# Lead exposure among children from native communities of the Peruvian Amazon basin

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**ABSTRACT** **Objective.** *To assess potential risk factors associated with elevated blood lead levels (BLLs) among children in two communities from the Corrientes River basin in the Peruvian Amazon.*
**Methods.** *Children aged 0–17 years were screened for BLLs, hemoglobin levels, and anthropometric measures. Dwelling, family, and child data were collected through a parental questionnaire. Statistical analysis included descriptive and bivariate analysis. Multiple linear and logistic regressions using generalized estimating equations were also conducted to determine associated risk factors. A map of each community was drawn to examine the spatial distribution of BLLs.*
**Results.** *Of 208 children (88 from 23 households of the Peruanito community and 120 from 28 households of Santa Isabel), 27.4% had BLLs ≥ 10 μg/dL. The geometric mean (± standard deviation) BLL was 8.7 ± 4.0 μg/dL (range 3.0–26.8 μg/dL). In the total population, linear regression analysis indicated that age was positively associated with BLLs (*$P < 0.05$*). Logistic regression analysis showed that boys had 2.12 times greater odds of having BLLs ≥ 10 μg/dL than girls (*$P < 0.05$*). Among the children 0–3 years, those whose mothers had BLLs ≥ 10 μg/dL had 45.0% higher odds of presenting BLLs ≥ 10 μg/dL than children whose mothers had BLLs < 10 μg/dL (*$P < 0.05$*).*
**Conclusions.** *Older age, male gender, and mothers' BLL ≥ 10 μg/dL were the main risk factors for elevated BLLs. The higher risk in boys 7–17 years suggests that exposure could be related to specific activities in this group, such as fishing and hunting. Continuous monitoring of BLLs in the Corrientes River population is recommended.*

**Key words** Lead poisoning; lead poisoning, nervous system, childhood; risk factors; Peru.

Chronic exposure to lead (Pb) continues to be a public health problem in Latin America. The identified sources have mainly been Pb-containing gasoline, Pb-using industries, and some traditional activities (1). Industrialization has rapidly expanded in Peru in the last decade, in both urban and rural areas, carrying a significant risk of Pb exposure for the residents. For instance, elevated blood Pb levels (BLLs) associated with leaded gasoline have been found in professional drivers and police officers in large cities such as Lima (2), Trujillo (3), and Arequipa (4).

Studies in Lima and El Callao found that concentrations of mineral deposits located near homes and schools were the main sources of Pb in children (5). The main example of Pb contamination in Peru was in the mining center of La Oroya. In 1999, Peru's Ministry of Health surveyed the BLLs of 139 children aged 3–10 years and reported levels ranging from 14.7 to 79.9 μg/dL. The mean BLL was 43.5 μg/dL and all participants had BLLs ≥ 10 μg/dL (6).

A nonclassic case of Pb exposure was reported in native communities of the Amazon basin of Peru. In 2006, a toxicological evaluation of 125 adults and 74 children in 7 native communities on the Corrientes River showed that 66.0%

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of children had BLLs ≥ 10 μg/dL (7). The Pb concentration in samples of river water and sediments was also analyzed, but results were inconclusive. While oil activity (established in this territory for more than 40 years) was suggested to be the main source of Pb exposure (8–10), a lack of comprehensive information maintains uncertainty about potential sources of exposure, pathways, and risk factors. Two evaluations in other Corrientes communities (9) confirmed previous results that children were the population group at highest risk.

Pb exposure in young children is of particular concern because they absorb it more readily than adults, and their developing nervous systems are particularly vulnerable to the effects of Pb. Even low to moderate levels of Pb have been associated with deleterious effects in children (11).

This study aimed to explore the potential risk factors associated with elevated BLLs in children from two native communities of the Corrientes River basin.

