine Except Rectum	9	10.95	.44	.86	.99	
Rectum	3	4.07	.23	.51	.90	.99
Biliary Passages & Liver	2	1.96	.15	.31	.66	.87
Liver Not Specified	0	1.18	.12	.23	.48	.70
Pancreas	12	6.12	.29	.66	.98	
Respiratory System	44	30.87	.80	.99		
Larynx	2	1.55	.14	.27	.57	.80
Trachea,Bronchus,& Lung	41	28.93	.78	.99		
Other Respiratory	1	0.39	.09	.13	.23	.34
Breast	2	2.21	.16	.34	.70	.91
Female Genital Organs	1	1.75	.15	.29	.61	.84
Other Parts of Uterus	1	0.41	.09	.13	.24	.36
Prostate	8	8.94	.38	.80	.99	
Urinary Organs	10	6.30	.30	.67	.98	
Kidney	5	2.46	.17	.36	.74	.93
Bladder & Other	5	3.84	.22	.49	.89	.99
Other & Unspecified Sites	13	11.62	.45	.88	.99	
Skin	5	1.68	.14	.28	.60	.83
Brain	1	2.51	.18	.37	.75	.94
Bone	1	0.58	.10	.15	.30	.45
Unspecified Sites (minor)	6	6.11	.29	.65	.98	
Lymphatic & Hematopoietic	10	9.54	.40	.82	.99	
Lympho-Reticulosarcoma	5	2.71	.18	.39	.78	.95
Hodgkin's Disease	2	0.98	.12	.20	.42	.67
Leukemia & Aleukemia	2	4.22	.23	.52	.92	.99
Other	1	1.63	.14	.28	.59	.82

TABLE 40

ESTIMATED POWER FOR OBSERVED AND EXPECTED DEATHS OCCURRING AMONG WHITE MALES FOR SELECTED CANCER SITES AT VARYING LEVELS OF RELATIVE RISK

Cancer Site	OBS	EXP	Relative Risk			
			1.5	2.0	3.0	4.0
All Cancer Sites	108	98.82	.99			
Buccal Cavity & Pharynx	0	3.13	.20	.43	.83	.97
Digestive Organs	27	31.36	.81	.99		
Esophagus	1	2.37	.17	.35	.73	.92
Stomach	2	6.77	.32	.69	.98	
Intestine Except Rectum	7	9.67	.40	.82	.98	
Rectum	3	3.72	.22	.48	.88	.99
Biliary Passages & Liver	2	1.70	.14	.28	.40	.83
Liver Not Specified	0	1.06	.12	.21	.44	.66
Pancreas	12	5.62	.28	.62	.97	
Peritoneum & Other	0	0.45	.09	.14	.25	.38
Respiratory System	43	29.91	.79	.99		
Larynx	2	1.51	.14	.26	.56	.79
Trachea, Bronchus, & Lung	40	28.03	.77	.99		
Other Respiratory	1	0.36	.08	.12	.22	.33
Breast	1	0.15	.07	.09	.14	.19
Prostate	8	8.79	.38	.79	.99	
Urinary Organs	10	5.96	.29	.64	.97	
Kidney	5	2.31	.17	.35	.72	.92
Bladder & Other	5	3.65	.21	.47	.87	.99
Other & Unspecified Sites	11	10.46	.42	.85	.99	
Skin	4	1.53	.14	.27	.56	.79
Bone	1	0.53	.09	.15	.28	.42
Unspecified Sites (minor)	6	5.46	.27	.61	.96	
Lymphatic & Hematopoietic	8	8.70	.37	.79	.99	
Lympho-Reticulosarcoma	4	2.46	.17	.36	.74	.93
Hodgkin's Disease	1	0.90	.11	.19	.40	.60
Leukemia & Aleukemia	2	3.86	.22	.49	.89	.99
Other	1	1.63	.14	.26	.55	.78

TABLE 41

ESTIMATED POWER FOR OBSERVED AND EXPECTED DEATHS OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES FOR SELECTED CANCER SITES AT VARYING LEVELS OF RELATIVE RISK

Cancer Site	OBS	EXP	Relative Risk			
			1.5	2.0	3.0	4.0
All Cancer Sites	84	80.44	.99			
Buccal Cavity & Pharynx	0	2.56	.18	.37	.76	.94
Digestive Organs	19	25.90	.74	.99		
Esophagus	1	1.93	.15	.31	.65	.87
Stomach	1	5.70	.28	.63	.97	
Intestine Except Rectum	3	7.92	.35	.75	.99	
Rectum	3	3.10	.19	.42	.82	.97
Biliary Passages & Liver	2	1.39	.13	.25	.47	.76
Liver Not Specified	0	0.89	.11	.19	.39	.41
Pancreas	9	4.59	.25	.55	.93	.99
Peritoneum & Other	0	0.37	.09	.13	.22	.33
Respiratory System	35	23.77	.71	.99		
Larynx	2	1.23	.12	.23	.49	.72
Trachea, Bronchus, & Lung	32	22.24	.68	.99		
Other Respiratory	1	0.30	.08	.12	.20	.29
Breast	1	0.12	.07	.09	.13	.17
Prostate	7	7.39	.33	.73	.99	
Urinary Organs	7	4.90	.26	.57	.94	.99
Kidney	2	1.87	.15	.30	.64	.86
Bladder & Other	5	3.03	.19	.42	.82	.97
Other & Unspecified Sites	9	8.45	.37	.78	.99	
Skin	2	1.23	.12	.23	.49	.71
Bone	1	0.44	.09	.14	.25	.37
Unspecified Sites (minor)	6	4.43	.24	.54	.92	.99
Lymphatic & Hematopoietic	6	7.06	.32	.71	.99	
Lympho-Reticulosarcoma	3	1.98	.15	.32	.66	.88
Hodgkin's Disease	1	0.73	.10	.17	.35	.52
Leukemia & Aleukemia	1	3.16	.20	.43	.83	.97
Other	1	1.20	.12	.23	.48	.71

1. The results are based on the incomplete ascertainment of deaths occurring among cohort members. Proportionate mortality and not mortality rates were utilized, and excesses found could be due to deficits in other causes of death. However, since only minor deficits in non-cancer mortality were found, diabetes mellitus (PMR = 0.74), diseases of the circulatory system (PMR = 0.92), and disease of the digestive system (PMR = 0.75) the likelihood of such a bias affecting the results would be minimal.

2. For rare malignancies, where the expected number of deaths was less than five, the PMRs are not stable and could be strongly affected by one additional observed death. The use of the Poisson distribution to assess statistical significance for these causes, however, produces a more conservative result than would a chi-square test.

3. Although a priori hypotheses regarding the site specific carcinogenic potential of petroleum solvents were presented, statistical testing for all sites was accomplished, thus increasing the liklihood that some significant results could be obtained merely by chance. Since this was primarily a hypothesis generating study, two-tailed, rather than one-tailed significance testing was used.

4. Because power to detect increases in true relative risk of less than two was low for most cancer sites except lung, negative findings do not constitute good evidence for

the absence of increased risk. Significant results for sites with low power are more suggestive of actual increased risk, since the excess will, by necessity, be larger than for a site with greater power.

5. No information is available on potential confounders, such as cigarette smoking. Since no excesses were found for noncancer smoking-related deaths of the circulatory or respiratory systems, it is probable that this cohort did not smoke more than the standard population. Other potential confounders such as diet and alcohol use were unavailable for consideration.

6. Although plant ownership and/or operatorship, as well as the specific solvent(s) in use at each plant over time is well documented, a very basic assumption has been made that such ownership and/or operatorship is equivalent to actual exposure. This assumption has certainly been violated at times, however, the nature of the Oklahoma dry cleaning industry supports that this assumption is generally valid.

Standardized Mortality Analysis

Standardized Mortality Ratio analysis for white males exposed to petroleum solvents only is presented. The total number of white males included in the analysis totaled 1938 individuals. These have contributed a total of 56875 person years of experience to the study as can be seen from table 42.

Table 42

DATE 04/05/88
TIME 16:02:47

LIFE TABLE ANALYSIS SYSTEM

REPORT NO: LT20402

DISTRIBUTION OF PERSON-YEARS BY LATENCY /EXPOSURE
ONLY PETROLEUM SOLVENT EXPOSURE
RACE : WHITE SEX : MALE

LATENCY	EXPOSURE							
	1MOS - 5YRS	5YRS - 10YRS	10YRS - 15YRS	15YRS - 20YRS	20YRS - 25YRS	25YRS - 30YRS	30YRS & OVER	TOTAL
UNDER - 5YRS	6088.07	0.00	0.00	0.00	0.00	0.00	0.00	6088.07
5YRS - 10YRS	2284.42	4161.71	0.00	0.00	0.00	0.00	0.00	6446.14
10YRS - 15YRS	2035.66	944.99	3652.02	0.00	0.00	0.00	0.00	6634.67
15YRS - 20YRS	1800.50	813.53	899.13	3137.13	0.00	0.00	0.00	6650.30
20YRS - 25YRS	1483.47	670.18	767.64	547.30	3019.32	0.00	0.00	6495.91
25YRS - 30YRS	1194.40	526.82	638.77	462.42	540.36	2607.70	0.00	5970.49
30YRS & OVER	1850.07	1059.68	1604.66	1098.94	1453.82	1740.03	9782.86	18590.06
TOTAL	16735.61	8186.34	7562.83	5245.80	5013.51	4347.73	9782.86	60874.74

Table 43 presents the observed and expected deaths, standardized mortality ratios and 95% confidence limits for major causes of death occurring among petroleum solvent exposed white males. What is so striking about the data is the large number of expected deaths 2341.9 when compared to the observed deaths at 964. Few additional deaths obtained after this analysis were not included. It is worth noting that the total expected number of deaths was larger than the total white male cohort, alive and dead, being analyzed. As a consequence, most of the SMRs were significantly decreased. The SMRs for three major categories of diseases were elevated, but none reached statistical significance. These include mental, psychoneurotic and personality disorders (SMR = 2.08, GL = 0.67 - 4.87), bone and organs of movement (SMR = 2.04) and other causes and blank ICD (SMR = 2.24, CL = 1.92 - 2.60). The subcategory, acute nephritis, was also elevated (SMR = 2.04).

Table 44 presents the observed and expected deaths, SMRs, and 95% confidence limits for selected cancer sites occurring among petroleum solvent exposed white males. Here again, except for cancers of the bone (SMR = 2.10), breast (SMR = 1.88), peritoneum (SMR = 1.25) and kidney (SMR = 1.06). The SMRs for all other cancer sites were less than 1.0, and in many instances, these values were satisfactorily significant.

TABLE 43

OBSERVED AND EXPECTED DEATHS, SMRS, AND 95% CL FOR MAJOR CAUSES OF DEATH OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES

CAUSE OF DEATH	OBS	EXP	SMR	95% CL
All Causes	964	2341.91	0.41**	0.39- 0.01
Tuberculosis	4	12.76	0.31**	0.09- 0.80
All Malignant Neoplasms	164	307.16	0.53**	0.46- 0.62
Diabetes Mellitus	9	27.76	0.32**	0.15- 0.62
Diseases of the Blood and Blood Forming Organs	3	6.81	0.44	0.09- 1.28
Mental, Psychoneurotic and Personality Disorders	7	4.73	1.48	0.59- 3.05
Alcoholism	5	2.40	2.08	0.67- 4.87
Nervous System	84	293.38	0.28**	0.23- 0.36
Circulatory System	368	1212.58	0.30**	0.27- 0.34
Respiratory System	58	167.25	0.34**	0.26- 0.44
Digestive System	17	44.95	0.37**	0.22- 0.61
Genito-Urinary System	16	49.56	0.32**	0.18- 0.52
Acute Nephritis	3	1.59	1.88	0.39- 5.52
Bone and Organs of Movement	4	1.96	2.04	0.56- 5.23
Unknown Causes	7	26.51	0.26**	0.11- 0.54
Accidents	34	83.93	0.40**	0.28- 0.57
Violence	15	21.39	0.70	0.34- 1.16
Other Causes and Blank ICD	174	77.63	2.24**	1.92- 2.60

* $p < 0.05$ **$p < 0.01$

TABLE 44

OBSERVED AND EXPECTED DEATHS, SMRs, AND 95% CL FOR SELECTED CANCER SITES OCCURRING AMONG PETROLEUM SOLVENT EXPOSED WHITE MALES

Cancer Site	OBS	EXP	SMR	95% CL
Buccal Cavity & Pharynx	6	9.41	0.63	0.23- 1.39
Digestive Organs	40	102.45	0.39**	0.28- 0.53
Esophagus	3	6.44	0.46	0.09- 1.36
Stomach	3	23.43	0.12**	0.03- 0.37
Intestine Except Rectum	10	34.07	0.29**	0.14- 0.54
Rectum	5	12.45	0.40*	0.13- 0.94
Biliary Passages & Liver	2	5.59	0.35	0.04- 1.29
Liver Not Specified	2	2.89	0.69	0.08- 2.49
Pancreas	13	15.98	0.81	0.43- 1.39
Peritoneum & Other	2	1.60	1.25	0.15- 4.52
Respiratory System	60	37.39	0.89	0.68- 1.15
Larynx	3	3.82	0.78	0.16- 2.29
Trachea, Bronchus & Lung	56	62.59	0.89	0.68- 1.16
Other Respiratory	1	0.98	1.02	0.03- 5.68
Breast	1	0.53	1.88	0.05-10.49
Prostate	13	49.34	0.26**	0.14- 0.44
Urinary Organs	13	20.54	0.63	0.34- 1.08
Kidney	6	5.64	1.06	0.39- 2.31
Bladder & Other	7	14.91	0.46*	0.19- 0.96
Other & Unspecified Sites	23	32.31	0.71	0.45- 1.07
Skin	6	6.85	0.87	0.32- 1.91
Bone	3	1.42	2.10	0.43- 6.16
Unspecified Sites (minor)	9	18.13	0.49*	0.23- 0.94
Lymphatic & Hematopoietic	8	23.87	0.33**	0.14- 0.66
Lympho-Reticulosarcoma	3	6.09	0.49	0.10- 1.44
Hodgkin's Disease	1	1.66	0.60	0.02- 3.35
Leukemia & Aleukemia	2	12.53	0.15**	0.02- 0.58
Other	2	3.59	0.55	0.07- 2.01

*p < 0.05 **p < 0.01

Relationship between the PMR and SMR

Statistics and Results

The relationship between the PMR and SMR statistics was discussed in some detail in the methods and materials section of this report.

It is worth noting that the PMR cannot indicate the risk of death from any specific cause, but can detect any excess or deficit in the proportion of death from that cause. Since the sum of the proportion of deaths from each cause must equal one, a large deficit from a single cause of death will produce an excess from other causes. Competing risks of death can create an artificially high PMR for a particular cause due to any large deficit from one cause. It has been shown that if the overall SMR from a study population is significantly less than 100, as is the case in our study, each cause specific PMR will be biased upward by the amount of the differential (228,229). Conversely, if the SMR exceeds 100, each PMR will be biased downward.

The cause specific PMR approximate the cause specific SMR if the overall SMR is equal to 1.00, that is, the mortality rates are similar in the study and comparison groups.

It is worth noting that the few causes of death whose SMRs were found to be elevated also had PMRs that were elevated. The trends were similar. However, many of the

cause specific cancer deaths whose PMRs were over 100 produced SMRs that were significantly lower than 100.

The standard mortality ratio analysis included a significantly large number of deaths assigned to the category other causes and blank ICD. This was due to our inability to obtain cause of death when our follow-up data identified the individual as deceased.

