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Occupational lead exposure in Finland

V. Shipyards and shipbreaking

by SAKARI TOLA, M.D.,¹ and VEIKKO KARSKELA, M.D.²

TOLA, S. and KARSKELA, V. Occupational lead exposure in Finland: V. Shipyards and shipbreaking. *Scand. j. work environ. & health* 2 (1976) 31–36. Three Finnish shipyards and two shipbreaking enterprises were studied for lead exposure. Blood lead (Pb-B) concentration was measured for 568 workers in the shipyards and 13 workers in the shipbreaking enterprises. Erythrocyte δ -aminolevulinic acid dehydratase (ALAD) activity was determined for 139 workers in one shipyard and 7 workers in one shipbreaking enterprise. Hemoglobin level was determined for 545 workers in the three shipyards and 7 workers in one shipbreaking enterprise. Lead exposure in the shipyards was relatively low. No Pb-B value exceeded 70 $\mu\text{g}/100$ ml. The most exposed occupations were welders, plumbers, painters, repairmen, and sheet metal workers. The mean Pb-B did not exceed 40 $\mu\text{g}/100$ ml in any of these groups. In both shipbreaking enterprises one Pb-B value exceeded 70 $\mu\text{g}/100$ ml, the mean Pb-B values of all the workers in the two enterprises being 51 and 46 $\mu\text{g}/100$ ml, respectively. ALAD values corresponded well with the respective Pb-B values. All the hemoglobin mean values were normal, and there were no statistically significant differences between the hemoglobin values of different groups.

Key words: shipyards, shipbreaking, lead, blood, δ -aminolevulinic dehydratase.

Lead exposure in shipbuilding and, especially, in shipbreaking is well-known (2, 5, 6). Reported cases of lead poisoning have usually occurred in connection with burning lead-coated plates. This hazardous work is common in shipbreaking still today, but it is decreasing in shipbuilding. Other jobs that may expose workers to lead are spray painting with lead-containing paints and various types of soldering. During recent years in Finland, a few cases of lead poisoning have been reported among shipbreakers, but none among shipbuilders. This article reports the results of a survey on lead exposure in shipbuilding and shipbreaking in Finland during 1971 through 1973.

MATERIAL

Shipyards

Two shipyards in Helsinki (A and B) and one in Turku (C) were included in the study.

Shipyard A. Shipyard A employed 2,098 workers at the time of the study. Because knowledge was needed about the usability of erythrocyte δ -aminolevulinic acid dehydratase (ALAD) in screening for lead exposure, we first drew a random sample of 225 workers and measured their erythrocyte ALAD activities. A more detailed description of the screening process has been described earlier (8), and therefore it is only briefly summarized in the following.

In Finland Pb-B values above 30 $\mu\text{g}/100$ ml are not found in the normal urban or rural population without occupational exposure (4). On the other hand, there is a considerable safety margin between 30 $\mu\text{g}/100$ ml and the highest recom-

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mended level of 70 $\mu\text{g}/100\text{ ml}$. From previous studies we know that an ALAD activity of 500 μmol of porphobilinogen (PBG) per hour per liter of packed red blood cells (RBC) corresponds to a blood lead (Pb-B) concentration of about 30 $\mu\text{g}/100\text{ ml}$. We therefore considered it justified to use an ALAD activity of 500 μmol s of PBG per hour per liter of RBC as a criterion of occupational exposure to lead. In the whole sample of 225 workers we found 20 men with ALAD values below this level. The occupational distribution of these men was as follows: 5 welders, 3 painters, 3 ship repairmen, 3 plumbers, 2 carpenters, 2 interior installation apprentices, 1 mechanic, and 1 gateman. All the workers in these occupational groups, with the exclusion of the gatemen, were used as a basis for further study. In addition fire watchmen and electricians were included since they were thought to be exposed to lead even though the ALAD screening did not reveal such exposure. The total number of workers employed in these nine occupations was approximately 1,400. About 10 % of the workers in each occupational group were chosen for further study. They generally came from the same work sites as the workers with the low ALAD values. The total number of workers included in the more extensive study was 141, and the results presented herein refer to these 141 men. Their mean age was 33.4 years (SD 11.8). The median exposure time was 4.6 years [first quartile (Q_I) = 0.9, third quartile (Q_{III}) = 9.9. years].

Shipyards B. Shipyards B employed 1,300 workers at the time of the study. Stratified sampling was performed in eight occupational groups so that 15 to 20 workers would be taken from each. A total number of 94 workers (90 men, 4 women) was included in the study. The mean age was 36.4 years (SD 14.6), and the median exposure time was 6 years (Q_I = 1.1, Q_{III} = 14.0 years).

