Malaria and Pneumonia Effects on Rice, Vanilla Production and Rural Household Income In Madagascar: A Quantitative Study

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Research

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Abstract

Background: In Madagascar, malaria remains the leading cause of consultation and deaths at hospital at all ages and pneumonia is one of the main causes of the under-five mortality and account for 45% of children hospitalizations. The number of cases and deaths has not decreased during the last ten years. This paper aims to determine the effects of malaria and pneumonia on rice and vanilla production and income.

Methods: We use data from survey lead by the authors on 975 households and 3,586 individuals of the SAVA region in the northeast of Madagascar. After checking the presence of endogeneity, ordinary least-square method was used instead of two-stage least squares.

Results: Our results showed that malaria has no effect on production, and therefore does not affect income. Pneumonia has an effect on production of rice and vanilla. Moreover, the cost of malaria and pneumonia healthcare burdened by households affect their consumption.

Conclusions: Therefore, pneumonia should be considered in the same way as malaria due to its effects on production and investment to fight against these two diseases must be strengthened in order to decrease the costs for the households.

1. Background

Diseases affect households’ welfare directly by their effect on income and indirectly by the healthcare cost. By reducing physical capacity, they induce a decline in labor productivity, then in production and therefore in income [1][2]. For a sick child, the reduction in cognitive capacity affects education [3], therefore the qualification of the future workforce and future income [4].

The prevalence of malaria and pneumonia is still high in some parts of Madagascar and may induce a loss of welfare for affected households. Concerning malaria, there are direct and indirect costs associated with this disease [5]. Several authors suggested that malaria does not affect household production or income. According to Breman et al. (2006), because of the risk of contracting malaria, rural population in endemic areas avoids practicing intensive cultivation [6]. Audibert et al. (2009) in their research on the effects of malaria on the production of cocoa and coffee, found non-economic effect of malaria [7]. They explained that malaria causes a little or no disability. Generally, fever, nausea and tiredness last on average three days. For Russel (2004) malaria costs are low (from 4.54–7% of income per month in Nigeria) [8]. On the opposite, according to Kioko (2013) the effect on production can be significant if malaria appears during periods of large farm work [9]. Audibert, Mathonnat and Henry (2003) found significant effects of malaria on cotton production because this last requires intensive cultivation [10]. Willis and Hamon (2018) found that eliminating malaria in sub-Saharan Africa by 2040 would lead to a reduction in poverty rates among agricultural households by 4 to 26 percentage points [11]. Indirectly, diseases cause loss of time as more household time may be devoted to caring for the sick. Part of the time intended for producing, studying and performing non-market activities is spent on care [1]
Beside time lost, malaria induces financial cost for healthcare. If the cost burdened by households is too high, they may choose as a solution, either to reduce their consumption of non-medical goods, or to resort to savings, to sell goods, to use borrowing or mortgaging their own property. This situation causes the fall in their savings, the reduction in their assets and influences not only the current consumption but also their future consumption.

Studies on pneumonia focused on the cost of this disease and his treatment but not on its effects on agricultural production or income. Studying the case of two companies in the United States, Sato et al. (2013) showed that the number of wasted day due to pneumonia was three times higher than that due to other sickness. And, according to Santana et al. (2018), absenteeism and deaths due to pneumonia have a significant cost.

The first objective of this paper is to determine the effects of both diseases on production and income of households of the SAVA region, which is located in the northeast of Madagascar. We chose to study rice, which is the staple food of the Malagasy people and vanilla, which is the main agricultural export product. The second objective is to estimate malaria and pneumonia healthcare cost. The SAVA region was chosen because malaria was the leading cause of morbidity and mortality, and pneumonia was the sixth leading cause of hospital morbidity and the third cause of mortality at all ages. Then, this region is the main producer of vanilla in Madagascar, 28% of all cultivated areas, and rice constitutes 40% of all cultivated areas (Data of the Center for Research, Studies, Support to Economic Analysis in Madagascar, CREAM, 2016).

