The Assessment of Probable Impact of Chlororganic Compounds and Dioxins on Mortality of Industrial Workers

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Introduction

Technological processes at the plant Khimprom in the city of Ufa, the Republic of Bashkortostan, are based on the production of chlorine and on the processes of various hydrocarbons chlorination.
The plant has been existing in Ufa beginning from the 40s. The period from 1961 to 1969 was a period of production capacities development and industrial facilities growth, including the production of 2,4,5-trichlorophenoxyacetic acid and 2,4,5-trichlorophenolate of copper (2,4,5-T). Those years are supposed to be the most probable period of the beginning of industrial workers and the city of Ufa population exposure to dioxin. The actual dioxin concentrations in the air of the working zone and in the city air for that period were not measured, however, it can be assumed with a high degree of probability, that for the plant area the concentrations were by several orders higher than for the city air, because at the plant there had been registered group (1961) and mass (1966-1970) cases of a skin disease (chloracne). Later on, in the early 70s, the production of amine salt of 2,4-dichlorophenoxyacetic acid (2,4-D) with improved environmental parameters was adopted. Chloracne was diagnosed only to the workers who were connected with the tetrachlorobenzol production, and also with the production of 2,4,5-trichloro- phenoxcyacetic acid and 2,4,5-T. Cases of chloracne were not registered among the workers of other shops and the city population.
The given paper represents a comparative analysis of oncological mortality for 2,4,5-T and 2,4-D shops workers as compared to the city of Ufa population with the purpose of assessment of probable dioxin impact at industrial plants.

Experimental Methods

We made initial data bases on all people who had worked at Khimprom for the period from 1942 to 1994, and also a data base on mortality of Ufa population for the period from 1960 to 1990. The linkage of both data bases allowed to make the third data base: the information about dead citizens who had ever worked at Khimprom. The last data base was made more precise by means of special additional operations. The analysis was made on the basis of the exponent dependence of oncological disease rate (mortality) on the age:

$$Z(T,t) = r_2 * T^{Q_1} * (t - t_0)^{Q_2} = Z(T_0, t_0) * \left(\frac{T}{T_0}\right)^{Q_1} * \left(\frac{t - t_0}{t_0}\right)^{Q_2}, \qquad (1)$$

where Z - age disease rate (mortality),
T - age,
t - the current year,
t_0 - the starting point for counting (the year of the beginning of technogenic impact),
r_2 - the proportion coefficient,

Q_1, Q_2 - the exponent for age and time.

The exponent Q_1 defines the actual level of age oncological disease rate (mortality). Models (1) are allometric models. In compliance with the model (1) the values Q_1 for all forms of malignant tumours and for all age groups both for men and women for the period from 1961 to 1994 for the city of Ufa were calculated, i.e. the age oncological risks were defined.

In the process of comparative analysis on the basis of actual data on age oncological risks in the city of Ufa we simulated the anticipated number of oncological lethal cases for different shops of Khimprom. The modelling was made in two variants:

a) the exponent Q_1 in the exponential model (1) for the Khimprom workers and for the city population was coincident, i.e. a hypothesis was assumed that age oncological risks for Khimprom workers coincided with those for the city population;

b) the exponent Q_1 in the exponential model (1) for Khimprom workers was higher than for the city population.

The scheme of modelling of anticipated death cases for Khimprom shops may be represented as follows:

1. The main initial data base on every death case in Ufa {M} was grouped according to time periods, sex and age. For the same time periods statistical data on the number of people in the given age groups were obtained. The data on age mortality received in this way were processed with the purpose of receiving an allometric model of oncological mortality for the city of Ufa, i.e. the initial allometric standards.

2. On the basis of the received standards for age oncological mortality in the city of Ufa we calculated the anticipated number of people who had worked at Khimprom and died of cancer, depending on whether the regularities of forming the age oncological mortality (or their allometric model) coincide or not with the city of Ufa. The methods allow to increase the exponent in the model by any number of units for every of the analysed periods - a set of numbers υ_k corresponds to these values. Three hypotheses were treated with $\upsilon = 0; 1; 2$. This is the way to receive hypothetical standards $Z'_K\ (T)$ (Fig. 1, 2).

3. The data base on all Khimprom workers - {W}- was grouped for every analysed period according to sex and age structure so that as a result of performing this procedure we received the age structures of workers (or those who had ever worked) - W_K (T).

4. For every analysed period we calculated the number of anticipated death cases for every age group $S_K\ (T)$. These values are small. This is due to both a relatively small number of sampling in relation to the whole city population and rather a small period of time (about 30 years) from the moment of dioxin exposure. So in further analysis we must take into consideration statistical scatter of death cases in every age group. For this purpose we model a set of samples with the mean coinciding with $S_K(T)$.

