

A METHOD OF EVALUATING WORKERS' EXPOSURE TO HARMFUL SUBSTANCES

R. FRANT and J. H. C. VAN MOURIK

Philips' Gezondheidscentrum, Eindhoven, Nederland

Two methods of investigation are open to the industrial physician responsible for protecting a group of employees against the consequences of handling harmful substances. Originally, medical examination of workers was the only method available, but later on this was supplemented by analysis of the atmosphere in which they worked. Although the absorption of a harmful substance takes place mainly *via* the lungs, the quantity absorbed cannot be worked out exactly from the concentration found in the air, for the "work load" (individual effort), the associated respiratory minute volume, and the size of the particles in the air, determine how much of the substance gets into the body by respiration. Moreover, it is also possible for absorption to take place *via* the skin or the intestinal tract. Medical examination reveals the total effect of the quantity of poisonous substance that has been absorbed over a longish period, but, for the purpose of prevention, this knowledge comes too late. However, if methods of production in the factory remain the same there should be no surprises. The great value of periodical medical examinations is in providing a check on whether hygienic measures are being carried out in accordance with instructions, and whether they are effective. If the data from such examinations be arranged in a manner we shall describe below, the investigator will be in a position to detect slovenly working and other slight departures from correct procedure, such as would not be noticed in the course of an incidental inspection.

The evaluation of the results of medical examinations is rendered difficult by the range of biological variation exhibited by individuals. Often it is not easy to say whether a state of poisoning exists or not, particularly where the amount of harmful substance absorbed has been small.

The truth of this was once again confirmed by van Wely¹, who set out to determine what symptoms of lead poisoning were detectable among 59 applicants for employment who had never worked with lead or its compounds. In this group he found as many complaints and irregularities, *e.g.*, constipation and abdominal pains, as in a group of lead-workers. Only laboratory tests showed that the latter were actually in a worse condition.

It is, nevertheless, possible, given data on a group of persons, even one not containing cases of poisoning, to evaluate the data without running up against the above difficulties to any great extent. The procedure to be described

allows "contamination" with lead, for example, to be estimated before any more-or-less clear case of poisoning has arisen. Lead in the form of an inorganic compound has been taken as an example because it is with this that most experience has been gained; however, the procedure can, in principle, be followed for any other substance, but is most suitable for substances giving rise to sharply defined symptoms and laboratory results with clear limits.

In a possible case of lead poisoning, the various subjective and objective symptoms and the laboratory findings are each given a point-rating corresponding to their significance. The following have been chosen amongst the clinical symptoms:

General impression	Extensor weakness
Irregular stools	Tremors
Constipation	Lead line in gums
Colic	Livid complexion

Each of the above rates one point. Hence the maximum obtainable by one person is 8, and the maximum obtainable by a group of N persons is $8N$. The total number of points actually awarded, in respect of symptoms observed, is n . This figure divided by the maximum obtainable and multiplied by 100 gives the group percentage.

$$\text{Group percentage} = \frac{100n}{8N} \text{ (see Table 1)}$$

One member of the group may make a big difference to the group percentage, and for this reason the totals scored by individuals are shown separately. This is a matter demanding close attention, since otherwise, in a group whose exposure has been slight, a case of lead poisoning might remain undetected.

Table 1. Clinical examination

Month of examination	Number examined (N)	General impression	Irregular stools	Constipation	Colic	Extensor weakness	Tremors	Lead line	Livid complexion	Group score (n)	Group percentage	Distribution of number of individuals examined by number of points they scored									
												Individual scores									
													0	1	2	3	4	5	6	7	8

.....Department

The results of laboratory tests are tabulated in the same way. The determination of the porphyrinuria, of basophilic granulation and of the haemoglobin content are the routine methods used. In view of the importance of their quantitative aspect the findings are rated according to the following scheme.

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Table 2. Scaling of the results of laboratory investigations

	<i>Point rating</i>		
	0	1	3
Porphyrinuria ($\mu\text{g/l.}$)	< 200	200-400	> 400
Percentage basophilic granulation per thousand	< 0.5	0.5-3.0	> 3
Percentage haemoglobin content, by Sahli method	> 80	60-80	> 60

Here the maximum score obtainable is 9 for one man and $9N$ for a group of N people. If the score actually awarded to a group is n , the group percentage will be $\frac{100n}{9N}$. The table below will serve as an example.

Table 3. Laboratory tests

Month when tests were performed	Number tested (N)	Basophilic granulation	Porphyrinuria	Haemoglobin	Group score (n)	Group percentage	Distribution of number of individuals tested by number of points they scored									
		Rating					Individual scores									
		0	1	3			0	1	3	0	1	2	3	4	5	6
Department X																
2/57	14	10 4 0	12 0 2	13 1 0	11	8.7	9	2	1	1	1	-	-	-	-	-

Here, too, it is advisable to keep watch for any member or members of the group with a high individual score. A high score almost always means that excessive absorption of lead has taken place (and determining the lead content of the blood and urine may confirm this interpretation). The source of contamination is just as likely to have been outside as inside the factory. We found an example of outside contamination in a girl who was employed on soldering. Apart from her, every member of the large group in which she worked had a very low score, and this immediately suggested that she had been absorbing lead outside her place of employment. It was in fact found that she was living on a remote farm where the well-water was contaminated with lead.

We have been subjecting a number of factory departments to periodical investigation along these lines. Relatively low lead concentrations were found in all departments—we have never had a clear case of lead poisoning—and, accordingly, we were able to divide them up into the following three classes:

		<i>Average group percentage for</i>	
		<i>Clinical examination</i>	<i>Laboratory tests</i>
No danger	approx. 1/10th M.A.C.	0-3	0-2
Some danger	approx. $\frac{1}{2}$ M.A.C.	0-3	3-5
Causing concern	approx. M.A.C.	0-3	8-20

Our classification shows that there is some correlation between the results of laboratory tests and those of air analyses. The third class, regarded as a matter of concern, comprised one department where, for several years, the group percentage had been steadily rising from one periodical investigation to the next. It proved impossible to effect any improvement by adopting simple measures, and a thorough reorganization was therefore decided upon. Taking the group percentage as a criterion, we had an earlier warning and more exact indication of the approaching danger than we should otherwise have had.

As already stated, our experience with the method was gained in departments where the danger from lead poisoning could be kept under reasonably good control. Consequently, the group percentages found were always low. Those for the clinical examinations were found to vary between 0 and 4, even in groups whose members remained the same from one investigation to the next. Group percentages for laboratory tests varied between 0 and 12. Fluctuations within this range, therefore, have little significance. The figure of 23.3 per cent, the highest found for the department in the third class, is, however, significant; the group percentage for that department remained round about 20 when investigations were repeated.

As long ago as 1943 Foulger² pointed out the great value of regarding the entire exposed group as the patient instead of treating each worker individually. He used blood-pressure measurements as a general means of indicating whether poisoning had taken place. The method employed by us is more specific for the kind of poisoning being investigated, and the indications it gives are more exact.

References

- ¹ P. A. van Wely. Unpublished report, 1957
- ² J. H. Foulger. *Principles And Practice Of Industrial Medicine* (Wampler), p. 150, Baltimore (1943)