

Draft version. July 27/95

**Environmental Chromium Pollution and Cancer:  
Studies Conducted by Zhang et al. at JinZhou, China**

by  
ChemRisk  
Alameda, California  
Irvine, California

September, 1995

REPORT.CAR

8/7/95

WB-0062

Draft version. July 27/95

## Executive Summary

WB-0063

## **I.Introduction:**

A report by Zhang and Li (1987) was cited in the Toxicological Profile for Chromium published by the Agency for Toxic Substance and Disease Registry (ATSDR). The original report was written in Chinese and was translated to English by the ATSDR. (see Appendix A)

The article by Zhang and Li (1987) is a summary of a number of environmental and health studies of an episode of groundwater contamination by hexavalent chromium (Cr6+) and other chemicals that occurred in JinZhou County in the LiaoNing Province of China. In this 5 1/2 page (in translation) summary article, only one paragraph dealt with the cancer mortality study of the residents.

The specific statements made by the ATSDR about the results presented in the article by Zhang and Li (1987) are listed in Appendix A. Those statements that directly or indirectly relate to cancer are addressed in this report. An important component of those statements is listed here:

"A retrospective mortality study conducted on a population who resided in a polluted area near an alloy plant that smelted chromium in the People's Republic of China found increased incidences of lung and stomach cancer....The adjusted mortality rates of the exposed population ranged from 71.89 to 92.66 per 100,000, compared with 65.4 per 100,000 in the general population of the district. The adjusted mortality rates for lung cancer ranged from 13.17 to 21.39 per 100,000 compared to 11.21 per 100,000 in the general population. The adjusted mortality rates for stomach cancer ranged from 27.67 to 55.17 per 100,000, which were reported to be higher than the average rate for the whole district (control rates not reported). The higher cancer rates were found for those who lived closer to the dump site (Zhang and Li, 1987). No other information was provided, and it was not possible to estimate exposure levels based on the description of the pollution process. The exposed population was probably exposed by all environmentally relevant routes (i.e., air, drinking water, food, soil)." (pg 57)

These statements closely correspond to those contained in Zhang and Li (1987) and supposedly represent the results of Dr. Zhang's research. These statements imply that cancer incidence was associated with the oral ingestion of Cr6+. If true, this would be the first and only study to report such an association.

To obtain more complete information on this research, ChemRisk contacted Dr. Zhang and requested copies of the primary research reports that were the basis of the summary article of Zhang and Li (1987) and the statements by the ATSDR. Dr. Zhang provided copies of three written reports. (Appendices B-D). In a number of phone conversations, he also provided valuable background information on the interpretation of his written reports as well as additional research information that is not contained in the written reports. These materials are reviewed below with respect to the implied association between cancer and oral ingestion of Cr6+.

## **II. Background Information on China and Cancer in China**

Currently, China is divided into 30 provinces. LiaoNing Province is in the north east part of China, bordering BoHai Bay and North Korea.

JinZhou County is one of approximately 41 counties that comprise LiaoNing Province. In the 1960s and 1970s, JinZhou County was divided administratively into a downtown region of JinZhou City and six suburbs: ZhongTun, Nuer River Region, GuoShu, West Suburb, North Suburb and XueJia. The area is on the plain adjacent to BoHai Bay. The climate is mild and windy; the wind mostly comes from the southwest. The suburbs are engaged primarily in agriculture though there are several industrial plants located there.

A cancer mortality survey was conducted in China in 1973-1975. Cancer rates were found to vary

## **II. Study Design and Results**

The internal report by Zhang and Li (1985) on the mortality analysis of this population (Appendix B) is the primary source of information for the study design.

in the article on the mortality

not contained us with his studies, the results of which had been summarized in the only published report previously available to us. This report presents the background information we obtained from Dr. Zhang as well as certain analyses of those data that he provided to us. Our analyses focused on the reported higher cancer rates in the areas around the JinZhou Alloy Plant and the reported association of these higher cancer rates with the distance from the plant.

Dr. Zhang provided to us a report on the studies of environmental Cr6+ pollution in the JinZhou area. The original copies of this report in Chinese is attached as is a translations of each. This report is discussed in Section II.

Dr. Zhang provided to us two written reports on analyses of cancer mortality. One report addressed the association between cancer incidence and the No.6 Petroleum Plant in ZhongTun, a suburb of JinZhou. The other report examined the association between cancer incidence and potential exposure to Cr6+ from the Alloy Plant. The original copies of these articles in Chinese are attached as are translations of each. These two reports are discussed in Section III. The results of the study of mortality and Cr6+ uses information on the environmental pollution study discussed in Section II.

## **II. Chromium Pollution in the JinZhou Area**

### **III. Examination of Cancer Mortality of the Residents of the JinZhou Area**

#### **III.1 "Study of the Effect of Environmental Pollution in JinZhou Area on Residents Health: I. Mortality Analysis"**

### III. 2 "Analysis of Malignant Neoplasm in the Suburb of JinZhou"

In 1970's Dr.Zhang and some other researchers investigated the chromium contamination in JinZhou area in P.R.China. They conducted several studies to examine the effect of chromium contamination on human health, and arrived on the following conclusions:

"..... hexavalent chromium contamination of water , soil and crops might be the key factor of higher tumor rate. In a rat experiment in 1980, it was confirmed that hexavalent chromium caused a high deformity rate of bone marrow cell chromosomes. This result proved the causation relationship between high chromium concentration and human health."

