More evidence of unpublished industry studies of lead smelter/refinery workers

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Background: Lead smelter/refinery workers in the US have had significant exposure to lead and are an important occupational group to study to understand the health effects of chronic lead exposure in adults. Recent research found evidence that studies of lead smelter/refinery workers have been conducted but not published. This paper presents further evidence for this contention.

Objectives: To present further evidence of industry conducted, unpublished epidemiologic studies of lead smelter/refinery workers and health outcomes.

Methods: Historical research relying on primary sources such as internal industry documents and published studies.

Results: ASARCO smelter/refinery workers were studied in the early 1980s and found to have increased risk of lung cancer and stroke in one study, but not in another.

Conclusions: Because occupational lead exposure is an on-going concern for US and overseas workers, all epidemiologic studies should be made available to evaluate and update occupational health and safety standards.

Keywords: Lead smelter, Lead refinery, Smelter workers, Occupational health, Lead exposure, Lung cancer, Cerebrovascular disease

Background

In 1980, an article published in the American Journal of Industrial Medicine (AJIM) pointed out the dearth of literature on the mortality of smelter workers: "In view of the historic importance of smelter workers in the field of occupational medicine, however, it is surprising that until very recently little data were available about the mortality experience of these workers".¹

The authors' observation was astute. At the time the AJIM article appeared (1980), there was one published cohort study of the mortality of US lead smelter/refinery workers,² and several published studies of the mortality of US copper smelter workers (Anaconda (Montana),³ Tacoma (Washington),⁴⁻⁸ and Kennecott (Utah)⁹), all but two^{3,8} of these studies were industry sponsored. Two of the industry-sponsored studies^{6,9} were turned over to NIOSH/OSHA in unpublished form during the mid-1970s occupational standard setting process for inorganic arsenic, and were subsequently published.

A recent study presented evidence that the mortality experience of some US lead smelter workers was studied in the 1960s, yet the results do

not appear to have been published.¹⁰ This article presents evidence from the early 1980s that further supports this contention.

US primary lead smelting/refining

In the mid-1970s, the US was a world leader in primary smelting of lead, producing approximately 579 000 mt of lead in 1975,¹¹ at six primary lead smelters. Primary smelting is a key step in the production of lead from ore that has been mined. Smelting involves heating concentrated ore to high temperatures to separate metals of interest from impurities in the ore. Refining is the last stage of lead production. At lead refineries lead bullion is melted to recover precious metals and to remove any remaining contaminants. Prior to the promulgation and enforcement of federal occupational standards for lead, primary lead smelter and refinery workers in the US could have very high exposures to lead. Mean airborne lead concentrations measured in primary smelters and lead refineries have been reported to be as high as 4470 µg/m³.¹² For comparison, the OSHA Permissible Exposure Limit for lead set in 1978 is 50 µg/m³, averaged over an 8-hour day.¹³ Primary smelting and refining of lead no longer occurs in the United States. The last operating primary lead smelter, located in Herculaneum, Missouri closed in 2013. However, primary

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production of lead worldwide continues to increase, with production topping four million metric tons in 2010. Increasingly, primary production of lead occurs in China and other developing countries.¹⁴ Thus, the health effects of lead exposure in primary smelting and refining remains a significant occupational health issue.

Cohort studies of the mortality experience of US primary lead smelter/refinery workers

In 1972, when National Institute for Occupational Safety and Health (NIOSH) published its first criteria document on lead, there were no published studies of the mortality experience of US primary lead smelter/refinery workers available for consideration.¹⁵ In 1975, as debate ensued over a protective occupational lead standard, with lead industry advocates generally arguing for no change in the existing 200 µg/m³ workplace air standard and that a Blood Lead Level (BLL) of 80 µg/dL in an adult worker was not necessarily harmful,¹⁶ the first retrospective cohort study was published that included workers in US primary lead smelters and refineries. This study was funded by the International Lead Zinc Research Organization (ILZRO) and included a large population of workers from 16 US lead plants, but only one primary smelter and two refineries. Though the workers in the ILZRO cohort had high exposure to lead during the period studied, battery plant workers, who comprised the majority of workers in the study (4680 of 7032), had lower average blood lead levels than smelter/refinery workers (63 µg/dL compared to 80 µg/dL).² None of the lead plants included in the study were identified by name. The authors concluded, "Considering the high levels of exposure in this population of workers and the small deviations from expected mortality, one can be optimistic in predicting no detectable effect on the mortality of male adults from occupational exposure to lead controlled in conformity to currently recommended environmental and biologic standards".² This industry-funded study supported the lead industry's contention that a change in the existing workplace lead standard was not needed.

