Scand J Work Environ Health 1983;9(6):463-469

<https://doi.org/10.5271/sjweh.2386>

Issue date: Dec 1983

Evaluation of the current risk of lead poisoning in the ceramics industry.

by [De Rosa E](#), [Toffolo D](#), [Sigon M](#), [Brighenti F](#), [Gori GP](#), [Bartolucci GB](#)

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/6673104

This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).

Evaluation of the current risk of lead poisoning in the ceramics industry

by Edoardo De Rosa, MD, Daniela Toffolo, MD, Massimo Sigon, MD, Franco Brighenti, MD, Gian P Gori, PhD, Giovanni B Bartolucci, MD¹

DE ROSA E, TOFFOLO D, SIGON M, BRIGHENTI F, GORI GP, BARTOLUCCI GB. Evaluation of the current risk of lead poisoning in the ceramics industry. *Scand j work environ health* 9 (1983) 463–469. The authors evaluate the current possibility of lead poisoning in the production of ceramic tiles, an industrial sector which has always been considered dangerous due to the use of lead-rich glazes. The study was conducted in nine plants, four of which were repeatedly monitored (five checks on 94 exposed subjects). The other five plants (for a total of 221 exposed subjects) were only checked once. An analysis of all the results showed a clear reduction in mean blood lead levels, which the authors believe was due to the use of glazes with less lead. The results obtained were generally satisfactory; they indicated a definite improvement in the situation with respect to the authors' previous investigations, even for jobs in which workers were more frequently exposed. The data overlap those observed in the production of artistic pottery, which has always been considered less dangerous.

Key terms: blood lead levels, environmental hygiene, glazes, lead concentration in glazes, pottery.

The risk of lead poisoning in the ceramics industry has been evaluated in various ways in different countries by interested authors. In particular, exposure to lead in this industrial sector has been considered occasional (11), among the less dangerous industries when compared with other work (20), or else important, although limited, as regards the number of cases (12).

In Italy in recent years many publications have shown high risk, both on the artisan and the industrial level (1, 4, 15, 18). In this country risk has always been considered low in the production of artistic ceramics (2, 6, 10, 19), and the good results obtained refer mainly to the reduced use, for economic reasons, of lead oxides in the materials used to cover or decorate ceramics (19).

Sometimes contrasting opinions on the real extent of risk are due to the fact that

very often "ceramic production" is indicated without the type of finished product being specified. In one type of work, there may be a high content of lead-rich glazes (eg, tiles) although they are used to a far smaller extent in artistic products or are even unnecessary for sanitary fittings.

Specific risk may thus vary as a function of the technology used, different glaze application methods, and the higher or lower percentage of lead in glazes. Other differences may be due to the kind of job done and the observance of personal hygiene.

The particular attention paid to the problem of lead in the Italian ceramics industry is linked to the largescale production of tiles for building – 37 % of world production (16). In this type of work glazes with percentages of lead oxides varying from 5 to 50 % are used (16), and their preparation and application involve a decidedly high risk, as indicated by both environmental (17) and biological data (7).

Protective measures, personal hygiene, and improvements in the work environment may lead to a large reduction in risk (5, 8). This was the conclusion reached in one of our previous works, and accord-

¹ Istituto di Medicina del Lavoro, Università di Padova, I-35127 Padova, Italy.

Reprint requests to: Dr E De Rosa, Istituto di Medicina del Lavoro, Università di Padova, Via Facciolati 71, I-35127 Padova, Italy.

ing to which we hypothesized that further preventive success could be obtained only through the reduction of the quantities of lead in glazes (8).

In glazes lead has such important technological and esthetic functions that, although compositions with less lead are currently being developed, the total elimination of this element is not yet possible, at least in the sector producing building tiles (16). Therefore, in the present study, we wished to verify the situation in the ceramics industry some time after our previous investigations in order to evaluate the current possibility of lead poisoning in this industrial sector.

Subjects and methods

In nine plants producing tiles for the building industry with a wet-glaze process, we checked 315 workers by means of blood lead measurements, believed to be valid as a parameter (14) of exposure.

