Artículo Original / Original Article

Is anemia a public health problem among children under five years ago in Peru? Findings from a national healthcare administrative database (2012 and 2016) using Geographic Information Systems

¿Es la anemia un problema de salud pública entre los menores de cinco años en el Perú? Análisis de una base de datos administrativa nacional de salud (2012 y 2016) empleando Sistemas de Información Geográfica

ABSTRACT

The objective of this study was to assess the change in the prevalence of anemia among under-five children attending public health services in Peru between 2012 and 2016, according to their place of residence, and to identify spatial clusters of districts with a high prevalence of anemia. An analytical cross-sectional study was carried out, based on data from the Nutritional State Information System from 2012 and 2016. We calculated the spatial autocorrelation of anemia prevalence at the district level using a global and local Moran's I index. The prevalence of anemia was 34.4% (2012) and 40.3% (2016). In 2012 and 2016, 41.7% and 46.5% of districts, respectively, had a prevalence of anemia considered a severe public health problem according WHO criteria. Positive spatial autocorrelation was found between the prevalence of anemia and the districts for both years (2012 Moran's I: 0.22; 2016: 0.31, both $p < 0.001$). Of the total number of districts, 8.3% (2012) and 12.6% (2016) presented a high prevalence of anemia and were also surrounded by districts with high prevalence. Anemia is a public health problem among children under five in Peru attending public health services and we identified areas with a higher concentration of anemia prevalence. Spatial patterns of anemia should be considered in the development and implementation of health interventions. Keywords: Anemia; Children; Geographic Information Systems; Peru; Preschool; Spatial Analysis (Source: MeSH).

RESUMEN

El objetivo del estudio fue evaluar la prevalencia de anemia en menores de cinco años atendidos en servicios de salud públicos en Perú entre 2012-2016 e identificar conglomerados espaciales de distritos de alta prevalencia de anemia. Se realizó un estudio analítico de corte transversal, basado en los datos del Sistema de Información del Estado Nutricional del Perú 2012 y 2016. La autocorrelación espacial de la prevalencia de anemia a nivel distrital se calculó utilizando el índice I de Moran global y local. Se encontró una prevalencia de anemia del 34.4% (2012) y 40.3% (2016), con 41.7% (2012) y 46.5% (2016) de distritos con prevalencias de anemia consideradas como

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grave problema de salud pública según clasificación OMS. Se encontró una autocorrelación espacial positiva entre la prevalencia de anemia y los distritos (Moran's I 2012: 0.22; 2016: 0.31, ambos $p < 0.001$), donde 8.3% (2012) y 12.6% (2016) de distritos con alta prevalencia se encontraban rodeados por distritos con alta prevalencia. La anemia es un problema de salud pública en menores de cinco años en el Perú atendidos en servicios de salud públicos. Existen áreas con mayor concentración de prevalencia de anemia. Los patrones espaciales de anemia deben considerarse en el desarrollo y la implementación de intervenciones de salud.

Palabras clave: Análisis espacial; Anemia; Perú; Preescolar; Sistemas de Información Geográfica (Fuente: DeCS).

INTRODUCTION

Anemia is a condition in which the number of red blood cells or their oxygen-carrying capacity is insufficient to meet physiologic needs. Anemia is the most common blood disorder worldwide and mainly affects developing countries¹. According to World Bank data, the highest prevalence of anemia in 2016 occurred in preschool children (41.7%)².

The World Health Organization (WHO) defines anemia as a public health problem when it affects 20% or more of a population³. The United Nations (UN), as part of the 2030 Agenda and its Sustainable Development Goals, launched the Zero Hunger Challenge, to inspire a global movement towards a world free from hunger and malnutrition within a generation⁴. Thus, the 191 member countries of UN have accepted the commitment to fight against malnutrition, which could have a positive impact on the economy of the countries, global health, and social development⁴.

