Perspectives Correspondence

The correspondence section is a public forum and, as such, is not peer-reviewed. EHP is not responsible for the accuracy, currency, or reliability of personal opinion expressed herein; it is the sole responsibility of the authors. EHP neither endorses nor disputes their published commentary.

Definition of Occupational Lead Toxicity in Greece

doi:10.1289/ehp.10442

We read with interest the article of Kosnett et al. (2007) in which the authors offered medical recommendations for the health management of lead-exposed adults. These recommendations were intended to apply to all workers who have the potential to be exposed by lead ingestion, even in the absence of documented elevations in air lead levels. Based on the literature and their experience, Kosnett et al. recommended that individuals be removed from occupational lead exposure if a single blood lead level (BLL) exceeded 30 µg/dL or if two successive BLLs measured over a 4-week interval were ≥ 20 µg/dL.

The definition of occupational lead toxicity is difficult because it is not possible to determine a precise BLL below which symptoms never occur, or a BLL at which symptoms are always reported. Moreover, individual susceptibility should always be recognized. Several attempts have been made over the years to define lead toxicity among adult workers based mainly on clinical investigations [Agency for Toxic Substances and Disease Registry (ATSDR) 2007].

In Greece the occupational exposure to lead is regulated by the Presidential Decrees 94/1987 (1987) and 338/2001 (2001). According to these decrees, the diagnosis of lead toxicity in adult workers is based on the integration of data obtained from the patient's medical history, a physical examination, laboratory tests, and tests of specific organ function. An employee with a BLL of \geq 40 µg/dL and exposure to lead at concentrations > 75 μ g/m³ of air per 8-hr time-weighted average (TWA) require environmental and medical intervention (action levels). The maximum acceptable BLL for an adult worker is 70 µg/dL (BLL > 70 µg/dL should result in removal from lead exposure), but the permissible airborne exposure limit is < 150 µg/m³ per 8-hr TWA. Presidential Decree 94/1987 (1987) prohibits "prophylactic" chelation for the prevention of elevated BLLs. Although these standards have provided guidance that has been beneficial for Greek occupational health physicians, they have not been substantially changed since 1987 [action level, BLL \geq 50 µg/dL; maximum acceptable level, BLL = 70 μ g/dL; permissible airborne exposure limit, air lead (workplace) < $150 \ \mu\text{g/m}^3$ (8-hr average)]. Therefore, a

reformation of these standards is needed in Greece, on the basis of recent health effects studies, such as those on standards or regulations of health agencies.

Prevention of lead toxicity is a collaborative effort between primary care clinicians and public health agencies. Primary prevention is best achieved through the use of engineering controls, personal protective equipment, and good work practices. The occupational health physician can have the greatest impact on prevention through worker education and instruction in proper personal hygiene techniques. Also, the observance of up-to-date guidelines would contribute to the elimination of occupational lead toxicity in Greece.

The authors declare they have no competing financial interests.

Elias E. Mazokopakis Department of Internal Medicine Naval Hospital of Crete Chania, Crete, Greece E-mail: emazokopakis@yahoo.gr

Theodore C. Constantinidis Laboratory of Hygiene and Environmental Protection Medical School Democritus University of Thrace Alexandroupolis, Greece

REFERENCES

- ATSDR. Case Studies in Environmental Medicine (CSEM): Lead Toxicity. ATSDR Publication No: ATSDR-HE-CS-2001-0001. Atlanta, GA:Agency for Toxic Substances and Disease Registry. Available: http://www.atsdr.cdc.gov/HEC/ CSEM/lead/docs/lead.pdf [accessed 11 September 2007]. Greek Presidential Decree 94/1987. 1987. Protection of Workers
- Exposed to Metal Lead and Combinations of Lead lons. Greek Presidential Decree 338/2001. 2001. Protection of
- Occupational Health and Safety of Workers Exposed to Chemical Agents.
- Kosnett MJ, Wedeen RP, Rothenberg SJ, Hipkins KL, Materna BL, Schwartz BS, et al. 2007. Recommendations for medical management of adult lead exposure. Environ Health Perspect 115:463–471.

