



# A Pilot Study to Evaluate the Knowledge and Perceived Health Effects of Climate Change in Lagos State, Nigeria

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## Abstract

**Background:** Climate change is one of the challenges impeding malaria elimination. Given that Lagos is vulnerable to climate change effects, where public awareness programme and other mitigating interventions on climate change exist, we conducted this study to assess the knowledge and perceived effects of climate change, cultural definition of climate change and vulnerability to increased risk of malaria in Lagos State, Nigeria.

**Methods:** This was a cross-sectional pilot study of 43 mothers of children under five years old using a household questionnaire in malaria holo-endemic communities of Amuwo Odofin local government area of Lagos State. Data were analysed using IBM SPSS (Version 23.0) software.

**Results:** Of 43 respondents interviewed, 97.7% were married, most were artisans (44.2%) and traders (32.6%). Their ages ranged from 25 to 41 years with mean of 34.9 years. All (100.0%) had a minimum of secondary education. All (43, 100.0%) reported observed changes in the climate with increased extreme hot weather and heavy rains and flooding. Fewer (79.1%) respondents had heard about climate change while 61.9% correctly knew the cause(s) of climate change. Only 18.0% knew climate change poses risks to health with 90.7% perceiving it as a future risk. Respondents' education had no positive association with their knowledge of climate change and its health risks ( $p>0.05$ ). None owned and used LLINs for malaria prevention with core reason being "it's hotter to sleep under LLIN".

**Conclusion:** Results showed a mixture of pervasive knowledge and misconceptions of climate change in population studied. Intensified public health education on potential effects of climate change and the need to reduce vulnerability to malaria using LLINs therefore becomes imperative in the study communities.

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**Keywords:** Knowledge; Perception; Health effects; Household; Malaria; LLIN use; Climate change; Lagos; Nigeria.

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## Background

Overwhelming evidence shows that climate change is one of the most challenging environmental and public health concerns around the world as vulnerability to its impacts continue to manifest increasingly [1]. Globally, it is projected to cause 250,000 additional deaths due to malaria and other health issues. However, awareness of climate change and its impacts particularly on health is very low in developing countries where it is misconceived to be a distant problem of the developed countries [2]. In Nigeria, there is paucity of empirical data on the knowledge of climate change and its perceived impacts on health particularly in Lagos State despite efforts at addressing climate change issues by the government.

Most research on climate change adopt atmospheric and bio-physical perspectives, describing it more as an environmental problem than a health problem [1,3]. There is paucity of literature on climate change from socio-cultural perspective [4]. Available literature from Nigeria depicts climate change more as an environmental problem than as a health issue [3]. In recent years, the vulnerability to the impact of climate change in Nigeria has continued to manifest across the ecological zones of the country, particularly Lagos documented as one of the few examples of cities at risk from floods or sea level rise in the world [1,3]. In a metropolitan area like Lagos, increased heavy and prolonged rainfalls will cause more flooding to be exacerbated by poor sanitary behaviour and attitude of residents affecting the environment. This has potential to increase of breeding sites for mosquitoes, mosquito abundance, increase human-vector contact and malaria transmission.

Climate change has become one of the challenges impeding malaria elimination [5]. This could stall the progress achieved in malaria control and jeopardise efforts directed at the elimination of malaria globally particularly in Nigeria that has remained a major contributor to global malaria burden and it is a leading cause of under-five mortality and morbidity [5]. According to Costello *et al.*, [1] malaria is a particularly climate-sensitive disease, significantly influenced by changes in temperature, rainfall, as well as the frequency and severity of extreme weather events. The warming weather condition will provide climate suitability for malaria transmission with increased convection currents laden with odour blend that attract mosquitoes to humans. Knowing that about 80% of malaria transmission occurs inside the house [6] where Long Lasting Insecticidal Nets (LLINs) are standard recommendation for effective malaria prevention, the perception of LLIN as being inconvenient and a heat-causing material when used and the extent to which people would be willing to sleep under it as documented by previous studies [7,8] particularly in a situation where surface temperature is rising is of serious concern.