For Latin America and the Caribbean region, between 1995 and 2016, the prevalence of anemia among children under five decreased from 39.2% to 28.4%². However, there is heterogeneity within this region. Countries such as Chile, Argentina, and Uruguay have prevalences close to 20%, while countries such as Bolivia and Haiti have prevalences that exceed 45%. The degree of success in the implementation of different programs related to supplementation could explain, in part, the differences found between countries^{5,6}.

In Peru, although there was a reduction in the national prevalence of anemia in children under five from 37.7% to 33.3% between 2010 and 2016, the reduction was unequal, with differences according to the area of residence⁷. Among children under five, the highest rate of anemia was reported in those from 6 months to 3 years (43.6%), and those from lower socioeconomic quintiles (53.8%) compared with the highest socioeconomic quintile (28.4%)⁷. In terms of residence, under-five children living in rural areas were most affected (prevalence of 41.4%), with a difference of 11.3% compared to those living in the urban area in 2016⁷. Moreover, anemia is an economic problem in Peru, representing approximately 0.9% of the national GDP in cost for cognitive loss, days of schooling and loss of productivity, for the period 2009-2010⁸.

In recent years, the use of healthcare administrative databases has increased for the development of research at the population level⁹. Likewise, Geographic Information Systems (GIS) are being used as a tool for epidemiological research, allowing the development of interventions in the field of public health including maternal and child health problems^{10,11}. However, the use of these tools for public health is limited in Peru, not yet achieving a territorial disaggregation to identify priority groups in which to take action.

In order to explore if there are regional groups with a higher prevalence of anemia considering the territorial characteristics of Peru, the objective of this study was to assess the change in the prevalence of anemia among under-five children attending public health services in Peru in the

last five years (2012 and 2016), according to their place of residence, and to identify spatial clusters of districts with high prevalence of anemia.

MATERIALS AND METHODS

Design and population

An analytical cross-sectional study was conducted among children under five attending public health services in Peru in the years 2012 and 2016. It was estimated that 2012 and 2016, there was an under-five children population of 2,923,685 in 2012 and 2,845,845 in 2016¹². At the time of the execution of this study, the last annual available database corresponded to 2016.

The Peruvian territory is divided into three natural regions: 1) the Coast, which borders the Pacific Ocean and has the largest urban population, 2) the Andes, which borders the Andes Mountains and 3) the Amazonian, part of the Peruvian Amazon rainforest. Geopolitically, the Peruvian territory is divided into 24 departments (first level of national subdivision) plus a constitutional province called Callao, which is considered as a department from an administrative point of view. These departments are divided into provinces (second level of national subdivision), and these are divided into districts (third level of national subdivision).

Data sources

Data from the Nutritional State Information System (SIEN, by its Spanish acronym) was used, provided by the National Institute of Health of Peru (INEL, by its Spanish acronym)¹³. The SIEN was implemented in 2003, which systematically records, processes, reports, and analyzes the information on the nutritional status of : under-fives and mothers who come to all public health services in Peru from the local to the national level. The SIEN database has been used previously to study the health status of women and children^{14,15}. For children, information collected in the SIEN includes weight, height, age, and sex. The SIEN is used to generate monthly on malnutrition, overweight, obesity, and anemia in this population. The total number of children under five evaluated in public health services and the total number of children with anemia were obtained from the SIEN.

Information reported in SIEN is obtained during appointments within the Growth and Development program in all the public health services. These appointments include a nutritional assessment of anthropometric measures that are carried out by trained nursing personnel. All the evaluations within this program are conducted according to the "*Norma Técnica de Salud para el Control del Crecimiento y Desarrollo de la niña y el niño menor de cinco años*" (a Peruvian technical health standard for the control of growth and development of children under five)¹⁶. In SIEN, an anemia case was defined based on the value of hemoglobin (Hb) according to WHO recommendations, which considers anemia if the hemoglobin is less than 11.0 g/dl, with an altitude correction cut-off point. The measurement of hemoglobin

levels was conducted according to the “*Norma Técnica de Salud para el Control del Crecimiento y Desarrollo de la niña y el niño menor de cinco años*” requiring a blood sample for laboratory test or the use of an hemoglobinometer¹⁶.

