

Occupational exposure to benzene in China

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ABSTRACT Of a total of 528 729 workers exposed to benzene or benzene mixtures in China, 508 818 (96.23%) were examined. Altogether 2676 cases of benzene poisoning were found, a prevalence of 0.51%. A higher prevalence of benzene poisoning was found in the cities of Hangzhou, Hebei, Nanjing, Shenyang, and Xian. The geometric mean concentration of benzene in 50255 workplaces was 18.1 mg/m³ but 64.6% of the workplaces had less than 40 mg/m³. There was a positive correlation between the prevalence of benzene poisoning and the concentration in shoemaking factories. The prevalence of benzene induced aplastic anaemia in shoemakers was about 5.8 times that occurring in the general population. The results of this investigation show the need for practicable hygiene standard to prevent benzene poisoning.

In China today benzene is used more and more widely as industry develops. In the 1950s it was used in painting, shoemaking, and in the production of benzene hexachloride. At that time 3917 benzene workers in factories were examined and 481 cases of chronic benzene poisoning were found, a prevalence rate of 10.1% (reported at 1st National Conference of Occupational Health and Disease in China, 1960). In the 1970s 33312 benzene workers were examined in cities or areas of 12 provinces and 366 cases of chronic benzene poisoning were found, a prevalence rate of 1.1%. To obtain scientific evidence for recommending protective measures against benzene intoxication an investigation of the whole country was undertaken from 1979 to 1981.

Subjects

The subjects for investigation included workers exposed to benzene or benzene mixtures working in all factories in the whole country. They worked in the painting, paint production, shoe manufacturing, organic synthesis, insulation varnish, and printing industries, and rubber and petroleum refineries.

Methods

INDUSTRIAL HYGIENE SURVEY

In every factory the processes of production and pro-

ductive measures were surveyed and the atmospheric benzene concentration determined by gas chromatographic or colorimetric methods.

PERSONAL EXAMINATION

Enquiries about occupational history, personal health, physical examination, and blood counts were made on every worker and diagnosed according to the Criteria of Chronic Benzene Poisoning issued in 1974 by the Ministry of Health in China. These are: (1) history of benzene exposure, (2) leucopaenia ($V < 4000/\text{mm}^3$), and (3) other blood disorders excluded.

Results

Between 1979 and 1981 workers in 28 provinces except Tibet and Taiwan, were investigated.

GENERAL STATUS

Of the 528 729 workers exposed to benzene or benzene mixtures in the country, 508 818 (96.23%) were examined. Of these, 26 319 (4.98%) were exposed to benzene and 502 410 (95.02%) to mixtures containing benzene. The benzene mixtures usually contained benzene, toluene, and xylene in varying concentrations. The source of the benzene (and mixtures) was mainly petroleum refineries.

There were 27 808 factories using benzene as a solvent or as a chemical intermediate in the whole country, of which data were obtained from 19 965 factories. Within these premises the benzene concentration of 50155 workplaces was deter-

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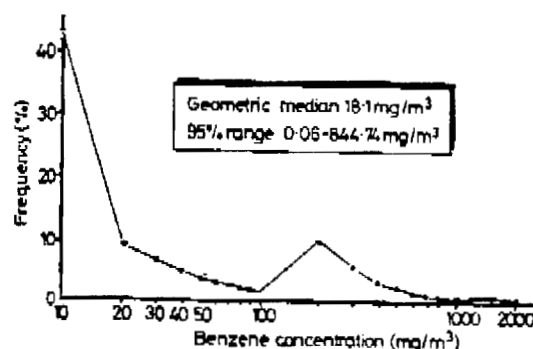


Fig 1 Frequency distribution of benzene concentration.

and in 32486 workplaces (64.6%) it was less than 40 mg/m³. The geometric mean concentration of benzene was 18.1 mg/m³ and the 95% range was 0.06-844.74 mg/m³; 1.3% of workplaces had benzene concentrations in excess of 1000 mg/m³ (fig 1).