Effective malaria treatment and prevention using Artemisinin-based Combination Therapies (ACTs) and LLINs respectively could be compromised as the former could give rise to parasite resistance and combined with the latter to undermine efforts towards achieving the pre-elimination targets of 2014-2020 National Malaria Strategic Plan on the reduction of malaria-related deaths to zero in Nigeria as well as the 2030 targets of both the Global Technical Strategy for Malaria (2016-2030) [9] and the Sustainable Development Goals (SDGs) [10] respectively.

Given the widespread practice of self-treatment for clinically suspected malaria and knowing that treatment of patients for malaria without parasitaemia in high transmission area, such as

Lagos, leads to unnecessary drug pressure, [11] it is of concern that increasing malaria risk and possible misdiagnosis of malaria for febrile case management at home through presumptive treatment, the most prominent being fever, in the face of high temperature caused by climate change could contribute to over-diagnosis of malaria and irrational use of antimalarials and possible development of resistance to these drugs. Given the problem of over-diagnosis and over-treatment of malaria in populations reported in study by Oladosu and Oyibo [12] where only 16.9% of febrile 1,027 children aged 0 to 5 years tested in Lagos, Nigeria were slide positive, the increased temperature and changes in levels of precipitation being experienced consequent to climate change, the extent to which appropriate diagnosis of malaria can be made by care-givers of febrile children under five years of age in differentiating high body temperature caused by high parasitaemia from rise in body temperature caused by mere high room temperature based on the Home Management of Malaria guideline will become more challenging.

Malaria and climate change are both of serious global public health concern hence we have malaria-related targets of Sustainable Development Goal (SDG) 3 and targets of SDG 13 to combat climate change and its impacts by the year 2030 [10].

It is in realisation of the above that the systematic study of the knowledge and perceived effects of climate change on household health and resource capacity particularly as it relates to prevention and treatment of malaria in communities of Lagos State, Nigeria becomes imperative. Knowledge of how socio-behavioural and economic factors affect and are affected by disease patterns and disease control efforts is important for identifying future needs and opportunities for improved control of diseases [13]. The objectives of this pilot study were to: 1) Assess the knowledge of respondents about climate change among mothers of under five children in selected communities of Lagos State; 2) Know the perceived effects of climate change and vulnerability to increased risk of malaria in among study population; and 3) Investigate household resource allocation for health and the prevention and treatment of malaria. We believe that this preliminary study will provide relevant insights to guide a large-scale study to provide important information on knowledge and perception of effects of climate change and the confounding factors such as perceived risk of exposure to vector-borne diseases like malaria among vulnerable populations. The analyses provide context to support National Malaria Control Programme and malaria control policy makers at the State and local government levels in their LLIN decision-making and planning processes.

## Methods

### Study design and setting

This is a pilot cross-sectional community-based study carried out between July and August 2019 in Agboju and Alakija communities of amuwo odofin Local Government Area (LGA) of Lagos State, South West Nigeria (Figure1). Lagos is a coastline cosmopolitan city and vulnerable to impacts of climate change<sup>1</sup> and malaria is holo-endemic with high transmission<sup>14</sup> and public awareness programme on climate change exist [3]. The State has dry and wet seasons with an annual mean rainfall of 138.7mm. The annual mean maximum and minimum temperature are 31.45°C and 23.7°C respectively. The annual mean relative humidity is 70%. The annual reported cases of malaria that Received a Diagnostic Test (RDT or microscopy) in the State

fluctuated between 789,085 in 2009 to 743,725 in 2013 [15]. Malaria is perennial in the State with about 97% of the population at risk of the disease but there is high transmission of malaria during the rainy season between April and November [16]. Lagos is a socio-cultural melting point but is essentially a Yoruba-speaking environment.

### Study population

The main target population studied are mothers of children under five years of age in the communities of the LGA. The inclusion criteria for participation in the household survey included: Aged 20 years and above, being a mother/carer of a child/children under five years of age; able and willing to provide written informed consent to participate in the study; be willing to complete the questionnaire and permanent residency in selected study communities.

### Sample size determination and sampling procedures

A sample size of 43 was calculated using the table for a minimum sample size estimate for a population survey with 95% confidence interval using the formula: [17]

$$n = \frac{Z^2[p(1-p)]}{d^2}$$

where n = sample size, Z = 1.96, p = 0.50, d = 0.15.

$$n = \frac{1.96^2[0.5(1-0.5)]}{0.15^2}$$

The sample size of 43 mothers of under five children for the household survey was selected from two communities of a purposively selected LGA. Multi-stage sampling approach that involved a combination of purposive, stratified, simple random and systematic sampling techniques [18] was adopted in the selection of respondents for the household survey.

