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CHRONIC MALNUTRITION AMONG CHILDREN UNDER FIVE IN PERU: SPATIAL ANALYSIS OF NUTRITIONAL DATA, 2010-2016

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Conflicts of interest: None to declare.

ABSTRACT

Background. Peru has implemented various strategies seeking to improve nutritional indicators in children under five years old. However, high prevalence of malnutrition in some regions still remains. The aim of this study was to assess changes in regional prevalence and to determine the presence of district conglomerates with a high prevalence of chronic childhood malnutrition (CCM) in 2010 and 2016.

Methods. A comparative descriptive analysis by regions and a district-level spatial analysis were conducted employing indicators reported by the Nutritional Status Information System.

Results. 23.9% (561.090/2.343.806) children under five years evaluated in Peru during 2010 and 18.0% (394.049/2.193.268) evaluated during 2016 were chronic malnutrition (reduction of 5.9 percentage points). We identified a decline of 7.6 percent points in rural areas and the persistence of prevalence above 30% in only one region (Huancavelica). The spatial analysis identified clusters of districts with high prevalence in 20% (379/1834) of Peruvian districts in 2010, and 17.2% (316/1834) of those in 2016, which are mainly spread across the sierra and jungle regions.

Conclusions. Peru has made significant progress in reducing stunting in children. Nevertheless, it still represents a health problem due to high prevalence in the sierra region, as well as expansion to jungle districts in 2016.

Key words: Geographic Information Systems, Spatial Analysis, Malnutrition, Child, Peru, Infant Nutrition Disorders.

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RESUMEN

Desnutrición crónica en menores de cinco años en Perú: análisis espacial de información nutricional, 2010-2016

Fundamentos. En Perú se han implementado diversas estrategias buscando mejorar los indicadores nutricionales en menores de cinco años. No obstante, persisten altas prevalencias de desnutrición en algunas regiones. El objetivo de este estudio fue evaluar los cambios en las prevalencias regionales y determinar la presencia de conglomerados distritales con altas prevalencias de desnutrición crónica infantil (DCI) en los años 2010 y 2016.

Métodos. Se realizó un análisis descriptivo espacial por regiones y un análisis espacial distrital a partir de los indicadores reportados por el Sistema de Información del Estado Nutricional.

Resultados. El 23,9% (561.090/2.343.806) de menores de cinco años evaluados en Perú durante el 2010 y el 18,0% (394.049/2.193.268) de evaluados en 2016 presentaron desnutrición crónica (reducción de 5,9 puntos porcentuales). Se identificó una reducción de 7,6 puntos porcentuales en el área rural y la persistencia de prevalencias por encima de 30% en una sola región (Huancavelica). El análisis espacial identificó que en el 2010 existieron agrupaciones distritales de altas prevalencias en el 20% (379/1834) de distritos peruanos y en el 17,2% (316/1834) de distritos para el 2016, los cuales están distribuidos principalmente en la región de la sierra y selva.

Conclusiones. En Perú se han logrado importantes avances en reducir la desnutrición crónica infantil, sin embargo, aún representa un problema de salud por las altas prevalencias en la sierra y la expansión hacia distritos de la selva en 2016.

Palabras clave: Sistemas de Información Geográfica, Desnutrición, Niño, Perú

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INTRODUCTION

An adequate nutrition is indispensable for healthy growth, however, in some countries, the nutritional transition process implies changes in nutritional indicators that are related to changes in caloric intake and expenditure, mediated by the interaction of economic, demographic, environmental and cultural factors[1]. Childhood undernutrition continues to be a major public health problem in low and middle income nations and causes a high global burden of disease[2]. Just in 2010, an estimated 104 million malnourished children were reported worldwide, a problem that contributes to almost a third of the deaths of this population group[3]. Likewise, given the low cost of some interventions to reduce undernutrition in developing countries[4], special attention should be given to this health problem, as the estimated economic burden of this problem is high[5].

