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ARTICLE

Climatic Variables and Food Security of Villagers during the COVID-19 Pandemic in the Districts of Huancayo, Peru

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ABSTRACT

The study investigated the relationship between climatic variables and food security in households in the districts of Huancayo (Chongos Alto, Viques, Pucará, and Huancayo) during the COVID-19 pandemic. A cross-sectional observational study was conducted with a sample of 272 households out of 36,453. Food security data were collected through questionnaires, and climatic variables (temperature, humidity, and precipitation) were obtained from CEPREANDES weather stations between September 2020 and February 2021. The results showed that 44.49% of households experienced mild food insecurity, while 55.5% experienced moderate food insecurity. Recorded climatic conditions included maximum temperatures of 28 °C in Pucará and 27 °C in Huancayo, and a minimum of −8 °C in Chongos Alto. Relative humidity reached 89% in Pucará and 87% in Chongos Alto and Huancayo, while maximum rainfall was 28 mm in Chongos Alto and 23 mm in Huancayo. Multivariate analysis revealed that relative humidity had a significant association with moderate food insecurity (B = 16.406; 95% CI: −64735 to 64768), increasing the risk 16 times under high humidity conditions. No significant relationships were found with temperature (B = −7.107; 95% CI: −77320 to 77306) or precipitation (B = −7.831; 95% CI: −25690 to 25674). It was concluded that relative humidity is a key factor in food security, particularly during

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the pandemic, while other climatic variables showed no significant impacts. These findings highlight the need for urgent adaptations to climatic challenges in vulnerable contexts.

Keywords: Food Security; COVID 19; Epidemiological Map; Climatic Factors

1. Introduction

The food security situation in Peru shows problems of contagion by COVID-19 in food chains, due to the lack of control in markets, which would lead to a lack of safety and a decrease in food availability [1].

According to the Food and Agriculture Organization of the United Nations (FAO), since the 1996 World Food Summit (WFS), food security 'at the individual, household, national and global levels is achieved when all people, at all times, have physical and economic access to adequate, safe and nutritious food to meet their dietary needs and preferences for a healthy, active and healthy life.

In Peru, it is poverty, which refers to the economic inability to buy a basic food basket, coupled with the health crisis that makes it difficult to transport food to markets, as well as to mobilize the necessary inputs for agricultural production, which will affect food production and producers' incomes [2]. There is a close relationship between anemia, poverty and lack of knowledge about healthy eating. Falling incomes and changes in food prices lead to changes in the composition of the diet, resulting in reduced portion sizes, but also in lower quality of food [3].

Food instability caused mainly by the pandemic has led to uncertainty about the availability and accessibility of food, and the population's ability to access it [2]. Pandemic-related food insecurity can be classified as short-term transient and temporary food insecurity. Transient food insecurity is relatively unpredictable but can be both sudden and chronic (long-term/persistent) mainly in developing countries [4].

The components of household food security depend on a supply of safe and nutritious food for the whole family; stability of the family's food supply throughout the year and from year to year; and that each family member receives enough food to meet their nutritional needs; not only physical, but also economic and social acquisition of culturally acceptable food [5]. Growing food in the field must be healthy food (avoiding exposure to pests or pesticides or contamination by harmful pesticides), harvesting, transporting food, storing, processing and selling. Food should meet the basic micronutrient and energy needs of all members of the family, as well as ideal tastes or quantities [6].

The situation of food insecurity among the children of landless farmers and the children of seasonal workers is increasing. These children are susceptible to food insecurity and nutritional risks during the first years of life, as shown by the mortality rate. On the other hand, the level of food security depends on the sanitation status of the household to provide better nutrition for children. It also depends on nutritional knowledge, control of household resources and the availability of certain consumption goods and services. Also, women in poor households are more susceptible to income reduction and their workload is more affected by situations such as poor health, falling prices, and access to services [7].

Food is the main source of exposure to pathogens, both chemical and biological (viruses, parasites and bacteria). When contaminated with pathogens and chemicals at unacceptable levels or with other hazardous properties, they present health risks to consumers [8]. Although it is highly unlikely that COVID-19 is transmitted through food or food packaging, as coronaviruses cannot replicate in food, as they require an animal or human host to do so; however, food can be contaminated by unsanitary hands of agricultural harvesters, processors, and people preparing and serving food in restaurants and in the home due to the stability of SARS-CoV-2 on surfaces; thus, indirect transmission of the virus is possible [9].

Agriculture is a fundamental activity for human development, as it provides food, and in many cases, it is the main source of food consumption and sustenance for several households. Food supply is strongly linked to agriculture, as this sector is responsible for producing and marketing food. According to the FAO, 80% of food comes from family farming; however, one of the challenges it must face is climate change, which affects the yield of agricultural production in different ways and these effects can lead to changes in the livelihoods of people who depend on agriculture and thus

their food security[10].

On our planet there are several different climatic zones for each geographical space; this can happen due to a wide range of factors that can affect every condition, such as temperature, humidity, pressure, wind, precipitation, solar radiation, etc. Those are the geographical factors[11]. Coronavirus transmission can be affected by several factors, including weather and climate[12]. Climatic factors can play an important role as they have an impact on the transmission, spread and survival of the coronavirus[13].

