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The ceramics industry and lead poisoning

Lead poisoning in relation to technology and jobs

by Edoardo De Rosa, MD, Franco Brighenti, MD, Andrea Rossi, MD,
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DE ROSA E, BRIGHENTI F, ROSSI A, CAROLDI S, GORI GP, CHIESURA P. The ceramics industry and lead poisoning: Lead poisoning in relation to technology and jobs. *Scand j work environ health* 6 (1980) 306—311. The investigation evaluates the risk of lead absorption for 288 ceramics industry workers. Cases were studied in relation to sex, type and length of exposure, production plant characteristics, and jobs performed. The difference linked with sex was amplified by the fact that men usually performed the decidedly higher risk jobs, such as those connected with the direct use of ceramic glazes, in which — although to a variable extent — high percentages of lead are used. In fact, decreasing amounts of lead absorption were found for workers engaged in the operations of glazing, kiln work, maintenance and decoration, selection coming last. It was concluded that, in the Italian ceramics industry, lead exposure is linked to the use of lead-rich glazes and that this exposure may thus vary according to the different jobs or different technological cycles. Although female workers primarily carry out decoration and selection jobs, they nonetheless show high levels of lead in their blood, exceeding 1.9 $\mu\text{mol/l}$ — the limit currently recommended for women.

Key terms: blood lead level, glazes, occupational lead exposure, pottery.

The ceramics industry is highly developed in Italy, the greatest European producer of ceramic products (artistic products, tiles and sanitary fittings). The most intensely studied work risk has always been that linked with the inhalation of dusts containing silica (the dioxide of silicon). In the last 10 a the number of companies producing tiles for building has grown progressively larger, one consequent possibility being the occurrence of lead poisoning caused by the high levels of this metal in ceramic glazes.

The extent of this risk is presumably linked not only to the quantity of lead glazes used, but also to the technical uses to which the glazes themselves are put (eg, delicate brush application in small quantities in the case of artistic ceramic

work, less delicate application and larger quantities for the hand decoration of industrial ceramics, large-scale spraying and dry application in tile production). This work risk is generally considered small in other countries. In fact, in the meeting "Health Conditions in the Ceramic Industry" held in London in 1969, only one report dealt with this subject, and it affirmed that lead poisoning is not a principal risk since it is only occasionally found (7). In a large-scale investigation on the levels of lead in blood (PbB) of workers exposed in various ceramic industries in Finland, the authors concluded that the ceramic sector was one of the least dangerous (18).

These conclusions cannot be extended to Italy where, in the last few years, evident cases of lead poisoning have been reported, together with cases of workers for whom tests revealed dangerous levels of lead absorption (1, 12).

Since we have sometimes been able to observe manifest cases of lead poisoning

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Table 1. Age, length of exposure and blood lead (PbB) levels of workers examined in each plant.

Plant ^a	Number of workers	Age (a)	Exposure (months)	PbB ($\mu\text{mol/l}$)
		Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
1	74	29 $\pm$ 13.2	40.2 $\pm$ 27.7	2.7 $\pm$ 0.6
2	71	32.7 $\pm$ 11.4	76.5 $\pm$ 28.5	2.1 $\pm$ 0.5
3	40	31.7 $\pm$ 11.4	34.9 $\pm$ 25	2.8 $\pm$ 1.1
4	39	27.9 $\pm$ 13.9	51.9 $\pm$ 33	3.8 $\pm$ 1.1
5	25	35.6 $\pm$ 16.4	75.4 $\pm$ 49.8	3.8 $\pm$ 1.2
6	18	27.6 $\pm$ 8.6	111.8 $\pm$ 97.1	1.6 $\pm$ 0.5
7	12	30 $\pm$ 7.2	93 $\pm$ 97.3	1.8 $\pm$ 0.7
8	9	23 $\pm$ 6.8	2.8 $\pm$ 0.8	4.2 $\pm$ 0.6
Total	288	30.4 $\pm$ 12.5	57.7 $\pm$ 48.1	2.8 $\pm$ 1.1

^a Plants 1, 2, 3, 4: tiles (wet-glazing process); plant 5: tiles (dry-glazing process); plants 6, 7: artistic ceramics; plant 8: ceramic glazing.

in our institute and since only a small number of reports has been published on the subject, we organized the present study on an exposed population.