2. Methods

Malaria was still the leading cause of consultations at all ages and the leading cause of deaths for the under-five at hospital level. Pneumonia was the first cause of consultations and the leading cause of deaths for children under five. According to the Ministry of Health, 45.4 per cent of hospitalizations and 5.8 per cent of hospital mortality for children under five years were related to pneumonia. If the total number of pneumonia cases is four times less than the total number of malaria cases, the total number of cases and deaths did not decrease during ten years (Data of the Institute of Social Hygiene, 2015). Due to the lack of campaigns, the awareness rate for pneumonia prevention measures was very low. This disease should be deserved as much attention as malaria and is concerning by neither vertical nor horizontal program. Therefore, this paper aims to determine the effects of malaria and pneumonia on production and income of households in Madagascar, by studying the case of the SAVA region.

2.1. Study area

Our study focuses on rural areas where 80 per cent of Malagasy people live and where diseases prevalence are highest. In 2016, malaria prevalence was higher in rural areas (5%) than in urban areas (2%) [23]. In addition, cooking with wood or charcoal or cow dung is the main risk factor for pneumonia in rural area [24].
SAVA is a region of the northeast of Madagascar, constituted by four districts: Sambava, Antalaha, Vohémar and Andapa. Sambava, the regional capital, is located at 1,194 km from Antananarivo, the capital of Madagascar. SAVA region has a dense hydrographic network. Its climate is characterized by a dry and cool season from May to November and warm and humid season beginning in December. Then the strongest heat is recorded in January and February. July and August are the coolest months. The temperature varies from 18 °C to 31 °C. Malaria was the leading cause of death in the region and pneumonia was the sixth cause at all ages (Data of the SAVA Regional Health Office, 2015). The area exploited represents in 2016, 14.8 per cent of the 1.3 million hectares of arable land (Data of the Center for Research, Studies, Support to Economic Analysis in Madagascar, CREAM, 2016). Rice covers 40 percent of the total cultivated area and cash crops 42.5 percent, of which 28 percent for the vanilla and 11 per cent for the coffee. The remaining area is used for food crops such as maize, cassava, sweet potatoes, beans, vegetables and tropical fruits.

Techniques used are still rudimentary. Yields are low, as the use of organic or chemical fertilizers and pesticides is not yet sufficiently developed. Attached to ancestral beliefs, producers rather invoke the blessing of ancestors to obtain good returns. Concerning rice crop, soil preparation for sowing is carried out from November to January and consists of irrigating soil and trampling it. Seeds come mainly from previous crops. Weeding and harvesting are done manually. It takes place between May and July.

Vanilla crop is one of the main sources of income in the region. From September to October, men and women carry out the artificial fertilization of vanilla, an activity that is done manually. Punching of young vanilla pods is made from November to February. It is a process used to fight against the theft of vanilla. Harvested between June and September, pods are scalded. It is an operation that lasts 48 hours and which consists in immersing pods in hot water in order to stop the vegetable life. After curing in wooden boxes, pods are removed from the covers in which they have been stored and are exposed for one week to be dried. Dried vanilla pods are sold on the local market. Some economic operators prefer to collect green vanilla pods from producers. To obtain quality products to be exported, they ensure preparation, packaging and storage.

### 2.2. Data collection

In 2016, we conducted surveys in the SAVA region, in the districts of Sambava, Andapa and Antalaha. Districts include communes each composed of several villages.

A two-stage sampling was conducted. First, the “communes” were randomly selected. Then, all the villages at more than five kilometer from the nearest health center of each selected commune were included in the sample. Households to be surveyed were those randomly selected and whose head was willing to give consent for the survey. The number of selected households in each village depends on the total number of households in the village. We surveyed a total number of 975 households for the three districts and within them, all their members, that is 3,586 respondents. For individuals under 15 years old, the parents or guardians were interviewed.
We used two types of questionnaires, one for the household survey and one for the individual survey. For household survey, the head of the household or his wife was the respondent. We also asked questions about household characteristics, farming, household expenditures and consumption. Then, each individual in the household was interviewed. The questionnaire included information on each individual, agricultural activity, non-agricultural, health and malaria and pneumonia costs.

