STATEMENT

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ON AN APPRAISAL OF THE POTENTIAL HAZARD OF THE ABSORPTION OF LEAD FROM THE AMBIENT URBAN ATMOSPHERE BY THE GENERAL POPULATION OF THE UNITED STATES

The problem posed in the title of this statement was initiated, in relation to the general use of gasoline containing lead as a fuel for motor vehicles, in 1926. Prior to that time, that is from 1923 through 1925, this fuel had been in limited use in a few areas in the United States. From early in 1923, when commercial trials had proved successful and offered promise of wider usage of the fuel, the hygienic significance of the lead discharged from the exhaust pipes of automobiles was questioned, and an investigation of this matter was sponsored by the principals in the development of this antiknock additive and carried out in the United States Bureau of Mines Experimental Station in Pittsburgh, Pennsylvania.

From that time on, this problem has been under investigation in a variety of ways, and by a series of methods which have been developed and refined to bring effective clinical, epidemiological, physiological and chemical skills to bear upon it. The bulk of the investigative work has been done by the staff of the Kettering Laboratory or by that of its progenitor, the Eichberg Laboratory of Physiology, in the College of Medicine of the University of Cincinnati, under the financial sponsorship of the producers and distributors of lead antiknock compounds in the United States, through agreements between representatives of these industries with the Board of Directors of the University. In recent years, the cost of the work has been shared by other industrial organizations, including representatives of the petroleum industry, and by the Division of Air Pollution of the Public Health Service. In addition to the work of the

Kettering Laboratory, there have been governmental investigations in this country and abroad both early (United States Public Health Service, 1925, and British Ministry of Health, 1928-29) and lately, (Swiss Leaded Gasoline Commission, 1947-60, and United States Public Health Service, 1961-64), and these have served not only to develop information of their own, to contribute to better understanding of the problem, but have confirmed the methods and findings of the Kettering Laboratory at a number of crucial points, and have established, firmly, a large body of factual information. This information has been summarized in a more extensive memorandum which is offered at this time, and is documented by copies or reproductions of the original contributions, (plus a translation of the Swiss report), many of which are no longer readily available elsewhere. Certain other publications have appeared, from time to time, on various aspects of this general subject, to add to its extensive literature, but the record of some forty years of observation and investigation of matters at issue here are covered by the documents offered herewith.

It is the purpose of this brief statement to call attention to the three main features of the evidence which has been adduced by these investigations, and to put them in their proper perspective at this time and in their relation to the future.

1. The Sources and Quantities, and the Disposition of Lead Absorbed from the General Urban Environment

The contribution made to the absorption of lead by that inhaled from the ambient air by persons in the general population, is small, being appreciably less than that absorbed daily from the alimentary tract. The latter quantities derive from the ingestion of food and beverages, each item of which contains some lead, the composite amount ranging from a minimum of somewhat less than 0.1 milligram to somewhat more than 4 milligrams, and averaging (for a large number of adults) approximately 0.3 milligram, per day (individual adults average about 0.12 to 0.38 mg. per day, dependent upon their size, activity, choice of

food, and appetite). While the precise quantity of lead absorbed from the respiratory tract of an individual cannot be determined directly, the relationship between that absorbed from the alimentary and respiratory tracts, respectively, is demonstrated indirectly by the relative magnitude of the physiological response, in the form of an increase in the rate of excretion of lead in the urine, to an increase in the alimentary intake of lead, as contrasted with that induced by a comparable increase in the concentration of lead in the inhaled air. For example, the increase in the urinary excretion of lead is prompt and readily discerned, when the alimentary intake of lead is increased four-fold, whereas there is only a dubious trend toward an increase, when the concentration of lead in the inhaled air has been increased six- or seven-fold during approximately one-third to one-half of each 24-hour period. In physiological terms, these results mean that six or seven times the very small quantity that is absorbed in the lungs, under ordinary environmental conditions, is yet a quantity so small as to be obscured by that which is being absorbed regularly from the alimentary tract. This same conclusion would appear to be justified by the observation that the persons investigated in Los Angeles, in the "Three Cities Survey" (Publication No. 999-AP-12 of the Public Health Service) could not be differentiated from those in Cincinnati by means of the levels of the concentration of lead in their urine or blood, despite the fact that the average annual concentration of lead in the atmosphere of Los Angeles is nearly twice that of Cincinnati.