Subjects and methods

In all, 288 workers from eight ceramic factories were examined. They worked in the manufacture of different products: tiles for building purposes (four plants using a wet-glazing process, one plant using a dry-glazing process), artistic ceramics with hand decoration (two plants), and one small company producing ceramic glazes. The workers were divided, according to the job they had always done, into the following groups: group A: glazers, who cover the product with lead-rich glazes; group B: kiln workers, who transport and load products into the kilns; group C: various workers, who carry out maintenance and cleaning and in any case are always inside the work environment during the workday; group D: decorators who paint ornamental motifs with brushes; group E: those who select (or discard) finished products and pack them. Office personnel who do not work in the area of exposure were excluded.

The age of the total sample ranged between 15 and 60 a, most females being between 20 and 30 a and most males between 30 and 40 a. The average length of exposure was 58 months, there being no significant differences between the men

Table 2. Average blood lead concentrations according to sex.

	PbB ($\mu\text{mol/l}$)
	Mean $\pm$ SD
Males	3.0 $\pm$ 1.2
Females	2.2 $\pm$ 0.7

and women. PbB was measured according to the Westerlund-Helmerson method (19).

The average value of PbB of occupationally nonexposed subjects is, for our laboratory, the following: $1.3 \pm 0.4 \mu\text{mol/l}$ ($26 \pm 8 \mu\text{g}/100 \text{ ml}$) for males and $1 \pm 0.4 \mu\text{mol/l}$ ($20 \pm 9 \mu\text{g}/100 \text{ ml}$) for females (4).

The PbB level is a valid reference parameter in the evaluation of exposure, and it is widely used in investigations of this type (9). The behavior of the values of PbB observed was analyzed as a function of sex, type of factory, length of exposure, and job. Student's t-test was used for the statistical study, together with a one-way analysis of variance (nested classifications) (16).

Results

Table 1 shows the number of subjects examined in each company.

Table 2 shows that the values of the men were statistically highly significantly higher than those of the women ($t = 8.32$;

$p < 0.001$). As regards jobs, table 3 shows how the average levels of PbB decreased from job A to E. The work of groups A, B, and C, for which the highest levels of PbB were encountered, is carried out almost exclusively by men.

We compared the groups in pairs, in order to evaluate the statistical significance of the differences observed (table 4). It was clear that the average PbB levels of the glazers (A) was much higher than those of groups C, D and E (and higher, but to a less extent, than those of group B). In turn, group B had values that were significantly higher than those of groups

D and E, but it did not differ from group C (various operations) in this respect. This last group showed a significantly higher value only with respect to group E, which did not differ from group D.

Since length of exposure was not equal for the various jobs, we believed it would be useful to determine whether the difference in PbB levels between various jobs was still significant after the workers were separated into different classes of length of exposure. An analysis of variance, one-way with nested classifications (16) (table 5), showed that the length of exposure was not a significant source of variation ($F =$

Table 3. Blood lead (PbB) levels, length of exposure and sex distribution of the workers according to job category.