In the first four plants (A, B, C, D) 94 workers were followed by means of five blood lead determinations. The second determination was made six months after the first, and the third, fourth, and fifth tests took place one, two, and three years, respectively, after the second. The total number of exposed workers in the examined plants was greater than that used for this study. However we thought it best to consider only those workers who underwent all the tests, who did not change

type of job during the course of our investigation, and who were not absent from work for prolonged periods.

In the other five plants (E, F, G, H, I) we checked the blood lead level of 221 workers only once, during the interval between tests 4 and 5 of the workers from plants A, B, C, and D.

Table 1 shows the age and exposure of the subjects at the time of the first test of the workers from plants A, B, C, and D and at the time of the single test of the workers in plants E, F, G, H, and I.

The blood lead levels of the workers were measured according to the method of Westerlund-Helmerson (21) with the use of an atomic absorption spectrophotometer (Perkin-Elmer). The blood lead values of nonexposed subjects in our laboratory are the following: 1.3 (SD 0.4) $\mu\text{mol/l}$ for men and 1.0 (SD 0.4) $\mu\text{mol/l}$ for women, as we have already reported (7).

The precision of the method was tested in our laboratory during the entire period of monitoring. The standard deviation of the method error from double determinations, as computed in our laboratory, has constantly remained between 0.09 and 0.15 $\mu\text{mol/l}$. The precision of the method was estimated from measurements of the lead in three blood samples (one less than 1.0 $\mu\text{mol/l}$, one more than 2.4 $\mu\text{mol/l}$, and the third inbetween) from 10 different runs. The average coefficient of variation was 4 (range 3.2–5.1) %.

Table 1. Characteristics (sex, age, length of exposure) of the workers examined.

Sex	Number	Age (years)			Length of exposure (months)		
		Mean	SD	Range	Mean	SD	Range
Males							
Plants A, B, C, D ^a	50	40	23	17–62	58	40	2–216
Plants E, F, G, H, I ^b	174	40	11	21–58	72	48	3–264
Females							
Plants A, B, C, D ^a	44	22	7	14–45	51	36	9–138
Plants E, F, G, H, I ^b	47	29	10	19–52	51	39	6–180
Total							
Plants A, B, C, D ^a	94	30	13	15–62	55	38	2–216
Plants E, F, G, H, I ^b	221	38	12	19–58	68	47	3–264

^a Plants A–B–C–D : test 1.

^b Plants E–F–G–H–I : single testing.

The recoveries of added lead varied between 96.3 and 102.0 %.

In an Italian comparative study (1981–1982) employing spiked samples, we tested the accuracy of the method. The results are given in table 2.

Student's t-test and t-test (paired) were used for the statistical analyses.

Results

Table 3 shows the results of the five blood lead tests carried out on 94 subjects in plants A, B, C, and D. From Student's t-paired test, it may be seen that the mean blood lead level of all the subjects was reduced statistically significantly between tests 1 and 2 and between tests 2 and 3, while no significant difference was found between the other tests.

A similar trend was also seen when the men and women were considered separately. Table 4 shows the mean blood lead

value of the same subjects subdivided by plant. In all four cases, a statistically significant reduction in blood lead was found between tests 2 and 3, while a similar trend between tests 1 and 2 was only observed for plants B and D.

Table 5 shows our subjects subdivided by job (excluding kiln workers, since there were only three of them). Between tests 1 and 2 the mean blood lead values showed

Table 2. Italian comparative study for controlling blood lead analyses.

Year	Added ($\mu\text{mol/l}$)	Measured by our laboratory ($\mu\text{mol/l}$)
1981	0.53	0.48
	1.59	1.45
	2.65	2.56
1982	0.53	0.58
	0.53	0.68
	1.59	1.64
	1.59	1.59

Table 3. Average blood lead (PbB) values for the 94 subjects from plants A, B, C, and D, according to sex, over five tests. Comparison between the first test and following ones made with Student's t-test (paired).