PREVALENCE RATE AND DISTRIBUTION OF BENZENE POISONING

Among the benzene workers examined, 2676 cases of benzene poisoning were found, a prevalence rate of 0.51%. The prevalence rate of benzene poisoning was 0.94% in the workers exposed to benzene and 0.44% in the workers exposed to benzene mixtures; this difference is statistically significant ($p < 0.05$). The prevalence rate of benzene poisoning was higher in

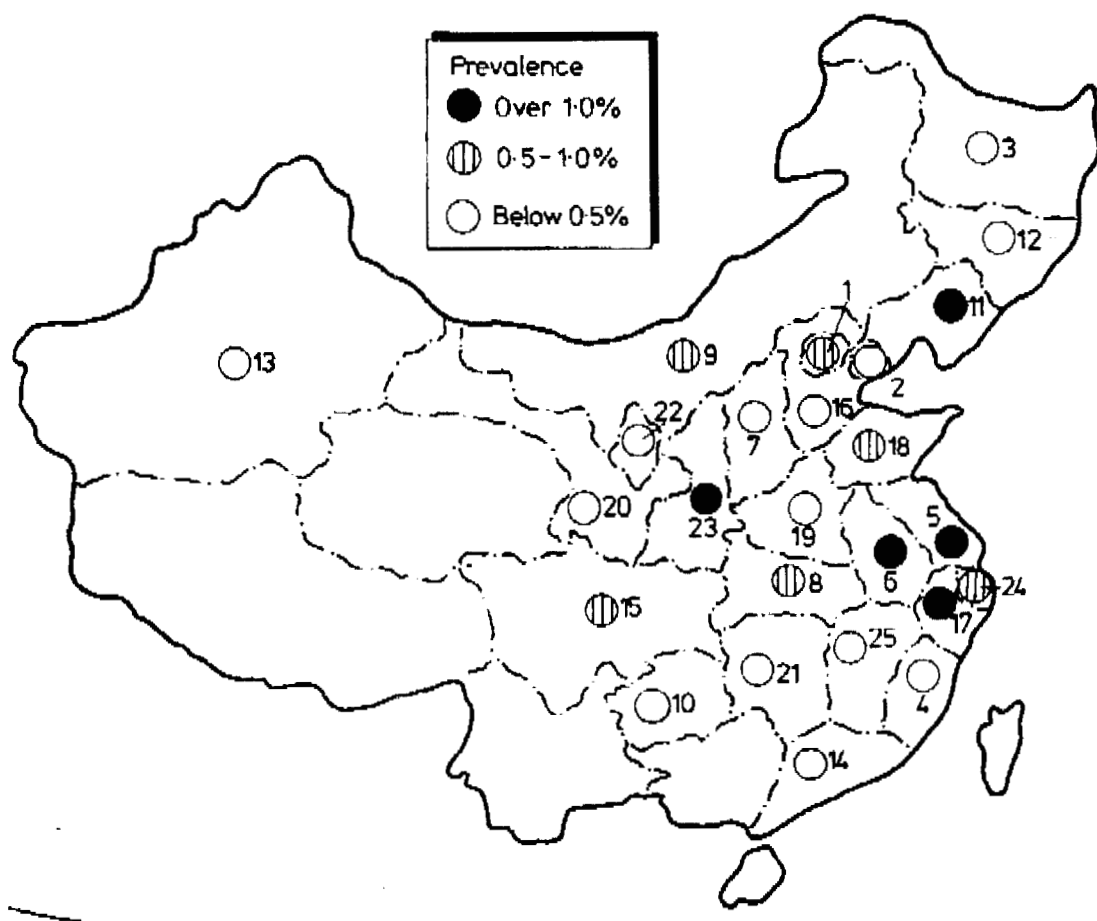


Fig 2 Distribution of benzene poisoning in big cities. (1) Beijing (2) Tianjing (3) Harbin (4) Fuzhou (5) Nanjing (6) Hefei (7) Yinchuan (8) Wuhan (9) Huhhaote (10) Guiyang (11) Shenyang (12) Changchun (13) Wulumuqi (14) Guangzhou (15) Chengdou (16) Shijiazhuang (17) Hangzhou (18) Jinan (19) Zhengzhou (20) Lanzhou (21) Changshu (22) Taiyuan (23) Xian (24) Shanghai (25) Nanchang.