Optimal climatic parameters such as temperature, wind speed, relative humidity and precipitation can be considered as major variables that trigger the existence and spread of viruses[14]. Researchers report in their study on food security in Asia and the Pacific in the midst of the COVID-19 pandemic. They note that strict quarantine measures have affected food supply chains and also point out that nutrition and household food consumption have been affected by loss of jobs and income and limited access to food. They warn that prolonged blockade, shortages of lab our and input supplies can reduce the scale of crop production[14]. In the UK, increased unemployment, reduced working hours and enforced self-isolation can lead to increased food insecurity, exacerbating diet-related health inequalities[15].

In research conducted in the state of Vermont on the impact of COVID-19 on food insecurity, 3219 people were surveyed. They concluded that since the declaration of the pandemic there has been a significant increase in food insecurity in Vermont, accompanied by significant barriers to food access with potential impacts on individual health, including mental health and malnutrition, as well as on future health costs[16].

Studies in El Salvador[17] on food and nutrition security from the perspective of the COVID-19 pandemic found that 36% of adults are food secure, 20% are marginally food secure and 44% are food insecure. It noted that the short-term effects of the COVID-19 pandemic are disproportionately affecting low-income and food-insecure households already struggling to meet basic needs[18]. Recent research assessing insecurity found that loss of employment during the pandemic was an influential factor in increasing food insecurity[1].

Studies conducted in the country on an assessment of household food security in Lima during the 2020 COVID-19 quarantine adopted a descriptive, cross-sectional, non-experimental design for a sample of 232 people surveyed using virtual questionnaires to assess food security. The questionnaire was adapted and validated according to the Latin American and Caribbean Food Security Scale (ELCSA)[19], which covers 5 dimensions: availability, accessibility, use, stability and institutionality. As a result, 29.3% of Lima households were in mild food insecurity (FSI) and 15.5% in moderate food insecurity (MFI). 30.2 % of the access dimension was found in FSI and 5.6% in MFI. 5% related to the availability dimension found in LAI, 20.3% in LAI, 3.9% in AMI and 3.9% in severe food insecurity (FSI); in the stability dimension, 8.2% in mild food insecurity (FSI) in the institutional dimension and 65.3% in Lima families live with food security. It was concluded that 34.7% of Lima households were food insecure during the quarantine period[20]. The report carried out by the Ministry of Development and Social Inclusion together with the World Food Program me on the assessment of food security in Peru, taking poverty, child malnutrition, lack of access, availability and limited food consumption as indicators. The publication of the Map of Vulnerability to Food Insecurity focused at local, district, provincial and departmental levels identified that in the province of Huancayo, the districts of Chongos Alto have a high level of food insecurity, Pucará has a medium level of food insecurity, Viques has a medium level of food insecurity and Huancayo has very low levels of food insecurity[21]. The COVID-19 pandemic situation would exacerbate food vulnerabilities due to restrictions in food production or limited economic access, affecting the quantity and quality of food consumed. Ministry of Women's Development and Social Inclusion.

2. Materials and Methods

The present study was carried out in the districts of Huancayo (Chongos Alto, Viques, Pucará and Huancayo), Region: Junín, Peru. Geographical location. Chongos Alto at an altitude of 3538 masl, Viques at 3182 masl, Pucará at 3350 masl and Huancayo at 3256 masl. The study areas were chosen based on the high prevalence of chronic malnutrition and its association with food insecurity[22].

The research was done through direct observation and household interviews in the districts of Huancayo. The study

was carried out using scientific methods as a support, as it is a social, planned and controlled cognitive process to verify hypotheses, explain facts and problems of reality through the acquisition of new knowledge. A quantitative approach was employed, using collection instruments to establish the relationship between food security and climatic factors.

The study used analytical, observational, cross-sectional design, as it was a research study in which the variables were not manipulated, and the phenomena were observed in their natural form and then analyzed. Variables under study: 1. Food security with the following dimensions: availability, accessibility, use and stability considering eight dependent variables. 2. Climatic factors with the dimension of the analysis of climatic variables and considering three independent variables [22].

The target population of the study consisted of households belonging to the districts of: Chongos Alto, Viques, Pucará and Huancayo. The sample size was obtained by considering the total number of households in the four districts, an adjustment was made using the statistical formula used in opinion polls, in this case the confidence is 95% and the error is 5%. Simple random sampling. The data collection technique for the dependent variable was a survey to collect information on the dimensions of food security, considering the availability, accessibility, use and stability of food, as well as data on the state of health and general aspects of the household and its economy. The survey consisted of 40 questions related to the dimensions of food security such as: availability, accessibility, use and stability of food; the questions were closed and open, coded and specific for each of the sections. Moderate and mild food insecurity and prevalence is based on the Food Insecurity Experience Scale (FIES). It is constructed using the FIES Survey Module, which consists of eight questions relating to people's access to adequate food and can be easily integrated into various types of population surveys. Based on the measure, the degree of severity can be identified, with moderate food insecurity being a situation in which people face uncertainty about their ability to obtain food and are forced, at certain times of the year, to reduce the quantity or quality of the food they consume. This is due to lack of money or other resources. While severe food insecurity is a situation where people are likely to have run out of food, suffer from hunger and, in the most extreme case, go for days without food, putting their health and well-being at serious risk [23].

