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Original Research

Predictive model of stunting in the Central Andean region of Peru based on socioeconomic and agri-food determinants

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ABSTRACT

Objectives: A limitation in the design and monitoring of public health policies is the lack of conceptual models to explain their results. The objective of this study was to develop a predictive model of stunting in children under 5 years of age in the central Andean region of Peru, using socioeconomic and agro-productive predictors.

Study design: Cross-sectional data of 380 families in 15 districts of the central region of Peru. WHO criteria were used to define stunting prediction model.

Methods: An explanatory and predictive study of stunting in children was carried out considering causality criteria through Chi-square tests and bivariate logistic regression. Family food production, maternal education, breastfeeding practices and others determinant related to rural zone conditions were considered as explanatory variables in stunting of children under 5 years old. Three exhaustive models for predicted the presence of stunting was developed.

Results: Stunting percentage was 40.3. To Hosmer and Lemeshow test, the best fit was the model that considered the level of maternal education, timely consumption of colostrum, birth weight and guinea pig rearing, having high reliability ($P < 0.05$).

Conclusions: A predictive model for early detection of stunting risk in rural areas of the Andean region was developed based on simple and easily applied indicators. Effective policies are required to improve the feeding practices of pregnant women, increase breastfeeding and promote guinea pig raising for self-consumption and improve the nutritional status of children.

1. Introduction

Worldwide, almost 200 million children under 5 year of age suffer from stunting, emaciation, or a mix of both [1]. In Peru, the stunting average is 12%; however, it exceeds 33% in many rural areas, while it is 5% in Metropolitan Lima [2]. The average data covers extreme values, there are high Andean communities with more than 60% [3]. Stunting is closely related to the food insecurity of rural families in the central highlands, due to the limited availability and access to food of high nutritional value [4,5]; the little produced in their plots does not meet their food needs, one part is stored for a short period, being children the most vulnerable to an adequate consumption of protein food and sources of micro nutrients. Their diets are eminently energetic (potatoes, corn, barley), the consumption of meat, milk, eggs, fish, fruits, and vegetables is rare or nil [4,6].

Malnutrition is closely linked to poverty [1] and within health inequities, stunting responds to environmental and socioeconomic determinants [7–12], such as maternal education, home hygiene [13], age and sex of the child, period between births, age of the mother at the birth [14], the low birth weight and poor health of the pregnant [15]; therefore, in rural conditions, considering that the impact variable of the nutritional food system is stunting, this indicator must be correctly evaluated [16].

These health inequalities could be estimated in advance and prevent malnutrition in vulnerable populations, by identifying the main underlying determinants and risk factors for nutritional inequalities in children in Peru [17].

A limitation in the design and monitoring of public health policies is the lack of accurate and timely data [1] and the lack of conceptual models to explain, validate and project their results [18,19]. In Peru, most public policies and interventions in health and nutrition are not supported by scientific evidence [20,21]. There is sufficient scientific evidence on

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chronic undernutrition and its determinants, but for multiple reasons they may not be adequately used in the formulation of policies and interventions; their attention may be diverted to other particular or group interests, or respond to global pressures, and put at risk the objectives of sustainable development linked to nutritional food security. Another problem would be that scientific evidence is not adequately disseminated and political considerations continue to dominate, and even when scientists can specify the severity of nutrition and public health problems and predict risks, the adoption of policy responses is the responsibility of government leaders, with politicization of scientific and technical information being observed [22–25].

The magnitude of the effect of stunting determinants differs in the coast, highlands and jungle [22]; due to socioeconomic, cultural and geographic diversity [23]. Information about the immediate causes of stunting could be used to generate predictive models [26], that allow identifying high-risk communities to formulate nutrition policies that promote effective public health interventions [27].

In many studies carried out in high Andean communities in the Peruvian highlands, stunting is associated with mothers' educational level, with the consumption of colostrum, frequency of consumption of protein foods, correct feeding practices, complete vaccination, early stimulation, consumption of drinking water, correct elimination of excreta, food support and raising of minor animals [28,29]. associations that could be integrated into a mathematical model that allows, in advance, to identify children at risk of stunting.

