ISSN: 3066-716X
Research Article
Journal of Clinical and Biomedical Advances

Perception of Climatic and Non-Climatic influence on Malaria Prevalence in Upper River Region of The Gambia

Ugochinyere Agatha Okafor[1*], Sidat Yaffa[1], Umberto D'Alessandro[2], Vincent Nduka Ojeh[3], & Iddisah Alhassan[1]

[1]*West Africa Service Center on Climate Change and Adapted Land use, School of Agriculture and Environmental Sciences, Department of Climate Change and Education, University of The Gambia.*
[2]*Medical Research Council Unit The Gambia at the London School of Hygiene and Tropical, Banjul, The Gambia*
[3]*Taraba State University, Jalingo, Nigeria*

[*]Corresponding author: Ugochinyere Agatha Okafor, West Africa Service Center on Climate Change and Adapted Land use, School of Agriculture and Environmental Sciences, Department of Climate Change and Education, University of The Gambia.

Submitted: 04 April 2025 **Accepted:** 10 April 2025 **Published:** 17 April 2025

https://doi.org/10.63620/MKJCBA.2025.1040

Citation: *Agatha, O. U., Yaffa, S., Alhassan, I., Alessandro, D. U., & Nduka, O. V. (2025). Perception of Climatic and Non-Climatic influence on Malaria Prevalence in Upper River Region of The Gambia. J of Clin Bio Med Adv, 4(2), 01-10.*

Abstract
Despite the scale-up of intervention, malaria remains a burden in the Upper River Region of The Gambia. Climate changes and non-climatic conditions can substantially influence malaria prevalence, and further affect the coverage of preventive interventions. This work aimed at exploring the different climatic and non-climatic risk factors associated with malaria. Using a descriptive research method and a parallel mixed-method approach, 381 households from seven districts were surveyed from 4th to 24th September 2023. Data were analyzed with StataSE 18 and Nvivo. Descriptive statistics were performed, in addition to thematic analysis, and the significant influence of environmental and socioeconomic factors on malaria prevalence in the region was further analyzed using Chi-square (X2). The work revealed an influence of rainfall and flood on the prevalence of malaria in the region, with a significant association of some measured environmental and socioeconomic factors at a p-value of 0.05. These results will provide individuals, professionals, government, and policymakers valuable information for better-targeting malaria control efforts.

Keywords: Knowledge, Climate Change, Prevalence, Malaria, Flooding, Rainfall, Socioeconomic Factors, Environmental Health

Introduction

The effect of climate change on the burden of infectious diseases, particularly vector-borne diseases such as malaria, is currently debated [1]. Climate plays a major role on the malaria dynamics and distribution and climate change will increase malaria transmission in certain geographical areas depending on demographic, socioeconomic, and ecological factors [2, 4]. According to the IPCC WGII Sixth Assessment Report, the distribution and prevalence of malaria are influenced by rising temperatures and changing rainfall patterns (high confidence) and Sub-Saharan Africa has an ideal climatic condition for endemic malaria transmission [5, 6].

Projections on the influence of climate change on malaria estimated an increase in population at risk of 1.6 million by 2030 and 1.8 million by 2050, although other factors can influence malaria transmission [7, 8]. The development of the malaria parasite and its transmission is accelerated by changing temperature, rainfall, flooding, moisture conditions of the environment, and other non-climatic factors [6, 9-15]. The above-mentioned climatic variables favor the breeding, proliferation, mating, longevity, dispersal, blood-feeding behavior, and oviposition of mosquitoes [11, 16-20]. The Gambia aims at eliminating malaria, i.e., interruption of local transmission, by 2030(21). Nevertheless, malaria transmission is still ongoing despite a good coverage of control interventions, with the highest prevalence of infection in eastern Gambia, ie., 31.1% in the region's south bank and 36.8% north bank in [21, 22]. Investigating both climatic and non-climatic factors becomes paramount for identifying the factors responsible for residual transmission so that control interventions may be targeted more efficiently.

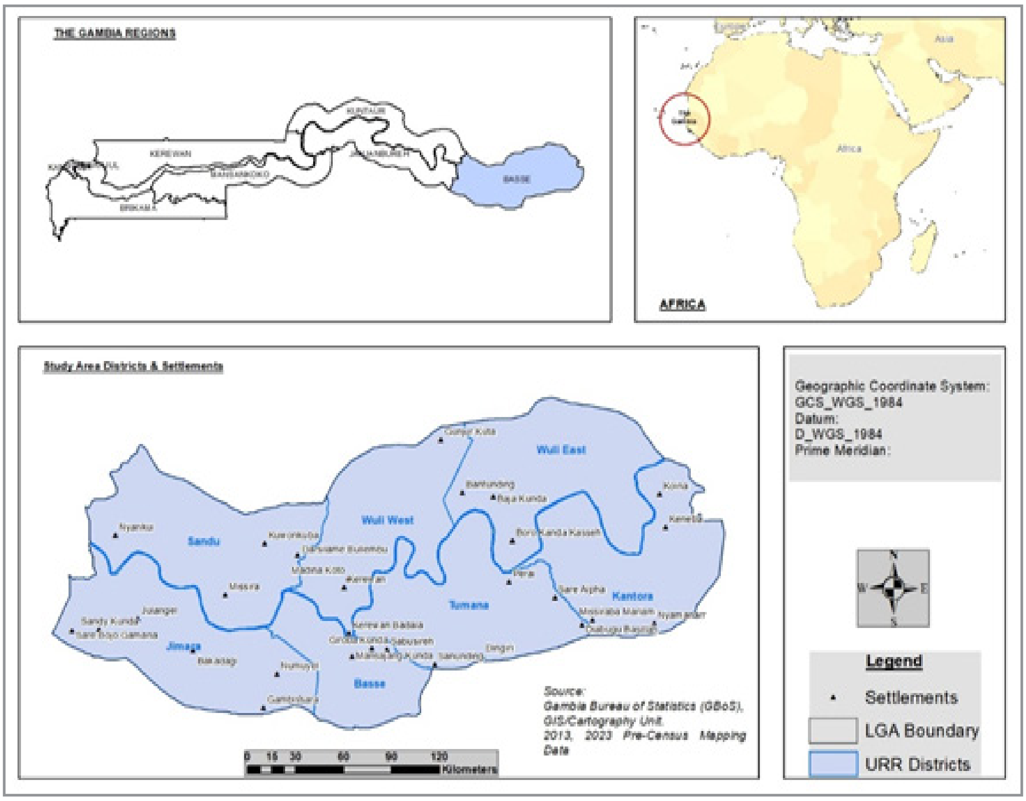
Studies have reported a significant effect of climatic variables on the longevity of mosquitoes and the development of malaria parasites in the mosquito, and, subsequently, malaria prevalence [7, 17]. They have shown spatial and temporal variation in the prevalence of malaria infection using environmental temperature alongside rainfall and humidity. Nevertheless, the interaction between climatic factors and disease transmission is complicated and multifaceted, with mosquito survival, parasite development within the vector, and disease transmission potential restricted above and below certain temperature thresholds [16, 17]. Additionally, optimal ranges for climatic suitability vary depending on the vector species, pathogen, and region, with disease transmission further influenced by other social and ecological factors [3].

