Environmental Research 163 (2018) 194–200

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Declines in adult blood lead levels in New York City compared with the United States, 2004–2014

Alexis Feinberg[a,*], Wendy McKelvey[b], Paromita Hore[b], Rania Kanchi[a], Patrick J. Parsons[c,d], Christopher D. Palmer[c,d], Lorna E. Thorpe[a]

[a] NYU School of Medicine, Department of Population Health, New York City, USA
[b] NYC Department of Health and Mental Hygiene, Division of Environmental Health, New York City, USA
[c] Laboratory of Inorganic and Nuclear Chemistry, Wadsworth Center, New York State Department of Health, Albany, NY, USA
[d] Department of Environmental Health Sciences, University of Albany, Albany, NY, USA

ARTICLE INFO

Keywords:
Adults
Blood lead
NYC HANES
Biomonitoring
Disparities

ABSTRACT

Objectives: To assess changes in lead exposure in the New York City (NYC) adult population over a 10-year period and to contrast changes with national estimates, overall, and by socio-demographics and smoking status.
Methods: We used measurements of blood lead levels (BLLs) from NYC resident adults who participated in the NYC Health and Nutrition Examination Surveys (HANES) in 2004 and 2013–2014. We compared estimates of geometric means (GM), 95th percentiles, and prevalence of BLL ≥ 5 μg/dL overall and by subgroups over time, with adults who participated in the National HANES (NHANES) 2001–2004 and 2011–2014.
Results: The GM BLLs among NYC adults declined from 1.79 μg/dL in 2004 to 1.13 μg/dL in 2013–2014 (P < .0001). The declines over this period ranged from 30.1% to 43.2% across socio-demographic groups and smoking status (P < .0001 for all comparisons), and were slightly greater than declines observed nationally. The drop in prevalence of elevated BLLs (≥ 5 μg/dL) was also greater in NYC (4.8–0.5%), compared with NHANES (3.8–2.0%). By 2013–2014, NYC adults with lower annual family income (< $20,000) no longer had higher GM BLLs relative to those with higher incomes (≥ $75,000), a disparity improvement not observed nationally. Likewise, GM BLLs and 95th percentiles for non-Hispanic black adults in NYC were lower than GM BLLs for non-Hispanic white adults. Non-Hispanic Asian adults had the highest GM BLLs compared with other racial/ethnic groups, both in NYC in 2013–14 and nationally in 2011–2014 (1.37 μg/dL, P = .1048 and 1.22 μg/dL, P = .0004, respectively).
Conclusion: The lessening of disparity in lead exposure across income groups and decreasing exposure at the high end of the distribution among non-Hispanic black and Asian adults in NYC suggest that regulatory and outreach efforts have effectively targeted these higher exposure risk groups. However, Asian adults still had the highest average BLL, suggesting a need for enhanced outreach to this group. Local surveillance remains an important tool to monitor BLLs of local populations and to inform initiatives to reduce exposures in those at highest risk.

1. Introduction

Lead is a ubiquitous environmental contaminant, and exposure remains a public health concern for both children and adults in the United States (US). Though much literature has focused on children whose developing nervous systems are particularly susceptible to toxic effects of lead, and who have increased potential for exposure via hand-to-mouth behavior and a higher gastrointestinal absorption rate, lead can be toxic throughout the lifespan (National Toxicology Program, 2012; Woolf et al., 2007). In addition, recent studies have suggested that effects of childhood exposure persist with age (Cecil et al., 2008; Mazumdar et al., 2011; Reuben et al., 2017). Studies of exposure to lead in the range of 20 – 50 μg/dL, levels well above observed population averages, suggest increased risk of peripheral neuropathy, renal dysfunction, sperm abnormalities, and decreased male fertility (Abadin et al., 2007). Pregnant women are especially vulnerable because lead can cross the placenta and harm the fetus' developing nervous system. Increased bone demineralization during pregnancy—releasing stored lead from past exposure—further increases risk of adverse reproductive outcomes (Bellinger, 2005; Borja-Aburto et al., 1999). Recent evidence