The Oklahoma State Department of Health could not locate a deceased person's certificate of death without specific identifiers including county of death. This information was not always available. The process of obtaining out of state certificates of death was much slower that we had anticipated. For instance, on December 16, 1987, we submitted a request to obtain certificates of deaths for 13 cohort members who were known to be dead, to the Texas Department of Health. A response was received dated June 10, 1988 requesting that we complete a 3 page questionnaire on the study before our request would be honored. This was typically the experience we have had with a number of states.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Petroleum hydrocarbon exposures and their effects on health have been extensively studied using animal models, bioassay techniques, and cohort mortality methodologies. To date, the evidence for the carcinogenicity of petroleum hydrocarbons has been inconsistent, and when present, increases in risk have been low. In human studies, definitions of exposures, exposure levels, and durations of exposure have been difficult to specify. The magnitude of the numbers of workers exposed to petroleum fractions, however, necessitates that any increased risks found in selected epidemiologic and animal toxicologic studies be recognized, and their actual impact on worker health and safety be specifically studied. Structure/activity relationships have been undertaken in recent years which indicate that the C_8-C_{10} branched aliphatic fractions present in petroleum solvents and gasoline may be responsible for some increased risk reported. Stoddard solvent has been used in the dry cleaning industry since 1928 and is a petroleum fraction

that encompasses the hydrocarbons most suspect of adversely effecting human health. The archival of the licensure records of the Oklahoma State Dry Cleaners Board has made possible the reconstruction of the solvent specific use characteristics of a cohort of nearly 3,315 dry cleaners identified as owners and/or operators of solvent using dry cleaning plants. The broad expanse of time for which these records apply has enhanced the opportunity to assess the solvent specific influences on the proportionate mortality occurring among this cohort. This study represents the largest mortality study of solvent exposed dry cleaners in which the specific solvent of concern is known, and an index of duration of exposure is available.

Conclusions

A. Oklahoma has consistently maintained a dry cleaning industry which has used a disproportionately high percentage of petroleum solvents.

B. The archival of records at the State Dry CIeaners Board was found to be a valid and complete record of the dry cleaning industry in the State of Oklahoma between 1941 and 1985.

C. The solvent use characteristics of dry cleaning plants were identifiable in 99.5 per cent of the cases.

D. Owners and family members have represented between 29 and 42 per cent of the total industry workforce.

E. Nearly 59 per cent of the owners and/or operators of dry cleaning plants were white males, with exposures to petroleum solvents, averaging 10.5 years, without known exposure to synthetic solvents. The conclusions which follow are related to this specific subset of the cohort.

F. No excess in overall cancer mortality was found. A significant excess was seen for the categories mental, psychoneurotic and personality disorders due to alcoholism, genito-urinary system due to acute nephritis, chronic nephritis and renal sclerosis, bone and organ movement due to arthritis and spondylitis. PMRs for all malignant neoplasms appear to be independent of latency and years of exposure. A significant excess in overall cancer deaths was found to occur in cohort members between the ages 75-79.

G. An excess in respiratory system cancers was detected. All excesses in proportionate mortality due to trachea, bronchus and lung cancer occurred among those who died at age 65 and older. No relationship was noted to years of latency or years of exposure. Elevated PMRs were noted for all group with more than 15 years of exposure reaching significance for those with 18-19 years of exposure. A significant PMR was also note for 39 of 56 lung cancer cases whose latency was greater than 30 years.

H. A 45% excess in proportionate mortality due to pancreatic cancer was noted. Four of thirteen deaths occurred among men younger than age 65. Consistent elevations in PMRs are seen for all categories of duration of exposure between 10-29 years. No pancreatic cancer deaths occurred with less than 20 years of latency.

I. A single death due to breast cancer yielded an elevated, nonsignificant PMR having a wide confidence interval.

J. Excesses found for kidney cancer among the entire cohort were retained when only petroleum solvent exposed white males were analyzed. The six kidney cancer deaths occurred among men aged 60 - 79.

K. A moderate increase in skin and bone cancer was found. A slight increase in bladder cancer was found. Four of seven deaths were among those with less than ten years of exposure and six of seven appeared after twenty years of latency.

L. No significant excesses were found for cancer deaths due lymphatic and hematopoietic cancers or liver cancer.

L. Stomach cancer represents the only site for which a significant deficit in proportionate mortality was found.

M. The power to detect an excess or deficit in overall or site-specific cancer deaths was adequate at relative risks of four or less for most major sites of interest.

Recommendations

A. **Exposure levels to petroleum solvent vapors should be reduced by (1) training in, and enforcing good work practices, (2) proper plant maintenance and elimination of leaks, (3) encouraging the use of local exhaust ventilation to reduce solvent exposure levels around washers and tumble dryers.**

B. A primary focus of this research was to carry out an SMR analysis. This was an unusual cohort to follow-up. First, no Social Security # or date of birth information was available on the cohort members, the first is crucial for a successful follow-up and the second is important for the SMR analysis. Second, the follow-up period was longer than usual, forty seven years. Third, mortality tapes were not accessable, and specific county of death information had to be available before a successful search was begun or had a chance of producing a certificate of death. Arrangements with other state departments of health took longer than anticipated or was planned for. Fourth, non-traditional methods of follow-up were employed. Inspite of these difficulties, an 88% follow-up rate was achieved, 6% of which we could not obtain a certificate of death for the cause of death essential for a successful SMR analysis. The budgeted resources were not adequate to complete the study and do an adequate SMR analysis. The PMR analysis was successful, but with additional time for follow-up, the SMR analysis would have more successful. Therefore, we are recommending that NIOSH avail some additional funding for one more year of follow-up and analysis.

REFERENCES

1. CDC, Table V. "Years of Potential Life Lost, Deaths, and Death Rates, by Cause of Death, and Estimated Number of Physician Contacts, by Principal Diagnosis, United States," MMWR, 32: 411 (1983).

2. Silverberg, E. and Lubera, J. Cancer Statistics, 1988, CA - Canc. J. Physicians., 38: 5-22 (1988).

3. Doll, R. and Peto, R. "The Causes of Cancer: Quantitative Estimates of Avoidable Risks of Cancer in the United States Today," JNCI, 66: 1191-308 (1981).

4. Handbook of Mutagenicity Test Procedures. B.J. Kilbey, M. Legator, W. Nichols, and C. Rumel, Editors, Elsevier Scientific Publishing Company/North-Holland Biomedical Press, Amsterdam, 1977.

5. Higginson, J. and Muir, C.S. "The Role of Epidemiology in Elucidating the Importance of Environmental Factors in Human Cancer," Cancer Det. Prev., 1: 79-105 (1976).

6. Department of Health, Education, and Welfare. Estimates of the Fraction of Cancer in the United States Related to Occupational Factors. Bethesda, Md.: National Cancer Institute, National Institute of Environmental Health Sciences, National Institute for Occupational Safety and Health, 1978.

7. Davis, D. L., Bridbord, K. and Schneiderman, M. "Estimating Cancer Causes: Problems in Methodology, Production, and Trends," Banbury Report 9: Quantification of Occupational Cancer, pp. 285-316. Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y. (1981).

8. Newhouse, M. L. and Berry, G. "Predictions of Mortality from Mesothelial Tumours in Asbestos Factory Workers," Br. J. Indus. Med. 33: 147-51 (1976).

9. Parkes, H. G. "Identification of Carcinogenic Hazards from Aromatic Amine Exposure and Measures of Control," Prevention and Detection of Cancer Part I: Prevention. H.E. Nieburgs, Editor, Marcel Dekker Inc., New York, 1978.

10. CDC. "Leading Work-Related Diseases and Injuries United States," MMWR 33: 125-28, (1984).

11. Decoufle, P. "Occupation," Cancer Epidemiology and Prevention. D. Schottenfeld and J.F. Fraumeni, Jr., Editors, W.B. Sanders, Philadelphia, 1982, pp. 318-35.

12. Selikoff, I. J. "Constraints in Estimating Occupational Contributions to Current Cancer Mortality in the United States," Banbury Report #9: Quantification of Occupational Cancer. R. Petro and M. Schneiderman, Editors, Cold Spring Harbor Laboratory, New York, 1981, pp. 3-17.

13. Higginson, J. "Lifestyle and Cancer," Cancer Forum, 1981, pp. 4-14.

14. U.S. Public Health Service: Smoking and Health. A Report of the Surgeon General. PHS Pub. No. 79-50066. Washington, D.C.: U.S. Department of Health, Education, and Welfare, Public Health Service, Office on Smoking and Health, 1979.

15. Davis, D. L., Bridbord, K. and Schneiderman, M. "Cancer Prevention: Assessing Causes, Exposures, and Recent Trends in Mortality for U.S. Males 1968-1978," Teratogen Carcinogen Mutagen, 12: 105-35 (1982).

16. Lloyd, J. W. and Ciocco, A. "Long-Term Mortality Study of Steelworkers I. Methodology," J. Occup. Med., 11: 299-310 (1969).

17. McMichael, A. J., Spirtas, R. and Kupper, L. L. "An Epidemiologic Study of Mortality Within a Cohort of Rubber Workers 1964-1972," J. Occup. Med., 16: 458-464 (1974).

18. Monson, R. R. and Nakano, K. K. "Mortality Among Rubber Workers. I. White Male Union Employees in Akron Ohio," Am. J. Epidemiol., 103: 284-296 (1976).

19. Andjelkovich, D., Taulbee, J. and Symons, M. "Mortality Experience of a Cohort of Rubber Workers, 1964-1973," J. Occup. Med., 18: 387-394, (1976).

20. Creech, J. L. and Johnson, M. N. "Angiosarcoma of Liver in the Manufacture of Polyvinyl Chloride," J. Occup. Med., 16: 150-151 (1974).

21. Blair, A., Decoufle, P. and Grauman, D. "Causes of Death Among Laundry and Dry Cleaning Workers," Am. J. Public Health, 69: 508-511 (1979).

22. Duh, R. W. and Asal N. R. "Mortality Among Laundry and Dry Cleaning Workers in Oklahoma," Am. J. of Public Health, 74: 1278-1280 (1983).

23. Katz, R. M. and Jowett, D. "Female Laundry and Dry Cleaning Workers in Wisconsin: A Mortality Analysis," Am. J. Public Health, 73: 305-307 (1981).

24. National Institute for Occupational Safety and Health, Cupational Characteristics of Cancer Victims in Massachusetts, 1971-73, Cincinnati, Ohio: NIOSH, September, 1984, DHHS Publication No. (NIOSH) 84-109.

25. Brown, D. P. and Kaplan, S. D. Retrospective Cohort Mortality Study of Dry Cleaner Workers Using Perchloroethylene, NIOSH, Contract No. 210-77-0094, August, 1980, updated draft, December, 1985.

26. National Institute for Occupational Safety and Health, Occupational Mortality in Washington State, 1950-1979, Cincinnati, Ohio: NIOSH, October, 1983, DHHS Publication No. (NIOSH) 83-116.

27. Nakamura, K. "Mortality Patterns Among Cleaning Workers," Sangyo Igaku, 27: 24-37 (1985).

28. Dry Cleaning. (Gove, P.B., ed.) Webster's Third New International Dictionary. (Unabridged.) Springfield, MA: G & C Merriam, 1971. p.696.

29. Federal Trade Commission. What's New About Care Labels. (Pamphlet.)

30. Sigworth, V. "Dry Cleaning," Encyclopedia Americana. Chicago, IL: Encyclopedia Americana, 1973, p. 312.

31. Bowra, C.M. Classical Greece. Time, New York, 1965, p.32.

32. Johnson, A.E., Drycleaning. Merrow, Watford, England, 1971, p. 45.

33. Michelsen, E.M. Remember The Years: 1907-1957. National Institute of Drycleaning, (NID), National Institute of Drycleaning now International Fabricare Institute (IFI), Silver Spring, MD., 1957.

34. Shepley, M.A. "Drycleaning," Textiles, 10: 47-51 (1981).

35. Spomar, J. The Official Fabric Care Coloring Book for Children and Adults. Dalton, IL, 1979, p. 43.

36. Edelstein, S.M. Camphene et le Degraisseur--The Origins of Drycleaning., Amer. Dyest. Rep. 46: 1-8 (1957).

37. Garfield, E. "Drycleaning Part 2. Commercial History and Social Impacts: Ironing Out Some Pressing Problems," Current Contents, 22: 3-10 (1985).

38. Practical Dry Cleaner, Scourer and Garment Dryer. W.T. Brannt, J.B. Gray, Editors, H.C. Baird, New York, 1924, p. 378.

39. Commercial Standard CS3-41, National Bureau of Standards, U.S. Department of Commerce, Washington, D.C., 1928.

40. "Slow Motion in D.C." FDA Proposes to Ban Carbon Tetrachloride. Consumer Bull., 51: 39-40 (1968).

41. "Chemicals EPA Wants to Label", Chem. Week, 127: 23-24 (1980).

42. Laundry-Cleaning Council. The Safe Handling of Perchlorethylene Drycleaning Solvent. Downers Grove, IL: LCC, 1980. 12 p.

43. Fisher, W. of the International Fabricare Institute. Telecon with R. Petrone, U. of Oklahoma, October 10. Use of Fluorochlorohydrocarbon Solvents in the Commercial and Industrial Dry Cleaning Sectors.

44. Stucker, J. 1986. Telecon with R. Petrone, U. of Oklahoma, October 14. Proportions of cartridge versus diatomaceous earth filters.

45. Fisher, W. of the International Fabricare Institute. Telecon with R. Petrone, U. of Oklahoma, October 12. Proportions of Petroleum Solvent Use in the Commercial and Industrial Dry Cleaning Sectors.

46. NFPA. Report No. 32, Dry Cleaning Plants, National Fire Protection Association. Boston, Massachusetts, 1979.

47. U.S. Bureau of the Census. 1981. 1977 Census of Service Industries, Subject Series. Laundry, Cleaning, and Garment Services. SC_77-S-3. U.S. Government Printing Office. Washington, D.C.

48. Rosenthal, S. 1981a. Washex. Telecon with J. Viola, EEA Inc., January 29. Trends in petroleum equipment use and sales.

49. Godfrey, J. 1980. Jack Godfrey & Sons. Telecon with J. Viola, EEA Inc., October 6. Equipment life, plant finances and trends, and petroleum solvent use.

50. Siu, R. 1980. Textile Rental Services Association of America. Telecon with J. Viola, EEA Inc., December 12. Linen suppliers and indistrial launderers.

51. U.S. Bureau of the Census. 1957. Census of Business: 1954. Volume V. Selected Service Trades -Summary Statistics. U.S. Government Printing Office. Washington, D.C.

52. U.S. Bureau of the Census. 1966. Census of Business 1963. Volume VI. Selected Services -Summary Statistics. U.S. Government Printing Office. Washington, D.C.

53. U.S. Bureau of the Census. 1972. 1967 Census of Business. Selected Services - Special Report: Establishment and Firm Size. BC_67(S)SS-1. U.S. Government Printing Office. Washington, D.C.

54. U.S. Bureau of the Census. 1975. 1972 Census of Selected Service Industries. Subject Series. Establishment and Firm Size. U.S. Government Printing Office. Washington, D.C.

55. U.S. Bureau of the Census. 1980a. 1977 Census of Service Industries. Subject Series. Establishment and Firm Size. U.S. Government Printing Office. Washington, D.C.

57. U.S. Bureau of the Census. 1976a. 1972 Census of Selected Service Industries. Area Statistics. U.S. Government Printing Office. Washington, D.C.

58. U.S. Bureau of the Census. 1976b. 1972 Census of Selected Service Industries. Summary and Subject Statistics. Government Printing Office. Washington, D.C.

59. U.S. Bureau of the Census. 1980b. 1977 Census of Service Industries. Geographic Area Series. United States. U.S. Government Printing Office. Washington, D.C.

61. U.S. Bureau of the Census. 1970. 1967 Census of Business. Selected Services - Subject Reports. Laundries, Cleaning Plants, and Related Services. U.S. Government Printing Office. Washington, D.C.

62. International Fabricare Institute (IFI). 1975. Results of a Membership Survey. Special Reporter. January.

64. Lester, E. 1980. American Laundry. Telecon with J. Viola, EEA Inc., September 26. American's retail outlets, petroleum dry cleaning regional patterns of use, equipment life, and the sales trend.

