Universal Journal of Public Health 10(6): 590-595, 2022 http://www.hrpub.org
DOI: 10.13189/ujph.2022.100606

Community Health Services and Blood Lead Reduction in Children

Juan Morales[1,*], Elizabeth Mar ía Yovera-Sandoval[2], Marlene Raquel Basilio-Rojas[3]

[1]Faculty of Health Sciences, eHealth Research Center, University of Sciences and Humanities, Lima, 15304, Peru
[2]Faculty of Humanities and Social Sciences, Primary Education, University of Sciences and Humanities, Lima, 15304, Peru
[3]Mi Peru Health Center, DIRESA Callao, Bellavista, 07016, Peru

Received September 17, 2022; Revised October 24, 2022; Accepted November 24, 2022

Cite This Paper in the Following Citation Styles

***(a):** [1] Juan Morales, Elizabeth Mar ía Yovera-Sandoval, Marlene Raquel Basilio-Rojas , "Community Health Services and Blood Lead Reduction in Children," Universal Journal of Public Health, Vol. 10, No. 6, pp. 590 - 595, 2022. DOI: 10.13189/ujph.2022.100606.*

***(b):** Juan Morales, Elizabeth Mar ía Yovera-Sandoval, Marlene Raquel Basilio-Rojas (2022). Community Health Services and Blood Lead Reduction in Children. Universal Journal of Public Health, 10(6), 590 - 595. DOI: 10.13189/ujph.2022.100606.*

Copyright©2022 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract Objectives: To assess the effect of multidisciplinary community health services on reducing blood lead in children. Material and methods: Retrospective observational study, before-after type. The information of an intervention program in the “Mi Peru” district was analyzed. The population consisted of 1,191 children of both genders who had results of blood lead level and who were evaluated during 2016 and 2017. The sample consisted of 187 children with blood lead levels ≥10 μg/dL. Community health services had three components: comprehensive multidisciplinary care, health education and house calls. Results: The blood lead level at the start of the intervention, 88.5% (n=139) belonged to category II and 11.5% (n=18) belonged to category III. At the end of the intervention, 66.9% (n=105) resulted in category I, the proportion of lead levels belonging to categories II and III was reduced to 29.9% (n=47) and 3.2% (n=5) respectively. In relation to the blood lead level at the beginning of the intervention and at the end of the intervention, the initial mean of 13.96 μg/dL was reduced to 8.96 μg/dL and the median from 12.40 μg/dL to 8.20 μg/dL ($p<0.001$). Conclusions: Community health services reduced blood lead levels in children with elevated blood lead levels. It is suggested to promote and strengthen the comprehensive house calls and health education about the risks of lead exposure.

Keywords Community Health Services, Lead Poisoning, Child Preschool, Child, Peru

1. Introduction

Lead exposure is a global problem [1]. Responsible for half a million premature deaths and 9.3 million disability-adjusted life years (DALYs), lead exposure accounts for 2.5% of the global burden of ischemic heart disease and 12.4% of the global burden of idiopathic intellectual disability [2].

Environmental pollution and human exposure originate from the production and recycling of batteries, metal recycling, and foundries [3,4]. These occupational sites are widely distributed throughout the world and affect children; high average blood lead was reported more frequently in Mexico and countries in the Caribbean, South America, and South Asia [5]. Children with blood lead levels in Latin American countries are higher compared to children in the United States [6].

Lead concentrations in soil, air, and water can be especially high near smelters; most human exposure to lead occurs through ingestion or inhalation [1]. There is high airborne lead exposure in lead battery recycling facilities, and airborne lead concentrations correlate with the blood lead level of workers [4]. Children living near these locations are also at risk for elevated blood lead levels [3].

Lead is a potent neurotoxin, whose toxicity is greater in children than in adults [1]. Young children and women of childbearing age are the most vulnerable to exposure and the toxic effect [4]. There is almost no function in the body that is not affected by lead [1,3]. Neurological manifestations and complications of lead include developmental delay, lower IQ, higher academic failure, and lower overall life achievement; in childhood, even low-level exposure can affect learning and educational achievement and neurological development [7]. Exposure to lead is also associated with an increased risk of cardiovascular disease and coronary heart disease [8].

