Increased Subjective Symptom Prevalence among Workers Exposed to Trichloroethylene at Sub-OEL Levels

YU-TANG LIU, CHUI JIN, ZHEN CHEN, SHI-XIONG CAI, SONG-NIAN YIN, GU-LAN LI, TAKAO WATANABE, * HARUO NAKATSUKA, * KAZUNORI SEIJI, *† OSAMU INOUE, *† TOSHIO KAWAI, ‡ HIROHIKO UKAI § and MASAYUKI IKEDA *

Institute of Occupational Medicine, Chinese Academy of Preventive Medicine, Beijing, China, * Department of Environmental Health, Tohoku University School of Medicine, Sendai 980, † Tohoku Rosai Hospital, Sendai 980, ‡ Kinki Regional Safety and Health Service Center, Industrial Health and Safety Association, Osaka 541, and § Kyoto Industrial Health Association, Kyoto 604

LIU, Y.-T., JIN, C., CHEN, Z., CAI, S.-X., YIN, S.-N., LI, G.-L., WATANABE, T., NAKATSUKA, H., SEIJI, K., INOUE, O., KAWAI, T., UKAI, H. and IKEDA, M. Increased Subjective Symptom Prevalence among Workers Exposed to Trichloroethylene at Sub-OEL Levels. Tohoku J. exp. Med., 1988, 155 (2), 183-195 — Over 100 workers exposed to trichloroethylene (TRI) mostly at less than 50 ppm during the production or vapor degreasing operation and about an equal number of the non-exposed control workers were examined for subjective symptoms, hematology, serum biochemistry, and sugar, protein and occult blood in urine. Essentially all the clinico-laboratory tests stayed normal, and there was no significant difference in the findings between the exposed and the controls. Thus, no clinically significant effects of TRI exposure were found in the blood and liver functions among the exposed workers as compared with the controls. The prevalence of the subjective symptoms was, however, significantly higher in the exposed group than in the controls, and dose-response relationship could be established in some selected symptoms such as nausea, heavy feeling in the head, forgetfulness, tremor in extremities, cramp in extremities and dry mouth, although the exposure was low. The findings warrant further attention to the effects of TRI especially on the central nervous system at the concentration lower than, e.g., 50 ppm. —— diffusive sampling; hematology; liver function; subjective symptoms; trichloroethylene

Received April 18, 1988; revision accepted for publication May 23, 1988.
Contact point: Prof. Masayuki Ikeda, Department of Environmental Health, Tohoku University School of Medicine, Sendai 980, Japan.
Requests for reprints to: Prof. M. Ikeda, Department of Environmental Health, Tohoku University School of Medicine, Sendai 980, Japan.
Trichloroethylene (TRI) has been one of the most popular industrial degreasing solvents (Inoue et al. 1983) with annual consumption of well over 70 kilotons in Japan in 1985 (Ministry of International Trade and Industries 1986) or more than 80 kilotons in U.S. in 1986 (Starck 1987). Apart from its carcinogenic potential in mice (National Cancer Institute 1976), it is well known that this chlorinated hydrocarbon has a potent narcotic capacity when dense vapor is inhaled. Reviewing of the literatures (National Institute for Occupational Safety and Health 1977; World Health Organization 1981; International Programme on Chemical Safety 1985) disclosed, however, that only few articles are available for the effects of this important solvent on the nervous system of the workers exposed at the current occupational exposure limit (OEL) of, e.g., 50 ppm (American Conference of Governmental Industrial Hygienists 1987; Deutsche Forschungsgemeinschaft 1987; Japan Association of Industrial Health 1987), and that the information is even scarce on the effects at sub-OEL levels.

In the present study, two groups of TRI-exposed workers, one in a TRI-synthesizing workshop and the other in a metal degreasing workshop, were examined for the nervous system-related and other subjective symptoms together with possible effects on the liver functions, and the prevalence of the symptoms was evaluated in relation to the intensity of exposure to the vapor. The results are described in this article. Comparable studies on two aromatics of benzene and toluene are reported in separate articles (Yin et al. 1987; Lee et al. 1988).

