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Veterinary Vaccine Imports in Algeria: An Econometric Analysis, 2013–2020

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Abstract
Veterinary vaccines play a central role in preventing infectious animal diseases, protecting livestock health, and supporting the stability and productivity of animal-production systems. This study investigates the relationship between veterinary vaccine imports and selected livestock and poultry indicators in Algeria over the period 2013–2020. The analysis considers the monetary value of veterinary vaccine imports as the dependent variable and examines chicken meat production, cattle population, and sheep population as explanatory variables. Descriptive statistics, Pearson correlation analysis, and multiple linear regression were employed to assess the relationships among the variables and to identify their individual and joint contributions to variations in veterinary vaccine imports. The findings reveal statistically significant relationships between veterinary vaccine imports and the three production and livestock indicators. Chicken meat production and cattle population exhibit negative relationships with vaccine imports, whereas sheep population shows a positive relationship. Among the explanatory variables, chicken meat production presents the strongest statistical significance, followed by sheep population and cattle population. The overall results support the proposed hypotheses and highlight the relevance of livestock and poultry production indicators in understanding patterns of veterinary vaccine imports in Algeria. The study provides an econometric perspective that can contribute to the analysis of animal-health product demand and the planning of livestock health and disease-prevention strategies.
Keywords: veterinary vaccines; imports; Algeria; livestock; poultry; econometric analysis; multiple regression.

1. Introduction

1.1 Background and Research Context

Veterinary vaccines constitute an important component of animal-health systems because they are used to prevent and control infectious diseases affecting livestock and poultry. Effective vaccination programs can reduce disease occurrence and transmission while contributing to better animal health and productivity [1].

The economic importance of animal disease prevention extends beyond veterinary health. Livestock diseases may generate economic losses through mortality, reduced productivity,

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treatment expenditures, and restrictions on animal production and trade. Consequently, animal-health measures such as vaccination are relevant to agricultural productivity and food-security objectives[2].

The importance of vaccination also depends on the epidemiological and institutional context. Vaccine demand is not necessarily proportional to the number of animals because it may be influenced by disease prevalence, epidemiological risk, vaccination coverage, government control programs, procurement policies, vaccine availability, and prices

Algeria has substantial livestock resources and an important poultry-production sector. Data on livestock populations and agricultural production are available through international agricultural databases such as FAOSTAT. At the same time, veterinary vaccine imports represent an important component of the country's animal-health supply system.

The present study focuses specifically on the monetary value of veterinary vaccine imports. Import value may reflect not only quantities imported but also product composition, international prices, exchange-rate movements, procurement timing, and institutional purchasing decisions. International trade databases such as UN Comtrade provide information that can be used to examine trade flows of veterinary pharmaceutical products. [3].

Therefore, examining the relationship between vaccine imports and livestock and poultry indicators can provide an initial quantitative perspective on the factors statistically associated with the development of veterinary vaccine imports in Algeria.

1.2 Research Problem

Algeria's livestock and poultry sectors have experienced different production and population trends during the study period. Chicken meat production remained relatively stable during the first part of the period before increasing substantially after 2017. The cattle population reached a maximum in 2015 and subsequently declined, whereas the sheep population generally increased throughout the period.

At the same time, veterinary vaccine imports fluctuated considerably from one year to another. These different trajectories raise the question of whether changes in livestock and poultry indicators are statistically associated with changes in the monetary value of veterinary vaccine imports.

Accordingly, the main research question is:

To what extent are annual changes in veterinary vaccine import values in Algeria statistically associated with chicken meat production, cattle population, and sheep population during 2013–2020?

The study investigates statistical associations rather than claiming causal relationships.

1.3 Research Gap

Previous research has examined the economic consequences of animal diseases, the importance of disease prevention, and the role of veterinary interventions in livestock production. International organizations have also emphasized vaccination and veterinary services as important components of animal-health management [4].

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However, relatively limited empirical work has specifically examined the statistical relationship between the monetary value of veterinary vaccine imports and aggregate livestock and poultry indicators in Algeria. [5].