The legislative measures of the countries regarding the prohibition of the use of lead in gasoline have improved the protection of the health of the population against lead [9]. In Spain, despite primary prevention measures, the danger of lead poisoning is still present; the highest levels of blood lead occur in children of low socioeconomic status, of immigrant origin, low educational level of the parents and with low iron bioavailability [10]. At the community level, educational and environmental interventions of families can also contribute to the reduction in the level of blood lead in the population [11,12].

In Peru, the Callao Region has sources of lead that contaminate the air and soil. In children living near a metal smelter and lead recovery, a high proportion of children with elevated blood lead levels have been found [13]. The Regional Health Authority (DIRESA Callao) in cooperation with the Local Government has carried out health interventions in the community, whose favorable results can serve to promote and strengthen community health care.

The objective of this study is to evaluate the effect of community health care on the reduction of blood lead in children living in the district of “Mi Perú”, located in the Callao Region.

2. Materials and Methods

2.1. Design

Intervention study in which community health services were considered as the intervention. Information from an intervention program developed in the district of “Mi Perú”, in the Callao Region, was analyzed.

2.2. Population and Simple

The population consisted of 1,191 preschool and school-age children, of both sexes, who had blood lead level results during the evaluation in 2016 and 2017. The participants were residents of areas surrounding the lead source.

All children with blood lead levels ≥10 µg/dL were chosen for the study. Of the 1191 children evaluated, 187 were included with the following criteria: Children of both sexes with blood lead levels belonging to category II (10 to 19.99 µg/dL) or category III (20 to 44.99 µg/dL), who received multidisciplinary health services (medicine, nursing, nutrition and psychology).

The variables included in the study were: sex, blood lead level before and after the intervention, nutritional evaluation, psychological evaluation, calcium administration and number of home visits. Participants with incomplete or insufficient data on these variables were excluded. Out of a total of 187 participants, 30 were excluded due to noncompliance with any of the criteria described.

2.3. Study Variables

Dependent variable: Blood lead level, which was obtained from the epidemiological investigation records of each participant. Blood lead results were classified into five categories: category I (<10 µg/dL), category II (10 to 19.99 µg/dL), category III (20 to 44.99 µg/dL), category IV (45 to 69.99 µg/dL) and category V (⩾70 µg/dL) (14). Children who had lead levels within category III or more were subjected to determination by the atomic absorption spectrophotometry method.

In the children evaluated, the blood lead levels found were category I, II and III. No cases belonging to category IV or V were found.

Independent variables: Community health care, which consisted of multidisciplinary care campaigns, health education and home visits. To carry out these activities, an instrument called "public health epidemiological research sheet on risk factors for exposure and intoxication by heavy metals and metalloids" was used, which consisted of specific sections for each occupational group. All participants had the same opportunity to go through the entire chain of professional services.

2.4. Interventions and Procedures

2.4.1. First Phase

All children residing in the lead exposure risk area were progressively admitted for evaluation by the health care team made up of doctors, nurses, nutritionists, psychologists, social workers, and laboratory technicians.

The participation of the health care team was carried out in the children's area of residence, running campaigns during weekends, according to the programming of the local health authorities.

2.4.2. Second Phase

Children with lead levels classified in category II and III were admitted to the follow-up program by the same health team for one year. Blood lead level controls were performed every six months for those belonging to category II and every three months for category III. Those belonging to category III, in addition to the usual evaluation of the health team, were evaluated by specialists in otolaryngology, pediatrics, pneumology, and neurology from the reference hospitals of the Callao Region.

2.4.3. Third Phase

The intervention program consisted of community health care, which had three components:

- Comprehensive multidisciplinary care

Extra-mural work in the area of residence. The children received comprehensive care from health professionals and individual health education: medicine, nutrition, psychology, nursing and social worker.

The comprehensive care consisted of the delivery of health care services by each professional group to the children in the context of their family and community.

As part of the medical care, the children evaluated were prescribed calcium gluconate with vitamin D3. According to institutional protocol, a total of six 200 ml bottles were administered to children under five years of age, eight bottles to children 6 to 7 years of age, and ten bottles to children over eight years of age.

- Collective health education

Aimed at parents on the risks of exposure to lead, hygiene habits in household members, cleanliness in the home, and demonstration sessions on nutrition.