5. Further on the samples from this set corresponding to the number of death cases in every age group for every period were summarised and we received a sample of anticipated death cases. The volume of this sample coincides with the volume of the set and equals to N. In our study we assumed N equal to 10 000.

6. The distribution of the anticipated death cases is compared to the actual value M_0, which is received by correlation of the name data bases {M} and {W}.The described methods of modelling are realised by means of standard mathematical software Matlab.

Results and Discussion

It is known that for most kinds of cancer the disease rate definitely increases with age. There are many indications to the fact that for cancer development a coincidence of several events resulting in cells mutation, independent from each other and rare enough, is required. Epidemiological statistics allows to calculate that from two to seven independent random events, each of them of low probability, are required to convert a normal cell into a tumour one. The number of these events finally defines the exponent in the model of oncological disease rate (mortality) (1). The higher the exponent in the model, the more intensively the risk of age oncological disease rate (mortality) increases. Every of these random events may be considered as an additional carcinogenic factor regardless of its origin. Consequently, the considered model situations with the increase of the exponent in the model (1) are in fact an addition of one or two extra carcinogenic factors. In other words, if the actual number of cases of oncological pathology is equal to the anticipated number, on condition that the exponent in the model for Ufa equals to that of Khimprom, then dioxins are not an additional carcinogenic factor for this group of industrial workers. And on the contrary, if actual number of death cases of cancer at Khimprom is equal or close to the anticipated number on condition of increasing the exponent in the model of oncological disease rate by one or two units, then respectively we have the confirmation of the impact of one or two additional carcinogenic factors.

Figures 3 and 4 show the distribution of the anticipated number of dead who died at working or post-working age among the workers of two shops 2,4,5-T and 2,4,-D at Khimprom. The received distributions are correlated with the actual number of oncological deaths. The distributions reflect statistical scattering resulting from the fact that the analysed groups were small in number. The uncertainty of this kind is unavoidable and results from the nature of the analysed object, therefore the received results have a probability character.

So, the analysis of Figure 3 shows that the probability of the fact that in the model of oncological mortality at Khimprom the exponent is by one unit higher is approximately by two times lower than the probability of the fact that in the city and at Khimprom the age oncological mortality is being formed equally. The actual number of deaths of malignant neoplasms coincides with the modal value of the anticipated number. At the same time, the probability of increasing the exponent in the model by two units at the shop 2,4-D is by an order lower than the probability of a zero hypothesis. Consequently, it can be assumed with a high degree of probability that the age oncological mortality at the shop 2,4-D is close enough to the average city indicators.

On the contrary, for the shop 2,4,5-T with equal probability we can see the possibility of increasing the exponent in the model both by one or by two units. The actual number of death cases is considerably different from the anticipated value for the city mortality standard and also from this value with the introduction into the model of one additional factor. So, the most probable is a hypothesis according to which at the given shop there existed at least one additional carcinogenic factor. A similar analysis was made for other shops of Khimprom, what allows to make the following conclusions.

Conclusions

1. The production of 2,4,5-T contributed to increasing the levels of occupational risks what manifested itself in actual increase of oncological mortality among the shop workers as compared to the city population and to the workers of other shops.
2. The revealed effects could not be fully related to dioxins only, because they were present together with other toxic substances of chlororganic compounds group, the content of which in the air of the working area was also high.
3. Oncological mortality among the workers of 2,4-D production practically does not differ from the plant level and is rather close to the city level.

Oncological mortality of men, Ufa (per 100 000)

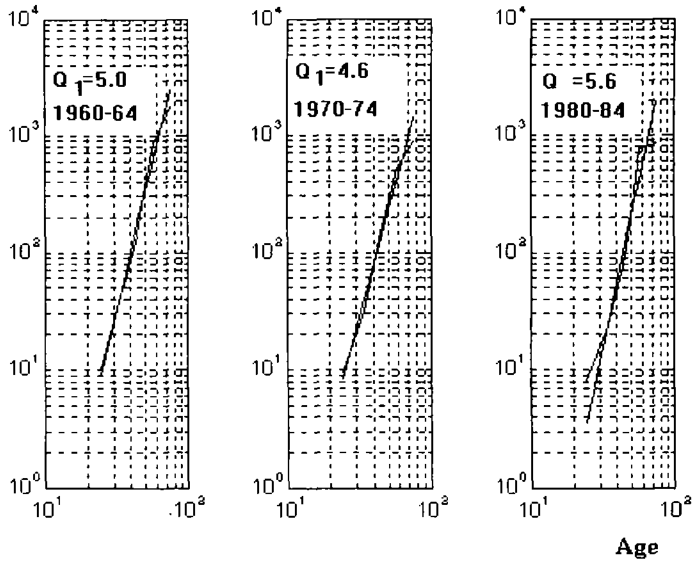

Figure 1

Oncological mortality of women, Ufa (per 100 000)

