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RESEARCH ARTICLE

MALARIA IN CHILDREN UNDER 5 AND VULNERABILITY OF MOTHERS IN THE TOWN OF ZUÉNOULA (CENTRAL-WESTERN CÔTE D'IVOIRE)

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ABSTRACT

Despite the intensification of control measures and the policy of free treatment in Côte d'Ivoire, malaria remains a health problem and a factor of vulnerability for mothers of children under 5. This study aims to analyze the influence of malaria in children under 5 on the vulnerability of mothers. The results of this study are based on data from the field survey and documentary research. The survey was carried out among 389 mothers who had brought their children to the paediatric ward for a malaria-related consultation. The survey covered a three-month period from June to August 2021. The study revealed that the high incidence of diagnosed malaria in children under 5 years of age is the result of local environmental conditions conducive to the proliferation of vector species. The risk of exposure to Anopheles bites is highest among children living near shallows, garbage dumps, grass clumps, stagnant puddles and in households where mothers store water in uncovered containers. In addition, childhood malaria causes mothers to lose between three and twenty-six days of activity per year. This loss of activity varies significantly according to socio-professional category, and also has a significant influence on the depletion of the savings of the mothers surveyed. Secondly, 17% of the mothers surveyed had contracted a debt ranging from 10 000 CFA francs ($16.15) to 30 000 CFA francs ($48.44), especially in the case of neuromalaria. This study leads to the conclusion that malaria endemicity among children due to precarious local environmental conditions is a factor in the economic vulnerability of mothers of children under 5 in the town of Zuénoula.

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INTRODUCTION

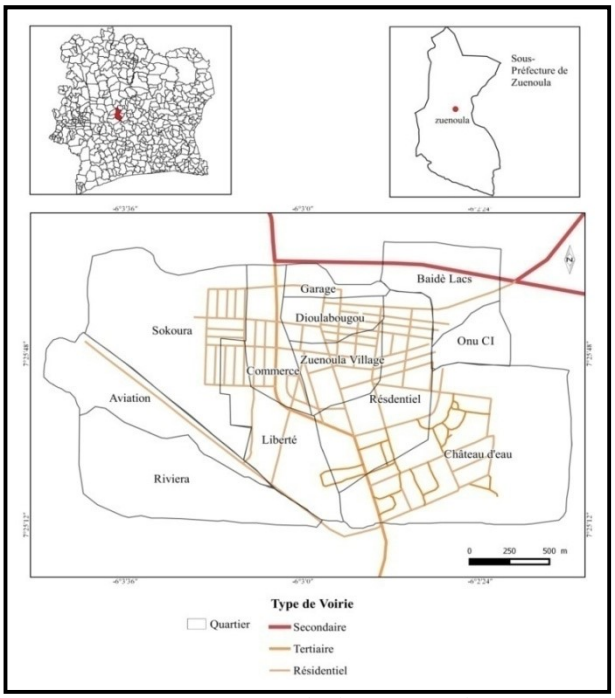
According to the World Health Organization's 2020 report, children under the age of 5 accounted for 67% of malaria-related deaths worldwide in 2019. According to the same source, Africa will account for 94% of malaria cases and deaths in 2019. As in other sub-Saharan African countries, malaria is the leading cause of morbidity and mortality in children under 5 in Côte d'Ivoire. The malaria incidence rate among these children rose from 492.9‰ in 2018 to 596.4‰ in 2019. The increase in the incidence rate was estimated at 21% (MSHP and DIIS, 2019, p.130). With a view to strengthening health security, Côte d'Ivoire has adopted a National Health Development Plan (PNDS) 2016-2020, the general aim of which is to improve the population's state of health through the provision of quality health services (MSHP, 2016, p.7). It also introduced, in 2011, the policy of free access to all malaria-related care and preventive services in public health establishments. Despite the free health care measures adopted by Côte d'Ivoire to combat malaria, it remains the leading cause of morbidity (70.82%) among children under 5 in the town of Zuénoula.

Malaria is both a health and a development problem. It is a factor in the economic vulnerability of urban households living in precarious conditions (A. S. KOUADIO *et al*., 2022, p.4). In rural areas, however, the disease has no direct or indirect effect on the production of cash crops such as coffee and cocoa (M. AUDIBERT *et al*., 2009, p.160). It does, however, disrupt agricultural calendars (M. H. K. KANGA *et al.*, 2018, p.72). It can be a source of both direct and indirect economic losses (M. AUDIBERT, 2004, p.30). The fight against malaria is a real economic burden (A.D MEVA'A, 2016, p.29). Malaria has an adverse effect on school performance (J. THUILLIEZ, 2009, p.171). According to S. NKOUSSA, (2012, p.77) the mother's activity has an indirect influence on malaria prevalence through the mother's level of education, her household's standard of living and the region's degree of endemicity. According to the latter, a self-employed mother has the opportunity to adjust her schedule to take better care of her young child. In addition to the expense involved in treating malaria cases, the disease could have a negative impact on the capacity and productivity of the working population. This is the case for mothers in the informal sector in the town of Zuénoula. Malaria in children under 5 is a cause of vulnerability among mothers.