**Materials and Methods**

*Population studied*

The survey was conducted in 1987 in two workshops in the factories in northern China. About 100 TRI-exposed workers and similar number of non-exposed controls of both sexes were examined (Table 1). The age ranged from less than 20 years to over 50 years in both groups. The exposed workers were all subjects either in Workshop A in one plant to synthesize TRI by chlorination of acetylene, or in Workshop B in the other plant where TRI was employed for vapor-degreasing of metal parts. They (including women) served on three shifts [0800 to 1600, 1600 to 2400 (midnight) and 2400 to 0800]. Control workers were all subjects engaged in the production and packing of H₂/O₂/N₂ (but not Cl₂) gases in the former plant, or lathe or grinder operators in the latter.

*TRI exposure*

The time-weighted average concentration in the breath zone air during the entire shift (about 8 hr) was measured by the use of diffusive samplers placed on the chest of each worker. Carbon cloth, K-filter TF 1500 (Toyobo Co., Osaka), was employed as the adsorbent; the cloth was packed in aluminum foil immediately after the exposure and kept refrigerated until analyzed by carbon disulfide extraction followed by FID-capillary gas-chromatography (Hirayama and Ikeda 1979; Ikeda et al. 1984; Kasahara and Ikeda 1987).

*Subjective symptom survey*

Self-completion questionnaire for solvent workers (Inoue 1968) supplemented with three pancytopenia-related questions (Yin et al. 1987) was employed as previously described (Yin et al. 1987; Lee et al. 1988). Furthermore, two more questions (No. 58 Bloody,
strawberry jam-like feces and No. 59 Frequent flatus) were added (after the suggestion by Prof. A. Sato, Yamanashi Medical College, Kofu) as the symptoms common in intestinal cystoid pneumatosis cases for which TRI has been suspected to be a causative agent (Sato et al. 1984). Thus, Part 1 of the questionnaire consisted of 12 questions on the symptoms during work, whereas Part 2 was with 59 questions on the symptoms in the recent 6 months. When the completed questionnaire was submitted, the responses were confirmed by a public health nurse at an interview. The questionnaire is originally in Japanese and was translated into Chinese for the use in the present study. The English version has been published elsewhere. The numbering of the symptoms in the present report is as in the English version (Yin et al. 1987).

In evaluating the subjective symptom prevalence, the exposed workers were divided into three groups when necessary, i.e., those exposed to TRI at 1-10 ppm, 11-50 ppm and 51-100 ppm; 50 ppm is the current OEL in many countries (American Conference of Governmental Industrial Hygienists 1987; Deutsche Forschungsgemeinschaft 1987; Japan Association of Industrial Health 1987), whereas 10 ppm was selected as a round number which divides those exposed at 1-50 ppm into two groups of roughly equal size. No consideration was made regarding the smoking and drinking habits, as most of men were smokers (<70%) but drank very little while women were essentially nonsmokers and nondrinkers.

Clinico-laboratory examinations

The examination was carried out at the end of the shift, at least 4 hr after any meal. In addition to routine physical examination, venous blood (from cubital vein) and urine were collected from each worker. The samples were transferred to analytical laboratories within 48 hr. Serum and urine samples were immediately frozen there at −20°C till analyses. hematology [counting of white blood cells (WBC), red blood cells (RBC) and platelets (PLT), and determination of hemoglobin concentration (HB) and hematocrit (HT)] and serum biochemistry [assays of aspartate aminotransferase (ASAT or GOT: EC 2.6.1.1), alanine aminotransferase (ALAT or GPT: EC 2.6.1.2), gamma-glutamyl transpeptidase (gamma-GTP: EC 2.3.2.1), alkaline phosphatase (ALP: EC 3.1.3.1), choline esterase (CHE: EC 3.1.1.8), lactate dehydrogenase (LDH: EC 1.1.1.27), leucine aminopeptidase (LAP: EC 3.4.1.1), thymol turbidity test (TTT), zinc turbidity test (ZTT) and determina-
tion of total bilirubin (BIL) were conducted with a Coulter Counter (Model S+4) and a Hitachi Blood Chemistry Analyzer (Model 716 Hitachi, Ibaragi), respectively.

The normal ranges employed for hematology (Yin et al. 1987) and liver function items (Seiji et al. 1987) were as previously reported except that 118 to 220 and 103 to 175 Goldbarg units were taken as the normal range for men and women, respectively, in leucine aminopeptidase assay. Protein, sugar and occult bleeding in urine were examined with Iatrocheck® (testapes supplied by Iatron Laboratories, Inc., Tokyo).