2. The Quantities of Lead Absorbed Under General Environmental Conditions, As Compared with Those Associated with the Danger of Lead Poisoning

The quantities of lead found in the tissues and organs of persons in the general population (those who have not been subjected to occupational or other unusual environmental conditions, with respect to lead), and in transit, i.e., into, through, and out of the tissues, are not associated with any form of intoxication by lead that is known to physicians, investigators, or

physiologists. Apprehension as to subtle or presently incomprehensible effects that might be sustained as the result of the absorption of the minute quantities of lead that occur in the ordinary environment, is wholly unjustified by the facts of biology, clinical medicine, and the extensive information concerning the toxic manifestations of lead. In support of this opinion one need not claim that everything is known about the effects of the absorption of lead, and that nothing more is to be learned. No such assurance is given to anyone on any subject. But there is no virtue in dire imaginings that go entirely beyond human experience, and nothing is more futile than indulgence in gloomy speculation as to what might occur beyond the scope of probability. We have not so nearly freed our people from their real and present dangers that we can afford to concentrate our efforts and resources on the banishment of imaginary risks that may appear in the future. Some of the present apprehension is due to the deservedly bad reputation that has been attached to lead through the centuries, and to a somewhat naive but persistent impression that, since comparatively large quantities of lead, poorly defined until recently, have been capable of inducing illness, any quantity must be somewhat harmful. Physiological and toxicological knowledge lends no support to this impression. Nothing is more applicable, generally, in biological science than the principle of the quantitatively adequate stimulus, be it beneficial or injurious. Moreover, despite the statement ~~of a recent speaker~~ on this subject that "lead is (not) familiar to the body," the fact is that no living thing, and no remnant of an organism once alive on this planet, has yet been found to be free of lead. Lead is a constituent of the stones of the earth; of the soil, derived, in part, from stones; of its waters, and its plant and animal life, including the human species. Some controversy has been aroused recently as to whether the quantity involved in the case of man is minute or subminute. The best observations available now say that the quantity of lead in the body of natural, primitive man was smaller than that of modern man in the United States. How much smaller

it was, in all parts of the primitive earth, is unknown and unknowable, but there can be no doubt that lead in some concentration has been a familiar constituent of the human body since man first appeared on this planet. This fact presents us with the reasonable certainty that there is some point or range of concentration in living organisms, including man, above which lead exerts its toxic effects, and below which it is innocuous. That such phenomena have been demonstrated and confirmed by many observers, under conditions of carefully controlled observations, is not at all surprising, but is, rather, to be expected.

In referring to somewhat less than logical viewpoints, concerning the present issue, and to somewhat irrelevant ideas, it may be appropriate to point out that certain prolonged or apparently irreversible sequelae of a severe attack of lead poisoning have no necessary or even likely relationship to the orderly sequence of the physiological processes which operate within the organism - the human body - in its usual environment. Such sequelae are the after-effects of the positive derangement of a physiological mechanism or an anatomical structure by a grossly abnormal degree of absorption of lead, which has induced a severe episode of lead intoxication. Our discussion here is concerned with whether or not lead is capable of exerting a harmful effect on persons, young or old, healthy or not, who live under the usual or ordinary environmental conditions in modern urban life as it has been described in relation to lead. Whether persons who have been subjected to other and more severe conditions productive of lead poisoning are restored to their normal physical and physiological state, on their return to the common or general environment, is quite another matter, although an important one to which attention should be and has been paid elsewhere.

