

The Lead Industry and Lead Water Pipes “A MODEST CAMPAIGN”

| Richard Rabin, MSPH

Lead pipes for carrying drinking water were well recognized as a cause of lead poisoning by the late 1800s in the United States. By the 1920s, many cities and towns were prohibiting or restricting their use. To combat this trend, the lead industry carried out a prolonged and effective campaign to promote the use of lead pipes. Led by the Lead Industries Association (LIA), representatives were sent to speak with plumbers' organizations, local water authorities, architects, and federal officials. The LIA also published numerous articles and books that extolled the advantages of lead over other materials and gave practical advice on the installation and repair of lead pipes. The LIA's activities over several decades therefore contributed to the present-day public health and economic cost of lead water pipes. (*Am J Public Health*. 2008;98:1584–1592. doi:10.2105/AJPH.2007.113555)

SINCE THE CENTERS FOR

Disease Control and Prevention began to establish acceptable blood lead levels for young children in the 1960s, the concentration at which blood lead levels have been thought to have significant health effects has steadily declined. That concentration has been reduced from 60 µg/dL to the current level of 10 µg/dL, which was established in 1991.¹ Research conducted in the past few years, however, suggests that there are health effects below that level, and that IQ declines at a faster rate below 10 µg/dL than above.^{2,3}

Although lead-based paint is the single most important contributor to elevated blood lead levels in children, if just a few micrograms of lead per deciliter of blood are of concern and if we are to truly prevent the health effects of lead exposure in the United States, then water, as well as other sources of lead, must also be addressed. Water consumption is estimated to contribute, on average, about 10% to 20% of a child's total lead intake, and for infants fed formula, 40% to 60% of their lead exposure.⁴

In the past 2 decades, legislation and regulations at the federal level have helped to reduce water lead concentrations.^{5–7} Nevertheless, lead in drinking water continues to be a public health concern. Over the past several years, significantly elevated lead levels in many cities have provoked public outcry. Lead-contaminated water in homes and schools has been detected in Boston, MA^{8,9}; Durham, NC¹⁰; and Camden, NJ,¹¹ among many others. In Washington, DC, in 2004, there was considerable

public concern when more than half the homes with lead service pipes were found to exceed the Environmental Protection Agency's (EPA's) action level of 15 parts per billion.¹² Public interest in this matter is evident from a computer search of general interest and business publications for the period between January 1995 and April 2007 with the terms *water* and *lead pipes* that yielded 220 articles.¹³

Recent US history has been marked by many environmental and public health crises initiated or exacerbated by corporate actors despite knowledge (or reasonable suspicion) that an activity or chemical exposure was particularly hazardous. Childhood lead paint poisoning,^{14,15} asbestos-related deaths,^{16,17} and tobacco-related diseases and mortality¹⁸ are a few of these. Here I review the evidence that lead pipes for water distribution were installed well after they were considered a public health threat and examine the corporate activities and other factors contributing to their continued use.

BACKGROUND

Although the use of lead pipes for water distribution has a centuries-old history, installation of lead pipes in the United States on a major scale began in the late 1800s, particularly in the larger cities.¹⁹ By 1900, more than 70% of cities with populations greater than 30 000 used lead water lines.¹⁹ Although lead was more expensive than iron (the material of choice until that time), lead pipes had 2 significant advantages over iron ones: they lasted much longer than iron (about 35 years compared with 16) and, because they are more malleable, they could be more easily bent around existing structures.¹⁹

Concerns about the potential toxicity of lead from water that passes through lead pipes were documented even before lead came into widespread use. In 1859 a collection of articles was published presenting the views of various engineers, physicians, and public health officials. The editor of those articles began by noting the objections raised by residents of New York City and Boston to the introduction of lead for service pipes (the pipes that carry water from the street main to a building) and indoor plumbing:

In other cities of the United States and of Europe the same feeling has at times more or less agitated the public mind, without leading however, thus far, to any serious modification of the long established practice [of installing lead pipes], that I am aware of, except in Hartford, Conn.^{20(pii)}