65. Oklahoma House Journal 1939, House Bill 232.

66. Session Laws of Oklahoma 1941, Chapter 17, Section 2, p. 244.

67. Jack Lincoln Shops, Inc. v. State Dry Cleaners' Board, 192 Oklahoma 251, 59 paragraph 757, p. 672.

68. Plott, C. R. "Occupational Self-Regulation: A Case Study of the Oklahoma Dry Cleaners," J. of Law and Econ., 8: 195-222 (1965).

69. Reich, A. and Cormany, C.L. Dry Cleaning and Laundering, in Kirk-Othmer Encyclopedia of Science and Technology, Vol. 8, 1976 pp 50-67.

70. Washex, Instruction Manual for Washex Washers and Filters. Publication No. T-559a. Wichita Falls, Texas. September, 1974.

71. Sluizer, M., Institute of Industrial Launderers, Telecon with S. Plaisance, TRW Inc., April 10. Size of the industrial petroleum dry cleaning industry and the throughput of a typical plant, 1981.

72. Phillips, R., Dry Cleaning. National Institute of Drycleaning, Inc. Silver Spring, Marland, 1966.

73. Watts, A. and Fisher, A. Results of Membership Survey of Dry Cleaning Operations. Joliet, Illinois. IFI Special Reporter 3-1. January-February, 1975.

74. National Institute of Occupational Safety and Health (NIOSH), Criteria for a Recommended Standard ... Occupational Exposure to Refined Petroleum Solvents, DHEW (NIOSH). Publication No. 77-192, p. 246, 1977.

75. Seitz, W., Principles and Practices of Dry Cleaning: Student Notebook, New York School od Dry Cleaning, Inc., New York, N.Y., 1985.

76. Marvel Manufacturing Co., Washex Machinery, Inc., American Laundry Machinery, W.M. Cissel Manufacturing Co., VIC Manufacturing Co., and Challenge-Cook Brothers, Inc. 1980. Telecon Survey with Corey, TRW Inc., March 18-April 25. Sizes of petroleum dry cleaning equipment and expected sales for 1980.

77. IFI., An Introduction to Industrial Dry Cleaning Methods, Part One. IFI Special Reporter. Volume One, Number Three. International Fabricare Institute. Joliet, Illinois., 1973.

78. Jernigan, R. and Lutz, S. 1980. An Evaluation of the Emission Reduction Potential of a Solvent Recovery Dry Cleaning Dryer. TRW Inc. Research Triangle Park, North Carolina (EPA Contract No. 68-03-2560). February. [Pico Rivera].

79. NID., Estimation of Solvent Vapor Emission from Petroleum Dry Cleaning Plants. National Institute of Drycleaning. Publication No. T-486. Silver Spring, Maryland. February, 1971.

80. Puritan., Sales Brochure: Modern Filtration Means Puritan Filtration. R.R. Street and Company. Oakbrook, Illinois. Bulletin No. 1289., 1980

81. Bee, W. and Fisher, W. Report on Cartridge Filtration Life. International Fabricare Institute (IFI). Joliet, Illinois. Focus No. 1., 1976.

82. Plaisance, S., A Study of Petroleum Dry Cleaning Cartridge Filter Element Emissions. TRW, Inc. Research Triangle Park, North Carolina (EPA Contract No. 68-02-3063). February, 1981.

83. Washex. Installation, Operation and Maintenance Manual for Washex Vacuum Stills. Publication No. T-513d. Wichita Falls, Texas. July, 1973.

84. Fisher, W., ABC's of Solvent Mileage, Part 1. International Fabricate Institute (IFI). Joliet, Illinois. Special Reporter Vol. 3, No. 4. July-August, 1975.

85. Jernigan, R. and Kezerle, J. Evaluation of the Potential for Reduction of Solvent Losses through a Washex Petroleum Vacuum Still Sump. TRW Inc. Research Triangle Park, North Carolina, EPA Contract No. 68-03-2560, Task No. T5013). February, 1981.

87. Oberg, M. "A Survey of the Petroleum Solvent Inhalation Exposure in Detroit Dry Cleaning Plants," Am. Ind. Hyg. Assoc. J., November-December: 547-550 (1968).

88. Andrasik, I. International Fabricare Institute, Telecon with R. Petrone, U. of Oklahoma, February 18, 1986, Petroleum Solvent Exposures.

89. "How to Reduce Hazards in Drycleaning", Health and Safety Survey Report, American Dry Cleaner, Jan: 90-95 (1985).

90. Tuskes, P. City of Houston, Occupational Health, Radiation and Noise Control. Letter to R. Petrone, U. of Oklahoma, February 26, 1985. Stoddard Solvent Exposures Measured in Houston Dry Cleaning Plants.

91. NIOSH Technical Report. Engineering Control Technology Assessment of the Dry Cleaning Industry, DHEW (NIOSH) Publication No. 81-136, October, 1980.

92. Coler, H.R. and Rossmiller, H.R. "Tetrachloroethylene Exposure in a Small Industry," Arch. Ind. Hyg. Occup. Med., 8: 227-233 (1953).

93. Ludwig, H.R., Meister, M.V. Roberts, D.R. and Cox, C. "Worker Exposure to Perchloroethylene in the Commercial Dry Cleaning Industry," Am. Ind. Hyg. Assoc. J., 44: 600-605 (1983).

94. Materna, B.L. "Occuputional Exposure to Perchloroethylene in the Dry Cleaning Industry, Amer. Ind. Hyg. Assoc. J., 46: 268-73 (1985).

95. Cook, W.A. "Maximum Allowable Concentrations of Industrial Atmospheric Contaminants," Ind. Med., 14: 936-46 (1945).

96. Sayers, R.R., Fieldner, A.C., Yant, W.P. and Thomas, B.G.H. "Experimental Studies on the Effect of Ethyl Gasoline," Report of U.S. Bureau of Mines, 1927.

97. Drinker, P., Yaglou, C.P. and Warren, M.F. "The Threshold Toxicity of Gasoline Vapor," J. Ind. Hyg. Toxicol., 75: 225-32 (1943).

98. American Conference of Governmental Industrial Hygienists. Report of the Sub Committee on Threshold Limits, in Proceedings of the Eighth Annual Meeting, ACGIH, Chicago, April 7-13, 1946.

99. American Conference of Governmental Industrial Hygienists. Report of the Committee on Threshold Limits, in the Transactions of the 10th Annual Meeting, ACGIH, Boston, April 1948, 3pp.

100. American Conference of Governmental Industrial Hygienists. TLVs--Threshold Limit Values for 1949, in Proceedings of the 11th Annual Meeting, ACGIH, Detroit, April 1949, 3pp.

101. Elkins, H.B. The Chemistry of Industrial Toxicology. New York, John Wiley and Sons Inc., 1950, pp. 101-110.

102. American Conference of Governmental Industrial Hygienists. Threshold Limit Values of Airborne Contaminants and Intended Changes Adopted by ACGIH for 1970. Cincinnati, ACGIH, 1970, pp. 1-27.

103. American Conference of Governmental Industrial Hygienists, Committee on Threshold Limit Values. Documentation of the Threshold Limit Values for Substances in Workroom Air, ed. 3, 1971. Cincinnati, ACGIH, 2nd printing, 1974, pp. 233-35.

104. American Conference of Governmental Industrial Hygienists. TLVs--Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1974, 94 pp.

105. American Conference of Governmental Industrial Hygienists. TLVs--Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1976. Cincinnati, ACGIH, 1976, pp. 154.

106. Permissible Levels of Toxic Substances in the Working Environment--6th Session of the Joint ILO/WHO Committee on Occupational Health, Geneva, June 4-10, 1968. Geneva, International Labour Office, Occupational Safety and Health Series No. 20. 1970, pp. 203,334.

107. Winell, M. "An International Comparison of Hygienic Standards for Chemicals in the Work Environment," Ambio, 4: 34-36 (1975).

108. Gerarde, H. W. "The Ubiquitous Hydrocarbons," Soap Chem. Specialties, 43: 8 (1967).

109. WHO. International Agency for Research on Cancer Monographs on the Evaluation of Carcinogenic Risk of the Chemical to Man: Certain Polycyclic Aromatic Hydrocarbons and Heterocyclic Compounds. Vol. 3, 271 pp., 1973.

110. NIOSH Petroleum Refinery Workers Exposure to PAHs at Fluid Catalytic Cracker, Coker, and Asphalt Processing Units, DHEW (NIOSH) Publication No. 83-111, May, 1983.

111. Elkins, H. B., Pagnotto, L. D. "Benzene Content of Petroleum Solvents," AMA Arch. Ind. Health, 13: 51-54 (1956).

112. API Toxicological Review--Petroleum Naphthas. American Petroleum Institute, New York, 1969, p.6.

113. Carpenter, C.P., Kinkead, E.R., Geary, D.L., Jr., Sullivan, L.J. and King, J.M. "Petroleum Hydrocarbon Toxicity Studies--III. Animal and Human Response to Vapors of Stoddard Solvent," Toxicol. Appl. Pharmacol., 32: 282-97 (1975).

114. Mellan, I. Handbook of Solvents--Pure Hydrocarbons. Reinhold Publishing Corp., New York, 1957, Vol. 1, pp. 249.

115. Exxon Petroleum Solvents, No. Lubetext DG-1P. Exxon Co. USA, Houston, 1974, p. 9.

116. "Hygienic Guide Series--Stoddard Solvent (Mineral Spirits, Whie Spirits)," Am. Ind. Hyg. Assoc. J., 36: 553-58 (1975).

117. National Fire Protection Association: National Fire Codes-A Compilation of NFPA Codes, Standards, Recommended Practices, and Manuals; Flammable Liquids, Boiler-Furnaces, Ovens, NFPA No. 32-1972.

118. American Society for Testing and Materials (ASTM)

119. Gleason, M.N., Gosselin, R.E., Hodge, H.C., Smith, R.P. Section II. Ingredients Index, in Clinical Toxicology of Commercial Products, ed. 3. Baltimore, The Williams and Wilkins Co., 1969, pp. 85, 97, 111, 152.

120. Stecher, P.G. (ed). The Merck Index--An Encyclopedia of Chemicals and Drugs, ed. 8. Rahway, N.J., Merck and Co. Inc., 1968, pp. 599, 619, 697, 800, 983.

121. Organic Solvent, in NPIRI Raw Materials Data Handbook-Physical and Chemical Properties, Fire Hazard and Health Hazard Data, Vol. 1. Bethlehem, Pa., National Printing Ink Research Institute, Francis MacDonald Sinclair Memorial Laboratory, 1974, p. I4.

122. Fabricare News, International Fabricare Institute, (IFI), Vol. 7, No. 11, Nov. 1978.

123. Halder, C.A., Warne, T.M. and Hatoum, N.S. Renal Toxicity of Gasoline and Related Petroleum Naphthas in Male Rats. In: Advances in Modern Environmental Toxicology. Volume VII. Renal Effects of Petroleum Hydrocarbons. (M.A. Mehlman, G.P. Hemstreet, J.J. Thorpe, and N.K. Weaver, eds.). Chptr. VI, pp. 73-87. Princeton Scientific Publishers, Inc., Princeton, New Jersey, 1984.

124. Carpenter, C.P., Kinkead, E.R., Geary, Jr., D.L., Sullivan, L.J. and King, J.M. "Petroleum Hydrocarbon Toxicity Studies. III. Animal and human response to vapors of Stoddard Solvent," Toxicol. Appl. Pharmacol., 32: 282-297 (1975).

125. Carpenter, C.P., Kinkead, E.R., Geary, Jr., D.L., Sullivan, L.J. and King, J.M. Petroleum Hydrocarbon Toxicity Studies, VI. Animal and human response to vapors of "60 Solvent," Toxicol. Appl. Pharmacol., 34: 374-394 (1975).

126. Carpenter, C.P., Geary, Jr.,D.L., Myers, R.C., Nachreiner, D.J., Sullivan, L.J. and King, J.M. Petroleum Hydrocarbon toxicity Studies. XV. Animal and human response to vapors of "High Naphthenic Solvent," Toxicol. Appl. Pharmacol., 41: 251-260 (1977).

127. Phillips, R.D. and Egan, G.F. "Subchronic Inhalation Exposure of Dearomatized White Spirit and C_{10}-C_{11} Isoparaffinic Hydrocarbon in Sprague-Dawley Rats," Fund. Appl. Toxicol., 4: 808-818 (1984).

128. MacNaughton, M.G. and Uddin, D.E. Toxicology of Mixed Distillate and High-Energy Synthetic Fuels. In: Advances in Modern Environmental Toxicology. Volume VII. Renal Effects of Petroleum Hydrocarbons (M.A. Mehlman, G.P. Hemstreet, J.J. Thorpe, and N.K. Weaver,eds.), Chptr. IX, pp. 121-132. Princeton Scientific Publishers, Inc., Princeton, New Jersey.

129. MacFarland, H.N., Ulrich, C.E., Holdsworth, C.E., Kitchen, D.N., Halliwell, W.H. and Blum, S.C. "A Chronic Inhalation Study with Unleaded Gasoline Vapor," J. Amer. Coll. Toxicol., 3: 231-248 (1984).

130. Halder, C.A., VanGorp, G.S., Hatoum, N.S., and Warne, T.M. "Gasoline Vapor Exposures. Part I. Characterization of Workplace Exposures," Am. Ind. Hyg. Assoc. J., 47: 164-172 (1986).

131. Halder, C.A., VanGorp, G.S., Hatoum, N.S., and Warne, T.M. "Gasoline Vapor Exposures. Part II. Evaluation of the Nephrotoxicity of the Major C_4-C_5 Hydrocarbon Components," Am. Ind. Hyg. Assoc. J., 47: 173-175 (1986).

132. Aranyi, C., O'Shea, W.J., Halder, C.A., Holdsworth, C.E., and Cockrell, B.Y. "Absence of Nephropathy in Rats Exposed Subchronically to Volatile Hydrocarbon Mixtures Pertinent to Gasoline," submitted for publication.

134. Anderson, L. "Carcinogenicity Study on Fischer 344 rats and B6C3F1 mice exposed to unleaded gasoline vapor," Environmental Protection Agency (Memorandum to J.H. Somers). May 6, 1983.

135. Haydon, D.A., Hendry, B.M., Levinson, S.R. and Requena, J. "The Molecular Mechanism of Anaesthesia," Nature (London) 268: 356-358 (1977).

136. NIOSH, Criteria for a Recommended Standard. Occupational Exposure to Alkanes (C_5-C_8). U.S. Department of Health Education and Welfare, USA (1977).

137. Couri, D. and Milks, N. "Toxicity and Metabolism of Neurotoxic Hexacarbons n-Hexane, 2-Hexanone, and 2,5-Hexanedione," Annu. Rev. Pharmacol. Toxicol., 22: (1982).

138. Ono, Y., Takeuchi, Y., Hisanaga, N., Iwata, M., Kitoh, J., and Sugiura, Y. Neurotoxicity of Petroleum Benzine Compared with n-Hexane," Int. Arch. Occup. Environ. Hlth., 50: 219 (1982).

139. Savolainen, H. and Pfaffli, P. "Neurochemical Effects of Extended Exposure to White Spirit Vapour at Three Concentration Levels," Chem. Biol. Interact., 39: 101 (1982).

140. Thompson, R. J., Kynoch, P. A. M., and Sarjant, J. "Immunohistochemical Localization of Creatine Kinase-BB Isoenzyme to Astrocytes in Human Brain," Brain Res., 22: 423 (1980).

141. Langer, G. A. "The Structure and Function of the Myocardial Cell Surface," Am. J. Physiol., 235: H461 (1978).

142. Verkkala, E., Pfaffli, P., and Savolainen, H. "Comparisons of Local Neurotoxicity of Three White Spirit Formulations by Percutaneous Exposure of Rat Tail Nerve," Toxicology Letters, 21: 293-299, (1984).

143. Rector, D. E., Steadman, B. L., Jones, R. A. and Siegel, J. "Effects on Experimental Animals of Long Term Inhalation Exposure to Mineral Spirits," Toxicol. Appl. Pharmacol., 9: 257-268 (1966).