On the other hand, the World Health Organization (WHO), together with the United Nations Children's Fund (UNICEF) and the World Bank (WB), produced a report stating that between 1990 and 2014 the global prevalence of childhood undernutrition under five was reduced from 39.6% to 23.8%, which means a reduction of 96 million cases, even, children living in developing countries accounted for two-thirds of chronically undernourished children[6]. Similarly, the results of the Demographic and Family Health Survey (ENDES, Encuesta Demográfica y de Salud Familiar) conducted by the National Institute of Statistics and Informatics of Peru (INEI) show that between 2000 and 2013, the prevalence of chronic childhood undernutrition in Peru declined from 31% to 17.5%[7].

Despite this decline worldwide, it is necessary to bear in mind that there are still marked territorial differences in the concentration of cases of undernutrition, negatively affecting areas from rural, dispersed, indigenous and low-income populations[8,9]. Using this scenario, a series of researches using geographic information systems (GIS) to analyze public health problems have been developed in recent years[10], so it has been suggested that the combination of studies related to undernutrition where the GIS could be useful to improve the study of complex phenomena such as this in certain geographic areas[11,12]. However, in Peru most of the published studies analyze the socioeconomic, demographic and cultural factors associated with chronic childhood undernutrition and few studies have been published on issues of childhood malnutrition incorporating these tools with the highest level of territorial disaggregation which allows the availability of relevant, consistent and actual information for the formulation of public policies and/or for monitoring the progress of the implemented measures.

The aim of this study is to assess changes in regional prevalence of chronic childhood undernutrition under five years of age in Peru, as well as to identify the presence of Peruvian district clusters with a high prevalence of this condition among children during 2010 and 2016.

MATERIAL AND METHODS

We used a descriptive analysis to determine the prevalence of chronic childhood undernutrition according to geographical characteristics and a spatial analysis based on the nutritional indicators reported by the Nutritional Status Information System (SIEN, Sistema de Información del Estado Nutricional). The reported indicators correspond to the registered cases of chronic childhood undernutrition between January 1 and December 31 of 2010 and 2016 of children under five years old who were evaluated in growth and development controls in all public health services (ESP, establecimientos de salud públicos) in Peru. It should be noted that by 2010 the SIEN collected nutritional information from 79% of the projected population of children under five years old and 77% in 2016.

The regions were used as unit of analysis to determine the prevalence in each of them and

for the spatial analysis, the districts of Peru were considered smaller territorial units. The political-administrative territorial division of Peru consists of 25 regions that are made up of 196 provinces and 1854 districts. However, according to its geography has a natural territorial division constituted by three natural regions: coast, sierra, and jungle.

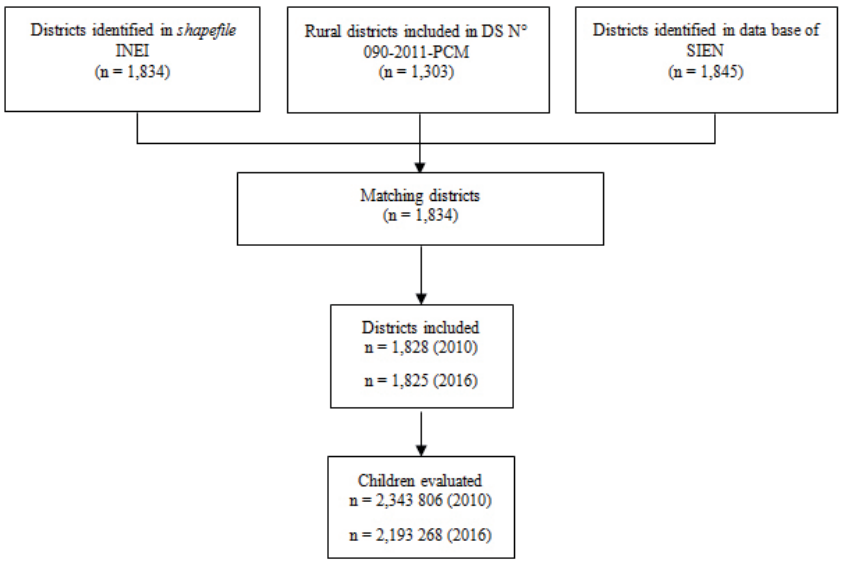
The information of the evaluated children and cases of chronic childhood-undernutrition was obtained in a Microsoft Excel® 2013 (Microsoft, Redmond, WA) spreadsheet from SIEN website, belonging to the National Center for Food and Nutrition (CENAN, Centro Nacional de Alimentación y Nutrición) of the National Institute of Health of Peru (INS, Instituto Nacional de Salud). The purpose of the SIEN is to record, process, report and analyze nutritional information of the population that comes from primary health care centers and hospitals of the public health system of Peru, under the Ministry of Health (MINSA) and Regional Governments.

