Ninth Annual Convention
Greater New York Safety Council
April 19, 20 and 21, 1938

Occupational Disease No. 1
Session No. 22
Paper No. 54

INDUSTRIAL LEAD POISONING

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The Occurrence of Lead Poisoning in Industry

The available statistics indicate that there has been a progressive decline in the incidence of fatal lead poisoning in the United States during the past eighteen or twenty years. Considering the obvious inadequacies in these statistics one may doubt that they represent the facts reliably, but cannot escape the conclusion that the more hazardous types of occupational lead exposure have been brought under some degree of control. The data provided by state compensation agencies also points to a fairly general trend toward reduction in the incidence of non-fatal lead poisoning over the period of years and in the areas for which information is recorded. Thus in Ohio the number of compensated cases of plumbism in 1928 was 180, while in 1936 such cases totaled 112. The decrease in the number and rate of cases of lead poisoning has not been so great or so consistent from year to year as has been the decline in fatal cases, and indeed an actual diminution in such cases has probably not occurred in all parts of the United States. Experience has demonstrated that when the attention of industrial management has been directed toward hazardous lead exposure by the increased cost of excessive labor turnover, occupational health insurance, sickness and disability benefits, or civil suits, or through the efforts of informed hygienists, something is done to improve operating conditions. Otherwise an attitude of laissez faire is likely to exist. Thus, in hygienically backward regions of the country, industrial plants can be found in which seriously disabling and fatal cases of lead poisoning occur, not as the unforeseen consequence of some unusual or temporary change in plant conditions, but as the result of normal but grossly hazardous plant operations. Moreover, plant managers with no experience in the handling of lead compounds may undertake the manufacture or processing of lead-bearing materials, only to make use of unsafe methods long abandoned by more experienced and wiser management. Many other factors have exerted their influence to offset partially the advances made toward the progressive elimination of industrial plumbism, among which the most troublesome, perhaps, is the continual change in technical and manufacturing procedures whereby new opportunities for lead exposure are introduced into the industry. In any case, we may not take excessive pride in the improvement that has been achieved in recent years, but rather should we feel disappointment and chagrin that the available means of controlling dangerous lead exposure have been inadequately and incompletely applied.

It will be of some interest to visualize the occupational distribution of fatal cases reported in the United States registration area, and of non-fatal cases compensated in Ohio, for the year 1935, as shown in Table I. The data on Ohio do not cover all the industries and occupations that give rise to lead poisoning since some of these are not represented in Ohio; nor do the numbers of cases as listed indicate the true status of occupations with respect to their relative hazards. However, some of the common sources of occupational plumbism are illustrated. Comparison of the numbers of cases in the two columns shows that industries with a relatively high occurrence of non-fatal poisoning may have a low or negligible frequency of fatalities. These data, when considered in relation to the approximate numbers of persons employed in the several occupations, further suggest that safety measures carried out in certain industries have tended to eliminate the more dramatically hazardous types of lead exposure without reducing the exposure to a safe level. Whether true or not this thesis is of academic importance only, for the fact remains that the present incidence of lead poisoning is still unnecessarily high and can be reduced greatly through the use of suitable methods of control. This is not to say that there are not difficult problems to be met in certain industries. Some dusty lead compounds are manufactured and handled by methods which can be rendered safe only by the exercise of continual vigilance and the application of unusual engineering skill. What is needed in some instances is the willingness on the part of manufacturers to abandon certain processes in favor of others which can be controlled more satisfactorily, even though the product may be inferior in some respects to that obtained by other methods. Purely for the purpose of an example, and not to single out one manufacturing method for criticism, the old Dutch process is employed for the manufacture of a type of white lead which is regarded in some circles as superior to that obtained by other methods of manufacture. I may be in error, but I do not believe that the advantageous qualities of the product justify the cost of the measures required to safeguard the various operative steps of this process. That such qualities justify the tolerance of unsafe conditions in plants which use this process cannot be accepted. In general, however, it is not necessary to make sweeping changes in manufacturing methods. There are, in fact, few types of occupational lead exposure that offer serious or unsurmountable obstacles to modern engineering methods of attack. What is really required is an understanding of the means of detecting dangerous lead exposure. Satisfactory methods are available for this purpose - methods which not only will demonstrate the existence and the general magnitude of the hazard but also will identify the operations and conditions which are responsible for it.