144. Riley, A. J., Collings, A. J., Browne, N. A., and Grasso, P. "Response of the Upper Respiratory Tract of the Rat to White Spirit Vapour," Toxicology Letters, 22: 125-131 (1984).

145. Srbova, J., Teisinger, J. and Skramorsky, S. "Absorption and Elimination of Benzene in Man," Arch. Ind. Hyg. Occup. Med., 2: 1-8 (1950).

146. Das, M. L., Orrenius, S. and Ernster, L. "On the Fatty Acid and Hydrocarbon Hydroxylation in Rat Liver Microsomes," Eur. J. Biochem., 4: 519-523 (1968).

147. Frommer, U., Ullrich, V. and Orrenius, S. "Influence of Inducers and Inhibitors on the Hydroxylation pattern of N-Hexane in Rat Liver Microsomes," FEBS Lett., 41: 14-16 (1974).

148. Carpenter, C. P., Geary, D. L., Myers, R. C., Nachreiner, D. J., Sullivan, L. J. and King, J. M. "Petroleum Hydrocarbon Toxicity Studies XVII. Animal Responses to N-Nonane Vapour," Toxicol. Appl. Pharmacol., 44: 53-61 (1978).

149. Khan, S. and Pandya, K. P. " Biochemical Studies on the Toxicity of N-Octane and N-Nonane," Environ. Res. 22: 271-276 (1980).

150. Khan, S, Mukhtar, H. and Pandya, K. P. "N-Octane and Nonane-Induced Alterations in Xenobiotic Metabolising Enzyme Activities and Lipid Peroxidation of Rat Liver," Toxicology, 15: 239-245 (1980).

151. Pandya, K. P. and Khan, S. "Effect of N-Octane and N-Nonane Administration on Alkaline Phosphatase Activity in Tissues of Female Rats," Biochem. Pharmacol., 31: 201-203 (1982).

152. Khan, S. and Pandya, K. P. "Hepatotoxicity in Albino Rats Exposed to N-Octane and N-Nonane," Journal of Applied Toxicology, 5: 64-68 (1985).

153. Massarrat, S. "Alkaline Phosphatase in the Subcellular Fractions of Normal and Damaged Human Liver," Enzyme, 12: 402-408 (1971).

154. Popper, H., Koch-Weger, D. and Huega, J. "Serum and Hepatic Enzymes in Experimental Liver Damage," J. Mount Sinai Hosp., 19: 256-263 (1952).

155. Norum, R. R. "Enzymology of Cholesterol Esterification," Scand. J. Clin. Lab. Invest. Suppl., 33: 7-13 (1974).

156. Nau, C., Neal, J. and Throton, M. "C_9-C12 Fractions Obtained From Petroleum Distillates. An Evaluation of Their Potential Toxicity," Arch. Environ. Health, 12: 382 (1966).

157. Grant, W. M. "Toxicology of the Eye, ed. 2. Springfield, Ill., Charles C. Thomas, 1974, pp. 801-804.

158. Conaway, C. C., Schreiner, C. A. and Cragg, S. T. Mutagenicity Evaluation in Petroleum Hydrocarbons. In Advances in Modern Environmental Toxicology, Applied Toxicology of Petroleum Hydrocarbons. H. N. MacFarland, C. E. Holdsworth, J. A. MacGregor, R. W. Call and M. L. Kane, Eds. Vol. 6: 89-107. Princeton Scientific Publishers. Princeton, NJ., 1984.

159. Gochet, B., deMeester, C., Leonard, A., and DeKnudt, G. Lack of Mutagenic Activity of White Spirit," Int. Arch. Occup. Environ. Health., 53: 359-364 (1984).

160. Horton, A. W., Denman, D. T., and Trosset, R. P. "Carcinogenesis of the Skin, The Accelerating Properties of Aliphatic and Related Hydrocrbons," Cancer Res., 17: 758-766 (1957).

161. Sice, J. "Tumor-Promoting Activity of n-Alkanes and 1-Alkanols," Toxicology and Applied Pharmacology, 9: 70-74 (1966).

162. Phillips, R. D. and Egan, G. F. "Teratogenic and Dominant Lethal Investigation of Two Hydrocarbon Solvents," The Toxicologist, 1: 15 (1981).

163. Braunstein, L. E. "Subacute Yellow Atrophy of the Liver Due to Solvent," JAMA, 114: 136-138 (1940).

164. Scott, J. L., Cartwright, G. E. and Wintrobe, M. M. "Acquired Aplastic Anemia--An Analysis of Thirty-Nine Cases and Review of the Pertinent Literature," Medicine, 38: 119-72 (1959).

165. Prager, D. and Peters, C. "Development of Aplastic Anemia and the Exposure to Stoddard Solvent," Blood, 35: 286-87 (1970).

166. Churchill, D. N., Fine, A., and Gault, M. H. "Association Between Hydrocarbon Exposure and Glomerulonephritis. An Appraisal of the Evidence," Nephron, 33: 169-172 (1983).

167. Sperace, G. A. "Idiopathic Pulmonary Hemosiderosis," Am. Rev. Resp. Dis., 88: 330-337 (1963).

168. Heale, W. F., Matthiesson, A. M., and Niall, J. F. "Lung Hemorrhage and Nephritis," Med. J. Aust. 3: 355-357 (1969).

169. Klavis, G. and Drommer, W. "Goodpasture's Syndrome and the Effect of Benzene," Arch. Tox., 26: 40-50 (1970).

170. Beirne, G. J. and Brennan, J. T. "Glomerulonephritis Associated with Hydrocarbon Solvents," Archs. Envir. Hlth., 25: 365-369 (1972).

171. D'Apice, A. J. F., Kincaid-Smith, P., Becker, G. J., Loughhead, M. G., Freeman, J. W. and Sands, J. M. "Goodpasture's Syndrome in Identical Twins," Ann. Intern. Med., 88: 61-62 (1978).

172. Kleinknect, D. Morel-Maroger, L., Callard, P., Adhemar, J. P. and Mahieu, P. "Antiglomerular Basement Membrane Nephritis After Solvent Exposure," Archs. Intern. Med., 140: 230-232 (1980).

173. Ehrenreicht, T., Yunis, S.L. and Churg, J. "Membranous Nephropathy Following Exposure to Volatile Hydrocarbons," Environ. Res., 14: 35-45 (1977).

174. Cagnoli, L., Casanova, S., Pasquali, S., Donini, U. and Zucchelli, P. "Relationship Between Hydrocarbon Exposure and the Nephrotic Syndrome," Lancet 1: 1068-1069 (1980).

175. Von Scheele, C., Althoff, P., Kempni, V. and Schelin, H. "Nephrotic Syndrome Due to Sub-Acute Glomerulonephritis-Association with Hydrocarbon Exposure?" Acta. Med. Scand., 200: 427-429 (1976).

176. Zimmerman, S. W., Groehler, K. and Beirne, G. J. "Hydrocarbon Exposure and Chronic Glomerulonephritis," Lancet, 2: 199-201 (1975).

177. Lagrue, G., Kamalodine, T., Guerrero, J. Hirbec, G., Zhepova, F. and Bernaudin, J. F. "Nephropathies Glomerulaires Primitives et Inhalation De Substances Toxiques," J. Urol. Nephrol., 4-5: 323-329 (1977).

178. Ravnskov, U. "Exposure to Organic Solvents -A Missing Link in Poststreptococcal Glomerulonephritis," Acta. Med. Scand., 203: 351-356 (1978).

179. Finn, R., Fennerty, R. G. and Ahmad, R. "Hydrocarbon Exposure and Glomerulonephritis," Clin. Nephrol., 14: 173-175 (1980).

180. Ravnskov, U., Forsberg, B. and Skerfving, S. "Glomerulonephritis and Exposure to Organic Solvents," Acta. Med. Scand., 205: 575-579 (1979).

181. Sackett, D.L. "Bias in Analytic Research," J. Chron. Dis., 32: 51-63 (1979).

182. van der Lann, G. "Chronic Glomerulonephritis and Organic Solvents," Int. Archs. Occup. Envir. Hlth., 47: 1-8 (1980).

183. Tuttle, T. C., Wood, G. D., Grether, C. B., Johnson, B. L. and Xintaras, C. "A Behavioral and Neurological Evaluation of Dry Cleaners Exposed To Perchloroethylene," DHEW (NIOSH) Publication No. 77-214, 1977.

184. Stemhagen, A., Slade, J., Altman, R. and Bill, J. "Occupational Risk Factors and Liver Cancer," Am. J. Epidem., 117: 443-454 (1983).

185. Hernberg, S., Korkala, M., Asikainen, U., and Riala, R. "Primary Liver Cancer and Exposure to Solvents," Int. Arch. Environ. Health, 54: 147-153 (1984).

186. Bryan, J. "Risk Factors in Hypernephroma," a doctoral dissertation, University of Oklahoma Health Sciences, 1983.

187. Asal, N. R., Geyer, J. R. and Lee E. T. "Risk Factors in Renal Cell Carcinoma," National Cancer Institute Grant 1-RO1-CA31059-04, Final Report, 1986.

188. McLaughlin, J. K., Mandel, J. S., Blot, W. J., Schuman, L. M., Mehl, E. S., and Fraumeni, J. F. "A Population-Based Case-Control Study of Renal Cell Carcinoma," J. Natl. Cancer Inst., 72: 275-284 (1984).

188a McLaughlin, J. K., Blot, W. J., Mehl, E. S., Stewart, P. A., Venable, F. S. and Fraumeni, J. F. "Petroleum-Related Employment and Renal Cell Cancer," J. Occup. Med., 27: 672-674 (1985).

189. Chapman, J. W., Connolly, J. G., and Rosenbaum, L. Occupational Bladder Cancer: A case-control study, In: Connolly J. G., (Ed.): Carcinoma of the Bladder. New York: Raven Press, 1981, pp. 45-54.

190. Smith, E. M., Miller, E. R., Woolson, R. F., and Brown, C. K. "Bladder Cancer Risk Among Laundry Workers, Dry Cleaners, and Others in Chemically-Related Occupations," J. Occup. Med., 27: 295-297 (1985).

191. Kaplan, I. and Zeligman, I. "Occupational Dermatitis of Railroad Workers," Arch. Dermatol., 85: 95-102 (1962).

192. Ramos, H. and Shama, S. K. Health Hazard Evaluation Determination, Report No. 72-107-88 (General Electric Co. Inc.). Cincinnati, National Institute for Occupational Safety and Health, Hazard Evaluation Services Branch, 1973, 8 pp.

193. Markel, H. L. and Shmumes, E. Health Hazard Evaluation Determination, Report No. 72-33-129 (Barker Greeting Card Co). Cincinnati, National Institute for Occupational Safety and Health, Hazard Evaluation Services Branch, 1974, 15 pp.

194. Larsen, L. B. and Shmunes, E. "Occupational Health Case Report, No. 6 - Stoddard Solvent," J. Occup. Med., 16: 276-278 (1974).

195. Miettinen O. S. and Wang, J. "An Alternative to the Proportionate Mortality Ratio," AM. J. Epidemiol., 103: 226-235 (1981).

197. Pitha, J. V., Hemstreet, G. P., Asal, N. R., Petrone, R. L., Trump, B. F., and Silva, F. G. "Occupational Hydrocarbon Exposure and Renal Histopathology," Tox. Ind. Health, submitted for publication.

198. Cantrell, A. "Annual refining Survey," Oil Gas J., 78: 130-160 (1980).

199. A Mortality Study of Petroleum Refinery Workers, Project OH-I, prepared for the American Petroleum Institute. Berkeley, California: Tabershaw/Cooper Associates (1974).

200. Hanis, N. M., Stavraky, K. M., and Fowler, J. L. "Cancer Mortality in Oil Refinery Workers," J. Occup. Med., 21: 167-174 (1979).

201. Theriault, G. and Goulet, L. "A Mortality Study of Oil Refinery Workers," J. Occup. Med., 21: 367-370 (1979).

202. Rushton, L. and Anderson, M. R. "An Epidemiological Survey of Eight Oil Refineries in Britain," Br. J. Ind. Med., 38: 225-234 (1981).

203. Schottenfeld, D., Warshauer, M. E., and Zauber, A. G. "A Prospective Study of Morbidity and Mortality in Petroleum Industry Employees in the Unites States -A Preliminary Report," Quantification of Occupational Cancer. Peto, R. and Schneiderman, M. Editors, Cold Spring Harbor, NY, Cold Spring Harbor Laboratory, 1981, pp. 247-265.

204. Thomas, T. L., Waxweiller, R. J., Moure-Eraso, R., Itaya, S., and Fraumeni, J. F. "Mortality Patterns in Among Workers in Three Texas Oil Refineries," J. Occup. Med., 24: 135-141 (1982).

205. Hanis, N. M., Holmes, T. M., Shallenberger, L. G., and Jones, K. E. "Epidemiologic Study of Refinery and Chemical Plant Workers," J. Occup. Med., 24: 203-212 (1982)

206. Wen, C. P., Tsai, S. P., McClellan, W. A., and Gibson, R. L. "Long-term Mortality Study of Oil Refinery Workers: I. Mortality of Hourly and Salaried Workers," Am. J. Epidemiol., 118: 526-542 (1983).

207. Gaferer, W. M. "Disabling Morbidity and Mortality from Cancer Among Male Employees of an Oil Refining Company with Reference to Age, Site, and Duration, 1933 - 1938, Inclusive," Public Health Rep., 55: 1517-1526 (1940).

208. Baird, V. C. "Effects of Atmospheric Contamination on Cancer Mortality in Petroleum Refinery Employees," J. Occup. Med., 9: 145-220 (1967).

209. Thomas, T. L., Waxweiler, R. L., and Moure-Eraso, R. "Mortality Among Workers Employed in Petroleum Refining and Petrochemical Plants," J. Occup. Med., 22: 97-103 (1980).

210. Wen, C. P., Tsai, S. P., and Weiss, N. S. "A Population-Based Cohort Study of Brain Tumor Mortality Among Oil Refinery Workers with a Discussion of Methodologic Issues of SMR and PMR," in Peto, R. and Schneiderman, M. (Eds): Quantification of Occupational Cancer. Cold Spring Harbor, NY, Cold Spring Harbor Laboratory, 1981, pp. 413-422.

211. Savitz, D. A. and Moure, R. "Cancer Risk Among Oil Refinery Workers," J. Occup. Med., 26: 662-670 (1984).

212. Futagaki, S. K. Petroleum Refinery Workers Exposure to PAHs at Fluid Catalytic Cracker, Coker, and Asphalt Processing Units. NIOSH Publication No. 83-111, National Institute for Occupational Safety and Health (NIOSH), Cincinnati, Ohio, May, 1983.

213. Raabe, G. "Kidney Cancer Epidemiology in Petroleum Related Studies. In: Proceedings of the Workshop on the Kidney Effects of Hydrocarbons. Boston, July 1983, American Petroleum Institute, December, 1983.

214. Enterline, P. E., Viren, J. "Epidemiologic Evidence for an Association Between Gasoline and Kidney Cancer," Env. Health Perspec., 62: 303-312 (1985).

215. Nelson, W., Ege, J. F., Ross, M., Woodman, L. E. and Silverman, L. "Sensory Response to Certain Industrial Solvent Vapors," J. Ind. Hyg. Toxicol., 25: 282-285 (1943).

216. Astrand, I., Kilbam, A. and Ovrum, P. "Exposure to White Spirit - I. Concentration in Alveolar Air and Blood During Rest and Exercise," Scan. J. Work Envir. Health, 1: 15-30 (1975).

217. Gamberale, F., Annwall, G. and Hultengren, M. "Exposure to White Spirit - II. Psychological Functions," Scan. J. Work Envir. Health, 1: 15-30 (1975).

218. Pederson, L. M. and Cohr, K. "Biochemical Pattern in Experimental Exposure of Humans to White Spirit. I. The Effects of a 6 Hours Single Dose," Acta. Pharmacol. et Toxicol., 55: 317-324 (1984).