A positive effect of maternal health education and behaviors on infant nutritional status is reported [13]. Higher educational level impact is explained by the means used by mothers to assume good dietary practices through an adequate choice, preparation and intrafamily distribution of food; that they are interested in and adequately use the information and nutritional warnings provided through different media (Reyes et al., 2019; Mancini et al., 2017) [30,31]. Regarding birth weight, included in several conceptual models of stunting depends directly on maternal nutrition; rural community health programs that consider nutritional supplementation to pregnant women allowed improving birth weight, decreasing the subsequent risk of poor growth and development (Mridha et al., 2016) [32]. On the other hand, in rural communities, improved small animal husbandry increased consumption and sales to buy other foods and improve dietary diversity and promoting animal protein, and micronutrient intake (Hossain et al., 2021) [33].

For these reasons, early identification and prevention of stunting in vulnerable populations should be a priority as outlined in the 2015–2030 Sustainable Development Goals [34]. Although, Peru has shown significant economic progress [35], with improvements in children's health and nutrition [36,37], many studies report differences in the distribution of stunting in the country, pointing out big gaps in stunting and anemia [38,39].

Regarding the development of predictive models, they were originally designed to study some diseases and public health problems [40, 41], but they can also be formulated to predict stunting [27,42].

In Peru, no similar studies have been carried out to predict stunting, therefore, the objective of this study was to formulate predictive models that can be used in the design and evaluation of strategies, scenarios, or policies that reduce the stunting in conditions of central highlands of Peru.

2. Methods

2.1. Study design and setting

The explanatory and predictive study is based on analysis of the data set of a cross-sectional study carried out in 380 rural families from 38 Andean communities in 15 districts of the central region from Peru, who have children under 5 years of age and with complete information in their anthropometric surveys and measurements.

The cross-sectional study population corresponded to 1050 peasant families with children under 5 years of age, and the sample size used was determined considering 38% prevalence of stunting in the Junín Region, following recommendations for studies of public nutrition in communities [43]. Data were collected using a structured questionnaire via a face-to-face interview.

2.2. Stunting indicators

The survey considered variables of food availability, access and use, as well as anthropometric information and Hemoglobin (Hb) concentrations [43,44]. Weight and height were measured using standardized procedures [45], and Hb concentrations were measured on a portable hemoglobinometer using capillary blood samples [46–48]. Anthropometric Z scores of the children were calculated based on the WHO 2006 growth standards, using the WHO AnthroPlus software [49].

2.3. Socioeconomic and agro-productive indicators

The mother's educational level was classified as low level and high level (without studies/primary and secondary/higher education), having farmland, bio-garden, and raising of major and minor cattle; the numerical indicators that were considered were: the number of family members, number of sleeping rooms, number of times a day of eating protein, energy and protective foods, birth weight, among others.

2.4. Stunting prediction models and statistical analysis

To determine the predictors of stunting we performed a univariate analysis using the Chi-square tests and Spearman's correlation; then, we performed a multivariate analysis. Variables with a $P < 0.05$ in univariate analysis were included in the logistic regression [50]. In final model, we used variables whose $P < 0.05$. The stunting prediction equations were developed using SPSS v.23.

2.5. Predictive model equation was

$$y = \frac{1}{1 + e^{-f(x)}}$$

where: $f(x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \ldots + \beta_n x_n$

To evaluate the overall robustness and goodness of fit of the developed models, the Hosmer and Lemershow test, which compares the observed probability of stunting risk with the expected probability and evaluates the fit of the data; the Nagelkerke R-squared, which indicates the variance of stunting explained by the model; and the overall percentage prediction values were used.

The significance of the regression coefficients used in the models was considered with a confidence level of 95%.

The first predictive model included as dichotomous exogenous variables, colostrum consumption within the first 6 h after birth, family farmland, family bio-garden, raising cows, sheep, pigs, guinea pigs or chickens, and if the child had anemia.

The second predictive model, in addition to the first, included as exogenous polytomous variables at the mother age ($<30>$ years), maternal educational level (No education/primary and secondary/higher), marital status (single, cohabiting, married), sex of the child, housing (own, rented or from the parents), the place where they excrete their excreta (conventional or open ground bathroom), the birth weight of the evaluated child ($<2.5>$ kg), and the frequency of consumption of the main foods.

The third predictive model included additional numerical exogenous variables: number of family members, rooms used by the family only for sleeping, maternal age, age of exclusive breast milk, times of consuming protein and protective foods per day, birth weight and altitude-adjusted blood hemoglobin concentration [51], in accordance with the WHO indications [52].