The Measurement of Lead Exposure

The measurement of lead exposure in anticipation of its effects cannot be accomplished effectively by purely clinical means. Nor can it be done satisfactorily through the study of any of the non-specific physiological reactions of the body to lead absorption. The so-called "lead line" of the gums or of the anal tissues is not specific for lead, nor is it related, in rapidity of appearance or in extent, to known quantities or concentrations of absorbed lead. The increase in reticulocytes, or in diffuse or punctate basophilia of the erythrocytes is substantially constant in its occurrence as a response to some degree of increase in lead absorption, but it is not the result of lead absorption alone, nor is the response sufficiently uniform in quantity to give a reliable clue to the magnitude of the lead absorption of an individual or group of individuals. From the point of view of prophylaxix, the blood changes share with the "lead line" the virtue of being non-specific signs of lead absorption rather than of intoxication, and they are clinically useful in the detection of lead exposure, but they are not sound criteria for estimating the magnitude of lead exposure. Their use as such is but a makeshift, to be relied upon only when adequate methods for measuring the magnitude of the exposure are not available.

Poisoning from the ingestion of lead compounds is of infrequent occurrence in industry partly because of the general excellence of wash room and lunch room facilities in industrial plants and the resultant promotion of orderly and cleanly habits among the workmen, but chiefly because of the preponderant opportunities for intoxication from the inhalation of particulate lead compounds which contaminate the atmosphere of workrooms. In other words, the ingestion of lead compounds in the course of the day's work can be and is largely prevented through the exercise of ordinary care, while the prevention of lead inhalation is attended by much greater difficulties. In certain industries careful supervision is needed to maintain the degree of personal cleanliness that is required for the avoidance of lead ingestion, and where this is the case such supervision should be provided, for seriously disabling lead poisoning can occur from lead ingestion alone, as is demonstrated adequately by its occurrence in the general population, especially among children. An overwhelming proportion of cases of industrial lead poisoning, however, is due to inhaled lead. It follows, therefore, that determinations of the lead content of the atmosphere of workrooms yields fairly comprehensive information as to the magnitude of the occupational lead hazards in such rooms. Satisfactory methods for estimating the atmospheric lead content have been devised and employed extensively in a variety of industries, not only in hygienic surveys but also in the routine periodic testing of plant conditions, especially in relation to changes inequipment and operating methods.* The development of these methods, their practical application to the study of plant processes, and the correlation of data obtained by their use with the results of clinical studies on workmen, have provided a practical means for the appraisal of industrial lead hazards. As experience has been gained it has become increasingly apparent that it is feasible to express the magnitude of the lead hazards of a plant and of its individual operations in terms of the lead content of properly selected air samples, and to anticipate with reasonable accuracy the probable results of exposure, especially with respect to the severity of the intoxication which is likely to be associated with a given magnitude of exposure.

