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 2,676 cases of benzene poisoning were found, a prevalence of 0.51%. A higher prevalence of benzene poisoning was found in the cities of Hangjou, Hefei, Nanjing, Shenyang, and Xian. The geometric mean concentration of benzene in 50,255 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 a 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 33,312 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 protective 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 (WBC <4000/mm³), 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 19,969 factories. Within these premises the benzene concentration of 50,255 workplaces was determined.
Occupational exposure to benzene in China

and in 32,486 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 1 Frequency distribution of benzene concentration.

the cities of Hangjou, 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 LEUCOPENIA AND THE BENZENE CONCENTRATION IN DIFFERENT INDUSTRIES
Based on the data from 24,985 factories, the relation between the incidence of leucopenia (WBC < 4000/mm³) and the percentage of factories with low benzene concentration (< 40 mg/m³) was estimated. The correlation coefficient was -0.5 (p < 0.05). That is to say, leucopenia 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 2740 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 mg/m³ in 86% of the factories and about 10 mg/m³ in only a few factories. These results show that cases of benzene poisoning may occur even in factories with low concentration (< 40 mg/m³). It therefore 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 months to 19 years. Most cases came from shoemaking and paint production factories but a few also came from gluing and repairing and some from packing insecticides. The benzene concentrations were generally above the hygiene standard, 93–1156 mg/m³.

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. All 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 mg/m³.

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 new 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 30 to 62. They were exposed to benzene from seven to 25 years, except for one worker who was exposed for...
Occupational exposure to benzene in China

only two years. There were four painters, one shoe-
maker, 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 distribu-
tion of benzene poisoning in different industries and
the relation between benzene poisoning and the air-
borne 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 27,080 factories or
workshops used benzene and the prevalence of ben-
zeine 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 fac-
tories 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 sol-
vent. 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) TWA1 the same as the maximum permis-
sible level in the United Kingdom.² 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 stan-
dard 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 cer-
tain. 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.

We thank Professor Li Yuru and Dr Robert Murray, presi-
dent of the International Commission on Occupational
Health, for a critical review of this manuscript.

This investigation was supported by the Ministry of Health
and Local Health Administrative Authorities in China.

This paper was reported at the permanent Commission and
International Association on Occupational Health Scientific
Committee on Maximum Permissible Limits Meeting on

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