- Home visit

Its purpose was to reinforce comprehensive counseling, complete the delivery of calcium gluconate with vitamin D3 and the results of the laboratory test. The home visit form was used. This activity was carried out by the nursing and social worker staff.

2.5. Statistical Analysis

The data was collected in an Excel file, which was exported to IBM SPSS Statistics 23. Before processing, the data was cleaned according to the study criteria.

The Kolmogorov-Smirnov test was performed to assess the normality of the lead level. Because it did not comply with the normal distribution, the non-parametric Wilcoxon test was used, considering $p<0.05$ values as significant.

2.6. Ethical Aspects

The confidentiality of the data was respected. The project was evaluated and approved by the Ethics Committee of the University of Sciences and Humanities (CEI Act No. 071-2019).

3. Results

The study involved 157 children with a mean age of 5.8 years (SD=2.7; range: 2 to 12), 59.9% (n=94) made up of boys and the remaining fraction of girls, the predominant group was from 5 to 9 years.

Blood lead level at the beginning of the intervention, 88.5% (n=139) belonged to category II and 11.5% (n=18) to category III. At the end of the intervention, 66.9% (n=105) were within category I, the proportion of lead levels belonging to category II and III were reduced to 29.9% (n=47) and 3.2% (n=5), respectively.

Of 139 children with lead levels belonging to category II, after the intervention, 77.7% (n=108) became category I. While of the 18 children initially belonging to category III, after the intervention, 44.4% (n=8) became category II and 27.8% (n=5) became category I.

All the children underwent a nutritional and psychological evaluation at least once within the intervention period, 88.5% (n=139) presented two nutritional evaluations and 60.5% (n=95) two psychological evaluations.

Table 1. General characteristics and intervention activities in children with elevated blood lead levels

Variables	n	%
Total	157	100
Sex		
Female	63	40.1
Male	94	59.9
Age group		
0 a 4	57	36.3
5 a 9	79	50.3
10 a 14	21	13.4
Initial lead category		
II	139	88.5
III	18	11.5
Final lead category		
I	105	66.9
II	47	29.9
III	5	3.2
Number of nutritional evaluation		
Two	139	88.5
One	18	11.5
Number of psychological evaluation		
Two	95	60.5
One	62	39.5
Calcium administration		
Complete	142	90.4
Incomplete	15	9.6
Number of home visits		
Two	150	95.5
One	7	4.5

Of the sample, 90.4% (n=142) received a full dose of calcium gluconate with vitamin D3. All children were visited at home at least once and 95.5% (n=150) twice (Table 1).

Regarding the blood lead level at baseline and at the end of the intervention, the initial mean of 13.96 µg/dL was reduced to 8.96 µg/dL, while the median was reduced from 12.40 µg/dL to 8.20 µg/dL ($p<0.001$) (Table 2).

Table 2. Lead levels before and after intervention in children with elevated blood lead levels

Lead levels	Before	After	p-value *
Total	157	157	<0.001
Minimum	10	3	
Maximum	32,1	22,3	
Mean	13,96	8,96	
SD	4,56	4,06	
P25	10,85	5,90	
P50 (median)	12,40	8,20	
P75	15,10	10,80	

*Wilcoxon Test SD: Standard Deviation

4. Discussion

The objective of the present study was to evaluate the effect of multidisciplinary community health care on the reduction of blood lead in children. Median blood lead levels decreased significantly after the health intervention.

It is not possible to specify which of the interventions could have had a greater effect on the decrease in lead levels. Health education was oriented to washing hands, fruits and other foodstuffs, as well as cleaning home environments and improving protective barriers such as windows and doors that contribute more to the reduction of lead concentration in the children's residence.

There is evidence that leads competes for absorption in the intestine with divalent metals such as iron and calcium, and iron and calcium deficiency is associated with increased lead absorption in children [15]; however, the contribution of calcium supplementation in reducing blood lead has not been shown.

In the present study, calcium carbonate with vitamin D was the supplement administered to the children. In this regard, for children with lead levels between 5-9 µg/dL and 10-19 µg/dL, the CDC recommends environmental assessment to evaluate sources of exposure and nutritional counseling related to calcium and iron intake; however, for higher levels, administration of these elements is not emphasized [16].