The nutritional information of SIEN is obtained from the evaluation of the anthropometric measures during the care by control of growth and development to the under five years in the ESP at the national level. Anthropometric processes, conditions, and techniques have been standardized in the Technical Standard of Health for the Control of Growth and Development of children under five[13]. The determination of a case of chronic undernutrition is based on the criteria established by the World Health Organization (WHO) that considers the existence of chronic undernutrition when height for age is less than two standard deviations (SD) [13,14]. The results of each of the nutritional assessments along with age, sex, date of care, district of residence, and others, are included in pre-established forms, which are sent to data recording centers for registration in the SIEN and then sent to the central level of consolidation. A variety of quality controls and record monitoring are included at each stage of the process, with the aim of avoiding duplication of information or incorrect filing of records[15].

From the spreadsheet, each district was characterized as urban or rural according to Supreme Decree No. 090-2011-PCM, which was imported into the statistical software Stata 14.2 (StataCorp LP, College Station, TX, USA). A descriptive and cross-sectional analysis was carried out to determine the prevalence of chronic undernutrition in children under five years of age and its percentage variation between the years included in the study according to the natural regions and the area of residence (urban or rural) with confidence intervals 95% as well as for each of the 25 regions.

For the spatial analysis, the official cartographic base of the districts of Peru from the National Institute of Statistics and Informatics (INEI, Instituto Nacional de Estadística e Informática) was downloaded from the website of the Ministry of the Environment (http://geoservidor.minam.gob.pe/geoservidor/download.aspx). Consequently, the spreadsheet was integrated to the cartography through the GeoDa program version 1.6.7 (GeoDa Center for Geospatial Analysis and Computation, Arizona State University, Tempe, AZ, USA), which obtained the layer with the districts prevalence of chronic undernutrition in which the spatial analysis was performed (figure 1). The Moran Global Index was used to explore spatial clustering at country level with a significance level of 0.05 that assessed the spatial randomness hypothesis of the district prevalence of chronic undernutrition. The results of the index vary between -1 and +1, being categorized in: a) positive spatial autocorrelation values greater than zero, b) randomized distribution for values equal to zero, and c) spatial dispersion for values below zero. Likewise, the presence of district clusters with high/low prevalence of undernutrition was evaluated, using the Morán local index with a significance level of 0.05[16]. The clustering crite-

Figure 1
Diagram of elaboration of the cartographic base district



rion used for the nearest neighbor was the Queen type.

Finally, a software ArcGIS Desktop version 10.5 (ESRI Inc. Redlands, CA, USA) was used to represent cluster maps.

The study did not require the approval of an ethics committee because it is an analysis of aggregated secondary data that was obtained from a public domain and freely accessible that does not allow the identification of the evaluated children.

RESULTS

Of the 2,343,806 children under five years evaluated in Peru during 2010, a total of 561,090 (23.9%) had chronic undernutrition and from 2,193,268 children under five evaluated during 2016, a total of 394,049 (18.0%), presented chronic undernutrition. Likewise, according to district prevalence, in 2010 a total of 1,828 districts had an average prevalence of 28.8% (95% CI: 28.1-29.4) and in 2016 from a total of 1,825 districts the mean prevalence was 22.5% (95% CI: 22.0-23.1).