Editor's note: In accordance with journal policy, Kosnett et al. were asked whether they wanted to respond to this letter, but they chose not to do so.

Serum PFOA Levels in Residents of Communities Near a Teflon-Production Facility

doi:10.1289/ehp.10468

In a recent article, Tillett (2007) reported on research by the University of Pennsylvania NIEHS (National Institute of Environmental Health Sciences) Center of Excellence in Environmental Toxicology (CEET). CEET deputy director Edward Emmett described analyses of perfluorooctaonic acid (PFOA) in blood serum collected during mid-2004 from residents of towns near DuPont's Teflon production facility in Parkersburg, West Virginia. Results of the analyses, which identified PFOA levels "60–75 times higher than in the general population," were presented at a community meeting in October 2005, and "[DuPont] began offering bottled water to all residents being serviced in the Little Hocking Water District within days" of the meeting (Tillett 2007).

If the criterion for offering bottled water was high serum PFOA levels in residents of West Virginia and Ohio towns with PFOAcontaminated drinking water, then DuPont should have offered bottled water to Little Hocking, Ohio, and other towns well before October 2005. There would have been ample reason for concern about high serum PFOA levels because by 2001 there were reports in the scientific literature of animal studies that showed PFOA to be a developmental and liver toxicant, as well as a multisite carcinogen (Morgan and Cory-Slechta 2006).

In July 2004, the U.S. Environmental Protection Agency (EPA) sued DuPont for failure to file with the agency reports on PFOA required to be submitted under section 8(e) of the Toxic Substances Control Act [TSCA 8(e)] (U.S. EPA 2004a). In December 2004, a count was added (U.S. EPA 2004b) covering the company's failure to submit data obtained in July 2004 indicating that 10 community residents exposed to PFOA-contaminated drinking water in the area near Parkersburg, West Virginia, had serum levels of PFOA ranging from 15.7 to 128 ppb (mean, 67 ppb) (U.S. EPA 2004b) The U.S. average serum level of PFOA is approximately 5 ppb (U.S. EPA 2004b).

Each of the 10 individuals in the 2004 group was exposed to PFOA through drinking water provided by the Lubeck (WV) Public Service District (LPSD) where, according to DuPont,

[the level of PFOA in the drinking water] averaged approximately 0.5 ppb over the last several years. All ten of the individuals tested claim to have stopped using the contaminated public drinking water as their primary source of drinking water approximately three years ago. (Bilott 2004)

The concentration of PFOA in LPSD water (0.5 ppb) was well below recent levels in Little Hocking, but serum PFOA levels were still several times greater than 5 ppb. Also, given the half-life of PFOA in humans of approximately 4 years, it is likely that the high serum levels in the test group reflected exposures through drinking PFOA-contaminated water > 3 years before serum was taken, plus ongoing exposure from kitchen use, bathing/showering, and home-grown fruits and vegetables. The possible importance of exposure from homegrown fruits and vegetables was noted for the Little Hocking population (Tillett 2007).

Included in the U.S. EPA's December 2005 settlement of the agency's case against DuPont, although not mentioned in the agency press release (U.S. EPA 2005a), was a count related to DuPont's failure to submit to the U.S. EPA, as required by TSCA 8(e), the results of analyses of serum samples taken in 2002 from the same 10 people whose serum was analyzed in 2004 (U.S. EPA 2005b). PFOA levels in the 2002 survey were reported as 10-85 ppb (mean, 33.3 ppb). The 2002 data were submitted to the U.S. EPA in December 2004 (Robertson 2005) by Robert Bilott, the principal attorney in a civil suit against DuPont for contaminating drinking water with PFOA in the Ohio River Valley.

Also, 5 of the 10 individuals in the 2002 and 2004 studies participated in a 2001 PFOA analysis (Robertson 2005). DuPont disclaimed participation in or substantive knowledge of that survey, and the 2001 data were not included in the U.S. EPA's settlement with DuPont. In 2001, PFOA levels in the five survey participants ranged from 13 to 63 ppb (mean, 37.2 ppb).