Some scholars state that malaria transmission and prevalence of infection are mainly influenced by temperature, while others argue that other factors such as the minimal temperatures, amount of rainfalls, and relative humidity are also important [12, 23]. In addition to the complex relationship and overwhelming evidence that climatic variables affect substantially malaria transmission, deeper knowledge of the environmental, cultural, and socioeconomic elements that affect malaria at the household and societal levels is required [7]. This will necessitate an integrated strategy that takes into account climate change as well as other factors that influence malaria transmission [8].

This study used a mixed-method approach to capture comprehensive and detailed information on the knowledge of climatic influence on malaria, in addition to the major climatic and non-climatic influence on malaria transmission in the region. Determining the climatic variables and the socioeconomic factors associated with malaria prevalence in the region could help to decrease its burden in the Upper River Region of The Gambia.

Methodology

Study area



The study was conducted in the Upper River Region of The Gambia (URR) among household heads randomly selected in each of the seven districts in the region, namely Kantora, Tumana, Basse Fuladu East, Jimara, Wuli West, West East, and Sandu. The region has a land mass of about 2000 sq km and a population density of 116/Km2 (GBoS, 2013).

The Gambia lies in the tropical wet and dry or savanna climate zone, which has a distinct long dry season and short rainy season. URR is crossed by the river of The Gambia, a large, slow-moving waterway, characterized by tidal movements and saltwater intrusion as far as 200km upriver., creating breeding sites for malaria vectors. The estimated annual rainfall is between 800mm and 1200mm and the average number of rainy days ranges from 54 days in Banjul to 31 days in URR where there are often floods following the rains.

The yearly average temperature is 31.85°C (89.33°F), about 2.3% higher than in other regions in The Gambia. In the dry season, the highest average temperature is between 33.22°C and 42.42°C, while in the wet season, the lowest average is between 19.48°C and 27.99°C, a conducive temperature that supports the development and transmission of P. falciparum. At temperatures below 20oC P. falciparum cannot complete its life cycle and thus cannot be transmitted.

Research Design/ Data Sampling Techniques

A parallel mixed-method approach, comprising equal strength of a qualitative strand and a quantitative strand, was used for the collection of primary data. The quantitative survey involved face-to-face interviews with selected household heads using structured questionnaires, while the qualitative study elicited information through Focus Group Discussions (FGDs), and Key Informant Interviews (KIIs) using a topic guide.

For the survey, it was assumed a prevalence of 50%, and a margin of error of 5%, resulting in a sample size of 376 individuals, which was increased to 381 to account for unforeseen errors. A total of 91 individuals, irrespective of gender, were purposively selected for the qualitative study within the age bracket of 30-80 years and included 31 Key Informants (Alkalo/chief), and 60 individuals (41 males and 19 females) for the FGDs. Each FGD involved a maximum of 10 participants. Seven (7) FGDs were organized across and the surveyed were carried out from 4th to 24th September 2023. Data were analysed with StataSE 18 and Nvivo.

Pilot Testing of the Research Instrument

The research instruments were first reviewed by the researcher supervisors to ensure content validity and appropriateness, clarity, relevance, and suitability for the research. The instruments were further reviewed by the Research Ethics Committee at the University of The Gambia. A pilot testing was conducted in three selected settlements in the Basse district to check its suitability and adapt it if needed, to ensure the reliability and validity of the questionnaire and topic guide. The questionnaire was further revised after piloting and translated back into English language and checked for clarity. Moreover, the reliability of the questionnaire data was further tested using Cronbach alpha reliability statistics.

Strategies to Deal with Validity Threats in Qualitative Data

This work employed various formats to deal with threats to validity relevant to qualitative research. The standards taken to reduce threats to descriptive and interpretative validity included: asking open-ended questions, verbatim transcripts of the interviews, presenting participant quotations without shortening, peer debriefing, collecting and analyzing quality data, and providing thick descriptions of the setting, participants, and themes. The triangulation employed both in data collection techniques and sampling strategies aids in solving the threat of both interpretative and theoretical validity [24, 25].

Data Processing

To assess the knowledge of the influence of climate change on malaria, we employed a 5-point Likert scale (Strongly Agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly Disagree = 1). The true strength and rate of either agreement or disagreement were measured using the mean score of the total respondents to evaluate the certainty of the response and determine which climatic factors were perceived to have a greater influence on malaria. The true strength was measured by the degree to which respondents agreed or disagreed with the concept. However, the rate of perception in this regard is given by: the frequency of response in each scale divided by the total respondents' response, multiplied by the attributed scale value.

The rate of perception is measured by the additional value above or below the attributed scale value from the mean score. Any value at the midpoint of 3.0 is considered neutral and is not measured. The percentage analysis was further used to evaluate the perception of the population on the major climatic factors associated with malaria prevalence. Multivariate regression was applied to investigate some of the socio-demographic factors influencing their perception. Moreover, the frequency, percentage, and statistically significant influence of non-climatic parameters (environmental, social, and economic factors) on the perceived climatic variables responsible for malaria prevalence in the regions were equally investigated using Pearson's Chi-square.

The themes and sub-themes were extracted using NVivo 14 to analyse the qualitative data, whilst Stata 18 was employed to perform a descriptive quantitative data analysis.