**FIGURE 1. Location of the Corrientes River basin in Loreto region, Peru**


## METHODS

### Setting and study population

This cross-sectional study took place in the Corrientes River basin in the Amazon basin of Peru. It is an area of tropical forest located in the Loreto region (Figure 1). Since the early 1970s, this territory has been an important setting for oil exploitation, connected with negative impacts on the environment and the well-being of the native population (10).

The native population (approximately 8 000) is composed of 36 communities along the basin, made up of three ethnic groups. Their subsistence is based on traditional activities such as hunting, fishing, agriculture, and gathering edible forest products.

Two communities were selected for this study: one exposed and one not exposed to oil activities. The criteria to define exposure were based on the distance between the community and the nearest oil installation, the occurrence of oil spills, and employment of the population to perform remediation activities. Peruanito (total population = 154) lies in the basin of the Corrientes River, approximately 5 km (straight line distance) from the nearest oil installation. The last registered oil spill in this community occurred in 2007; however, minor spills from the oil pipeline (which crosses the community area) occur frequently according to the population. In Peruanito, men are temporarily employed by the oil company to perform remediation activities. On the other hand, Santa Isabel (total population = 235) lies on the basin of the Copalyacu River (tributary of the Corrientes River), approximately 28 km (straight line distance) from the junction of the Corrientes and Copalyacu Rivers, and does not have a history of oil activities.

Participants included all children aged 0–17 years ($n$ = 233) from the two communities whose families had lived there for the past 5 years and whose parents consented to their participation.

### Blood Pb testing

The children were evaluated in their communities between January and February 2009. A trained phlebotomist drew a capillary sample from each child and tested BLLs with a portable LeadCare analyzer (ESA, Chelmsford, Massachusetts, United States of America) (12). Standard controls were run every 30 samples with a new test kit. Each new kit was calibrated before use. Additional venous blood samples were collected from participants who showed LeadCare BLLs ≥ 10 μg/dL. Blood samples (6 mL) were collected in evacuated plastic tubes (Vacutainer green cap tubes, heparin lithium), and stored at –20°C until analysis. BLLs were measured at the private Blufstein laboratory (Lima) using graphite furnace atomic absorption spectrophotometry (GFAAS) (graphite furnace HGA 900 and spectrophotometer analyst 400, PerkinElmer) with the Zeeman background correction method (13). The samples were diluted 1:9 with a solution containing 0.2% ammonium dihydrogen phosphate and 0.1% Triton X-100. All the samples were prepared once and the concentration was determined in duplicate. The detection limit (0.21 μg/dL) was calculated as 3 standard deviations of the blank (10 repetitive measurements of the lowest sample concentration detected by the instrument). To assess precision, the coefficients of variation (CVs) for 10 repetitive measurements of 3 standard concentrations were obtained. The CVs for 10, 20, and 40 μg/dL, were 2.2%, 0.7%, and 0.7%, respectively. Accuracy and reliability were ensured by analyzing quality control samples along with the study samples. The results for Lyphochek whole blood metals level 1 (lot 3670) were 9.37 ± 0.51 μg/dL (mean ± standard deviation, $n$ = 7) versus the recommended range of 7.1–11.2 μg/dL. For level 2 (lot 36702) the results were 25.43 ± 1.19 μg/dL ($n$ = 7) versus the recommended range of 21–31 μg/dL. In total, 60 venous blood samples were drawn from the children and the results were compared with the corresponding LeadCare results from the capillary blood samples. The correlation coefficient was 0.75 and the regression equation was log 10[GFAAS BLL results = 0.72(log 10(LeadCare BLL results)] + 4.06).

The BLLs of the mothers of 50 young children (0–3 years) were also determined by the LeadCare analyzer protocol.