Data on nutritional food security variables were collected in the household interview. Data on climate variables were collected on a data collection sheet from the weather stations of the Centre for the Prevention of Risk Management (CEPREANDES), including maximum temperature, minimum temperature, relative humidity and precipitation [22].

The data were entered into a database in the Jamovi software version 26, and quality control was carried out based on the periodic review of 10% of the interviews at random. The statistical analysis consisted of a first stage of descriptive analysis, obtaining summary measures and frequency distribution. The bivariate analysis consisted of determining the association of climate variables with food security in the context of COVID-19. A logistic regression test was used with a significance level of 5%. A measure of strength of association was also calculated as a prevalence ratio with 95% confidence intervals. Finally, a logistic regression model was constructed to develop and verify the reliability of the instruments. By Cronbach's Alpha reliability coefficient of the instrument found in the research, the instrument ranges from 0.72 to 0.99 which shows that the instrument has excellent reliability and is applicable to the study sample.

3. Results and discuss

3.1. Food Safety

3.1.1. Head of Household

The results obtained regarding who is the head of the household by district, in which 78.1% reflect that it is the father and 21.9% is the mother in the district of Huancayo. Likewise, for the district of Pucará, 85.5% is the father and 14.5% is the mother. For the district of Chongos Alto, 88.9% is the father and 11.1% is the mother, and finally for the district of Viques, 86% is the father and 13.4% is the mother.

Occupation of the Head of Household

The results obtained regarding the occupation of the head of household by district show that 35.6% of the head of household is an employee, 24.7% is a worker, 20.5% is a trader and 13.7% is a driver in the district of Huancayo. Likewise, for the district of Pucará, 53.6% are farmers, 15.9% are traders and workers and 7.2% are employees. For the district

of Chongos Alto, 55.6% are farmers, 28.6% are workers, 7.9% are traders, 6.3% are drivers and 1.6% are teachers. Finally, for the district of Viques 47.8% are farmers, 25.4% are workers, 13.4% are drivers, 9.0% are traders, and 4.5% are teachers.

3.1.2. Frequency of Food Consumption

Carbohydrates

The source of carbohydrates with the highest daily consumption in the four districts was potato with 98%, 98.6%, 100 and 95.5% in Huancayo, Pucará, Chongos Alto and Víques respectively. According to FAO (2014), this tuber is one of the main sources of food for the world's population after maize[23]. Potato consumption in Peru reached 85 kg/person in 2015, due to factors such as public policy, the increase in trade of this tuber, as well as the consumption of various Andean dishes that include potatoes[24].

The Ministry of Agriculture and Irrigation (Minagri) indicates that national consumption of milled rice increased by 50% over the last 15 years, from 1.2 million tonnes in 2002 to 1.8 million tonnes in 2016. These values are reflected in the results obtained, since, as can be seen, there is high rice consumption in the areas where work was carried out. It also coincides with that reported by the National Institute (2009), which indicates an average consumption of 47.6% in urban areas and 36.2% in rural highlands. Andean cereals such as cañahua are not consumed and quinoa is consumed infrequently 4.8% and 3.0% in Chongos Alto and Víques.

Fats and Lipids

There is higher daily consumption of oil in the four districts 97.3%, 92.8%, 93.7% and 95.5% compared to the consumption of animal fats such as butter 2.7%, 0.0%, 0.0% and 3.0% in Huancayo, Pucará, Chongos Alto and Víquez respectively. According to the National Institute of Statistics and Informatics (2009), there is a higher consumption of oil than animal fats; this is in line with the findings of the present study.

Proteins

Of vegetable origin. Beans are consumed once or twice a week and more frequently in the district of Huancayo 78.1% followed by Chongos Alto 79.4%, Viquez 76.1% and Pucará 69.6%. The other legume is the broad bean, consumed most frequently in the district of Chongos Alto 97.2%, followed by Viques 83.6%, Pucará 82.6% and 78% in Huancayo. Nutritionally, pulses stand out for their high protein content, between 15 and 40%, with a high content of lysine and threonine, amino acids in which cereals are deficient. The UN reports that pulses are natural foods of vegetable origin with a large amount of different nutrients such as protein, minerals, fibre and antioxidants. In addition, the Food and Agriculture Organization of the United Nations (FAO) reports that by eating plenty of fibre, regular consumption will help prevent cardiovascular diseases, such as obesity, diabetes and cancer.