219. Pederson, L. M. and Cohr, K. "Biochemical Pattern in Experimental Exposure of Humans to White Spirit. I. The Effects of Repetitive Exposures," Acta. Pharmacol. et Toxicol., 55: 325-330 (1984).

220. Pfaffli, P., Harkonen, H. and Savolainen, H. "Urinary Dimethylbenzoic Acid as an Indicator of Occupational Exposure to White Spirit," J. of Chromatog., 337: 146-150 (1985).

221. Kegels: "[A Case of Aplastic Anemia of a Probable Occupational Origin Due to White Spirit]," Arch. Belg. Med. Soc. Hyg. Med. Trav. Med. Leg., 16: 161-74 (1958).

222. Gittelsohn A., Senning J. "Studies on the Reliability of Vital and Health records: I. Comparison of Cause of Death and Hospital Record Diagnoses," Am. J. Public Health, 69: 680-689 (1979).

223. Bauer F.W. and Robbins S.L. "An Autopsy Study of Cancer Patients I. Accuracy of the Clinical Diagnoses (1955 to 1965) Boston City Hospital," J. Am. Med. Associ., 221: 1471-1474 (1972).

224. Percy, C., Stanek, E. and Gloeckler, L. "Accuracy of Cancer Death Certificates and Its Effect on Cancer Mortality Statistics," AJPH., 71: 242-250 (1981).

225. Engel, L. W., Strauchen, L. C. and Heid, M. "Accuracy of Death Certification in an Autopsied Population with Specific Attention to Malignant Neoplasms and Vascular Disease," Am. J. Epidemiol., 111: 99-112 (1980).

226. Mantel, N., and Haenszel, W. "Statistical Aspects of the Analysis of Data from Retrospective Studies of Disease," J. Natl. Cancer Inst., 22: 719-748 (1959).

227. Jarvholm, B., "Comparing Mortality in an Occupational Cohort with Incidence Rates of the General Population - the Bias Introduced Through the Use of Five-Year Age Intervals", Am. J. Epid, 125: 747-749, (1987).

228. DeCoufle, P., Thomas, T. L., and Pickle, L. W. "Comparison of the Proportionate Mortality Ratio and the Standardized Mortality Ratio Risk Measures," Am. J. Epid., 111: 263-269 (1980).

230. McMichael, A. J. "Standardized Mortality Ratios and the "Healthy Worker Effect:" Scratching Beneath the Surface," J. Occup. Med., 18: 165-168 (1976).

229. Wong, O. and DeCoufle, P. "Methodological Issues Involving the Standardized Mortality Ratio and Proportionate Mortality Ratio in Occupational Studies," J. Occup. Med., 24: 299-304 (1982).

231. Waxweiler, R. J., Beaumont, J. J., Henry, J. A., Brown, D. P., Robinson, C. F., Ness, G. O., Wagoner, J. K., and Lemen, R. A. "A Modified Life-Table Analysis System for Cohort Studies", J. Occup. Med., 25: 115-124 (1983).

232. Rothman K. J. and Boice J. D. Epidemiologic Analysis with a Programmable Calculator, NIH Publication No. 79-1649, page 29, equations 17, 18, and 19, 1979.

234. Bailar J. C. "Significance Factors for the Ratio of a Poisson Variable to its Expectation," Biometrics, pp: 639-643 (1964).

235. "Regulation Covering the Identification, Classification and Regulation of Potential Occupational Carcinogens," Occupational Safety and Health Administration, Title 29, Part 1990.144 of the Code of Federal Regulations, Federal Register, 29(Jan. 16) (1980).

236. Haines, T. and Shannon, H. "Sample Size in Occupational Mortality Studies," J. Occup. Med., 25: 603-608 (1983).

237. Beaumont, J. J. and Breslow, N. E. "Power Cosiderations in Epidemiological Studies of Vinyl Chloride Workers," Am. J. Epid., 114: 725-734 (1981).

238. Cutler, S. J., Schneiderman, M. A., and Greenhouse, S. W. "Some Statistical Considerations in the Study of Cancer in Industry," Am. J. Public Health, 44: 1159-1166 (1954).

239. Molina, E. C. Poisson's Exponential Binomial Limit. Huntington, NY: Robert E. Krieger Publishing Company, 1973.

240. Armitage, P. Statistical Methods in Medical Research. Oxford, England: Blackwell Scientific Publications, 1971.

241. World Health Organization. Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death. Ninth revision, Vol. 1. Geneva: WHO, 1977.

APPENDIX A

PERCENTAGES OF COMMERCIAL DRY CLEANERS USING PETROLEUM SOLVENTS

TABLE 45

PERCENTAGES OF COMMERCIAL DRY CLEANERS USING PETROLEUM SOLVENT, BY STATE AND IFI DISTRICT, 1963-1974

District and State	1963	1967	1974[a]
District I	30	24	22
Connecticut	27	20	
Maine	42	34	
Massachusetts	27	22	
New Hampshire	49	28	
New York	27	23	
Rhode Island	39	35	
Vermont	58	61	
District II	38	35	35
Delaware	39	29	
District of Columbia	24	16	
Maryland	37	37	
New Jersey	29	26	
Pennsylvania	37	37	
Virginia	53	44	
West Virginia	57	55	
District III	67	65	36
Alabama	69	64	
Florida	59	54	
Georgia	72	71	
Mississippi	81	83	
North Carolina	67	64	
South Carolina	72	73	
Tennessee	58	58	
District IV	34	33	27
Indiana	45	43	
Kentucky	50	47	
Michigan	34	35	
Ohio	25	23	

TABLE 45 (Continued)

District and State	1963	1967	1974[a]
District V	54	52	28
Illinois	52	51	
Iowa	65	64	
Minnesota	40	36	
Nebraska	65	61	
North Dakota	63	68	
South Dakota	70	67	
Wisconsin	54	50	
District VI	73	74	42
Arkansas	81	82	
Kansas	71	72	
Louisiana	72	72	
Missouri	63	59	
Oklahoma	73	75	
Texas	75	78	
District VII	44	41	27
Arizona	44	49	
Colorado	41	43	
Idaho	72	67	
Montana	58	60	
Nevada	50	32	
New Mexico	65	67	
Oregon	52	48	
Utah	60	54	
Washington	40	40	
Wyoming	71	67	

TABLE 45 (Continued)

District and State	1963	1967	1974[a]
District VIII	30	25	11
Alaska			
California			
Hawaii			
United States	48	46	26

[a]Figures in 1974 are for plants using petroleum solvent only. Including plants with both petroleum and PCE facilities, the 1974 petroleum use, on a national basis was 32 per cent.

APPENDIX B

CHEMICALS TYPICALLY USED BY DRY CLEANERS FOR SPOTTING

CHEMICALS TYPICALLY USED BY DRY CLEANERS FOR SPOTTING

- Acetic acid
- Acetone
- Ammonium hydroxide
- Ammonium silico fluoride
- Amyl acetate
- Amyl alcohol
- Benzene
- Borax
- Butyl alcohol
- Butyl cellusolve
- Carbon disulfide
- Carbon tetrachloride
- Castor oil
- Chloride of lime (calcium chlorohypochlorite)
- Chlorinated soap
- Chloroform
- Cresylic acid
- Citric acid
- Diethyl ether
- Dry or wet cleaning soap
- Ethyl acetate
- Ethyl alcohol (denatured with methanol)
- Ethylene dichloride
- Ethylene glycol
- Formic acid
- Glycerine (glycerol)
- Hydrofluoric acid
- Hydrochloric acid
- Hydrogen peroxide
- Hexalin
- Isopropyl alcohol
- Lactic acid
- Lysol
- Magnesium carbonate
- Methanol
- Mineral spirits
- Oleic acid
- Oxalic acid
- Picrin
- Potassium permanganate
- Propylene dichloride
- Pyridine
- Rapid acting enzymes for albumen
- Sodium cyanide (rare)
- Sodium hydrosulphite
- Sodium chloride
- Sodium lauryl sulphonate
- Sodium perborate
- Sodium pyrophosphate
- Sodium sulphite
- Sodium thiosulphite
- Sulphonated alcohol
- Sulphonated oils
- Sulphurous acid
- Tetrachloroethane
- Tetrachloroethylene
- Tetralin
- Trichloroethylene
- Tri-sodium phosphate
- Turpentine
- Xylene

APPENDIX C

OCCUPATIONS WITH POTENTIAL EXPOSURES TO PETROLEUM SOLVENTS

OCCUPATIONS WITH POTENTIAL EXPOSURES TO SOLVENTS

Adhesive makers	Leather japanners
Ammonia synthesis workers	Metal cleaners
Asphalt coating workers	Naphtha workers
Ceramic production workers	Oil processors
Degreasers, metal	Painters
Detergent makers	Paintmakers
Dry cleaners	Perfume extraction workers
Enamel makers, synthetic	Petrochemical workers
Farmers	Petroleum refinery workers
Fat and oil processors	Photographic chemical makers
Fungicide handlers	Printers
Garage workers	Resin makers
Heating fuel handlers	Rocket fuel handlers/makers
Herbicide handlers	Rubber coaters/makers
Hydrogen manufacturing workers	Stainers
Ink production workers	Stain makers
Insecticide handlers	Typesetters
Jet fuel handlers/makers	Varnish makers
Kerosene handlers	Wax makers
Laboratory workers, chemical	Wood preservation makers
Lacquers	Wool process workers

APPENDIX D

INITIAL LICENSURE APPLICATION FORM AND EXAMPLES OF SUBSEQUENT REVISIONS

P Y (IN USE 1941)

APPLICATION FOR STATE BOARD LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING AND - OR PRESSING

TO THE STATE DRY CLEANERS BOARD OF OKLAHOMA
STATE CAPITOL
OKLAHOMA CITY, OKLAHOMA

(122)

The undersigned applicant hereby makes application for license to engage in the cleaning, dyeing and-or pressing business pursuant to the provisions of House Bill No. 232 of the Eighteenth Oklahoma Legislature, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning AUG 1, 1941, and ending December 31, 1941, unless sooner suspended or revoked, and in connection therewith states:

ADA

1. QUALITY CLEANERS ; 117 E MAIN St.
Name of Applicant—Please print legibly or fill out with typewriter — Main Address in State

2. Applicant is White ✓ ; Colored ......

3. Owner of cleaning, dyeing and-or pressing establishment is Tom Fullerton (Name).

4. Proprietor or manager in active charge thereof is — — (Name).

5. State how long applicant has been in the cleaning, dyeing and-or pressing business.
(a) In Oklahoma 25 yrs.; Elsewhere ...... yrs.

6. Is applicant actually engaged in the business of cleaning? yes (yes or no) Dyeing? ...... (yes or no) Pressing? yes (yes or no)

7. State whether applicant intends to engage in the business of Cleaning ...... (yes or no); Dyeing ...... (yes or no); Pressing ...... (yes or no).

8. Does applicant operate an agency? no (yes or no)

9. Give description of building in which establishment is located. Brick (State whether brick, concrete, frame or sheet iron.)

10. Give number of the following machines and equipment used by applicant in the operation of his or its business: Boilers 1; H. P. 3; Pressing Machines 1; Washers 1; Extractors 1; Pressure Filters ......; Stills 1; Drying Rooms or Cabinets 1; Tumblers ......; Kind of Cleaning Fluid Used Stod Sol; No. Delivery Trucks 1.

11. Give entire amount of gross cleaning, dyeing and-or pressing business done during preceding yr. $ 2700.00

12. License Fee of $ 3.00 payable to State Dry Cleaners Board of Oklahoma is enclosed herewith, based on ONE ($1.00) DOLLAR per thousand on gross business done during preceding calendar year. (Provided that no fee shall be in any sum less than THREE ($3.00) DOLLARS or more than FORTY ($40.00) DOLLARS. If applicant was not engaged in the business at the time of passage of this act then his or its license (Registration) fee shall be TEN ($10.00) DOLLARS.

13. Has applicant previously been refused license by this Board or a Dry Cleaners Board of any other state?
No (yes or no) If so, when ...... ; where ......

14. Has applicant read House Bill No. 232 enacted by the Eighteenth Oklahoma Legislature, regulating the cleaning, dyeing and-or pressing business in Oklahoma ...... No (yes or no)

15. Give total number of employees 1

Dated this 30 day of July, 1941.

OAC
JL

Quality Cleaners
Tom Fullerton
(Applicant's Signature)

APPROVED THIS ...... DAY OF ...... , 194...

STATE DRY CLEANERS BOARD

By ...... Chairman.

License No. 565

Issued 9-5, 1941

In Use 1942 - 1945

1944

APPLICATION FOR STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING AND-OR PRESSING

The undersigned applicant hereby makes application for license to engage in the cleaning, dyeing and-or pressing business pursuant to the provisions of 59 O. S. 1941 Sections 741 and 756, inclusive, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning JANUARY 1, 1944 and ending DECEMBER 31, 1944 unless sooner suspended or revoked, and in connection therewith states:

(127)

1. C & S Cafeteria (Name of Establishment)
Please print legibly, or fill out with typewriter

2. 314 E. Main (Location of Establishment)
Street & Number City County

3. Owner of cleaning, dyeing and-or pressing establishment is E. A. Myers (Name)

4. Proprietor or manager in active charge there of is Ercil L. West (Name)

5. Applicant is White: X ; Colored: .....

6. State how long applicant has been in the cleaning, dyeing, and-or pressing business at present location 14 yrs.; Elsewhere X yrs. State previous location X

7. Is applicant actually engaged in the business of cleaning? ..... Dyeing? ..... Pressing? .....

8. State whether applicant intends to engage in the business of Cleaning? ... Dyeing? ..... Pressing? .....

9. Give description of building in which establishment is located Brick
(State whether brick, concrete, frame or stone iron.)

10. Give number of the following machines and equipment used by applicant in the operation of his or its business: Boilers 1 ; H.P. 15 ; Pressing Machines 2 ; Washers 1 ; Extractors 1 ;
Pressure Filters / ; Stills 0 ; Drying Rooms or Cabinets 1 ; Tumblers 1
Kind of Cleaning Fluid used Petroleum Solvent No. of Delivery Trucks one

11. Does applicant operate an agency at some other address No
yes or no

12. Does applicant do any wholesale cleaning, dyeing, and-or pressing No.
yes or no

13. Give entire amount of GROSS cleaning, dyeing, and-or pressing business done from January 1, 1943 to December 31, 1943 $ 10,000

14. License Fee of $ 10.00 (Check X, Money order ☐, Cash ☐,) payable to State Dry Cleaners Board of Oklahoma is enclosed herewith, based on ONE ($1.00) DOLLAR per thousand, and fractional part thereof, on gross business done during preceding calendar year. (Provided that no fee shall be in any sum less than THREE ($3.00) DOLLARS or more than FORTY ($40.00) Dollars. If applicant was not engaged in the business at the time of passage of this act then his or its license (Registration) fee shall be TEN ($10.00) DOLLARS.

15. Has applicant previously been refused license by this Board or a Dry Cleaners Board of any other state No
yes or no

16. Give total number of employees 5

17. Give 1943 License Number 314

NOTE: Any change made during the year affecting the above information, should be immediately reported to your State Board. Use back of this application for any comments or detailed explanations.

Dated this 12 day of May 1944.

