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Home Lead-Work as a Potential Source of Lead Exposure for Children

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Summary. Health examinations for lead poisoning were made on 62 family members from 15 families of homes carrying on lead work, such as quench-hardening in a molten lead bath and type-printing, as work at home. The most interesting findings concern the occurrence of cases with an unduly high lead absorption among children, but not among adult family members other than home lead-workers. The home environments of the children with an unduly high lead absorption represented contamination with housedust high in lead contents. The ingestion of the contaminated housedust by hand-to-mouth is probably responsible for the excessive lead exposure of the affected children. The results of the present study suggest that contanimation of housedust with lead due to home lead-work constitutes a possible hazardous source of lead exposure for children.

Key words: Lead – Children – Home lead-work – Lead-containing housedust

Introduction

Significant lead sources other than lead-based paint on houses have been identified in the children's environment. These include: airborne lead emitted from automobile exhaust or industrial sources, particularly smelters; lead settled on dust or soil outdoors or indoors; and lead dust carried home on work clothing and shoes (WHO Task Group, 1977). Besides these, we consider home lead-work, that is, lead work carried on at home, to be a potential source of lead exposure for children because it possibly provides a source of lead contamination for household surface dust. However, home lead-work has not received much attention as a lead source among children.

Several kinds of home lead-work have been extensively carried on in Japan. The present work was thus designed to study the presence of excessive lead exposure among children occupying homes where lead work is conducted.

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The results of the present study have shown contamination of the home environment with lead dust due to home lead-work to be a hazardous souce of lead for children.

Material and Methods

Subjects Examined

The present work included two study populations. One consisted of 33 family members from eight households occupying homes where the tempering of cutlery by quenching in a molten lead bath (800 to 1100°C) was conducted; and the other consisted of 29 family members from seven households occupying homes where type-printing was done.

The members of each study population were categorized into three groups. Group I comprised the adult family members regularly or occasionally employed in the home lead-work as mentioned above. The other family members not engaged in the home lead-work were subdivided into two groups by age, one of which (Group II) consisted of the family members older than 14 years of age, and the other (Group III) of those less than 12 years of age. Tables 1 and 2 list the number of members of each household by study group. Tables 3 and 4 give the age distribution of Groups II and III, respectively.

All the subjects were submitted to the laboratory tests for lead poisoning.

Analytical Methods

The laboratory tests included measurements on venous blood samples for lead (PbB) and on about 12-h urine samples for lead (PbU), coproporphyrin (CPU), and δ-aminolevulinic acid (ALAU). PbB and PbU were analyzed using the flameless atomization technique involving a chelation extraction procedure (Kubasik and Volosin 1973; Volosin et al. 1975). CPU was determined by the spectrophotometric method, including extraction with ethyl acetate and hydrochloric acid; ALAU, by the method of Tomokuni and Ogata (1972).

The coefficient of variation, calculated from 10 analyses on the same samples, was: PbB-, 6.3; PbU-, 4.0; CPU-, 2.9; ALAU-analysis, 2.3%.

Household Lead Contamination

We assessed the lead contamination of the home environment of two families (A and K) whose children demonstrated an increased PbB ($\geq 30\,\mu g/100\,g$) in the present examination.

Air lead samples were obtained at the different indoor sites by either a high-volume sampler or a low-volume sampler equipped with Toyo GB-100 glassfiber filter. The filters were placed into acidic solution and heated to dissolve lead. The lead was determined by atomic absorption spectrometry (AAS).

Surface dust samples were collected from various indoor sites by brushing surface dust with a new soft paintbrush onto clean paraffin-paper. The dust samples were dried, dissolved in acidic solution and heated at 80°C. The extracts were filtered and analyzed for lead by AAS. The lead contents were expressed as micrograms of lead per g dry weight of dust (ppm).

Surface dust samples collected from a home where no lead work had been done served as controls.

Results

Laboratory Tests

We apply the following criteria to the results of the present laboratory tests: PbB $\geq 30\,\mu g/100\,g$ as an undue lead absorption according to a statement by the

Table 1. Number of family members by group for the cutlery-tempering households

Family	Total	Group I	II	III
A	8	2	3	3
B	5	1	2	2
C	6	3	3	
D	2	1	1	
E	3	2	1	
F	4	3	1	
G	4	4		
H	1	1		
Total	33	17	11	5

Table 2. Number of family members by group for type-printing households

Family	Total	Group I	II	III
I	6	2	2	2
J	6	2	2	2
K	5	2		3
L	3		2	1
M	4		2	2
N	3	3		
O	2	2		
Total	29	11	8	10

Table 3. Age distribution of Group II

Age in yr	Cutlery-tempering households	Type-printing households
14–18	3	2
≥21	8	6
Total	11	8

Center for Disease Control (1975); PbU ≥ 30 μg/l, CPU ≥ 100 μg/l, and ALAU ≥ 7.0 mg/l, each as an abnormally raised value according to our previous investigation (Katagiri et al. 1979).