### 2.3. Descriptive analysis

The average size of surveyed households is four individuals per household (standard deviation: 1.5, median: 4). Most households are mononuclear with the head of household, spouse and children (41.4%). In 7.67 percent of the cases, grandchildren are part of the household. The average (median) age of the sample population is 25.2 (20) years (standard deviation: 18.7).

There are on average two rooms per dwelling (median: 2, varies between 1 and 12 pieces). In 9.15 percent of cases, the kitchen serves as bedroom. Cooking smoke pollutes home, the majority (65 per cent) do not have a chimney. Dwellings are very traditional. The roof is made of sheet metal for 64 percent of households and 29 percent in palm or vegetal. The wall is made either of wood or plant for the majority. Dwellings are thus still precarious and the majority of households does not have access to electricity and use kerosene (64%). Access to drinking water is still very limited, 62 per cent of households do not have access to it. According to the definition of the World Summit for Children, water is drinkable when it comes from: tap water or in the courtyard, plot, public fountain, tabular well or borehole, protected well or protected source, bottled water and rainwater catchment. Moreover, the environment remains threatened insofar 76 per cent of households still use wood for fuel causing domestic pollution. Finally, only 8 percent of households have access to improved sanitation. Possession and use of sanitary contribute to the improvement of hygiene conditions of the population. This information is necessary because dwellings characteristics, domestic pollution and hygiene could explain the prevalence of diseases (Appendix A1).

In the studied case, children under 15 years old are the most vulnerable to malaria without distinction of sex. Children under-five years old are the most affected by pneumonia. Although previous studies [25] have shown that people over 65 years old are the most vulnerable, no pneumonia cases have been detected in this group (Table 1).
Table 1
Number of malaria and pneumonia cases recorded in the year preceding the survey

| Total population | Malaria cases among women | Malaria cases among men | Pneumonia cases among women | Pneumonia cases among men |
|------------------|---------------------------|-------------------------|----------------------------|--------------------------|
| N = 3,586 (100%) |                           |                         |                            |                          |
| Under-five       | 12 (6.09)                 | 19 (10.16)              | 6 (3.05)                   | 2 (1.07)                 |
| 5–15 years       | 36 (8.93)                 | 44 (9.91)               | 8 (1.79)                   | 4 (0.82)                 |
| 15–65 years      | 36 (3.22)                 | 80 (5.52)               | 10 (0.86)                  | 15 (1.00)                |
| > 65 years       | 1 (2.38)                  | 0 (0)                   | 0 (0)                      | 0 (0)                    |

Note: number (frequency in % in brackets)

Source: Authors’ survey, 2016

Concerning malaria, there is a peak between November and December, during the rainy season. It is the rice field preparation period and punching period of vanilla. Concerning pneumonia, there is a peak in May, August and from November to January. The month of May corresponds to the cold season. In August, it is neither too cold nor too hot and from November to January, it is the rainy season. The fact that the number of cases of pneumonia is high in August can be explained by other determinants than climate.

Whether in the case of malaria or in the case of pneumonia, households consult especially health facilities (Appendix A2). In the case of malaria, after health facilities, private doctors are the most frequented and in case of pneumonia, CHWs are the most consulted. When malaria or pneumonia becomes severe, hospitalization is required.

2.4. Econometric model: effects of malaria and pneumonia on rice and vanilla production and income

We apply the model used by Ersado (2005) when he studied the relationship between the use of irrigation dam, level of production and health [26]. For the agricultural production function and total income function, we have:

\[ G(Q, T, L_q, P, E, S, A, H_1, H_2, M, V) = 0 \]
\[ G(R, T, L_q, P, E, S, A, H_1, H_2, M, V_1, V_2) = 0 \]

As none of the surveyed individuals reported having suffered from malaria and pneumonia at the same time in the year preceding the survey, comorbidity was not considered in our model.