In particular, there is limited quantitative evidence simultaneously examining chicken meat production, cattle population, and sheep population as explanatory variables of veterinary vaccine import values.

This study addresses this gap by applying a multiple linear regression model to annual Algerian data for 2013–2020. The analysis is intended as an exploratory econometric assessment and does not establish causal effects. [6].

1.4 Research Objectives

The main objective of this study is to examine the statistical relationship between veterinary vaccine imports and selected livestock and poultry indicators in Algeria during 2013–2020.

The specific objectives are to:

1. Describe the evolution of veterinary vaccine imports, chicken meat production, cattle population, and sheep population.
2. Examine the Pearson correlations between the study variables.
3. Estimate the partial statistical relationships using multiple linear regression.
4. Evaluate the explanatory performance of the regression model using R^2, adjusted R^2, and the F-test.
5. Assess the statistical significance of the individual regression coefficients.
6. Identify the main econometric limitations affecting the interpretation of the results.

1.5 Research Hypotheses

The study tests the following hypotheses:

H1: Chicken meat production is significantly associated with veterinary vaccine imports in Algeria.

H2: Cattle population is significantly associated with veterinary vaccine imports in Algeria.

H3: Sheep population is significantly associated with veterinary vaccine imports in Algeria.

H4: Chicken meat production, cattle population, and sheep population jointly provide significant explanatory information for veterinary vaccine imports.

The statistical significance level is set at 5%.

Section 1 : Materials and Methods

1.1 Study Design

The study uses a quantitative econometric approach based on annual Algerian data covering the period 2013–2020.

The dependent variable is the monetary value of veterinary vaccine imports. Three explanatory variables are included:

- **X_1:** Chicken meat production.
- **X_2:** Cattle population.
- **X_3:** Sheep population.

1.2 Data and Variables

The database contains eight annual observations from 2013 to 2020.

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Table 1: Variables used in the econometric analysis

Symbol	Variable	Unit
Y	Veterinary vaccine imports	Million USD
X_1	Chicken meat production	Thousand tonnes (kt)
X_2	Cattle population	Heads
X_3	Sheep population	Heads

Agricultural production and livestock population indicators are commonly reported through international agricultural statistical systems, while international merchandise trade statistics provide information on import values[7].

1.3 Study Database

Table 2: Annual data used in the analysis, Algeria, 2013–2020

Year	Y: Vaccine imports (million USD)	X_1: Chicken meat production (kt)	X_2: Cattle population	X_3: Sheep population
2013	10.70	261.300	1,909,455	26,572,980
2014	16.60	262.000	2,049,652	27,807,734
2015	13.70	267.000	2,149,549	28,111,773
2016	13.50	269.000	2,081,306	28,135,986
2017	19.50	266.000	1,895,126	28,393,602
2018	12.10	377.380	1,816,280	28,723,994
2019	14.50	385.794	1,786,351	29,378,561
2020	12.50	489.650	1,740,183	30,905,560

Source: Ministry of Agriculture and Rural Development (MADR), Algeria.

1.4 Econometric Model

The multiple linear regression model is specified as:

$$\mathbf{Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \varepsilon_t}$$

where:

- Y_t = veterinary vaccine import value;
- X_{1t} = chicken meat production;
- X_{2t} = cattle population;
- X_{3t} = sheep population;
- β_0 = constant;
- β_1, β_2, β_3 = estimated coefficients;

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- ε_t = error term.

The coefficients are interpreted as conditional statistical associations rather than causal effects.

1.5 Statistical Methods

The analysis consists of descriptive statistics, Pearson correlation analysis, and multiple linear regression.

The regression model is evaluated using R^2, adjusted R^2, the overall F-test, individual coefficient significance tests, and the Durbin–Watson statistic. Statistical significance is evaluated at the 5% level.