Comparisons of the lead content of the tissues, body fluids and excreta of the majority of persons in the general population, with those found in persons ~~that~~ who have been subjected to unusual environmental conditions, have been

afforded by situations that have resulted in lead poisoning in recent decades, apart from cases of lead poisoning in industry. There have been numerous outbreaks of non-occupational lead poisoning in times past and present (more frequently in the past). Insofar as these have affected the adult population, they have been associated most frequently, but not without exception, with the contamination of food and beverages, including alcoholic beverages made without the care and technical knowledge that obtains at present in qualified manufacturing circles. "Epidemics" of lead poisoning have occurred in the past from the use of wine "sweetened" with lead acetate, and from the contamination of beer in the course of its brewing. And even now, illicit stills, not confined entirely to certain southern and mountainous states, with their condensing equipment of automobile radiators and other soldered coils, have yielded brands of whiskey which have sickened many persons and paralysed not a few, and not solely because of their content of alcohol. These and many other improvisations of ingenious and incautious men have furnished individual and multiple cases of lead poisoning in the general population. Many uses of lead, lead alloys and soldered equipment have resulted in both slight and gross contamination of specific items of food in their production and preparation for use, while certain common household utensils of an earlier period, such as the pewter vessels, pitchers, mugs and steins of our forebears, must have elevated the daily intake of lead in food and drink well above that of the present day. The use of lead pipes for the general distribution of the water supply was once common in certain areas of New England, and some of the original pipes are still in use.

The systematic and salutary efforts of the Federal Food and Drug Administration, aided by the often sporadic and more limited observations of physicians and medical investigators in all parts of the country, have unearthed and modified or eliminated a host of faulty practices and sources of contamination, and it is evident that such official and unofficial activities are necessary for the policing of the quality, in this and other respects, of

A different, as well as an illuminating, situation is that of the tragic occurrence of lead poisoning among children, in our older cities with their areas of poor and crowded housing, from lead-containing interior paints that have been applied repeatedly in the past, and are now crazing, flaking and disintegrating, or are available on window sills and like structures, to the exploring, chewing and sucking infant. This threat results in hundreds, if not thousands, of cases of lead poisoning, every year, among children in the United States, mostly within the age group of one to four years. Many of these cases are of the most severe type, and the mortality among them, as they appear in hospital practice, is of the order of twenty-five per cent. Much larger numbers of children, in all probability, are subjected to this hazard to a degree that does not result in toxic manifestations of a type that prompt unobservant parents to seek medical attention. The physical, sociological and economic conditions that are productive of these tragic results is worthy of extensive consideration and of deep concern in this, the wealthiest society that exists on the earth, and certain epidemiological and clinical features of this situation deserve persistent and thorough investigation. For present purposes, however, it is important to recognize that the poisoning of these children is not something insidious, induced by some factor of susceptibility in the very young. Rather, as a rule, they have ingested massive doses of lead over periods of time ranging from a few months to one year or ~~perhaps even~~ two, and when they come to the attention of a physician at office or hospital, following a convulsive seizure or some other alarming form of severe intoxication, their tissues, body fluids and excreta are found to contain high concentrations of lead. Indeed, the highest values found in our experience have come from this source.

From such conditions as those described above as having affected adults and children in the general population, a sufficient number of cases, aside from those derived from hazardous industries, have kept alive within the medical profession - not in all physicians, but in many - familiarity with the clinical

pattern of lead poisoning. Moreover, and highly pertinent to this discussion, another dimension has been added by modern chemical technology in providing us with analytical methods for determining the extent of the absorption of lead which is required to induce or set the stage for intoxication by lead. By this means we have learned that the "susceptibility" of people to lead - that elusive factor which for so many years covered our ignorance and stifled our inquiry into the nature and sources of hazard - has distinct quantitative limitations as to dosage; that the person with lead poisoning, newly induced, has a gross elevation of the lead content of his tissues and excreta, over that which is found in persons who have not been involved in the same exposure to lead, and are not threatened by its effects. The adult, for example, in a home which is highly dangerous for the crawling or toddling child, is wholly unaffected, since he has no inclination or compulsion to eat the crazing or scaling paint from walls or woodwork. Thus it is that the hazard of lead poisoning arises not so much from the abundance of lead in the human environment, as from the means by which an adequate quantity, i.e., a toxic dose, is taken into the internal medium of the body. Now, armed with an effective analytical tool, it has been possible to separate fact from supposition, to put the finger on cases of lead poisoning, and to establish the nature of the factor or factors by which it was caused. It is rare, indeed, that such factors remain obscure, when they are sought out by experienced investigators.