## Hemoglobin and anthropometrics

The hemoglobin (Hb) level was determined with a HemoCue portable device (HemoCue, Lake Forest, California, United States) from additional blood drops from the same finger prick as the blood for the Pb testing. Quality control was performed using standard HemoCue controls each time the instrument was used. A nursing technician measured weight with a mechanical pediatric scale (maximum capacity 16 kg) for children younger than 2 years old and an upright scale (maximum capacity 160 kg) for the older ones. Height was measured with a standarized wooden board. In children younger than 2 years, length was measured in the recumbent position with a calibrated lengthboard. Children wore light underclothing, and their shoes and hair ornaments were removed before the measurement.

## Parental questionnaire

Parents completed an interview-administered questionnaire that included: demographic information; dwelling characteristics such as the presence of painted walls, location of the kitchen (inside or outside the dwelling), and the water supply (river or well); storage of potentially contaminating elements at home (gasoline and car batteries); indicators of socioeconomic status such as ownership of a radio and a motorboat; parents' education, occupation, and history of employment at the oil company; cooking and traditional practices (use of self-prepared remedies and glazed pottery); time of breastfeeding and health history (number of disease events in the past month); children's habits related to Pb exposure (consuming soil, chewing or sucking toys); and childrens' consumption (frequency and amount) of wild animal meat, fish, and other traditional foodstuffs.

## Risk map

A map of each community, including houses and communal constructions, was drawn to look for possible associations between spatial localization of the participants' places of residence and BLLs.

## Ethics

The study was approved by the Review Board of the Universidad Peruana Cayetano Heredia, Lima. All parents of the participants received an explanation of the study objectives and procedures in Spanish and in their native language before they signed the informed consent form. The study findings were communicated to the communities in coordination with the Federation of Native Communities of the Corrientes River (FECONACO) and the Regional Directorate of Health (DIRESA) in Loreto. All parents received their children's BLL, Hb, and anthropometric results on individual tracking cards elaborated together with DIRESA Loreto and FECONACO. Children with elevated BLLs were referred to the nearest health center for medical evaluation.

## Data analysis

Demographic data were categorized by gender and four age groups. Data on Hb levels were used to determine anemia status following the cutoff points from the third National Health and Nutrition Examination Survey (children 0–4 years: 11.0 g/dL, children 5–11 years: 11.5 g/dL, boys 12–14 years: 12.5 g/dL, girls 12–14 years: 11.8 g/dL, nonpregnant women older than 15 years: 12.0 g/dL, pregnant women: 11.0 g/dL, men older than 15 years: 13.3 g/dL) (14). Data on height and weight were used to calculate height-for-age, weight-for-age, and height-for-weight $Z$-scores using NutStat from Epi Info 3.5.1™ (Centers for Disease Control and Prevention, Atlanta, Georgia, United States). Thresholds of $Z$-scores < –2 were used to determine stunting, undernutrition, and wasting.

Next, descriptive analyses were examined for all variables. Because of their skewed distribution, BLLs were transformed to a log 10 scale.

To assess associations among all single variables and BLLs, geometric mean differences were examined by Student's $t$-test and analysis of variance. Certain variables such as the presence of painted walls, parents' education, use of self-prepared remedies, utilization of glazed pottery, time of breastfeeding, number of disease events in the past month, and traditional food consumption were excluded from the analysis because of their small variability.

To investigate the simultaneous effects of different variables on BLLs, models of multivariate linear regression were produced using the backward selection procedure ($P$ < 0.1). The final models were reassessed by using a generalized estimating equation (GEE) to account for the correlation of BLLs among children in the same household.

Logistic regression models (applying the GEE) were also conducted to assess the impact of different variables on the likelihood of children having elevated BLLs (≥ 10 μg/dL).

Multilinear and logistic regression models were prepared for the total population and by gender and age groups (because of small sample sizes and similarities between means, age groups 7–13 years old and 14–17 years old were merged) to evaluate specific risk factors.