The second US cohort mortality study of smelter workers was published in 1985,¹⁷ with a follow-up study published in 1992.¹⁸ It was conducted by NIOSH at the Bunker Hill smelter in Idaho and remains the only epidemiologic cohort study exclusively focused on the mortality of US primary lead smelter workers. Because the first study on this cohort was published in 1985, after the Occupational Safety and Health Administration (OSHA) lead standard was set in 1978, its findings did not inform the standard setting process. The 1985 study found excess deaths from chronic renal disease and renal cancer.¹⁷

Evidence of unpublished industry studies of primary lead workers

A recently published article examined documents produced in legal discovery relating to internal industry discussion of findings from a mortality study of workers in American Smelting and Refining Company (ASARCO) lead smelters and refineries between 1946 and 1960, and completed in 1966. At the time, ASARCO was one of the world's largest producers of nonferrous metals. The discussion about the findings was recorded in internal corporate correspondence, but the same was unable to be located (missing study 1). One key finding was that the lead workers studied had excess deaths from cancer, though specific cancer site/s were not mentioned, but not from kidney disease, hypertension or stroke. The study was not published in the peer reviewed literature based on a search of pubmed.¹⁰

While conducting research on another topic and reading internal lead industry documents, the author became aware of additional ASARCO studies examining the mortality experience of lead smelter and refinery workers, at the East Helena lead smelter in Montana and at the Omaha lead refinery in Nebraska. I present the discussion of the findings, which occurred at an internal industry meeting, and report the context of other published research on the mortality experience of highly lead-exposed workers. Like missing study 1 above, the East Helena and Omaha studies (missing studies 2 and 3) were not published in the peer-reviewed literature based on a search of pubme.

Methods

This article relies on historical research and was developed out of a larger project examining the public health and environmental impacts of the US primary smelting industry. This project involved searching diverse archival records on the US primary smelting industry including EPA Superfund records, the OSHA docket on the occupational lead standard, records from lawsuits involving the smelting industry, literature searches, and extensive web searches to identify grey literature on the US smelting industry. Additionally, the peer-reviewed literature was searched to identify epidemiologic studies of the mortality experience of workers in primary lead smelting/refining. The collected documents were organized into a timeline to develop a chronological sequence of events and studies and to facilitate analysis. The specific document which points to unpublished industry studies of primary lead smelter workers was obtained as part of the discovery process in a lawsuit brought by lead exposed children and their parents who lived near a primary lead smelter. The document contains meeting notes from a Lead Industries Association (LIA) Environmental

Health Committee meeting in 1982. In the following paragraphs, the research reported in the LIA documents is presented and discussed in the context of important regulatory events in the late 1970s and early 1980s and the evolving science of occupational lead exposure among highly exposed smelter/refinery workers.

Results

Context of occupational lead regulation in the early 1980s and the US primary lead industry

The early 1980s were a critical time for the US lead industry. The OSHA lead standard was set in 1978 at 50 µg/m³ after the publication of two NIOSH criteria documents on lead, numerous hearings, and a significant debate among labor, public health, and industry. The standard requires both air and biological monitoring with medical removal of workers at BLLs greater than or equal to 50 µg/dL. After removal, workers cannot return to jobs with significant lead exposure until their BLL is 40 µg/dL or lower. Even though the standard was to be phased-in over time and full compliance was not required until 1989, the standard, was sharply contested, particularly by the primary smelting and refining industry. When the standard was set there were seven primary lead smelters/refineries operating in the US. The 1980s saw closures of primary lead smelters in El Paso, Texas, Kellogg, Idaho and conversion of the Buick smelter in Missouri to secondary smelting (Table 1). By the late 1980s there were four remaining lead smelter/refineries, three of which were owned by ASARCO (East Helena, Glover and Omaha), and one owned by Doe Run (formerly the/Joseph Lead Company/St. Joe Minerals/St. Joe's) in Herculaneum, Missouri.¹⁹