For children from 6 months of age, hemoglobin was classified as normal (Hb ≥ 11.0 g/dl), mild anemia (Hb between 10.0 - 10.9 g/dl), moderate anemia (Hb between 7.0 - 9.9 g/dl) and severe anemia (Hb < 7.0 g/dl). The results of each evaluation are recorded in a standard format that contains the child's national identity document number, which allows for their follow-up and identification in any public health service. All the registries are recorded manually in the public health service in pre-established formats, which are sent to data recording centers for its registration in the SIEN and subsequent national consolidation. In the various stages of the process, there are quality controls and monitoring of records, as well as automated processes that allow obtaining the last record of each child according to the number of the national identity document, which avoids duplication of information (e.g., in a case where a child goes to several health services).

To determine urban or rural district the Supreme Decree 090-2011-PCM was used, and to categorize the membership of the district to a natural region the classification of the Peruvian Data Institute was used¹⁷.

Data Analysis

The prevalence of anemia was determined according to natural regions, area of residence (urban/rural), and the 25 geopolitical regions and 1834 districts of Peru. For this purpose, statistical software Stata 14.2 (StataCorp LP, College Station, TX, USA) was used, and the results were exported to a Microsoft Excel® 2013 spreadsheet (Microsoft Corporation, USA).

To classify the prevalence of anemia by regions and districts as a public health problem, the criteria established by the WHO were used: $< 5\%$, not a public health problem; 5% to 19.9% , mild public health problem; 20% to 39.9% , moderate public health problem; and, $\geq 40\%$ is a severe public health problem³. The results were integrated into the spreadsheet of prevalences of anemia using a geographical location code called “ubigeo”. This code is used officially in Peru to code the divisions of the national territory and is commonly used in investigations that include spatial data.

For the spatial autocorrelation analysis, GeoDa software version 1.12.1 was used (GeoDa Center for Geospatial Analysis and Computation, Arizona State University, Tempe, AZ, USA). Moran's I is a global spatial autocorrelation measurement of the overall clustering of the data and yields only one statistic to summarize the whole study area while local Moran's I index (LISA) identifies clustering in individual units¹⁸. To conduct the spatial autocorrelation analysis, the spreadsheet was integrated into a cartographic database of 1834 districts in shapefile format (.shp). Then, the global and LISA was calculated to evaluate significant spatial correlations between districts. The groups were classified

into four categories: high-high (high-rate areas surrounded by high areas), high-low (high surrounded by low areas), low-low (low surrounded by areas of low rates) and low-high (low-rate areas surrounded by high rate). Finally, the results were presented on a district map nationwide using ArcGIS Desktop version 10.5.1 (ESRI Inc., Redlands, CA, USA).

Ethical issues

The Approval of an ethics committee was not required to conduct this study because it is an analysis of secondary data obtained from a public source and free access, which does not provide identifying variables on the children included in the database. The SIEN data, available in the Spanish language from the data source, used in this study can be obtained at the following website (accessed February 20, 2019): <https://web.ins.gob.pe/es/alimentacion-y-nutricion/vigilancia-alimentaria-y-nutricional/vigilancia-del-sistema-de-informacion-del-estado-nutricional-en-%20EES>.

RESULTS

A total of 210,547 children under five in 1529 districts for 2012 and 511,397 children under five in 1834 districts for 2016 were studied. Regarding cases of anemia, 72,489 (34.4%) in 2012 and 20,6042 (40.3%) in 2016 were reported (percentage points change of 5.9% between years of study). According to the WHO classification, anemia in 2016 was a severe public health problem. At the national level, an increase in the prevalence of anemia was reported in both rural and urban areas, with 35.3% (rural) and 33.7% (urban) in 2012 and 37.7% (rural) and 42.3% (urban) in 2016 (percentage points change of 2.4% and 8.6% in the rural and urban areas between years of study, respectively) (Table 1).