With the large-scale introduction of lead service pipes, numerous public health and newspaper accounts of lead poisoning from drinking water began to appear with increasing frequency. From

the late 1800s to the early 1900s, numerous journal articles and reports appeared documenting the dangers to health of lead pipes.^{21–28} One published bibliography in 1943 listed more than 100 articles and reports in English on lead poisoning from drinking water.²⁹ In 1890 the Massachusetts State Board of Health advised the state's cities and towns to avoid the use of lead pipes.¹⁹ By the turn of the century, there was little doubt in the public health community that lead water pipes were to be avoided. By the 1920s, many cities had concluded that the engineering advantages of lead were outweighed by the public health risks, and local and state plumbing codes were revised to prohibit or limit the use of lead pipes for water distribution.^{19,30}

THE LEAD INDUSTRIES ASSOCIATION

The Lead Industries Association (LIA) was formed in 1928 as the lead industry's trade organization. Its membership encompassed both producers and users of lead products and included all the major producers. Lead mining and manufacturing was dominated by just 6 companies (all LIA members) until the 1960s: the National Lead Company, American Smelting and Refining, Anaconda, the Hecla Mining Company, Eagle Picher, and the St Joseph Lead Company.³¹ The National Lead Company was by far the largest.³²

As would be expected of an industrial trade association, a central function of the LIA was to promote the sale of its members' products. Lead pipe, of course, was one of them.

We are endeavoring to keep abreast of any impending changes in plumbing codes. . . .

We have also been investigating the use of lead in service pipe and other applications. We have been accumulating useful information pertaining to lead and expect soon to make it the basis of a modest educational campaign within the limits of the current budget.³³

Although most of the lead industry's efforts to promote the use of lead in plumbing emphasized the positive (i.e., the advantages of lead over other materials), there clearly was some concern that the potential health hazard of lead pipes could jeopardize the market for lead pipes. In his 1929 report to the membership, the secretary noted that,

“Water is much more wholesome from earthenware pipes than from lead pipes. For it seems to be made injurious by lead, because white lead paint is produced from it; and this is said to be harmful to the human body.”

Vitruvius, first-century-BC Roman architect and engineer, De architectura

Of late the lead industries have been receiving much undesirable publicity regarding lead poisoning. I feel the association would be wise to devote time and money on an impartial investigation which would show once and for all whether or not lead is detrimental to health under certain conditions of use.³³

This public alarm over lead exposure can be attributed at least in part to reports in the popular press. In 1924, the *New York Times* reported on a medical conference that highlighted nonindustrial sources of lead, including lead paint.³⁴ During the Depression, it was not uncommon for poor persons to use old battery casings for fuel, and there were newspaper reports of families being lead poisoned.^{35,36}

Although subsequent LIA reports implied that the secretary primarily had lead paint in mind as the cause of this adverse publicity, the association also felt the need to address the public's concerns regarding lead pipes. For instance, in 1930 the LIA investigated a case of lead poisoning in conjunction with the Charleston Water Works.³⁷ (The findings of the investigation were inconclusive: lead service pipes had recently been installed, but contamination of the home was possible because the father was a house painter.³⁸)

From its inception until at least the early 1970s, the lead pipe manufacturers and their association used a wide variety of methods to promote their products, including the publication of numerous educational materials and model standards, attendance at professional meetings, and lobbying of local, state, and federal government agencies. In 1931, the LIA prepared a booklet and a "model" standard for lead pipes.³⁹ It also published the first edition of the book, *Useful Information About Lead*,⁴⁰ which described the many products made of lead. The chapter on plumbing advises that "the best material in a water service, though it may be slightly more expensive at first, is really an economy, and the best material is usually lead."^{40(p74)} The exception, it notes, is

when the water is very soft, or of swampy or peaty origin, that lead should not be used, but under those conditions other metals are also soluble, so lead may be used by adding a little sodium silicate solution to the water, as is done occasionally—or using tin-lined lead pipe.^{40(p74)}

The LIA's 1934 annual meeting minutes record an "intensive" effort to reverse the downward

trend in the use of lead pipes; contacts are reported with city officials, master plumbers, and plumbing associations. Over the next 2 decades, the LIA continued to promote lead pipes through contacts with plumber organizations and local boards, by lobbying federal agencies, and by publishing newsletters.