After the OSHA standard was set in 1978, the lead industry, represented by the LIA launched legal appeals. By 1981, their legal appeals had been defeated. However, some members of the industry were hoping for a reprieve from the standard in the context of Reagan Administration's emphasis on "regulatory relief" and at this time, some primary

lead smelting companies were seeking variances from provisions of the standard and trying to negotiate compliance with OSHA.²⁰ According to an internal industry document written by a St. Joe Minerals employee, with Reagan's inauguration, "the lead industry saw an opportunity to get a review of what it envisioned as an impossible standard to achieve, certainly with regards to air levels and possibly with regards to blood lead goals. Since various industry segments within LIA had different needs, the various groups within the industry diverged in regard to how to seek to take advantage of regulatory reform. The primary lead industry brainstormed all possible options short of legislative relief including variances, extended settlement agreements in the context of enforcement actions, and new rule-making".²⁰

Indicative of the difficulty some primary smelters would have meeting the new standard, a manager at St. Joe's wrote in 1982 that the company had "in excess of 40%" of workers with BLLs above 50 µg/dL.²¹ Similarly, ASARCO reported to OSHA in 1977 that if the medical removal standard was set at 50 µg/dL, between 34 and 71% of their workers in primary and secondary smelters would have to be removed.²²

ASARCO at East Helena and Omaha

Conflict around the implementation of the OSHA standard was the larger context in May of 1982, when a meeting of the LIA's Environmental Health Committee was held. Regulatory updates on the OSHA lead standard and EPA regulations on lead were discussed and recorded in the minutes. Updates were also provided on research projects funded by ILZRO as well as research conducted by individual lead companies.²¹ The members of the LIA's Environmental Health Committee included representatives from mining and smelting companies in the US and abroad, including St. Joe's, ASARCO, Mitsui Mining and Smelting, and Australian Associated Smelters, among others.²³

Research was a critical aspect of the industry's strategy to fend off strict regulation and timely enforcement of workplace standards and on-going

Table 1 US primary lead smelters/refineries operating in 1978 and years of operation

Smelter/Refinery Name, Location & Ownership	Years of operation
Bunker Hill smelter, Kellogg Idaho (Bunker Hill Smelting Company/Gulf Resources)	1917–1981
El Paso smelter, El Paso Texas (ASARCO)	1887–1999; lead smelter closed in 1985; copper smelter remained open until 1999
Omaha Lead Refinery, Omaha, Nebraska (ASARCO)	Early 1870s–1997
Buick smelter, Bixby, Missouri (St. Joe's/Doe Run)	1966–1988; primary lead smelting ended in 1988; became a secondary smelter
East Helena smelter, East Helena, Montana (ASARCO)	1888–2001
Glover smelter/refinery, Glover, Missouri (ASARCO/after 1998 owned by Doe Run)	1968–2003
Herculaneum Smelter/Refinery, Herculaneum, Missouri (St. Joe's/Doe Run)	1892–2013

research projects were discussed among LIA members. With respect to on-going research, the Committee's meeting minutes note that W. Clark Cooper (of the consulting firm Tabershaw-Cooper Associates) was working on updating the ILZRO funded retrospective cohort study of lead industry workers mentioned previously and originally published as Cooper and Gaffey, 1975. The updated study was published in 1985.²⁴ A study on "fertility effects" was said to be "still bogged down". Additionally, "six prospective 5-year studies on chronic lead impacts (one sponsored by LIA) [were] moving ahead slowly".²¹ Findings from studies conducted by ASARCO and Noranda (mining and smelting company) were also discussed. The minutes state:

*Asarco and Noranda reported on studies they conducted. Most of the results were neutral. The only items of interest were excess death from lung cancer and strokes at Omaha [an ASARCO owned lead refinery] from a retrospective study there. No reasons were offered. It especially surprised Nelson [Kenneth Nelson, Vice President of Environmental Affairs, ASARCO], since E. Helena [an ASARCO lead smelter] came out completely clean. Noranda reported that a nerve conduction study at a mine smelter revealed a slower response among miners than the smelter workers which surprised them.*²¹

Unfortunately, it is not possible to evaluate the scientific validity of either of the ASARCO studies mentioned in the meeting minutes since a full report of the studies was not found, only the brief discussion of the key findings recorded in the minutes. Additionally, a search of the published, peer-reviewed literature turned up no mortality studies of ASARCO's Omaha or East Helena lead workers consistent with the above description. However, the findings reported in the meeting minutes, though limited, are interesting, particularly when viewed the context of the evolving literature on highly lead-exposed workers.