RESULTS

Intensity of TRI exposure

The monitoring of exposure to TRI (Table 2) disclosed that the time-weighted average value for each exposed worker ranged up to 100 ppm in both sexes, and that the majority was, however, exposed below 10 ppm and some at 11–50 ppm. Only 8 out of the solvent workers were exposed at the concentrations above the current occupational exposure limit (OEL) of 50 ppm (American Conference of Governmental Industrial Hygienists 1987; Deutsche Forschungsgemeinschaft 1987; Japan Association of Industrial Health 1987). Contrary to the expectation that the exposure should be less intense in the production plant (i.e., Workshop A) rather than the degreasing plant (Workshop B), the level was significantly ($p < 0.05$ by chi-square test) higher among men in Workshop A than in Workshop B, whereas the difference in women was insignificant ($p > 0.10$) possibly because only two exposed women were available in Workshop B. The difference in exposure intensity between the two sexes was of borderline significance ($0.05 < p < 0.10$).

Prevalence of subjective symptoms

The prevalence of subjective symptoms was compared between the control and exposed workers in terms of the rate defined as

| Table 2. Number of exposed workers by sex, by workshop and by the intensity of exposure to trichloroethylene |
|---|---|---|---|---|
| Sex | Workshop | Trichloroethylene level (ppm)† | | |
|     |     | 1–10 | 11–50 | 51–100 | Total |
| Men | A | 24 | 15 | 4 | 43 |
|     | B | 31 | 5 | 0 | 36 |
|     | A + B | 55 | 20 | 4 | 79 |
| Women | A | 9 | 9 | 4 | 22 |
|      | B | 2 | 0 | 0 | 2 |
|      | A + B | 11 | 9 | 4 | 24 |

†Time-weighted average concentration during the 8-hr shift.
Table 3. Comparison in subjective symptom prevalence between the control and exposed workers, and possible dose-dependency in prevalence

<table>
<thead>
<tr>
<th>Part in questionnaire</th>
<th>Sex</th>
<th>Comparison between</th>
<th>Rate§ at trichloroethylene level (ppm) of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Controls</td>
<td>Exposed</td>
</tr>
<tr>
<td>Part 1 (12 questions)</td>
<td>Men</td>
<td>85 46 0.045</td>
<td>79 186 0.196**</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>26 14 0.045</td>
<td>24 30 0.104**</td>
</tr>
<tr>
<td></td>
<td>Men + Women</td>
<td>111 60 0.045</td>
<td>103 216 0.175**</td>
</tr>
<tr>
<td>Part 2 (59 questions)</td>
<td>Men</td>
<td>85 246 0.049</td>
<td>79 848 0.182**</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>26 69 0.045</td>
<td>24 223 0.157**</td>
</tr>
<tr>
<td></td>
<td>Men + Women</td>
<td>111 315 0.048</td>
<td>103 1,072 0.176**</td>
</tr>
</tbody>
</table>

**p < 0.01 by chi-square test.
†Number of respondents.
‡Total number of affirmative answers in each part.
§The rate calculated as

Total number of affirmative answers
Number of respondents × Number of questions in the part.
the rate of the affirmatives over the total questions. The comparison on the responses of the workers (Workshops A and B combined) to the questionnaire (Part 1 with 12 questions and Part 2 with 59 questions, separately) disclosed that the rate was significantly higher ($p < 0.01$) in the exposed than in the controls either in men, women or the combination both in Part 1 and Part 2 (Table 3), indicating that the exposed workers had more subjective symptoms than their counterpart controls. The examination for possible dose-dependency (right half in Table 3) revealed that the prevalence increased at the highest exposure concentration range in Part 2 questions both in men and women, and also in the combination, whereas dose-dependent increase was not clear in Part 1 questions.

As the affirmative answer rate was about 3 times higher in the exposed workers than in the controls (Table 3), the symptoms that were $\geq 3$ times more common in the exposed than in the controls were selected among the 12 symptoms in Part 1 and 59 symptoms in Part 2. The selection was separately made for the three groups of workers, i.e., men in Workshop A, women in Workshop A and men in Workshop B. The prevalence among women in Workshop B was not examined because only 4 controls and 2 exposed were available there.