Ethical Consideration

The research was conducted based on the tenets of Climate Change and Education, at the University of the Gambia. The study was approved by the University of the Gambia Ethics Committee on the 28th of August 2023. Written consent was secured from the participants after explaining the study's aim, objectives, and procedures. Participation in the study was voluntary, and participants were free not to answer the survey, or to withdraw their participation without penalty. The individual answers were anonymized and referenced instead.

Results

Table 1 presents the knowledge of climate change/variables influence on malaria infection on the Likert scale 5-point. The result reveals that a higher percentage of the respondent (55.12%) believe that climate change has an impact on malaria as they demonstrate their disagreement with the statement that" Climate change has no impact on malaria transmission". However, only 10.24% of the population strongly disagree with the concept. Additionally, the total mean score value on this concept is seen at approximately 3.0 points which stands for neutral. The implication is that climate change may or may not influence malaria, despite the opinion of the majority. On the other hand, a higher percentage of respondents disagree with the concept that decreased rainfall (59.32%) and drought (39.37%) increased malaria transmission, slightly in conformity with their mean score value seen at 2.67 and 2.61 respectively. However, the strength of disagreement is somehow weak as the mean score is above the attributed point 2 with a rate of 0.67 and 0.61 respectively, approximately 3.0 means score value that stands for neutral. This also suggests uncertainty on the effect of the variables on malaria. The population was equally neutral on increased malaria transmission in increased humid temperatures, in complete alignment with the mean score value of approximately 3.0 points for neutral.

Furthermore, a strong agreement was noted on the concept of the influence of warmer temperatures on mosquitoes' survival (38.85%), increased biting and abundance of mosquitoes (70.60%) during the rainy season in addition to the influence of flood on malaria prevalence (62.99%). A total mean score value of 3.82 (approx. 4.0) was noted on the concept of the influence of warmer temperatures on mosquito survival. This implies agreement with the concept, although the agreement is not very strong as the means score is -2 from the attributed value four (4) for agreement. The concept can be considered agreed on, but not strongly agreed. On the other hand, there is strong agreement on the concept of increased malaria prevalence during flooding (4.57), abundance of mosquitoes, and increased mosquito biting during the rainy season (4.69) as explained by their mean score value, approximately 5 points. The result demonstrates that knowledge of the influence of flood and rainfall on malaria is very certain among the population more than other accessed variables.

Table 1: Knowledge of the Influence of Climate Change Variables on Malaria

Variables	Percentage (Mean score value)					Mean score
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	
Climate change has no impact on malaria transmission	8.66 (0.43)	24.67 (0.99)	11.55 (0.35)	44.88 (0.90)	10.24 (0.10)	2.77
Mosquitoes survive better at warmer temperatures	38.85 (1.94)	26.51 (1.0.6)	16.54 (0.50)	15.49 (0.31)	2.62 (.03)	3.84
Increasing humidity increases malaria prevalence	11.29 (0.56)	18.90 (0.76)	38.06 (1.14)	30.97 (0.62)	0.79 (.01)	3.09
Floods can increase malaria prevalence	62.99 (3.15)	34.12 (1.36)	1.05 (.03)	0.79 (.02)	1.05 (.01)	4.57
A decrease in rainfall leads to malaria prevalence	6.56(0.33)	21.26 (0.85)	8.66 (0.26)	59.32 (1.19)	4.20 (.04)	2.67
Droughts favor the transmission of malaria	2.10 (0.10)	14.44 (0.58)	34.91 (1.05)	39.37 (0.79)	9.19 (0.09)	2.61
Mosquito bites more and in abundance during raining season	70.60 (3.53)	28.08 (1.12)	0.52 (.02)	0.26 (.01)	0.52 (.01)	4.69

Source: Field data, 2023. Numbers in parentheses indicate the percentage of households while those without are the frequencies.

Perception of the population on the influence of climatic variables on malaria was further presented in Figure 1. Floods and increased rainfalls are perceived as favoring factors for malaria while average rainfalls, lower temperatures, and even higher temperatures are considered less important.

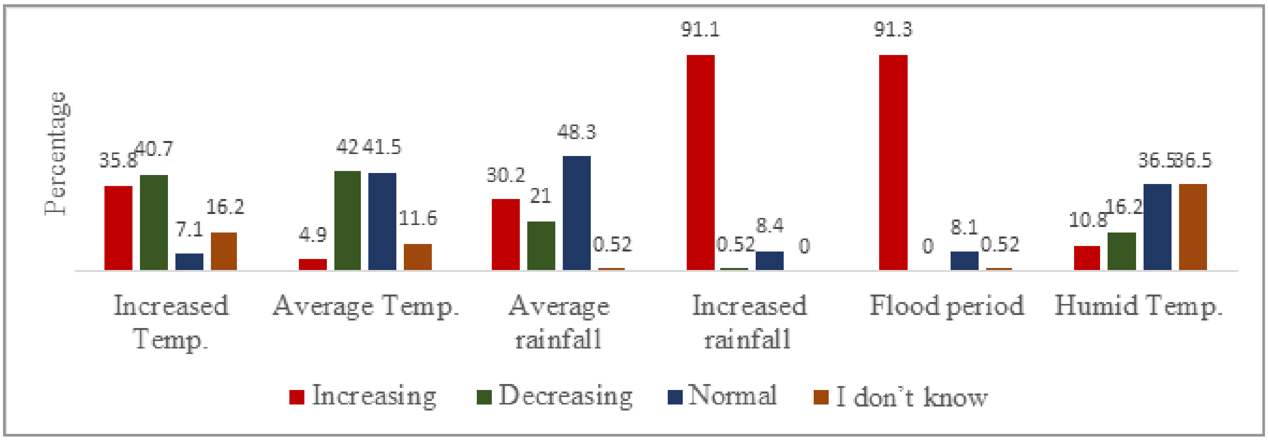


Figure 1: Perception of Climatic Influence on Malaria Prevalence in the Region.

Qualitative findings (Table 2) also identified rainfalls as a factor that significantly influences malaria prevalence in the region as highlighted in 37 coded files with 72 references, and floods with 44 references in 33 coded files. Temperature had 7 references from 4 coded files and humidity had just 3 references from 3 coded files.