### Data collection procedures

Of the 45 mothers of children less than five years old approached for interview with the survey questionnaire, the questionnaire was eventually administered to 43 participants representing 4.4% non-response rate. The household survey was preceded a formative study with two FGD sessions held among the adult male and female groups in the communities. The feedback from the formative study was used to enrich the content of the questionnaire.

Data collection procedure involved the use of interviewer-administered semi-structured questionnaire and observation. The main contents of the questionnaire were questions on socio-demographic information about the respondents such as their age, religion, level of education, marital status and occupation, knowledge, beliefs, perceptions and practices about malaria, cultural definition (local terms) of climate change, household malaria preventive measures and treatment options, health seeking behaviour, household income and expenses on health and estimated amount spent on malaria prevention and treatment per year. During the household survey, observation was used to document the actual use or non-use of LLIN for malaria prevention.

At some point during the course of administering the questionnaire, all the 43 women interviewed were subjected to health education on climate change by the research assistants to assess their perception on climate change and its likely effects of health based on the new knowledge.

Two trained and experienced interviewers administered the questionnaires. The interviewers were trained together under the same conditions prior to the survey and were closely supervised and monitored by the principal investigator in the field.

Ethical approval (Assigned Number UI/SSHEC/2020/0022) for the study was obtained from the Social Sciences and Humanities Research Ethics Committee, University of Ibadan. The informed consent of all research participants was sought and obtained before enlisting them into the programme after the purpose of the study, the benefits, risks and discomforts involved in participating in the study were duly explained to them using an informed consent form. The research was conducted in accordance with universal ethical principles.

### Data analysis

Data from completed questionnaires were coded and entered into the computer and analysed using IBM SPSS (Version 23.0) software. Statistical analysis of the data set followed two steps. First, univariate analysis was carried out involving basic descriptive statistics including frequency distribution of each variable on the questionnaire, percentages, means and medians. Second, bivariate analysis using contingency tabulations (Chi-Square) was performed at significance level of 0.05 to examine associations between important independent and dependent variables with regard to the specific objectives of the study.

### Results

#### Socio-demographic characteristics of respondents

Table 1 shows the socio-demographic background of respondents. The age of the respondents ranged from 25 to 41 years with an average age of 34.9 years and a median age of 35 years. Most (97.7%) were married, a little over half (53.5%) were Christians; all (100.0%) had minimum of secondary education and most were artisans (44.2%) and traders (32.6%). Household demographic structure. The household size of the women interviewed ranged from 2 to 6 persons with a mean of 4 persons. They had one to five children and one to two children under five years with a mean of two children and a mean of one under five child respectively. On how long have the respondents have been living continuously in their respective communities, this ranged from 2 to 15 years with a mean of 6.2 years and a median of 5 years. The type of accommodation respondents reside with their households were: Flat (46.5%); a room and parlour apartment (41.9%); single room (9.3%); and duplex (2.3%).

#### Knowledge of climate change among respondents

The women were asked question to ascertain if they have heard of climate change or not. A very large proportion (79.1%) of the women interviewed reported to have heard about climate change (Figure 2). Results showed the distribution of the respondents' level of awareness of climate change according to their level of education (Figure 3). Awareness of climate change was higher among respondents with tertiary education (83.3%) compared to those with secondary education (77.4%).

The women were asked questions to ascertain their knowledge of climate change. Thirty-four (79.1%) described climate change as both a natural and human-induced phenomenon while 20.9% were undecided. Table 2 shows that 72.1% correctly knew and mentioned different forms of air pollution ranging from vehicular, industrial to indiscriminate bush burning as contributing factors to climate change. Respondents' education

had no positive association with their knowledge of climate change ( $p>0.05$ ).

A little over half (51.2%) of respondents reported not knowing the local name(s) people in their community used for climate change in their language. However, it appears that a few other respondents interpreted the term climate change according to the particular climatic event they usually face in the areas where they live. The local names including “ayi pada oju ojo” which literally translates to mean “change in weather” (7.0%), “orun po” which literally translates to mean “excessive sunlight” (7.0%) and “ayi pada igba/akoko” which literally translates to mean “change in time” (14.0%) were mentioned. Nine (20.8%) of respondents were undecided on any local name or term for climate change.