This study aims to analyze the burden of malaria among mothers of children under 5 in the city of Zuénoula. The first part analyzes the malaria situation in children under 5 in the town of Zuénoula, based on diagnosed morbidities. The second part also analyses the financial constraints linked to the cost of malaria treatment.

MATERIALS AND METHODS

Presentation of the study framework: A town in west-central Côte d'Ivoire, Zuénoula is located in the Marahoué region. It is a commune, sub-prefecture and department chief town. The town of Zuénoula is made up of indigenous Gouro, Dioula (Malinké) and other nationals from Côte d'Ivoire and the West African sub-region. Zuénoula is made up of twelve (12) neighborhoods and three types of road,as shown on Map 1. Three public health centers (the general hospital, the PMI and the Service de Santé Scolaire et Universitaire (SSSU) and one private health center (Centre médical Emmanuel) offer modern health care to the people of Zuénoula. Situated between forest and savannah, the town of Zuénoula offers favorable environmental conditions for the spread of mosquitoes. Indeed, field observations have highlighted several breeding grounds. These include unauthorized garbage dumps, stagnant pools of water and tufts of grass, shallows, a valley, etc. These are breeding grounds for the mosquitoes that transmit malaria.



Source: Open street map. Production: KOFFI Athanase 2021

Map 1. Location of the town of Zuénoula

Data collection: A questionnaire survey was carried out among 389 mothers at the pediatric ward of Zuénoula General Hospital, given that mothers are closer to children under 5. They are more involved in their children's health than men (boys). The general hospital's pediatric center was chosen for the survey because of its dense technical facilities. Being better equipped, it receives more patients than the others. It carries out laboratory tests to diagnose pathologies. Carrying out the survey at this center ensures that the child of the mother questioned is indeed suffering from malaria, through the results of the thick drop. Mothers included in the survey are those with a child under the age of 5 suffering from malaria. Thus, any mother who came to the pediatric ward of the Hôpital Général (HG) de Zuénoula with her child under 5 suffering from malaria after diagnosis by the health worker (doctor or nurse) and who agreed to answer the questions was taken into account in the survey. The technique used was the accidental method. A total of 421 mothers were surveyed during the survey period from June 2021 to August 2021(3 months), 389 of whom reside in the town of Zuénoula.

This study on the town of Zuénoula took into account only the 389 mothers residing in the town. The survey was administered on the basis of semi-open questionnaires to give mothers a greater choice of answers. The survey collected data on diagnosed cases of malaria, mothers' income, malaria-related expenses in terms of transport, and the cost of caring for children suffering from malaria. In addition to the primary data obtained from the questionnaire survey of 389 mothers, documentary research provided additional information that enabled this work to be carried out.

Data processing and analysis: The data collected was organized and processed. Statistical processing of the data was made possible by the use of IT tools. The graphs and tables were produced using Microsoft Excel and IBM SPSS-20.0. SPSS-20.0 facilitated automatic data analysis. For data processing, codes were assigned to each mother surveyed. For text processing, we chose Microsoft Word. To measure the degree of relationship between variables, Mann-Kendall, chi² and Fisher tests were performed. The Mann-Kendall test was used to analyze the evolution of malaria cases diagnosed from 2015 to 2021 in children under 5. The Fisher test was used to assess the evolution of diagnosed malaria cases by age group. The influence of lost working days on the depletion of surveyed mothers' savings was also assessed using the chi² test. These correlation tests were carried out to test the significance of the difference between the different variables. At the 5% significance level, if the p-value is less than 0.05%, the difference is said to be statistically significant. Thus, an upper limit is given for the significance of the relationship. Most often p=0.05 (significant), p= 0.001(very significant), p= 0.0001(highly significant). These values have been taken into account in the interpretation of the tests carried out in this work. Furthermore, to analyze intermonthly variation in rainfall and diagnosed malaria cases, the reduced-centered index formula presented by François Grosjean *et al.* (2011, p.70) in "*la statistique en clair*" was used. The formula is worded as follows Ii = (X i - X)/σ, where Ii = Morbidity index; X i = Malaria cases; X = Mean of diagnosed malaria cases; σ = Standard deviation value of malaria cases. Statistical tests and graphical illustrations were performed using XLSTAT 2014 software. Maps were produced using QGIS.2.0.1 software.

RESULTS

Variations in the number of malaria diagnoses over time

The weight of malaria in consultations of children under 5 from 2017 to 2021 in the town of Zuénoula: As in other towns in Côte d'Ivoire, children under 5 are heavily affected by malaria in the town of Zuénoula. Malaria accounts for a high proportion of consultations. Table 1 illustrates this.

Table 1. Proportion of malaria in consultations for children under 5 in the town of Zuénoula

Years	Population under 5 seen in consultation	Confirmed cases of malaria	Percentage
2017	5368	3925	73.12%
2018	5789	4164	71.93%
2019	6071	4498	74.09%
2020	5783	3466	59.93%
2021	5049	3820	75.66%
Total	28060	19873	70.82%

Source: PMI, SSSU, HG Pediatrics, Centre médical Emmanuel, 2021

Malaria accounts for more than half of all consultations among children under 5. In the town of Zuénoula, environmental conditions are conducive to the proliferation of malaria vector species. In this area, 55% of respondents stated that the risk of exposure to mosquito bites is high. According to these respondents, the town of Zuénoula offers an environment conducive to the proliferation of malaria vector species. They associate the proliferation of mosquitoes in the town of Zuénoula with the presence of low-lying areas, the proximity of the Bandama river, the proliferation of patches of grass, and the proliferation of garbage heaps and wastewater stagnation points.