Households grow food and cash crops.
The agricultural production function is: \[ Q = Q(T, L_{ef}, P, E, S, A, H, M, V) \]

Households mainly produce rice as food crop and vanilla as cash crop (Author survey, 2016). Thus, two types of agricultural function were considered, one for the rice and one for the vanilla. Production \( Q \) is therefore the quantity produced of rice, alternatively vanilla, in kg given the cultivated area.

\( T \) is the total cultivated area in rice (vanilla) in m\(^2\).

\( L_{ef} \) is the use of extra-family labor (binary, 1 if yes and 0 if no). Households engage extra-familial labor, particularly during the period of soil preparation, rice harvest and during the period of vanilla artificial fertilization (authors’ survey, 2016).

\( P \) is the practice of agricultural activity (binary, 1 principal and 0 if secondary).

\( E \) education is the last class completed by the head of the household. According to Coelli and Fleming (2004), the producer's level of education has a positive impact on the level of production [27].

The relationship between age of the head of the household \( A \) and the level of production can be positive or negative. Some authors believe that young people may adopt different and more modern production techniques while others think that older people are more experienced [27].

\( S \) sex of the head of household, is a binary variable with \( S = 1 \), if the head of household is a woman, otherwise \( S = 0 \). Most studies have shown that the production and income are lower when the head of household is a woman [27].

Size of the household \( M \) must be considered when family members help each other in carrying out agricultural activities [28].

\( H \) is the health variable. \( H_1 \) measured the total confirmed malaria and \( H_2 \) measured pneumonia cases occurred in the household one year, preceding the survey.

For the rice production function, we also add variable \( V \), cash crop practice. This is a binary variable equal to 1 if yes, 0 if not. For the vanilla production function, variable \( V \) represents the cultivation of food crops. It is also a binary variable.

Since the crop is purely traditional, households do not use other inputs (fertilizers and pesticides).

The income function \( R \) is of the form, considering the same variables cited above:

\[ R = R(T, L_{ef}, P, E, S, A, H_1, H_2, M) \]

Where \( R \) is the total household income that includes cash crop income (coffee, cocoa, clove and vanilla) and food crop income (the part of food crops: rice, cassava, sweet potatoes, potatoes, corn, peanuts,
peas, lentils, chickpeas, carrot, cabbage, tomato, onion, and fruits that is sold on local markets). Income from the sale of these products is obtained by multiplying the quantity for sale of each product by the price of the product. Non-farm income, when exists, is added to the farm income.

The variables of interest, malaria \((H_1)\) and pneumonia \((H_2)\) can be suspected of endogeneity. These diseases can influence agricultural production and income. Practicing agricultural activities can expose individuals to these diseases. Indeed, the humidity in the fields is favorable to the development of mosquito larvae. Moreover, cold and humidity can cause a respiratory infection. Then, the higher households income, the better they can protect themselves against disease.

First, health production function was developed to identify the determinants of the two diseases occurrence. The number of malaria and pneumonia cases can depend mainly on the environment \(X\) where households live (characteristics of the material of the walls and the roof causing the presence of mosquitos, the type of fuel causing respiratory diseases, and so forth), the practice of agricultural activity \(P\), the use of extra-family labor \(L_{ef}\) and the total cultivated area \(T\). With these three last variables, it is possible to determine whether members of the household are exposed to these diseases due to agricultural activities or not. Finally, total income \(R\) was also taken into account.

The health production function is expressed as: 
\[
H = H(X, P, L_{ef}, T, R),
\]

and estimated using a covariance analysis. The specificity of this analysis is that it considers both quantitative and qualitative variables. Dependent variables are the total number of cases of confirmed malaria and pneumonia in the household in the year preceding the survey.