The respondents mentioned different sources through which they access information about climate change. These ranged from the internet/social media (4.7%) to newspapers, magazines and journals (83.7%) and friends/neighbours (86.0%) (Figure 4).

Doing a self-assessment of their level of knowledge of climate change based on the information they had heard or read about it from all sources, 81.4% believed they had moderate knowledge while 4.7% believed their knowledge about climate change was high.

When the respondents were asked about any observed changes in climate in their communities compared to what obtained in the last 5 years and when they were younger, all (43, 100%) reported they observed increased heat waves from extreme hot weather, heavy and intense rain storms and flooding, rising sea level and coastal surges. Fewer number (42, 97.7%) however reported observing decreased number of days in which cold weather from harmattan is experienced in the last 5 years. In contrast, a smaller number (34, 79.1%) of the respondents could correctly attribute the observed rising level of hotter temperature, increased intensity of rainstorms and flash floods, rising sea level and coastal surges, declining agricultural produce and changing seasonal patterns they experience in their environment to climate change.

#### **Knowledge and perception of health effects of climate change among respondents**

Results showed that a very few (18.0%) knew that climate change poses risk to human health and had perceived vulnerability before being given health education on climate change (Figure 5). While most (90.7%) perceived climate change as a future risk, 9.3% perceived it as a current risk.

Following the health education with brief explanation on climate change and its effects on health given the women, knowledge and perception of climate change and its health effects among them improved as all (43, 100.0%) respondents now believed that climate change poses risk to human health and had perceived vulnerability after health education, in contrast to 90.7% who perceived climate change as a future risk before the health education, virtually all (100.0%) the respondents perceived climate change as a current risk. Statistical test showed that respondents’ education had no positive association with their knowledge of the health effects of climate change ( $p>0.05$ ).

When the respondents were prompted on the major health challenges of people in their communities, the most recurring

perceived major health challenges mentioned fall into Communicable Diseases (CDs) category. These included tuberculosis (100.0%), HIV/AIDS (100.0%) and malaria (95.3%). The Non-Communicable Diseases (NCDs) mentioned included diabetes (100.0%), mental stress/depression (100.0%) and injury (2.3%) (Table 3).

When the women were prompted on how they perceived climate change will likely affect human health, there was a general consensus from the responses that malaria is one of the perceived ways they believed climate change will likely affect the health of people in the study communities. Aside from malaria, other perceived likely effects of climate change on health mentioned included safe water shortage, typhoid, dysentery, heat stroke, respiratory infections and predisposition to allergies (Table 4).

#### **LLIN ownership and use for malaria prevention among respondents**

Despite the fact that all (43, 100.0%) of respondents knew mosquitoes spread malaria and reported increased malaria cases in their households over the last 5 years with cases of malaria episodes among their household members in the past month preceding the survey, none of the women reported owning and using LLINs for malaria prevention.

#### **Reasons for non-use of LLINs**

When the respondents were asked about what restrained them from LLIN use by the women, they all (43, 100.0%) echoed “it causes heat” or “it is hotter sleeping under LLIN”. Rather than owning LLINs for use, the respondents reported their preference for chemical spraying through the use of insecticides (97.3%), environmental management through draining of stagnant water (100.0%), cutting of overgrown bushes and grasses in the home environment (97.7%) and clearing of drainages (2.3%), other practices that included window screening with net (95.3%) and burning of mosquito coil as repellent (95.3%).

#### **Malaria treatment practices among respondents**

All (100.0%) respondents revealed going straight to the private hospital as their most preferred place of seeking treatment for malaria. They usually seek medical help outside the home to handle the malaria after one to two days of onset of the signs/symptoms when the illness remains somewhat the same and unsure of nature of illness (2.3%) and when further treatment is perceived necessary and required (97.7%). They pointed out that they are more likely to take ACTs drugs (97.7%) and analgesics (2.3%).