The Prospect for the Future

It has been stated above in positive terms, that the general environmental factors in the national community, with respect to lead - the lead in the generally available food and beverages and that in the general ambient air - pose no present threat to the health of the population. What then of the future and of changes that may bring about a threatening condition?

First, let it be said, in an approach to this matter, that both general and specific methods are available, out of the experience of the past three decades, for detecting changes in the lead content of the food and beverages of the country, and in that of the ambient atmosphere. The available methods are also capable of providing reliable information as to the extent to which such changes affect the rate of absorption of lead by representative groups in the population. Moreover, in view of the potentialities for change in the environment of a technological society such as ours, ordinary prudence calls for periodic surveys for the purpose of keeping our information up to date on this and on many other features of the environment, especially that of the cities in which the large and increasing proportion of our population resides. (Parenthetically, some comment may be justified about a fact which seems not to have impressed itself sufficiently upon investigators in the field of environmental health. The clues to the environmental threats of our time are found largely within the complex operations of industry. Here they arise, and here they develop their most obvious situations and consequences. Here is the site at which we should man the hygienic field with skilled technical and medical observers to detect, interpret, and bring under control the hazards that stem from modern technology. This is the largest and most important void in the armamentarium of public health in the United States, as well as in the other industrial nations of the world, and it is one which should be recognized and filled at the earliest possible time, for the safety of the people who do the work of the world, and for that of the larger group who are supported by their efforts.)

To return to our primary subject, it should be noted that the current level of the exposure of our population to lead has undergone little, ~~if any~~, change during the past three decades, and that there is no trend that suggests the likelihood of increase in the near future. On the contrary, such evidence as there is suggests that there has been some decrease lately. There is

no assurance that this is significant or that it will continue, but if it should continue, such a trend would not be wholly unexpected. Several factors can be assembled to account for a progressive decrease in the lead content of our food and beverages, among which, the more sophisticated selection and use of pesticides, the policing of the Federal Food and Drug Administration, and the growing awareness of their responsibilities among the major producers and processors of food and drink, assume significant proportions. How far these factors may be counter-balanced by improvisations of various kinds cannot be judged, but there is some reason for restrained optimism in this regard.

With respect to the contamination of the atmosphere of our streets and highways with air-borne lead from the exhausts of automobiles, due consideration must be given to the improbability that the mere multiplication of automobiles, without respect to their distribution in specific areas of a city or system of roadways, need result in an increase in the concentration of lead in a specific segment of the atmosphere. Here again, there is some indication that the density of automobile traffic in certain cities has approached the maximum that is compatible with sustained transportation, and along with this, suggestive evidence has been found of some reduction in the lead content of the atmosphere, in association with changed patterns of traffic. Whatever may be the outcome of the rapidly changing structure of metropolitan centers in the United States, significant changes in the concentration of lead in the air are not to be expected over-night, while physiological effects which might be induced by a significant increase in the concentration of lead in the air cannot be conceived of in the terms of lead poisoning, but rather must be thought of as changes in the rates of the absorption, excretion and retention of lead. Such changes could be expected to reach measurable proportions only after a period of years. We think and speak here, not of imminent danger, but of a potential risk that may

be developed ultimately, if or when the rate of the absorption of lead by persons in the general population exceeds the excretion of lead by an increment that is capable of producing a dangerous concentration of lead within the body at some time within the life span of the individuals concerned. The present situation involves no possible threat of catastrophe and no likely hazard of any kind. The visualization of danger, in this instance, is, at best, an imaginative venture into presumption, or, at worst, an apprehensive magnification of a remote possibility.