Then, in both production and income functions, we used instrumental variables for malaria and pneumonia, according to the results of the health production function. The test of Wu-Hausman, is used to check for the endogeneity of the health variable to determine the most suitable method for estimating production and income functions, the ordinary least squares (OLS) method or the two-stages least squares (2SLS) method which take into consideration the endogeneity of explanatory variables.

3. Results

3.1. Econometric results: Economic losses due to malaria and pneumonia

Relationship between the source of water, combustible, lightning and malaria and between combustible, roof material, the fact than kitchen serves at the same time bedroom and pneumonia was shown (Appendix A3). We instrumented malaria and pneumonia variables by these variables. The endogeneity test (Table 2) showed that for the rice and vanilla production functions and income function, malaria and pneumonia variables are not endogenous. The p-value for this test is greater than 0.05, the OLS is therefore better than the 2SLS. This confirms results of the health production function showing that
agricultural activity has no effect on the prevalence of malaria or pneumonia. Table 2 presents estimations of rice production function (I), vanilla production function (II) and total income function (III) (Table 2).
Table 2
Determinants of agricultural production and income functions

| Variables                      | Rice | Vanilla | Total income |
|-------------------------------|------|---------|--------------|
|                               | I OLS | II OLS | III OLS     |
| Constant                      | -5.5*** (0.00) | 2.47*** (0.00) | 12.55*** (0.00) |
| **Land**                      |      |         |              |
| Area (m²) (log) T             | 0.00 (0.70) | 0.00 (0.93) | 0.06** (0.03) |
| **Labor**                     |      |         |              |
| Practice of agricultural activity | -1.25 (0.12) | - (0) | -0.30 (0.80) |
| Use of extra-familial labor $L_{ef}$ | 0.48*** (0.00) | 0.36*** (0.00) | 0.53*** (0.00) |
| **Human capital**             |      |         |              |
| Size of household M           | -0.02 (0.56) | 0.02 (0.62) | -0.02 (0.58) |
| **Head of household**         |      |         |              |
| Sex S                         | -0.48*** (0.00) | -0.44*** (0.00) | -0.55*** (0.00) |
| Education level E             | 0.05 (0.10) | -0.01 (0.84) | 0.16*** (0.00) |
| Age A                         | 0.05*** (0.00) | 0.03 (0.23) | 0.06*** (0.00) |
| Age²                          | -0.00*** (0.00) | -0.00 (0.43) | -0.00*** (0.00) |
| **Health variables**          |      |         |              |

Note: ***, **, * Respectively significant at 1%, 5% and 10%
### Variables

| Variables                        | Rice I OLS | Vanilla II OLS | Total income III OLS |
|----------------------------------|------------|----------------|-----------------------|
| Malaria                          | 0.04 (0.59)| 0.03 (0.81)    | -0.01 (0.94)          |
| Pneumonia                        | -0.28* (0.09)| -0.51** (0.03)| -0.05 (0.82)          |
| R²                               | 0.10       | 0.05           | 0.18                  |
| Fisher                           | 9.03*** (0.00) | 3.01*** (0.00) | 16.53*** (0.00)       |
| Wu-Hausman Endogeneity test      | 3.82 (0.14) | 0.79 (0.67)    | 0.49 (0.78)           |
| Observations                     | 790        | 376            | 864                   |

Note: ***, **, * Respectively significant at 1%, 5% and 10%

Source: Authors survey, 2016

Among 975 households surveyed, 790 grow rice (81 percent) and 376 vanilla (38.5 percent). In addition, calculation of income level was only possible for the 864 households.

Malaria has no impact on rice and vanilla production, or income. Although the prevalence of malaria in this study area is higher than the national prevalence, it remains low. This fact may partly explain this lack of effect. We tested the robustness of these results in two ways. We first check whether malaria may have a heterogeneous effect according to wealth level. Using the quintiles, the question was, has malaria a higher economic effect for the poor than the less poor or the rich? Then, instead of malaria cases, we introduced the Disability Adjusted Life Years (DALY) lost due to malaria in the model. We estimated the DALYs from our data. The results did not change.