It would be helpful if members of the public had ready access to the results of the 2001, 2002, and 2004 LPSD population surveys. A bibliographic database [Toxic Substances Control Act Test Submissions (TSCATS), U.S. EPA, Washington, DC] tracked TSCA 8(e) submissions to the U.S. EPA and could be accessed through such data providers as TOXLINE (National Library of Medicine 2007), but TSCATS was shut down some years ago; it appears that, regarding TSCA 8(e) reports on PFOA, TOXLINE is current only through perhaps 2001 at the latest (National Library of Medicine 2007). The majority of TSCA 8(e) reports on PFOA were submitted to the agency starting in 2001. PDF versions of TSCA 8(e) reports for approximately 2000-2006 are nominally available through a U.S. EPA website (U.S. EPA 2007); as of April 2007, submissions for 2000-2004, which had been online 2 years ago, were no longer available (U.S. EPA 2007). The 2004 survey data are available online at that U.S. EPA website (Bilott 2004).

The author was employed as a staff toxicologist at the U.S. EPA, where she worked on Teflon litigation from mid-2003 to mid-2005.

Myra L. Karstadt

Drexel University School of Public Health Philadelphia, Pennsylvania E-mail: myrakarstadt@verizon.net

REFERENCES

- Bilott R. 2004. Letter to CM Auer, ME Weber, M Dominiak, 0 Hernandez, J Seed, U.S. Environmental Protection Agency. Re: PFOA-Exposed Community Blood Sample Results. FYI-1004-01480. Available: http://www.epa.gov/ oppt/tsca8e/pubs/8ehq/2005/january05/fyi-1004-01480a. pdf [accessed 5 September 2007].
- Morgan MG, Cory-Slechta D. 2006. Letter to SL Johnson, 30 May 2006. SAB Review of EPA's Draft Risk Assessment of Potential Human Health Effects Associated with PFOA and Its Salts. Available: www.epa.gov/sab/pdf/sab_06_006. pdf [accessed 4 September 2007].
- National Library of Medicine. 2007. TOXLINE. Available: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?TOXLINE [accessed 27 April 2007].
- Robertson P. 2005. Letter to CM Auer, U.S. Environmental Protection Agency. Further DuPont Voluntary Response to EPA's November 4, 2004, Request. Submission to AR-226 and TSCA 8(e) Office. Supplement to December 20, 2004 Submission. Washington, DC:U.S. Environmental Protection Agency.
- Tillett T. 2007. Research helps clean up a water supply. Environ Health Perspect 115:A134.
- U.S. EPA. 2004a. EPA Takes Enforcement Action against DuPont for Toxic Substances Reporting Violations [Press Release]. Available: http://yosemite.epa.gov/opa/admpress. n s f/f 28 1 2 c 1 a 8 4 8 4 b 3 b 5 8 5 2 5 7 2 a 0 0 0 6 5 0 c 0 2 / afdc5785fd9ee05585256ecb0522cee!OpenDocument [accessed 4 September 2007].
- U.S. EPA. 2004b. EPA Files New Claim Alleging DuPont Withheld PFOA Information [Press Release]. Available: http://yosemite.epa.gov/opa/admpress.nsf/ f 28 1 2 c 1 a 8 4 8 4 b 3 b 5 8 5 2 5 7 2 a 0 0 0 6 5 0 c 0 2 / 826fe743d67d744685256f620074c136!OpenDocument [accessed 4 Sentember 2007].
- U.S. EPA. 2005a. EPA Settles PFOA Case against DuPont for Largest Environmental Administrative Penalty in Agency History [Press Release]. Available: http://yosemite.epa.gov/ opa/admpress.nsf/3dcd568e448fb35e852572a000658eed/ fdcb2f665cac66bb852570d7005d6665!0 penDocument [accessed 5 September 2007].
- U.S. EPA. 2005b. In the Matter of E.L. duPont de Nemours and Company, Wilmington, DE. Consent Agreement and Final Order. Available: http://www.epa.gov/compliance/ resources/agreements/tsca/dupontpfoasettlement121405. pdf [accessed 7 September 2007].
- U.S. EPA 2007. 8(e) Notices and FYI Submissions. Available: http:// www.epa.gov/opptintr/tsca8e/pubs/8eandfyisubmissions. htm [accessed 5 September 2007].