Comparison of prevalence of leucopaenia in
industries using benzene

Industries	Workers	Cases	%
Shoemaking	19213	240	1.25
Paint producing	12359	67	0.54
Painting	101379	415	0.41
Spray painting	175313	682	0.39
Benzene refining	6452	11	0.17
Chemical synthesis	42766	190	0.44
Pharmaceuticals	6576	41	0.62
Rubber	13877	56	0.40
Insulation varnish	24370	101	0.41
Printing	15453	46	0.30
Loading workers	870	7	0.80
Others	35906	142	0.40
Total	454542	1998	

the cities of Hangzhou, Hefei, Nanjing, Shenyang, and Xian (fig 2).

RISK OF BENZENE IN DIFFERENT TYPES OF INDUSTRIES

There were about 280 000 paint workers and this was the largest group of workers examined. The percentages of workers in painting, organic synthesis, insulation varnish, and shoemaking industries were 63.6, 10.9, 5.4, and 4.2 respectively. The printing, rubber, and refinery industries were all less than 3.5%. The prevalence rate of benzene poisoning was 1.25% in the shoemaking industry and 0.54% in the painting industry (table).

RELATION BETWEEN THE INCIDENCE OF LEUCOPAENIA AND THE BENZENE CONCENTRATION IN DIFFERENT INDUSTRIES

Based on the data from 24985 factories, the relation between the incidence of leucopaenia (WBC $< 4000/\text{mm}^3$) and the percentage of factories with low benzene concentration ($< 40 \text{ mg}/\text{m}^3$) was estimated. The correlation coefficient was -0.5 ($p < 0.05$). That is to say, leucopaenia is more likely to occur in industries in which the benzene concentration is high.

CONCENTRATION RESPONSE RELATION OF BENZENE

Among the 141 shoemaking factories were 28 in which benzene poisoning was found. Among the 7740 workers employed were 124 cases of benzene poisoning. A positive relation between the prevalence of poisoning and airborne benzene concentration was found (fig 3) and the correlation coefficient was 0.42 ($p < 0.05$). The benzene concentration was higher than $25 \text{ mg}/\text{m}^3$ in 86% of the factories and about $10 \text{ mg}/\text{m}^3$ in only a few factories. These results show that cases of benzene poisoning may occur even in factories with low concentration ($< 40 \text{ mg}/\text{m}^3$). It there-

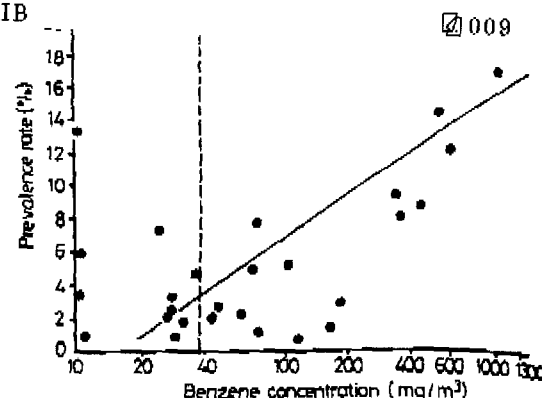


Fig 3 Relation between benzene concentration and prevalence in shoemaking industry.

fore seems desirable to consider the revision of the present hygiene standard for benzene.

APLASTIC ANAEMIA AND LEUKAEMIA

Twenty four cases of aplastic anaemia and nine of leukaemia were found in this investigation. Of the 24 cases of aplastic anaemia, complete records were available in 17: seven men and 10 women aged from 18 to 61. They were exposed to benzene from 3.5 months to 19 years. Most cases came from shoemaking and paint production factories but a few also came from glueing and repairing and some from packing insecticides. The benzene concentration! were generally above the hygiene standard $93-1156 \text{ mg}/\text{m}^3$.

For example, in a shoemaking factory sandals were produced from July 1980 to March 1981. A mixture of chlorobutadiene and benzene (1:3) was used as an adhesive. Four cases of aplastic anaemia were detected among the 211 manual workers employed in this workshop during the eight month period. A showed typical signs, symptoms, and changes in the blood and bone marrow. The workers with aplastic anaemia had been exposed to benzene for an average latent period of 118.5 days and their daily mean concentration was estimated to be about $1035.6 \text{ mg}/\text{m}^3$. The total amount of inhaled benzene was about 8278 g. The incidence of aplastic anaemia in this factory was 1.9% and it was ordered to stop production after the cases occurred. They then used a solvent containing no benzene and no further cases developed.