## RESULTS

The final study sample consisted of 208 children aged 0–17 years. Children from Peruanito ($n$ = 88) and Santa Isabel

($n$ = 120) belonged to 23 and 28 households, respectively. Ten percent of the children registered in the census did not participate because they were away from their communities during the fieldwork (families usually stay on their farms for weeks). The geometric mean (± geometric standard deviation) LeadCare BLL was 8.7 ± 4.0 μg/dL (range 3–26.8 μg/dL) and 27.4% had a BLL ≥ 10 μg/dL.

Bivariate analyses showed that the variables gender, age, ownership of a radio and a motorboat, storage of gasoline at home, and mother's BLL (in the 0- to 3-year-old group) were associated with the children's BLLs ($P < 0.05$) (Table 1).

The linear regression analysis with backward elimination ($P < 0.1$) in the overall population retained the variables age and gender, which were maintained after the adjustment by clustering. In the group aged 0–3 years ($n$ = 50), the variables mother's BLL, storage of gasoline, and car batteries were retained. However, after the GEE was applied, the only variable with significant association was the mother's BLL ($P < 0.05$) (Table 2). In the group aged 4–6 years ($n$ = 47), no variable was associated. In the group aged 7–17 years ($n$ = 109), gender was the only variable retained and it was maintained after adjusting by clustering ($P < 0.01$). Stratified analysis per gender in the last group retained the variables of age and ownership of a radio for boys ($n$ = 50), but after the GEE only age was associated. In the group of girls ($n$ = 59) no variable was retained (Table 2).

Neither anemia status, stunting, nor being underweight was associated with BLLs (no child presented wasting). Typical habits of the children, dwelling characteristics, and exposure to oil activities through parents' employment or community of residence were not associated with BLLs either.

The logistic regression model in the overall study population reported that boys were 2.12 times more likely than girls to have BLLs ≥ 10 μg/dL ($P < 0.05$). Children aged 4–6 and 7–17 years had 2.8 times and 3.7 times greater likelihood of having BLLs ≥ 10 μg/dL than those in the 0- to 3-year age group, respectively. Among the children aged 0–3 years, the odds of having BLLs ≥ 10 μg/dL were 45.0% higher for those whose mothers had BLLs ≥ 10 μg/dL ($P < 0.05$) than for those whose mothers had BLLs < 10 μg/dL (Figure 2). In the 4- to 6-year age group, no variable was associated with the odds of having BLLs ≥ 10 μg/dL. In the group aged 7–17 years, boys were 5.3 times more likely than girls to have BLLs ≥ 10 μg/dL ($P < 0.01$). The map of the dwellings in each community did not suggest a possible relationship between BLLs and spatial

**TABLE 1. Descriptive characteristics and blood lead levels in children from two study communities ($n$ = 208) in Corrientes River basin, Peru, 2009**