The weight of malaria in the reasons for consultation showed a decreasing trend from 2017 to 2021. However, this decrease is not very significant. It is attested by the p-value (p= 0.817) of the Mann-Kendall trend test at the 5% significance level. This drop can be explained by improved access to long-acting impregnated mosquito nets. Indeed, apart from routine distribution, which takes place exclusively during antenatal consultations and vaccination sessions, the 2017 mass distribution campaign enabled all households to benefit from long-acting impregnated mosquito nets. The use of long-acting impregnated mosquito nets has reduced the risk of children under 5 being exposed to mosquito bites.

Inter-month variation in diagnosed malaria cases: Morbidities diagnosed in the three health services show oscillations. These can be seen in figure 1.

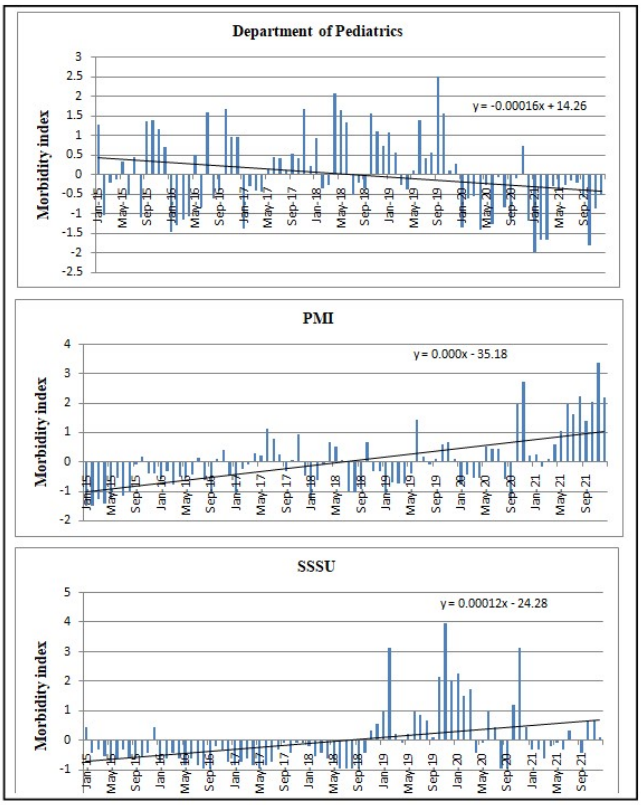


Figure 1. Inter-monthly variation in diagnosed morbidity from 2015 to 2021

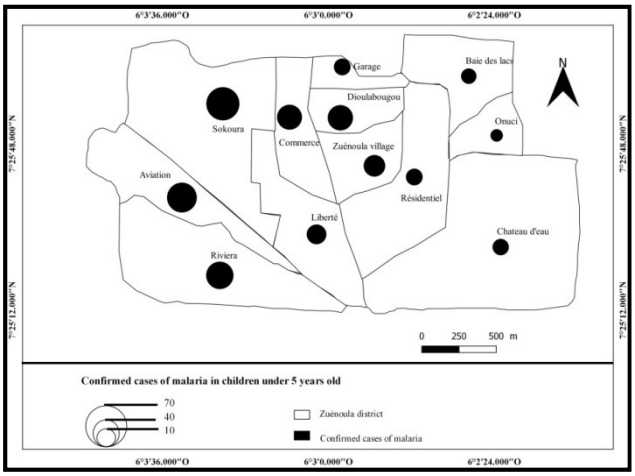
In the pediatrics department of the Hôpital Général (HG), months of high diagnosed morbidity are distinguished in September 2019 (423 cases), April 2018 (395 cases), October 2016 (366 cases), November 2017 (366 cases), May 2018 (364 cases) and July 2016 (360 cases). Low morbidity months were also recorded. These were January 2021 (115 cases), October 2021 (127 cases), February 2021 (137 cases), March 2021 (138 cases), January 2016 (150 cases) and April 2020 (155 cases). The Zuénoula PMI, like the pediatric department, recorded months of high diagnosed malaria cases and months of low diagnosed malaria cases. High malaria cases were observed in November 2021 (192 cases), November 2020 (166 cases), August 2021 (147 cases), December 2021 (145 cases), October 2012 (139 cases) and October 2020 (137 cases). SSSU also recorded months of high diagnosed morbidity. These were November 2019 (46 cases), February 2019 (38 cases), November 2020 (38 cases), January 2020 (30 cases), October (29 cases) and December 2019 (28 cases). Low morbidity months were recorded. January 2017, April 2017, June 2017, May 2016, July 2016 with 1 case respectively. The amplitude of morbidity indices ranged from -1.99 to +2.47 in the pediatrics department of Zuénoula General Hospital. Morbidity indices are subdivided into downward and upward sequences. The variability of the indices reveals 6 surplus sequences. The first surplus sequence was observed over the period from September to December 2015, with indices ranging from +0.70 to +1.37. It covered a period of 4 months. The second sequence of high morbidity was observed from October 2016 to December 2016 with indices ranging from +0.93 to +1.64. A long period of high diagnosed morbidity was observed from May 2017 to January 2018. This surplus phase spanned 9 months with morbidity indices varying between 0.09 and 1.64. Another surplus phase, relatively short compared with the previous one, was observed over a three-month period from April 2018 to June 2018. Morbidity indices over the period ranged from +1.32 to +2.06. The fifth surplus phase was observed over the period from October 2018 to February 2019. It includes 5 months of high diagnosed morbidity. Morbidity indices range from +0.54 to +1.53. From May 2019 to December 2019, a long phase of diagnosed malaria cases was observed, with indices ranging from +0.08 to +2.47. In addition, 9 bearish phases were recorded over the period from January 2015 to December 2021. Index amplitudes range from -0.06 to -1.99. The first bearish phase covers the period from February 2015 to April 2015. Indices range from -0.12 to -1.03. After this period comes a second bearish phase spanning 4 months. It runs from January to April 2016, with morbidity indices ranging from -1.08 to -1.48. Unlike the previous phase, the third bearish phase is short. It was recorded from August 2016 to September 2016. It spanned two months. The morbidity indices are estimated at -0.61 and -0.42 respectively. The fourth phase of low morbidity, from January 2017 to April 2017, lasted 4 months. Morbidity indices ranged from -0.29 to -1.40. Like the second phase, the fourth bearish phase was short-lived. It runs from February to March 2018, with indices estimated at -0.37 and -0.28 respectively. The fifth bearish phase covers the period from July 2018 to September 2018. This phase lasts 3 months. Indices range from -0.22 to -0.50. Like the 4ème bear phase, the sixth covers a two-month period, with morbidity indices estimated at -0.28 and -0.38. Between the seventh bear phase, which runs from January to October 2020, and the eighth, which runs from December 2020 to December 2021, lies the month of November, with a positive morbidity index (+0.73). The seventh bearish sequence, with indices varying between -0.10 and -1.41, lasted 10 months. The eighth, on the other hand, lasted 13 months. Indices ranged from -0.16 to -1.99.