* Correspondence to: Department of Population Health NYU School of Medicine, 227 East 30th Street, 7th floor, Room 720, New York, NY 10016, USA.
E-mail address: Alexis.Feinberg@nyumc.org (A. Feinberg).

https://doi.org/10.1016/j.envres.2018.01.049
Received 10 November 2017; Received in revised form 19 January 2018; Accepted 31 January 2018

suggests adverse lead-associated health effects in adults at lower exposure levels, including below the blood lead level (BLL) of 10 μg/dL, adopted in 2009 by the US (CDC) as the case definition for an elevated BLL for adults, as well as below the CDC adult reference level of 5 μg/dL adopted in 2015 (National Toxicology Program, 2012; CDC, 2017a). Indeed, epidemiological studies have found an association between low-level lead exposure and increased risk of cardiovascular effects, such as increased blood pressure, hypertension, myocardial infarction, and all-cause and cardiovascular mortality (Navas-Acien et al., 2007; Menke et al., 2006; Gambelunghe et al., 2016).

In the US, adult BLLs have decreased over time in large part due to national and local legislative efforts that phased out lead from sources such as gasoline (Kovarik, 2005), paints (Jacobs et al., 2002) and solder in canned food (Bolger et al., 1996) and water pipes (Brown and Margolis, 2012), as well as regulated industrial emissions (US Environmental Protection Agency, 2017a). Data from the recurrent National Health and Nutrition Examination Survey (NHANES) have reported the progressive decline in BLLs (Muntner et al., 2005; Jain, 2016), with recent studies documenting declines in mean BLLs from 1.65 μg/dL (95% confidence limits [CL] = 1.62,1.68) in 1999–2000 to 0.84 μg/dL (95% CL = 0.82,0.86) in 2013–2014 (Tsoi et al., 2016). Regardless, adults can still be exposed to environmental lead through lead-contaminated dust (Whitehead et al., 2014; Farfel et al., 2003; Schneitzer et al., 1990), soil (Mielke and Reagan, 1998; Schwarz et al., 2016; Datko-Williams et al., 2014) and drinking water (mostly through the corrosion of plumbing materials that contain lead) (Brown and Margolis, 2012). Work place exposures account for most instances of BLL greater than 25 μg/dL in non-pregnant adults (CDC, 2011), particularly in the construction industry where workers can be exposed during renovations, repairs, and demolitions that disturb old, lead-based paint (CDC, 2013). Adults can also be exposed to lead through jobs and hobbies such as jewelry or stained glass making involving lead-based solder (Abadin et al., 2007) and firearms shooting with lead primer or ammunition (Laidlaw et al., 2017). Lead-contaminated products such as certain imported food or spices (Cowell et al., 2017), cosmetics (Bocca et al., 2014), traditional remedies and medications (Karri et al., 2008; Breeher et al., 2013; CDC, 2012; Hore et al., 2014) and lead glazed ceramics (Rebeniak et al., 2014) are other potential sources of exposure. Finally, cigarette smoking has been identified as another source of exposure (Bernhard et al., 2005).

Population-based biomonitoring documenting declines in lead exposure in the general population provides support for continued implementation of regulations, interventions, and outreach and education to reduce exposure risks (Jain, 2016; Tsoi et al., 2016). Blood lead surveillance, both locally and nationally, can demonstrate the effectiveness of approaches to reduce lead hazards and help characterize persistent exposure patterns. Findings can be used to inform future control strategies (Gwynn et al., 2009). In 2004, New York City (NYC) conducted the first local-level HANES with a representative sample of NYC adults, and found that BLLs among NYC adults were similar to national estimates (McKelvey et al., 2007). Using population-based data from NYC HANES and NHANES, the objectives of this study were to estimate BLLs in NYC adults 10 years later and to contrast 10-year changes in BLLs at the city level to changes in national estimates from the same period. We also examined disparities in lead exposure by socio-demographic variables and smoking status over time.