The association issued a bulletin for distribution to water works officials. LIA members who produced plumbing supplies made donations to the Plumbing and Heating Industries Bureau. The usefulness of cooperation with that organization was clear:

As the Bureau was founded to promote the wider use of modern plumbing, it is essential that the role which lead plays in modern plumbing installations be not overlooked. Our cooperation with this Bureau will insure that lead receives ample and proper consideration.⁴¹

A key part of the campaign to boost sales of lead pipe was the hiring of an agent to, in the words of the LIA secretary,

work on our behalf and I am pleased to report that the work has more than met with an excellent reception. It has grown so quickly and so strongly that it has reached a stage at which it is really too large a problem for one man working in the Eastern part of the United States alone to handle. We have rekindled an interest on the part of master and journeymen plumbers in the use of lead. We have pointed out to municipalities the risks that they run in advocating substitutes for lead and have received the endorsement of numerous important State master plumbers and journeymen plumbers associations with whom the subject has been discussed. . . . Since the first of the year, even greater advances have been made and we firmly believe that in a comparatively short time there will be growing evidence of the advantageous results accruing [sic] to our members from this work.⁴¹

The report of the LIA's agent, Robert Dick, enumerates the year's specific accomplishments:

- (a) One code approved and put into operation, requiring lead wherever it is advisable to use lead in the plumbing system.
- (b) One town enforcing the use of lead throughout plumbing systems although not called for by its code.
- (c) Nine cities and towns with revised codes calling for lead throughout. These codes now ready to be submitted to the various councils for adoption.
- (d) Forty-eight cities and towns working on revisions to require lead throughout, but with the codes not yet ready for submission to council.
- (e) Forty-eight cities and towns in which no immediate action can be taken due either to political or financial conditions, or in a few cases, to opposition to the use of lead.⁴¹

Although this report does not mention the health-related reasons lead had been losing ground to other plumbing materials, it does discuss the economic pressures brought on by the Depression:

The present time is a critical time for this work because during the depression years, the plumbing industry has experienced intense competition from the installations of handymen and others not actually engaged in the plumbing business so that the plumbers are now looking for anything that will protect their interests against these outsiders.⁴¹

Dick went on to explain that requiring the use of lead would be in the interest of professional plumbers because the installation of lead fixtures and pipes required a level of skill that others did not possess. This self-interest on the part of plumbers probably accounts for the reported success that the LIA had in persuading the

numerous plumber organizations to endorse the use of lead. Even into the 1940s, this economic motivation played some role in plumbers' desire to allow or even require lead. In Denver in 1947, when a proposal was made to permit iron and steel for domestic plumbing, the master plumbers organization blamed "self-seeking speculative builders," and one journeyman plumber was quoted as attributing the proposal to an attempt to "move '90-day wonders' and handymen into an industry which protects the health of the community."⁴²(p77)

According to the secretary, 1938 was a banner year for the LIA. The association now had 3 representatives working on its Plumbing Promotion Program. Most of their time was taken up that year by attendance at 24 state conventions of master plumbers and by speaking at 19 of them. Outreach materials were produced and distributed to plumbers who were actively attempting to change their local building codes. The association's trade publication, *Plumbers' Forum*, had a mailing list of 22 500. Plans were announced to "work with various housing authorities to have lead specified in the plumbing of . . . large developments."⁴³ Plumbing code regulations were changed in Pennsylvania (to require lead for plumbing), Massachusetts (removal of the 5-foot limitation on lead), and in dozens of other cities. In this connection, the secretary reminded the members that

It must be remembered that adoption of laws, as above, is slow work, but once adopted, make a relatively permanent requirement of lead. In many cities, we have successfully opposed ordinance or regulation revisions which would have reduced or eliminated the use of lead. We have prevented elimination of

lead work from examinations for plumbers' licenses in New York and other cities, and have introduced license examinations with a lead work requirement in many places where no examinations for lead work were formerly required.⁴³(pp3-4)