Editor's note: We appreciate Karstadt's time and interest in commenting on our news article, and her added perspective on the circumstances surrounding the Little Hocking and Parkersburg exposures.

Blood Lead and Water Treatment

doi:10.1289/ehp.10453

Miranda et al. (2007) recently reported the results of their investigation into the relationship between blood lead levels and residual water treatment in two locations in North Carolina. Their conclusion that "the change to chloramine disinfection may lead to an increase in blood lead levels, the impact of which is progressively mitigated in newer housing" is not borne out by their analysis. Their ecologic study design cannot be used to determine causation, and their recommendation to change lead screening strategies based on their study seems premature.

Their analysis relied on ecologic assignment of drinking water exposures based on residence location, census-level exposures for housing age, and other risk factors for lead exposure. They provided no information on differences in water chemistry, such as pH or corrosivity, or on the presence of lead in the distribution systems or service lines. These characteristics are important to determine the likelihood of lead leaching, regardless of the type of residual disinfectant used. In fact, the water serving Wayne County, North Carolina, is heterogeneous. Whereas the city of Goldsboro is served by surface water sources, the rest of Wayne County is served by seven smaller sanitary districts that rely on groundwater. Further, among the groundwater sources there is considerable variability in the water quality. The Wayne Water Districts, erroneously referred to by Miranda et al. (2007) as "Wayne Water Systems," are composed of five of the seven sanitary districts in Wayne County and had 39 wells in 2006, about half of which receive no treatment. The remaining half are treated for iron removal, fluoride, chlorine, and phosphate. The pH for Wayne Water Districts water ranges from 6.5 to 7.5, whereas Goldsboro Water usually maintains a pH > 8.0.

Miranda et al. (2007) stated that they

expected that the effect of chloramines on [blood lead levels] would be less important and eventually unimportant as [they] moved into newer and newer housing stock.

However, they offered no explanation for their *a priori* hypothesis of interaction. In fact, according to the U.S. Environmental Protection Agency (1993), the opposite would be true:

Lead levels decrease as a building ages. This is because, as time passes, mineral deposits form a coating on the inside of the pipes (if the water is not corrosive). This coating insulates the water from the solder.

In the categorical analysis, stratifying housing age by 25-year categories may have led to misclassification. In 1988 the Consumer Product Safety Commission (CPSC 1988) began enforcing the Federal Hazardous Substances Act restricting the use of lead solder in plumbing. The cutoffs used by Miranda et al. (2007) combine the years 1976-1988 together with newer housing stock that would not have lead solder in the plumbing. It is also curious that the tax parcel data from which they assigned housing age characteristics differs markedly from that reported in the 2000 U.S. Census (U.S. Census Bureau 2000). Where Miranda et al. (2007) reported 15.6% of Wayne County housing stock built before 1925, the U.S.

Census reported just 7.6% built before 1939 (U.S. Census Bureau 2000).

Miranda et al. (2007) were unable to include 25% of records; missing these data could have biased the results. For example, if a higher proportion of the missing children were from Seymour Johnson Air Force Base, which is annexed to the city of Goldsboro and which receives water from the Goldsboro Water System, this could have overestimated the effect of switching to chloramine if the missing children had lower blood lead levels. Children who reside on military bases tend to have lower lead exposures, regardless of the housing stock (Stroop et al. 2002).

Miranda et al. (2007) should have considered the possible impact of Hurricane Floyd. The September 1999 hurricane left many homeless; flooding, demolition, and construction activities could well have affected children's blood lead levels to a greater extent in Goldsboro compared with the rest of Wayne County. Indeed, the raw blood lead level data show an increase county-wide in the year 2000, supporting an effect of the hurricane.

The analysis conducted by Miranda et al. (2007) is interesting, and additional studies with individual-level exposure measurements should be conducted. However, their study does not provide a basis for recommending a broad alteration of blood lead screening strategies. States need to do better to ensure that blood lead screening strategies are inclusive, especially for lowincome children who are at the greatest risk of undetected elevations in blood lead levels. The recommendation of Miranda et al. (2007) to exclude certain children based on water-disinfection practices could have substantial unintended impacts. In accordance with recommendations of the U.S. Preventive Services Task Force (2007), a more prudent approach to prevent lead exposure via drinking water is that municipalities ensure careful corrosion control and remove lead service lines and distribution pipes, regardless of the method of residual disinfectant used.