Section 2 : Empirical Results and Discussion

2.1 Descriptive Statistics

Table 3:Descriptive statistics

Variable	Mean	Minimum	Maximum	Standard deviation
Veterinary vaccine imports	14.14	10.70	19.50	2.78
Chicken meat production	322.27	261.30	489.65	85.77
Cattle population	1,928,488	1,740,183	2,149,549	149,585
Sheep population	28,503,761	26,572,980	30,905,560	1,259,015

2.2 Evolution of the Variables

Veterinary vaccine imports fluctuated considerably over the study period. Import values increased from USD 10.70 million in 2013 to USD 16.60 million in 2014, declined in 2015 and 2016, and reached a maximum of USD 19.50 million in 2017. Imports subsequently decreased to USD 12.10 million in 2018, increased to USD 14.50 million in 2019, and declined again to USD 12.50 million in 2020.

Chicken meat production remained relatively stable between 2013 and 2017, ranging from 261.3 to 269 kt. It then increased markedly, reaching 377.38 kt in 2018, 385.794 kt in 2019, and 489.65 kt in 2020.

The cattle population reached its highest level in 2015 at 2,149,549 heads and subsequently declined to 1,740,183 heads in 2020.

In contrast, the sheep population showed an overall increasing trend, rising from 26,572,980 heads in 2013 to 30,905,560 heads in 2020[8].

2.3 Pearson Correlation Analysis

Table 4:Pearson correlation matrix

Variable	Vaccine imports	Chicken production	Cattle population	Sheep population
Vaccine imports	1.000	-0.327	0.163	0.027

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Chicken production	-0.327	1.000	-0.795	0.895
Cattle population	0.163	-0.795	1.000	-0.598
Sheep population	0.027	0.895	-0.598	1.000

The Pearson correlations indicate a weak negative association between vaccine imports and chicken meat production (r = −0.327). The correlation between vaccine imports and cattle population is weakly positive (r = 0.163), while the correlation with sheep population is very weak (r = 0.027).

The explanatory variables themselves show relatively strong correlations. In particular, chicken meat production and sheep population have a correlation of 0.895, while chicken meat production and cattle population have a correlation of −0.795. These relationships indicate potential multicollinearity and require caution when interpreting the individual regression coefficients.

2.4 Multiple Linear Regression

The estimated regression equation is:

$$\hat{Y} = -56.641 - 0.0965X_1 - 0.0000171X_2 + 0.00000473X_3$$

Table 5. Multiple regression coefficients

Variable	Coefficient (B)	p-value	Direction
Constant	−56.641	—	—
Chicken meat production (X_1)	−0.0965	0.006	Negative
Cattle population (X_2)	−0.0000171	0.043	Negative
Sheep population (X_3)	0.00000473	0.007	Positive

Source: Authors' calculations using IBM SPSS Statistics.

Chicken meat production has a negative and statistically significant coefficient (B = −0.0965; p = 0.006). Conditional on the other variables in the model, higher chicken meat production is statistically associated with lower veterinary vaccine import values.

Cattle population also has a negative and statistically significant coefficient (B = −0.0000171; p = 0.043).

Sheep population has a positive and statistically significant coefficient (B = 0.00000473; p = 0.007).

These coefficients represent conditional statistical associations. They should not be interpreted as evidence that changes in livestock or poultry production directly cause changes in vaccine imports.

2.5 Overall Model Performance

Table 6: Regression model summary

Statistic	Value
R^2	0.880
Adjusted R^2	0.791
F-statistic	9.814
Degrees of freedom	3, 4
p-value	0.026
Durbin–Watson	2.27

Source: Authors' calculations using IBM SPSS Statistics.

The model explains approximately 88.0% of the observed variation in veterinary vaccine import values within the sample. The adjusted R^2 is 0.791, indicating that approximately 79.1% of the variation remains explained after adjustment for the number of explanatory variables.

The overall F-test is statistically significant ($F = 9.814$; $p = 0.026$), indicating that the explanatory variables jointly provide statistically significant information about the dependent variable at the 5% level.

The Durbin–Watson statistic of 2.27 does not indicate strong evidence of first-order residual autocorrelation. Nevertheless, this statistic should be interpreted cautiously because the model is estimated from only eight annual observations.

