



UNION CARBIDE CORPORATION  
Corporate Health, Safety and Environmental Affairs Department

67-File  
RECEIVED  
MORTALITY MAR 26 1984  
OLD RIDGEBURY ROAD, DANBURY, CT 06817  
FSP

March 16, 1984

Mr. Mike Ezzell  
Bureau of State Health Planning  
and Resource Development  
Texas Department of Health  
1100 West 49th Street  
Austin, Texas 78756

Dear Mr. Ezzell:

I have enclosed a copy of my talk, "Brain Cancer Mortality in Texas Chemical Plants", which was presented at the Seminar on Cancer Prevention and Control in January per your request dated February 3, 1984.

As this paper has not been submitted for publication elsewhere, please feel free to publish it in the proceedings of the conference. I would appreciate receiving a copy of the proceedings when available. Thank you.

Sincerely,

*Susan G. Austin*

Susan G. Austin, Sc.D.  
Corporate Director of Epidemiology

SGA/rjk  
Enc.

cc: J. B. Browning  
D. H. Glenn, M.D.  
T. A. Lincoln, M.D.  
F. S. Provenzano  
R. C. Wise

UCC 097537

BRAIN CANCER MORTALITY IN  
TEXAS CHEMICAL PLANTS  
BY DR. SUSAN G. AUSTIN  
CORPORATE DIRECTOR OF EPIDEMIOLOGY  
UNION CARBIDE CORPORATION  
DANBURY, CT

JANUARY, 1984

I AM VERY PLEASED TO HAVE AN OPPORTUNITY TO PARTICIPATE IN THIS VERY TIMELY CONFERENCE ON THE SUBJECT OF CANCER IN THE STATE OF TEXAS. THE QUESTION OF AN ASSOCIATION BETWEEN BRAIN CANCERS AND EMPLOYMENT WITHIN THE PETROCHEMICAL INDUSTRY SURFACED IN THE LATE '70'S AND WAS THE SUBJECT OF A NATIONAL ACADEMY OF SCIENCE CONFERENCE IN NEW YORK IN 1980.<sup>1</sup> UNFORTUNATELY, ALTHOUGH A NUMBER OF VERY DISTINGUISHED SCIENTISTS ATTENDED THIS CONFERENCE, AND MUCH WORK AND STUDY WAS UNDERWAY, TOO FEW RIGOROUS STUDIES HAD BEEN COMPLETED AND RESULTS WERE TOO INCONSISTENT TO PERMIT PROPER SCIENTIFIC CONCLUSIONS TO BE DRAWN. HOWEVER, THE PICTURE IN 1984 IS SOMEWHAT DIFFERENT AS A NUMBER OF VERY GOOD STUDIES HAVE BEEN COMPLETED AND REPORTED IN THE OPEN SCIENTIFIC LITERATURE.

- 2 -

BECAUSE UNION CARBIDE OPERATES SEVERAL CHEMICAL PLANTS IN TEXAS, OUR EPIDEMIOLOGY DEPARTMENT HAS BEEN ACTIVELY INVOLVED WITH INVESTIGATIONS OF OUR EMPLOYEES AND HAS FOLLOWED VERY CLOSELY THE PUBLICATION OF RESULTS OF OTHER COMPANIES WHO HAVE STUDIED THIS SAME QUESTION. IN THE NEXT FEW MINUTES, I WOULD LIKE TO BRIEFLY REVIEW THE METHODS AND RESULTS OF STUDIES WHICH HAVE BEEN CONDUCTED IN UNION CARBIDE'S PLANTS IN TEXAS AND PROVIDE AN INTERPRETATION OF THESE RESULTS IN VIEW OF THE RESULTS OF OTHER STUDIES THAT HAVE BEEN SUBSEQUENTLY RELEASED.

IN 1978, THE DIAGNOSIS OF BRAIN CANCER IN TWO TEXAS CITY EMPLOYEES PROMPTED AN OSHA INVESTIGATION OF THAT PLANT. CLOSER INSPECTION OF DATA AVAILABLE THROUGH THE PLANT MEDICAL DEPARTMENT INDEED REVEALED WHAT APPEARED TO BE A CLUSTER OF BRAIN CANCER CASES.

UCC 097539

THIS PROMPTED TWO OSHA/NIOSH PUBLICATIONS; ONE IN THE MORBIDITY AND MORTALITY WEEKLY REPORTS<sup>2</sup> AND THE OTHER IN THE AMERICAN JOURNAL INDUSTRIAL MEDICINE.<sup>3</sup> VARIOUS OSHA REPORTS POSTULATED THAT THE EXCESS WAS AS LARGE AS TWO TO FOUR-FOLD OVER NORMAL BACKGROUND RATES AND SUGGESTED THAT VINYL CHLORIDE, OR DIETHYL SULFATE MAY HAVE BEEN RESPONSIBLE. MOREOVER, THE AUTHORS SUGGESTED THAT THE SPECIFIC CELL TYPE "GLIOBLASTOMA MULTIFORME", WAS PROPORTIONATELY OVER-REPRESENTED IN THE SAMPLE OF CASES AVAILABLE FOR SCRUTINY.