In cities where lead had fallen out of favor for a number of years, there was the danger that, even if a revised plumbing code reinstated lead as a permitted or required material, there would not be a sufficient number of plumbers trained in its installation and repair. Consequently, the LIA expended some effort to train a labor force skilled in working with lead. Cooperating with the Federal Committee on Apprentice Training, in 1938 the LIA established classes in several cities, including Chicago; Pittsburgh; San Francisco; St Paul, Minnesota; Wilkes-Barre, Pennsylvania; Youngstown, Ohio; and Phoenix. In addition, it began preparation of the section on lead of the *Standard Text on Plumbing*, to be published by the National Association of Master Plumbers.⁴⁴

The pipe manufacturing members of the LIA were also concerned about the failure of lead plumbing, stemming from poor quality goods, and thereby leading to the discontinuation of lead products. In response, the LIA developed a series of standards for various lead plumbing products, including pipes and caulking. According to the LIA secretary, numerous entities adopted these standards, including the American Water Works Association, New York City, and several other cities.⁴⁴

In 1940 several federal agencies including the War and Navy Departments, the Public Buildings Administration, and the US Housing Authority were involved in major construction projects for "defense building." As a result, LIA staff expended much effort in

Washington to ensure the inclusion of lead in the specifications for plumbing. Their efforts apparently met with considerable success, because "lead plumbing is now included in many Federal government master specifications where it had been excluded for many years."⁴⁵ But because these specifications were only optional, association staff had to make personal visits to many of the federal construction projects to persuade those in charge that lead was preferable to other materials. These efforts were also successful, according to the secretary.

At the same time, the LIA initiated or continued several activities that it expected would have long-term benefits for the lead industry by institutionalizing the use of lead in plumbing nationwide:

A simplified standard for lead fittings was put into effect at the end of the year. Also the first steps toward obtaining a Commercial Standard for lead pipe, traps and bends and calking lead, promulgated by the National Bureau of Standards, were taken. It is expected that Federal Specifications for lead pipe, traps and bends will follow soon after adoption of the Commercial Standards.⁴⁵(p6)

An initial success was the publication in 1940 by the Bureau of Standards of a new *Plumbing Manual*,⁴⁶ which served as the basis for the specification of lead plumbing in federal construction projects. The manual has a cautionary note: "Lead piping in water-supply lines shall not be used unless it has been definitely determined that no poisonous lead salts are produced by contact of lead with the particular water supply."⁴⁶(p14) However, given the numerous factors that could affect a water supply's plumbosolvency, it is not clear how it could be known for certain in advance that

“no poisonous salts” would be dissolved in the water.

By the 1940s, the lead industry had become alarmed at the public’s growing wariness of all things lead, including lead pipes:

There is hardly an outlet for lead to which one can turn today without encountering, in some measure, the question of the lead hazard to the public. So fundamental is this problem to the future welfare of the lead industries and the continued manufacture and use of many important lead products, such as white lead, red lead, litharge, sheet lead and lead pipe that unless some immediate attention is paid to the problem above and

“cannot overemphasize [the] importance [of our health and safety work]. The toxicity of lead poses a problem that other nonferrous industries generally do not have to face. Lead poisoning, or the threat of it, hurts our business in several different ways.”

beyond what the Association has already accomplished and is currently doing, the opposing forces may grow strong enough to do us injury which it would take years of work to correct.⁴⁷

Between 1941 and 1949, the LIA reduced its plumbing campaign field staff from three to two. However, it continued its usual promotional work around lead pipes:

The promotional work in the plumbing and water works field continues as in the past . . . with master and journeyman plumbers, plumbing inspectors, instructors and others, to see that lead is adequately provided for by plumbing codes through the country and to see that plumbers are trained to know how to handle and install lead work.^{48(p5)}

In the LIA’s 1952 book *Lead in Modern Industry: Manufacture, Applications and Properties of Lead,*

*Lead Alloys, and Lead Compounds,*⁴⁹ the industry continued its promotion of lead service lines; more than 1500 copies were sold in the first 2.5 months after publication.⁵⁰ However, this edition did not caution the reader (as it did in 1931) about conditions under which lead might not be advisable.