Table 2: Qualitative Finding on Climatic Influence on Malaria Prevalence in URR

Sub-themes	NCFs	NCRs	Respondent's statements
Rainfall	37	72	There is too much malaria at this time (rainy season). I have been sick for the last ten days and have not gone to the farm since then. Too much rain causes malaria and this is the season for malaria.

Flood	30	41	When there is a flood in the community, there is always lots of standing water around which serves as a breeding space for mosquitoes.
Temperature	4	7	The increased temperature often led an increased number of the population that will be sick as a result of mosquitoes biting, but it reduces when the temperature is cold.
Humid temperature	3	3	I think humidity also has little influence on malaria.

Note: NCFs stands for the number of coding files and NCRs number of coding references

The perception of the population on the climatic variables associated with the persistence of malaria in the region was significantly influenced by their age and the years lived in the region at a p-value of 0.004 and 0.002 respectively as shown in Table 3.

Table 3: Influence of Socio-demographic Factors on the Perception of the Population of the Climatic Variables Associated with Malaria Prevalence in the Region

Perception	coefficient	P>|t|	[95% conf. interval]
District	-.0000667	0.998	-.0491759 .0490426
Age	.0125724	0.004	.0040511 .0210937
Occupation	-.0336323	0.557	-.1460519 .0787874
Years lived in the region	.1933408	0.002	.0703377 .3163439
constant	1.039902	0.003	.0703377 .3163439

To further investigate the reasons for residual malaria transmission in the regions, non-climatic factors such as environmental, social, and economic factors, were also considered using both qualitative and quantitative methods (Table 4 and Figure 2). Several environmental, social, and economic factors are perceived as important in increasing the malaria risk. Improper drainage systems, swamps, stagnant water, poor environmental hygiene, bushes, and garbage are all significantly associated with an increased malaria risk (Table 4). The quantitative result finding (Table 4) further aligns with the qualitative result (Figure 2). For example, during one of the FGDs respondents stated that:

The dirty surroundings and stagnant water bodies are the cause of malaria in our communities. In those days, bed nets were not available but there was less malaria because of the clean environment (FGD Fatoto and Tumana).

Among the social factors, unprofessional health personnel and the quality of health facilities were thought associated with higher malaria risk. The results of the FGD further throw more light on these.

Thus:
In our region, maybe due to the vast land of bushes, we have lots of malaria in some villages, but for Bakadagi is very minimal (KII Jimara).

I believe that doctors here are not professional because each time you go to the hospital the doctors will conclude is malaria without testing. People should be tested first before they come to that conclusion (KII Taibatou Wuli West).

Poor hospital facilities and health personnel made most of the community hesitant to go to the hospital, they would rather stay home and treat themselves using local herbs (FGD Kantora). The region is close to rice farms, which also contribute to the increase in malaria especially during the rainy season. Malaria is more prevalent in the region than in CRR and LRR because of our rice cultivation.

Not surprisingly poverty (low income, unemployment) is also associated with a higher risk of malaria.

Influence of Non-Climate Factors on the Prevalence of Malaria
To further investigate the reason for the persistence of malaria, non-climatic factors such as environmental, social, and economic factors were also considered using both qualitative and quantitative methods. The results in Table 4.13 revealed a significant non-association of environmental pollutants and population density with malaria prevalence in the region at a p-value of 0.000. The percentage result opinion shows an influence of improper drainage systems (71.1%), swamps (79.5%), improper garbage disposal (69.6%), and bushes around homes (68.5%) on malaria, with a statistically significant p-value (0.000) observed in the Pearson Chi-square test result. The highest percentage of the population (94.5%) demonstrates that stagnated water and poor environmental hygiene are the most prevalent environmental factors influencing malaria prevalence. However, only stagnant water indicated a statistically significant association with malaria prevalence at a p-value of 0.000 in the test result. This may suggest that poor environmental hygiene could also arise from stagnant waters in the environment.

Additionally, there is a statistically significant influence of weak health facilities (95.8%), poor health care (96.6%), and unprofessional healthcare personnel (72.2%) on malaria prevalence, at a p-value of < 0.5. There is also a statistically significant influence of economic factors, low income from the business output, and unemployment, on malaria at a p-value of 0.000, at percentage responses of 63.8% and 56.4% respectively.

Table 4: Influence of Non-Climatic Factors on Malaria Prevalence in the Region

Environmental factors	Has influence %		No influence %		Pearson Chi2	P value
	Freq	%	Freq.	(%)		
Environmental pollutant	169	44.4	212	55.6	192.6464	0.000***
Population density	112	29.4	269	70.6	178.9893	0.000***
Improper drainage system	271	71.1	110	28.9	92.6178	0.000***
Swamps	303	79.5	78	20.5	54.0382	0.000***
Stagnant water	360	94.5	21	5.5	48.9049	0.000***
Poor environmental hygiene	360	94.5	21	5.5	17.0788	0.585
Bushes	265	69.6	116	30.5	70.9133	0.000***
Garbage	261	68.5	120	31.5	130.7062	0.000***
Social factors						
Agricultural development	190	49.87	191	50.1	40.3574	0.003***
Population movement	152	39.9	229	60.1	157.1531	0.000***
Urbanization	90	23.6	291	76.4	59.4107	0.000***
Poor health facility	365	95.8	16	4.2	40.315	0.0003***
Poor healthcare	368	96.6	13	3.4	36.0731	0.0010**
Unprofessional healthcare personnel	275	72.2	106	27.8	87.3375	0.000***
Educational background	110	28.9	271	71.1	155.4839	0.000***
Employment status	92	24.2	289	75.9	789133	0.000****
Economic factors						
Low income from business output	243	63.8	138	36.2	63.8812	0.000***
Unemployment	215	56.4	166	43.6	66.6847	0.000***
Low salary	172	45.1	209	54.9	67.4779	0.000***