A second method which is available for measuring the lead hazards of an occupation, is based on the fact that lead is eliminated from the body of exposed persons at a rate which is determined by the magnitude and duration of the exposure, and in a manner which tends to identify the portal of entry. Thus the periodic study of the alimentary and urinary excretory response of representative workmen to the lead exposure associated with their occupations within an industrial plant gives a cross-sectional picture of plant conditions which is not afforded by any other means. The method has the additional great advantage, from the view-point of the medical man that it provides useful and often indispensable information for the diagnosis of obscure and unusual cases of illness among workmen. Dangerous lead absorption sometimes occurs as the result of apparently insignificant changes in technical procedures. An occasional workman may be seriously poisoned in an occupation or plant that appears to be safe. Such cases are commonly attributed to unusual susceptibility. Actually one usually finds that such persons have absorbed toxic quantities of lead as the result of some unusual and unrecognized type of exposure. Workmen in the lead trades also develop illnesses unrelated to lead exposur . Abdominal pain in the lead worker is not always lead colic. The prompt analysis of a sample of blo and urine may serve to rule out lead intoxication and permit the recognition and tre ment of another type of illness. These, as well as numerous other practical conside ations fully justify the use of this general method of maintaining a check on the lo exposure associated with the operation of an industrial plant. Obviously it, like a sampling, must be carried out as an adjunct to clinical supervision. It may also be employed to advantage in combination with air analyses, using the latter to obtain prompt results in situations in which for various reasons it is difficult or inconvenient to obtain the necessary cooperation of the workmen.

* Discussions of methods can be found in Industrial Dust, (Hygienic Significance, Measurement and Control), by Drinker and Hatch, Mc-Graw-Hill Book Co. New York, 1936, in U. S. Public Health Bulletin No.217, 1935, by Bloomfield and Dallavalle, and in the Sixth Annual Year Book of the American Public Health Association, 1935-36, in a Supplement to the American Journal of Public Health 1936, 26: No.3,30-85.

The Recognition of Hazardous Lead Exposure

When hazardous lead exposure exists it gives rise to cases of lead poisoning, the number and severity of which vary in general with the severity of the exposure. Workmen may be removed from more hazardous jobs either periodically or when incipient plumbism manifests itself, and by being transferred to work involving less or no exposure, some unpredictable proportion of them may be spared the more serious consequence of their exposure. Unfortunately it is often impossible to detect incipient plumbism in time to obviate its effects. In my experience the most reliable indication of impending acute intoxication is found in the subjective symptoms of a workman when described under conditions that neither minimize or magnify them. Here however, one is dealing with actual intoxication and often in a stage which may give no clue to its ultimate severity. Moreover workmen often conceal their symptoms to retain their employment, or they magnify them from anxiety or intent to deceive. Doubtless for this reason undue reliance has been put upon certain laboratory procedures, especially microscopic blood changes, to provide warning of impending intoxication. Some industrial physicians have even resorted to a periodic deleading therapy in the case of heavily exposed workmen, with the idea of avoiding excessive accumulation of lead in their tissues, and thereby maintaining them in their occupations for longer periods of time. I hasten to condemn this latter procedure unreservedly as based more on faith and the spirit of adventure than on sound hygienic principle and practice, and as inspired by a greater zeal to serve industrial management than to protect endangered workmen. In the long run all such efforts to forestall the worst effects of admittedly unsafe working conditions are doomed to but incomplete success and, therefore, to failure, for cases of poisoning will occur if there is sufficient exposure, and sometimes without warning. Moreover the doctor is not serving his primary function in industry through such efforts. Obviously he should treat those who suffer from lead poisoning or any other occupational injury, but let us not delude ourselves or him in the belief that he is making any important contribution to industrial hygiene by so doing. His most important role in relation to the industrial intoxications is to develop and to employ his skill for their recognition and thereby to demonstrate the need for their control. His careful clinical study of a plant population should serve to detect the existence, the location and the nature of the occupational factors which injure the health of the workmen. This involves a considerable knowledge of the plant conditions and the process and a familiarity with changes in plant operations. It also requires thorough investigation of all types of illness, and adequate study of detailed and well ordered medical records on the plant personnel. With specific reference to lead hazards such as regime of medical supervision as is envisaged above involves a continued search for signs of abnormal lead absorption. Such signs are likely to be quite obvious where the methods for the control of exposure are ineffectual or haphazard but even under these conditions the more hazardous operations can be located by evidence that is apt to be so convincing as to justify remedial measures. As the magnitude of lead exposure in a plant is progressively diminished correspondingly more precise methods for detecting the effects of abnormal lead absorption come to be required, but the adequacy of any type of hygienic control which provides anything less than complete elimination of occupational lead exposure must rest upon the clinical data obtained on the exposed persons. The detection of hazardous lead exposure therefore is the one primary and indispensable contribution of the physician toward the control of industrial lead poisoning.