The same alternation of positive and negative sequences was observed at the Zuénoula PMI. The time series of morbidities diagnosed from January 2015 to December 2021 comprises 8 surplus sequences and 9 bearish sequences. The first two-month surplus sequence was observed from October to November 2016. Morbidity indices are estimated at +0.09 and +0.39 respectively. The second surplus sequence, longer than the first, covers 5 months. With morbidity indices varying between +0.24 and +1.12. It runs from April 2017 to November 2017. From January 2015 to September 2016, two downward sequences were observed. This was followed by a third phase lasting 2 months. This one, whose indices are respectively estimated at +0.04 and +0.92, was observed in October and November 2017. The fourth surplus phase took place between April 2018 and June 2018. It lasted 3 months, with indices varying between +0.04 and +0.64. Lasting 2 months with indices estimated at +0.16 and +1.40, the fifth sequence was observed over the period covering June and July 2019. After this sequence, another was observed after August 2019. The sixth surplus phase, which began in September 2019, ended in December 2019. In this sequence, the amplitudes of the indices are +0.09 and +0.67. Another surplus phase lasting three months was recorded in May 2020 and July 2020, with morbidity indices varying between +0.19 and +1.95. This was the seventh surplus sequence. Between the eighth surplus phase, which runs from October 2020 to January 2020, and the ninth surplus sequence, which covers the period from March 2021 to December 2021, lies the month of February 2021, characterized by low diagnosed morbidity. Morbidity indices for the eighth surplus sequence range from +0.19 to +2.69. On the other hand, morbidity indices for the ninth surplus sequence range from +0.09 to +3.34. The first bearish phase runs from January to September 2015, with indices varying between -0.11 and -1.49. It lasted 9 months. Between the first sequence and the second lies the month of October, with a positive index (+0.16). The second downward sequence observed in the time series of malaria cases diagnosed at the PMI runs from November 2015 to June 2016. This sequence lasted 8 months.

The third downward sequence, lasting two months, runs from August to September 2016. The morbidity indices are estimated at -0.61 and -1.04 respectively. The fourth surplus phase, which was longer than the third, covers a period of 4 months, with morbidity indices ranging from -0.11 to -1.09. This phase began in December 2016 and ended in March 2017. From December 2017 to March 2018, another downward phase was observed with morbidity indices ranging from -0.11 to -1.29. This was the fifth deficit phase. Between the three-month sixth phase, which runs from July 2018 to September 2018, and the seventh, which covers the period from November 2018 to May 2019, lies the month of October 2018. Morbidity indices for the sixth phase range from -0.91 to -1.04. By contrast, indices for the seventh bearish sequence range from -0.33 to -1.09. The eighth 4-month surplus sequence runs from January to April 2020, with indices fluctuating between -0.43 and -0.79. The ninth bearish phase lasts a short 2 months, from August to September 2020. Indices are estimated at -0.59 and -1.32 respectively. The same variations in diagnosed morbidity indices that were observed in the pediatrics department of the General Hospital and the PMI, also exist in the SSSU. The SSSU recorded 7 positive sequences, compared with 5 negative sequences. At SSSU level, the first remarkable surplus sequence was observed from November 2018 to March 2019. This 5-month sequence has morbidity indices ranging from +0.23 to +3.11. The second sequence, from May 2019 to March 2020, has morbidity indices ranging from +0.12 to +3.96. This sequence lasts 11 months. After this long-lasting sequence, a short-lived surplus phase was observed from June to July 2020, with indices of +0.44 and +0.97 respectively. This was the fourth such sequence. The fifth surplus sequence began in October 2020 and ended in December 2020. Between the sixth sequence and the seventh, which covers June and July 2021, there is a break in September 2021. The sixth sequence lasts 2 months, with indices estimated at +0.01 and +0.33 respectively. In contrast, the seventh sequence, with amplitudes of +0.12 and +0.65, lasts 3 months.