Animal origin. Poultry is consumed more frequently on a daily basis 67.1%, 18.8%, 1.6% and 37.3% in Huancayo, Pucará, Chongos Alto and Víquez, respectively, followed by milk, eggs and cheese. Viscera provides iron and are consumed with a frequency of 1 to 2 times per week in Víquez 71.6%, followed by Huancayo district with 68%. The frequency of fish consumption once or twice a week is 87.7%, 37.7%, 42.9% and 56.7% in Huancayo, Pucará, Chongos Alto and Víquez respectively; the highest frequency of consumption is in Huancayo. According to the National Institute of Statistics and Informatics (2009), the highest consumption of fish is in quintiles IV and V, coinciding with the results of the highest consumption in Huancayo compared to the other districts. However, the frequency of poultry consumption is lower in Huancayo compared to the other districts 32.9%, 71.0%, 90.5%, 47.8% Huancayo, Pucará, Chongos Alto and Víques respectively. The frequency of egg consumption is 78.1%, 84.1%, 92.1% and 70.1% in Huancayo, Pucará, Chongos Alto and Víques respectively, these results indicate that the frequency is higher in the districts farther from the city. Guinea pig is consumed more frequently in Chongos Alto 76.2% than in the other districts.

Vitamins and Minerals

The source of vitamins with the highest daily consumption in the four districts were fruits 83.6%; 79.4%, 79.4%, 78.3% and 64.4% in Víques, Chongos Alto, Pucará and Huancayo respectively. With respect to vegetables, consumption every day is 89% in the district of Huancayo, followed by Pucará 87%, Chongos Alto 71.4% and Víques 59.7%. Fruits and vegetables are important in daily consumption as they are essential foods in the human diet since they provide a large amount of nutrients necessary for the normal functioning of the organism. In general, a variety of fruits and vegetables rich in water help to stay hydrated, these foods are rich in

vitamins A, C, E, K and B complex. Fruits, especially citrus fruits, are also excellent sources of folic acid.

3.2. Economic Access

3.2.1. Main Work of the Family

The results obtained with respect to the family's main job by the district show that 46.6% of the family's main job was a public or private employee and 3.2% was dedicated to sales or service in the district of Huancayo. Likewise, in the district of Pucará, 56.5 % of the main job was in agriculture and 15.9 % was a laborer. For the district of Chongos Alto, 55.6% of their main job was agricultural activity; 3.2% and 25.4% were laborers. Finally, for the district of Viques, 44.8% of their main job was in agriculture and 20.9% were public or private employees.

3.2.2. Economic Income

The monthly income of households by district, 71.2% have an income greater than $257 dollars and 17.8% have an income between $177 and $257 dollars in the district of Huancayo. Likewise, for the district of Pucará, 34.8% have an income between $97 to $189 dollars; 24.6% have an income between $177 to $257 dollars; 20.3% have an income between $27 to $97 dollars and more than $257 dollars. For the district of Chongos Alto, 38.1% have an income between $27 and $97 dollars; 31.7% have an income between $97 and $180 dollars. Finally, for the district of Viques, 35.8% have an income between $27 to $97 dollars; 28.4% have an income between $97 to $180 dollars and 20.9% have an income between $177 to $257 dollars.

3.2.3. Spending on Food

The weekly expenditure on family food by district, in which 98.6% have an expenditure greater than $23 dollars in the district of Huancayo. Likewise, for the district of Pucará, 76.8% spend more than $23 dollars and 21.7% spend between $18 and $23 dollars. For the district of Chongos Alto, 58.7% spend more than $23 dollars; 33.3% spend between $17 and $23 dollars. Finally, for the district of Viques, 44.8% have an expenditure greater than $23 dollars; 23.9% have food expenditures between $17 to $23 dollars and less than $23 dollars.

4. Food Production and Availability

4.1. Availability of Land for Cultivation

The availability of land for cultivation by district in which 97.3% in the district of Huancayo has land for cultivation. Likewise, 85.2% in Pucará, 77.8% in the district of Chongos Alto and 70.7% in the district of Viques have land available for cultivation.

4.2. Biogarden to Grow

In the district of Huancayo, 12.3% of the respondents' households have a family bio-garden, while 62.3% in Pucará, 57.1% in the district of Chongos Alto and 49.3% in the district of Viques have a family bio-garden. Likewise, 62.3% in Pucará, 57.1% in the district of Chongos Alto and 49.3% in the district of Viques have a family bio garden.

4.3. Destination of Food Production

The destination of agricultural production by district, in which 100% is destined for self-consumption and sale, due to the fact that only two households in the district of Huancayo have agricultural land. Likewise, in the district of Pucará, 55.4% is destined for self-consumption and sale, 42.9% is destined only for self-consumption and 1.8% is destined for sale. In the district of Chongos Alto, 59.2% is used for self-consumption and sale and 40.8% is used only for self-consumption. Finally, in the district of Viques, 63.0% of the land is used only for self-consumption, 34.8% for self-consumption and sale and 2.2% for sale.

4.4. Destination of Animal Husbandry

The destination of livestock raising by district, in which 95.7% is for self-consumption and 4.3% is only for sale. Likewise, in the district of Pucará, 58.1% of the animals are for self-consumption and 41.9% are for self-consumption and sale. In the district of Chongos Alto, 62.5% is used for self-consumption and 37.5% for self-consumption and sale. Finally, in the district of Viques, 74.0% of the land is used only for self-consumption, 24.0% is used for self-consumption and sale and 2.0% is used only for sale.