2.6 Hypothesis Testing

The statistical results provide evidence supporting the four hypotheses at the 5% significance level.

H1 is supported because chicken meat production has a statistically significant coefficient ($p = 0.006$).

H2 is supported because cattle population has a statistically significant coefficient ($p = 0.043$).

H3 is supported because sheep population has a statistically significant coefficient ($p = 0.007$).

H4 is supported because the overall regression model is statistically significant ($p = 0.026$).

Among the individual hypotheses, **H1 shows the strongest statistical significance (p = 0.006)**, followed by **H3 (p = 0.007)** and **H2 (p = 0.043)**.

Among the four hypotheses, **H1 is the hypothesis most closely associated with the study findings**, as chicken meat production exhibits the strongest statistical significance among the individual explanatory variables (**p = 0.006**).

Overall, the findings provide statistical support for the four research hypotheses, indicating significant associations between veterinary vaccine imports and the selected poultry and livestock indicators, both individually and jointly**.**

3. Discussion

The regression results reveal statistically significant associations between veterinary vaccine imports and all three explanatory variables, but the direction of these associations differs.

The negative coefficient for chicken meat production indicates that, after controlling for cattle and sheep populations, higher chicken meat production is statistically associated with lower veterinary vaccine import values. This finding should not be interpreted as evidence that increasing poultry production reduces vaccine demand. Import values may also be influenced

by vaccination strategies, disease-control programs, procurement decisions, vaccine prices, inventory levels, and other factors not included in the model.

The negative association between cattle population and vaccine imports should similarly be interpreted cautiously. A reduction in cattle numbers does not necessarily imply lower animal-health requirements, because vaccine procurement may depend on disease-control priorities rather than population size alone.

The positive coefficient for sheep population indicates that increases in sheep numbers are statistically associated with higher veterinary vaccine import values when the other explanatory variables are held constant. This relationship may be consistent with the importance of animal-health management in larger sheep populations, although the present study cannot establish a causal mechanism.

An important methodological issue is the strong correlation among the explanatory variables. The correlation between chicken production and sheep population is 0.895, while the correlation between chicken production and cattle population is −0.795. Such relationships may affect the stability and interpretation of individual regression coefficients.

The high R^2 value should therefore not be interpreted as proof that the three livestock and poultry indicators fully determine veterinary vaccine imports. Import demand can also be affected by disease outbreaks, vaccination campaigns, government procurement, international prices, exchange rates, domestic production, product composition, and inventory management.

The very small sample is another important limitation. The regression is based on only eight annual observations and estimates three explanatory coefficients plus a constant. Consequently, the statistical results should be considered exploratory and interpreted with appropriate caution.

Future research should extend the observation period and incorporate more detailed variables, including epidemiological indicators, disease outbreaks, vaccination coverage, government expenditure, import prices, exchange rates, domestic vaccine production, and disaggregated vaccine categories.

4. Conclusion

This study examined the statistical relationship between veterinary vaccine imports and three key livestock and poultry indicators in Algeria over the period 2013–2020.

The multiple linear regression model showed a high explanatory capacity, with an **R^2 of 0.880** and an **Adjusted R^2 of 0.791**. The overall model was statistically significant at the 5% level, with **$F(3,4) = 9.814$** and **$p = 0.026$**.

Chicken meat production showed a negative and statistically significant relationship with veterinary vaccine imports, with a coefficient of **−0.0965**. Cattle population also showed a negative and statistically significant relationship, with a coefficient of **−0.0000171**, whereas sheep population showed a positive and statistically significant relationship, with a coefficient of **0.00000473**. Among the explanatory variables, chicken meat production showed the strongest statistical significance (**$p = 0.006$**), followed by sheep population (**$p = 0.007$**) and cattle population (**$p = 0.043$**).

These findings indicate significant statistical relationships between veterinary vaccine imports and the livestock and poultry indicators considered. Overall, the results provide statistical

support for the four research hypotheses, both with respect to the individual relationships and the joint contribution of the explanatory variables to the model.

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