AS AN APPROPRIATE FOLLOW-UP TO THESE ALLEGATIONS, A COLLABORATE UCC/NIOSH INITIATED A COHORT MORTALITY STUDY OF ALL EMPLOYEES WHO WORKED ONE DAY OR MORE AT THE PLANT BETWEEN 1941 AND 1979 WAS INITIATED.<sup>4</sup> UNION CARBIDE PLANT PERSONNEL PROVIDED THE CLERICAL SUPPORT TO IDENTIFY AND CODE DEMOGRAPHIC AND WORK HISTORY DATA FOR SOME 9,000 CURRENT AND FORMER EMPLOYEES.

UNION CARBIDE PLANT STAFF ALSO ASSISTED NIOSH IN THE TRACING OF TERMINATED EMPLOYEES AND THE LOCATION OF DEATH CERTIFICATES FOR DECEDENTS. AN ANALYSIS TAPE WAS GIVEN TO UNION CARBIDE AT THE COMPLETION OF FOLLOW-UP WHICH PROVIDED THE BASIS FOR UNION CARBIDE'S OWN ANALYSIS AND INTERPRETATION OF THIS STUDY.

TWO CASE CONTROL STUDIES WERE ALSO CONDUCTED SIMULTANEOUSLY.<sup>5,6</sup> BOTH THE UNION CARBIDE STUDY AND THE NIOSH STUDY DEFINED A "CASE" AS A PRIMARY BRAIN TUMOR, ALTHOUGH NIOSH RESTRICTED ITS ANALYSIS TO GLIOMAS. UCC'S ANALYSIS WAS BASED ON 21 CONFIRMED BRAIN TUMORS, 17 GLIOMAS AND 4 MENINGIOMAS. THOSE TWO STUDIES DIFFERED IN THEIR METHODS AND SELECTION OF CONTROLS. THE UNION CARBIDE STUDY SELECTED TWO CONTROL GROUPS OF 80 DEATHS EACH, RANDOMLY, FROM ALL DEATHS KNOWN TO THE COMPANY IN 1979.

THE NIOSH STUDY EMPLOYED STRINGENT MATCHING CRITERIA, SELECTING FOUR TO SIX CONTROLS PER CASE FROM AMONG ALL COHORT MEMBERS. BOTH STUDIES FOCUSED ON THE SAME 37 CHEMICALS TO WHICH AT LEAST FOUR OF THE BRAIN TUMOR CASES HAD BEEN EXPOSED DURING EMPLOYMENT. (TABLE 1) IN ESSENCE, BOTH STUDIES ADOPTED A RESEARCH STRATEGY THAT SAID "IF ANYTHING IN THE PLANT IS CAUSING THESE BRAIN TUMORS, IT HAS TO BE AT LEAST ONE OF THESE CHEMICALS". UCC ALSO LOOKED AT AN ADDITIONAL 5 CHEMICALS, SUSPECTED OR KNOWN TO BE CARCINOGENIC POTENTIAL. (TABLE 2)

DURING THE COURSE OF THE TEXAS CITY INVESTIGATION, A NIOSH SEARCH OF STATE-WIDE CANCER CASES REVEALED A BRAIN TUMOR DEATH AMONG UNION CARBIDE EMPLOYEES AT THE SEADRIFT PLANT. THIS LED TO THE INITIATION OF A SIMILAR INVESTIGATION BY NIOSH OFFICIALS AT THAT PLANT.<sup>7</sup> UNION CARBIDE'S EPIDEMIOLOGY DEPARTMENT MONITORED THE PROGRESS

OF THAT INVESTIGATION BUT DID NOT ACTIVELY PARTICIPATE IN THE ANALYSIS OR INTERPRETATION OF RESULTS.

THE RESULTS OF THAT STUDY, WHICH HAVE NOT BEEN PUBLISHED IN THE OPEN LITERATURE, INDICATED NO EXCESS OF BRAIN CANCERS AT SEADRIFT. I BELIEVE NIOSH WILL INCLUDE THIS STUDY IN THEIR REPORT, THUS THERE IS NO NEED TO MENTION IT FURTHER AT THIS TIME.

THE RESULTS OF BOTH THE NIOSH AND THE UNION CARBIDE ANALYSIS OF THE TEXAS CITY COHORT STUDY INDICATED NO OVERALL EXCESS OF "ALL CAUSE" MORTALITY OR "ALL CANCER" MORTALITY. (TABLE 3) HOWEVER, AN APPROXIMATE TWO-FOLD EXCESS OF BRAIN CANCER DEATHS AMONG HOURLY MALE EMPLOYEES WAS FOUND. (TABLE 4). THIS EXCESS WAS BASED ON DEATHS THAT OCCURRED BETWEEN 1945 AND 1979 IN THE NIOSH STUDY. UCC'S ANALYSIS WENT ONLY THROUGH 1977.