Like malaria, pneumonia had no economic effect on household income. On the opposite, this disease causes a significant negative effect on the production of rice and vanilla.

Our results show that the production of rice, vanilla and income depend mainly on the use of extra-family labor, sex for vanilla production function and age of the head of household for rice production function as well as on the cultivation of cash crops and food crops for the income function. Indeed, the use of extra-family labor can increase the production and the income. Vanilla production and income are lower when the head of the household is a woman than in the opposite case. The older the head of household
is, the higher his production and income, this fact can be explained by his experience. Finally, the practice of cash crop and food crop and the total land area explain the increase in income.

3.2. Costs of malaria and pneumonia

Respondents with malaria or pneumonia consult public health centers or private health facilities or CHWs. Direct costs include travel, consultation, treatment, hospitalization, and food expenditures during hospitalization. The direct costs of malaria represent 5.9 percent of the monthly income of households whatever the type of care. This proportion is close to that found by Russel (2004) who reported that for households in Nigeria, the direct costs of malaria are between 2.66–4.1 percent and 4.54-7 percent of monthly income [8]. Concerning pneumonia, the financial cost is 3.7 to 5 percent of the monthly income of households. Table 3 shows the cost of these diseases by district.

Table 3
Direct costs of malaria and pneumonia by district

|                      | Malaria          |                  |         | Pneumonia       |                  |         |
|----------------------|------------------|------------------|---------|------------------|------------------|---------|
| Average costs (USD)  | Sambava          | Andapa           | Antalaha| Sambava          | Andapa           | Antalaha|
| Transport costs      | 0.67             | 1.63             | 1.36    | 0.59             | 0.15             | 0.17    |
| Consultation and treatment fees | 5.70           | 9.00             | 8.38    | 7.70             | 6.52             | 6.08    |
| Total                | 6.37             | 10.64            | 9.75    | 8.29             | 6.68             | 6.25    |
| Income per month (USD)| 165              | 179              | 159     | 165              | 179              | 159     |
| Proportion to monthly income (%) | 3.8             | 5.9              | 6.1     | 5.0              | 3.7              | 3.9     |

Source: Authors’ survey, 2016

In Andapa and Sambava, the majority of respondents with malaria consulted mainly health centers (28.26% in Sambava and 41.67% in Andapa) or private doctors (39.13% in Sambava and 20.83% in Andapa) (Appendix A4). It means that there is no fixed cost schedule at health centers and at private doctors. Concerning pneumonia, the cost is lowest in Antalaha where the 33.33 percent of the households used CHWs. It is the highest in Sambava where the households used mainly health centers (12.50%) or private doctors (12.50%). Cost of hospitalization is not yet considered in this Table 3. In the case of hospitalization, the average cost per episode of malaria is 50.25 USD, or 30 percent of monthly household income and 42.8 USD per episode of pneumonia, or 25.6 per cent of monthly household income.

Among interviewees, 49 percent are willing to pay for care, among them, 11 household heads said that they can pay more than 1,000,000 MGA, or 312.5 USD per year to invest in their health, and the remainder was willing to pay on average 28,621 MGA, or 8.94 USD per year. Half (50.24%) of the interviewees have no opinion.

4. Discussion
Our results show that malaria does not affect either production (whether rice or vanilla) or income. It in line with previous malaria studies \[8\] \[6\] \[7\]. We can explain this result by the fact that adults affected by this disease are able to work to ensure agricultural activities. The mean duration of an episode is six days and the annual number of episodes of malaria is one (author’s survey, 2016). In the SAVA region, children under 15 years old are the most vulnerable to malaria. However, the fact that a child falls ill does not necessarily lead to a suspension of household income-generating activities. Another is that since it is a household production, families through historical experience (learning) would have known how to modify division of labor to reallocate an ill person to less tedious aspects (tasks) of operations as the malaria duration is short.