Cutlery-Tempering Households

Abnormal measurements were much more common among members of Group I than among those of Groups II and III (Table 5). This will be understood by the fact that the members of Group I were working with lead.

Table 4. Age distribution of Group III

Age in yr	Cutlery-tempering households	Type-printing households
4		1
5	1	1
6	1	2
7	1	
8		3
9	1	
10	1	
11		1
12		2
Total	5	10

The most notable results, however, concern the difference in the laboratory findings between Groups II and III: Group III showed a much greater mean value and a higher frequency of abnormally raised values compared with Group II, for PbU, CPU, and ALAU.

Several investigators have reported PbB values for children to be similar to or even lower than those for adults (WHO Task Group 1977). Katagiri et al. (1979) observed no appreciable difference in the values of PbU, CPU, and ALAU between children and adults. When considered together with these facts, the foregoing results suggest that, among the family members unconcerned in the cutlery-tempering work, children have a higher lead exposure than older family members.

To see in more detail whether children have a higher risk of excessive lead exposure, we compared the laboratory findings for each member of the family A with three children (Table 6). One of the three children demonstrated a moderately increased PbB (35.4 μg/100 g) along with an excessive ALAU (9.4 mg/l); the other two children either had increased CPU or ALAU, or both. In contrast, adult members of Group II presented no laboratory evidence of excessive lead exposure.

Type-Printing Households

All the members of Groups I and II, except one with a slightly increased PbU (32.6 μg/l), showed normal values for each laboratory tests. Among the children of Group III, however, two children had increased PbB (42.0 and 44.6 μg/100 g, respectively) (Table 7).

The two children with increased PbB were siblings in the family K. Table 8 gives the laboratory findings for all the members of this family. While parents engaged in the type-printing operations presented no laboratory findings suggestive of excessive lead-exposure, two of their children had both elevated PbB and a slightly excessive PbU. These results indicate that, in a home where type-

Table 5. Laboratory findings by group for the cutlery-tempering households

Group	n	PbB (μg/100 g) Mean (range)	No. of PbB ≥30 μg/100 g	PbU (μg/l) Mean (range)	No. of PbU ≥30 μg/l	CPU (μg/l) Mean (range)	No. of CPU ≥100 μg/l	ALAU (mg/l) Mean (range)	No. of ALAU ≥7.0 mg/l
I	17	35.1 (13.2–92.2)	12	64.6 (5.7–291.4)	13	84.0[c] (12–1455)	6	5.8 (2.1–15.1)	5
II	11	13.7[a] (6.5–21.5)	0	13.8 (6.1– 31.4)	1	35.9 (14– 75)	0	4.6 (2.2– 8.1)	1
III	5	21.8[b] (15.4–35.4)	1	12.6 (7.1– 19.6)	0	78.0 (36– 133)	1	7.7 (4.3–10.3)	3

n = Number of subjects

[a] $n=8$; [b] $n=4$; [c] this value was calculated excluding an extreme of 1455 μg/l

Table 6. Laboratory findings for all the members of family A

Group	Family member no.	Sex	Age in yr	PbB (μg/100 g)	PbU (μg/l)	CPU (μg/l)	ALAU (mg/l)
I	1	m	39	39.1	45.0	70	3.8
	2	m	30	40.9	30.0	107	5.2
	3	m	72	21.5	13.6	20	2.2
II	4	f	37	16.8	29.3	75	4.7
	5	f	70	7.3	6.6	32	5.1
III	6	m	5	–	19.6	83	10.3
	7	m	7	20.7	9.2	133	7.9
	8	f	9	35.4	14.6	96	9.4

printing is conducted, children are in much greater danger of suffering from lead exposure than the family members employed in type-printing.

Lead Contamination of Home Environment

We found two families (A and K) whose children demonstrated an undue lead absorption. We thought that household lead contamination due to home lead-work was possibly responsible for excessive lead expousre among the children in these two families. Thus, we analyzed the lead contents of indoor housedust and air samples from the homes of these two families.

Atmospheric lead (PbA) concentrations in the home of family A were on the somewhat dangerous order (50 μg/m^3) only in front of a lead furnace located in the cutlery-tempering workshop, but on the safe order (2 μg/m^3) in the kitchen in close proximity to the workshop (Table 9). The parents of this family told us that their children seldom, if ever, had access to the workshop. PbA concentrations in the home of family K were within the safe level (2 μg/m^3) even in the type-printing workshop (Table 9). Thus, we conclude that the children of these two families have not been exposed to the hazardous levels of PbA in their homes.

Tables 10 and 11 represent the lead contents of surface dust samples. Control dust samples contained lead ranging from 42 to 373 ppm. When compared with this control dust, floor dust of the home workshops contained extraordinarily high concentrations of lead. The content of lead in floor dust of other rooms was less, but still higher than that in the control dust. These results show that home lead-work contributes significantly to lead contamination of house dust in rooms other than the home workshops. Home lead-workers possibly carry lead to a living room and other rooms from a home workshop on their clothing.