Sex	PbB ($\mu\text{mol/l}$)									
	Test 1		Test 2		Test 3		Test 4		Test 5	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Males (N = 50)	2.6	0.9	2.3	0.6	1.8	0.6	1.7	0.5	1.7	0.3
		$p < 0.005$			$p < 0.001$					
Females (N = 44)	2.2	0.5	1.9	0.5	1.2	0.4	1.2	0.3	1.1	0.3
		$p < 0.001$			$p < 0.001$					
Total (N = 94)	2.4	0.7	2.1	0.6	1.5	0.6	1.5	0.5	1.4	0.5
		$p < 0.001$			$p < 0.001$					

Table 4. Average blood lead (PbB) values for the 94 subjects in plants A, B, C, and D. Comparison between the first test and following ones made with Student's t-test (paired).

Plant	PbB ($\mu\text{mol/l}$)									
	Test 1		Test 2		Test 3		Test 4		Test 5	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
A (N = 36)	2.1	0.6	2.1	0.5	1.5	0.5	1.4	0.4	1.4	0.5
				$p < 0.001$						
B (N = 20)	2.7	0.9	2.1	0.7	1.6	0.7	1.3	0.6	1.3	0.5
		$p < 0.001$			$p < 0.001$					
C (N = 23)	2.4	0.7	2.2	0.5	1.5	0.4	1.5	0.5	1.5	0.5
				$p < 0.001$						
D (N = 15)	2.6	0.8	2.1	0.8	1.6	0.7	1.5	0.6	1.4	0.5
		$p < 0.001$			$p < 0.001$					

Table 5. Average blood lead (PbB) values for the 94 subjects in five tests according to job in plants A, B, C, and D. Comparison between tests 2 and 3 made with Student's t-test (paired).

Job	PbB ($\mu\text{mol/l}$)									
	Test 1		Test 2		Test 3		Test 4		Test 5	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Glazing (N = 22)	2.9	0.9	2.6	0.6	2.1	0.5	1.9	0.4	1.9	0.4
Decoration (N = 36)	2.3	0.4	2.0	0.4	1.3	0.3	1.3	0.3	1.1	0.3
Selection (N = 19)	2.0	0.8	1.9	0.8	1.3	0.6	1.2	0.4	1.2	0.5
Miscellaneous (N = 14)	2.2	0.8	2.2	0.3	1.6	0.4	1.6	0.4	1.6	0.4

Table 6. Average blood lead (PbB) values for the 221 subjects according to sex and according to plant.

	Number	PbB ($\mu\text{mol/l}$)	
		Mean	SD
Sex			
Males	174	1.6	0.5
Females	47	1.1	0.4
Total	221	1.5	0.3
Plant			
E	48	1.5	0.6
F	53	1.4	0.5
G	25	1.7	0.3
H	71	1.4	0.5
I	24	1.7	0.5

Table 7. Average blood lead (PbB) values for the 221 subjects according to job in plants E, F, G, H, and I.

Job	Number	PbB ($\mu\text{mol/l}$)	
		Mean	SD
Glazing	66	1.8	0.5
Decoration	27	1.1	0.3
Selection	57	1.3	0.5
Miscellaneous	32	1.4	0.5
Kiln work	39	1.4	0.5

a slight reduction for glazers, decorators, and selectors, although statistical significance was not reached. Instead, a comparison of tests 2 and 3 showed a distinct reduction, statistically significant for all jobs considered, while the results of tests 3, 4, and 5 all more or less over-

lapped. Last, glazers always had blood lead levels which were higher, on the average, than those of workers in other jobs.

Table 6 shows the data from the single measurement made on 221 subjects in plants E, F, G, H, and I. The table shows the mean blood lead levels with the relative standard deviation, both for the total number of subjects examined and for the subjects subdivided by sex and plant. In the latter case, the blood lead levels ranged from a minimum of $1.4 \mu\text{mol/l}$ to a maximum of $1.7 \mu\text{mol/l}$ – not substantially different from the values measured in plants A, B, C, and D in more recent checkups (table 4).