In Bandung, Indonesia, daily calcium supplementation for three months significantly reduced lead levels in children aged 9 to 11 years. Among children supplemented with 500 mg Calcium, from a mean of 14.1 µg/dL before the intervention, it went to 7.1 µg/dL ($p<0.0001$), in children supplemented with 250 mg Calcium, it decreased from 14.8 µg/dL to 8.7 µg/dL ($p<0.0001$), and in children without Calcium, it went from 13.7 µg/dL to 12.1 µg/dL ($p=0.02$) [17]. Nonetheless, in a randomized trial, in children with blood lead levels of 10 to 45 µg/dL, supplemented with 1800 mg of Calcium daily for three to six months, although blood lead levels decreased, it had no effect on the change in blood lead levels [18].

Community health care has likely contributed to lowering lead levels in living spaces and the environment, thereby reducing blood lead in children. A previous study found as risk factors linked to elevated lead levels, residence with dirt floor (OR: 2.92; 95% CI: 1.26-6.78), dirt eating habit in children (OR: 1.76; 95% CI: 1.02-3.07), pencil biting or sucking (OR: 1.86; 95% CI: 1.12-3.10) and toy biting or sucking (OR: 1.97; 95% CI: 1.16-3.33) [13], which could be changed by health education and home visits.

In India, non-pharmacological alternatives consisting of intense education and avoidance of potential environmental sources of lead resulted in a significant reduction in the blood lead level in school children [11]. In the United States, educational and environmental interventions for families had benefits in terms of increasing parental knowledge of lead exposure prevention and cleanliness in the home, and consequent reduction of lead dust levels in the home. Although a reduction in blood lead level in children was achieved, it was not possible to attribute this solely to the intervention, but also to the outcome of national public health interventions [12].

The community health care provided by the multidisciplinary team also had an educational component aimed at parents, to the extent that these are applied at home, favorable results are expected. A previous study found that blood lead levels ≥10 µg/dL occurred at a higher rate in children whose parents received no lead education ($p<0.001$) [13].

Implementation of health literacy and prevention programs is important in children's health care [19]. Educating parents through audiovisual programs and pamphlets focusing on the harmful effects of lead can be effective for children with elevated blood lead levels [20]. In Minneapolis, Minnesota, in a neighborhood at high risk for lead exposure, participants who received 20 biweekly educational sessions by peer educators of the same ethnicity for one year and quarterly booster sessions for two years thereafter were more likely to maintain blood lead levels <10 µg/dL than controls. The intervention reduced the risk of blood lead ≥10 µg/dL by approximately 34%; however, it could not be assured in education alone [21].

The home visit in the present study was carried out not only to deliver the pharmacological supplements, but also for educational purposes, to generate changes in the parents' attitudes regarding lead exposure; this activity was carried out by both professional and technical personnel. In Milwaukee, Wisconsin, brief (one-hour) home visits by paraprofessionals for lead exposure education, nutritional suggestions, and dusting practices and behavioral changes resulted in a reduction in lead exposure of 4.2 µg/dL or approximately 34% [22].

In Canada, one-year follow-up of children whose families received educational home visits, as well as assistance with home dust control measures, resulted in a significant decrease from 0.5 to 4 µg/dL. These changes were possibly due at least in part to intervention programs at the community level, since there was no improvement in local environmental conditions [23].

Maternal education and home cleaning consisting of damp mopping of floors, sponge cleaning of walls and horizontal surfaces, and efficient vacuuming, followed for approximately 12 months, produced a 17% decrease in blood lead. In homes that were cleaned 20 or more times during a year, children had an average blood lead reduction of 34% [24].

Lead is very permanent in the environment and exposure in humans occurs through several ways, such as respiratory, digestive or skin contact [3]. In European countries, lead is included among environmental risk factors [25]. In Spain, since the 1980s, the concentration of lead in the child population has had a decreasing evolution and is attributed to the legislative measures that have regulated the maximum amount of lead in gasoline, from 1987 until its total prohibition in August 2001 [9]. These provisions can be reinforced by measures at the community level, especially if lead sources exist.