Considering natural regions, the highest prevalence was found in the Coast (38.7%) for 2012 and in the Sierra region (44.6%) for 2016. Comparing areas of residence in each natural region, in 2012, the highest prevalences were found in the urban area of the Coast (38.7%), the rural area of the Andes (33%), and in the rural area of the Amazon region (41.7%). In 2016, the highest prevalences were found in the urban area of the Coast (36.1%), the Andes (49.2%), and the Amazon region (39.1%) (Table 1).

According to WHO classification, we found that 637 (41.7%) in 2012 and 852 (46.5%) districts in 2016 had a prevalence of anemia in the range considered a severe public health problem. In addition, 359 (23.5%) districts in 2012 and 622 (33.9%) districts in 2016 presented a prevalence of anemia in the range considered a moderate public health problem (Table 2).

According to geopolitical regions, in 2012, the regions of Loreto (58.7%), Ayacucho (52.2%) and Apurímac (47.3%) had the highest prevalence of anemia in children under five, while in 2016, Puno (62.1%), Ucayali (53.4%) and La Libertad (55.7%) presented the highest prevalence. The regions of Cusco, Puno and La Libertad presented the highest percentage of changes in the prevalence of anemia in under-fives between 2012 and 2016 with increases of 33.7%, 43.9%, and 23.2%, respectively (Table 2).

Table 1. Number of reported events and anemia prevalence among under-fives attending public health services according to natural regions and area of residence. Peru, 2012-2016.

Characteristics		Number of children evaluated	Number of events and prevalence of anemia n %	
Residence Area				
2012	Urban	117 957	39 796	33.7
	Rural	92 590	32 693	35.3
2016	Urban	290 934	122 944	42.3
	Rural	220 463	83 098	37.7
Natural Region				
2012	Coast	45 629	17 641	38.7
	Andes	118 264	36 982	31.3
	Amazonian	26 999	7 395	38.3
2016	Coast	131 306	46 507	35.4
	Andes	275 262	122 898	44.6
	Amazonian	104 829	36 637	34.9
Coast region				
2012	Urban	42 027	16 283	38.7
	Rural	3 602	1 358	37.7
2016	Urban	116 041	41 923	36.1
	Rural	15 265	4 584	30
Andes region				
2012	Urban	52 111	15 170	29.1
	Rural	66 153	21 812	33
2016	Urban	125 950	61 908	49.2
	Rural	149 312	60 990	40.8
Amazonian region				
2012	Urban	23 819	8 343	35
	Rural	22 835	9 523	41.7
2016	Urban	48 943	19 113	39.1
	Rural	55 886	17 524	31.4

Regarding anemia as a public health problem, for 2012, 369 (24.1%) and 636 (41.6%) districts were considered with a moderate and severe problem, respectively. For 2016, 605 (33.0%) and 848 (46.2%) of the districts had a prevalence considered as a moderate or severe problem. Besides, in this last year, almost all the districts of the regions of Ucayali (93.3%), Puno (88.1%) and Madre de Dios (88.1%) included in the evaluation presented a prevalence of anemia considered in the range of a severe problem (Table 2).

In terms of spatial analysis, a positive and statistically significant spatial autocorrelation was found for anemia in 2012 (0.2190; $p < 0.001$) and 2016 (0.3061; $p < 0.001$). For 2012, the local Moran Index found in 153 (8.3%) districts

was considered high-high, indicating the presence of districts with a high prevalence of anemia surrounded by districts with a high prevalence. These districts were located mostly in the central Andes and northern Amazonian region of the country. For 2016, 231 (12.6%) high-high districts were found, mostly located in the central and southern Andes (Figure 1). For both years of study, the predominance of districts distributed within the high-high conglomerates occurred in the rural area, with 112 (2012) and 160 (2016). Of the 11 regions that did not present districts in high-high conglomerates in 2012, the regions of Arequipa, Madre de Dios, Tacna, Cuzco, and Puno presented at least one in 2016. In addition, these last two regions occupied the first

Table 2. Number of reported events of anemia in under-fives according to regions and classification of districts as a public health problem. Peru, 2012-2016.