THE QUESTION OF WHETHER OR NOT THERE IS AN EXCESS AMONG, THIS OCCUPATIONAL COHORT IS NO LONGER IN DOUBT. HOWEVER, THIS RESULT IS NOT ALTOGETHER SURPRISING SINCE THE STUDY WAS CONDUCTED BECAUSE OF THE SUSPICION OF AN EXCESS AT THE OUTSET.

THE REAL QUESTION BECAME WHETHER OR NOT THIS EXCESS COULD BE DEMONSTRATED IN OTHER SIMILAR PLANTS AND BE RELATED TO OCCUPATIONAL FACTORS, SUCH AS SPECIFIC EXPOSURES AND LEVELS OF EXPOSURE.

THIS SINGLE COHORT STUDY PROVIDED LITTLE INFORMATION WITH WHICH TO EVALUATE THE QUESTION OF CAUSALITY. LENGTH OF EMPLOYMENT ANALYSES AND LATENCY ANALYSES ARE INTERESTING, BUT DIFFICULT TO INTERPRET IN AND OF THEMSELVES. IN THE LENGTH OF EMPLOYMENT ANALYSIS, (TABLE 5), IT CAN BE SEEN THAT BOTH SHORT-TERM EMPLOYEES AND LONG-TERM EMPLOYEES HAD AN ELEVATED RISK WHEN A LATENCY PERIOD OF TWENTY YEARS WAS BUILT INTO THE

4357B

ANALYSIS. DIFFERENT GROUPING OF LOE CATEGORIES MAY RESULT IN AN APPARENT INCREASING TREND, AS WAS SEEN IN THE NIOSH ANALYSIS, HOWEVER THE INTERPRETATION OF THESE SMRS IS DIFFICULT, AT BEST.

THE CASE CONTROL STUDIES FAILED TO INDICATE THAT ANY OF THE 37 CHEMICALS, OTHER THAN CARBON DIOXIDE IN THE NIOSH STUDY, WERE SIGNIFICANTLY RELATED TO THE BRAIN CANCERS, AND THE ASSOCIATION WITH CO<sub>2</sub> WAS DISCOUNTED BY NIOSH FROM BEING A CAUSAL ONE. (TABLE 6) IT IS TRUE THAT NEITHER OF THESE STUDIES ATTEMPTED TO LOOK FOR ASSOCIATIONS WITH EXPOSURE TO TWO OR MORE CHEMICALS. IT WAS CONCLUDED, HOWEVER, THAT INSUFFICIENT EVIDENCE WAS AVAILABLE TO RELATE THESE BRAIN TUMORS TO SPECIFIC OCCUPATIONAL FACTORS. VINYL CHLORIDE IN PARTICULAR WAS EXONERATED.

IT IS IMPORTANT TO NOTE THE TYPES OF BRAIN TUMORS THAT WERE INCLUDED IN THIS CASE SERIES. (TABLE 7) ALTHOUGH THE  
4357B

MAJORITY OF THE MALIGNANT TUMORS WERE OF THE CELL TYPE CLASSIFIED AS ASTROCYTOMA OR GLIOMA (TUMORS ARISING FROM THE GLIAL CELLS - SPECIFICALLY THE ASTROCYTES), THERE WERE ALSO FOUR MENINGIOMAS, AN ANATOMICALLY DIFFERENT TYPE OF TUMOR, AND SOME TUMORS THAT WERE INCORRECTLY CLASSIFIED ON THE DEATH CERTIFICATES.

CONTRARY TO THE INITIAL SUSPICION, GLIOBLASTOMA MULTIFORME WAS NOT OVERREPRESENTED IN THIS CASE SERIES. IT HAS BEEN REPORTED BY DR. FRED HOCHBERG THAT THIS TUMOR TYPE REPRESENTS 80% OF ALL PRIMARY MALIGNANT BRAIN TUMORS ASSOCIATED WITH MORTALITY IN ADULT MALES. ONE CAN BE MISLED IF MORBIDITY STATISTICS OR STATISTICS ON ALL PRIMARY BRAIN TUMORS ARE REFERENCED, AS THIS DIAGNOSIS REPRESENTS THE SECOND LEADING CAUSE OF CANCER AMONG CHILDREN AND IN THIS POPULATION GROUP, GLIOBLASTOMA MULTIFORME IS EXTREMELY RARE.

IN CONCLUSION, AN EXCESS (WHICH IS SMALLER THAN HAD BEEN ,ORIGINALLY ANTICIPATED) HAS BEEN CONFIRMED AT THE LARGER OF TWO UNION CARBIDE CHEMICAL PLANTS IN TEXAS. THE "HYPOTHESIS" OF AN OCCUPATIONAL ASSOCIATION WITH THE PETROCHEMICAL INDUSTRY WAS (AND IS) IN NEED OF CONFIRMATION FROM CASE CONTROL STUDIES AS WELL AS OTHER STUDIES CONDUCTED ON INDEPENDENT CHEMICAL PLANTS (WHERE NO A PRIORI EXCESS HAD BEEN SUGGESTED).