The positive results of the intervention program for the reduction of blood lead in children are based on the continuity and follow-up of patients and their families, which is the most important characteristic of Primary Care [26]. Monitoring of lead levels in the highest risk areas and evaluation of blood lead levels in the exposed population are the measures that should continue. Multidisciplinary participation seeks to empower families to increase their capacity to respond to the problem, and each participating professional identifies the conditions of risk for more individualized and timely attention.

The results of the present study should be interpreted considering the following limitations. First, the study design and retrospective nature; second, the human resources involved were different for each health campaign which may have influenced the quantity and quality of information delivered; third, intervention or pressure exerted by the authorities regarding the source may have reduced lead emission; and fourth, all participants had the same opportunity to go through the entire chain of professional services, receive health education and home visit. However, not all of them complied with the programmed activities in due time. The strength of the study lies in the sufficient dedication to community health care, especially health education and home visits.

4. Conclusions

Community health care can help reduce blood lead in children. It is suggested to promote and strengthen comprehensive home visits, emphasizing health education regarding the risks of exposure to lead. Subsequent specific interventions may clarify the effectiveness in reducing blood lead.

REFERENCES

[1] CSEM, Case Studies in Environmental Medicine, Agency for Toxic Substances and Disease Registry, “Lead Toxicity”, 2017. [Online]. Available: https://www.atsdr.cdc.gov/csem/lead/docs/CSEM-Lead_toxicity_508.pdf. [Accessed: 23-sep-2022].

[2] Landrigan P, Fuller R, Acosta N, Adeyi O, et al., “The Lancet Commission on pollution and health”, Lancet, vol. 391, no 10119, pp.462-512, 2018. DOI: 10.1016/S0140-6736(17)32345-0.

[3] Wani AL, Ara A, Usmani JA, “Lead toxicity: a review”, Interdiscip Toxicol, vol. 8, no 2, pp.55–64, 2015. DOI: 10.1515/intox-2015-0009.

[4] World Health Organization. “Recycling used lead-acid batteries: health considerations”, Geneva; 2017. [Online]. Available: https://apps.who.int/iris/bitstream/handle/10665/259447/9789241512855-eng.pdf?sequence=1. [Accessed: 23-sep-2022].

[5] Clune AL, Falk H, Riederer AM. “Mapping global environmental lead poisoning in children”, Journal of Health and Pollution, vol.1, no. 2, pp. 14–23, 2011. DOI: 10.5696/2156-9614.1.2.14.

[6] Olympio KPK, Gonçalves C, Salles FJ, Ferreira APS da S, Soares AS, Buzalaf MAR, et al., “What are the blood lead levels of children living in Latin America and the Caribbean?”, Environ Int., vol. 101, pp.46–58, 2017. DOI: 10.1016/j.envint.2016.12.022.

[7] Hon KL, Fung CK, Leung AKC, “Childhood lead poisoning: an overview”, Hong Kong Med J., vol. 23, no. 6, pp. 616–21, 2017. DOI: 10.12809/hkmj176214.

[8] Chowdhury R, Ramond A, O’Keeffe LM, Shahzad S, Kunutsor SK, Muka T, et al., “Environmental toxic metal contaminants and risk of cardiovascular disease: Systematic review and meta-analysis”, BMJ, vol. 362, pp. k3310, 2018. DOI: 10.1136/bmj.k3310.

[9] Llop S, Porta M, Martinez MD, Aguinagalde X, Fernández MF, Fernández-Somoano A, et al., “Estudio de la evolución de la exposición a plomo en la población infantil española en los últimos 20 años. Un ejemplo no reconocido de «salud en todas las políticas»?” Gac Sanit, vol. 27, no. 2, pp. 149-155, 2013. DOI: 10.1016/j.gaceta.2012.01.019.

[10] Ruiz-Tudela L, Vázquez-López MA, García-Escobar I,

Cabrera-Sevilla JE, Gómez-Bueno S, Martín-Gonzalez M, et al., "Blood lead level in a paediatric population of south-eastern spain and associated risk factors", Int J Environ Res Public Health, vol. 18, no. 4, pp.1825, 2021. DOI: 10.3390/ijerph18041825.

[11] Vishwanath P, Prashant A, Devanand D, Nayak N, D′souza V, Venkatesh T, "Screening of school children for blood lead levels and attempts to reduce them by nonpharmacological means in a coastal city of India", Indian J Med Sci, vol. 62, no. 5, pp. 185–92, 2008.