#### **Respondents’ household income and expenditure on household health and malaria**

The details of the respondents’ monthly personal and household incomes are presented in Table 5. The personal income of the respondents per month ranged from ₦15,000.00 (US\$41.67) to ₦120,000.00 (US\$333.33) [Mean= ₦34,232.56 (US\$95.10), Median= ₦30,000.00 (US\$83.33)]. About 60.0% of the respondents earned below the country’s national monthly minimum wage of ₦30,000.00 (US\$83.33) with only one (2.3%) earning no income. All (43, 100.0%) of the respondents had other members of their household such as husbands and older children contributing to the household income per month that ranged from ₦25,000.00 (US\$69.44) to ₦800,000.00 (US\$2,222.22). Only one (2.3%) of respondents had a household earning below the national monthly minimum wage. They had an average

and median household income of ₦122,441.86 (US\$340.12) and ₦90,000.00 (US\$250.00) per month respectively. The average annual personal and household income of the women therefore is ₦410,790.72 (US\$1,141.10) and ₦1,469,302.32 (US\$4,081.40) respectively.

The estimated household expenses on health every year that was reported by the respondents ranged from ₦15,000.00 (US\$41.67) to ₦110,000.00 (US\$305.56) [Mean = ₦24,000.00

(US\$66.67), Median = ₦12,000.00 (US\$33.33)]. The estimated yearly household expenditure on malaria prevention and treatment ranged from ₦2,000.00 (US\$5.56) to ₦74,000.00 (US\$205.56) [Mean = ₦13,348.84 (US\$37.10), Median= ₦12,000.00 (US\$33.33)]. The results showed that household monthly health expenditure takes about 20.0% of the household monthly income of an average respondent. While 55.6% of the household monthly health expenditure is on malaria, malaria takes 10.9% of the average household monthly income.