4.5. Climatic Factors

Shows the behavior of the climatic variables in the districts of Chongos Alto, Viques, Pucará and Huancayo, studied between September to December 2020 and January to February 2021, each represented by colors and lines; it is observed that the highest temperature of 28 °C occurred in Pucará on October 20 and in Huancayo of 27 °C on November 20. The minimum temperature in Chongos Alto was –8 °C on October 28, 2020. The districts of Pucará, Chongos Alto and Huancayo had the highest relative humidity with 89% and 87% on November 28 and 30 and 87% on December 18, 2020, respectively. There was more precipitation in Chongos Alto reaching 28 mm on January 05 and in Huancayo 23 mm on January 20, 2021 (**Figure 1**).

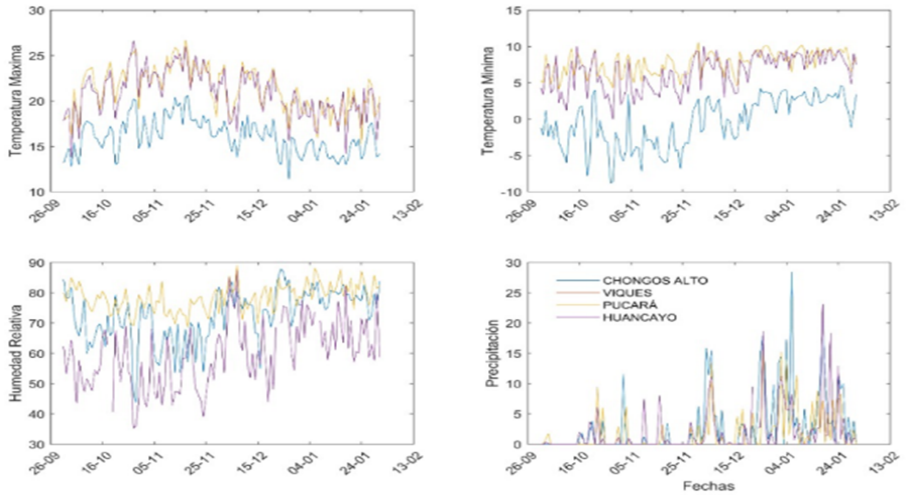

Figure 1. Time series behavior of maximum and minimum temperature, relative humidity and rainfall studied between September and December 2020 and January to February 2021 in the districts of Huancayo

Source: SENAMHI- Huayao Meteorological Station.

The cross-correlation indicates that there is a positive correlation between climatic variables and COVID-19 cases. In the districts under study, the time lag (Lag) ranges from 4 to 15 days, since they are different localities. With respect to maximum temperature, in Huancayo there is a correlation of Max –0.36 with a Lag of 15 (infections occur every 15 days), in Chongos Alto there is a correlation Max –0.24 and a Lag of 12, because in these two districts there was a maximum temperature between 27 and 26 °C on October 20 and November 20, 2020 (**Figure 2**).

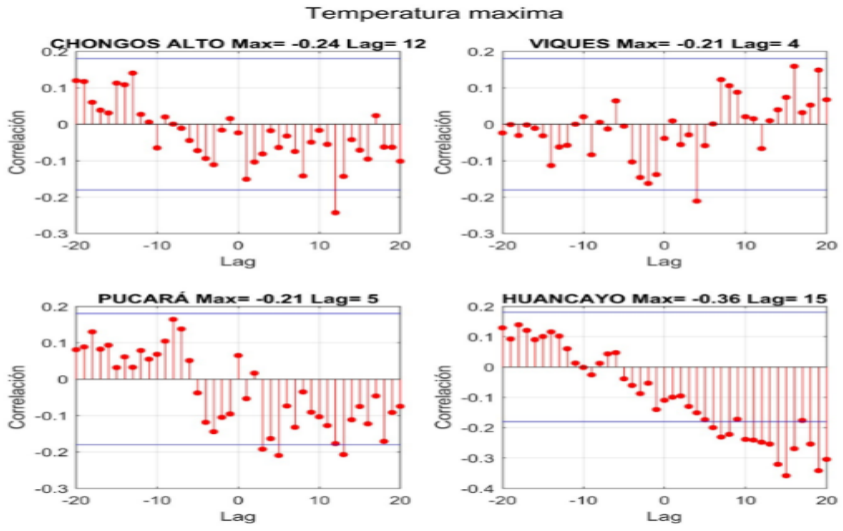

Figure 2. Cross-correlation of COVID-19 positive cases and maximum temperature in the districts.

Source: SENAMHI- Huayao Meteorological Station.

The cross-correlation shows that there is a positive correlation between the climatic variables and the COVID-19 cases, with respect to the minimum temperature, Chongos Alto has a correlation Max 0.16, and the Lag is 17 and in Huancayo the correlation is 0.24 and the Lag is 13. The minimum temperature in Chongos Alto was –8 °C on October 25, 2020 (**Figure 3**).

The cross-correlation shows that there is a positive correlation between the climatic variables and the Covid-19 cases; with respect to relative humidity, Chongos Alto has a correlation Max –0.13 and a Lag –14 and the district of Huancayo has a correlation Max 0.17 and a Lag of 11. The districts of Chongos Alto and Huancayo had a relative humidity of 87% on December 18 and 87% on November 28, 2020, respectively (**Figure 4**).