***significance at the 0.01, ** significance at the 0.5 level, *Significance at the 0.10 level, ource: Field data, 2023.

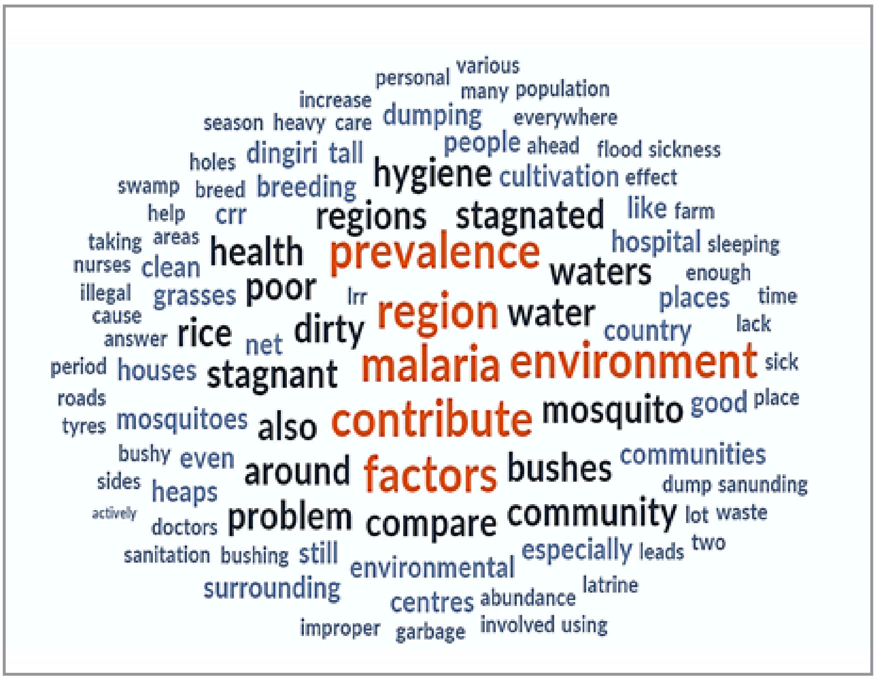


Figure 2: Qualitative findings on the influence of non-climatic factors on malaria prevalence in the region.

Discussion

The result of the study reveals the knowledge of the population on the few concepts of climate change on malaria transmission. It also highlights the major perceived climatic variables responsible for the prevalence of malaria and other environmental, economic, and social factors that exacerbated the influence of climatic factors on the persistence of malaria in the region [7, 17, 26, 27]. Thus, the result shows that the population is aware of the influence of warmer temperatures on mosquito survival, consistent with on the significant effect of warmer temperatures on vector survival and the development and maturation of the malaria parasite. In addition, a thermally stable lowland region is already warm enough for mosquito vectors to reproduce [2, 28]. However, increasing temperatures are not perceived as a major contributing climatic factor to malaria transmission (Figure 1 and Table 2). In the last few decades, the average temperature has been favorable for malaria transmission. The development of the malaria parasite in the vector occurs at temperatures between 18 and 32oC, and any temperature outside this range would influence the parasite development [16, 26, 29, 30]. The population further reiterates the point that malaria prevalence in the region is influenced also by the average and minimum temperature in the region. The findings of both the qualitative and quantitative components are consistent and disagree with some previous studies that reveal the influence of maximum temperature on malaria prevalence in their study regions [4, 12].

The association between hydrological parameters; (rainfall and flood) and the abundance and the biting rate of mosquitoes is well perceived by the population, and it is not surprising [29, 31]. Indeed, the population knows that malaria occurs mainly during the rainy season or immediately after, and they have rightly observed that the burden of malaria increases with the abundance of stagnant water, particularly during floods. Moreover, the health education programs implemented by the Ministry of Health have probably shaped the opinion of the local population. Rainfall influences mosquito population dynamics as it provides good breeding conditions for anopheles mosquitoes [29, 32]. Regions with seasonal rainy periods and variations in rain patterns, especially in Sub-Sahara Africa where malaria is already considered endemic will always experience a gradual increase in mosquito activity as soon as rainfall begins [33]. Furthermore, floods also create suitable breeding sites for mosquitoes therefore, there is a tendency for communities that experience flooding to experience a high malaria burden [34, 35]. The current research finding could also be attributed to green vegetation around the houses, workplaces, and construction sites, availability of water in ponds and ditches, and stagnant water in potholes and tires, all these conditions can be breeding sites for the vector in support of [31, 34]. In addition, the peak of malaria transmission occurs in October-November, especially during the harvesting period also in agreement with [30, 36, 37].

The concept of the link between humid temperature and malaria is not well understood by the population, although such conditions are favorable for the survival of the malaria vectors and the development of malaria parasites in the vector [11, 17]. A relative humidity equal to or greater than 60% encourages the breeding and proliferation of plasmodium parasites [16, 38]. Importantly, the population's perception of these factors was significantly influenced by their age and the years of residence in the region at a p-value of 0.004 and 0.002 respectively. 84.8% of the respondents fall within the age bracket of 31-70 and 62% of them have lived in the region for more than 20 years. Therefore, most participants were able to appreciate the evolution of climate over time in the region and their perception can be considered reliable.

Despite overwhelming evidence of the influence of hydrological parameters on malaria prevalence, other environmental and socioeconomic factors influence significantly its endemicity. Almost all the environmental and socioeconomic factors investigated in URR increase significantly the influence of climatic variables on malaria endemicity. As already reported by other investigations environmental factors such as environmental improper drainage systems, swamps, stagnant water, bushes around the house, and garbage promote malaria transmission [39, 40].

An inadequate drainage system could result in floods, stagnant water, and ultimately an environment favorable for vector breeding and thus higher transmission. The nearness of bushes around the environment supports mosquito activities, as mosquitoes breed and multiply in such areas especially when it is damp or waterlogged, in agreement with [40]. The work by 40reported a higher prevalence of malaria (23.23%) among the participants living in bushy areas than those living in non-bushy areas (9.23%).

Furthermore, dirty environment and stagnated water are the top environmental factors influencing malaria prevalence in the region as noted in both qualitative and quantitative findings. A study by (40) also reported a higher prevalence (15.35%) of malaria among those residing in an area with stagnant water than those residing in an area with no stagnant water (9.47%). the finding also conforms with qualitative research findings by where poor sanitation and poor drainage systems were considered the main factors contributing to mosquito breeding in the study area [41]. Additionally, when households improperly dispose of waste, it increases the level of water pools of stagnant water, forming a breeding space for mosquitoes. This finding supports that revealed high malaria incidence in locations closer to dumping sites [42].