Nine cases of benzene leukaemia were found in this investigation, six men and three women aged from 18 to 62. They were exposed to benzene from seven to 10 years, except for one worker who was exposed

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only two years. There were four painters, one shoemaker, one insecticide packing worker, one cleaner, and two analytical technicians. Of the cases, six were diagnosed as acute myelocytic leukaemia, whereas the others were diagnosed as acute erythroleukaemia, acute monocytic leukaemia, and acute lymphocytic leukaemia, respectively. Six had had a preceding leukopaenic or pancytopenic period.

Discussion

This is the first report describing in detail an investigation of the occupational benzene hazard in the whole of China. The results of the investigation underline the risk of benzene and present the distribution of benzene poisoning in different industries and the relation between benzene poisoning and the airborne concentration. It provides an important scientific basis for evaluating the risk from benzene in China.

DISTRIBUTION OF BENZENE POISONING

More than 500 000 workers were exposed to benzene or benzene mixtures, the largest number exposed to industrial chemicals. A total of 27803 factories or workshops used benzene and the prevalence of benzene poisoning was 0.5%. This is much lower than reported in the 1950s (10.1%), and shows that the hygiene conditions of workplaces was in general better than at that time. Nevertheless, the situation regarding benzene poisoning was worse in a few factories and cities, calling for special attention in these places.

Benzene was usually used as a solvent and as a starting material in organic synthesis. Most of the benzene workers (about 90%) used benzene as a solvent. The results showed that the prevalence rate of benzene poisoning was significantly lower in workers exposed to benzene mixtures (containing toluene, xylene, and benzene) than in benzene workers. The use of toluene and xylene instead of benzene is an effective measure for preventing benzene poisoning. Hara, at a lecture in China in 1979, also reported this to be an important measure for controlling benzene poisoning.

HYGIENE STANDARD FOR BENZENE

At present, the maximum allowable concentration of benzene in the workplace in China is 40 mg/m³. The present United States threshold limit value is 10 ppm (32 mg/m³) TWA, the same as the maximum permissible level in the United Kingdom. In this

investigation cases of benzene poisoning were found in factories where the benzene concentration was less than 40 mg/m³; therefore the present hygienic standard should be lowered. Whether it should be decreased to less than 25 mg/m³ remains to be studied further.

RISK OF SEVERE BENZENE POISONING

Many papers have reported on benzene poisoning.^{3,4} Recovery from mild poisoning is the general rule, but when aplastic anaemia develops recovery is less certain. Sixteen cases of aplastic anaemia diagnosed during this investigation were distributed among six provinces, a prevalence of 3.5/100 000. In the shoe-making industry the prevalence was 12.1/100 000 as compared with that in the general population in Japan and Sweden which ranges from 1.5 to 2.4/100 000⁵ and about 2.1/100 000 among the general population in Mudanjiang (the north east of China). The prevalence among shoemakers was 5.8 times that of the general population. The investigation showed that aplastic anaemia could develop in about 118 days in workers exposed to benzene concentrations at a level of 1035.6 mg/m³. Further study is necessary in order to have a better understanding of the course of benzene induced aplastic anaemia.

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References

- 1 Rinsky RA, Young RJ, Smith AB. Leukemia in benzene workers. *Am J Ind Med* 1981;2:217-45.
- 2 Brief RS, Lynch J, Beinath T, Scala RA. Benzene in the workplace. *Am Ind Hyg Assoc J* 1980;41:616-23.
- 3 Laskin S. *Benzene toxicity (a critical evaluation)*. Washington-London: Hemisphere Publishing Corporation, 1978.
- 4 Thorpe JJ. How much benzene causes cancer? *Hydrocarbon Processing* 1978;57:172-4.
- 5 Yang C. Study on aplastic anemia in China (a review). *Chinese Journal of Hematology* 1980;1:3-5.