The cross-correlation shows that there is a positive correlation between the climatic variables and the COVID-19 cases; with respect to precipitation in Huancayo there is a correlation of Max = 0.23 and a Lag = 20 and Pucará has a correlation of Max = 0.33 and Lag = 17. Where there was more precipitation in Chongos Alto on January 05 and in Huancayo on January 20, 2021 (**Figure 5**).

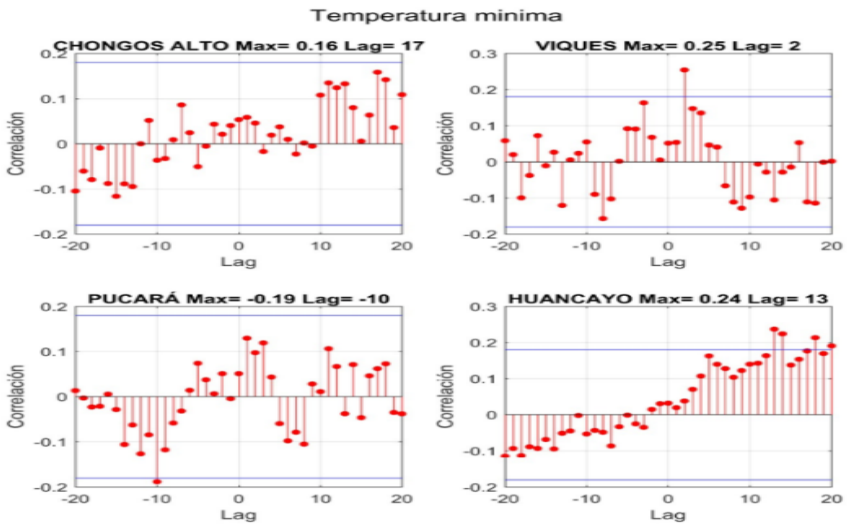

Figure 3. Cross-correlation of COVID-19 positive cases and Minimum temperature in Huancayo districts.

Source: SENAMHI- Huayao Meteorological Station.

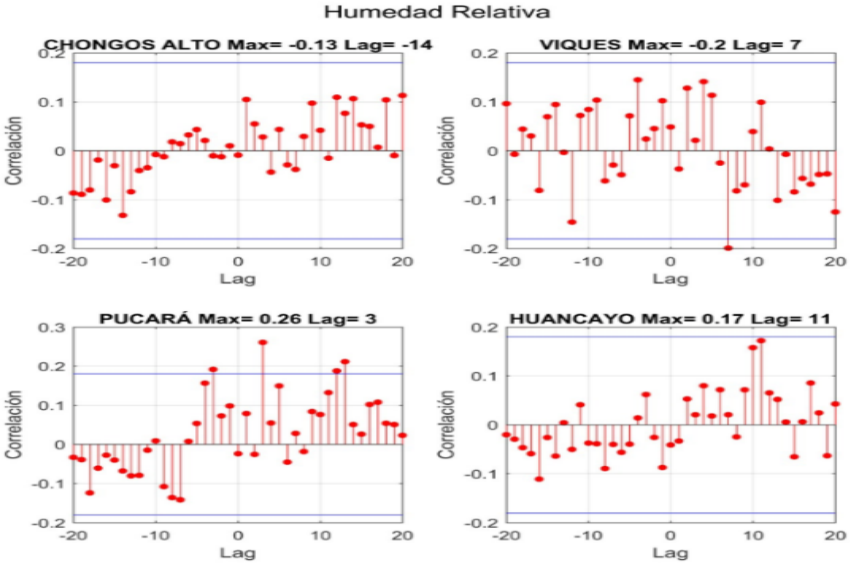

Figure 4. Cross-correlation of positive COVID-19 cases and relative humidity in the districts of Huancayo.

Source: SENAMHI- Huayao Meteorological Station.

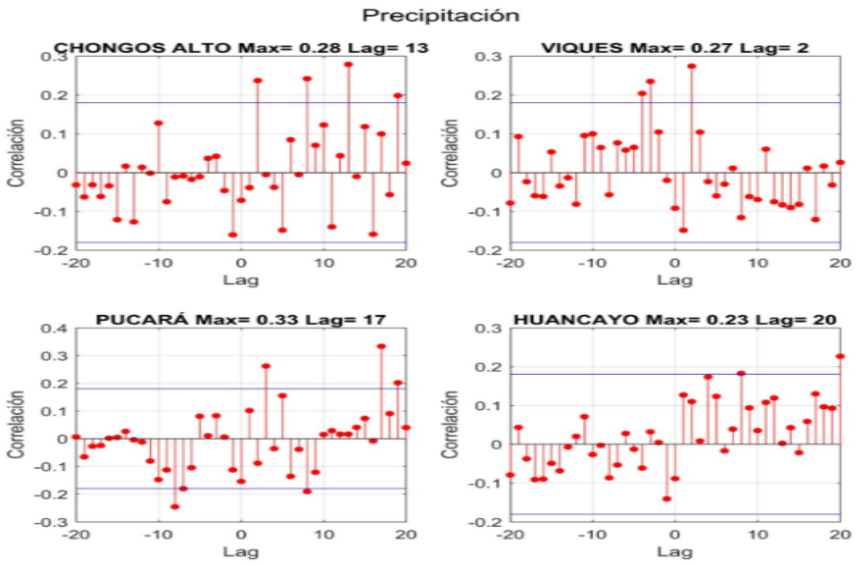

Figure 5. Cross-correlation of positive COVID-19 cases and Pluvial Precipitation in the districts of Huancayo.