| Variable | No. | % | Geometric mean BLL, μg/dL | GSD, μg/dL | BLL ≥ 10 μg/dL | |
|---|---|---|---|---|---|---|
| | | | | | No. | % |
| Individual | | | | | | |
| Age, years | | | | | | |
| 0–3 | 52 | 25 | 7.6 | 3.1 | 7 | 13.5 |
| 4–6[a] | 47 | 22.5 | 8.0 | 2.9 | 13 | 27.6 |
| 7–13[a] | 72 | 34.6 | 9.4[b] | 4.4 | 24 | 33.3 |
| 14–17[a] | 37 | 17.9 | 9.5[b] | 5.0 | 13 | 35.1 |
| Gender | | | | | | |
| Girls | 115 | 44.7 | 7.8 | 3.4 | 24 | 20.9 |
| Boys | 93 | 55.3 | 9.7[c] | 4.5 | 33 | 35.5 |
| Anemia | | | | | | |
| Yes | 38 | 18.3 | 7.7 | 3.7 | 7 | 18.4 |
| No | 170 | 81.7 | 8.8 | 4.0 | 50 | 29.4 |
| Chewing/sucking toys[d] | | | | | | |
| Yes | 30 | 57.7 | 8.3 | 3.7 | 6 | 20.0 |
| No | 22 | 42.3 | 6.7 | 1.8 | 1 | 4.5 |
| Eating soild | | | | | | |
| Yes | 5 | 9.6 | 8.5 | 4.1 | 1 | 20.0 |
| No | 47 | 90.4 | 7.5 | 3.1 | 6 | 12.7 |
| Stunting | | | | | | |
| Yes | 25 | 13.7 | 8.3 | 4.5 | 8 | 32.0 |
| No | 157 | 86.3 | 8.9 | 4.0 | 45 | 28.7 |
| Underweight | | | | | | |
| Yes | 30 | 16.4 | 8.4 | 4.4 | 7 | 23.3 |
| No | 153 | 83.6 | 8.8 | 4.0 | 46 | 30.1 |
| Dwelling | | | | | | |
| Kitchen location | | | | | | |
| Outside | 110 | 52.8 | 8.7 | 3.8 | 34 | 30.9 |
| Inside | 98 | 47.2 | 8.6 | 4.1 | 23 | 23.5 |
| Water to cook/drink | | | | | | |
| Well | 122 | 58.7 | 8.9 | 3.9 | 47 | 30.7 |
| River | 86 | 41.3 | 8.4 | 4.0 | 23 | 26.7 |
| Own a radio | | | | | | |
| Yes | 64 | 30.8 | 9.7[b] | 5.0 | 21 | 32.8 |
| No | 144 | 69.2 | 8.2 | 3.4 | 36 | 25.0 |
| Own a motorboat | | | | | | |
| Yes | 79 | 37.9 | 9.4[b] | 4.0 | 27 | 34.2 |
| No | 129 | 62.1 | 8.2 | 3.7 | 30 | 23.3 |
| Storage of a car battery | | | | | | |
| Yes | 37 | 17.8 | 7.6 | 3.9 | 7 | 18.9 |
| No | 171 | 82.2 | 8.9[b] | 4.0 | 50 | 29.2 |
| Storage of gasoline | | | | | | |
| Yes | 94 | 45.2 | 9.2[b] | 4.1 | 31 | 32.9 |
| No | 114 | 54.8 | 8.2 | 3.8 | 26 | 22.8 |
| Family | | | | | | |
| Mother's BLL[d] | | | | | | |
| < 10 μg/dL | 35 | 70 | 6.7 | 3.0 | 3 | 8.6 |
| ≥ 10 μg/dL | 15 | 30 | 9.3[c] | 2.9 | 4 | 26.7 |
| Father`s work at the oil company | | | | | | |
| Yes | 36 | 17.3 | 8.5 | 4.5 | 8 | 22.2 |
| No | 172 | 82.7 | 8.7 | 3.9 | 49 | 28.5 |
| Oil spill cleanup | | | | | | |
| Yes | 28 | 13.5 | 8.5 | 4.3 | 4 | 14.3 |
| No | 180 | 86.5 | 8.7 | 4.0 | 53 | 29.4 |
| Community of residence | | | | | | |
| With oil activity | 88 | 42.3 | 9.08 | 3.9 | 26 | 29.5 |
| Without oil activity | 120 | 57.7 | 8.38 | 4.1 | 31 | 25.8 |

***Notes:*** BLL: blood lead level, GSD: geometric standard deviation.
[a] Compared with 0- to 3-year age group.
[b] $P < 0.05$.
[c] $P < 0.01$.
[d] Applies only to 0- to 3-year age group.