The author is an employee of the City and County of San Francisco Department of Public Health; her position is funded under a work order from the San Francisco Public Utilities Commission, which switched to chloramine for residual disinfection in 2004. The San Francisco Public Utilities Commission had no role in the preparation, review, or approval of this letter.

June M. Weintraub

San Francisco Department of Public Health/Environmental Health Section San Francisco, California E-mail: june.weintraub@sfdph.org

REFERENCES

- CPSC (Consumer Product Safety Commission). 1988. Don't Use Solder that Contains Lead for Work on Drinking Water Systems: Safety Alert. CPSC Document 5056. Available: http://www.cpsc.gov/CPSCPUB/PUBS/5056.html [accessed 5 September 2007].
- Miranda ML, Kim D, Hull AP, Paul CJ, Galeano MA. 2007. Changes in blood lead levels associated with use of chloramines in water treatment systems. Environ Health Perspect 115:221–225.
- Stroop DM, Dietrich KN, Hunt AN, Suddendorf LR, Giangiacomo M. 2002. Lead-based paint health risk assessment in dependent children living in military housing. Public Health Rep 117:446–452.
- U.S. Census Bureau. 2000. Profile of Selected Housing Characteristics: 2000. Data Set: Census 2000 Summary File 3 (SF 3). Wayne County, North Carolina. Available: http:// factfinder.census.gov/servlet/QTTable?_bm=y&-qr_name= DEC_2000_SF3_U_DP4&-ds_name=DEC_2000_SF3_U&-_lang=en&-_sse=on&-geo_id=05000US37191 [accessed 10 May 2007].
- U.S. Environmental Protection Agency. 1993. Actions You Can Take To Reduce Lead In Drinking Water. EPA 810-F-93-001. Available: http://www.epa.gov/safewater/lead/lead1.html [accessed May 10, 2007].
- U.S. Preventive Services Task Force. 2006. Screening for elevated blood lead levels in children and pregnant women: recommendation statement. Pediatrics 118:2514–2518. Available: http://www.ahrq.gov/clinic/uspstf06/lead/ leadrs.htm [accessed 10 May 2007].

Blood Lead and Water Treatment: Miranda et al. Respond

doi:10.1289/ehp.10453R

In response to our study (Miranda et al. 2007), in which we found an association between age of housing, water treatment practices, and blood lead levels, Weintraub concludes that

a more prudent approach to prevent lead exposure via drinking water is that municipalities ensure careful corrosion control and remove lead service lines and distribution pipes, regardless of the method of residual disinfectant used.

Unfortunately, this approach has fallen notably short as evidenced by tests of residential tap water in Washington, DC (Edwards and Dudi 2004), Greenville, North Carolina (Renner 2005), and in 2006, in Durham, North Carolina (Biesecker 2006). Each of these cities had increased levels of lead in tap water following a change in water treatment practices necessitated by a switch to chloramines for disinfection.

We stand by our hypothesis that the effect of chloramines on blood lead levels would be less important in newer housing stock. Weintraub cites a U.S. Environmental Protection Agency Fact Sheet (U.S. EPA 1993) as evidence that older buildings would pose less, not more, of a lead risk because of the protective effect of mineral deposits coating the inside of the pipe. However, as the U.S. EPA noted, lead levels decrease as a building ages only "if the water is not corrosive." An increase in the

corrosivity of treated water after a switch to chloramines may expose lead that was shielded by mineral deposits (Schock 1990). This supports our reasoning that newer housing without lead service lines or lead solder and low-lead fixtures would pose less exposure risk.

We did not use an ecologic study design in our analysis. Our outcome variable was an individual measure of blood lead level, and our explanatory variables were either individual or census-level measures. We did not attempt to infer an individual-level association of variables from an association demonstrated only for aggregated variables.

We coined the phrase "Wayne Water Systems" to represent the collection of water systems in Wayne County, North Carolina, that do not use chloramines. "Wayne Water Systems" includes the five water systems that make up the Wayne Water Districts, as well as the five other active community water systems (Fremont, Fork, Pikeville, Mt. Olive, and Southern Wayne) in the county. We should have noted this in the text.