It was found that the prevalence of chronic undernutrition among children under five years of age has decreased nationally in 2016 compared to 2010, with a higher absolute difference (Δ) in some regions compared to others. Table 1 shows the prevalence of these cases has decreased in a greater proportion in the rural area (Δ -7.6). These results are reflected by a larger reduction in the natural regions of the sierra and jungle than the coast (Δ -8.4, -4.0 and -2.7, respectively), which have larger areas of rural areas.

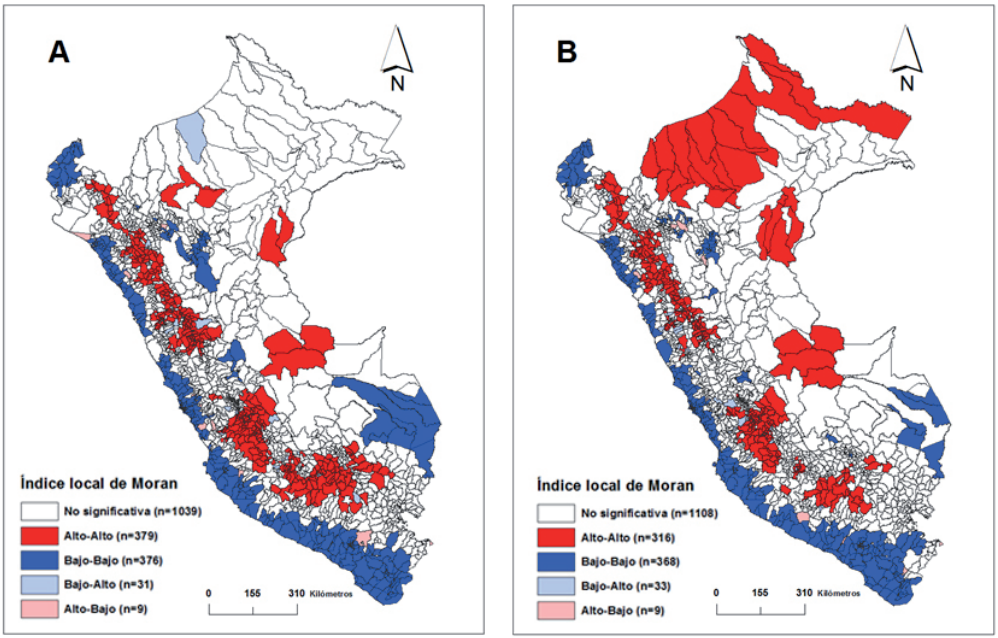
Respect to the prevalence of chronic undernutrition and the changes occurred between the two years for the regions of Peru, it was obtained that region with the highest prevalence was Huancavelica (44.82% and 34.63% in 2010 and 2016 respectively), however, the subsequent positions have shown variations between both years. In 2010, the regions with the highest prevalence of undernutrition after Huancavelica were Apurímac (38.38%),

Table 1
Prevalence of chronic undernutrition and absolute percentage differences according to regions of Peru between 2010 and 2016