"In the region located north to TangHezi (location of the alloy plant, which was the source of the chromium contamination) ..... It is necessary to conduct further study to investigate the reason of the high malignant neoplasm death rate. "

"More study is needed to investigate the relation between the environmental pollution and human health, especially malignant neoplasm."

The need for further epidemic study of the relationship between the chromium contamination and resident's health (especially neoplasm death) lead us to conduct this data analysis. The purpose of this study is examining the association of  $\text{Cr}^{+6}$  exposure with cancer. We consider the following measures as the outcomes : number of death caused by cancer, number of death caused by stomach cancer , number of death caused by lung cancer, number of death caused by cancer other than lung and stomach, total number of death and number of death not caused by cancer.

#### II. Study design of the mortality studies conducted by Dr.Zhang:

The first step of the mortality study was collecting information of number of death and reason of death. The overall adjusted cancer death rate of JinZhou area was  $66.35/10^5$ , which was below the average of LiaoNing province. Among the regions in JinZhou area, only ZhongTun( where the

No.6 Petroleum company was) and Nuer River Region ( where the alloy company was,) had cancer death rate slightly higher than the average of LiaoNing province. In Dr.Zhang's mortality studies, he used villages as the study units. His study method is to examine the association between pollution and cancer by comparing cancer death rate of each village and considering the geological conditions of those villages as well. If the number of death cause by cancer is partially attributable to some contamination, we should see the dose responds pattern, which is the higher the concentration of the contamination is, the higher the cancer death rate.

The chromium contamination from alloy plant is a complex contamination with air,water, soil, and food polluted. Among them, the underground water contamination is the key appearance. The measure of air pollution is made by the distance from the contamination source with consideration of the wind direction. The water and soil and food contamination was made by measure of the chromium concentration in them. Because the contamination procedure is that underground water was contaminated first then the soil was contaminated by the moving underground water, and then the crops grown on those fields was contaminated, so the chromium concentration in water, in soil and in foods are highly correlated. The measure of the chromium concentration of underground water may reflect the overall severity of the contamination.

Dr.Zhang's method was validated by its success in identifying No.6 petroleum company as the pollution source of ZhongTun region. He showed a consistent dose response relation of malignant neoplasm in ZhongTun area. However the lack of a parallel dose responds structure in Nuer River region leaves the question of whether the higher cancer death rate in Nuer River area is attributable to the chromium contamination from the alloy plant to further studies.

### **III. Exposure, Mortality and Population Data:**

In our data set, we have chromium concentration in most villages in JinZhou area. Some of them have more than one measure between 1965-1979. We have total population and death rates (cancer death rate, lung cancer death rate, stomach cancer death rate, total death rate) for most of the villages. This data set covers all the data information in Dr.Zhang's former papers.

### **IV: Difference Between Different Regions:**

There are six regions in JinZhou area. They are ZhongTun region, Nuer River region, Xuejia

region, Guoshu region, North Suburb region and West Suburb region. We model the number of death caused by cancer in these six regions by Poisson regression model. The improvement from the model supporting six different death rate in those regions (totally individual death rate model) compared to the model supporting no difference of cancer death rate among those six regions (totally uniform death rate model) can be measured by goodness of fit. ( $p$ -value=0.30, improved goodness of fit=difference of  $-2\log\text{likelihood}=6.07$ ). Loglikelihood test shows that the model supporting two different levels of cancer death rate in those six regions (one death rate is for GuoShu, Nuer River and ZhongTun; the other one is for the West and North suburb and XueJia) significantly improves the goodness of fit compared to the totally uniform death rate model ( $p$ -value=0.03, improve goodness of fit =4.75). The improvement of goodness of fit from the totally individual death rate model to the totally uniform death rate model is 6.07; 78% of them comes from the improvement of two group death rate model compared to the uniform death rate model. The difference of death rate within each group composites the rest 22% of the total improvement of goodness of fit. At the same time, the improvement of goodness of fit from two group model to the totally individual model is not statistically significant ( $p=0.86$ ). The conclusion we draw from this data analysis is that there are some difference between the death rate among these six regions, while the difference mainly comes from the difference between the group of higher rate (Nuer River, ZhongTun, XueJia) and the group of lower rate (West and North suburb, Guoshu).



Table I

## 1970-1978 Death Rates By Region of Suburb of JinZhou

	Total Suburb. Area	Zhong Tun	Nuer River	West Suburb	Xue Jia	North Suburb	GuoShu
1973-75 total death rate	407.34	504.42	518.58	496.87	530.96	421.95	355.76
1970-74 malignant neoplasm	51.42	58.35		47.86		42.93	57.03
1973-78 malignant neoplasm	65.40	73.31	74.40	56.68	61.90	48.98	59.15
1973-78 Adjusted malignant neoplasm	66.35	68.43	68.79	54.33	57.51	45.93	64.66

\* All rate is in  $1/10^5$ .

TABLE 1

7/28/95

WB-0070