Rachel West
Applicants Signature

(Do not write below this line)

APPROVED THIS DAY OF , 1944
STATE DRY CLEANERS BOARD

By

License Number

Issued , 1944

Receipt Number 7916

Deposit Slip No. 12

(IN USE 1946 - 1949)

APPLICATION FOR STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, AND/OR PRESSING

The undersigned applicant hereby makes application for license to engage in the cleaning, dyeing and/or pressing business pursuant to the provisions of 59 O. S. 1941 Sections 741 to 756, inclusive, Title 59, Chap. 17, pg. 197, Session Laws 1945, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning with date of issuing and ending DECEMBER 31, 194__ unless sooner suspended or revoked, and in connection therewith states:

1. BUSY B'S CLEANERS & LAUNDRY (Name of Establishment)
   PLEASE PRINT LEGIBLY, OR FILL OUT WITH TYPEWRITER
2. 303 W LILY MADILL MARSHALL (Location of Establishment)
   STREET CITY COUNTY
3. Owner of cleaning, dyeing and/or pressing establishment will be RANDAL BULLARD ~~CLARENCE BREWSTER~~ (Name)
4. Proprietor or manager in active charge thereof will be Same (Name)
5. Applicant is White ✓ ; Colored ____
6. State previous experience in cleaning, dyeing and/or pressing business and give location: ____
7. State whether applicant intends to engage in the business of Cleaning? Yes Dying? No Pressing? Yes
8. Has applicant been furnished with a copy of the regulations for installing a dry cleaning plant in Oklahoma? Yes (✓) No (___).
9. Give description of building in which establishment is to be located and furnish drawings, using back of this application if necessary. Concrete walls & Ceiling - Separate from main Bldg -
10. Give number of the following machines and equipment to be used by applicant in the operation of his or its business: Boilers 1; H. P. 15; Pressing Machines 3; Washers 1; Extractors 1; Pressure Filters 1; Stills no; Drying Rooms or Cabinets 0; Tumblers 1 Kind of Cleaning Fluid to be used [illegible] Is all of the above equipment of substantial construction and manufactured for dry cleaning purposes? yes
11. Will applicant operate an agency at some other address? no
12. Will applicant do any wholesale cleaning, dyeing and/or pressing? no
13. License Fee of $15.00 plus original inspection fee of $35.00, a total of $50.00 payable to State Dry Cleaners Board of Oklahoma is enclosed herewith: (Check ✓, Money Order ☐, Cash ☐.)
    NOTE: Inspection fee of $35.00 does not apply to veterans of World War II.
14. Has applicant previously been refused a license by this Board or a Dry Cleaners Board of any other state? Yes ___ No ✓ If answer is yes, give details ____
15. If applicant is a veteran of World War II give service Serial No. ____

Dated this 24 day of July 1947

CK
[illegible]

Clarence Brewster
Applicant's Signature

(Do not write below this line)

DENIED
APPROVED THIS 2? DAY OF July 1947
STATE DRY CLEANERS BOARD

By: ____
License Number 1023
Issued ____

Receipt Number 5565
Deposit Slip No. 311

(IN USE 1950 - 1965)

APPLICATION FOR STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, AND/OR PRESSING

The undersigned applicant hereby makes application for license to engage in the cleaning, dyeing and/or pressing business pursuant to the provisions of 59 O. S. 1941 Sections 741 to 756, inclusive. Title 59, Chap. 17, pg. 197. Session Laws 1945, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning with date of issuing and ending DECEMBER 31, 19 51 unless sooner suspended or revoked, and in connection therewith states:

1. Robran-Laundry & Dry Cleaners Agency (Name of Establishment)

2. Marietta Oklahoma (Love) (Location of Establishment)

3. Owner of cleaning, dyeing and/or pressing establishment will be Walter W Robran (Name)

4. Proprietor or manager in active charge thereof will be Mrs A L Nett (Name)

5. Applicant is White —; Colored ____

6. State previous experience in cleaning, dyeing and/or pressing business and give location: 1 yr Gainesville Texas

7. State whether applicant intends to engage in the business of Cleaning? — Dyeing? ✓ Pressing? —

8. Has applicant been furnished with a Pamphlet containing a copy of the Law, Rules and Regulations of this department? Yes (—) No (____).

9. If application is for "Press Shop" or "Agency" License, give name of Wholesaler who will do cleaning and/or Pressing. Customer Robran Laundry - Gainesville, Texas

10. Give number of the following machines and equipment to be used by applicant in the operation of his or its business: Boilers 0; H. P. 0; Pressing Machines 0; Washers 0; Extractors 0; Pressure Filters 0; Stills 0; Drying Rooms or Cabinets 0; Tumblers 0; Kind of Cleaning Fluid to be used: Petroleum ☐; Synthetic ☐. Is all of the above equipment of substantial construction and manufactured for dry cleaning purposes? None

11. Will applicant operate an agency or Sub-Station at some other address? This is an agency

12. Will applicant do any wholesale cleaning, dyeing and/or pressing? No

13. Amount of Bailee Insurance to be carried and name of Company (a) $1750.00 Gulf-Ins-Co. Dallas

14. License Fee of $15.00 plus original inspection fee of $35.00, a total of $50.00 payable to State Dry Cleaners Board of Oklahoma is enclosed herewith (Check ☐, Money Order ✓ Cash ☐.) Amount $ 50.00

NOTE: Inspection fee of $35.00 does not apply to veterans of World War II.

15. Has applicant previously been refused a license by this Board or a Dry Cleaners Board of any other state? Yes____ No ✓ If answer is yes, give name of State ____

16. If applicant is a veteran of World War II give service Serial No. ____

Dated this 12th day of April, 19 51

CE

Applicant's Signature

(Do not write below this line)

DENIED
APPROVED THIS ____ DAY OF ____

STATE DRY CLEANERS BOARD

By ____

License Number 155

Issued 4-11-51

Receipt Number 451

Deposit Slip No. 1676

(IN USE 1966 - 1976) Year 1966

APPLICATION FOR STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, AND/OR PRESSING

The undersigned applicant hereby makes application for license to engage in the cleaning, dyeing and/or pressing business pursuant to the provisions of 59 O. S. 1961 Section 741 to 760, inclusive, Title 59, Chap. 17, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning with date of issuing and ending DECEMBER 31, 19 66 unless sooner suspended or revoked, and in connection therewith states:

1. ECON-O-WASH LAUNDRY (Name of Establishment) (Please Print Legibly, or Fill Out With Typewriter)

2. 210 NORTH LINCOLN (Street) - SAND SPRINGS (City) OKLAHOMA (County) Telephone No. CI 59103

3. Type of Ownership: Individual ___ Partnership ✓ Corporation ___ Other ___ (Check One)

4. Name(s) of individual owner, partners or corporate officers: JERRY A. & RODERICK S. CURNEY

5. Proprietor or manager in active charge thereof will be JERRY A. CURNEY (Name)

6. State previous experience in cleaning, dyeing and/or pressing business and give location: NONE

7. State whether applicant intends to engage in the business of Cleaning? ✓ Dyeing? ___ Pressing? ___ Coin-Operated? ✓ Agency? ___

8. Has applicant been furnished with a Pamphlet containing a copy of the Law, Rules and Regulations of this department? Yes (✓) No (___).

9. If application is for "Press Shop" or "Agency" License, give name of Wholesaler who will do cleaning and/or Pressing NIS

10. Give number of the following machines and equipment to be used by applicant in the operation of his or its business: Boilers ___; H. P. ___; Pressing Machines ___; Washers ___; Extractors ___; Pressure Filters ___; Stills ___; Drying Rooms or Cabinets ___; Tumblers ___; Coin-Operated Machines 2; Kind of Cleaning Fluid to be used: Petroleum ☐ Synthetic ☑ Is all of the above equipment of substantial construction and manufactured for dry cleaning purposes? YES

11. Will applicant operate an agency or Sub-Station at some other address? NO

12. Will applicant do any wholesale cleaning, dyeing and/or pressing? NO

13. Amount of Bailee Insurance to be carried and name of Company NONE

14. License Fee of $15.00 plus original inspection fee of $35.00, a total of $50.00 payable to State Dry Cleaners Board of Oklahoma is enclosed herewith (Check ☑ Money Order ☐ Cash ☐) Amount $15 + 35 = 50
NOTE: Inspection fee of $35.00 does not apply to veterans of World War II.

15. Has applicant previously been refused a license by this Board or a Dry Cleaners Board of any other state? Yes ___ No ✓ If answer is yes, give name of State ___

(omit 16) If applicant is a veteran of World War II give service Serial No. AO 3143893

Dated this 10 day of FEBRUARY 1966

Jerry A. Curney
Applicant's Signature

(Do not write below this line)

DENIED
APPROVED THIS ___ DAY OF ___

STATE DRY CLEANERS BOARD

RECEIVED

Receipt Number 15

By ___

License Number ___

Issued 3-21

Deposit Slip No. ___

STATE DRY CLEANERS BOARD

3/15 Fee $50

(IN USE 1977 - 1984)

Year. ____

APPLICATION FOR STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, AND/OR PRESSING

The undersigned applicant hereby makes application for license to engage in the cleaning, dyeing and/or pressing business pursuant to the provisions of 59 O.S. 1983 Section 741 to 760, inclusive, Title 59, Chap. 17, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning with date of issuing and ending DECEMBER 31, 19__ unless sooner suspended or revoked, and in connection therewith states:

1. _____ (Name of Establishment)
(Please Print Legibly, or Fill Out With Typewriter)

2. _____ Telephone No. _____
(Street) (City) (County) (Zip)

3. Type of Ownership: Individual ___ Partnership ___ Corporation ___ Other _____
(Check One)

4. Name(s) of individual owner, partners or corporate officers: _____

_____

5. Proprietor or manager in active charge thereof will be _____ (Name)

6. State previous experience in cleaning, dyeing and/or pressing business and give location: _____

_____

7. State whether applicant intends to engage in the business of Cleaning? ___ Dyeing? ___ Pressing? ___ Coin-Operated? ___ Agency? ___

8. Has applicant been furnished with a Pamphlet containing a copy of the Law, Rules and Regulations of this department? Yes (___) No (___).

9. If application is for "Press Shop" or "Agency" License, give name of Wholesaler who will do cleaning and/or Pressing.

_____

10. Give number of the following machines and equipment to be used by applicant in the operation of his or its business: Boilers ___; H.P. ___; Pressing Machines ___; Washers ___; Extractors ___; Pressure Filters ___; Stills ___; Drying Rooms or Cabinets ___; Tumblers ___; Coin-Operated Machines ___; Kind of Cleaning Fluid to be used: Petroleum ☐; Synthetic ☐. Is all of the above equipment of substantial construction and manufactured for dry cleaning purposes? _____

11. Will applicant operate an agency or Sub-Station at some other address? _____

12. Will applicant do any wholesale cleaning, dyeing and/or pressing? _____

13. Amount of Bailee Insurance to be carried and name of Company _____

14. License Fee of thirty-five ($35.00) dollars for a press shop or agency plus original inspection fee of thirty-five ($35.00) dollars; a Total of seventy ($70.00) dollars payable to State Dry Cleaners Board of Oklahoma, or Fifty ($50.00) dollars for a Coin-Op or Dry Cleaning plant plus original inspection fee of ($50.00) dollars, a total of $100.00 dollars payable to State Dry Cleaners Board of Oklahoma is enclosed herewith (Check ___ Money Order ___ Cash ___) Amount $_____ Note: Inspection fee does not apply to Veterans (of a National Emergency). (Individual ownership only).

15. Has applicant previously been refused a license by this Board or a Dry Cleaners Board of any other state?
Yes ___ No ___ If answer is yes, give name of State _____

16. If applicant is a veteran of a National Emergency give service Serial No. _____

Dated this _____ day of _____ 19__

_____
Applicant's Signature

(Do not write below this line)

DENIED
APPROVED THIS _____ DAY OF _____
STATE DRY CLEANERS BOARD

Receipt Number _____

By _____

License Number _____

Deposit Slip No. _____

Issued _____

APPENDIX E

ANNUAL LICENSURE RENEWAL FORM AND EXAMPLES OF SUBSEQUENT REVISIONS

(IN USE 1946 – 1948)

1946

APPLICATION FOR RENEWAL OF STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, AND/OR PRESSING

The undersigned applicant hereby makes application for renewal of license to engage in the cleaning, dyeing and/or pressing business pursuant to the provisions of 59 O. S. 1941 Sections 741 to 756, inclusive, title 59, Chap. 17, pg. 197, Session Laws 1945, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning JANUARY 1, 1946 and ending DECEMBER 31, 1946 unless sooner suspended or revoked, and in connection therewith states:

1. The Altus Laundry & Cleaner's (Name of Establishment)
   PLEASE PRINT LEGIBLY, OR FILL OUT WITH TYPEWRITER
2. 214 East Broadway Altus (Location of Establishment)
   STREET CITY
3. Owner of cleaning, dyeing and/or pressing establishment is Mann & Tyman (Name)
4. Give entire amount of GROSS cleaning, dyeing, and or pressing business done from January 1, 1945 to December 31, 1945 $ —
5. License Fee of $ 15.00 (Check ☑, Money Order ☐, Cash ☐) payable to State Dry Cleaners Board of Oklahoma is enclosed herewith, based on ONE DOLLAR and FIFTY CENTS ($1.50) per thousand, and fractional part thereof, on gross business done during 1945. Providing that no fee shall be in any sum less that FIFTEEN ($15.00) DOLLARS; and provided further that a penalty of $5.00 per month, or major fraction thereof, shall be added if application is not made on or before February 1, 1946.
6. Give total number of employees. 3
7. Give 1945 License Number 368

NOTE: Any change made during the year affecting the above information, should be immediately reported to your State Board. Use back of this application for any comments or detailed explanations.

IN CASE you have not previously been licensed, do not use this form. Request this Board to furnish you with License application Form 2.

Dated this 27th day of ____ 1946

I CERTIFY the information contained herein is true. Mann & Tyman
Applicant's Signature

O-K
(Do not write below this line)

APPROVED THIS 12 DAY OF ____ 1946

STATE DRY CLEANERS BOARD

By ____

License Number ____

Issued ____ 1946

RECEIVED JAN

Receipt Number 4074

Deposit Slip No. 183

Form 11

(IN USE 1949 ONLY) 1949

APPLICATION FOR RENEWAL OF STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, AND/OR PRESSING

The undersigned applicant hereby makes application for renewal of license to engage in the cleaning, dyeing and/or pressing business pursuant to the provisions of 59 O. S. 1941 Sections 741 to 756, inclusive, Title 59, Chap. 17, Page 197, O. S. L. 1945, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning JANUARY 1, 1949 and ending DECEMBER 31, 1949 unless sooner suspended or revoked, and in connection therewith states:

1. Altus Laundry & Dry Cleaners (Name of Establishment)
PLEASE PRINT LEGIBLY, OR FILL OUT WITH TYPEWRITER

2. 214 West Bdwy. Altus, Jackson (Location of Establishment)
ST. & NO. CITY COUNTY

3. Owner of cleaning, dyeing and/or pressing establishment is Roy L. Mann W.G. Wyman (Name)

4. Give entire amount of GROSS cleaning, dyeing, and/or pressing business done from January 1, 1948 to December 31, 1948 $ —

5. License Fee of $. 15.00 (Check ☒, Money Order ☐, Cash ☐,) payable to State Dry Cleaners Board is enclosed herewith, based on ONE DOLLAR and FIFTY CENTS ($1.50) per thousand and fractional part thereof, on Gross business done during 1948. Providing that no fee shall be in any sum less than FIFTEEN ($15.00) DOLLARS; and provided further that a penalty of $5.00 per month, or major fraction thereof, shall be added if application is not made on or before February 1, 1949.

6. Give total number of employees at present: 3

7. Give 1948 License Number 368

8. If Application is for Press Shop or Agency License, give name of Firm doing wholesale cleaning: _____

9. On the reverse side hereof find listed the State License Number, Firm Name, Name of Owner and Address of every Person, Firm or Corporation being served at wholesale prices by applicant.

Dated this 10th day of January, 1949.