The first 10-month bear phase was observed from February 2015 to November 2015. Indices oscillated between -0.30 and -0.72. The second bearish sequence, longer than the first, covers a period of 34 months. It runs from January 2016 to October 2018, with morbidity indices ranging from -0.08 to -0.94. After this long surplus phase, two short sequences were respectively observed. These were the third bearish sequence covering April and May 2020 with indices respectively estimated at -0.40 and -0.08, and the fourth extending from August to September 2020 with the same indices of -0.94. The last remarkable sequence was observed from January 2021 to June 2021. It lasted 6 months. The amplitude of the indices for this fifth bearish sequence is estimated at -0.08 and -0.62. The inter-month variability of malaria cases diagnosed in the pediatrics department of the Zuénoula General Hospital shows a decreasing trend from January 2015 to December 2021. At the PMI and SSSU, the inter-monthly variability observed from January 2015 to December 2021 shows an increasing trend. Seasonal peaks in diagnosed cases vary by health service and year.

Spatial inequalities revealed by malaria cases diagnosed in the town of Zuénoula: Children under 5 are unequally affected by malaria depending on where they live. This unequal distribution according to place of residence is shown on Map 2. Confirmed cases of malaria from the General Hospital pediatrics department, the PMI and the SSU reveal three levels of malaria transmission according to where children under 5 live: high malaria transmission, medium malaria transmission and low malaria transmission. Map 2 shows the uneven spatial distribution of confirmed malaria cases in the infant and child population across Zuénoula's neighborhoods. Indeed, children under 5 living in the Sokoura and Aviation districts are the most affected by malaria, with 17.99% and 14.65% respectively of confirmed malaria cases, according to a survey of children's mothers at the general hospital's pediatric ward. Compared with the proportions in Sokoura and Aviation, children under 5 living in the Zuénoula village, Riviera, Commerce and Dioulabougou districts are less affected by malaria.



Source: PMI, SSSU, HG pediatrics, 2021 Production: KOFFI Athanase, 2021

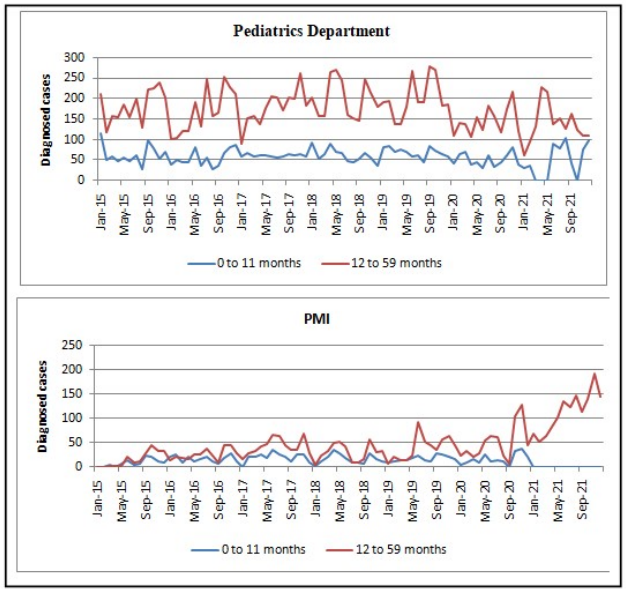
Map 2. Distribution of malaria cases in children under 5 years of age by district of residence

These neighborhoods respectively account for 7.71%, 12.34%, 10.28% and 10.54% of confirmed malaria cases in children under 5. However, the Onci, Baie des lacs, Château d'eau, Garage, Résidentiel and Liberté neighborhoods have the lowest malaria rates, at 2.57%, 3.86%, 4.37%, 4.63%, 4.63% and 6.43% respectively. The Sokoura and Aviation neighborhoods have the highest malaria morbidity among children under 5, due to precarious environmental conditions. These two neighborhoods account for 32.64% of diagnosed cases. Environmental conditions in these two neighborhoods are conducive to the proliferation of larval breeding sites. These two neighborhoods are dotted with collections of stagnant water, shallows, garbage heaps and clumps of grass. The precarious environmental conditions in which children under 5 live accentuate the risks of transmission. There are no drains in these neighborhoods to evacuate rainwater. The proliferation of water collections during the rainy season also encourages the growth of breeding grounds. The risk of malaria transmission is higher for children under 5 whose parents live in the lowlands. Apart from these factors, the practice of storing water at home in uncovered containers over long periods encourages the proliferation of malaria-transmitting species. Children under 5 whose parents live in backyards with vegetable gardens are highly exposed to the risk of malaria transmission.