Social factors such as unprofessional health personnel, poor health facilities and care, have been identified to influence vector abundance and malaria prevalence in alignment with other research in different studied regions [6, 15, 39, 43]. The statistical significance for all the access variables is seen at a p-value of less than <0.05, suggesting a strong association with malaria prevalence in the region. Agricultural development, especially massive rice development projects in the region as revealed clearly in qualitative findings contributes to malaria increase in the region as wet or irrigated rice farms are suitable sites for vector breeding [20, 44, 45]. Show higher malaria prevalence in areas close to irrigated rice fields than in non-rice rice-growing areas this further implies that urban development and population movements are likely to influence any vector-borne diseases [20, 39]. As new and modern development changes the outlook of rural patterns to urban settings like the building of gigantic infrastructures such as factories, industrial, construction of roads, and others, it creates highly heterogeneous socio-economic and environmental conditions conducive for malaria transmission.

Malaria treatment depends on the availability of health facilities, good health services, and professional healthcare personnel [6, 43]. Therefore, when access to health care is limited, malaria patients are not treated, with the risk of some of them evolving towards severe disease and death. The attitude of healthcare providers toward addressing and providing adequate medical attention to malaria patients, in addition to unprofessional healthcare personnel, will hinder the progress of the malaria reduction program, influence malaria prevalence, and expose more vulnerable populations to malaria risk.

The statistically significant influence of three accessed economic factors: poor income from the business output, unemployment, and low salary on malaria prevalence in the region proves that there is a bilateral relationship between poverty and malaria [46]. Low income hinders the ability to provide effective prevention and protective measures such as living in a suitable house that is well-sealed from mosquitoes, use of insecticide-treated bed nets that will serve the whole household, and use a closed container for household water storage. The research finding agrees with studies that reported a higher risk of malaria among those who engage in craft (22.8%) and unemployed (22.1%) compared with civil servants (8%) [47]. It further revealed a higher prevalence of lower-income earners (43.4%) than higher-income earners (5.1%). Unemployment was also a risk factor, with the highest prevalence (25.49%) in a work by [40].

Conclusion

In conclusion, climate change is likely to affect malaria prevalence differently across regions, and a complete understanding of the dynamic of influence is the key to an effective adaptation strategy. The new result obtained by looking at the climatic variables associated with malaria prevalence in the region revealed no effect of temperature on malaria and brings to note rainfall and flood as the two major climatic factors along with interplay with poverty and other environmental and socioeconomic factors intensifying the vulnerability of this region to impact of this disease.

This is a wake-up call for the government and the communities to engage in some discipline in ensuring proper environmental cleaning exercises every month, especially during the rainy season. The government should look into designing a good efficient drainage system, a better place for the disposition of rubbish in proximity to the community, and putting a well-trained officer for efficient waste management, professionalism in the healthcare sector, and the academic pedigree of the health personnel should be assessed before recruiting. The health personnel should also be encouraged to further learn and improve their skill. Government help is highly solicited for the rehabilitation of most of the health Centers in the region and support to household heads to encourage proactive measures in malaria treatment and prevention.

As poor socioeconomic and environmental factors increase the risk of malaria infection, better socioeconomic conditions; good housing, good drainage system, standard health centers, professional health workers, education and awareness on the subject matter, and good environment cleaning habits, will reduce the malaria risk and then work towards achieving sustainable development goal (SD3).

The strength of this work is the combination of both quantitative and qualitative work to determine the major climatic influence of malaria prevalence, and in looking at other non-climatic parameters capable of exacerbating malaria prevalence in a given region. The main weakness however lies in the inability to use a geographic information system (GIS) to map the districts in the region with the highest prevalence.

Acknowledgments

I wish to thank the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), The Gambia for the PhD scholarship awarded to me through which I wrote this paper. My profound gratitude goes to the sponsors and coordinators of short courses on Qualitative and Mixed Method Research Methodology, and Basic Epidemiology and Statistics, for offering me the opportunity and prerequisite knowledge from which I drew inspiration and skill to develop this paper. Finally, I acknowledge the efforts of all my supervisors for their support throughout this research period and, for taking the time to read over the work before it was submitted.

Author Contribution

Ugochinyere Agatha Okafor conceptualized the idea, reviewed the literature, collected data analyzed data, and wrote the paper. Sidat Yaffa, Umberto D'Alessandro, Vincent Nduka Ojeh, and Iddisah Alhassah supervised and proofread the work.

Ethical Approval and Informed Consent Statement

The University of The Gambia Research Ethics Committee approved the study. Written informed consent was provided for the participants All the respondents were informed about the confidentiality of the data.

Competing Interests

The authors declare no competing interests.

Funding

No external funding was provided for this paper.

Data Availability

The data will be made available on request.

Reference

1. Caminade, C., McIntyre, K. M., & Jones, A. E. (2019). Impact of recent and future climate change on vector-borne diseases. Annals of the New York Academy of Sciences, 1436(1), 157–173. https://doi.org/10.1111/nyas.13950
2. Blanford, J. I., Blanford, S., Crane, R. G., Mann, M. E., Paaijmans, K. P., & Schreiber, K. V. (2013). Implications of temperature variation for malaria parasite development across Africa. Scientific Reports, 3, 1300. https://doi.org/10.1038/srep01300
3. Kulkarni, M. A., Duguay, C., & Ost, K. (2022). Charting the evidence for climate change impacts on the global spread of malaria and dengue and adaptive responses: A scoping review of reviews. Global Health, 18(1), 1. https://doi.org/10.1186/s12992-021-00793-2
4. Zerihun, T., Zewotir, T. T., & Kebede, E. (2023). Seasonal and spatial variations of malaria transmissions in northwest Ethiopia: Evaluating climate and environmental effects using generalized additive model. Heliyon, 9(4), e15252. https://doi.org/10.1016/j.heliyon.2023.e15252
5. Intergovernmental Panel on Climate Change (IPCC). (2023). Summary for policymakers: Synthesis report. Contribution of Working Groups I, II, and III to the Sixth Assessment Report. https://www.ipcc.ch/report/ar6/syr/
6. Bayode, T., & Siegmund, A. (2022). Social determinants of malaria prevalence among children under five years: A cross-sectional analysis of Akure, Nigeria. Scientific Af-