Throughout the 1950s, the LIA continued its outreach to plumbing and related professionals. *Lead*, the LIA’s trade journal with a quarterly publication schedule and a distribution list of more than 50 000, carried a steady stream of articles on plumbing.⁵¹ The textbook, *Lead Work for Modern Plumbing*,⁵² which was first published in 1952, had by early 1956 reached a total distribution of more than 6500.⁵³

The theme of a continuous, serious threat to the lead industry because of the public’s alarm over the danger of lead exposure is again made explicit a few years later by the LIA’s secretary:

I cannot overemphasize [the] importance [of our health and safety work]. The toxicity of lead poses a problem that other nonferrous industries generally do not have to face. Lead poisoning, or the threat of it, hurts our business in several different ways. While it is difficult to count exactly in dollars and cents, it is taking money out of your pockets every day.^{54(p4)}

As before, he is most concerned about lead paint, but he makes clear that lead pipe sales are also at risk:

There is a law suit now pending in Milwaukee in which an apartment building tenant is suing the owner for \$200,000 damages for alleged lead poisoning from water passing through the building’s lead service pipe. Success of a suit like this could well mean the end of lead services not only in Milwaukee, but in Chicago and many another city, amounting to thousands of tons

of lead a year. We are working with the defense, and although the case does not come to trial for some months, our latest information is most encouraging.^{54(p4)}

Promotional activities continued at least until 1972, when the LIA issued the sixth printing of its text *Lead Work for Modern Plumbing*.⁵²

THE HISTORICAL CONTEXT

Given the medical and public health view that lead pipes were a clear danger to the public, one may ask how the lead industry could persist, with at least moderate success, in promoting and selling lead water pipes. Several factors contributed. One relates to the lingering doubts among water engineers and water authorities about the risks of lead pipes. Throughout the 19th century, attempts had been made by some physicians to link lead water pipes to cases of severe illness. However, these were met with considerable skepticism by water authorities, most of the medical community, and the general public: not everyone consuming water from lead pipes became sick, many of the symptoms of lead poisoning mimic those of other diseases, and the medical tests for diagnosing lead poisoning were not well developed. However, by the early 20th century, publication of the many medical articles and reports of the previous 20 to 30 years had made a compelling case for a relation between lead water pipes and lead poisoning.¹⁹

As indicated above, plumbers and water works engineers and officials favored lead pipes for their durability and other practical advantages. In addition, an extensive discussion among water works professionals and officials at their meetings and in their publications

clearly indicates that many of them were not as convinced as their counterparts in the public health community that lead water pipes were an unacceptable health hazard.^{55–63} This divided opinion can be seen in articles in professional journals, plumbing texts, and publications of more general interest. For example, the author of an article in the *Journal of the American Water Works Association* in 1938 believed the dangers of lead pipes to be exaggerated:

Lead ions seem to have a bad reputation, although some of it is not deserved when it comes to the traces found in most purified water supplies. If the very small amounts which persons ingest by drinking water and eating food, were as harmful as some people believe them to be, there would be many more cases of lead poisoning than are known to occur.^{57(p248)}

In 1934 and again in 1945, the *American City*, a magazine reporting on general and technical developments in the urban environment, approvingly reported on the installation and longevity of lead service pipes.^{64,65}

On the other hand, Harold Babbitt, a professor of sanitary engineering, strongly opposed the use of lead water pipes:

Lead is sufficiently soluble in water to offer a real menace to health and for this reason its use in contact with potable water should be restricted if not prohibited. Tests by the Massachusetts State Board of Health have shown lead content as high as 3 to 5 parts per million in natural waters and an increase of 50 to 100 per cent, and even more after the water has been standing in lead pipe. Since 0.5 parts per million is considered dangerous to health, the use of lead in water pipe or in contact with potable water should be prohibited.^{63(p267)}