With respect to the categorical analysis, stratifying housing age by 25-year categories did not lead to misclassification of the housing, in spite of grouping together houses built before and after the ban of lead solder in 1986. We performed model iterations with several different age categories of housing and presented the best-performing model. We did run a model with housing built after 1986 as a referent group, but we found the variable of 1976–1986 statistically insignificant.

We based our finding that 15.6% of the housing stock in Wayne County was built before 1925 on tax parcel data, which we consider to more accurately represent housing age than homeowner responses to ageof-housing questions posed by the U.S. Census. We would have preferred to include all blood lead records, but it was not possible because we could not geocode incomplete addresses. However, when we compared the blood lead levels of children from geocoded and nongeocoded addresses, we did not find a significant difference. Records of children from Seymour Johnson Air Force Base were included in the analysis.

In July 2006, the U.S. EPA proposed changes to the Lead and Copper Rule that would require water systems to notify, and obtain approval from, state regulatory agencies before changing a water treatment process (U.S. EPA 2006). As the U.S. EPA noted, if a water system notifies the state after changes have already been made, there may be little or no opportunity to minimize any corrosion problems to prevent lead from leaching from plumbing components. We suggest the use of housing age as a simple metric for states to use in designing a water monitoring program, and expanding blood lead screening in advance of changes in water treatment practices.

Weintraub states that our recommendations "to exclude certain children" based on water disinfection practices could have "substantial unintended impacts." This is a misrepresentation of our recommendations. Based on the Wayne County results (and those in Washington, Greenville, and Durham), we recommended that local health departments expand their scope of targeted screening in the years following the introduction of chloramines as a supplement to, not a replacement of, existing programs that are in place to provide blood lead screening services to children at risk of lead exposure. We also suggested that health departments might target more intensive outreach and education to residents of older housing, a strategy that would help focus limited resources on residences where additional lead sources may also be present.

Our recommendations are consistent with the U.S. EPA's rationale for revising the Lead and Copper Rule to require advance notification of water treatment changes, and with recommendations by water chemistry experts to closely monitor water lead levels after changing to chloramines for disinfection.

The authors declare they have no competing financial interests.

Marie Lynn Miranda Martha Keating Dohyeong Kim Andrew P. Hull Christopher J. Paul

M. Alicia Overstreet Galeano

Nicholas School of the Environment and Earth Sciences Duke University Durham, North Carolina E-mail: mmiranda@duke.edu

REFERENCES

- Biesecker M. 2006. Durham lead fear widens. News and Observer (Raleigh, NC), 13 June. Available: http://www. newsobserver.com/news/health_science/lead/story/ 450089.html [accessed 8 June 2007].
- Edwards M, Dudi A. 2004. Role of chlorine and chloramine in corrosion of lead-bearing plumbing materials. J Am Water Works Assoc 96(10):69–81.
- Miranda ML, Kim D, Hull AP, Paul CJ, Galeano MA. 2007. Changes in blood lead levels associated with use of chloramines in water treatment systems. Environ Health Perspect 115:221–225.
- Renner R. 2005. Chloramines again linked to lead in drinking water. Environ Sci Technol 39(15):314A. Available: http:// pubs.acs.org/isubscribe/journals/esthag-a/39/i15/html/ 080105news3.html faccessed 8 June 2007I.
- Schock M. 1990. Causes of temporal variability of lead in domestic plumbing systems. Environ Monit Assess 15(1):59–82.
- U.S. EPA (Environmental Protection Agency). 1993. Actions You Can Take to Reduce Lead in Drinking Water. EPA 810-F-93-001. Available: http://www.epa.gov/safewater/ lead/lead1.html [accessed 8 June 2007].
- U.S. EPA (Environmental Protection Agency). 2006. National primary drinking water regulations for lead and copper: short-term regulatory revisions and clarifications; proposed rule. Fed Reg 71:40828–40863. Available: http:// www.epa.gov/fedrgstr/EPA-WATER/2006/July/Day-18/w6250.pdf [accessed 4 September 2007].