THREE OTHER MAJOR PETROCHEMICAL EMPLOYERS IN THE TEXAS GULF COAST HAVE UNDERTAKEN SIMILAR INVESTIGATIONS, AND THE REPORTED FINDINGS HAVE NEITHER CONFIRMED THE PRESENCE OF A BRAIN CANCER RISK NOR ELUCIDATED ITS POSSIBLE CAUSE. THUS, NEITHER THE CASE CONTROL STUDIES CONDUCTED AT THIS PLANT NOR OTHER COHORT AND CASE CONTROL STUDIES CONDUCTED IN OTHER CHEMICAL PLANTS IN THE TEXAS-GULF COAST REGION HAVE PROVIDED SUFFICIENT CONFIRMATION FOR THE ORIGINAL HYPOTHESIS.

DUPONT REPORTED THE FINDINGS FOR OVER 2 MILLION OF ITS ACTIVE EMPLOYEES AS WELL AS 2.2 MILLION OF ACTIVE AND INACTIVE EMPLOYEES BETWEEN 1956 AND 1979.<sup>8</sup> BOTH THE INCIDENCE AND MORTALITY RATES FOR MALIGNANT BRAIN TUMORS WERE CONSISTENT WITH EXPECTATION BASED ON U.S STATISTICS. THE OVERALL STANDARDIZED INCIDENCE RATIO (SIR) WAS 1.02, AND FOR MALE HOURLY WORKERS WAS 0.99. THE STANDARDIZED MORTALITY RATIO (SMR) WAS 0.90 FOR ALL EMPLOYEES AND 0.81 FOR HOURLY MALE EMPLOYEES.

GULF REPORTED ON A STUDY OF 16,000 OF ITS WORKERS WHO WERE EMPLOYED AT A TEXAS REFINERY BETWEEN 1935 AND 1978.<sup>9</sup> THE OVERALL SMR FOR MALIGNANT BRAIN TUMORS WAS 0.91; FOR THOSE EMPLOYED LESS THAN 20 YEARS IT WAS 0.65 AND FOR THOSE EMPLOYED MORE THAN 20 YEARS IT WAS 1.09. NIOSH REPORTED THE FINDINGS OF ITS INVESTIGATION OF DOW CHEMICAL CORPORATION IN TEXAS BETWEEN 1940 AND 1977.<sup>10</sup> BASED ON A 5% SAMPLE OF SOME 2,000 CURRENT AND FORMER

EMPLOYEES, THE OVERALL SMR WAS ESTIMATED TO BE 57 BASED ON 25 OBSERVED BRAIN CANCER DEATHS. ALLOWANCES FOR MIGRATION INDICATED THAT THE MAXIMUM THE SMR COULD HAVE BEEN WAS 1.27.

THESE STUDIES, AS WITH ALL EPIDEMIOLOGIC INVESTIGATIONS, HAVE CERTAIN LIMITATIONS THAT PRECLUDE A DEFINITIVE ANSWER TO THE QUESTION OF WHETHER THERE IS AN INCREASED BRAIN CANCER RISK ASSOCIATED WITH EMPLOYMENT IN CHEMICAL MANUFACTURING PLANTS.

HOWEVER, AT A MINIMUM, THEY DO PROVIDE SOME ASSURANCE THAT THERE IS NO EPIDEMIC OF BRAIN CANCER IN THE TEXAS PETROCHEMICAL COUNTIES. IF INDEED THERE IS ANY RISK OF BRAIN CANCER ASSOCIATED WITH THE CHEMICAL INDUSTRY, IT IS LIKELY THAT THIS RISK WILL BE ASSOCIATED WITH A SPECIFIC SUBSTANCE OR GROUP OF SUBSTANCES AND NOT ASSOCIATED WITH "CHEMICALS" IN GENERAL. WE MUST KEEP IN MIND THAT PRESENT

EXPOSURE LEVELS ARE DIFFERENT AND LOWER THAN PAST.  
4357B

UCC 097549

CLEARLY, THERE IS SOME ELEVATION OF BRAIN CANCER MORTALITY RATES IN SOME AREAS OF TEXAS COMPARED TO THE GENERAL TEXAS POPULATION. MORE ATTENTION SHOULD BE GIVEN TO THE POSSIBILITY OF A PHENOMENON FIRST DESCRIBED BY DR. GREENWALD AS "THE DIAGNOSTIC SENSITIVITY BIAS".<sup>11</sup> THE POSSIBILITY EXISTS THAT THE INCREASED RATE OF CERTAIN DISEASES MAY BE INFLUENCED BY IMPROVED MEDICAL DETECTION AND ATTENTION TO THESE DISEASES.