			2010				2016				Δ
			Evaluated	Cases	%	95% CI	Evaluated	Cases	%	95% CI	
Place of residence		Urban	1,536,132	268,082	17.45	17.4-17.5		200,847	13.22	13.2-13.3	-4.2
		Rural	807,674	293,008	36.28	36.2-36.4	674,070	193,202	28.66	28.6-28.8	-7.6
Natural region		Cost*	890,755	136,035	15.27	15.2-15.3	915,758	115,233	12.58	12.5-12.7	-2.7
		Sierra**	1,126,130	340,077	30.20	30.1-30.3	983,501	214,157	21.77	21.7-21.9	-8.4
		Jungle***	326,921	84,978	25.99	25.8-26.1	294,009	64,659	22.00	21.8-22.1	-4.0
Regions	Coast	Callao	33,977	3,377	9.94	9.6-10.3	40,271	3,159	7.84	7.6-8.1	-2.1
		Ica	58,128	6,585	11.33	11.1-11.6	60,441	5,589	9.25	9.0-9.5	-2.1
		La Libertad	137,299	32,486	23.66	23.4-23.9	123,982	25,421	20,50	20.3-20.7	-3.2
		Lambayeque	73,050	15,070	20.63	20.3-20.9	72,441	12,594	17,39	17.1-17.7	-3.2
		Lima	386,788	33,511	8.66	8.6-8.8	422,570	31,044	7,35	7.3-7.4	-1.3
		Moquegua	11,348	902	7.95	7.5-8.5	11,086	604	5,45	5.0-5.9	-2.5
		Piura	144,788	39,383	27.20	27.0-27.4	142,590	33,659	23,61	23.4-23.8	-3.6
		Tacna	21,454	1,167	5.44	5.1-5.8	19,926	823	4,13	3.9-4.4	-1.3
		Tumbes	23,923	3,554	14.86	14.4-15.3	22,451	2,340	10,42	10.0-10.8	-4.4
	Sierra	Ancash	108,501	32,903	30.33	30.1-30.6	101,012	21,988	21,77	21.5-22.0	-8.6
		Apurímac	53,003	20,345	38.38	38.0-38.8	43,237	10,496	24,28	23.9-24.7	-14.1
		Arequipa	114,316	11,732	10.26	10.1-10.4	126,256	9,957	7,89	7.7-8.0	-2.4
		Ayacucho	75,249	25,902	34.42	34.1-34.8	62,437	14,990	24,01	23.7-24.3	-10.4
		Cajamarca	201,684	72,389	35.89	35.7-36.1	182,350	52,354	28,71	28.5-28.9	-7.2
		Cusco	161,179	48,098	29.84	29.6-30.1	129,698	26,263	20,25	20.0-20.5	-9.6
		Huancavelica	53,497	23,979	44.82	44.4-45.2	41,117	14,239	34,63	34.2-35.1	-10.2
		Huánuco	119,227	40,199	33.72	33.4-34.0	86,612	19,706	22,75	22.5-23.0	-11.0
		Junín	112,783	32,332	28.67	28.4-28.9	98,669	23,906	24,23	24.0-24.5	-4.4
		Pasco	31,068	8,006	25.77	25.3-26.3	22,864	5,171	22,62	22.1-23.2	-3.2
		Puno	95,623	24,192	25.30	25.0-25.6	89,249	15,087	16,90	16.7-17.2	-8.4
	Jungle	Amazonas	58,486	17,248	29.49	29.1-29.9	56,480	14,891	26,37	26.0-26.7	-3.1
		Loreto	106,224	32,775	30.85	30.6-31.1	106,229	27,632	26,01	25.7-26.3	-4.8
		Madre de Dios	20,325	2,717	13.37	12.9-13.8	13,614	1,649	12,11	11.6-12.7	-1.3
		San Martín	89,960	18,341	20.39	20.1-20.7	73,422	11,102	15,12	14.9-15.4	-5.3
		Ucayali	51,926	13,897	26.76	26.4-27.1	44,264	9,385	21,20	20.8-21.6	-5.6

* Conformed by the regions of Tumbes, Piura, Lambayeque, La Libertad, Callao, Lima, Ica, Moquegua and Tacna. ** Conformed by the regions of Cajamarca, Ancash, Huánuco, Pasco, Junín, Huancavelica, Cusco, Ayacucho, Apurímac, Arequipa and Puno. *** Conformed by the regions of Amazonas, Loreto, San Martin, Ucayali and Madre de Dios.