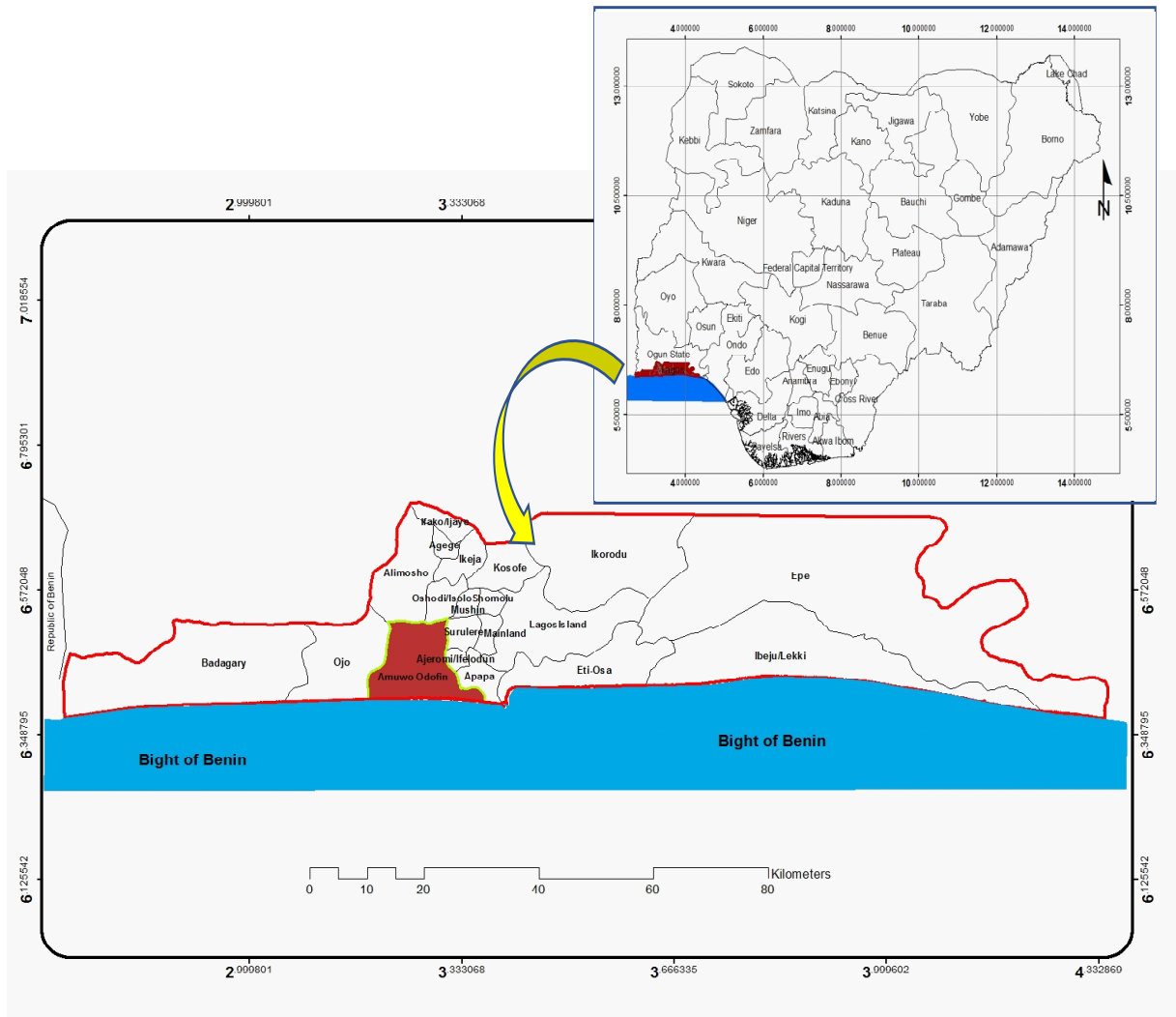


Figure 1: Lagos State map showing the study LGA.

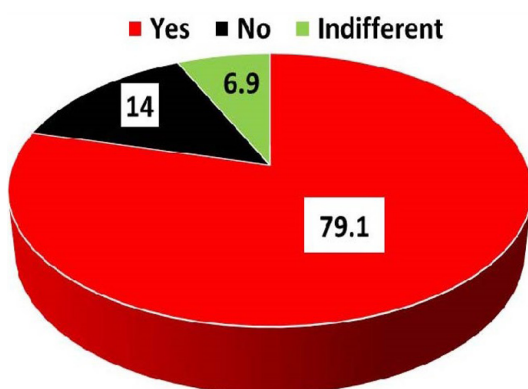


Figure 2: Percentage of respondents who reported to have heard or not about climate change.

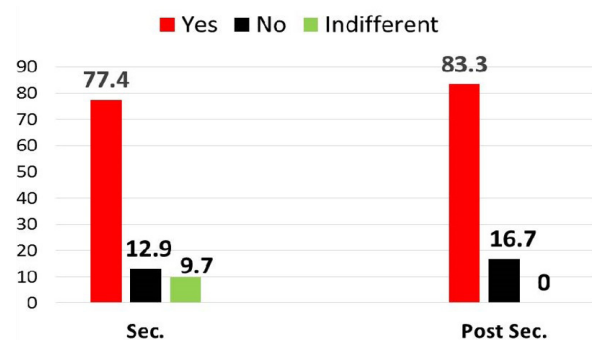
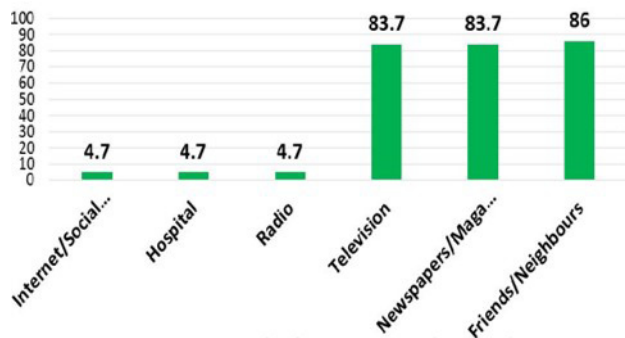


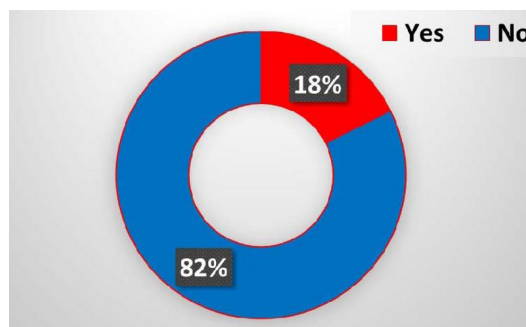
Figure 3: Distribution of respondents who have heard or not heard of climate change according to their level of education.