When a symptom was $\geq 3$ times more common in the exposed than in the controls in all of the three groups, the symptom was considered to be possibly related to TRI exposure. Thus, the following symptoms met the selection criteria, i.e., two symptoms of No. 9 Floating sensation and No. 10 Drunken feeling in Part 1, and 10 symptoms of No. 1 Heavy feeling in the head, No. 4 Nausea, No. 10 Light-headedness, No. 13 Forgetfulness, No. 15 Tremor in extremities, No. 16 Cramp in extremities, No. 26 Dry mouth, No. 30 Body weight loss, No. 32 Changes in perspiration pattern, and No. 44 Joint pain in Part 2. Further analyses of the prevalence (for men and women in the two workshops combined) in relation to the exposure intensity (Fig. 1) revealed that the rate increased steadily in symptom No. 4 (Nausea) (Fig. 1A) and that the additional increment at $> 50$ ppm was evident in symptom No. 1, 13, 15, 16 and 26 while the rates at 1–10 ppm and 11–50 ppm were equal to each other (Fig. 1B). No apparent dose-response relationship could be observed in other symptoms (Fig. 1C).

Regarding the response in the two symptoms of No. 58 Bloody, strawberry jam-like feces and No. 59 Frequent flatus, 3 and 14 exposed workers responded affirmatively to Questions No. 58 and 59, respectively, and it was 0 and 1 among the controls, when men and women in the two workshops were combined. The difference in the prevalence between the exposed and the controls was of borderline significance ($p < 0.10$) in Symptom No. 58 and statistically significant ($p < 0.01$) in Symptom No. 59. It should be added that very few complained
Symptoms Due to Trichloroethylene Exposure

Due to Trichloroethylene Exposure

189

hemodyscrasia-related symptoms [e.g., No. 34 Increased menstrual flow (women only), No. 54 Frequent bleeding from gums, No. 55 Frequent nasal bleeding, or No. 56 Frequent skin infection] both in the exposed group and the control group with no difference in the prevalence between the two.

Findings in hematology, liver function tests and urinalysis

The hematology and liver function test items were conducted in all subjects except for two women who could not offer enough blood (Table 1). Statistically significant difference (either in means or in the rate of abnormal/total cases in

Fig. 1. Three types of response in subjective symptom prevalence with increase in exposure intensity

The top (A), the middle (B) and the bottom (C) figures show the cases with a linear increase in subjective symptom prevalence, those with little change up to 50 ppm followed by an increase at the higher concentrations, and those with essentially no dose-response relationship, respectively. The symptom (in Part 2 unless otherwise specified) cited in A is No. 4 Nausea, those in B are No. 1 Heavy feeling in the head, No. 13 Forgetfulness, No. 15 Tremor in extremities, No. 16 Cramp in extremities and No. 26 Dry mouth, and those in C are No. 9 Floating sensation and No. 10 Drunken feeling (both in Part 1), No. 10 Light-headedness, No. 32 Changes in perspiration pattern, No. 38 Ringing in ears, and No. 44 Joint pain.
men or in women) was observed only in hematocrit values in hematology, and GPT, LAP and LDH in liver function tests. Such items are listed in Table 4 together with measured values. The low hematocrit values were however not associated with changes in other items to suggest anemia. Deviation from normal ranges of liver function indicators were all slight and of subclinical levels, except for two cases in which both GOT and GPT were elevated to a degree of clinical significance (GOT, 75 Karmen units; GPT, 115 Karmen units) in a 25 year-old nondrinking-nonsmoking exposed man, and to subclinical levels (GOT, 32 Kar- mén units; GPT, 24 Karmen units) in an exposed man at the age of 48 years who was a smoker but not a drinker. Regarding other items of hematology and serum biochemistry, all the values were essentially within the corresponding normal ranges and there was no statistically significant difference either in means or in the prevalences of abnormal values both in men and in women.

Urinalysis for protein and sugar disclosed positive cases with no clustering, i.e., one proteinuria case each, and 4 and 6 sugar-positive cases in the control and exposed groups, respectively. The statistical analysis suggested no bias in distribution of the cases between the two groups. Observation on occult bleeding was not informative. Thus, no association with TRI exposure was identified in the urinalysis items studied.