Table 7 shows the mean blood lead levels of the same 221 subjects subdivided by job. The results confirm that glazing is the work phase leading to the greatest risk of exposure.

Finally, table 8 shows the group distribution of the blood lead levels of the 94 repeatedly monitored subjects and of those tested only once separately.

Discussion

As already mentioned, the objective of our study was to verify the current risk of lead poisoning in the ceramics industry, with particular reference to wet-glazing in tile production. We believed this investigation to be topical since results obtained in follow-up studies on subjects exposed in this industrial sector gave the impression of a lower risk with respect to our previous experience (7, 8).

Table 8. Distribution of the 315 subjects examined, subdivided by sex according to three blood lead categories.

Sex	PbB ($\mu\text{mol/l}$)					
	< 1.9		1.9–2.9		> 2.9	
	Number	%	Number	%	Number	%
Males						
Plants A, B, C, D ^a	32	64	18	36	—	—
Plants E, F, G, H, I ^b	136	78	37	21.3	1	0.6
Females						
Plants A, B, C, D ^a	44	100	—	—	—	—
Plants E, F, G, H, I ^b	44	93.6	3	6.4	—	—

^a Plants A–B–C–D : test 5.

^b Plants E–F–G–H–I : single testing.

The results showed a clear decrease in the mean blood lead levels (well below the variability of the method) of the subjects between tests 2 and 3 and, to a less significant extent, between tests 1 and 2. The difference in tests 1 and 2 can be illustrated by a consideration of plants A, B, C, and D separately, as shown in table 4. In plants B and D the mean blood lead levels decreased from 2.7 (SD 0.9) and 2.6 (SD 0.8) $\mu\text{mol/l}$, respectively, in the first measurement to 2.1 (SD 0.7) and 2.1 (SD 0.8) $\mu\text{mol/l}$, respectively, in the second. The latter figures overlap those of plants A and C in both cases. Since plants B and D carried out environmental improvements (installation of aspiration equipment) in the interval between the tests and since the workers involved were also impressed with the importance of personal hygiene measures (all already practiced in plants A and C at the time of test 1) during this time, it may be deduced that the mean blood lead values between 2.1 and 2.2 $\mu\text{mol/l}$ were the results obtainable with the technologies then used and with the observance of both environmental and individual preventive measures.

One year after test 2, a clear decrease in the mean blood lead levels was observed, both for all subjects and for a subdivision of them by sex (table 3), plant (table 4), and job (table 5). The values we observed for test 3 did not differ for plants A, B, C and D; they also overlapped those of tests 4 and 5 without further significant reductions. It is evident that, during the course of the year between tests 2 and 3, a factor intervened which caused a clear

improvement in the situation. In our opinion this factor cannot be environmental improvement or the adoption of personal hygiene measures demonstrating their effects with time, since in plants A and C these preventive measures were already being practiced and therefore any decrease in the blood lead levels would not have taken place together with that found in plants B and D, but previously.

In our opinion reduction in the lead content of the glazes was the determining factor affecting these results. The tendency towards abolishing or reducing the lead percentage of glazes has already been reported in the literature (16, 19), at least as a possible factor in the tile sector, and as a definite factor in artistic ceramic work.

Again, in the sector we examined, this tendency seems general since the blood lead levels of the 221 subjects examined once in plants E, F, G, H, and I, which used identical technology and in which environmental and personal hygiene preventive measures were in use, did not differ significantly (Student's t-test) from those obtained in the last checkup of the 94 subjects who had been repeatedly monitored.

Moreover no statistically significant differences emerged for any of the subjects examined, either between the two groups subdivided by sex or between the different types of jobs (glazing, decoration, selection, miscellaneous).

The checkups of the two groups of exposed workers were done in the same period, and, although we had no previous information on the group of 221 workers

examined only once, we can state that the situation overlaps in the same period in all nine plants.

The final values show great general improvement, on an individual level too, as may be seen from table 8, which shows the blood lead values of the 315 subjects examined in the same period, which was our last.