A common, middle point of view was that lead pipes should

not be installed where the water supply was “soft” (lacking in certain minerals, primarily magnesium and calcium) or high in carbonic acid (carbon dioxide dissolved in water).^{55,56,59,61} The LIA’s Robert Ziegfeld also advanced this argument but suggested that conditions that affected lead would also attack other metals. (He neglected to mention, however, that other metals, such as iron and copper, are not as toxic as lead.⁶²) Another argument in favor of the use of lead pipes was that over time a thin coating forms on the interior pipe surface that prevents further corrosion. Furthermore, various chemicals could be added to the water to reduce the acidity. However, research and experience from the mid-1800s to the early 1900s in the United States and Great Britain provided considerable evidence that many other factors as well (not often discussed by water works professionals) could influence the plumbosolvency of a water supply.¹⁹ In other words, whereas a water supply that is hard or alkaline is less likely to result in an unhealthy concentration of lead, such a result may occur because of other factors. An example was provided by a 1928 study of several towns and cities in Illinois that had very hard water. In that study, lead levels ranged from 0.02 to 0.50 parts per million (1.3 to 33 times the modern EPA standard).⁶⁶

The lead industry also benefited from the absence, at the federal level, of the regulation of environmental health hazards. As several authors have noted, before the 1960s, the federal government did not play an active role in protecting the public from environmental or occupational hazards.^{67–70} In the Progressive Era of the first 2 decades of the 20th century, the federal government’s legitimate

role was to investigate hazards and recommend solutions to the responsible industry but not to legislate changes. In her investigations of the occupational hazards in several industries, including those with lead exposure, Alice Hamilton (a pioneer in occupational medicine in the United States) highlighted serious health hazards and made recommendations for their abatement but did not suggest legislative interference.⁶⁷ The next 4 decades marked a period of even less government activism, as manufacturers were assumed to investigate and control the hazards that they created.⁶⁷ The public health disasters of asbestos and lead paint, noted above, can be seen as products of this laissez faire era.

Another factor impeding a greater focus on lead pipes was the much greater concern regarding infectious diseases compared with the attention paid to environmental toxins in the first half of the 20th century.⁷¹ Prevention of water-borne diseases was a particular focus of attention for professionals who designed and installed domestic plumbing. Some indication of this greater concern about communicable disease can be seen from a computer search of *American Journal of Public Health* articles. The search terms *water* and *cross-connection* (a common cause of infectious disease from drinking water) yielded 20 articles for the 1930 to 1950 period, whereas *lead pipes* yielded only 3. Indeed, at least 1 of the National Lead Company’s advertisements promoted lead pipes as providing a more “sanitary” water supply.⁷²

CONTINUED USE OF LEAD PIPES

The year 1930 is often given as the date after which few lead water pipes were installed in the

United States,^{19,30} and this downward trend was almost certainly the case. However, the reports and meeting minutes of the LIA cited above indicate that it had some success in slowing, and even in some cases reversing, that movement. Evidence of continued installation of lead pipes comes from other sources as well. The plumbing codes of some major cities, including Boston^{73,74} (JE Richardson, Boston Water and Sewer Commission, personal communication, January 29, 2007); Milwaukee, WI⁵⁴; Philadelphia, PA⁷⁴; Denver, CO⁴²; and Chicago, IL,^{43,75} still called for lead many years, even decades, beyond 1930. Besides these major cities, there is much suggestive evidence, both direct and indirect, that the installation of lead water pipes continued on a significant scale throughout the United States well beyond 1930. Cities and states usually based their plumbing codes on 1 of 3 model codes: the Building Officials and Code Administrators' (BOCA) plumbing code, the International Council of Building Officials' Uniform Plumbing Code, and the Southern Building Code Congress' Standard Plumbing Code. All 3 listed lead as an acceptable material for water distribution for several decades beyond 1930 (until 1981, 1988, and 1977, respectively).^{76–82}