Source: SENAMHI- Huayao Meteorological Station

Table 1 shows that mild food insecurity is 44.49% and moderate food insecurity is 55.51%.

The risk of Covid 19 is 1.8 times higher for a food insecurity villager (**Table 2**).

Table 3 The risk of moderate food insecurity is 16 times higher in conditions of high ambient relative humidity. However, no significant association was found between food insecurity and other climatic variables such as ambient temperature and rainfall during the study period. These findings highlight the relevance of relative humidity as a key factor in food security, especially in the context of the constraints and challenges generated by the COVID-19 pandemic.

Table 1. Food Insecurity of Villagers during the Covid-19 Pandemic in the Districts of Huancayo, Peru.

Food Insecurity	Frequencies	% of Total	% Accumulated
Mild food insecurity	121	44.49%	44.49%
Moderate food insecurity	151	55.51%	100.00%

Source: CEPREANDES- UNCP.

Table 2. Covid 19 and Food security of Villagers during the Covid-19 Pandemic in the Districts of Huancayo, Peru.

		95% Confidence Interval						95% Confidence Interval	
Predictor	**Estimator**	**Bottom**	**Top**	**EE**	**Z**	**p**	**R p**	**Inferior**	**Superior**
Constante	–1.1218	–1.8623	–0.3813	0.3778	–2.969	0.00299	0.3257	0.1553	0.6830
Covid19	0.6312	0.1427	1.1198	0.2493	2.532	0.01133	1.8799	1.1533	3.0641

Note: The estimators represent the log odds of 'food insecurity = mild food insecurity (2)' vs. 'food insecurity = moderate food insecurity'.
Source: CEPREANDES- UNCP.

Table 3. Association of climate variables and food insecurity of Villagers during the Covid-19 Pandemic in the Districts of Huancayo, Peru.

		95% Confidence Interval					
Predictor	**Estimator**	**Bottom**	**Top**	**EE**	**Z**	**P**	**Rp**
Constante	–1065.030	–4.101e–6	4.099e+6	2.092e+6	–5.092e–4	1.000	0.000
Temperature	–7.107	–77320	77306	39446	–1.802e–4	1.000	8.192e–4
Relative humidity	16.406	–64735	64768	33037	4.966e–4	1.000	1.333e+7
Fluvial precipitation	–7.831	–25690	25674	13103	–5.977e–4	1.000	3.971e–4

Note: The estimators represent the log odds of "FOOD INSECURITY = mild food insecurity" vs. "FOOD INSECURITY = moderate food insecurity".
Source: CEPREANDES- UNCP.

5. Discussion

The analysis revealed that 44.49% of households were mildly food insecure, while 55.5% were moderately food insecure. The risk of COVID-19 is 1.8 times higher for a food insecure population. Regarding the climatic conditions recorded in the districts studied Maximum temperature: 28 °C in Pucará and 27 °C in Huancayo. Minimum temperature: –8 °C in Chongos Alto. Relative humidity: The highest values were recorded in Pucará (89%), Chongos Alto (87%) and Huancayo (87%). Precipitation: The highest rainfall reached 28 mm in Chongos Alto and 23 mm in Huancayo. The risk of moderate food insecurity is 16 times higher in conditions of high ambient relative humidity. However, no significant association was found between food insecurity and other climatic variables such as ambient temperature and rainfall during the study period. For the time being, the present study strengthens the argument to consider that climate variables are associated with food security in the context of Covid-19 similar to the study of COVID-19 impacts on agriculture and food security, which resulted in a food crisis [25]. However, it should be noted that the risk of Covid 19 is 1.8 times higher for a food insecure population, a fact that was important during the COVID-19 pandemic, which directly affected food systems through impacts on food supply and demand, and indirectly—but equally important—through reduced purchasing power and capacity to produce and distribute food, and intensified care work, all of which will have differentiated repercussions and will affect the poor and vulnerable more severely [25].

The present study represents the first national and world experience in the estimation of climate variables associated with food security in the context of COVID-19, and there were several difficulties in its construction, mainly in the collection of data in the study areas.

One of the limitations in the study was in data collection.

Research shows that temperature, humidity and rainfall variability significantly affect agricultural productivity, which is crucial for food security. This highlights the need for climate monitoring systems and adaptive strategies to ensure stable production in the face of climate change. Moderate and mild food insecurity and prevalence is based on the Food Insecurity Experience Scale (FIES). It is constructed using the FIES Survey Module, which consists of eight questions relating to people's access to adequate food and can be easily integrated into various types of population surveys. Based on the measure, the degree of severity can be identified, with moderate food insecurity being a situation in which people face uncertainty about their ability to obtain food and are forced, at certain times of the year, to reduce the quantity or quality of the food they consume. This is due to lack of money or other resources. While severe food insecurity is a situation where people are likely to have run out of food, suffer from hunger and, in the most extreme case, go for days without food, putting their health and well-being at serious risk (24).