Figure 2
A. Spatial analysis of district prevalence of chronic undernutrition among children under five years of age, Peru 2010. B. Spatial analysis of district prevalence of chronic undernutrition among children under five years of age, Peru 2016



Cajamarca (35.89%), Ayacucho (34.42%) and Huánuco (33.72%), which belong to the natural region of the Sierra. Likewise, for the year 2016 a reduction in the prevalence was evidenced, becoming Huancavelica the only region with prevalence over than 30%; and evidenced that Cajamarca (28.71%) together with regions belonging to the natural jungle region, such as Amazonas (26.37%) and Loreto (26.01%) appear in the subsequent order with high prevalence of chronic undernutrition, unlike in 2010.

According to the changes in the regional prevalence of chronic undernutrition between 2010 and 2016, the regions with the greatest absolute percentage difference to 2016 were Apurímac (Δ -14.1), Huánuco (Δ -11.0), Ayacucho (Δ -10.4) and Huancavelica (Δ-10.2), while the regions with the lowest difference (Δ -1.3) were Lima, Madre de Dios, and Tacna, which also maintained the lowest prevalence in both periods.

The geospatial analysis showed a Moran Global Index of 0.62 (p = 0.001; z = 44.31) for the district prevalence of chronic undernutrition in children less than five years old treated in ESP during 2010 and 0.54 (p = 0.001, z = 39.1) for those of 2016.

According to the Moran Local Index, which allows visualizing the district clusters or groups, by 2010, a 20.7% (379/1834) of districts were in spaces where the ratio is high-high (prevalence above to the average). However, by 2016, a 17.2% (316/1834) of districts were found in a high-to-high ratio in most regions of the sierra, but with several districts in the jungle. Also, it was possible to visualize districts of 20.1% (368/1834) in blue color that are characterized by low prev-

alence, the same ones are mostly distributed in regions of the coast (figure 2).

DISCUSSION

The results of this study show that, although the prevalence of chronic undernutrition among children less than five years of age who are treated in ESP in Peru has decreased by almost six percent points between 2010 and 2016, there are still high prevalence with a marked inequality of which fluctuate between 4.13% and 34.63% by 2016, with Huancavelica as a the only region that persists with a prevalence of chronic undernutrition above 30% in 2016. In 2010, seven regions were identified with high prevalence (Huancavelica, Apurímac, Cajamarca, Ayacucho, Huánuco, Loreto and Ancash), with a prevalence greater than 40% in one of them, many of which have persisted with high prevalence in 2016 as well as high prevalence district clusters located predominantly in the natural region of the sierra and with a greater expansion towards the jungle.

In Peru, current trends in food consumption indicate a negative evolution due to the increase in caloric intake and foods rich in saturated fats, creating a scenario conducive to the development of nutritional problems. According to figures from the Food and Agriculture Organization of the United Nations (FAO), in Peru, the caloric intake has increased from 2,138 kcal in 1992 to 2,700 kcal per person per day in 2013. Similarly, the per capita consumption of grams of fats and proteins in the same period increased substantially[17]. However, national estimates show that more than 50% of children under three years do not reach the daily energy requirement, surpassing the urban to rural area by more than 20 percent points. Likewise, the highest percentage of children who fail to meet their energy and nutritional requirements are found in the sierra, jungle and under conditions of poverty or extreme poverty[18]. This geographical distribution for the caloric intake deficit is confirmed by the results of this study, in which the highest prevalence of chronic undernutrition was found in the areas described previously.

The results of the Demographic and Family Health Survey (ENDES) indicate that by 2014 the rate of chronic undernutrition in Peru had decreased by 16 and 8 percent points compared to 2000 and 2010, respectively[19]. Likewise, the figures for 2015 show a chronic undernutrition rate of 14.4%, with a difference of 18.5 percentage points between urban (9.2%) and rural (27.7%)[20]. In our study, the difference found between urban and rural areas is 15.44 percent points, which adding to the high prevalence of childhood anemia in rural areas (39.7%) reported by ENDES[20], would make this area in a context of great vulnerability that needs to be included on the public agenda as a priority issue.

Regarding the spatial analysis of prevalence in both years, there was a decrease in district prevalence in the regions from the sierra respect to 2010. In contrast, the prevalence of undernutrition was higher in the jungle. This movement or migration of areas in which childhood undernutrition is identified may be associated with special interventions that have been carried out by the government in the regions of the sierra[19, 21].