HEALTH SERVICES IN THE HOUSTON AREA APPEAR TO BE EXTREMELY SOPHISTICATED AND WELL DEVELOPED, AND IF THIS TRANSITION HAS TAKEN PLACE IN THE PAST 10 TO 20 YEARS, IT WOULD NOT BE SURPRISING TO SEE SOME DIFFERENCES IN DISEASE TRENDS RESULTING FROM AN IMPROVED MEDICAL CARE DELIVERY SYSTEM. THE QUALITY OF MEDICAL CARE MAY ALSO BE INFLUENCED TO SOME EXTENT BY THE ADEQUACY OF HEALTH INSURANCE COVERAGE THAT A PATIENT CARRIES. THEREFORE, EMPLOYED POPULATIONS WITH SUBSTANTIAL HEALTH CARE COVERAGE

MAY RECEIVE BETTER HEALTH CARE THAN OTHER SEGMENTS OF THE POPULATION WITH LESS ADEQUATE COVERAGE. MOST IMPORTANTLY, THE BRAIN TUMOR PROBLEM NEEDS TO BE PLACED IN PROPER PERSPECTIVE WITH OTHER HEALTH CARE PRIORITIES IN TEXAS.

A GREAT DEAL OF TIME AND EFFORT ON THE PART OF BOTH PRIVATE AND PUBLIC SECTOR HEALTH AGENCIES HAS BEEN DEVOTED TO THE CONSTRUCTION OF OCCUPATIONAL DATA BASES WHICH MAY PROVE USEFUL FOR TESTING SPECIFIC HYPOTHESES THAT ARISE IN THE FUTURE.

UNTIL A SPECIFIC, CONSISTENTLY IDENTIFIED ASSOCIATION IS FOUND, NO REMEDIAL OR PREVENTIVE ACTIONS CAN BE IMPLEMENTED. A SCIENTIFIC CONSENSUS REGARDING THE PROPER INTERPRETATION OF THE EVIDENCE AVAILABLE TO DATE IS GREATLY NEEDED IN ORDER TO DETERMINE THE APPROPRIATE NEXT STEP.

# REFERENCES

1. NEW YORK ACADEMY OF SCIENCES: BRAIN TUMORS IN THE CHEMICAL INDUSTRY, NEW YORK, 1980.
2. "GLIOBLASTOMA CLUSTER IN A CHEMICAL PLANT - TEXAS" MMWR 29: 359-365, 1980.
3. ALEXANDER, V., LEFFINGWELL, S. S., LLOYD, J. W., ET. AL., "BRAIN CANCER IN PETROCHEMICAL WORKERS: A CASE REPORT." AM. J. IND. MED. 1: 115-123, 1980.
4. A. AUSTIN, S. G., SCHNATTER, A. R., "A COHORT MORTALITY STUDY OF PETROCHEMICAL WORKERS." JOM 25(4): 304-312, 1983.  
  
B. WAXWEILLER, R. J., ALEXANDER, V., LEFFINGWELL, S. S., HARING, M., LLOYD, J. M., "MORTALITY FROM BRAIN TUMOR AND OTHER CAUSES IN A COHORT OF PETROCHEMICAL WORKERS." JNCI 70: 75-81, 1983.
5. AUSTIN, S. G., SCHNATTER, A. R., "A CASE CONTROL STUDY OF CHEMICAL EXPOSURES AND BRAIN TUMORS IN PETROCHEMICAL WORKERS." JOM 25(4): 313-320, 1983.
6. LEFFINGWELL, S. S., WAXWEILLER, R., ALEXANDER, V., LUDWIG, H. R., HALPERIN, W., "CASE-CONTROL STUDY OF BRAIN CANCERS AMONG WORKERS EMPLOYED BY A TEXAS CITY, TEXAS PETROCHEMICAL PLANT." (UNPUBLISHED), MAY, 1983.
7. REEVE, G. R., WAXWEILLER, R. J., LEFFINGWELL, S. S., "AN INVESTIGATION OF BRAIN AND LYMPHOPOIETIC CANCER AT A UNION CARBIDE PLANT IN SEADRIFT, TEXAS." NIOSH, SEPTEMBER, 1983.

8. PELL, S. O'BERG, M. T., KARRH, B. W., "CANCER EPIDEMIOLOGIC SURVEILLANCE IN THE DUPONT COMPANY." JOM 20: 725-740, 1978.
9. WEN, C. P., TSAI, S. P., GIBSON, R. L., "A REPORT ON BRAIN TUMORS FROM A RETROSPECTIVE COHORT STUDY OF REFINERY WORKERS." PROCEEDINGS OF THE NEW YORK ACADEMY OF SCIENCES WORKSHOP ON BRAIN TUMORS IN THE CHEMICAL INDUSTRY, NEW YORK CITY, OCTOBER 27-29, 1980.
10. REEVE, G. R., BOND, G. G., LLOYD, J. M., ET. AL., "AN INVESTIGATION OF BRAIN TUMORS AMONG CHEMICAL PLANT EMPLOYEES USING A SAMPLE - BASED COHORT METHOD." JOM 25: 387-393, 1983.
11. GREENWALD, P., FRIEDLANDER, B. R., LAWRENCE, C. E., ET. AL., "DIAGNOSTIC SENSITIVITY BIAS: AN EPIDEMIOLOGIC EXPLANATION FROM AN APPARENT BRAIN TUMOR EXCESS." JOM 23: 690-694, 1981.