**TABLE 2. Variables associated with log 10 transformed blood lead levels (μg/dL) in children from two study communities in Corrientes River basin, Peru, 2009 (multiple linear regression models adjusted by in-household clustering)**

| Variable | Coefficient β[a] | 95% CI |
|---|---|---|
| Model 1. Overall (*n* = 208) | | |
| Age (years) | 0.007 | 0.002–0.01 |
| Boys versus girls | 0.09 | 0.04–0.1 |
| Intercept | 0.7 | 0.6–0.8 |
| Model 2. Children aged 0–3 years (*n* = 50) | | |
| Mother's BLL | 0.03 | 0.01–0.04 |
| Intercept | 0.3 | 0.2–0.8 |
| Model 3. Children aged 7–17 years (*n* = 108) | | |
| Boys versus girls | 0.2 | 0.15–0.2 |
| Intercept | 0.36 | 0.03–0.7 |
| Model 4. Boys aged 7–17 years (*n* = 65) | | |
| Age (years) | 0.01 | 0.004–0.02 |
| Intercept | 0.7 | 0.2–1.2 |

***Notes:*** CI: confidence interval, BLL: blood lead level.
[a] Linear regression coefficient.

distribution of the participants' places of residence. However, it allowed for identifying clusters of households with children who presented elevated BLLs.

## DISCUSSION

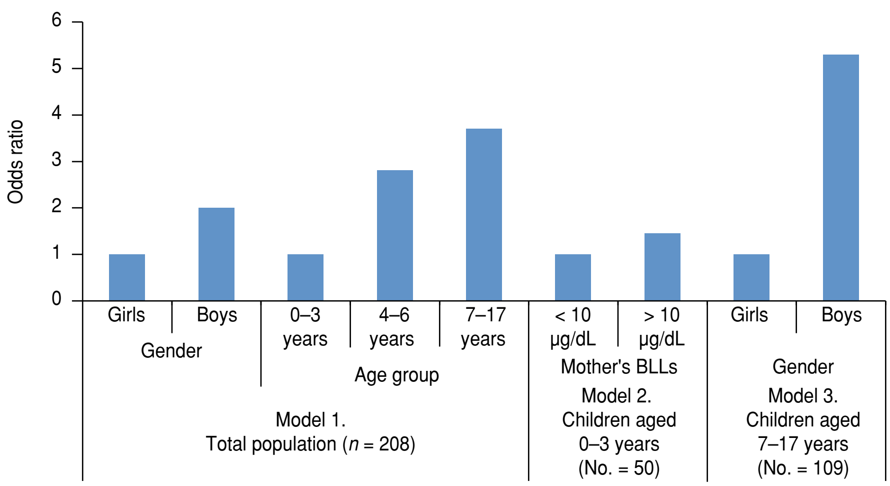
The results show that 27.4% of the children from the two study communities exceeded the Centers for Disease Control and Prevention BLLs of concern (≥ 10 μg/dL). This amount would increase to 87.0% if the threshold were lowered to ≥ 5 μg/dL. The geometric mean BLL was 8.7 μg/dL, with a highest value of 26.8 μg/dL. Peruvian children showed similar BLLs in Lima (7.1 μg/dL) and El Callao (9.6 μg/dL) (5), where the sources of Pb exposure were leaded gasoline and mineral storage. Higher BLLs were found in children who lived in mining areas, such as La Oroya (36.4 μg/dL) (15).

BLLs were higher in boys than in girls. Previous studies that described a higher risk of Pb exposure for boys attributed it to activities more frequently undertaken by young men; battery recycling, wire burning, and manufacturing Pb fishing sinkers at home have been reported as potentially risky activities for Pb exposure (16). Other studies have associated increased BLLs in boys with a higher exposure to soil and dust during their outdoor recreational activities and occupations (17). For example, elevated BLLs in boys from the Ecuadorian Andean region were attributed to their more active participation in Pb glazing operations (18). In the Corrientes communities, traditional roles and duties for men and women might influence the higher risk of Pb exposure in boys. While girls generally stay at home, taking care of siblings and doing housework, boys participate in outdoor activities like fishing and hunting (8). The latter would constitute a Pb exposure risk due to manipulation of Pb when preparing fishing sinkers. Because of the potential for Pb exposure, the U.S. Environmental Protection Agency advises against manufacturing Pb fishing sinkers and jigs at home (19). Hunting is another typically masculine activity, which has been related to Pb exposure. A study conducted in marksmen concluded that cleaning the bullet trap and inhaling fumes when shooting Pb ammunition were related to elevated BLLs (20). Even at home, boys are more prone to manipulating toxic products such as gasoline, motor oil, and car batteries.