According to this description, it is necessary to implement a multidisciplinary approach through public policies and programs aimed at reducing social inequalities in the rural area with the participation of the Ministry of Health with other ministries (Ministry of Social Inclusion, Ministry of Economy and Finance, and others), but also of the Regional Health Directorates, municipalities, in addition to the involvement of civil society in different levels of action, seeking in this way a multisectorial participation, in order to improve the budget for this objective.

Despite the important progress made by the Peruvian government in reducing a multifactorial problem such as chronic undernutrition[7], there are still regions such as Huancavelica, Cajamarca, Apurímac, Junín,

Ayacucho and Huánuco, whose prevalence are the highest in Peru and persist since 2010. These regions are the same as regions with the lowest Human Development Index (HDI) as reported by the United Nations Development Program (UNDP) in 2013[22]. The regions with the lowest HDI in 2012 were Cajamarca (0.38), Huánuco (0.37), Apurímac (0.34), Ayacucho (0.33) and Huancavelica (0.30), which also have lower scores in years of education and family income per capita which are factors that are usually associated with the presence of undernutrition[23,24,25]. To these factors should be added those of the regions such as the rugged geography and dispersed populations that leads to the families have limited access to health services that could be attending mostly by non-medical health personnel due to the concentration of professionals in the country's capital[26]. In addition, there are others that together are usually called determinants of access to health. In these regions, it is important to consider the presence of dispersed communities, which can lead to trips of hours and days to be attended in a health center with limited hours of care or lack of staff. Another determinant may be the language or dialect of the community that may lead to not being understood by the health personnel of the majority hispanic speaking[27]. These determinants are some of the many that exist that have not been evaluated or have not been taken into account in the public agenda topics.

The World Bank has evaluated and published three factors that are considered to have been associated with declining undernutrition between the years 2000 and 2015. These factors, mainly political ones, were first, Peru assumed a strong political commitment to malnutrition with measurable goals in the short term. Second, Peru adopted a multisectoral strategy to support the supply and demand of nutrition services, empowering parents with information and decision-making about the consequences of undernutrition relating to their children. Finally, the government directed a larger budget to the regions with the greatest needs, through the result budget, whose objective is to obtain optimal results that justify the need for the requested budget[19]. These factors are closely related to the results shown in this study, that is, the decrease in prevalence in some regions of Peru, mainly regions of the sierra. However, it is also evident that the work done has not been equal or equitable in all regions, since there are regions in the jungle with a high prevalence of chronic undernutrition that have not benefited from the intervention by the Peruvian government.

As limitations of the study should be pointed out those derived from the use of secondary sources in which inconsistencies may occur in the coding or filling of the instruments used, as well as in the report of cases by the ESP. However, to obtain SIEN data and results, a number of quality controls and monitoring of records are included, which limit the duplication of information or the incorrect use of electronic records. It should be noted that the SIEN results are representative of the population of children attending public health establishments in Peru, that is, the population that attends Social Security (EsSalud) and private health institutions are excluded. Despite the limitations, we consider that this study is one of the first to identify, through a comparative spatial analysis, existing inequalities in the district prevalence of chronic undernutrition in children, which would identify and prioritize the district areas with the greatest need of intervention.

In conclusion, the prevalence of chronic undernutrition in children has decreased in 2016 compared to 2010 in Peru, but this decrease persists in rural areas despite the fact that the urban-rural gap has been reduced, being reflected by the persistence of regions such as Huancavelica mainly and the presence of regions of the jungle such as Amazonas and Loreto, as the regions with the highest prevalence in 2016. There is no doubt that, in Peru, significant progress has been made by the government to give compliance with

the constitutional duty to guarantee health to its citizens. However, what we found in this study reinforces the idea of include in the study of health phenomena the geographical perspective, since residing in some areas could have a negative effect on the health indicators associated with other factors as determinants of health.

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