Compared with Sokoura and Aviation, the malaria situation among children under 5 appears less alarming in the Zuénoula village, Riviera, Commerce and Dioulabougou neighborhoods, according to cases diagnosed. These neighborhoods respectively account for 7.70%, 12.34%, 10.28% and 10.54% of cases diagnosed in Zuénoula's health services. In Zuénoula village and Dioulabougou, the environment is marked by the presence of gutters clogged with household refuse, solid waste and mud, and a few collections of water that constitute larval breeding grounds influencing the incidence of malaria. The way water is stored in these neighborhoods encourages the proliferation of larval breeding grounds. Some households store water in uncovered containers. This action contributes to the multiplication of larval breeding grounds. The absence of weeds, and more or less acceptable cleanliness, helps to reduce the incidence of malaria in these two neighborhoods. Riviera is a particularly grassy area, located close to a drained valley. This geographical situation exposes residents to mosquito bites. However, the absence of water and garbage collections close to homes in the neighborhood limits the incidence of malaria. In the shops, there are no gutters to drain away wastewater. The three public health centers in the town of Zuénoula are located in this neighborhood, which facilitates access to health care for local residents. As a result, parents regularly bring their children to these centers, which could influence the number of consultations, or even the number of malaria-infected children, compared with other neighborhoods where access to healthcare is limited by distance. The average level of malaria incidence is also due to the fact that the Commerce district benefits from certain

environmental and socio-economic conditions. Indeed, the Commerce district is reserved for administrative and commercial services (sub-prefecture, town hall, banks, department stores). It's approximately in the center of town and enjoys a special level of cleanliness (regular garbage collection, regular sweeping of alleyways, regular cleaning) compared with other districts. These combined actions help to limit the incidence of malaria.

Diagnosed morbidities vary by age group: Malaria cases diagnosed in children under 5 years of age vary significantly according to age group. The evolution of malaria cases diagnosed at the general hospital's paediatric department and at the PMI is shown in figure 2.



Source: Processing of data from Pediatrics, PMI, SSSU, 2021

Figure 2. Trends in diagnosed malaria cases by age group

From January 2015 to December 2021, 19627 cases of malaria were diagnosed in the pediatric department of Zuénoula General Hospital. A total of 4939 cases were diagnosed in children under 12 months of age. They represent 33.63% of cases diagnosed in the pediatric department. On the other hand, 66.37% of cases were recorded in the 12 to 59 months age group. In the 12 to 59 months age group, a total of 14688 cases were diagnosed. In the same period, from January 2015 to December 2021, 4,973 cases of uncomplicated malaria were diagnosed. Of these 4,973 cases, 1,166 were diagnosed in children under 12 months of age. This represents 23.45% of cases diagnosed at the PMI. Among children aged between 12 and 59 months, the number of cases diagnosed was 3807, i.e. 76.55% of all cases diagnosed. At the 5% significance level, the p-value ($p < 0.0001$) of the Fisher test shows a significant variation. The incidence of malaria is higher in children aged between 12 and 59 months than in those aged between 0 and 11 months. This can be explained by the fact that children aged 12 to 59 months are mostly weaned on breast milk. These weaned children no longer have maternal antibodies (anti-malaria antibodies from the mother) or acquire a labile and incomplete immunity to ensure their protection, and are therefore more exposed to diseases in general, and in particular to malaria, which is endemic in Zuénoula, given its weight in consultations (70.82%). High malaria morbidity in children aged 12 to 59 months may also be due to the fact that these children are most often abandoned or handed over as soon as they become a little older (2 to 5 years), or as soon as a little brother or sister arrives. What's more, mothers give them less attention than younger children, due to their fragility in the first few months of life. As a result, these children are more exposed to Anopheles bites, which are responsible for malaria transmission.

Financial constraints related to the burden of malaria in the town of Zuénoula

Mothers' savings depleted by the disruption to their activities caused by malaria in children under 5 years of age: Given that in the town of Zuénoula, malaria is the leading cause of morbidity and mortality in children under 5 (70.82% of reasons for consultation and 28 child deaths in 2018), the children's mothers interrupt their economic activities several times to care for their malaria-sick children. This is particularly the case for those engaged in petty trade (selling peanuts, corn, oranges, sweet bananas, mangoes) and those whose agricultural activities are their source of income generation in Zuenoula. The disease thus has a negative impact on the economic situation of mothers. It also causes an annual loss of time of between three and twenty-six days for their economic activities. This loss of time can be seen in Table 2.