I CERTIFY the information contained herein is true. W. G. Wyman
Applicant's Signature

OK
QC

(Do not write below this line)

APPROVED THIS 11 DAY OF Jan, 1949.
STATE DRY CLEANERS BOARD

BY _____

License Number 767

Issued _____, 1949.
(Form 1)

Receipt Number 1233

Deposit Slip No. 294

RECEIVED
JAN 11 1949

(IN USE 1950 – 1952) 1950

APPLICATION FOR RENEWAL OF STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, AND/OR PRESSING

The undersigned applicant hereby makes application for renewal of license to engage in the cleaning, dyeing and/or pressing business pursuant to the provisions of 59 O. S. 1941 Sections 741 to 756, as amended by Chap. 17, Title 59, Page 197, O. S. L. 1945, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning JANUARY 1, 1950 and ending DECEMBER 31, 1950 unless sooner suspended or revoked, and in connection therewith states:

1. The Altus Laundry & Dry Cleaners (Name of Establishment)
PLEASE PRINT LEGIBLY, OR FILL OUT WITH TYPEWRITER

2. 214 West Broadway (Street) Altus (City) Jackson (County) (Location of Establishment)

3. Owner of cleaning, dyeing and/or pressing establishment is Roy L. Mann Partner (Name)
E. G. Wyman Partner

4. Give entire amount of GROSS cleaning, dyeing, and/or pressing business done from January 1, 1949 to December 31, 1949 $ –

5. License Fee of $ 15.00 + 2.00 penalty = 17.00 (Check ☒, Money Order ☐, Cash ☐) payable to State Dry Cleaners Board is enclosed herewith, based on ONE DOLLAR and FIFTY CENTS ($1.50) per thousand and fractional part thereof, on Gross business done during 1949. Providing that no fee shall be in any sum less than FIFTEEN ($15.00) DOLLARS; and provided further that a penalty of $5.00 per month, or major fraction thereof, shall be added if application is not made on or before February 1, 1950.

6. Give total number of employees at present: 3

7. Give 1949 License Number 368

8. Give amount of Fire and Theft (Bailee) insurance carried on customer garments and name of company. –

9. If Application is for Press Shop or Agency License, give name of Firm doing wholesale cleaning: –

10. On the reverse side hereof find listed the State License Number, Firm Name, Name of Owner and Address of every Person, Firm or Corporation being served at wholesale prices by applicant.

Dated this 10th day of January 1950.

I CERTIFY the information contained herein is true. E. G. Wyman
Applicant's Signature

(Do not write below this line)

RECEIVED JAN 19 1950

APPROVED THIS ____ DAY OF ____ 1950.
STATE DRY CLEANERS BOARD

BY ____

License Number 368

Issued ____ 1950.

Receipt Number 9164

Deposit Slip No. 510

(Form 1)

(IN USE 1953 – 1956)

1953

APPLICATION FOR RENEWAL OF STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, AND/OR PRESSING

The undersigned applicant hereby makes application for renewal of license to engage in the cleaning, dyeing and/or pressing business pursuant to the provisions of 59 O. S. 1941 Sections 741 to 756, as amended by Sections 1 to 7 of Chap. 17, Title 59, Page 197, O. S. L. 1945, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning JANUARY 1, 1953 and ending DECEMBER 31, 1953, unless sooner suspended or revoked, and in connection therewith states:

1. Altus Laundry and Dry Cleaners (Name of Establishment)
PRINT LEGIBLY, OR FILL OUT WITH TYPEWRITER

2. 214 East Broadway Altus Jackson number 6 (Location)
STREET CITY COUNTY PHONE NO.

3. Owner of Cleaning, Dyeing and/or Pressing establishment is Roy L. Mann partnership (Name)
W. G. Wyman

4. Give entire amount of GROSS cleaning, dyeing, and/or pressing business done from January 1, 1952, to December 31, 1952: $ ———

5. License Fee of $ 15.00 Penalty of $ ——— Total $ 1.00 (Check ☒, Money Order ☐, Cash ☐.) payable to State Dry Cleaners Board is enclosed herewith, based on ONE DOLLAR and FIFTY CENTS ($1.50) per thousand and fractional part thereof, on Gross business done during 1952. Providing that no fee shall be in any sum less than FIFTEEN ($15.00) DOLLARS; and provided further that a penalty of $5.00 per month, or major fraction thereof, shall be added if application is not made on or before February 1, 1953.

6. Give total number of employees at present: 3

7. Give 1952 License Number 368

8. Give amount of Fire and Theft (Bailee) insurance carried on customer garments and name of company:
$1400.00 Springfield Fire & Marine

9. If Application is for Press Shop or Agency License, give name of Firm doing wholesale cleaning: ———

10. On the reverse side hereof find listed the State License Number, Firm Name, Name of Owner and Address of every Person, Firm or Corporation being served at wholesale prices by applicant.

11. Are you a veteran of World War I ———, World War II ———, Korea ——— (Please check one, if you are a veteran.)

Dated this 29th day of January 1953.

I CERTIFY the information contained herein is true, W. G. Wyman
Applicant's Signature

OK

(Do not write below this line)

APPROVED THIS ——— DAY OF ——— 1953.
STATE DRY CLEANERS BOARD

License Number 364 Receipt Number 2657

Issued ——— 1953 Deposit Slip No. 813

(Form 1)

RECEIVED JAN 31 1953

(IN USE 1957 - 1959) **1957**

APPLICATION FOR RENEWAL OF STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, AND/OR PRESSING

The undersigned applicant hereby makes application for renewal of license to engage in the cleaning, dyeing and/or pressing business pursuant to the provisions of 59 O.S. 1941 Sections 741 to 756, as amended by Sections 1 to 7 of Chap. 17, Title 59, Page 197, O.S.L. 1945, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning JANUARY 1, 1957, and ending DECEMBER 31, 1957, unless sooner suspended or revoked, and in connection therewith states:

1. Master Cleaners (Name of Establishment)
   Please Print Legibly, Or Fill Out With Typewriter
2. 2717 Classen (Street) Oklahoma City (City) Oklahoma (County) JA-4-1788 (Phone No.) (Location)
3. Owner of Cleaning, Dyeing and or Pressing Establishment is Ash, Norris, etal (Name)
4. Give entire amount of cleaning, dyeing and/or pressing business done from January 1, 1956, to December 31, 1956. $
5. License Fee of $ [illegible] Penalty of $ _____ Total $ 76.50 (Check [X] Money Order [ ], Cash [ ]), payable to State Dry Cleaners Board is enclosed herewith, based on ONE DOLLAR and FIFTY CENTS ($1.50) per thousand, and fractional part thereof, on Gross business done during 1956. Providing that no fee shall be in any sum less than FIFTEEN ($15.00) DOLLARS; and provided further that a penalty of $5.00 per month, or major fraction thereof, shall be added if application is not made and proper fee paid on or before February 1, 1957.
6. Give total number of employees at present: 8
7. Give 1956 License Number 528
8. Give amount of Fire and Theft insurance carried on customer garments and name of company:

   _____
9. If Application is for Press Shop or Agency License, give name of Firm doing wholesale cleaning:

   _____
10. On reverse side hereof find listed the Firm Name, Name of Owner and address of every Person, Firm or Corporation being served at wholesale prices by applicant.

Dated this 24 day of January, 1957

I CERTIFY the information contained herein is true. Ash Norris
Applicant's Signature

(Do not write below this line)

APPROVED THIS _____ DAY OF _____, 1957
STATE DRY CLEANERS BOARD

License Number 528 Receipt Number _____

Issued _____, 1957 Deposit Slip No. _____
(Form 2)

RECEIVED JAN 21 1957

(IN USE 1960 – 1964) **1960**

APPLICATION FOR RENEWAL OF STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, AND/OR PRESSING

The undersigned applicant hereby makes application for renewal of license to engage in the cleaning, dyeing and/or pressing business pursuant to the provisions of 59 O.S. 1941 Sections 741 to 756, as amended by Sections 1 to 7 of Chap. 17, Title 59, Page 197, O.S.L. 1945, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning JANUARY 1, 1960, and ending DECEMBER 31, 1960, unless sooner suspended or revoked, and in connection therewith states:

1. MASTER CLEANERS (Name of Establishment)
*Please Print Legibly, Or Fill Out With Typewriter

2. 2717 CLASSEN (Street) OKLAHOMA CITY (City) OKLA. (County) JA 4-1788 (Phone No.) (Location)

3. Owner of Cleaning, Dyeing and/or Pressing Establishment is ASA S. & JOHN S. HARRIS (Name)

4. Give EXACT TOTAL AMOUNT of cleaning, dyeing and/or pressing business done from January 1, 1959, to December 31, 1959. $ —

5. License Fee of $ 60.00 Penalty of $ _____ Total $ 60.00 (Check ☑, Money Order ☐, Cash ☐), payable to State Dry Cleaners Board is enclosed herewith, based on ONE DOLLAR and FIFTY CENTS ($1.50) per thousand, and fractional part thereof, on Gross business done during 1959. Providing that no fee shall be in any sum less than FIFTEEN ($15.00) DOLLARS; and provided further that a penalty of $5.00 per month, or major fraction thereof, shall be added if application is not made and proper fee paid, on or before February 1, 1960.

6. Give total number of employees at present (not including self or members of family) 7

7. Give total number of members of family employed (including self) 1

8. Give total wages paid in 1959, as shown on your Social Security Record $ 18,939.05

9. Give 1959 License Number 528

10. Give amount of Fire and Theft insurance carried on customer garments and name of company:
$2,000 Dixie Mutual

11. If Application is for Press Shop or Agency License, give name of Firm doing wholesale cleaning:
_____

12. On reverse side hereof find listed the Firm Name, Name of Owner and address of every Person, Firm or Corporation being served at wholesale prices by applicant.

Dated this 13 day of JANUARY 1960

I CERTIFY the information contained herein is true. Lee B. Harris
Applicant's Signature

M
1.0

(Do not write below this line)

APPROVED THIS _____ DAY OF _____ 1960
STATE DRY CLEANERS BOARD

RECEIVED
JAN 18 1960
STATE DRY CLEANERS BOARD

License Number 572 Receipt Number 2253

Issued 1/28 1960 Deposit Slip No. 2277

(Form 2)

(IN USE 1968 - 1983)

APPLICATION FOR RENEWAL OF STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, STORAGE AND/OR PRESSING

(Complete and return to: State Dry Cleaners Board, P.O. Box 53181, Capitol Station, Oklahoma City, Okla. 73105)

The undersigned applicant hereby makes application for renewal of license to engage in the cleaning, dyeing, storage and/or pressing business pursuant to the provisions of 59 O.S. 1961 Sections 711 to 756, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning JANUARY 1, 1968, and ending DECEMBER 31, 1968, unless sooner suspended or revoked, and in connection therewith states:

1. Quality Cleaners (Name of Establishment)
   Please Print Legibly, Or Fill Out With Typewriter
2. 111 So. 6 — McAlester — Pitts. — GA3-4379 (Location)
   Street — City — County — Phone No.
3. Owner of Cleaning, Dyeing, Storage and/or Pressing Establishment is [illegible] (Name)
4. Give EXACT TOTAL AMOUNT of cleaning, dyeing, storage and/or pressing business done from January 1, 1967, to December 31, 1967. $
5. License Fee of $16.50 Penalty of $5.00 Total $21.50 (Check ☐, Money Order ☐, Cash ☐), payable to State Dry Cleaners Board is enclosed herewith, based on ONE DOLLAR and FIFTY CENTS ($1.50) per thousand, and fractional part thereof, on Gross business done during 1967. Providing that no fee shall be in any sum less than FIFTEEN ($15.00) DOLLARS; and provided further that a penalty of $5.00 per month, or major fraction thereof, shall be added if application is not made and proper fee paid, on or before February 1, 1968.
6. Give total number of employees at present (not including self or members of family) 2 - 1968, 1 - 1967
7. Give total number of members of family employed (including self) 1
8. Give total wages paid employees in 1967, as shown on your Social Security Record $
9. Give 1967 License Number 864
10. Give amount of Fire and Theft insurance carried on customer garments and name of company:
    1500.00
11. Give Workmen's Compensation Insurance policy number and name of company
    (For plants having two (2) or more employees)
12. If Application is for Press Shop or Agency License, give name of Firm doing wholesale cleaning:
13. Application for: Petroleum X; Synthetic ______; Agency ______ (Check One)
14. On reverse side hereof find listed the Firm Name, Name of Owner and address of every Person, Firm or Corporation being served at wholesale prices by applicant.

Dated this 6 day of Feb, 1968.

I CERTIFY the information contained herein is true. [signature]
Applicant's Signature

(Do not write below this line)

APPROVED THIS ______ DAY OF ______ RECEIVED FEB 8 1968 STATE DRY CLEANERS BOARD, 1968.

STATE DRY CLEANERS BOARD

License Number ______ Receipt Number ______

Issued ______, 1968. Deposit Slip No. ______

(Form 2)

(IN CURRENT USE 1984 -) 1984

APPLICATION FOR RENEWAL OF STATE LICENSE TO ENGAGE IN THE BUSINESS OF CLEANING, DYEING, STORAGE AND/OR PRESSING

Complete and return to: State Dry Cleaners Board,
Room 307 4001 North Lincoln Oklahoma City, Oklahoma 73105

The undersigned applicant hereby makes application for renewal of license to engage in the cleaning, dyeing, storage and/or pressing business pursuant to the provisions of 59 O.S. 1983 Sections 741 to 756, and the rules and regulations promulgated and adopted by the State Dry Cleaners Board, for a period beginning JANUARY 1, 1984 and ending DECEMBER 31, 1984, unless sooner suspended or revoked, and in connection therewith states:

1. _____ (Name of Establishment)
Please Print Legibly, Or Fill Out With Typewriter

2. _____ (Location)
Street City Zip County Phone No.

3. Owner of Cleaning, Dyeing, Storage and/or Pressing Establishment is _____ (Name)

4. Give EXACT TOTAL AMOUNT of cleaning, dyeing, storage and/or pressing business, less wholesale work done from January 1, 1983 to December 31, 1983. $_____

5. License Fee of $_____ Penalty of $_____ Total $_____ (Check ____, Money Order ____, Cash ____), payable to State Dry Cleaners Board is enclosed herewith, based on two dollars ($2.00) per thousand, and fractional part thereof on gross business less wholesale work done during 1983. No fee shall be in any sum less than thirty-five ($35.00) dollars for a Press shop or Agency, twenty ($20.00) dollars for a Coin-Op and fifty ($50.00) dollars for a Dry Cleaning plant. If the license fee is not paid by March 1, 1984 a penalty of twenty-five ($25.00) dollars will be added and twenty-five ($25.00) dollars for each month or major fraction thereof, after March 1, 1984.

6. Give total number of employees at present (not including self or members of family) _____

7. Give total number of members of family employed (including self) _____

8. Give total wages paid employees in 1983, as shown on your Social Security Record $_____

9. Give amount of Bailee Fire and Theft insurance carried on customer garments and name of company:

_____

10. Give Workmen's Compensation Insurance policy number and name of company _____

11. If Application is for Press Shop or Agency License, give name of Firm doing wholesale cleaning:

_____

12. Application for: (Check One) Petroleum _____; Synthetic _____; Agency _____; Coin Op. _____

13. On reverse side hereof list the Firm Name, Name of Owner and address of every Person, Firm or Corporation being served at wholesale prices by applicant.

Dated this _____ day of _____ 1984.

