Cancer Mortality and Cr^{+6} Exposure in JinZhou, China, 1970-1978

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Abstract

The amount and distribution of chromium contamination in the groundwater of the JinZhou area of China has been presented previously.[1] At the beginning of the contamination episode in 1965, average concentrations of hexavalent chromium (Cr^{+6}) in the affected groundwater of villages ranged from 0.0045 ppm to 2.55 ppm. To assess the long term effect of these levels of Cr^{+6} exposure on human health, we conducted a retrospective mortality study of approximately 100,000 residents living in selected regions and villages of the JinZhou suburbs during 1970-1978.[2] In the Cr^{+6} contaminated villages, the death rates from all cancer, stomach cancer and lung cancer were not positively correlated with the amount of Cr^{+6} contamination. Some of the highest cancer rates were observed in the villages that were the last to receive Cr^{+6} contaminated groundwater and that had the lowest average measured groundwater Cr^{+6} concentrations. All the villages in the contamination pathway had higher cancer death rates compared to the immediately adjacent regions. These results do not indicate an association of cancer mortality with these levels of exposure to Cr^{+6} contaminated groundwater. The observed pattern of cancer mortality might reflect the influence of lifestyle or environmental factors not related to Cr^{+6}. Further follow-up of this cohort is recommended to assess the possible influence of Cr^{+6} and other risk factors on cancer mortality.

Background:

The JinZhou area of LiaoNing Province is composed of a downtown area and six suburb regions: Nuer River Region, ZhongTun Region, GuoShu Region, West Suburb Region, North Suburb Region, and XueJia Region. (Figure 1) The suburb regions are primarily agricultural but are the home of several industrial plants. JinZhou Alloy Plant and No.6 Petroleum Plant are the two largest plants. JinZhou Alloy Plant started regular chromium production in 1965, at which time a large amount of Cr^{+6} containing waste water was discharged.[1] The discharged waste water contributed to the Cr^{+6} contamination only at the beginning of this episode. The Cr^{+6} contained in chromate ore processing residue from the plant was the main source of the Cr^{+6} contamination. The ore residue was accumulated uncovered on an open area next to the plant and transferred Cr^{+6} into the underground water when it was dissolved with rain. Due to the movement of the underground water and the local geological characteristics, a long and narrow contaminated area was formed along the dried river bed of the Old Nuer River. (Figure 1) The contamination continued from the plant until

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1982 when a seepage prevention wall was built around the ore residue dump site. Residents living in the villages located along Old Nuer River were exposed to Cr^{+6} by using well water that had been contaminated with Cr^{+6}.

Retrospective Mortality Studies:

We conducted a series of retrospective mortality studies of the approximately 100,000 residents living in the JinZhou suburb regions in 1970-1978.[2] Most residents were farmers (>95%) who had lived in the JinZhou suburb regions (>95%) for most of their lives. Residences were concentrated in agricultural villages, and there was minimal migration within the population. We examined the death records in the local police departments to locate all deaths that occurred in this population between 1970 to 1978. A standard form was used to abstract the data and to record the cause of each death. All survey staff received training, and a follow-up survey was conducted for part of the death records to ensure the quality of the abstracted data. Age-adjusted cancer rates were calculated for each of the six regions and for each of the five villages in the contamination pathway. The death rate was calculated by dividing the observed number of cancer deaths in 1970-1978 by the size of the population in 1975 estimated from the 1982 census.

Groundwater Cr^{+6} contamination in 1965 was measured at drinking water wells for each village in the contamination pathway. (Table 1) In general, higher levels of the Cr^{+6} contamination occurred in the villages closer to the pollution source, the mound of ore residue next to the JinZhou Alloy Plant. Because concentrations in subsequent years were not available and may differ from those found in 1965, dose-response relationships were examined using the distance of the villages from the source as surrogate for exposure. The Poisson regression model was used in which the expected rate of cancer depends linearly on distance from the contamination source: Rate of Cancer = a + b* distance. Negative values for the slope b indicate that proximity to the source was associated with greater cancer death rates.

Results:

The adjusted cancer death rate for the six suburb regions are as follows: Nuer River Region, 68.79 per 100,000 people per year; for ZhongTun Region, 68.43; for GuoShu Region, 64.66; for West Suburb Region, 54.33; for XueJia Region, 57.51; for North Suburb Region, 45.93. The rates for three of these regions are comparable to the 1973-1975 rate of 66.11 per 100,000 for LiaoNing province.

The death rates of total cancer, lung cancer and stomach cancer for each village in the Cr^{6+} contamination path are presented in Table 1. Stomach cancer comprises a large proportion of the total cancer rate for these villages and for all of China. In general, villages closer to the contamination source do not have higher cancer rates. Some of the highest cancer rates were observed in the villages farthest from the contamination source with the lowest Cr^{6+} contamination. The dose-response models indicated positive association between cancer rates and the distance from the source, contrary to the expected direction of association if Cr^{6+} contamination were associated with higher cancer rates. These positive associations were not statistically significant.

Discussion:

The Cr^{6+} contamination followed long and narrow pathway that started near the JinZhou Alloy Plant in the Nuer River Region and extended to the West Suburb Region. Exposure to Cr^{6+} contamination was highest for the populations closest to the plant and lowest for the populations farthest from the plant. The cancer death rates for the six villages in the contaminated area were not correlated with the magnitude of Cr^{6+} contamination. Neither stomach cancer nor lung cancer indicated a positive association with Cr^{6+} contamination. The absence of a dose-response relationship between cancer and Cr^{6+} clarifies a translation and interpretation of our previous publication.[3] Although Cr^{6+} contamination cannot be ruled out as the reason for the high cancer death rates in these villages, these results do not support such a relationship. The relatively short latency period (i.e., 13 years, 1965 to 1978) covered in this study limits the interpretation of these findings regarding cancer and Cr^{6+} contamination. A mortality study with a longer follow-up period is recommended. These results suggest that lifestyle or environmental factors not related to the Cr^{6+} contamination may be a source of the variation in cancer rates. Additional studies to identify these factors are also recommended.

References:

(1) Zhang JianDong, Li XiLin. Chromium Pollution of Soil and Water in JinZhou. Journal of Chinese Preventive Medicine 1987; 21:262-264.

(2) Zhang JianDong, Li XiLin. Study of the Effect of Environmental Pollution in JinZhou Area on Residents' Health I. Mortality Analysis. ?????.

(3) Agency for Toxic Substances and Disease Registry. Toxicological Profile for Chromium. US Department of Health & Human Services, Public Health Service, TP-92/08, 1993, pg 57.