As regards women workers, we found only three cases in which the level of $1.9 \mu\text{mol/l}$ was exceeded. This value was the proposed maximum level recommended for women of fertile age during the Second International Workshop on Permissible Levels for Occupational Exposure to Inorganic Lead (22), and it has also been indicated as a threshold by the Occupational Safety and Health Administration of the United States (13).

In male workers, too, who generally undertake the more dangerous jobs, the results were also very satisfactory; in only one case was the recommended limit ($2.9 \mu\text{mol/l}$) (22) exceeded.

At this point an important comparison may be made between data from the ceramic sector and those from one of our previous investigations on artistic pottery work (6). In the latter sector, for 274 exposed workers, we found blood lead levels of 1.3 (SD 0.5) $\mu\text{mol/l}$ and average values of 1.7 (SD 0.7) $\mu\text{mol/l}$ for glazers (60 subjects) and 1.2 (SD 0.3) $\mu\text{mol/l}$ for decorators (178 subjects).

Our data thus show that the risk of lead poisoning in tile production is similar to that in artistic ceramics, which has always been considered less dangerous and less polluting (7, 10) on the basis of biological results and as a consequence of the use of glazes with less lead (19).

As already stated, in the light of our results, this great improvement can only be explained by a reduction in the lead content of the glazes used. Recent literature does not show data on the percentages of lead used for glaze composition in the years included in our study, and thus we do not have any technological proof of our hypothesis. However, it should be observed that the current market trend in Italy is for the production of tiles with more opaque colors, and thus for lower contents of lead in the glazes also, since one of the most important

properties of lead is to make the tile brilliant and glossy.

We believe that, in the future, high lead absorption will be found in tile glazers only occasionally and under particularly poor hygienic conditions. On the basis of our data, this consideration may probably be extended to include most Italian ceramic plants, although the biological monitoring of workers, albeit less frequently, will still be necessary. These positive conclusions regarding lead must not, however, lead to a slackening of the surveillance in these environments, mainly because of the presence of other toxic metals in glazes, eg, aluminum, titanium, nickel, copper, zinc, and, above all, cadmium, chrome and cobalt (3, 9).

We believe that professional risk in the ceramic tile industry is undergoing great change due to possible problems which have not been studied in depth previously, since attention was principally aimed at lead.

References

1. Alberti S, Salimei E, Cioppi E. La prevenzione del rischio da piombo in un ambiente artigianale. *Securitas* 57 (1972) 147–159.
2. Bertoni M, Cicognani R, Francesconi E, Gaiardi S, Lombardi I, Loreti AR, Monduzzi W. Rilevi ambientali ed epidemiologici della maiolica faentina. In: Atti del XLIII congresso nazionale della società italiana di medicina del lavoro ed igiene industriale, Parma Ottobre 1–4, 1980. Volume II. Tecnografica ed, Parma 1980, pp 59–76.
3. Candela S, Tonelli S, Torreggiani A, Vecchi G. Esposizione a nitrato di cobalto in un'azienda ceramica: Patologia respiratoria ed intervento di prevenzione. In: Atti del XLIII congresso nazionale della società italiana di medicina del lavoro ed igiene industriale, Parma Ottobre 1–4, 1980. Volume V. Tecnografica ed, Parma 1980, pp 141–146.
4. Cavalleri A. Influence of lead on health conditions of ceramic industry workers. In: Proceedings of the international seminar on the problems of lead and fluorine air pollution from industrial sources. Centro Ceramico Bologna ed, Bologna 1978, pp 213–229.
5. Cavatorta A, Mutti A, Falzoi M, Lucertini S, Cigala F, Franchini I. Monitoraggio biologico degli esposti a piombo nell'industria ceramica delle piastrelle della provincia di Parma. In: Atti del XLIII congresso nazionale della società italiana di medicina del lavoro ed igiene industriale, Parma Ottobre 1–4, 1980. Volume I. Tecnografica ed, Parma 1980, pp 231–236.
6. Chiesura Corona P, De Rosa E, Trevisan