**DISCUSSION**

The neurotoxic effects of TRI has been well recognized not only after acute or short-term exposure at relatively high concentrations [e.g., 1000 ppm for 2 hr (Vernon and Ferguson 1969)], but also the conditions to be encountered in occupational settings (Juntunen et al. 1980). For example, Takamatsu (1962) as early as 1962 concluded from a factory survey that workers complained various subjective symptoms frequently at the exposure level of 50 to 100 ppm and the complaints were even more frequent and characteristic at 150 to 250 ppm, whereas

---

**Table 4. Hematology and liver**

<table>
<thead>
<tr>
<th>Item</th>
<th>Normal†</th>
<th>Controls (85‡)</th>
<th>Exposed (79†)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hematocrit (%)</td>
<td>≥40.2</td>
<td>47.0±3.6 (2)</td>
<td>45.9±2.8* (4)</td>
</tr>
<tr>
<td>GPT (Karmen units)</td>
<td>0–20</td>
<td>8.2±6.2 (2)</td>
<td>11.6±13.8*(8*)</td>
</tr>
<tr>
<td>LAP (Goldbarg units)</td>
<td>118–220</td>
<td>170±26 (4)</td>
<td>180±30* (6)</td>
</tr>
<tr>
<td>LDH (C.W. units§)</td>
<td>50–400</td>
<td>240±92 (4)</td>
<td>259±72 (1)</td>
</tr>
</tbody>
</table>

Items shown are those in which significant difference (p<0.05, shown by*) was abnormal/total cases (by chi-square test) between the exposed and the controls are mean±s.d. (number of cases with abnormal values).

†Normal range.
‡Number of the subjects.
§Caubaud-Wroblewski units.
Symptoms Due to Trichloroethylene Exposure

The symptoms were unremarkable when the TRI levels were below 50 ppm. Similarly, Grandjean et al. (1955) observed that subjective complaints such as vertigo (50%), fatigue (45%), alcohol intolerance (36%) and headache (30%) were frequent among the workers exposed mostly at 20 to 40 ppm and up to ca. 300 ppm.

In another factory survey, El Ghawabi et al. (1973) found that headache (87%), dizziness (67%), sleepiness (53%) and nausea/vomiting (47%) were more common among the workers exposed at 41 to 163 ppm than among the nonexposed controls (0-30% depending on the symptoms). According to Bardodej and Vyskocil (1956), the workers exposed to TRI at 100 to 154 ppm complained of alcohol intolerance (63%), fatigue (47%), sleep disturbance (26%), headache (26%) and others, whereas those exposed at lower levels of 5 to 10 ppm also reported the same symptoms but at different rates, i.e., in the decreasing order of prevalence, headache (67%), fatigue (61%), sleep disturbance (22%), intolerance to alcohol (22%), etc. From a survey of a factory where TRI levels were higher than 10 ppm in 40% of about 200 air samples collected, Lilis et al. (1969) found that the most common complaints of the workers were dizziness (88%), headache (74%), fatigue (68%), irritability (56%) and nausea (43%). In contrast, Stewart et al. (1970) reported from controlled exposures of volunteers at 200 ppm that the only troublesome response was mild fatigue and sleepiness. Because of technical limitation of the days of the studies cited, the levels reported in factory surveys may not mean the breath zone air concentration but rather indicate the levels in the grab-sampled workroom air.

In the present study, diffusive sampling technique (Hirayama and Ikeda 1979; Kasahara and Ikeda 1987) was applied to measure precisely the time-weighted average exposure level of each worker. Although the measurement was made on particular days of study, there was no evidence to suggest that the values measured should deviate significantly from day-by-day levels of exposure.

<table>
<thead>
<tr>
<th>function tests</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal†</td>
<td>Controls (26‡)</td>
</tr>
<tr>
<td>≥33.6</td>
<td>40.0±2.7 (0)</td>
</tr>
<tr>
<td>0–20</td>
<td>7.0±4.5 (0)</td>
</tr>
<tr>
<td>103–175</td>
<td>150±25 (1)</td>
</tr>
<tr>
<td>50–400</td>
<td>201±64 (0)</td>
</tr>
</tbody>
</table>