Shipyards C. Shipyards C, the largest shipyard in Finland, employed 3,937 workers at the time of the study. Since possible lead exposure was already a bone of contention between the employer and employees when the study began, 15 different occupational groups were included in the study so that all occupations with

possible lead exposure would be represented. Most of the Pb-B samples were drawn from workers in occupational groups considered a priori to be exposed to lead. For this reason the number of workers in each occupational group, seen in table 3, varied considerably. The total number of workers studied was 333 (328 men, 5 women). Their mean age was 37.4 (SD 11.1), and the median exposure time was 9.9 years (Q_I = 6.2, Q_{III} = 18.1 years).

Shipbreaking enterprises

Two shipbreaking enterprises, one in Helsinki (A) and one in Imatra (B), were included in the study. All the workers employed at the time of the study were included. They were all men. The mean age of the workers from enterprise A

Table 1. Parallel analyses of blood lead concentrations ($\mu\text{g}/100\text{ ml}$) from the laboratories of the Institute of Occupational Health and shipyard C.

Sample	Institute of Occupational Health	Shipyards C
1	19	27
2	15	20
3	23	25
4	13	22
5	8	18
6	10	21
7	9	22
8	15	22
9	20	26
10	12	24
11	35	36
12	12	20
13	17	20
14	9	19
15	14	20
16	14	22
17	20	18
18	17	16
19	10	19
20	15	23
21	10	17
22	12	22
23	21	26
24	21	25
25	17	20
26	14	20
27	15	20
28	15	20
29	18	22
	Mean 15.5 SD 5.5	Mean 21.8 SD 3.9

Table 2. Blood lead (Pb-B) concentrations ($\mu\text{g}/100\text{ ml}$) of workers in different occupational groups in shipyards A and B. The means (M) and standard deviations (SD) have been calculated after logarithmic transformation.

Workplace and occupational group	Number of workers	Pb-B concentration ($\mu\text{g}/100\text{ ml}$)		
		M — SD	M	M + SD
Shipyard A	141	20	28	39
welders	20	25	34	47
carpenters	28	19	24	29
painters	17	20	28	40
plumbers	18	20	29	42
electricians	8	15	19	23
mechanics	17	21	28	39
repairmen	15	21	32	49
fire watchmen	5	18	22	26
interior installation apprentices	13	23	30	40
Shipyard B	94	17	22	29
welders	13	19	24	31
carpenters	12	15	20	25
painters	13	18	24	32
plumbers	10	18	23	30
electricians	10	18	22	28
sheet metal workers	17	16	22	29
engine department workers	9	13	17	23
filers	10	18	24	31

($N = 7$) was 36.8 years (SD 12.7) and the median exposure time was 5.5 years ($Q_I = 3.7$, $Q_{III} = 12.5$ years). The mean age of the workers from enterprise B ($N = 6$) was 46.8 years (SD 10.6), and the median exposure time was 8.0 years ($Q_I = 2.7$, $Q_{III} = 11.2$ years).

METHODS

The Pb-B concentrations were determined by Hessel's method (1). The method error of duplicate estimations was $2.1\ \mu\text{g}/100\text{ ml}$. A description has been given earlier of the strict method of control applied (7). In shipyard C the Pb-B analyses were performed in the laboratory of the shipyard, and parallel measurements were made at the Institute of Occupational Health in Helsinki, where all the other analyses were made. The results of the parallel analyses are shown in table 1. The difference between the means was $6.3\ \mu\text{g}/100\text{ ml}$, and the standard deviation of the parallel measurements was $5.1\ \mu\text{g}/100\text{ ml}$, the values of the shipyard laboratory being higher.

Erythrocyte ALAD activities were determined for the workers of shipyard A and shipbreaking enterprise A only. The activities were measured according to Nikkanen et al. (3). The results have been expressed as μmols of PBG formed during 1 hour of incubation at 37°C , per liter of RBC, as estimated from the previously determined hematocrit value, or μmols of PBG per hour per liter of RBC.

Hemoglobin measurements were made for the workers of all the shipyards and shipbreaking enterprise A. Hemoglobin (Hb) was determined by the standard method after conversion to cyanmethemoglobin.

RESULTS

Tables 2 and 3 illustrate the Pb-B concentrations of the workers from the shipyards. It should be stressed that the Pb-B analyses of shipyard C were not made with the same instrument as the other analyses, and the results from that shipyard are not directly comparable to the results of the other shipyards.

Table 3. Blood lead (Pb-B) concentrations of workers in different occupational groups from shipyard C. The means (M) and standard deviations (SD) have been calculated after logarithmic transformation. Note that the blood lead analysis made in shipyard C gave higher values than the analysis made at the Institute of Occupational Health (table 1).