2. Methods

2.1. Data sources

We used NYC HANES datasets from 2004 and 2013–2014 and NHANES datasets from 2001–2004 and 2011–2014. Data from two NHANES surveys were combined to increase the statistical reliability of the estimates. Only individuals aged ≥ 20 years with a blood lead level (BLL) were included in analyses. NYC HANES and NHANES are population-based cross-sectional surveys that use similar sampling schemes to generate representative estimates of the health of the NYC and US populations, respectively. Details of the study designs are described elsewhere (CDC, 2017b). The design of the first NYC HANES, completed in 2004, and the second survey, conducted in 2013–2014, were almost identical and have been previously published (Thorpe et al., 2006, 2015). NYC HANES standardized data-collection methodology allows for a comparison with NHANES national estimates.

2.2. NYC HANES laboratory methods

For NYC HANES 2004 and 2013–2014, venous blood was collected using K_2EDTA Vacutainers® (Becton, Dickinson and Company, Franklin Lakes, New Jersey, US) pre-certified by the analyzing laboratory for trace element analysis. Specimens were shipped with refrigerant packs to the Laboratory of Inorganic and Nuclear Chemistry at the New York State (NYS) Department of Health's (DOH) Wadsworth Center, Albany NY, where they were stored at −80 °C until analysis could begin. The Wadsworth Center is certified for blood lead testing under the federal Clinical Laboratory Improvements Amendments of 1988 (CLIA-88) and holds a NYS DOH clinical laboratory permit for blood lead and trace elements.

The laboratory method used for measuring blood lead in 2013–2014 was comparable to that used in 2004 (Palmer et al., 2006). In 2004, lead was measured in whole blood using a PerkinElmer Sciex (Shelton, CT) ELAN DRC Plus Inductively Coupled Plasma Mass Spectrometer (ICP-MS). In 2013–2014, the blood lead method had been transferred to a Thermo Scientific XSeries 2 ICP-MS. Over the period 2002–2017, the ICP-MS blood lead method performance was validated against international standards for lead in blood, thereby assuring measurement traceability (Murphy et al., 2009). The laboratory was also continually assessed through participation in eight external quality assessment schemes for blood lead, to assure measurement harmonization with other laboratories. Four levels of internal quality control (IQC) materials covering the expected range of exposure were analyzed at the beginning, end, and throughout each analytical run. Typical repeatability, or between-run imprecision, defined as the percent relative standard deviation (RSD), varied from 2.8% at 1.62 μg/dL to 2.0% at 5.95 μg/dL, 2.5% at 19.26 μg/dL, and 2.6% at 28.26 μg/dL. A repeat analysis was performed on any specimen exceeding an upper threshold of 5 μg/dL. In addition, 2.5% of all blood specimens were randomly selected for reanalysis. The method limit of detection (LOD) for ICP-MS varied between 0.05 and 0.10 μg/dL for both instrumental platforms used to analyze the 2004 and 2013–2014 specimens. All sample levels for both NYC HANES surveys exceeded the LOD.

2.3. NHANES laboratory methods

All NHANES analyses for BLL were conducted in the Inorganic Radiation Analytical Toxicology Branch, Division of Laboratory Sciences, within the CDC's National Center for Environmental Health, Atlanta, Georgia. The CDC laboratories are also CLIA-88 certified for blood lead and, from 2001 to 2004, the analytical method in use for blood lead transitioned from one based on electrothermal atomization atomic absorption spectrometry (ETAAS) using a transversely-heated graphite atomizer with longitudinal Zeeman background correction (Parsons and Slavin, 1993) to one based on ICP-MS. Like the Wadsworth laboratory, the specific quadrupole ICP-MS instrumentation used by CDC for blood lead testing has changed over the period of time specific to subsequent NHANES datasets (2003–2014) and includes the PerkinElmer Sciex (Shelton, CT) ELAN DRC II ICP-MS and later the PerkinElmer NexION 300 ICP-MS instrumentation. The CDC's ICP-MS method for blood lead is similar, but not identical, to that used by the NYS DOH Wadsworth Center. Nevertheless, the CDC and Wadsworth laboratories have routinely exchanged quality assurance samples for blood lead over the last 30 years, and have worked closely to improve