detected in the means (by t-test) or in the rates of the either in men or in women. The values in the table
In contrast to the case of a sister survey on toluene in which clear dose-response relationship was observed in the prevalence of many subjective symptoms (Lee et al. 1988), the dose-dependent increase in the prevalence of subjective symptoms was evident only in Part 2 symptoms (i.e., the symptoms in past 6 months) but not in Part 1 symptoms (i.e., those during work). The lack of dose-dependency in Part 1 symptoms is possibly due to the fact that the intensity of exposure was as low as less than 10 ppm for the majority of the workers studied, and only a few was exposed to TRI in excess of 50 ppm (Table 2). In addition, it should be kept in mind that the difference in the prevalence of subjective symptoms between the exposed and the controls is not necessarily attributable to TRI exposure. In fact, the exposed workers served on three shifts including late evening (1600–2400 midnight), early morning (0000 midnight-0800) and (0800–1600) morning shifts, while the controls worked only 0800–1600. Thus, the differences in the prevalences of the observed symptoms could possibly reflect the differences in the total working environment such as shift work in addition to the effects of the exposure to the solvent, as discussed by Grasso et al. (1984). Nevertheless, the two comparable prevalence rates at the lower TRI levels (0–10 ppm and 11–50 ppm) coupled with an increase in the prevalence at ≥51 ppm in Part 2 symptoms is worthy of noting, because the observation may suggest the possible presence of threshold at around 50 ppm, which is on the line to justify the present occupational exposure limit (OEL) (American Conference of Governmental Industrial Hygienists 1987; Deutsche Forschungsgemeinschaft 1987; Japan Association of Industrial Health 1987) in the view of CNS toxicity.

Although the number of the workers with over-OEL exposure was limited, the observation apparently warrants further study. In this connection, 5 symptoms of No. 1 Heavy feeling in the head, No. 13 Forgetfulness, No. 15 Tremor in extremities, No. 16 Cramp in extremities and No. 26 Dry mouth deserve attention as flection points are evident in the dose-response relationship of these symptoms (Fig. 1B). Of particular interest is the prevalence of headache. As reported by Bardodej and Vyskocil (1956) and in agreement with the observation by Lilis et al. (1969), the overall prevalence of headache (Symptom No. 2) in the exposed workers (men and women combined) was 31.1% but was highest (33.3%) among the least exposed (1–10 ppm) and lower at higher exposure levels (i.e., 21.0% at 11–50 ppm and 12.5% at 51–100 ppm), possibly reflecting strong pain-killing potency of TRI.

Attention was also paid to two symptoms (No. 58 Bloody, strawberry jam-like feces and No. 59 Frequent flatus), which were specifically added to the questionnaire in the present study. These symptoms were suggested as possible markers of intestinal cystoid pneumatosis for which TRI was suspected to be a causative agent (Sato et al. 1984). The increase in symptom prevalence was significant in the latter but of borderline significance in the former. Severe liver involvement was reported in several early day studies on cases with extensive TRI exposures.
For example, Kleinfeld and Tabershaw (1954) reported a case of fatality from hepatorenal failure due to accidental ingestion of this solvent. Joron et al. (1955) described a fatal case of massive liver necrosis after TRI exposure at several hundred ppm. Similar observation by other authors (Priest and Horn 1965; Clearfield 1970) followed. The effects on liver was further confirmed in recent reports of animal experiments with a single i.p. dose of <1000 mg/kg to mice (Rouisse and Chakrabarti 1986), or repeated oral dose of 1600 mg/kg (Buben and O’Flaherty 1985) or supply of feed containing TRI by 4.41% to rats (Melnick et al. 1987); all resulted in the liver damage as evidenced by elevated levels of GOT and GPT in serum or liver necrosis.

In occupational health practice, however, it has been reported that liver function tests including serum transaminase assays usually stayed normal among the subjects engaged in degreasing or paint stripping work with TRI (Albahary et al. 1959; Milby 1968). The present negative observation on possible liver damage among the workers exposed mostly to less than 50 ppm TRI is in confirmation of the experiences of Albahary et al. (1959) and Milby (1968). In fact, the TRI toxicity on the liver of rats is much weaker than well known hepatotoxic agents such as carbon tetrachloride, chloroform or dimethyl formamide (Lundberg et al. 1986). In the absence of any exposure-related findings in urinalysis and with very few complaints on palpitation as a sign of cardiac involvement (data not shown), physical checkup of TRI-exposed workers under the conditions studied should be focussed on the possible CNS effects as evidenced by the increased prevalences of the subjective symptoms.

Acknowledgments

We are grateful to Drs. Feng-Lin Zhu, Xiang-Rong Li, and Iun-Ming Lei (Shenyang, China), and Drs. Shu-Mei Cheng, Ting-Qin Yang, Chu-Xia Ren and Hai-Cheng Yu (Jinxi, China) for their support and collaboration in the factory survey. Thanks are also due to Prof. T. Suzuki (Tohoku Rosai Hospital, Sendai) and Prof. M. Tati (Occupational Health Service Center, Japan Industrial Safety and Health Association, Tokyo) for their interest in this work.

References