Occupation	Number of workers	Pb-B concentration ($\mu\text{g}/100\text{ ml}$)		
		M — SD	M	M + SD
Welders	51	19	24	29
Carpenters	5	19	21	24
Painters	47	17	20	24
Plumbers	48	16	20	25
Electricians	23	19	22	25
Mechanics	17	19	20	22
Fire watchmen	4	..	22	..
Sheet metal workers	73	19	23	28
Engine department workers	9	17	20	22
Filers	31	18	20	23
Cleaners and miscellaneous	6	17	18	20
Elevator operators	3	..	18	..
Pursers	4	..	19	..
Foundry workers	10	26	34	44
Rust removers	2	..	21	..
Total	333	18	21	27

In general lead exposure was low in the shipyards. No Pb-B values exceeding the highest recommended level of $70\text{ }\mu\text{g}/100\text{ ml}$, applied in Finland, were found. The highest exposure occurred among welders, plumbers, painters, repairmen, and sheet metal workers. The foundry workers in shipyard C also had relatively high values. There is no foundry in the other two shipyards. Although there were small differences between the occupational groups, exposure seemed to be relatively stable.

Table 4 illustrates the Pb-B concentrations of workers in the shipbreaking enterprises. The workers from enterprise A had higher Pb-B concentrations than those from enterprise B. There was one Pb-B value exceeding $70\text{ }\mu\text{g}/100\text{ ml}$ in both enterprises. During 1970 through 1974 five cases of lead poisoning received compensation as occupational diseases among the workers of these two workplaces.

Table 5 illustrates the erythrocyte ALAD activities of the workers of shipyard A and shipbreaking enterprise A. The values correspond well with the concomitant Pb-B concentrations. These results agree with the good negative correlation shown previously between the two parameters (7).

The Hb values from all workplaces fell

Table 4. Blood lead (Pb-B) concentrations of workers in shipbreaking. The means (M) and standard deviations (SD) have been calculated after logarithmic transformation.

Ship-breaking enterprise	Number of workers	Pb-B concentration ($\mu\text{g}/100\text{ ml}$)		
		M — SD	M	M + SD
A	7	33	51	80
B	6	32	46	64
A + B	13	33	49	72

within the normal range, and no statistically significant differences were detected between various occupational groups or even between the workers of ship-breaking enterprise A and the shipyard workers.

DISCUSSION

Lead exposure was surprisingly low in the three shipyards studied. Since the shipyards were studied comprehensively, but with somewhat different criteria for selecting workers for study, it seems improbable that there would exist some yet unrecognized lead hazard in this type

Table 5. Erythrocyte δ -aminolevulinic acid dehydratase (ALAD) activities of workers from shipyard A and shipbreaking enterprise A. The means (M) and standard deviations (SD) have been calculated after logarithmic transformation.

Workplace	Number of workers	Erythrocyte ALAD activity (μ mol PBG/h)		
		M — SD	M	M + SD
Shipyard A				
welders	19	279	444	709
carpenters	28	366	537	788
painters	18	360	470	617
plumbers	18	290	402	559
electricians	9	470	613	800
mechanics	17	315	454	655
repairmen	15	297	457	703
fire watchmen	5	617	727	857
interior installation apprentices	10	503	606	729
Total	139	336	491	716
Shipbreaking enterprise A	7	86	204	486

of work in Finland. Hence the risk for poisoning is apparently very low, provided that work methods do not radically change, and, according to the present investigation, routine surveillance based on Pb-B measurements is unnecessary. Annual ALAD measurement of workers in the most exposed occupations could well suffice with respect to lead exposure.

In shipbreaking the situation was quite different. There was a definite risk for lead poisoning in this work. In Finland most shipbreaking takes place in the two small enterprises studied, and it is not connected with ordinary shipyard work. This practice is a possible explanation for the low level of lead exposure in the shipyards. Such a concentration of work with a high risk of lead poisoning into a few small enterprises should also make the routine surveillance of workers very effective. In Finland regular examinations at least six times a year are prescribed by law for workers in the shipbreaking industry. Nevertheless, ignorance of the hazard resulted in 1975 in the lead poisoning of all five workers in a new shipbreaking enterprise, not included in this survey, after about half a year's work (Pb-B mean, 99 μ g/100 ml; range, 82–110 μ g/100 ml). This occurrence illustrates the importance of the

early recognition of health hazards. Although the medical monitoring of workers is important, the hazard of lead poisoning can never be eliminated simply by increasing the frequency of health examinations, and technical prevention should be emphasized.

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