I CERTIFY the information contained herein is true. _____
Applicant's Signature

(Do not write below this line)

APPROVED THIS _____ DAY OF _____ 1984.
STATE DRY CLEANERS BOARD

License Number _____ Receipt Number _____

Issued _____ 1984. Deposit Slip No. _____

(Form 2)

APPENDIX F

INITIAL AND ANNUAL PLANT INSPECTION FORMS

STATE DRY CLEANERS BOARD

ROOM 3161—STATE CAPITOL BUILDING

OKLAHOMA CITY, OKLAHOMA

Date_____

INSPECTION FOR NEW PETROLEUM PLANTS

Firm Name_____ Street & No._____ City_____

Order to_____ Copy of order to_____

Engaged in: Dry Cleaning?_____ Pressing?_____ Dyeing?_____

Construction of Building_____

Proximity to other property_____

Construction of Dry Cleaning Room: Walls_____

Floors_____ Roof_____ Skylights_____

Windows_____ Exits_____ Fire Doors_____

Ventilation_____

Dry Rooms: Location_____ Construction_____ Ventilated?_____ Steam Jet?_____

Lighting_____ Heating_____ Power_____

Electric Motors, explosion proof?_____ Switches_____ Overcurrent Devises_____

Boiler: Location_____ Fuel_____

Storage Tanks_____ Filters_____

Pumps_____ Relief valves_____

Washers_____ Liquid tight?_____ Grounded?_____ Overflow Pipe?_____

Piping_____

Emergency Drains_____

Still_____

Tumblers: Grounded?_____ Steam Jet_____ Vented outside?_____ Explosion Hatches_____

Fans housed and interlocked?_____ Extinguishing equipment_____

Extractors: Grounded?_____ Covered?_____ Drains to_____ Brakes_____

Fire extinguishers?_____ Smothering devise_____

Nearest Fire Department_____

No Smoking Signs?_____ Waste cans for lint, etc._____

Requirements:_____

_____

_____

STATE DRY CLEANERS BOARD

By_____

STATE DRY CLEANERS BOARD
Suite 307
4001 North Lincoln
Oklahoma City, Oklahoma 73105

Inspector_____
Date_____

HAZARDOUS INSPECTION

FIRM NAME_____ Street_____ City_____

OWNER_____ Copy of Inspection given to:_____

ENGAGED IN: Dry Cleaning_____ Pressing_____ Coin Op_____ Agency_____

Proximity to Other Property_____

DRY CLEANING ROOM: Walls:_____ Floor_____ Roof_____
Windows_____ Exits_____ Fire Doors_____
Fire Extinguishers_____ No Smoking Signs_____
Wiring_____ Cleanliness_____
_____

WASHERS:_____ Liquid Tight_____ Grounded_____ Motor explosion proof_____

TUMBLERS:_____ Grounded_____ Vented outside_____ Explosion hatches_____
Extinguishing equipment on tumbler_____ Motor explosion proof_____

EXTRACTORS_____ Covered_____ Drains to_____ Brakes_____
Motor explosion proof_____

BOILER ROOM LOCATION_____

TYPE OF CLEANING FLUID USED: Petroleum_____ Perchloroethylene_____ Fluorocarbon 113_____

Sufficient Exhaust Ventilation away from work area of employees to prevent excess fumes_____

Approved Respirator "Mask" Sanitary Condition available_____

Plant owner furnished with a pamphlet containing a copy of the law, Rules and Regulations of this Department: YES_____ NO_____

Corrections to be made:_____

_____

_____

NOTE: ANY NEW OR MODIFIED PERCHLOROETHYLENE PLANT INITIATED AFTER NOVEMBER 25, 1980 WILL BE SUBJECT TO EPA PROPOSED FEDERAL STANDARDS FOR DRY CLEANING IF OR WHEN ADOPTED.

STATE DRY CLEANERS BOARD

By_____

APPENDIX G

ICD ELEMENTS OF NIOSH DEATH CATEGORIES

NIOSH Code	Label	ICD Elements of NIOSH Death Categories			
		1949-1968, 5th Revision	1949, 6th Revision	1958-1967, 6th and 7th Revisions	1968-1978, 8th Revision
01*	Tuberculosis				
01†	Respiratory tuberculosis	13	001-008	001-008	010-012, 031
02	Other tuberculosis	14-22	010-019	010-019	013-019
02	Malignant Neoplasms (MN) of Buccal Cavity and Pharynx				
03	MN of lip	45A	140	140	140
04	MN of tongue	45B	141	141	141
05	MN of other parts of buccal cavity	45C, 45E	142-144	142-144	142-145
06	MN of pharynx	45F	145-148	145-148	146-149
03	MN of Digestive Organs and Peritoneum				
07	MN of esophagus	46A	150	150	150
08	MN of stomach	46B	151	151	151
09	MN of intestine except rectum	46C, 46E	152, 153	152, 153	152, 153
10	MN of rectum	46D	154	154	154
11+‡	MN of biliary passages and liver	46F	155, 156A	155	155, 156
12+‡	MN of liver not specified	No rates	No rates	156A	197.8
13	MN of pancreas	46G	157	157	157
14	MN of peritoneum and unspecified of digestive organs	46H; 46I	158, 159	158, 158	158, 159
04	MN of Respiratory System				
15	MN of larynx	47A	161	161	161
16	MN of trachea, bronchus, and lung	47B-47F	162, 163	162, 163	162, 163.0
17+	MN of other parts of respiratory system	No rates	No rates	160, 164	160, 163.1, 163.9
05	MN of Breast				
18	MN of breast	50	170	170	174
06	MN of Female Genital Organs				
19+‡	MN of cervix uteri	No rates	No rates	171	180, 234.0
20+‡	MN of other parts of uterus	48	171, 172-174	172-174	181, 182.0, 182.9
21	MN of ovary, fallopian tube, and broad ligament	49A, 49B	175	175	183
22	MN of other female genital organs	49C-49E	176	176	184
07	MN of Male Genital Organs				
23	MN of prostate	51B	177	177	185
24	MN of other male genital organs	51A, 51C-51E	178-179	178, 179	172.5, 173.5, 186, 187
08	MN of Urinary Organs				
25	MN of kidney	52A	180	180	189.0, 189.1, 189.2
26	MN of bladder and other urinary organs	52B, 52C	181	181	188, 189.9

09	**MN of Other and Unspecified Sites**				
27	MN of skin	53	190, 191	190, 191	172.0-172.4, 172.6-172.9, 173.0-173.4, 173.6-173.9
28+	MN of eye	No rates	No rates	192	190
29	MN of brain and other parts of nervous system	54	193	193	191, 192
30+	MN of thyroid gland	No rates	No rates	194	193
31+	MN of bone	No rates	No rates	196	170
32+	MN of connective tissue	No rates	No rates	197	171
33	MN of other and unspecified sites (minor)	450, 55	1566, 160, 164, 165, 192, 194-203, 205	1568, 165, 195, 198, 199	194, 195, 196, 197.0-197.7, 197.9, 198, 199
10	**Neoplasms of Lymphatic and Hematopoietic Tissue**				
34+	Lymphosarcoma and reticulosarcoma	No rates	No rates	200	200, 202.2
35+	Hodgkin's disease	No rates	No rates	201	201
36	Leukemia and aleukemia	74	204	204	204-207
37+	Other neoplasms of lymphatic and hematopoietic tissue	No rates	No rates	202, 203, 205	202.0, 202.1, 202.9, 203
11	**Benign and Unspecified Neoplasms of the Brain**				
38	Benign neoplasms of the brain	580	223	223	224, 225, 743.4
39	Neoplasms of unspecified nature of brain	570	237	237	238
12	**Diabetes Mellitus**				
40	Diabetes mellitus	61	260	260	250
13	**Diseases of the Blood and Blood-Forming Organs**				
41	Pernicious and hyperchromic anemias	73.A	280	280	281.0, 281.9
42	Anemias of other and unspecified type	738-730	291-293	291-293	209, 280, 281.1-281.4, 282, 283.0, 284, 285
43	Purpura and other hemorrhagic conditions	72	296	286	288, 287
44	All other diseases of blood-forming organs	75, 76	294, 295, 297-299	294, 295, 297-299	209, 275, 283.9, 288, 289.0, 289.9
14	**Mental, Psychoneurotic and Personality Disorders**				
45	Alcoholism	77	322	322	303
46	Other mental disorders	79, 84	300-321, 323-326	300-321, 323-326	290-302, 304, 305, 306.0, 306.1, 306.5, 306.6, 306.7, 306.9, 307, 308, 310-315, 333.0, 759.3, 781.5
15	**Diseases of the Nervous System**				
47	Vascular lesions affecting CNS	83	330-334	330-334	430-438
48	Multiple sclerosis	87	345	345	340

16	**Diseases of the Circulatory System**				
49	Rheumatic fever	58	400-402	400-402	390-392
50	Chronic rheumatic heart disease	90A, 92B, 92C, 93C, 95B	410-416	410-416	393, 394, 395.0, 396-398
51+‡	ASHD	94, 93D	420	420	410-413
52	Chronic endocarditis not specified as rheumatic	91C, 92A, 92D, 92E	421	421	395.9, 424
53‡	Other myocardial degeneration	93B, 93E	422	422	428
54	Other diseases of the heart	90B, 91A, 91B, 93A, 95A, 95C	430-434	430-434	429-423, 425-427, 429
55+‡	Hypertension with heart disease	131A	440-443	440-443	402.1, 402.9, 402, 404
56‡	Hypertension without heart disease	102	444-447	444-447	400.0, 400.2, 400.3, 401, 403, 440.1
57	Diseases of the arteries and veins	96-101, 103	450-468	450-468	289.1-.3, 446.0, 446.2-.9, 441.0-444.1, 444.3-446.9, 448.0, 448.2-.9, 447-461, 463-468, 734.1
17	**Diseases of the Respiratory System**				
58	Acute upper respiratory	104, 105	470-475	470-475	460-465
59	Influenza	33	480-483	480-483	470-474
60	Pneumonia (except newborn)	107-109	490-493	490-493	480-488
61	Bronchitis	106	500-502	500-502	466, 490, 491
62	Other respiratory diseases	110, 111, 113, 114A-E, 115	510-527	510-527	492, 500-508, 508-519
18	**Diseases of Digestive System**				
63	Diseases of the stomach and duodenum	117, 118	540, 541, 543	540, 541, 543	531-533, 535
64	Hernia and intestinal obstruction	122	560, 561, 570	560, 561, 570	444.2, 550-553, 560
65	Cirrhosis of the liver	124	581	581	571
19	**Diseases of the Genitourinary System**				
66	Acute nephritis	130	590	590	580
67+‡	Nephritis with edema, including nephrosis	No rates	No rates	591	581, 593.1
68‡	Chronic and unspecified nephritis and other renal sclerosis	131B, 132	591-594	592-594	582-584, 593.0
69	Infection of kidney	133	600	600	590
70	Calculi of urinary system	134	602, 604	602, 604	592, 594
71	Hyperplasia of prostate	137	610	610	600
72	Other diseases of male genital organs	138	611-617	611-617	601-607
73+‡	Diseases of the breast	No rates	No rates	620, 621	610, 611
74+‡	Diseases of the female genital organs	139	620-637	622-637	612-616, 620-624, 625.0-.2, 625.9, 626-629, 131
75	Abortion	140-141	650-652	650-652	640-645
20	**Diseases of the Skin**				
76	Infections of the skin	151-152	680-686	680-686	079.0, 079.1, 680-684, 686

77	Other diseases of the skin	153	700-716	700-716	696-707, 709, 716.0, 734.0, 757.0, 757.2
21	Diseases of the Bone and Organs of Movement				
78+‡	Arthritis and spondylitis	59	720-727	720-725	710-715
79+‡	Muscular rheumatism and rheumatism unspecified	No rates	No rates	726, 727	716.1, 717, 718
80	Osteomyelitis and periostitis	154	730	730	720
22	Unknown Cause				
81+	Unknown cause	162, 199, 200, blank	780-793, 795, blank	780-793, 795, blank	306.2-.4, 306.8, 780-793, 795, 796, blank
23	Accidents				
82	Transportation accidents	169-173	E800-866	E800-866	E809-845
83	Accidental poisoning	78, 178, 179	E870-895	E870-895	E850-877
84	Accidental falls	166A	E900-904	E900-904	E880-887
85	Other accidents	174-177, 180-185 166B-194 195C, D	E910-938 960-962	E910-938, 960-962	E890-929, 940-946
86	Medical complications and misadventure	195A, 196B	E940-959	E940-959	E930-936, E947-949
24	Violence				
87	Suicide	163, 164	E963, E970-979	E963, E970-979	E950-959
88	Homicide	165-168, 198	E964, E980-985	E964, E980-985	E960-978
25	Other Cause				
89	Other Cause	Residual	Residual	Residual	Residual

* Major NIOSH death category

† Minor NIOSH death category

‡ The following pairs of categories should be combined if there are person-years before 1950: 11 and 12, 19 and 20, 67 and 68, 73 and 74, 78 and 79

§ 51 and 53 should be combined if there are person-years after 1967; if there are person-years prior to 1950 the following four categories should be combined 51, 53, 55 and 56

11+; includes 1° and unspecified prior to 1950, 1° only after 1950.

12+; there is no category during fifth revision and sixth ICD's 156A is put into NIOSH 11 in 1949

17+; fifth ICD's 47F is put into NIOSH 16, fifth ICD's 550 is put into NIOSH 33, and sixth ICD's 160 and 164 are put in NIOSH 33 in the 1940s

19+; fifth ICD's 48A and sixth ICD's 171 are put into NIOSH 20 in the 1940s

20+; includes cervix and uterine cancer prior to 1950

29+; fifth ICD's 55E and sixth ICD's 192 are put into NIOSH 33 in the 1940s

30+; fifth ICD's 55C and sixth ICD's 194 are put into NIOSH 33 in the 1940s

31+; fifth ICD's 45D and 55B and sixth ICD's 196 are put into NIOSH 33 in the 1940s

32+; fifth ICD's 55E and sixth ICD's 197 are put into NIOSH 33 in the 1940s

34+; there is no category during fifth revision and sixth ICD's 200 is put into NIOSH 33 in 1949

35+; fifth ICD's 44B and sixth ICD's 201 are put in NIOSH 89 in the 1940s

37+; there is no category during fifth revision and sixth ICD's 202, 203, and 205 are put in NIOSH 33 in 1949

51+; includes other myocardial degeneration after 1967; includes part of myocardial degeneration and hypertension with heart disease prior to 1950

55+; there is some hypertension without heart disease prior to 1949 (part of 131A)

67+; there is no category in the fifth revision and sixth ICD's 591 is put into NIOSH 68 in 1949

73+; there is no category in the fifth revision and sixth ICD's 620 and 621 are put into NIOSH 74 in 1949

74+; contains breast disease prior to 1950

78+; includes rheumatism in the 1940s

79+; fifth revision ICD's 59C and sixth ICD's 726 and 727 are put into NIOSH 78 in the 1940s

81+; "Blank" indicates deaths without certificates

APPENDIX H

EMPLOYMENT HISTORIES OF RENAL CELL CARCINOMA CASES AND CONTROLS

TABLE 46

SOLVENT EXPOSURES, JOB TITLES, AND DURATIONS OF EXPOSURE FOR MALE RENAL CELL CARCINOMA CASES, POPULATION CONTROLS, AND HOSPITAL CONTROLS

Status	Number	Solvent Exposure	Job Title	Duration (Years)
Renal Cell Carcinoma Cases	1.	none	laundromat	1
	2.	petroleum	operator	8
		unknown	operator	2
		unknown	operator	5
		unknown	operator	7
	3.	none	washer	2
		none	route delivery	8
Population Controls	1.	unknown	presser	3
	2.	unknown	presser	1.5
	3.	? petroleum	presser	3
	4.	unknown	all depts	7
	5.	none	pick-up clerk	1
	6.	none	automatic laundry	8
Hospital Controls	1.	none	delivery	3
	2.	unknown	presser	2

TABLE 47

SOLVENT EXPOSURES, JOB TITLES, AND DURATIONS OF EXPOSURE FOR FEMALE RENAL CELL CARCINOMA CASES, POPULATION CONTROLS, AND HOSPITAL CONTROLS

Status	Number	Solvent Exposure	Job Title	Duration (Years)
Renal Cell Carcinoma Cases	1.	none	presser	2
	2.	none	pick-up clerk	1
	3.	unknown	presser	2
	4.	none	laundry operator	2
	5.	PCE	presser	2
		none	presser	1.5
	6.	unknown	presser	11.5
	7.	unknown	unknown	2
	8.	petroleum	presser	4
		unknown	unknown	8.5
Population Controls	1.	none	office clerk	4
Hospital Controls	1.	petroleum	all depts	34
	2.	petroleum	checker	3
	3.	petroleum	all depts	7
	4.	unknown	presser	5
		none	checker	1