The study shows that 44.49% of households are slightly food insecure, while 55.5% are at moderate levels. These results reflect a structural vulnerability that, although accentuated by the pandemic, is rooted in socioeconomic factors. The correlation between the basic education of the head of household and limited job opportunities highlights the need for educational and economic interventions aimed at improving the living conditions of these families.

Extreme temperatures, ranging from –8 °C in Chongos Alto to 28 °C in Pucará, together with high relative humidity (87%–89%) and significant rainfall (28 mm in Chongos Alto), evidence an unfavorable climatic environment. These conditions hindered agricultural production and animal husbandry, directly affecting the availability and stability of food in households.

Mobility restrictions and limited access to inputs aggravated agricultural production and distribution problems. It is important to discuss how the combination of these factors intensified food insecurity in the areas studied. The positive correlation found between daily cases of COVID-19 and climatic variables (temperature extremes, humidity and rainfall) indicates that environmental factors may influence the spread of the virus. In addition, confinement measures increase difficulties in the agricultural supply chain, generating a double burden for families in terms of food security.

The identification of vulnerability factors, such as the gender of the head of household, educational level, household size and economic income, highlights critical areas for the design of public policies. Prioritization of female-headed households and those with low levels of education is essential to address the inequalities that perpetuate food insecurity.

During the COVID-19 pandemic, a continuous flow of food supply is crucial to prevent the food crisis and minimize the detrimental impact on the world economy by strengthening agriculture and the food sector, which is one of the most significant sectors combined with health care. Consequently, the seriousness of the crisis must be realised by each nation and, in some cases, it should strengthen or relax the pandemic-dependent measures. The supply network should also be sufficiently flexible to adapt to the food supply chain issues. This is thus determined that the influence of COVID-19 is not excluded from food and agriculture. This pandemic is damaging crops, livestock and fisheries. Today's worldwide scenario needs food safety and security. Concerning the food safety for the most vulnerable sector of the population, the food supply chain has been severely damaged due to COVID-19. Furthermore, most migrant, informal, seasonal farm labour lose their employment that might influence food demand. Therefore, without affecting the food supply chain and taking the food security of the citizens into account, the government of different countries across the globe should use steps to limit the pandemic issue. Each government should establish its own policy to identify the impact and significance of modifying specific trade strategy features on agricultural inputs. This is particularly crucial if domestic agricultural production capacity is restricted and there is an increase in costs for certain foodstuffs[25].

6. Conclusions

Shows that mild food insecurity is 44.49% and moderate food insecurity is 55.51%.The risk of Covid 19 is 1.8 times higher for a food insecure villager.

The analysis revealed that 44.49% of households were slightly food insecure, while 55.5% were moderately food insecure. Regarding the climatic conditions recorded in the districts studied: Maximum temperature: 28 °C in Pucará and 27 °C in Huancayo. Minimum temperature: –8 °C in Chongos Alto. Relative humidity: The highest values were recorded in Pucará (89%), Chongos Alto (87%) and Huancayo (87%). Precipitation: The highest rainfall reached 28 mm in Chongos Alto and 23 mm in Huancayo.

The study demonstrates that relative humidity and confinement measures resulting from the COVID-19 pandemic had a significant impact on agricultural activity, affecting both crops and livestock. These effects had a direct impact on household food security in the districts of Huancayo.

The need to prioritize attention to the most vulnerable families was also identified, considering key factors such as the gender of the head of household, the level of education attained, employment, economic income, the size of the family nucleus and the risks associated with food insecurity. Most of the households studied are headed by parents with basic education levels (primary or secondary), which limits their job opportunities and, consequently, their income, compromising their ability to ensure adequate food.

In addition, the results revealed a positive correlation between the number of daily cases of COVID-19 and climatic variables such as maximum and minimum temperature, relative humidity and rainfall in the districts of Chongos Alto, Huancayo, Pucará and Viques. This underscores the combined impact of adverse climatic conditions and social constraints on food security during the pandemic.

It is therefore crucial to implement comprehensive strategies that address both climate challenges and socioeconomic inequalities, with a special focus on the most vulnerable households, to ensure the sustainability of food security in crisis contexts such as the one analyzed.

Author Contributions

Y.A.V.C.: execution, evaluation, data conservation and report writing; D.M.G.: methodology obtaining funding, supervision and validation; E.N.P.A.: revision validation; E.R.H.G.: conceptualization, methodology, statistics and validation writing. All authors have read and accepted the manuscript version.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of the National University of Central Peru.

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. In addition, written informed consent has been obtained from the participants and can be found in the data file.

Data Availability Statement

The data supporting the findings of this study are available at the URI repository: http://hdl.handle.net/20.500.12894/8951 dated 2023. The data are not publicly available due to privacy restrictions related to the protection of personal information of study participants.

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Conflicts of Interest

The authors declare that there is no actual or potential conflict of interest, including any financial, personal or other relationship.

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