There was an increase in the prevalence of elevated BLLs according to age (13.5% in the group aged 0–3 years, 27.6% in the group aged 4–6 years, 33.3% in the group aged 7–12 years, and 35.1% in the group aged 14–17 years). This finding does not concur with most studies describing a higher risk for elevated BLLs in the youngest children. Generally, these studies showed that Pb industrial and artisanal activities in the vicinity of residential areas contaminated the air, dust, and soil and that young children were more likely to absorb Pb than older ones because of their hand-to-mouth habit and the ingestion of dust and soil (21, 22). In this study setting, there is no Pb industry in the surroundings; the only industrial activity is oil exploitation. However, no significant difference was found in BLLs when the community exposed to oil activities was compared with the nonexposed community. Moreover, the results of recent evaluations of water and sediments, where no elevated Pb levels were found, also suggested that Pb exposure is not directly related to oil activities (23, 24).

In the youngest age group (0–3 years old), BLLs were significantly higher in those whose mothers had BLLs ≥ 10 μg/dL. Children from these communities are routinely breastfed until the age of 2.5 years (8). Thus, one explanation for Pb exposure in young children might be linked to maternal transmission when the mother's exposure is related to diet

**FIGURE 2. Variables associated with elevated blood lead levels (BLLs) (≥ 10 μg/dL) in children (0–17 years) from two communities of the Corrientes River basin, Peru, February 2009 (logistic regression models adjusted by in-household clustering)**



or occupation. For instance, studies in the native population of Cree in Canada found an association between the consumption of wild animal meat (hunted with Pb ammunition) in women and BLLs in their young children (transferred directly to the fetus through maternal blood or indirectly to the infant through breast milk) (25). Another possibility is the presence of a common source, such as a Pb-contaminated home environment. To illustrate, an association between elevated BLLs in children and their caregivers in Micronesia was attributed to the activities of melting batteries and making fishing sinkers within the household (16). In certain rural areas of China, Pb exposure in mothers and their children has been related to indoor coal burning (26).

In the 7- to 17-year-old group, the only predictor for elevated BLLs was age. In the stratified analysis by gender, age was associated with high BLLs but only in boys. This result might be attributed to the fact that as boys grow older they become more engaged in activities that involve contact with Pb (fishing with Pb weights and hunting with Pb ammunition) (8). In this respect, Pb exposure among aboriginal Canadian boys has been attributed to Pb shot used to hunt small game, Pb fishing sinkers, and the consumption of wild fowl and game contaminated with Pb (27). Although our study did not investigate these activities, further research will try to clarify their potential association with the elevated BLLs in this population.

One factor associated with BLLs in the bivariate analysis was the storage of gasoline at home. Despite the absence of road traffic in these communities, the use of gasoline motorboats is widespread, especially in boys aged 7–17 years, who drive motorboats as part of their daily activities (8). Further analysis is required to test the content of Pb in gasoline and to determine potential exposure to Pb through fumes.

Anthropometric indicators and anemia status were not associated with BLLs in this study. Although numerous studies have described an inverse association between BLLs and Hb (28), a World Health Organization report on inorganic lead indicated that a decrease in Hb usually starts when BLLs are > 20 μg/dL (29). In this study, very few participants exhibited such levels.

Other classic factors associated with BLLs in children, such as socioeconomic status, parents' education, and diet, were not considered in the analysis because of their low variability.

The uneven spatial distribution of elevated BLLs in the study population suggested rejecting the hypothesis of a specific site in the communities as the source of Pb contamination through air and dust emissions.