**Figure 4:** Sources of information on climate change among respondents.

**Table 1:** Socio-demographic background of respondents.

Socio-demographic characteristics	Frequency (n=43)	Percentage
<b>Age (in years)</b>		
25-29	5	11.6
30-34	15	34.9
35-39	14	32.6
40-44	9	20.9
<b>Marital status</b>		
Never married	1	2.3
Married	42	97.7
<b>Religion</b>		
No religion	1	2.3
Christianity	23	53.3
Islam	19	44.2
<b>Level of education</b>		
Secondary	31	72.1
Post-secondary	12	27.9
<b>Occupation</b>		
Housewife	4	9.3
Artisan	19	44.2
Formally employed in public sector	3	7.0
Formally employed in private sector	3	7.0
Trading	14	32.6
<b>Number of children</b>		
1-4	42	97.7
>4	1	2.3



**Figure 5:** Knowledge that climate change poses risk to human health among respondents before education.

**Table 2:** Knowledge of cause of climate change among respondents.

Causes mentioned	Frequency (n=43)	Percentage %
Vehicular pollution	31	72.1
Industrial pollution	31	72.1
Natural cause	6	14.0
Indiscriminate bush burning	31	72.1

**Table 3:** Respondents' perceived major health challenges in their communities.

Health problems	Frequency (n=43)	Percentage
Tuberculosis	43	100.0
Diabetes	43	100.0
Cancer	43	100.0
Arthritis and rheumatism	43	100.0
HIV/AIDS	43	100.0
Sexually transmitted infections	43	100.0
Ulcer	43	100.0
Eye problem	43	100.0
Mental stress/depression	43	100.0
Cough	42	97.7
Malaria	41	95.3
Injury	1	2.3
Diarrhoea	1	2.3
Cholera	2	4.7
Typhoid	2	4.7

**Table 4:** Respondents' perceived major health challenges in their communities.

Perceived ways climate change will affect human health	Not likely Number (%)	Likely Number (%)	Definitely Number (%)	Total Number (%)
Heat stroke	0	43 (100.0)	0	43 (100.0)
Typhoid	0	43 (100.0)	0	43 (100.0)
Dysentery	0	43 (100.0)	0	43 (100.0)
Renal disease	42 (97.7)	1 (2.3)	0	43 (100.0)
Safe water shortage	0	1 (2.3)	42 (97.7)	43 (100.0)
Malaria and other vector diseases	0	43 (100.0)	0	43 (100.0)
Respiratory infections	0	43 (100.0)	0	43 (100.0)
Allergies	0	0	43 (100.0)	43 (100.0)
Meningitis	0	42 (97.7)	1 (2.3)	43 (100.0)
Mental stress/depression	0	43 (100.0)	0	43 (100.0)

**Table 5:** Household income and expenses on household health and malaria.

Income/Expenses	Frequency	Percentage
<b>Personal income per month</b>		
< ₦30,000 (US\$83.33)	1	2.3
₦30,000 (US\$83.33) - ₦100,000 (US\$277.78)	26	60.5
₦100,001 (US\$277.78) - ₦150,000 (US\$416.67)	15	34.9
Total	43	100.0
<b>Household income per month</b>		
< ₦30,000 (US\$83.33)	1	2.3
₦30,000 (US\$83.33) - ₦100,000 (US\$277.78)	24	55.8
₦100,001 (US\$277.78) - ₦150,000 (US\$416.67)	11	25.6
₦150,001 (US\$416.67) - ₦200,000 (US\$555.56)	5	11.6
₦200,001 (US\$555.56) - ₦250,000 (US\$694.44)	0	0.0
> ₦250,000 (US\$694.44)	2	4.7
Total	43	100.0

## Discussion

This study examined the knowledge and perception of climate change and vulnerability to increased risk of malaria and assess household resource allocation for malaria management in communities of Lagos State.