Concerning pneumonia, it has no economic effect on household income, but, this disease causes a significant negative effect on the production of rice and vanilla. Indeed, compared to malaria, symptoms of pneumonia are more severe and may induce higher disability.

Therefore, we have shown that malaria and pneumonia do not affect household income. However, these diseases generate costs that affect household consumption. Thus, the types of non-medical goods that are affected by them and coping strategies were determined. Among households with one member affected by malaria or pneumonia, 24 percent had to borrow (interest rate information is not available), 5 percent had to sell some of their assets. No household has reduced his food and clothing expenditures. Almost, 78 percent of surveyed households reported having unmet needs. For 49 percent, it concerns housing, which is the most affected need in Sambava, Andapa and Antalaha. Therefore, housing are the most affected due to disease costs. Consumptions of food and clothing are not affected, since these are already the minimum for households’ members’ survival. When expenditures can no longer be changed, households are forced to borrow or to transfer their assets.

In this study, we did not ask for the episodes of malaria or pneumonia of extra-familial workforce. Then, we have based our study on declared confirmed cases, which only partially reflect malaria morbidity and do not reflect the possible state of tiredness caused by this disease. Therefore, it is better to carry out a biological study. For example, in his study on the relationship between malaria and education in Mali, Thuilliez (2009) considered the parasitaemia index (parasites / µL) by a blood sample (he counted the number of plasmodium on 300 leucocytes, assuming an average number of leucocytes of 7,500 / µL of blood) \[3\]. Then, a child has malaria if, in addition to symptoms related to this disease, he has parasitaemia greater than 500 Plasmodium falciparum / µL of blood.

5. Conclusion

We conducted a survey of 975 households and 3,586 individuals in the SAVA region in Northeast of Madagascar in 2016 in order to determine the economic effects of malaria and pneumonia. We developed agricultural production functions and income function.

Our results show that malaria does not affect either production (whether rice or vanilla) or income. Pneumonia which symptoms are more severe than those of malaria, negatively affects the production of
rice and vanilla. However, its effect on income is not significant. This can be explained by the compensation between agricultural and non-farm income. In fact, 40 per cent of people over 15 years old with pneumonia carry out non-agricultural activities.

In addition, malaria and pneumonia generate financial costs. On average, the financial costs are 9.9 USD for malaria and 7.3 USD for pneumonia. Some households practice loan or have had to sell their assets since they cannot modify their non-medical expenditures. Due to the costs of malaria and pneumonia, 28 percent of households were unable to satisfy their housing needs. Therefore, investment to fight against malaria and pneumonia must be strengthened in order to decrease the costs of these diseases for the households.

6. List Of Abbreviations

2SLS
two-stages least squares
CHW
Community Health Worker
DALY
Disability Adjusted Life Years
OLS
ordinary least squares
SAVA
Sambava, Antalaha, Vohémar and Andapa

Declarations

Ethics approval: as it is an empirical paper, during our survey, we collected economic data and purely quantitative data. We did not take blood samples or touch the human body. Hence, in Madagascar, the recourse to the Ethics Committee was not necessary. However, Ministry of Health of Madagascar approved the survey (Ref: 258 MSANP/SG/DGS/DSMER/SPPCM)

Consent for publication: Households gave their consent for the survey and the publication of the results. It should be noted that in the results, no names of the interviewees are mentioned.

Availability of data and material: data come from a survey performed by authors and data can be shared by the corresponding author on reasonable request.

Code availability: we use stata so, the dofile is available

Competing interests: The authors declare that they have no competing interests.

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**Authors’ contribution:** All authors (MVR, MA, VTA) contributed equally for the literature review, data analysis and data interpretation. Then, MVR wrote the article. The latter has been revised and MA and VTA approved the revision.

**Conflict of interest:** The authors declare that they have no conflict of interest.

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29. Appendices.