3. Results

3.1. Sample characteristics

The peasant families of the Central Andes of Peru descriptive variables are displayed in Table 1. Of total mothers 52.1% are of lower educational level (without studies/primary); their houses are mostly rustic material, with few rooms to sleep. 41.1% do not have a bathroom and eliminate their excreta in the open ground. A deficient consumption of protective foods (fruits and vegetables) and protein is evident, while all the meals of the day contain mainly potatoes (95%), with little consumption of red meat (4.5%), chicken (5.3%); with a higher consumption of guinea pig meat (17.7%) in families that have their raising. Regarding stunting, 11.6% had severe stunting, 26.6% had stunting and 35.3% were at risk of stunting, and 26.6% had a normal height/age condition.

3.2. Stunting, anemia and socioeconomic and agro-food indicators

Stunting prevalence was 40.3% and anemia prevalence was 62.9%. Of children 63.9% intake colostrum within the first 6 h of birth. The all families 71.6% have farmland on which they generally plant potatoes, corn, barley and broad beans, 24.5% have a bio-garden, 44.7% raise cows, 34.7% raise sheep, 29.2% raise pigs, 40% raise chickens/hens, and 63.7% raise guinea pigs for self-consumption and sale.

3.3. Variables associated with stunting

The variables evaluated that had significant associations with stunting are shown in Table 2. The variables that had a significant association were included in the generation of the prediction models.

3.4. Stunting prognosis with dichotomous exogenous variables

Dichotomous variables processed to generate this first model were the timely consumption of colostrum, the presence of anemia in child, the familiar possession of farmland and bio-garden, raised cattle, sheep, pigs, guinea pigs and poultry on their family farms.

Of the nine variables this first predictive model considered only two variables that showed a significant association with stunting ($P < 0.05$) the timely colostrum consumption (COC) within of the first 6 h after birth, and family guinea pig raising (RGP) (Table 3).

$$f(x) = 3.928 - 1.417(COC) - 1.137\ (RGP)$$

Predictive model of stunting with dichotomous variables:

$$y = \frac{1}{1 + e^{-(3.928-1.417(COC)\ -1.137\ (RGP))}}$$

Nagelkerke R square was 0.216, this value indicating the part of the stunting variance explained by the model. Hosmer and Lemeshow test, was 0.917, and overall percentage correctly classified was 68.4; values indicative of not being an adequate model to predict stunting in the context of the study.

The exponential values of B (Exp B) indicate the strength of the relationship and are multivariate OR values. An OR 0.242 indicates that when the child has not consumed colostrum in a timely manner (1/0.242 = 4.13) it has a 4.13 times greater chance of having stunting compared to one that has consumed colostrum in a timely manner. The OR 0.321 (1/0.321 = 3.12) for guinea pig raising indicates that when the child's family does not raise guinea pigs, the child is 3.12 times more likely to have stunting.

3.5. Stunting prognosis including polytomous exogenous variables

The variables included to generate this second model, in addition to significant variables in the first model, were the mother's age group, the mother's educational level, marital status, the sex of the child being evaluated, the tenancy regime of the house, the place where they deposit their excreta, classification of weight at birth and the frequency of consumption of the main protein, energy and protective foods.

Five variables showed significance in this second model (Table 4).

Predictive model based on polytomous and dichotomous variables:

$$y=\frac{1}{1+e^{-2.836+0.68(\mathrm{ME})+0.373(FS)-1.359(COC)+0.817(\mathrm{BW})-1.215(DCpotato)-0.305(DCegg)-1.147(\mathrm{RGP})}}$$

Nagelkerke R square was 0.293. Hosmer and Lemeshow test was 0.483, and overall percentage correctly classified was 72.9; these values show that it is a better model than the previous one but it is not reliable.

The highest ORs are observed in the predictor variables of timely consumption of broth, daily potato consumption and family raising of guinea pigs for self-consumption.

3.6. Stunting prognosis including numerical exogenous variables

Numerical variables included to generate this third model, in addition to the significant variables included in the second model, were number of

Table 1
Descriptive statistics variables of the peasant families of the Central Andes of Peru.