This study had certain limitations related to design and data collection methods. The cross-sectional design did not make it possible to account for changes in habits and exposures by season that could affect BLLs. Parents' lack of awareness of their children's activities might have introduced recall bias. Because of a lack of knowledge about potential Pb exposure in this type of setting, the questionnaire explored many factors, but not meticulously, which might have caused the small variability found among participants.

Other limitations were related to assessment of oil exposure and the outcome. Criteria to classify oil exposure were based on the authors' judgment and exposure was assigned to every individual in the same community, even though they did not have the same level of exposure. For assessment of BLLs, the LeadCare analyzer was used. It is not the gold standard analytical method but is recommended for large epidemiological studies in remote areas such as this study setting, where access to laboratory facilities is complicated. The validity of the instrument performance will allow regional health officers to continue monitoring programs using the same method.

## Conclusions

Almost a third of the children in these two communities had elevated BLLs (≥ 10 μg/dL). Taking into account previous studies, there seems to be chronic Pb exposure in this area. Older age, male gender, and mother's BLL ≥ 10 μg/dL were the main risk factors in this population. The greater risk in boys aged 7–17 years suggests that exposure is related to particular activities in this group such as fishing and hunting. Continuous monitoring of BLLs in the Corrientes River population is recommended.

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**RESUMEN**

## Exposición al plomo en niños de comunidades indígenas de la cuenca del Amazonas en el Perú

***Objetivo.*** Evaluar los potenciales factores de riesgo asociados con niveles elevados de plomo en sangre (Pbs) en niños de dos comunidades de la cuenca del río Corrientes en la Amazonia peruana.

***Métodos.*** Se estudiaron de manera sistemática los niveles de PbS, la concentración de hemoglobina y las medidas antropométricas en niños de 0 a 17 años. A través de un cuestionario efectuado a los padres se recopilaron datos sobre la vivienda, la familia y los niños. El análisis estadístico incluyó el análisis descriptivo y de dos variables. También se llevaron a cabo análisis de regresión logística y lineal múltiple usando ecuaciones predictivas generales para determinar los factores de riesgo asociados. Se trazó un mapa de cada comunidad para examinar la distribución espacial de los niveles de PbS.

***Resultados.*** De 208 niños (88 de 23 hogares de la comunidad de Peruanito y 120 de 28 hogares de Santa Isabel), 27,4% presentaron niveles de PbS ≥ 10 μg/dL. La media geométrica (± desviación estándar) de los niveles de PbS fue 8,7 μg/dL ± 4,0 (amplitud 3,0 a 26,8 μg/dL). En la población total, el análisis de regresión lineal indicó que la edad se asociaba de manera positiva con los niveles de PbS ($P < 0,05$). El análisis de regresión logística demostró que los varones presentaron una probabilidad 2,12 veces mayor de tener niveles de PbS ≥ 10 μg/dL que las niñas ($P < 0,05$). En los niños de ambos sexos de 0 a 3 años, aquellos cuyas madres tuvieron niveles de PbS ≥ 10 μg/dL presentaron 45,0% más probabilidades de exhibir niveles de PbS ≥ 10 μg/dL que los niños cuyas madres tuvieron niveles de PbS < 10 μg/dL ($P < 0,05$).

***Conclusiones.*** La mayor edad, el sexo masculino y niveles maternos de PbS ≥ 10 μg/dL fueron los principales factores de riesgo de presentar niveles elevados de PbS. El mayor riesgo en los varones de 7 a 17 años sugiere que en este grupo la exposición podría relacionarse con actividades específicas, como la pesca y la caza. Se recomienda llevar a cabo una vigilancia continua de los niveles de PbS en la población de la cuenca del río Corrientes.

**Palabras clave** Intoxicación por plomo; intoxicación del sistema nervioso por plomo en la infancia; factores de riesgo; Perú.