Table 2. Distribution of mothers according to annual loss of working days

Status socio-professional background of surveyed mothers	Annual loss of working days			Total
	[3- 10]	[11- 18]	[19 - 26]	
Housekeeper	57	113	14	184
	30.98%	61.41%	7.61%	100%
Civil servant	13	7	0	20
	65%	35%	0%	100%
Seamstress	12	18	2	32
	37.5%	56.25%	6.25%	100%
Hairdresser	10	16	4	30
	33,33%	53,34%	13,33%	100%
Retailer	33	75	6	114
	28.95%	65.79%	5.26%	100%
Student	7	2	0	9
	77,78%	22.22%	0%	100%
Total	132	231	26	389
	33.9%	**59.4%**	**6.7%**	**100%**

Source: Field survey data processing, 2021

According to the survey results, some 59.4% of mothers surveyed lost between 11 and 18 days of work per year. Mothers who lost 3 to 10 days of work represented 33.9% of those surveyed. On the other hand, some 6.7% of mothers surveyed were unable to work for a period ranging from 19 to 26 days. At the 5% significance level, the p-value of Fisher's test ($p= 0.034$) reveals a significant variation in lost working days according to socio-professional category. Losses of working days are higher among mothers working in the informal sector. Approximately 66% of mothers working in the informal sector lost 11 to 18 working days. These are mothers who derive their financial resources from trade, hairdressing and sewing. Disruption to the activities of mothers whose financial resources come from informal activities significantly reduces their income. These losses are more significant among mothers involved in the sale of seasonal agricultural produce. These include sellers of oranges, avocados, mangoes, peanuts and maize. The occurrence of malaria episodes during periods of high availability of these agricultural products prevents mothers from selling and having financial resources. The occurrence of malaria episodes among children under 5 contributes to the depletion of mothers' financial resources and savings. The level of savings depletion depends on the number of days of activity lost (table 3).

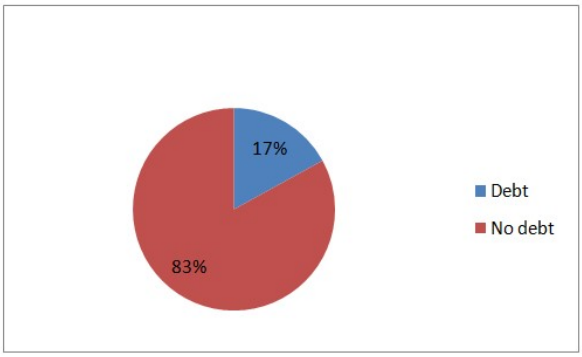
Table 3. Level of depletion of savings by surveyed mothers, according to loss of working days in the year

Annual loss of working days	Level of depletion of mothers' savings			Total
	Low	High	Very high	
[3- 10]	89	33	10	132
	67.42%	25%	7.58%	100%
[11- 18]	31	115	85	231
	13.42%	49.78%	36.8%	100%
[19 - 26]	0	8	18	26
	0%	30.77%	69.23%	100%
Total	120	156	113	389
	30,85%	**40,1%**	**29,05%**	**100%**

Source: Field survey data processing, 2021

At the 5% significance level, the p-value ($p < 0.0001$) of the chi² test reveals a highly significant influence of lost working days on the depletion of the savings of the mothers surveyed.

Mothers' indebtedness and the economic burden of malaria: in children under 5 years of age: In the face of endemic child malaria, low-income mothers run the risk of contracting debt or living without savings. The survey revealed that 17% of mothers surveyed had contracted a debt (figure 3) ranging from 10.000 CFA francs ($16.15) to 30.000 CFA francs ($48.44) to care for their children suffering from malaria. Cases of indebtedness are recurrent when it comes to severe malaria. In fact, low-income mothers living in poor households in the town of Zuénoula only turn to health facilities in the event of complications, or when their child's malaria becomes complicated. This observation was underlined by health workers. In such cases, the cost of treatment is enormous. With precarious financial resources and depleted savings, they are often unable to bear the economic burden generated by episodes of malaria. To cope with the cost of malaria, mothers resort to debt.



Source: Field survey data processing, 2021

Figure 3. Proportion of mothers who contracted a debt due to malaria

Among the 83% of mothers who have no recourse to debt, 53.09% live without savings due to the economic burden of malaria. These mothers, whose economic activities are hampered or disrupted by malaria episodes, are forced to live from day to day without savings. This prevents them from thinking about investing to escape poverty.