Variables	Min	Max	Average	S.D.
Mother's age	16.00	45.00	29.74	7.15
Number of family members	2.00	12.00	5.28	1.81
Number of sleeping rooms	1.00	6.00	2.04	1.09
Number of times of eating protein food per day	0.00	7.00	2.14	1.30
Number of times of eating protective foods a day	0.00	8.00	1.37	1.32
Birth weight of evaluated children (grams)	2000.00	4800.00	3029.79	449.82
Average number of cows per family	0.00	9.00	1.14	1.60
Average number of sheep per family	0.00	80.00	3.54	9.06
Average number of pigs per family	0.00	15.00	0.65	1.43
Average number of guinea pigs per family	0.00	100.00	6.47	10.16
Average number of birds per family	0.00	21.00	2.02	3.45
Weight of the evaluated child, kg	2.60	21.50	10.93	3.07
Height of the evaluated child, cm	47.00	113.20	80.52	12.48
Child's Hb level, adjusted for altitude, mg/dl	5.20	16.10	10.41	1.70
Height Z-score for age (WHO 2006)	−5.66	2.48	−1.69	1.28
Stunting prevalence. %	–	–	40.3	-
Anemia prevalence, %	–	–	62.9	-

family members, number of sleeping rooms only, final age of exclusive breastfeeding, number of times protein and protective foods consumed per day, birth weight in grams, altitude-adjusted Hb level, and mother's age in years.

This stunting prediction model included four variables that showed a significant association with stunting (Table 5). Of the approximately 30 variables evaluated, this model, which had the best fit, chose maternal education level, timely consumption of colostrum, birth weight and family raising of guinea pigs for self-consumption.

Predictive model of stunting based on polytomous, dichotomous and numerical variables:

$$y = \frac{1}{1 + e^{-(7.194 - 0.658(ME) - 1.321\ (COC) - 0.002(\mathrm{BW},\mathrm{g}) - 1.07(RGP))}}$$

Nagelkerke R square was 0.345. Hosmer and Lemeshow test was 0.967, and 74.5% overall percentage correctly classified; these values show that it is a better and reliable model than the previous models. The highest ORs are observed in the predictor variables of timely colostrum consumption, guinea pig raising, and maternal education. The lower OR was observed in birth weight. These four criteria make it possible to determine stunting in children under 5 years of age in rural high Andean areas of Peru.

3.7. Goodness of fit of models

Of the three prediction models generated in this study, the first, based on dichotomous variables, had the lowest reliability (Hosmer and Lemeshow test = 0.927), with a sensitivity of 68.4%; the second, which included some polytomous variables, had 0.483 of reliability, with 72.9% of sensitivity, and the third model, which additionally included birth weight as a numerical variable, had 0.967 reliability, with 74.5% sensitivity, being the best prediction model to determine the probability of a child under 5 years of age being stunting in the rural conditions of the central Andean highlands of Peru.

4. Discussion

Our findings confirm that rural families in the Peruvian highlands have very similar characteristics regarding lifestyle, housing characteristics, raising, crops, food and health practices [4], The food base of these populations is mainly given by potatoes and secondly by corn, and the frequency of consumption of fruits and vegetables is low or nil in some cases [13].

In the central region of Peru, stunting continues to be a serious problem that deprives a child of its right to grow and prosper [53]; the prevalence of stunting in this study was higher than the national average in rural area (25.6%), reported for the first half of 2018 [54]; it was also higher than the Junín region average for 2017 (17.3%); result indicative of the severity of stunting in the central highlands of Peru, as indicated by other studies [4,13,28,29], In this regard, the World Health Organization [55], indicates that the prevalence is very high when it exceeds 40% and interventions that counteract the problem should be carried out.

The early identification of younger children at high risk of stunting in the Peruvian highlands can be determined through the use of predictive models that consider variables closely linked to their socioeconomic and agro-productive context, as it is intended to demonstrate with this study.

The predictive model of stunting was developed taking into account a series of polytomous, dichotomous, and numerical variables that showed significant associations with stunting, including the consumption of colostrum at the correct time, the possession of farmland in which sows food for self-consumption and sale, the possession of a bio-garden to produce vegetables to incorporate in the daily diet, the raising of cows, sheep, pigs, guinea pigs and birds, the maternal educational level, birth weight of the child. After statistical processing, the predictive capacity that suggests the existence of a cause-effect relationship was determined [56].

Table 2
Stunting and its association with the variables evaluated.