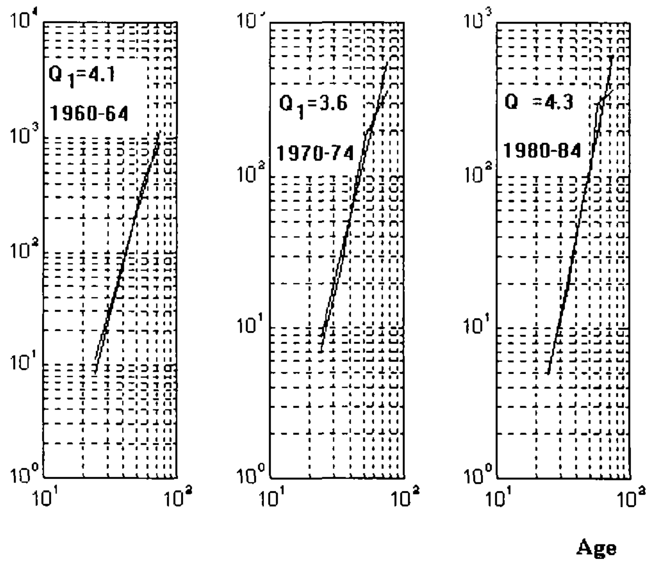

Figure 2

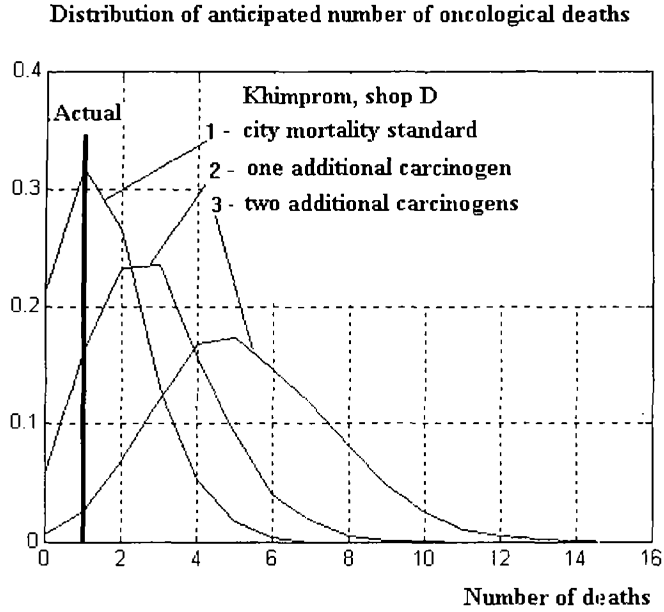

Figure 3

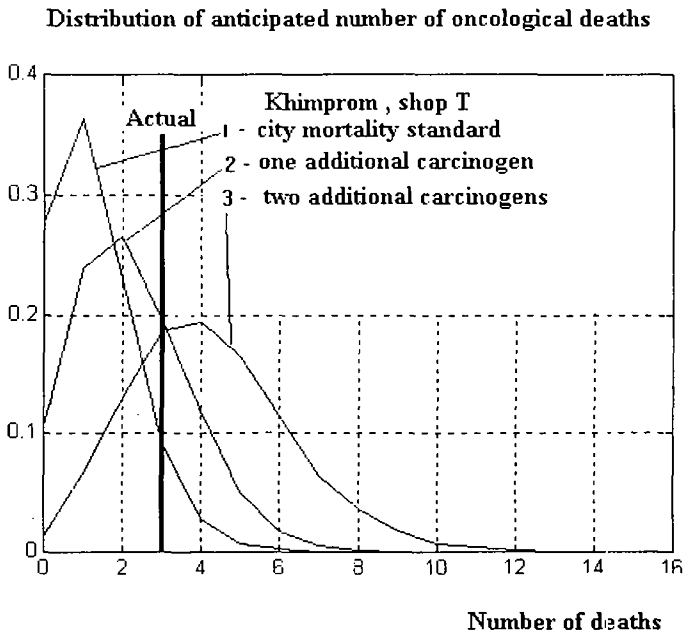

Figure 4