DISCUSSION

As in other towns in Côte d' Ivoire, malaria is the leading cause of morbidity in children under 5 in the town of Zuénoula. On average, it represented 70.82% of the reasons for consultation in this child population from 2015 to 2021. In addition, malaria cases diagnosed in children under 5 in public health services have evolved increasingly over this period. This trend can be explained by a number of factors, including precarious environmental, economic and financial conditions. The precarious environmental conditions in which children under 5 live accentuate the risk of malaria transmission. These results concur with those of I. M. CISSE *et al*, (2020, p.2740) in Tourou (Benin). These authors showed that the proliferation of stagnant water and clumps of grass modulates the risk of exposure to malaria. According to them, households living in an environment free of weeds and stagnant water are less exposed to malaria. The risk of exposure to mosquito bites is also high in households with yards covered in natural grass. Similar results were obtained by A. O. BRISSY *et al*., (2017, p.127) in Bouaké. According to these authors, the risk of anopheline aggression is higher in high-end homes with vegetable gardens. In these homes, the lawn serves as shelter for the Anopheles population. In these homes, the presence of lawns in the courtyard is a risk factor significantly associated with the occurrence of malaria. Added to this is the storage of water in open containers. Households in Zuénoula keep water at home in uncovered containers for long periods. This practice encourages the proliferation of malaria vector species. These results corroborate those of A. O. BRISSY *et al*, (2017, p.130). According to these authors, uncovered water storage equipment is a breeding ground for malaria transmission vectors. For them, these represent anthropogenic breeding sites in the vicinity of houses. Water conservation practices increase the risk of exposure to malaria. They concluded that home water conservation favored the establishment of breeding sites close to the host population. Exposure depends on proximity to the breeding sites of malaria transmission vectors. In addition, the unhealthy living environment created by the uncontrolled dumping of household waste and the dumping of wastewater in neighborhoods is a factor in the proliferation of breeding grounds for vector species. As a result, children living close to these breeding grounds are more exposed to the risk of malaria. Similar results were found by F. B. HUE BI *et al*, (2021, p.69) in Sinfra. They pointed out that unhealthy living conditions remain a risk factor for malaria in this town. In fact, according to these authors, the proportion of households exposed to malaria risk in the town of Sinfra is higher in unsanitary (85.42%) and moderately sanitary (56.32%) neighborhoods than in sanitary neighborhoods (4.55%). Thus, the precarious environmental conditions of the town of Zuénoula justify the malaria endemicity among children under 5 in the town of Zuénoula. At the 5% significance level, the p-value ($p < 0.0001$) of the Fisher test illustrates a significant variation in diagnosed malaria cases by age group. In Zuénoula, the incidence of malaria is higher in children aged between 12 and 59 months than in those aged between 0 and 11 months. This can be explained by the fact that children aged 12 to 59 months are mostly weaned on breast milk.

These weaned children no longer have maternal antibodies (anti-malaria antibodies from the mother) or acquire a labile and incomplete immunity to ensure their protection, and are therefore more exposed to diseases in general and to malaria in particular. The work of M. A. TRAORE (2019, p.19) reached the same conclusion. According to the author, childhood malaria appears after the disappearance of the newborn's protection by maternal antibodies and the progressive replacement of HbF by HbA, after the age of 3 months. The author concludes that after the disappearance of the maternal antibodies received by the child from its mother, the latter is exposed to numerous severe malaria attacks. Our results are also in line with those of CARNEVALE and VAUGELADE (1987, cited by T. S. KABORE, 2019, p.4). These authors state that anti-malarial antibodies transmitted by the mother to the child disappear progressively between 6 and 24 months of age. This means that children aged between 24 and 59 months are exposed to the risk of malaria. As a result, breast milk, which children usually receive from the very first months of life (0 to 11 months), protects them against diseases such as malaria. S. NKOUSSA (2012, p37) added that breastfeeding protects the child, because the absence of para-aminobenzoic acid (PABA) in breast milk limits the development of the parasite, which needs it to synthesize its DNA. As a result, children aged 0-11 months are better protected against malaria than those aged 12-59 months. The occurrence of malaria episodes in children under 5 years of age hampers mothers' economic activities. It contributes to their economic and financial vulnerability. Indeed, the occurrence of malaria episodes, especially severe malaria in children, leads to loss of working days, increased expenditure and depletion of savings among mothers. Because of the persistence of malaria and its economic burden, 53.09% of mothers surveyed live without savings. Similar results on the economic burden of malaria have been found by other authors. These include I. SEMEGA (2014, p.36). In the town of Kaédi, the author pointed out that the expenses generated by care (medicines and evacuations) and the drop in farmers' yields during the period of agro-pastoral activities considerably affect people's standard of living. As for B. NKEMBA *et al* (2014, p.915) have shown that households spend an average of 28% of their income on malaria treatment. According to these authors, a poor African family can spend a quarter of its annual income on malaria prevention and treatment. To add to this, L. H. A. BALLE, (2016, p.50) has shown that during the period of illness, individuals who are gainfully employed on a daily basis lose money due to their state of fragility and care-related expenses. According to the same author, one or more members of the household stop working to look after the sick person. This was the case for mothers of children under 5 surveyed in the town of Zuénoula.

The economic burden of malaria is felt most by mothers whose financial resources come from the informal sector. The adverse impact of malaria on informal sector players has been analyzed by A. S. KOUADIO *et al*, (2022, p.5). According to these authors, most working members of households are engaged in low-income informal activities, and those who fall ill with malaria lose between 4 and 7 working days. This corresponds to an average additional loss of income of around $22.72.

CONCLUSION

Childhood malaria endemicity due to precarious local environmental conditions is a factor of vulnerability for mothers in the town of Zuénoula. This vulnerability is reflected in the economic burden of malaria and the disruption of their economic activities. Although it is a health problem, the economic stakes of malaria are poorly elucidated in research. The healthcare costs associated with the persistence of malaria in children under 5 years of age are a burden for low-income mothers in the town of Zuénoula. Malaria is the main reason for health care expenditure among these children in different households in this town, as well as the loss of long working days among mothers. The risk of being economically vulnerable to malaria is higher among low-income mothers. Mothers without financial resources are forced into debt to cope with the economic burden of malaria. Thus, low-income mothers are more exposed to the economic burden of malaria in the town of Zuénoula.

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