Lead and lung cancer mortality: findings from the peer-reviewed literature

Specifically, the finding of an increased risk of lung cancer mortality among Omaha lead refinery workers is consistent with the findings of several epidemiologic studies of lead-exposed battery and smelter workers,^{25–27} and two meta-analysis.^{12,28} Other cohort studies of lead workers have found non-significantly elevated lung cancer mortality risk²⁹ while other studies have not reported an increased risk of lung cancer death associated with lead exposure.^{30–32} A recent study of 58 368 men who were part of a surveillance program, and primarily occupationally exposed, found an increased risk of lung cancer mortality with increasing BLL.³³

Lead and stroke mortality: findings from the peer-reviewed literature

The finding of increased stroke risk in Omaha refinery workers is consistent with other studies of highly lead-exposed workers. For example, an increased risk of cerebrovascular disease was first noted in a 1963 study of lead-exposed workers in a battery factory,³⁴ and has been reported in additional studies on this cohort,^{35,36} and in an Australian study of lead-poisoned smelter workers.³⁷ In the ILZRO cohort study mentioned previously, among lead smelter workers, there was an increased risk of mortality from CNS vascular lesions that was not statistically significant.²⁴ The Bunker Hill cohort evidenced a non-significantly elevated standardized mortality ratio for cerebrovascular disease that increased with length of exposure.¹⁸ An Agency for Toxic Substances and Disease Registry review in 2007 found support for an association between lead exposure and cerebrovascular disease.³⁸ A 2012 National Toxicology Program review concluded that even at low levels, in adults, lead exposure is associated with increases in blood pressure and an elevated risk of hypertension, which increases risk for cardiovascular disease. The same review found limited evidence for increased risk of cardiovascular mortality associated with low-level lead exposure.³⁹ A Taiwan study reported a significant reduction in cerebrovascular disease after phase-out of leaded gasoline in that country between 1981 and 2007.⁴⁰

Neither cancer nor cerebrovascular/cardiovascular disease risk from lead exposure has been part of occupational standard setting at the federal level. For decades researchers have called for revising the federal occupational lead standard to be more protective of workers and to reflect current understandings of health risks from lead.^{41–44} OSHA acknowledges that the 1978 lead standard is "outdated".⁴⁵ California is currently taking steps to revise their standard to be more protective of health and to help ensure that worker's BLLs stay below 10 µg/dL.⁴⁶

Though average blood lead levels in US adults are now 1.2 µg/dL,⁴⁷ elevated blood lead levels attributable to occupational exposures persist in thousands of US workers. For example, between 2002 and 2011, 11 536 US adults were identified as having blood lead levels greater than or equal to 40 µg/dL. Among those where exposure source was available, the vast majority (91%) of adult elevated BLLs were attributable to occupational exposures.⁴⁸

Conclusion

The published, peer reviewed literature on the mortality experience of US lead smelter/refinery workers appears to contain an incomplete record of the actual studies conducted. This study and a previous one present

evidence that at least three studies were conducted in ASARCO facilities of the mortality experience of lead workers that do not appear to have been published. Findings from these studies, if published, could contribute to the body of literature on lead smelter workers, perhaps clarifying some areas of uncertainty. For example, one challenge in studying endpoints like lung cancer mortality in lead smelter workers has been that there are other possible carcinogenic exposures in primary smelters (e.g. arsenic and cadmium), making it difficult to isolate the role of lead as an etiologic agent.²⁷ More studies, especially those with accurate biological and/or environmental exposure measurements could help to clarify this issue.

Because occupational lead exposure is an on-going concern for both US and overseas workers, it is important that all epidemiologic studies, particularly of large, highly exposed cohorts such as smelter/refinery workers be made available for researchers and regulators to evaluate and update occupational health and safety standards.

It is also essential that workers themselves have access to findings from epidemiologic studies conducted on them so that they may have an indication of possible increased risks of disease, monitor their own health, and receive appropriate screening tests to identify, and if necessary, treat occupationally related disease. Legislation is needed to require that companies report occupational health studies to state health and labor departments and to NIOSH and OSHA.

Primary lead smelting and refining increasingly occurs in China and developing countries where workers may face significant exposures, less monitoring, and less enforcement of occupational standards.⁴⁹ Epidemiologic studies on US lead smelter and refinery workers are still relevant to occupational and environmental health standard setting here and abroad, to overseas workers who now produce and refine most of the world's primary lead, and to the US workers themselves who were the subjects of these studies.

Disclaimer Statements

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Ethics approval Ethical approval was not needed. This research was not conducted on human subjects.

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