rican, 16, e01196. https://doi.org/10.1016/j.sciaf.2022.e01196
7. Onyango, E. A., Sahin, O., Awiti, A., Chu, C., & Mackey, B. (2016). An integrated risk and vulnerability assessment framework for climate change and malaria transmission in East Africa. Malaria Journal, 15, 551. https://doi.org/10.1186/s12936-016-1600-3
8. Onyango, E. A., Sahin, O., Awiti, A., Chu, C., & Mackey, B. (2016). An integrated risk and vulnerability assessment framework for climate change and malaria transmission in East Africa. Malaria Journal, 15(1), 1–12.
9. M'Bra, R. K., Kone, B., Soro, D. P., N'krumah, R. T. A. S., Soro, N., Ndione, J. A., Sy, I., Ceccato, P., Ebi, K. L., Utzinger, J., Schindler, C., & Cissé, G. (2018). Impact of climate variability on the transmission risk of malaria in northern Côte d'Ivoire. PloS one, 13(6), e0182304. https://doi.org/10.1371/journal.pone.0182304
10. Gontie, G. B., Wolde, H. F., & Baraki, A. G. (2020). Prevalence and associated factors of malaria among pregnant women in Sherkole district, Benishangul Gumuz regional state, West Ethiopia. BMC Infectious Diseases, 20(1), 573. https://doi.org/10.1186/s12879-020-05289-9
11. Fitchett, J. M., & Swatton, D.-A. (2022). Exploring public awareness of the current and future malaria risk zones in South Africa under climate change: A pilot study. International Journal of Biometeorology, 66(2), 301–311. https://doi.org/10.1007/s00484-020-02042-4
12. Akinbobola, A., & Hamisu, S. (2022). Malaria and climate variability in two northern stations of Nigeria. American Journal of Climate Change, 11(2), 59–78. https://doi.org/10.4236/ajcc.2022.112004
13. Al-Mekhlafi, H. M., Madkhali, A. M., Ghailan, K. Y., Abdulhaq, A. A., Ghzwani, A. H., Zain, K. A., Atroosh, W. M., Alshabi, A., Khadashi, H. A., Darraj, M. A., & Eisa, Z. M. (2021). Residual malaria in Jazan region, southwestern Saudi Arabia: the situation, challenges and climatic drivers of autochthonous malaria. Malaria journal, 20(1), 315. https://doi.org/10.1186/s12936-021-03846-4
14. Bezner R, Carlson C, Engelbreht C, Gan TY, Lavery C, Ndebele- M, . AC TO E N IO IT IT.
15. Zhao, X., Thanapongtharm, W., Lawawirojwong, S., Wei, C., Tang, Y., Zhou, Y., Sun, X., Cui, L., Sattabongkot, J., & Kaewkungwal, J. (2020). Malaria Risk Map Using Spatial Multi-Criteria Decision Analysis along Yunnan Border During the Pre-elimination Period. The American journal of tropical medicine and hygiene, 103(2), 793–809. https://doi.org/10.4269/ajtmh.19-0854
16. Segun, O. E., Shohaimi, S., Nallapan, M., Lamidi-Sarumoh, A. A., & Salari, N. (2020). Statistical modelling of the effects of weather factors on malaria occurrence in Abuja, Nigeria. International Journal of Environmental Research and Public Health, 17(10), 3474. https://doi.org/10.3390/ijerph17103474
17. Asgarian, T. S., Moosa-Kazemi, S. H., & Sedaghat, M. M. (2021). Impact of meteorological parameters on mosquito population abundance and distribution in a former malaria endemic area, central Iran. Heliyon, 7(12), e08477. https://doi.org/10.1016/j.heliyon.2021.e08477
18. Valerie, Y., Mavoungou, Y., Niama, A. C., Celina, R., Nombo, K., Voumbo, G. M., & Itoua, C. (2022). Knowledge and practices of pregnant women on malaria prevention in Brazzaville, Congo Open Journal of Preventive Medicine, 12, 85-95. https://doi.org/10.4236/ojpm.2022.125006
19. Fonseca, F., Worfarth-Couto, B., Santos, A., Marinho, R., Martinez, J. M., & Filizola, N. (2022). Hydrological scenarios and malaria incidence in the Amazonian context. Water, 14(8), Article 1162. https://doi.org/10.3390/w14081162
20. Chan, K., Tusting, L. S., Bottomley, C., Saito, K., Djouaka, R., & Lines, J. (2022). Malaria transmission and prevalence in rice-growing versus non-rice-growing villages in Africa: A systematic review and meta-analysis. The Lancet Planetary Health, 6(3), e257–e269. https://doi.org/10.1016/S2542-5196(21)00349-1
21. Welfare, S., & International, U. (2018). Republic of The Gambia Malaria Indicator Survey 2018 (September).
22. Mwesigwa, J., Okebe, J., Affara, M., Di Tanna, G. L., Nwakanma, D., Janha, O., Opondo, K., Grietens, K. P., Achan, J., & D'Alessandro, U. (2015). On-going malaria transmission in The Gambia despite high coverage of control interventions: a nationwide cross-sectional survey. Malaria journal, 14, 314. https://doi.org/10.1186/s12936-015-0829-6
23. Ayanlade, A., Sergi, C. M., Sakdapolrak, P., Ayanlade, O. S., Di Carlo, P., Babatimehin, O. I., ... & Jegede, M. O. (2022). Climate change engenders a better Early Warning System development across Sub-Saharan Africa: The malaria case. Resources, Environment and Sustainability, 10, 100080. https://doi.org/10.1016/j.resenv.2022.100080
24. Ihantola, E. M., & Kihn, L. A. (2011). Threats to validity and reliability in mixed methods accounting research. Qualitative Research in Accounting & Management, 8(1), 39–58. https://doi.org/10.1108/11766091111124694
25. Downing, S. M., & Yudkowsky, R. (2015). Assessment in health psychology. In Y. Benyamini, M. Johnston, & E. C. Karademas (Eds.), Assessment in Health Psychology (pp. 33–45). Hogrefe Publishing. https://elibrary.hogrefe.com/book/99.110005/9781616764524
26. Silue, S., & Kouassi, A. A. (2021). Assessing seasonal climate variability impact on the malaria patient's cases in the north of Côte d'Ivoire. European Journal of Applied Sciences, 9(6), 188–210. https://journals.scholarpublishing.org/index.php/AIVP/article/view/11254
27. Gatti, L. V., Basso, L. S., Miller, J. B., Gloor, M., Gatti Domingues, L., Cassol, H. L., ... & Neves, R. A. (2021). Amazonia as a carbon source linked to deforestation and climate change. Nature, 595(7867), 388-393. https://www.nature.com/articles/s41586-021-03629-6
28. Arab, A., Jackson, M. C., & Kongoli, C. (2014). Modelling the effects of weather and climate on malaria distributions in West Africa. Malaria Journal, 13, 126. https://malariajournal.biomedcentral.com/articles/10.1186/1475-2875-13-126
29. Valerie, T., Dornyo, O., Amuzu, S., Maccagnan, A., Taylor, T., & Taylor, T. (2022). Estimating the impact of temperature and rainfall on malaria incidence in Ghana from 2012 to 2017. Environmental Modeling & Assessment, 473–489. https://doi.org/10.1007/s10666-022-09817-6
30. Fall, P., Diouf, I., Deme, A., & Sene, D. (2022). Assessment of climate-driven variations in malaria transmission in Senegal using the VECTRI model. Atmosphere, 13(3), 1–21.