UCC 097553

TABLE 1. 37 CHEMICALS INCLUDED IN THE TEXAS CITY  
BRAIN CANCER CASE-CONTROL STUDY

|                 |                        |                 |
|-----------------|------------------------|-----------------|
| Acetaldehyde    | Hydrochloric Acid      | Styrene         |
| Acetic Acid     | Isopropyl Acetate      | Sulphuric Acid  |
| Acetone         | Methane                | Toluene         |
| Butadiene       | Methanol               | Vinyl Acetate   |
| Carbon Dioxide  | Methyl Ethyl Ketone    | Tergitols       |
| Diethanolamine  | Methyl Isobutyl Ketone | Chlorine        |
| Ethane          | Monoethanolamine       | Trichloroethane |
| Ethanol         | Propylene              | Sodium Sulphite |
| Ethylene        | Sodium Carbonate       |                 |
| Ethylene Glycol | Sodium Hydroxide       |                 |

TABLE 2. **KNOWN OR SUSPECT CARCINOGENS**  
**EVER USED AT TEXAS CITY**

Benzene

Di Ethyl Sulfate

Ethylene Dichloride

Ethylene Oxide

Vinyl Chloride

UCC 097555

TABLE 3  
OBSERVED AND EXPECTED DEATHS AND SMRs BY CAUSE FOR EMPLOYEES AT TEXAS CITY PLANT  
 (WHITE MALES 1941-1977)

| <u>CAUSE OF DEATH</u>            | <u>NO. OF DEATHS</u> |                 | <u>SMR</u> | <u>(95% CI*)</u> |
|----------------------------------|----------------------|-----------------|------------|------------------|
|                                  | <u>OBSERVED</u>      | <u>EXPECTED</u> |            |                  |
| ALL CAUSES                       | 765                  | 923.82          | 83†        | (77-89)          |
| MALIGNANT NEOPLASMS              | 150                  | 174.14          | 86         | (73-101)         |
| BENIGN AND UNSPECIFIED NEOPLASMS | 7                    | 2.98            | 235        | (94-483)         |
| CIRCULATORY DISEASES             | 348                  | 422.65          | 82†        | (74-91)          |
| RESPIRATORY DISEASES             | 26                   | 44.97           | 58†        | (38-85)          |
| DIGESTIVE DISEASES               | 21                   | 53.92           | 39†        | (24-60)          |
| EXTERNAL CAUSES OF DEATH         | 153                  | 147.20          | 103        | (88-122)         |

COHORT CHARACTERISTICS:

TOTAL NO. OF PERSONS, 6,588

TOTAL PERSON-YEARS, 137,745.2

AVERAGE ENTRY AGE, 27.51

CI INDICATES CONFIDENCE INTERVAL

†  $P < .05$

TABLE 4

OBSERVED AND EXPECTED DEATHS AND SMRs FOR EMPLOYEES WITH GREATER THAN  
SIX MONTHS' EMPLOYMENT BY CAUSE AND PAYROLL STATUS, NEOPLASMS ONLY  
(WHITE MALES 1941-1977)

| <u>CAUSE OF DEATH</u>            | <u>EVER HOURLY</u> |          |            | <u>NEVER HOURLY</u> |          |            |
|----------------------------------|--------------------|----------|------------|---------------------|----------|------------|
|                                  | <u>O</u>           | <u>E</u> | <u>SMR</u> | <u>O</u>            | <u>E</u> | <u>SMR</u> |
| MALIGNANT NEOPLASMS              | 109                | 121.21   | 90         | 16                  | 21.91    | 73         |
| LARGE INTESTINE                  | 7                  | 9.94     | 70         | 2                   | 1.73     | 116        |
| LIVER                            | 4                  | 2.19     | 183        | 1                   | 0.37     | 270        |
| PANCREAS                         | 8                  | 6.53     | 122        | 1                   | 1.12     | 89         |
| LUNG                             | 36                 | 39.72    | 91         | 3                   | 6.89     | 44         |
| BRAIN AND CNS                    | 10                 | 5.01     | 200*       | 0                   | 1.06     | 0          |
| PROSTATE                         | 2                  | 4.48     | 45         | 0                   | 0.63     | 0          |
| BLADDER                          | 1                  | 2.82     | 35         | 0                   | 0.44     | 0          |
| KIDNEY                           | 5                  | 3.27     | 153        | 0                   | 0.58     | 0          |
| LEUKEMIA                         | 8                  | 5.22     | 153        | 0                   | 1.10     | 0          |
| BENIGN AND UNSPECIFIED NEOPLASMS | 7                  | 2.02     | 346*       | 0                   | 0.42     | 0          |

