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Blood lead levels and risk factors in young children in France, 2008–2009

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ABSTRACT

Background: The exposure of children to lead has decreased in recent years, thanks notably to the banning of leaded gasoline. However, lead exposure remains a matter of public health concern, because no toxicity threshold has been observed, cognitive effects having been demonstrated even at low levels. It is therefore important to update exposure assessments. A national study was conducted, in 2008–2009, to determine the blood lead level (BLL) distribution in children between the ages of six months and six years in France. We also assessed the contribution of environmental factors.

Methods: This cross-sectional survey included 3831 children recruited at hospitals. Two-stage probability sampling was carried out, with stratification by hospital and French region. Sociodemographic characteristics were recorded, and blood samples and environmental data were collected by questionnaire. Generalized linear model and quantile regression were used to quantify the association between BLL and environmental risk factors.

Results: The geometric mean BLL was 14.9 μg/l (95% confidence interval (CI) = [14.5–15.4]) and 0.09% of the children (95% CI = [0.03–0.15]) had BLLs exceeding 100 μg/l, 1.5% (95% CI = [0.9–2.1] exceeding 50 μg/l. Only slight differences were observed between French regions. Environmental factors significantly associated with BLL were the consumption of tap water in homes with lead service connections, peeling paint or recent renovations in old housing, hand-mouth behavior, passive smoking and having a mother born in a country where lead is often used.

Conclusions: In children between the ages of one and six years in France, lead exposure has decreased over the last 15 years as in the US and other European countries. Nevertheless still 76,000 children have BLL over 50 μg/l and prevention policies must be pursued, especially keeping in mind there is no known toxicity threshold.

Introduction

Blood lead levels (BLLs) in children have decreased considerably over the last 20 years (CDC, 2012a; EFSA, 2010; Schulz et al., 2007). This decrease is the result of the control measures to regulate lead in petrol, paint, food and drinking water implemented in Europe and the United States since the 1970s. However, lead exposure remains an important public health concern, given the accumulating scientific evidence of adverse health effects at lower blood lead levels and the absence of a known toxicity threshold (Canfield et al., 2003; Jusko et al., 2008; Lanphear et al., 2005). The National Toxicology Program (NTP) in the United States, in a recent literature review, concluded that the presence of lead in the blood at a BLL < 100 μg/l is associated with delayed puberty and poorer cognitive performance, with a lower intelligence quotient (IQ) (NTP, 2012). Inverse relationships between BLL and IQ have been demonstrated in several studies, the strongest effects being observed at concentrations below 100 μg/l (Canfield et al., 2003; Jusko et al., 2008; Lanphear et al., 2005). The European Food Safety Agency (EFSA) has stated that a 12 μg/l (lower confidence limit of the benchmark dose) increase in BLL in children is associated with a 1 IQ point decrease in cognitive ability (EFSA, 2010), based on Lanphear's pooled analysis (Lanphear et al., 2005). The NTP has also concluded that the presence of lead in the blood at a BLL < 50 μg/l increases the risk of attention deficit hyperactivity disorder, academic deficits and problem behavior (NTP, 2012).

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Based on these new findings, the Advisory Committee of Childhood Lead Poisoning Prevention of the Centers for Disease Control and Prevention (CDC) recommended, in January 2012, replacing the "BLL of concern" of 100 μg/l with a reference value based on the 97.5th percentile of the American BLL distribution in children aged one to five years (estimated at 50 μg/l in 2007–2008; CDC, 2012b). This has led to an updating of CDC guidelines concerning BLL in children and the recommended use of a new reference value, 50 μg/l (CDC, 2012c). The German Federal Environmental Agency has also recently suspended the human biomonitoring value of 100 μg/l for lead in blood of children and set a reference value of 35 μg/l (based on the lower bound of confidence interval of the 95th percentile) for lead exposure in German children (Wilhelm et al., 2010).

The last survey of lead exposure in France was conducted in 1996 and showed that 2.1% (84,000) of children between the ages of one and six years had high BLLs (BLL ≥ 100 μg/l, the current action threshold in France). The risk factors for BLL identified in 1996 in France were living in a house built before 1949 (when white lead-based paint was still in use; Lucas, 2011), tap water consumption, hand-mouth behavior, parental hobbies involving the use of lead and traffic jam intensity (Huel et al., 1997).

A national anti-lead poisoning policy was set up in France in 1993, with actions focusing on primary prevention and screening. According to the French public health law of 2004 "Politique de Santé publique" (law no. 2004-806 of August 9, 2004), the aim was to decrease the percentage of children aged one to six years with a BLL exceeding 100 μg/l by 50% between 1996 and 2008. The French Institute for Public Health Surveillance (InVS) evaluated the extent to which this goal had been achieved, and assessed current blood lead levels in children living in France, by carrying out a national survey of blood lead levels in 2008–2009. It also checked whether the previously identified environmental risk factors for lead exposure persisted.