PbA levels were as low as 2 μg/m^3 both in the kitchen nearest the cutlery-tempering workshop in the home of family A and in the type-printing workshop in the home of family K. Therefore, the dispersal of PbA originated from the home workshops is likely to be a minor contributor to lead contamination of surface dust in rooms other than the home workshops.

Table 7. Laboratory findings by group for the type-printing households

Group	n	PbB (μg/100 g) Mean (range)	No. of PbB ≥30 μg/100 g	PbU (μg/l) Mean (range)	No. of PbU ≥30μg/l	CPU (μg/l) Mean (range)	No. of CPU ≥100 μg/l	ALAU (mg/l) Mean (range)	No. of ALAU ≥7.0 mg/l
I	11	16.4 (12.9–20.7)	0	13.5 (5.1–32.6)	1	43.9 (16–93)	0	3.2 (1.9–5.0)	0
II	8	11.7[a] (7.8–18.9)	0	12.1 (9.0–16.1)	0	38.7 (21–56)	0	3.6 (1.5–5.5)	0
III	10	27.6[b] (17.4–44.6)	2	16.8 (5.1–34.8)	1	44.1 (13–79)	0	4.0 (1.4–6.7)	0

n = Number of subjects

[a] n=6; [b] n=6

Table 8. Laboratory findings for all the members of family K

Group	Family member no.	Sex	Age in yr	PbB (μg/100 g)	PbU (μg/l)	CPU (μg/l)	ALAU (mg/l)
I	1	m	41	17.7	6.8	75	3.3
	2	f	38	7.0	6.2	84	2.9
III	3	f	11	18.2	5.1	27	1.4
	4	m	8	42.0	24.4	68	4.3
	5	m	4	44.6	34.8	79	5.5

Table 9. Air-lead concentrations in the homes of families A and K

Homes	Sampling sites	PbA ($\mu g/m^3$)
Cutlery-tempering workshop:		
Home of family A	In front of the lead furnace	50
	At about 3 m from the lead furnace	6
	Kitchen[a]	2
Home of family K	Type-printing workshop	2

[a] The kitchen was located nearest to the workshop

Table 10. Lead contents of household surface dust in the home of family A

Room	Surface dust sampled at	Lead contents of dust, ppm
Cutlery-tempering workshop	Earth floor[a]	6350
Living room	Carpeted floor	1580
	Window frames	750 480
	Television cabinet	380
Room for aged men	Carpeted floor	1040
	Window frame	260

[a] Surface soil was collected

From the present results we may conclude that contaminated househould dust is a major source of excessive lead exposure among the children of families A and K.

Discussion

Many reports have appeared since the early 1970s that show lead-containing housedust to be an important hazardous source of lead exposure for children

Table 11. Lead contents of household surface dust in the home of family K

Room	Surface dust sampled at	Lead contents of dust, ppm
Type-printing workshop	Floor near the type-stand	20386
	Floor	3031
	Desk	4560
	Window frame	1463
Living room	Carpeted floor	5320
	Window frame	422
Dinning room	Floor	678

(Needleman and Scanlon 1973; Sayre et al. 1974; Vostal et al. 1974; Lepow et al. 1975; Baker et al. 1977; Charney et al. 1980). The present study seems to be the first to point out that lead-containing housedust present in the homes where lead work is carried on provides a significant source of lead exposure for children. The mechanism of exposure is possibly that children suffer lead contamination of their hands by coming in contact with contaminated housedust, particularly that on the floor, and then ingest lead by frequent hand-to-mouth activities or by eating food with their contaminated hands.

The maximum daily permissible lead intake (DPI) from all sources for preschool children is estimated to be 300 μg; the daily lead intake from food, water, and air for unexposed preschool children, to be about 100 to 200 μg (King 1971). From this it follows that the extra daily intake of lead from 100 to 200 μg could reach the DPI. We found a housedust sample containing lead of 5320 ppm on the carpeted floor of a living room in family K. The ingestion by children of as little as 0.03 g a day of such dust results in an extra daily lead intake of 160 μg, thus approaching the DPI.

The family members, older than 14 years and not involved in the home lead-work, presented no laboratory evidence of unduly high lead absorption. A possible explanation for this is that they exhibit much less hand-to-mouth behavior and wash their hands more frequently.

Several kinds of home lead-work are found in Japan. These are type-printing, pottery decoration, and the tempering of the cutlery by quenching in a molten lead bath. The present study has shown home lead-work to be associated with excessive lead exposure for children. Periodic health examination of lead poisoning should be done on children of the households conducting home lead-work. Their parents hould be informed of the sources and risks of lead poisoning and the need to remove contaminated housedust accessible to children.

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