Job	Number of workers	PbB ($\mu\text{mol/l}$)	Males	Females	Exposure (months)
		Mean $\pm$ SD			Mean $\pm$ SD
A — glazing	77	3.6 ± 1.2	75	2	44.3 ± 36.1
B — kiln work	27	3.1 ± 1.0	27	—	60.6 ± 32.8
C — various operations	34	2.7 ± 1.1	32	2	62.9 ± 33.6
D — decoration	107	2.4 ± 0.8	24	83	66 ± 63.4
E — selection	43	2.1 ± 0.7	24	19	57.5 ± 35.5

Table 4. Results of the statistical analysis (Student's t-test) made of the job categories with respect to blood lead levels. (NS = not significant)

	A	B	C	D
A (glazing)	—			
B (kiln work)	$p < 0.05$	—		
C (various operations)	$p < 0.001$	NS	—	
D (decoration)	$p < 0.001$	$p < 0.001$	NS	—
E (selection)	$p < 0.001$	$p < 0.001$	$p < 0.01$	NS

Table 5. Average blood lead concentrations ($\mu\text{mol/l}$) and standard deviations observed for the job and length of exposure categories — One-way analysis of variance; samples within samples; nested classification. (Number of subjects shown in parentheses)

Months	Glazing (77)	Klin work (27)	Various operations (34)	Decoration (107)	Selection (43)
≤ 24 (83)	3.7 ± 1.2 (32)	3.6 ± 0.6 (3)	2.7 ± 1.4 (6)	2.3 ± 0.6 (33)	2.0 ± 0.7 (9)
25—60 (96)	3.4 ± 0.9 (24)	3.1 ± 0.9 (8)	2.8 ± 1.0 (13)	2.8 ± 0.9 (33)	2.0 ± 0.7 (18)
61—84 (44)	3.7 ± 1.5 (11)	2.7 ± 0.5 (8)	2.6 ± 0.7 (4)	2.1 ± 0.7 (12)	2.1 ± 0.1 (9)
> 84 (65)	3.8 ± 1.3 (10)	3.2 ± 1.4 (8)	2.4 ± 1.1 (11)	2.1 ± 0.7 (29)	2.2 ± 0.9 (7)

0.29; not significant). However the job categories did represent a significant source of variation ($F = 6.92$; $p < 0.01$).

Finally, table 6 shows the prevalence of females and males for whom the observed PbB values exceeded the limits currently recommended, ie, 1.9–2.9 $\mu\text{mol/l}$ (40–60 $\mu\text{g}/100\text{ ml}$) (20).

Discussion

The data we collected confirm that, in the ceramics industry, the use of colors (glazes) containing lead compounds causes a generic risk of excessive absorption of the metal. The level of risk may be related to the type of ceramic product, as well as to the method in which the compounds are used. The average PbB values measured in our investigation are comparable with the data supplied by Olivo & Vivoli (10) in a study on the population of the Emilia region, but they are higher than the values reported by Hernberg in Finland (6). The latter, in a study of ceramic workers from 1971 to 1977, did not observe average values higher than 1.9 $\mu\text{mol/l}$ (40 $\mu\text{g}/100\text{ ml}$); this difference may depend on technological characteristics of production. Results similar to ours, even if the means shown were a little higher, were obtained by Cavalleri (3) from 214 assays of PbB in ceramics industry workers. The hygienic situation of the Italian industries may evidently be compared, while that in Finland seems better.

It can be seen from the average PbB values measured that (i) lead absorption is limited in the field of artistic ceramic decoration (plants 6 & 7), where the glazes are applied with brushes and are relatively refined and not dispersive; (ii) it is greater in the glazing of ceramic building products (tiles), where the work is carried out on an industrial scale (conveyor belts, large quantities of glazes) and technological characteristics also seem to be important in determining the risk [The use of dry glazes (plant 5) in effect results in strong dispersion into the environment around the source, and therefore PbB levels are on the average high. Instead, the use of liquid glazes, even if sprayed, implies a less intense and less widespread danger (plants 1, 2, & 3) except when the hy-

Table 6. Distribution of male and female workers according to classes of blood lead (PbB) values.