31. Androga, D. A. (2020). A literature review about the impact of climate change on malaria in South Sudan. South Sudan Medical Journal, 13(5), 193–195.
32. Foley, J. E. (2018). Direct and indirect mechanisms for climate change to impact vector-borne disease. In Reference Module in Earth Systems and Environmental Sciences (pp. 1–8). Elsevier. http://dx.doi.org/10.1016/B978-0-12-409548-9.11034-6
33. Alexander, J., Dongarwar, D., Oduguwa, E., Varnado, L., Adenote, A., Bailey, J., Ezeudu, C., Nelson, P., Shavers, A., Telufusi, A., Spooner, K. K., Salemi, J. L., Olaleye, O. A., & Salihu, H. M. (2020). Temporal trends of gestational malaria in the United States. Parasite epidemiology and control, 11, e00191. https://doi.org/10.1016/j.parepi.2020.e00191
34. Oluwatimilehin, I. A., Akerele, J. O., Oladeji, T. A., Omogbehin, M. H., & Atai, G. (2022). Assessment of the impact of climate change on the occurrences of malaria, pneumonia, meningitis, and cholera in Lokoja City, Nigeria. Regional Sustainability, 3(4), 309–318. https://doi.org/10.1016/j.regsus.2022.11.007
35. World Health Organization. (2022). Global framework for the response to malaria in urban areas (pp. 1–50).
36. Kotepui, M., & Kotepui, K. U. (2018). Impact of weekly climatic variables on weekly malaria incidence throughout Thailand: A country-based six-year retrospective study. Journal of Environmental and Public Health, 2018, 1–8. https://www.hindawi.com/journals/jeph/2018/8397815/
37. Canelas, T., Castillo-Salgado, C., & Baquero, O. S. (2019). Environmental and socioeconomic analysis of malaria transmission in the Brazilian Amazon, 2010–2015. Revista de Saúde Pública, 53, 49.
38. Diouf, I., Rodriguez Fonseca, B., Caminade, C., Thiaw, W. M., Deme, A., Morse, A. P., Ndione, J. A., Gaye, A. T., Diaw, A., & Ndiaye, M. K. N. (2020). Climate Variability and Malaria over West Africa. The American journal of tropical medicine and hygiene, 102(5), 1037–1047. https://doi.org/10.4269/ajtmh.19-0062
39. Palaniyandi, M. (2021). The environmental risk factors significant to Anopheles species vector mosquito profusion, P. falciparum, P. vivax parasite development, and malaria transmission, using remote sensing and GIS: Review article. Journal of Mosquito Research, 12(4), 162–171.
40. Nyasa, R. B., Fotabe, E. L., & Ndip, R. N. (2021). Trends in malaria prevalence and risk factors associated with the disease in Nkongho-Mbeng; a typical rural setting in the equatorial rainforest of the South West Region of Cameroon. PLoS ONE, 16(5), e0251380. http://dx.doi.org/10.1371/journal.pone.0251380
41. Agyemang-Badu, S. Y., Awuah, E., Oduro-Kwarteng, S., Dzamesi, J. Y. W., Dom, N. C., & Kanno, G. G. (2023). Environmental management and sanitation as a malaria vector control strategy: A qualitative cross-sectional study among stakeholders, Sunyani Municipality, Ghana. Environmental Health Insights, 17, 1–16. https://journals.sagepub.com/doi/10.1177/11786302221146890
42. Tukura, E. D., Ojeh, V. N., Philip, A. H., & Ayuba, A. (2018). Assessing the potential health effect of solid waste dump site located close to residential areas in Jalingo, Taraba State using geospatial techniques. World News of Natural Sciences, 20(August), 160–175. www.worldnewsnaturalsciences.com
43. Bayode, T., & Siegmund, A. (2022). Social determinants of malaria prevalence among children under five years: A cross-sectional analysis of Akure, Nigeria. Scientific African, 16, e01196. https://doi.org/10.1016/j.sciaf.2022.e01196
44. Assi, S. B., Henry, M. C., Rogier, C., Dossou-Yovo, J., Audibert, M., Mathonnat, J., Teuscher, T., & Carnevale, P. (2013). Inland valley rice production systems and malaria infection and disease in the forest region of western Côte d'Ivoire. Malaria journal, 12, 233. https://doi.org/10.1186/1475-2875-12-233
45. Attu, H., & Adjei, J. K. (2018). Local knowledge and practices towards malaria in an irrigated farming community in Ghana. Malaria Journal, 17(1), 2–8. https://doi.org/10.1186/s12936-018-2291-8
46. Hutchins, H., Power, G., Ant, T., Teixeira da Silva, E., Goncalves, A., Rodrigues, A., Logan, J., Mabey, D., & Last, A. (2020). A survey of knowledge, attitudes and practices regarding malaria and bed nets on Bubaque Island, Guinea-Bissau. Malaria journal, 19(1), 412. https://doi.org/10.1186/s12936-020-03469-1
47. Akanbi, F. R. (2016). Socio-economic and demographic impact on malaria prevalence in Akoko South-west of Ondo state, Nigeria. International Journal of Infectious Diseases, 45, 214. http://dx.doi.org/10.1016/j.ijid.2016.02.488