$P < .05$

UCC 097557

Table 5: Observed and Expected Deaths Standardized Mortality Ratio (SMRs) for Malignant Brain Tumors for Hourly Employees Surviving a Minimum of Twenty Years Following Initial Employment at UCC-TC by Length of Employment

| <u>Length of<br/>Employment</u> | <u>No. of<br/>Employees</u> | <u>No. of<br/>PSYRS</u> | <u>Age</u> | <u>O</u> | <u>E</u> | <u>SMR</u> |
|---------------------------------|-----------------------------|-------------------------|------------|----------|----------|------------|
| 0 - 4.9                         | 1,350                       | 11,672                  | 48.24      | 4        | 1.14     | 3.51       |
| 5 - 9.9                         | 215                         | 1,840                   | 46.57      | 0        | 0.17     | 0 .        |
| 10 - 14.9                       | 121                         | 934                     | 48.68      | 0        | 0.09     | 0          |
| 15 - 19.9                       | 181                         | 1390                    | 54.98      | 1        | 0.17     | 5.78       |
| 20.+                            | 1,503                       | 13,125                  | 48.52      | 4        | 1.37     | 2.92       |
| TOTAL                           | 3,370                       | 28,959                  | 48.62      | 9        | 2.94     | 3.06       |

UCC 097558

TABLE 6A.

**PROPORTIONS OF CASES AND CONTROLS "EVER EXPOSED"  
15 YEARS OR MORE PRIOR TO DEATH BY CHEMICAL**

| <b>CHEMICALS</b>     | <b><u>ALL CASES</u></b> |                 | <b><u>GLIOMAS</u></b> |                 | <b><u>CONTROL I</u></b> |                 | <b><u>CONTROL II</u></b> |                 |
|----------------------|-------------------------|-----------------|-----------------------|-----------------|-------------------------|-----------------|--------------------------|-----------------|
|                      | <b><u>No.</u></b>       | <b><u>%</u></b> | <b><u>No.</u></b>     | <b><u>%</u></b> | <b><u>No.</u></b>       | <b><u>%</u></b> | <b><u>No.</u></b>        | <b><u>%</u></b> |
| Propylene            | 9                       | 33.3            | 8                     | 37.5            | 34                      | 61.8            | 25                       | 48.0            |
| Sodium Carbonate     | 9                       | 33.3            | 8                     | 37.5            | 34                      | 41.2            | 28                       | 57.1            |
| Sodium Hydroxide     | 11                      | 81.8            | 9                     | 77.8            | 37                      | 81.1            | 31                       | 80.6            |
| Sodium Sulfite       | 9                       | 44.4            | 7                     | 42.9            | 30                      | 26.7            | 23                       | 26.1            |
| Styrene              | 10                      | 20.0            | 9                     | 22.2            | 33                      | 39.4            | 27                       | 29.6            |
| Sulphuric Acid       | 10                      | 80.0            | 8                     | 75.0            | 34                      | 70.6            | 25                       | 64.0            |
| Tergitols            | 10                      | 40.0            | 9                     | 44.4            | 33                      | 42.4            | 27                       | 48.1            |
| Tetraethylene Glycol | 10                      | 30.0            | 9                     | 33.3            | 31                      | 25.8            | 26                       | 23.1            |
| Toluene              | 10                      | 20.0            | 9                     | 22.2            | 33                      | 39.4            | 27                       | 33.3            |
| Trichloroethane      | 9                       | 44.4            | 7                     | 42.9            | 30                      | 30.0            | 23                       | 30.4            |
| Triethylene Glycol   | 10                      | 30.0            | 9                     | 33.3            | 31                      | 25.8            | 26                       | 23.1            |
| Vinyl Acetate        | 10                      | 50.0            | 9                     | 55.6            | 33                      | 36.4            | 29                       | 37.9            |

UCC 097559

TABLE 6B.

**PROPORTIONS OF CASES AND CONTROLS "EVER EXPOSED"  
15 YEARS OR MORE PRIOR TO DEATH BY CHEMICAL**

| CHEMICALS              | ALL CASES |      | GLIOMAS |      | CONTROL I |      | CONTROL II |      |
|------------------------|-----------|------|---------|------|-----------|------|------------|------|
|                        | No.       | %    | No.     | %    | No.       | %    | No.        | %    |
| Acetaldehyde           | 9         | 22.2 | 8       | 25.0 | 32        | 31.3 | 28         | 46.4 |
| Acetic Acid            | 10        | 20.0 | 9       | 22.2 | 35        | 48.6 | 30         | 46.7 |
| Acetone                | 10        | 70.0 | 9       | 77.8 | 37        | 70.3 | 31         | 74.2 |
| Butadiene              | 9         | 44.4 | 7       | 42.9 | 31        | 58.1 | 24         | 58.3 |
| Carbon Dioxide         | 9         | 55.6 | 8       | 62.5 | 34        | 44.1 | 28         | 57.1 |
| Chlorine               | 9         | 44.4 | 7       | 42.9 | 30        | 26.7 | 23         | 26.1 |
| Diethanolamine         | 10        | 40.0 | 9       | 44.4 | 33        | 42.4 | 27         | 48.1 |
| Diethylene Glycol      | 10        | 30.0 | 9       | 33.3 | 31        | 25.8 | 26         | 23.1 |
| Ethanol                | 10        | 40.0 | 9       | 33.3 | 32        | 40.6 | 27         | 25.9 |
| Ethylene               | 9         | 88.9 | 8       | 87.5 | 34        | 55.9 | 25         | 52.0 |
| Ethylene Glycol        | 10        | 30.0 | 9       | 33.3 | 33        | 39.4 | 30         | 50.0 |
| Hydrochloric Acid      | 10        | 50.0 | 9       | 55.6 | 35        | 48.6 | 28         | 57.1 |
| Hydroxypropyl Acrylate | 10        | 20.0 | 9       | 22.2 | 32        | 21.9 | 27         | 29.6 |