PbB level ($\mu\text{mol/l}$)	Males		Females	
	N	%	N	%
< 1.9	33	18.2	38	35.8
1.9–2.9	60	32.9	50	47.2
> 2.9	89	48.9	18	17

gienic situation is particularly unsatisfactory (plant 4).], and finally (iii) the particular danger linked to dry-glaze working phases is confirmed by the high average (4.2 ± 0.6 $\mu\text{mol/l}$) found for nine workers from a small plant concentrating exclusively on the preparation (grinding and mixing) of glazes for subsequent application.

When the subjects are categorized according to job, it is clear how the possibility of lead absorption varies in relation to specific work activity. In the type of plant where production takes place in a single area, a higher-risk zone exists, ie, the glazing belt. While they carry out production phases, kiln workers who are near the glazing area are severely exposed. This observation must also be extended to those workers grouped under "various jobs"; while carrying out maintenance, they work in all departments and thus also in those areas where glazes are used the most. The last two groups — decoration and selection — are the farthest from the high exposure area. The higher average PbB values of the decorators than those carrying out selection can be explained by the fact that the decorators use lead-rich glazes (even though in small quantities) for finishing the product with ornamental motifs.

We found another report on the greater danger of glazing operations with respect to other types of work (3). The average PbB values referred to in that case (58 glazers) was 4.3 $\mu\text{mol/l}$, a level slightly higher than ours (3.6 $\mu\text{mol/l}$). However, a complete analysis of the jobs allowed us to show that there are different levels of risk in relation to different work methods. This situation is not evident from other literature. The decidedly high-risk jobs (glazing and kiln work) are traditionally done by men, while women predominantly

work in the less exposed areas. It is thus easy to see why, in our study, the observed average PbB values were higher for men than for women — much higher than could have been expected.

It appears that the length of exposure is not very important with respect to the modification of PbB levels; in effect, it may be believed that, at least from a certain moment on — and our cases do not define the situation in the preceding period of initial exposure — a steady state between absorption and elimination is reached (8).

We would also like to review our results in the light of both currently used criteria of acceptability and new knowledge on lead pathology. At the Second International Workshop on Permissible Levels for Occupational Exposure to Inorganic Lead, a limit of $2.9 \mu\text{mol/l}$ ($60 \mu\text{g}/100 \text{ ml}$) was recommended, even though this level is not considered acceptable (20). The same limit was proposed in the United States by the Occupational Safety and Health Administration (11). According to these new recommendations, 36.8 % of those exposed and examined in the present study showed higher values, and this percentage reached 71.4 % for the glazers. Moreover, we must remember that in 1975 Seppäläinen et al (15) showed, with electromyography, a reduction in the motor conduction speed of the ulnar nerve in subjects with PbB levels between 2.4 and $3.4 \mu\text{mol/l}$ (50 and $70 \mu\text{g}/100 \text{ ml}$, respectively). The average PbB levels of female workers is significantly lower than those of men because of the different jobs the women do. In our cases, 64.2 % of the women exposed showed a PbB value higher than $1.9 \mu\text{mol/l}$, ie, the maximum level recommended for women of fertile age, both with regard to possibility of damage to the fetus and the greater biological susceptibility to lead which women seem to show. [The earlier the increases in PPE take place, the earlier the neurotoxic alterations occur (13, 14, 17, 21)]. We must therefore conclude that job limitation does not seem sufficient to protect female workers when the risk is more or less present in the work environment, as was the case for the women we examined. We should also remember that, independently of sex, chromosome altera-

tions have been reported with PbB values of around $1.9 \mu\text{mol/l}$ ($40 \mu\text{g}/100 \text{ ml}$) (5).

In conclusion, we must again affirm that the risk of lead poisoning exists in the ceramics industry and that the level of risk is linked to the type of job performed. Technological modifications, personal hygiene, and biological monitoring (2) are the fundamental methods which can be used to reduce the danger of lead absorption. However, this danger will always be present to a greater or less extent, depending on the percentage of lead in the glazes used, and may be subject to efficient primary prevention.

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