[12] Campbell C, Gracely E, Tran M, Starkey N, Kersten H, Palermo P, et al., "Primary prevention of lead exposure-blood lead results at age two years", Int J Environ Res Public Health, vol. 9, no. 4, pp. 1216-1226, 2012. DOI: 10.3390/ijerph9041216.

[13] Morales J, Fuentes-Rivera J, Bax V, Matta H, "Niveles de plomo sanguíneo y factores asociados en niños residentes de un distrito del Callao", Arch Venez Farmacol y Ter, vol.37, no. 2, pp. 135-144, 2018.

[14] Ministerio de Salud. Guía técnica, Guía de práctica clínica para el manejo de pacientes con intoxicación por plomo, Lima, Perú, 2007. [Online]. Available: http://bvs.minsa.gob.pe/local/dgsp/264_DGSP238.pdf. [Accessed: 23-sep-2022].

[15] Kordas K, "The Lead Diet: Can Dietary Approaches Prevent or Treat Lead Exposure?", J Pediatr, vol. 185, pp. 224-231.e1, 2017. DOI: 10.1016/j.jpeds.2017.01.069.

[16] CDC, Centers for Disease Control and Prevention, "Recommended Actions Based on Blood Lead Level" [Online]. Available: https://www.cdc.gov/nceh/lead/acclpp/actions_blls.html. [Accessed: 05-jul-2019].

[17] Haryanto B, Sutrisna B, Djaja IM, "Effect of Calcium Supplementation on School Children's Blood Lead Levels in Indonesia", International Journal of Science and Research., vol. 4, no. 5, pp. 1620-1625, 2015.

[18] Markowitz ME, Sinnett M, Rosen JF, "A randomized trial of calcium supplementation for childhood lead poisoning", Pediatrics, vol. 113, no. 1, pp.e34-9 2004. DOI: 10.1542/peds.113.1.e34.

[19] Chaveepojnkamjorn W, Songroop S, Satitvipawee P, Pitikultang S, Thiengwiboonwong S, "Association between breastfeeding and child stunting among adolescent mothers", Universal Journal of Public Health, vol. 9, no. 6, pp. 484-491, 2021. DOI: 10.13189/ujph.2021.090617.

[20] Shen X, Yan C, Wu S, Shi R, "Parental education to reduce blood lead levels in children with mild and moderate lead poisoning: a randomized controlled study", Chinese J Pediatr, vol. 42, no. 12, pp. 892-7, 2004.

[21] Jordan CM, Yust BL, Robison LL, Hannan P, Deinard AS, "A randomized trial of education to prevent lead burden in children at high risk for lead exposure: efficacy as measured by blood lead monitoring", Environ Health Perspect, vol. 111, no. 16, pp. 1947-51, 2003. DOI: 10.1289/ehp.6352.

[22] Schultz B, Pawel D, Murphy A, "A retrospective examination of in-home educational visits to reduce childhood lead levels", Environ Res, vol. 80, no. 4, pp. 364-8, 1999. DOI: 10.1006/enrs.1998.3922.

[23] Hilts SR, Bock SE, Oke TL, Yates CL, Copes RA, "Effect of interventions on children's blood lead levels", Environ Health Perspect, vol. 106, no. 2, pp. 79-83, 1998. DOI: 10.1289/ehp.9810679.

[24] Rhoads GG, Ettinger AS, Weisel CP, Buckley TJ, Goldman KD, Adgate J, et al., "The Effect of Dust Lead Control on Blood Lead in Toddlers: A Randomized Trial", Pediatrics, vol. 103, no. 3, pp. 551-5, 1999. DOI: 10.1542/peds.103.3.551.

[25] Hänninen O, Knol AB, Jantunen M, Lim TA, Conrad A, Rappolder M, et al., "Environmental burden of disease in Europe: Assessing nine risk factors in six countries", Environ Health Perspect, vol. 122, no. 5, pp.439-46, 2014. DOI: 10.1289/ehp.1206154.

[26] Cinza Sanjurjo S, "La Atención Primaria, un camino para recorrer con nuestros pacientes", Semergen, vol. 42, no. 6, pp. 355-6, 2016. DOI: 10.1016/j.semerg.2016.05.009.