Of course, the listing of lead as a permitted material in plumbing codes does not, by itself, mean that it actually continued to be used on a large scale. However, the LIA itself confirmed such use of lead pipes for water distribution. At a 1963 symposium on lead, the LIA's Robert Ziegfeld stated that one of the principal uses of lead in construction was pipes for water distribution. "Pipe and extruded products" consumed 20000 tons in 1962.⁸³

In 1984 the EPA conducted a survey of 153 public water systems across the country to determine the extent of the use of lead pipes.⁷⁵ Most (91) of the systems in the survey had populations of over 100 000. Of the municipalities surveyed, 112 (73%) indicated that they had in the past installed lead service lines, and 5 specifically stated that lead had been permitted well beyond 1930. Seven systems answered that they currently (as of 1984) used whatever their code permitted. Chicago acknowledged that it still sanctioned the installation of lead service pipes. With passage of the Safe Drinking Water Act Amendments of 1986,⁵ installation of lead water pipes was finally prohibited nationwide.

The number of lead service lines installed in US cities since the 1920s probably cannot be estimated with any degree of certainty. In the EPA's 1984 survey, approximately 30% of the respondents could not offer any estimate of the number of lead service lines remaining in their cities. Nevertheless, it can be stated that with so many large cities that continued to permit the use of lead pipes, such as Boston; Chicago; San Diego, CA; Philadelphia; and Milwaukee among others, the number is likely quite significant.

DISCUSSION

Although most cities in the United States were moving away from lead water pipes by the 1920s, it appears that this trend was not universal. National model plumbing codes approved lead into the 1970s and 1980s, and most water systems based their regulations on those codes. Federal guidelines and specifications also sanctioned lead pipes at least into the 1950s. Water system engineers were debating the pros

and cons of lead at least into the 1940s. Perhaps most telling was the active campaign carried on by the lead and pipe manufacturers' trade organization, the LIA. To maintain sales of lead pipe, the LIA lobbied the government at all levels and targeted the people who both designed and installed water distribution systems with outreach and educational material and other resources. The association carried on its promotional campaign into the 1970s.

As noted in the introduction, recent research strongly suggests that lead exposure has health effects of public health significance below the level of concern designated by the Centers for Disease Control and Prevention. Indeed, no threshold for the effects of lead on cognition has yet been identified.⁸⁴ The number of children potentially affected is quite high. More than one quarter (25.6%) of children aged 1 to 5 years in the United States had a blood lead level at 5 µg/dL or higher in 1994 according to the third National Health and Nutrition Examination Survey.⁸⁵ Several recent studies also point to serious health effects in adults at very low blood lead levels, including cancer,⁸⁶ cardiovascular disease,^{86,87} peripheral arterial disease,⁸⁸ and death from all causes.⁸⁶ Therefore, although lead-based paint is the most significant source of childhood lead exposure, and occupational exposure is the main source for adults, we will have to address the contribution of water if we are to make acceptable progress in further reducing blood lead levels.

Although the number of lead service lines and other water distribution pipes installed as a result of the influence of the LIA and its pipe manufacturing members cannot be quantified, it is surely substantial. The American Water Works Association conducted a

national survey to estimate the cost of replacing lead service lines.⁸⁹ The average cost per replacement was \$3200, with a range of \$750 to \$16 000. The Washington, DC, water authority appropriated \$300 million to replace 23 000 lead service lines, plus some portion of 27 000 lines of unknown material.

Despite a voluminous literature on the dangers of lead water pipes, and based on such knowledge, a national trend to restrict and prohibit the use of lead for water distribution, the lead industry continued its promotion and sale of lead pipes for several decades. Note also that the LIA and its corporate members carried out a similar campaign to promote lead paint long after its hazards became known^{14,15} and are currently defending themselves against lawsuits by dozens of cities and states.^{90,91} In fact, at least two LIA members, the National Lead Company and Eagle Picher, manufactured both lead paint and lead pipes. Although the use of these products has long since ended, our cities and towns, and society as a whole, are still paying the price. ■

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