Regions	Year	Number of children evaluated	Number of events and prevalence of anemia			Districts with anemia as a public health problem*		
			n	%	Δ 2016-2012	Number of districts	Moderate (%)	Severe (%)
Amazonas	2012	4 388	854	19.5		57	9 (15.8)	8 (14.0)
	2016	23 163	5 561	24.0	+4.5	84	29 (34.5)	6 (7.1)
Ancash	2012	11 701	5 321	45.5		116	15 (12.9)	88 (75.9)
	2016	28 764	12 861	44.7	-0.8	166	44 (26.5)	97 (58.4)
Apurímac	2012	14 519	6 865	47.3		76	17 (22.4)	47 (61.8)
	2016	22 526	8 494	37.7	-9.6	80	39 (48.1)	27 (33.3)
Arequipa	2012	9 503	2 531	26.6		103	46 (44.7)	20 (19.4)
	2016	23 112	9 661	41.8	+15.2	109	23 (21.1)	68 (62.4)
Ayacucho	2012	8 544	4 461	52.2		89	9 (10.0)	68 (75.6)
	2016	33 077	9 908	30.0	-22.2	111	67 (57.8)	15 (12.9)
Cajamarca	2012	26 733	7 821	29.3		120	52 (43.3)	28 (23.3)
	2016	42 776	14 027	32.8	+3.5	127	47 (37.0)	37 (29.1)
Callao	2012	1 915	642	33.5		5	3 (60.0)	1 (20.0)
	2016	3 433	1 204	35.1	+1.6	6	3 (42.9)	2 (28.6)
Cusco	2012	18 776	3 138	16.7		106	23 (21.7)	10 (9.4)
	2016	37 998	19 143	50.4	+33.7	108	32 (29.6)	74 (68.5)
Huancavelica	2012	10 600	3 415	32.2		93	14 (15.1)	46 (49.5)
	2016	22 892	8 400	36.7	+4.5	94	41 (43.2)	29 (30.5)
Huánuco	2012	9 517	3 646	38.3		71	17 (23.9)	38 (53.5)
	2016	32 706	10 151	31.0	-7.3	76	37 (45.1)	26 (31.7)
Ica	2012	2 693	1 164	43.2		38	12 (31.6)	20 (52.6)
	2016	9 315	2 908	31.2	-12.0	43	20 (46.5)	13 (30.2)
Junín	2012	10 841	3 873	35.7		102	25 (24.5)	41 (40.2)
	2016	30 603	15 303	50.0	+14.3	123	28 (22.8)	78 (63.4)
La Libertad	2012	5 958	1 521	25.5		54	11 (20.4)	21 (38.9)
	2016	19 877	11 081	55.7	+30.2	83	13 (15.7)	59 (71.1)
Lambayeque	2012	4 070	1 580	38.8		32	11 (34.4)	12 (37.5)
	2016	11 790	5 231	44.4	+5.6	38	9 (23.7)	17 (44.7)
Lima	2012	21 890	9 367	42.8		125	29 (23.2)	65 (52.0)
	2016	54 431	19 683	36.2	-6.6	171	78 (45.6)	61 (35.7)
Loreto	2012	8 439	4 950	58.7		45	4 (8.5)	38 (80.9)
	2016	25 253	11 639	46.1	-12.6	51	11 (20.8)	34 (64.2)
Madre de Dios	2012	628	246	39.2		11	4 (36.4)	4 (36.4)
	2016	1 710	788	46.1	+6.9	11	1 (9.1)	9 (81.8)
Moquegua	2012	1 441	669	46.4		18	5 (27.8)	12 (66.7)
	2016	4 791	1 371	28.6	-17.8	20	10 (50.0)	6 (30.0)

...Table 2 (Continued).