Safe Limits of Lead Exposure

Comparatively recent studies of human lead absorption and excretion under normal environmental conditions and at various levels of experimental and occupational lead exposure have provided a sound physiological basis for the opinion advanced by industrial hygienists, that some degree of lead absorption can be borne without injury by human beings. It is now quite clear that man and other animals ingest small quantities of lead daily with their food and drink, and that they establish an equilibrium with their environment by means of which they maintain relatively constant concentrations of lead in their tissues and excreta, and a balance between lead intake and output. In experimental observations on human subjects, as yet unpublished, we have seen that within certain limits, which as yet have not been fully explored, an increased level of lead intake results in a temporary increase in the lead content of the tissues, with a progressive rise in excretion until a balance between intake and output is reached at a level higher than normal. Under such conditions progressive accumulation of lead does not occur in the tissues. We have obtained evidence, which has been detailed elsewhere, that at some incompletely defined level of lead intake the excretory processes fail to keep pace with lead absorption, and accumulation of lead occurs. It seems probable that lead intoxication occurs only as the result of the absorption of quantities of lead with which the body is unable to cope for some reason such as the foregoing. Conversely, it seems reasonable to suppose that so long as lead absorption and excretion are maintained in balance, lead intoxication will not occur, regardless of the length of time the exposure to lead is continued. Whether or not this is true over the entire range of balanced lead intake and output, has not been ascertained at present, but it can be accepted as fact that up to a certain level of intake and output, we are dealing with a set of normal or physiological processes which are no more associated with toxic manifestations than are a variety of metabolic reactions of other mineral constituents of the human body. This fact enables us to recognize that the poisonous properties hitherto attributed to lead and its compounds, are not necessarily associated with its mere presence in the tissues but rather with the occurrence of definite quantities or concentrations of the element therein. That is to say, lead is a dangerous constituent of the human body only when it occurs in toxic concentrations in the tissues. It is a dangerous factor in human environment only when it occurs in such form or in such quantity as to gain access to the body in toxic concentrations. The primary problem of industrial hygiene, in relation to lead compounds, therefore, is to determine the lowest injurious concentration of lead in human tissues.

For obvious reasons hygienic engineers have put their chief efforts into the study of plant conditions, employing the available and sometimes inadequate information as to the general state of health of workmen as a clue to the significance of lead exposure. By such means they have established criteria which if generally fulfilled in the lead industries would serve to eliminate a large proportion of presently occurring cases of lead poisoning. With the additional information which can now be supplied by the physician through maintained study of the physiological response of lead workers to the lead exposure of their occupations, more precise criteria for the recognition of potentially dangerous exposure can be set up. There is little room for doubt that by such combined efforts of the physician and the engineer, hazardous lead exposure can be brought under complete control, so that the many useful lead-bearing commodities of present and future industry can be produced without the payment of the present unjustified toll of illness and death among workmen.

TABLE I

Occupational Distribution of Cases of Plumbism in the Year 1935*

	Fatal Cases in the United States	Compensated Cases in Ohio
Painters	36	16
Paint Workers	6	
Foundry Workers		9
Storage Battery Factory Workers	2	23
Sanitary-ware Enamelers		13
Lead Workers	10	7
Printers, Electro-Typers and Lithographers	4	5
Potters		6
Automobile Factory Workers	1	
Miners	5	
Rubber Factory Workers	1	
Farmers	8	
Miscellaneous	23	23
Non-Occupational (mostly children)	34	
Total	130	102

*Adapted from the data of Frederick L. Hoffman as reported in U. S. Department of Labor Serial No. R, 669, U. S. Government Printing Office, Washington, D. C. 1938.