UCC 097560

TABLE 6C.

**PROPORTIONS OF CASES AND CONTROLS "EVER EXPOSED"  
15 YEARS OR MORE PRIOR TO DEATH BY CHEMICAL**

| <b>CHEMICALS</b>            | <b>ALL CASES</b> |          | <b>GLIOMAS</b> |          | <b>CONTROL I</b> |          | <b>CONTROL II</b> |          |
|-----------------------------|------------------|----------|----------------|----------|------------------|----------|-------------------|----------|
|                             | <b>No.</b>       | <b>%</b> | <b>No.</b>     | <b>%</b> | <b>No.</b>       | <b>%</b> | <b>No.</b>        | <b>%</b> |
| Isopropanol                 | 10               | 40.0     | 9              | 44.4     | 35               | 37.1     | 28                | 42.9     |
| Isopropyl Acetate           | 10               | 20.0     | 9              | 22.2     | 35               | 42.9     | 30                | 46.7     |
| Isopropyl Peroxydicarbonate | 10               | 30.0     | 9              | 33.3     | 32               | 21.9     | 27                | 29.6     |
| Lubricating Oils            | 9                | 33.3     | 8              | 37.5     | 34               | 44.1     | 29                | 62.1     |
| Methane                     | 8                | 62.5     | 7              | 57.1     | 32               | 53.1     | 25                | 52.0     |
| Methanol                    | 10               | 40.0     | 9              | 44.4     | 33               | 63.6     | 27                | 59.3     |
| Methyl Ethyl Ketone         | 10               | 30.0     | 9              | 33.3     | 33               | 27.3     | 27                | 29.6     |
| Methyl Isobutyl Ketone      | 10               | 20.0     | 9              | 22.2     | 33               | 27.3     | 27                | 29.6     |
| Monoethanolamine            | 10               | 40.0     | 9              | 44.4     | 33               | 48.5     | 27                | 48.1     |
| Nonane                      | 10               | 20.0     | 9              | 22.2     | 32               | 21.9     | 27                | 29.6     |
| Phosphoric Acid             | 10               | 20.0     | 9              | 22.2     | 31               | 22.6     | 27                | 22.2     |
| Potassium Hydroxide         | 10               | 30.0     | 9              | 33.3     | 31               | 25.8     | 26                | 23.1     |

UCC 097561

TABLE 6D.

**PROPORTIONS OF CASES AND CONTROLS EXPOSED  
TO FIVE CHEMICALS AT UCC TEXAS CITY AT LEAST  
15 YEARS PRIOR TO DEATH**

| CHEMICAL            | <u>ALL CASES</u> |                | <u>GLIOMAS</u> |                | <u>CONTROL I</u> |                | <u>CONTROL II</u> |                |
|---------------------|------------------|----------------|----------------|----------------|------------------|----------------|-------------------|----------------|
|                     | %                |                | %              |                | %                |                | %                 |                |
|                     | <u>Total</u>     | <u>Exposed</u> | <u>Total</u>   | <u>Exposed</u> | <u>Total</u>     | <u>Exposed</u> | <u>Total</u>      | <u>Exposed</u> |
| Benzene             | 9                | 11.1           | 8              | 12.5           | 30               | 26.7           | 23                | 4.3            |
| Diethylsulfate      | 10               | 40.0           | 9              | 33.3           | 33               | 42.4           | 27                | 29.6           |
| Ethylene Dichloride | 10               | 40.0           | 9              | 44.4           | 31               | 32.3           | 26                | 34.6           |
| Ethylene Oxide      | 9                | 22.2           | 8              | 25.0           | 30               | 20.0           | 26                | 23.1           |
| Vinyl Chloride      | 10               | 30.0           | 9              | 33.3           | 33               | 30.3           | 27                | 33.3           |

UCC 097562

TABLE 7. **DESCRIPTION OF 21 BRAIN TUMOR**  
**CASES BY TYPE OF TUMOR**

|                   |           |
|-------------------|-----------|
| <b>Glioma</b>     | <b>17</b> |
| <b>Meningioma</b> | <b>4</b>  |
| <b>Total</b>      | <b>21</b> |

UCC 097563