Regions	Year	Number of children evaluated	Number of events and prevalence of anemia			Districts with anemia as a public health problem*		
			n	%	Δ 2016-2012	Number of districts	Moderate (%)	Severe (%)
Pasco	2012	2 438	892	36.6		27	7 (25.9)	7 (25.9)
	2016	4 135	1 960	47.4	+10.8	28	9 (31.0)	17 (58.6)
Piura	2012	2 840	874	30.8		43	15 (34.1)	15 (34.1)
	2016	30 529	10 515	34.4	+3.6	64	31 (47.7)	25 (38.5)
Puno	2012	19 359	3 515	18.2		106	22 (20.8)	11 (10.4)
	2016	25 954	16 120	62.1	+43.9	109	11 (10.1)	96 (88.1)
San Martín	2012	7 895	3 005	38.1		48	5 (10.4)	20 (41.7)
	2016	5 799	2 258	38.9	+0.8	77	21 (27.3)	23 (29.9)
Tacna	2012	1 500	186	12.4		18	6 (33.3)	3 (16.7)
	2016	4 358	1 550	35.6	+23.2	27	7 (25.9)	13 (48.1)
Tumbes	2012	1 061	397	37.4		13	6 (46.2)	4 (30.8)
	2016	3 835	1 647	42.9	+5.5	13	3 (23.1)	6 (46.2)
Ucayali	2012	3 298	1 556	47.2		13	3 (23.1)	10 (76.9)
	2016	8 570	4 578	53.4	+6.2	15	1 (6.7)	14 (93.3)

* According to the classification of the World Health Organization (WHO): moderate (20 to <40%), severe $\geq 40\%$.

positions in 2016 in the number of districts within high-high conglomerates (Cuzco: 36; Puno: 72), both at the rural and urban levels (Table 3).

DISCUSSION

Our findings show that the prevalence of anemia in children under five attending public health services in Peru increased 5.9 percent points between 2012 and 2016, becoming a severe public health problem in the last year. The Andes region has presented the most considerable increase in the proportion of children affected by this problem, both in urban and rural areas. The spatial analysis shows an increase of districts within spatial conglomerates of a high prevalence of anemia, with a predominance of central and southern Andes of the country.

By 2016, four out of ten children evaluated had anemia. This value is higher than those reported by the National Institute of Statistics of Peru for the same year, a prevalence of 33.3% for children under five nationwide without distinction by establishment type (public or private)⁷. Owing to the magnitude of anemia in the country, the Peruvian state recently implemented the National Plan for the Reduction of Anemia 2017-2021, which intends to reduce the rate of anemia in children under three years of age to 19% by 2021¹⁹. In Latin America and the Caribbean, anemia in children under five is around 30%, a public health problem in countries with small and medium-sized economies such as Guatemala,

Figure 1: Spatial analysis of district anemia prevalence among children under five in Peru. A. 2012. B. 2016

Table 3. Districts with anemia in under-fives as a severe public health problem within conglomerates of high anemia prevalence identified in the spatial analysis by region and area of residence. Peru, 2012-2016.

Regions	Number of districts			Districts with anemia as a severe public health problem within conglomerates of high anemia prevalence*			
	Urban	Rural	Total	2012 Urban	Rural	2016 Urban	Rural
Amazonas	11	73	84	NI [¥]	2	NI	NI
Ancash	33	133	166	6	25	8	24
Apurímac	11	69	80	2	12	NI	NI
Arequipa	39	70	109	NI	NI	2	8
Ayacucho	15	96	111	5	18	NI	NI
Cajamarca	20	107	127	NI	NI	NI	NI
Callao	6	0	6	NI	NI	NI	NI
Cusco	31	77	108	NI	NI	9	27
Huancavelica	11	83	94	5	27	NI	NI
Huanuco	10	66	76	1	11	NI	3
Ica	28	15	43	1	1	NI	NI
Junín	45	78	123	6	4	15	17
La Libertad	40	43	83	3	NI	7	22
Lambayeque	30	8	38	NI	NI	NI	NI
Lima	75	96	171	3	NI	NI	1
Loreto	13	38	51	7	11	1	4
Madre de Dios	4	7	11	NI	NI	1	NI
Moquegua	4	16	20	NI	1	NI	1
Pasco	14	14	28	1	1	4	3
Piura	37	27	64	NI	NI	NI	NI
Puno	27	82	109	NI	NI	23	49
San Martín	34	43	77	NI	NI	NI	NI
Tacna	7	20	27	NI	NI	1	NI
Tumbes	9	4	13	NI	NI	NI	NI
Ucayali	5	10	15	1	NI	NI	1

* According to the classification of the World Health Organization (WHO): severe $\geq 40\%$.