Materials and methods

Study population and sampling

A national study of blood lead levels was carried out between September 2008 and April 2009. This cross-sectional survey involved 3831 children, aged from six months to six years, recruited by 143 hospital pediatrics departments in mainland France (n = 135) and French regions overseas (French West Indies and Reunion Island) (n = 8). A two-stage probability sample design was used: in the first stage, the primary sampling units were hospitals; in the second stage, we included hospitalized children from whom blood samples had been collected for medical purposes. The hospital sampling framework (n = 273 hospitals) was stratified by region. In each region, the 25% of hospitals with the highest proportions (from French Tax authorities data) of pre-1949 (*i.e.* before lead ban in paints, *cf.* supra) and poor housing in their catchment areas were classified as being in "high-risk areas"; the other hospitals (75%) were classified as being in "low-risk areas". The hospitals in "high-risk areas" and those located in the 4 French regions (Ile-de-France, Nord-Pas-de-Calais, Provence-Alpes-Côte d'Azur and Haute-Normandie) with the highest density of polluted industrial sites (registered sites in national database BASIAS) were intentionally oversampled, to increase the probability of sampling children with high BLLs and, therefore, of increasing the precision of estimates of the prevalence of high BLL. The high-risk area hospitals accounted for 45% of the samples analyzed. This oversampling was taken into account in the analysis by assigning sampling weights (the inverse of the probability of inclusion in the sample). The participation rate was 83% for hospitals. The exclusion criteria for children were severe diseases, and hospitalization for chelating treatment or follow-up for lead poisoning. The parents of the children who took part in the study were informed about the purposes of the study and gave their consent. The participation rate was 97% for parents. An individual written report on the results was sent to each family. Approval for the study was obtained from the French data protection authority (*Commission nationale de l'informatique et des libertés*, authorization no. 907,160) and a bioethics committee (*Comité de Protection des Personnes*, Hôpital Henri Mondor, no. CPP-IDF IX – 08-022).

Data collection

Venous blood samples (1.5 ml) were collected at the hospital by a nurse, on the occasion of a blood test, and were stored at 4 °C in the hospital laboratory, in accordance with a standardized protocol. During hospitalization of the child, the parents were interviewed, face-to-face, by pediatricians or nurses, using a standardized questionnaire. We collected information relating to socioeconomic, behavioral and environmental factors. The socioeconomic factors included the country of birth of the mother and of the child, eligibility for complementary free health insurance (CMUc, considered to be a good proxy for low socioeconomic status), parental education, parental occupation, parental home ownership status, family and house size, address of the family. Behavioral factors included tendency to scrape off or to nibble paint, tap water consumption and exposure to traditional medicine, cosmetics or ceramics. Possible exposure to lead through traditional medicine, cosmetics or ceramics was defined on the basis of the mother having been born in a country with high levels of lead. This variable was constructed from a list of countries in which lead is often found in these products (Bretin and Schapiro, 2006). The environmental factors considered were the presence of a lead branch pipe (pipe that connect a dwelling to the main service line in the street, from the water meter to the water main), age of the housing, presence of peeling paint within the dwelling or in common areas, renovation work involving high levels of dust production and environmental tobacco smoke (ETS). The presence of a lead branch pipe was investigated by tap water companies, for the address of each child. The age of housing was categorized on the basis of the risk of white lead paint being present: before 1949 (highest risk), after 1949 (lower risk) and unknown (Lucas et al., 2012). Based on the self-reported professions of the parents, a variable "parents' occupational exposure to lead" was thereafter defined by expert judgment, with three categories depending on the probability for each parent to be exposed: "occupationally exposed" (high probability to be in contact with lead metal in industrial or craft company), "possibly occupationally exposed" (building workers, farmers) and "occupationally non-exposed". ETS was defined as the number of hours per day for which the family members were exposed to smoking within the home.

Blood lead level determinations

Blood lead analyses were carried out in a central laboratory, by inductively coupled plasma mass spectrometry (ICP-MS). The blood samples were diluted (1:10) with an aqueous matrix modifier solution (0.2% butanol, 0.1% Triton and 1% nitric acid). The limit of quantification (LOQ) was 0.037 μg/l. In all cases, BLL was above the LOQ. All blood samples with a BLL greater than 80 μg/l were subjected to a second analysis, to confirm the results. Quality control procedures were performed: blanks and internal quality controls from reference materials (Utak blood samples of 27.91 μg/l and 394.92 μg/l) were analyzed for every 10 samples. External quality control procedures included participation in the AFSSAPS (French Agency for medical care safety) interlaboratory control (2007 and 2009) and the use of external samples from the INSPQ (National