Variable	Stunting, %		r	P-value
	Yes	No		
Timely consumption of colostrum	28.0	72.0	−0.333**	0.000
Non-timely consumption of colostrum	62.0	38.0		
Sex of child tested (male)	44.3	55.7	0.079	0.126
Sex of child tested (female)	36.5	83.5		
Birth weight (less than 3000 g)	52.1	47.9	0.210**	0.000
Birth weight (greater than 3000 g)	31.3	68.7		
Child have anemia	42.7	57.3	0.064	0.212
Child does not have anemia	36.2	63.8		
Maternal education (secondary & higher)	30.2	69.8	0.196**	0.000
Maternal education (No education & primary school)	49.5	50.5		
Mother's age (less than 30 years old	41.6	58.4	0.313	0.576
Mother's age (over 30 years)	38.8	61.3		
Marital status (Married)	37.0	63.0	−0.040	0.440
Marital status (Single or cohabiting)	41,4	58.6		
Ownership of farmland	39.0	61.0	−0.042	0.416
Ownership of farmland	43.5	56,5		
Ownership of vegetable garden	37.2	62.8	−0.041	0,247
Do not have a vegetable garden	41.6	58.4		
Raise guinea pigs	30.2	69.8	−0.273**	0.000
Do not raise guinea pigs	58.0	42.0		
Do not raise guinea pigs	40.8	59.2	0.009	0.865
Do not raise chickens/hens	39.9	60.1		
Raise pigs	39.6	60.4	−0.008	0.874
Do not raise pig	40.5	59.5		
Raise cows	37.6	62.5	−0.48	0.351
Do not raise cows	42.4	67.6		
Raise sheep	41.7	58.3	0.021	0.685
Do not raise sheep	39.5	60.5		

r = Spearman correlation.

Table 3
Predictive model components of stunting with dichotomous variables.

Variables	β	Standard Error	Wald	DF	*P*-value	Exp (*β*)
COC[a]	−1.417	0.235	36.326	1	<0.01	0.242 (4.132[c])
RGP[b]	−1.137	0.235	23.381	1	<0.01	0.321 (3.115[c])
Constant	3.928	0.494	63.199	1	<0.01	50.875

Nagelkerke R square = 0.216.
Hosmer and Lemeshow test = 0.917.
Overall percentage correctly classified = 68.4.
[a] Colostrum Consumption within the first 6 h after birth (Yes = 1, No = 2).
[b] Raising Guinea Pigs for family consumption (Yes = 1, No = 2).
[c] 1/Exp(β).

Table 4
Predictive model components of stunting with polytomous and dichotomous variables.

Variables	β	Standard Error	Wald	DF	*P*-valor	Exp (β)
ME[a]	0.680	0.242	7.930	1	<0.01	1.974
FS[b]	0.373	0.241	2.396	1	0.122	1.452
COC[c]	−1.359	0.246	30.642	1	<0.01	0.257 (3.891[g])
BW[d]	0.817	0.246	11.005	1	<0.01	2.264
DC[e] potato	−1.215	0.552	4.835	1	0.028	0.297 (3.367[g])
DC[e] egg	−0.305	0.265	1.329	1	0.249	0.737 (1.357[g])
RGP[f]	−1.147	0.246	21.766	1	<0.01	0.318 (3.145[g])
Constant	2.836	1.029	7.592	1	<0.01	17.047

Nagelkerke R square = 0.293.
Prueba de Hosmer y Lemeshow = 0.483.
Overall percentage correctly classified = 72.9.
[a] Maternal Education: Secondary or higher (Yes = 1, No = 2).
[b] Female Sex (Yes = 1, No = 2).
[c] Colostrum Consumption within the first 6 h after birth (Yes = 1, No = 2).
[d] Birth Weight, <3 kg (Yes = 1, No = 2).
[e] Daily Consumption (Yes = 1, No = 2).
[f] They raise guinea pigs for family consumption (Yes = 1, No = 2).
[g] 1/Exp(β).

Table 5
Predictive model components of stunting with polytomous, dichotomous and numerical variables.

Variables	β	Standard Error	Wald	DF	*P*-valor	Exp (β)
ME[a]	−0.658	0.246	7.156	1	<0.01	0.518 (1.931[e])
COC[b]	−1.321	0.251	27.635	1	<0.01	0.267 (3.745[e])
BW[c]	−0.002	0.000	29.495	1	<0.01	0.998 (1.022[e])
RGP[d]	−1.070	0.252	18.083	1	<0.01	0.343 (2.915[e])
Constant	7.194	1.043	47.561	1	<0.01	1331.516

Nagelkerke R square = 0.345.
Prueba de Hosmer y Lemeshow = 0.967.
Overall percentage correctly classified = 74.5.
[a] Maternal Education: Secondary or higher (Yes = 1, No = 0).
[b] Colostrum Consumption within the first 6 h after birth (Yes = 1, No = 0).
[c] Birth Weight (grams).
[d] Raising Guinea Pigs for family consumption (Yes = 1, No = 2).
[e] 1/Exp(β).