¥ Not identified.

Haiti, and Bolivia². In our study, the prevalence of anemia in the sample is higher in relation to the regional average and national averages of Latin American countries with medium-high economic incomes such as Peru. This situation could be explained by differences in the implementation of health programs between these countries and anemia in children under five^{6,20,21}.

According to natural regions, there was variability in the prevalence of anemia in children under five, being higher in the Andes region. Likewise, the departments circumscribed to the Andes region had the highest percentage increases in the prevalence of anemia in the urban sector between 2012 and 2016. Variations in the prevalence of anemia within this geographical area would respond to numerous risk factors, such as socioeconomic and geographic, influenced in some cases by the concurrence of parasites, nutritional deficiencies, exposures to metals, and deficiencies in the care of the child by the mother^{21,22,23,24}. In these regions, the

experience of health programs that include the delivery of micronutrients or nutritional supplements and low-interest money or micro-credit programs for low-income families report a decrease in the prevalence of anemia in children aged 6-8 years of age^{25,26,27}. Similar experiences reported in other low- and middle-income countries match with these findings and illustrate the need to evaluate the impact and scalability of these interventions, bearing in mind the difficulty that exists at the rural level for the continuity of these programs^{28,29,30,31}.

In 2012, anemia was a moderate public health problem in both urban and rural areas. In 2016, an increase in anemia was observed in both urban and rural areas, and anemia was considered as a severe public health problem in urban areas. For this same year, the INEI reported a similar prevalence of anemia in the general population of children under five, although, in this case, the highest proportion was in rural areas (41.4%). This difference could

be understood since the study presented here only includes cases of children attending public health services, and it is probable that non-anemic children from the urban area have greater access to private health services, not being included in our analysis. In general, the problem of anemia in the rural area is associated with health determinants such as education, nutrition, health, quality of life, poverty and economic level compared to the urban area where better socioeconomic status and better access to health services and care would favor a better state of health^{32,33}.

In general, there was an increase in districts with high-high prevalence conglomerates during the study period. The Moran index analysis identified the presence of high prevalence district conglomerates, located mostly in the Coast and Andes of Peru during 2012 and 2016, respectively. This trend is similar to that reported by a study in 2011, which identified a most significant prevalence in the regions indicated³³. The regions of Cusco, Puno and La Libertad occupy the first positions in districts within high-high conglomerates of anemia in the last year of study. It is also important to mention that, during 2016, there are still regions where anemia figures remain high to the point of being considered a severe public health problem, such as Ucayali, Puno and Madre de Dios, where almost all the districts included in the study presented this problem. The results of our study are consistent with those reported by the INEI as the most affected by anemia⁷. The identification of conglomerates with the most significant impact on anemia in children under five with the use of GIS is useful for the development of future intervention strategies and allows the use of resources in a prioritized manner.

We are aware that our research may have limitations due to the use of a secondary administrative base, the SIEN database in this case, which does not guarantee the correct filling of the analyzed data, nor the specificity and sensitivity of the tests used for the diagnosis of anemia in children under five. These limitations are common for any study that uses this type of data. Despite this, the use of a long-term administrative database to analyze the entire population of interest makes the results on anemia and identification of conglomerates of high prevalence useful to study anemia in under-five children in Peru as a first approach to addressing the problem with the use of GIS.

CONCLUSIONS

Anemia is a public health problem in Peru among under-fives. We identified clusters of high anemia prevalence at the district level. The recognition of areas with a high prevalence of anemia can be used to plan interventions and preventive-promotional strategies that focus on reducing the adverse effects of anemia in under-fives in areas with a greater need for prioritization.

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