- A, Acqua A. Differenziazione del rischio di saturnismo nell'industria ceramica secondo il settore, la mansione, la tecnologia impiegata. In: Atti del XLIII congresso nazionale della società italiana di medicina del lavoro ed igiene industriale, Parma Ottobre 1-4, 1980. Volume II. Tecnografica ed, Parma 1980, pp 183-189.
7. De Rosa E, Brighenti F, Rossi A, Caroli 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.
8. De Rosa E, Rossi A, Toffolo D, Brighenti F, Rosa A, Caroli S. The ceramics industry and lead poisoning: Long-term testing. *Scand j work environ health* 6 (1980) 312-315.
9. Fornaciari S, Renna E, Franchini I. Esposizione a metalli nell'industria ceramica delle piastrelle. In: Atti del XLIII congresso nazionale della società italiana di medicina del lavoro ed igiene industriale, Parma Ottobre 1-4, 1980. Volume I. Tecnografica ed, Parma 1980, pp 117-121.
10. Gobbo B, Malavolti L, Sommani L. Rischi, patologia e prevenzione nell'industria ceramica del comprensorio faentino. Atti del XLIII congresso della società italiana di medicina del lavoro ed igiene industriale, Parma Ottobre 1-4, 1980. Volume II. Tecnografica ed, Parma 1980, pp 41-57.
11. Knappet CR. Lead poisoning. In: Davies CN, ed. *International symposium: Health conditions in the ceramic industry*. Pergamon Press, Oxford 1969, p 215.
12. Markicevic A, Bertic T, Prpic-Majc D. An outbreak of lead poisoning in a ceramic factory. In: *Proceedings of the international seminar on the problems of lead and fluorine air pollution from industrial sources*. Centro Ceramico Bologna ed, Bologna 1978, pp 257-262.
13. Occupational Safety and Health Administration. Lead, occupational exposure, proposed standard. *Fed regist* 40 (1975) 45933-45938.
14. Odone P, Alessio L. Nuove vedute sui limiti "permissibili" nella esposizione professionale a piombo organico. *Med lav* 1 (1979) 3-7.
15. Olivo R, Vivoli G. Lead and fluorine air pollution in the ceramic industry district of Sassuolo and possible effects on human health. In: *Proceedings of the international seminar on the problems of lead and fluorine air pollution from industrial sources*. Centro Ceramico Bologna ed, Bologna 1978, pp 3-58.
16. Palmonari C, Timellini G. La tecnologia di produzione ceramica. In: Atti del XLIII congresso della società italiana di medicina del lavoro ed igiene industriale, Parma Ottobre 1-4, 1980. Volume I. Tecnografica ed, Parma 1980, pp 7-52.
17. Renna E, Busani G, Franchini I. L'inquinamento da piombo nella ceramica delle piastrelle. In: Atti del XLIII congresso nazionale della società italiana di medicina del lavoro ed igiene industriale, Parma Ottobre 1-4, 1980. Volume I. Tecnografica ed, Parma 1980, pp 93-115.
18. Rizzati E, Bergellini P. Il valore di screening dell'ALA e delle CP urinarie nei controlli periodici degli operai dell'industria ceramica esposti a rischio saturnino. *Boll soc med chir modena* 71 (1974) 205-214.
19. Scansetti G, Perrelli G, Giachino GM, Pavan I, Botta GC. Tecnologia e rischi lavorativi nell'industria della ceramica per la produzione di vasellame e stoviglie per uso domestico. In: Atti del XLIII congresso nazionale della società italiana di medicina del lavoro ed igiene industriale, Parma Ottobre 1-4, 1980. Volume II. Tecnografica ed, Parma 1980, pp 7-28.
20. Tola S, Hernberg S, Vesanto R. Occupational lead exposure in Finland: VI Final report. *Scand j work environ health* 2 (1976) 115-127.
21. Westerlund-Helmerson V. Determination of lead and cadmium in blood by a modification of the Hessel method. *At absorpt newsl* 9 (1970): 6, 133-134.
22. Zielhuis RL. Second international workshop permissible levels for occupational exposure to inorganic lead. *Int arch occup environ health* 39 (1977) 59-72.

Received for publication: 17 February 1983