Under the conditions of the study, the low maternal educational level, the lack of exclusive breastfeeding or continued breastfeeding, the decreased birth weight and the raising of guinea pigs are risk factors for stunting, according by UNICEF [1], who point out as a risk factor for stunting the lack of exclusive breastfeeding or continued breastfeeding, since breastfeeding favors the child's immune health, brain development, improves school performance and favors obtaining higher incomes in adulthood [56]. It is important to consider that, at the national level, in the first half of 2018, 67.9% of mothers fed children under six months of age with breast milk, the highest practice in rural areas (81.3%) than in the urban area (62.2%) [54], however, it is important to consider adequate and timely consumption of colostrum.

Regarding maternal educational level and birth weight, various studies have shown their association with stunting [7,11,13]. For the first quarter of 2018, the INEI reports that the percentage of children under 5 years of age with stunting of mothers without study or primary was 26.2% and for those of secondary and higher education 7.7%; characteristic closely related to stunting, being an important component of the predictive model created in this study [54].

A new variable that appears in the predictive model determined in this study is the raising of guinea pigs at the family level, which constitutes a high quality protein source for young children [1], being a risk factor for stunting (Table 4); being important to cover child nutrition from the community through family food diversification, such as raising small animals for self-consumption [57]; and contributing to the achievement of Sustainable Development Goals, giving greater attention to the nutritional needs of children, guaranteeing access to safe, nutritious and sufficient food throughout the year [58]. The predictive model developed will allow the risk of stunting to be detected in time.

4.1. Political implications

Although, Peru has been showing greater economic access that allows the reduction of nutritional deficiencies [53,59,60], stunting maintains a heterogeneous distribution with greater disparities in the rural highlands [54,61,62], where we have identified a high prevalence of stunting in child of mothers without studies or with only primary education, in children with inadequate birth weight and who do not consume colostrum in a timely manner, and in families that do not raise guinea pigs for self-consumption.

In this context, the mathematical model developed in this study allows predicting stunting in children under 5 years of age in the Andean highlands from simple and easy to collect information. Early identification of the children most likely to present stunting will allow better targeting [63] to implement improvement actions that contribute to food security and fulfillment of the sustainable development objectives [58].

This model could be used in rural health centers as public policy in the fight against stunting and to this end, governors should rely on this type of scientific and technical proposals [24,25], and promote their validation and use.

4.2. Strengths and limitations

The main strength of the present study is the use of data from a representative sample of the Peruvian central highlands, collected directly, using standardized methods to collect the analyzed variables. A multivariate analysis was used to establish the mathematical prediction models. On the other hand, the study has had some limitations. Firstly, it responds to a transversal study and it would have been desirable for it to be prospective but it is more expensive. Secondly, other limitation would be the use of verbal information provided by mothers of family regarding agro-productive variables.

A further limitation would be, the models generated in this study are based on a data set that is not as large in comparison to other studies aimed at predicting health problems; but they can be generalized to rural populations in the Peruvian highlands, due to similar lifestyle conditions, diet and lifestyles.

5. Conclusions

This study of the main determinants favoring stunting in the rural Andean zone allows the proposal of a predictive model based on covariates that are easily measured in health centers or during community vaccination campaigns. It is also the first to propose an important tool for use in screening for stunting risk in this context, based on information on maternal education, timely consumption of colostrum, birth weight, and guinea pig breeding for self-consumption.

There are no adequate published models to predict the risk of stunting in a rural population under 5 years of age in developing countries, especially in high Andean areas of agricultural vocation with subsistence production. We therefore propose a simple and effective predictive model of stunting risk that will require a validation study in a rural population different from the one used to generate the model. This model would be a useful public nutrition tool to target the at-risk child population, reduce the high prevalence of stunting, and reduce child morbidity and mortality in rural areas of developing countries.

There is insufficient evidence to support the inclusion of other predictors of stunting risk in rural conditions where the study was conducted, being the study novelty the importance of guinea pig breeding to improve the children nutritional status in Peruvian highlands.

Ethics of human subject participation

The research followed the ethical guidelines established for these studies. Families signed an informed consent form authorizing their voluntary participation in the survey and for the taking of anthropometric measurements and sampling of a drop of blood for the measurement of hemoglobin from their children under 5 years of age. The study was approved and registered by the Center for Research on Food and Nutritional Security of the National University of Central Peru (Code No. 072016103631).

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of competing interest

The authors declare that they have no competing interests.

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