Results showed a mixture of correct knowledge and misconceptions of climate change in the population studied. The high knowledge of climate change and its cause(s) by a larger proportion of the respondents is encouraging. While a predominant number of the respondents were familiar with the actual cause of climate change, a very few appeared to be largely unaware of man-made activities as its causes. This is important because correct knowledge of climate change and its cause(s) would significantly influence one's ability to appreciate messages targeted at addressing adaptation and mitigation strategies to combat the problem of climate change. In view of the number who have heard about climate change and their ability to have correctly mentioned the cause(s) of climate change could perhaps be attributed to their personal experience and observation of climatic changes around them or through the informal sources that include the media, relations, friends and neighbours rather than any previous formal training on issues of climate change. The opinion of climate change being "nature or God given" is far lower than the 31.1% and 16.3% reported among respondents and key informants in a climate change perception survey in Bangladesh [19].

The list of perceived ways climate change could likely affect human health including the likely spread and transmission of vector-borne diseases (such as malaria) and contagious diseases including typhoid, dysentery, meningitis and incidence of common mental stress or disorders evident in Table 4 corroborated those highlighted by Hajat *et al.*, [20] and Eke and Onafalajo [21].

It is of concern to emphasise that the perception and attitude of the respondents towards effects climate change poses to human health reflect them to regard it more as a problem of the future rather than a problem of the present, transcendental and that it poses no risk to health. This finding shows the potential to correct the bias in people's perception of climate change and its influence on the health of humans. The implication of

misconceptions about the climate change as a natural phenomenon (Table 2) and renal disease as a way many respondents perceived climate change will not likely affect human health evident (Table 4) is that such people will be taking inappropriate steps to make proactive adaptation decisions such as regular drinking of water for rehydration due to warmer-than-average temperatures to prevent renal problems out of ignorance. This is important given that all the women interviewed reported they observed heat waves from extreme hot weather have increased in their physical environment in the last 5 years. The consequences of poor knowledge of climate change as a phenomenon evidently linked to human actions and renal disease as a likely adverse health effect of climate change attributable to ignorance cannot be overemphasized. Health education emphasizing cause of climate change, its threat and impacts on health as it relates to possible effects of extreme weather patterns and how this could change the prevalence and range of both communicable and non-communicable diseases as well as the epidemiological outcome of this on disease patterns is seriously advocated because communities, with emphasis on the study population, need be educated and informed as emphasized by Costello *et al.*, [1] and Ansharyani [22].

The high patronage of private hospitals, which are primarily for-profit institutions owned by medical and other healthcare workers, for malaria treatment in the study perhaps explain why malaria treatment expenses takes a large proportion of the reported household health expenditure. Nevertheless, assurance of antimalarial drugs received through this formal private health sector operators is guaranteed for effective treatment because there is less risk that non-recommended treatments and poor-quality products may be used.

Given that significant health expenditure according to Onoka *et al.*, [23] places a significant financial burden on households and can force households to reduce consumption of other goods and services required for their daily living and well-being particularly in a vulnerable population like Nigeria, where 62.0% and 82.2% of households live at or below the international poverty standard of US\$1.25 and US\$2.00 per day respectively, [24] the reported spending of 20.0% of household income on health evidenced in this study is "catastrophic" in terms of constituting half of the World Health Organisation recommended global

threshold level of 40% of non-food consumption expenditure out of household income [25].

The estimated household expenses on malaria relative to household income reported in this study is higher than the 5.0% reported in Kenya but lower than the 13.0% reported in Nigeria by Shepard *et al.*, [26] and the 25.0% which Breman *et al.*, [27] projected an African family may spend of its income on malaria control. The economic burden of malaria relative to household income and total household health expenditure evident in results of this study is high and is likely to negatively impact on individuals and households, particularly the poor ones, as this could put unbearable strain on household resources to lead economically stable and healthy lives and the ability to pay for health care in terms of costs of drugs, LLINs, doctors' consultation fees and transport to and from health facilities. The risk is more precarious in settings such as Nigeria where prepayment systems grossly less predominates and households have to pay out of pocket for health care when they use health services [23].

The overwhelming health expenditure coming mainly from out-of-pocket expenditures vis-a-vis the expenditure share of household income reported by the National Bureau of Statistics [28] cannot be overemphasized in a situation where about 50.0% of the adult population experience at least one episode of malaria and children under five years have 2 to 4 attacks of malaria per year [29].

Despite the fact that access to LLINs was estimated to range between 40% and 60% in Nigeria and a few other high burden to high impact countries in Africa [30], it is surprising to note that the household ownership and use of at least one insecticide-treated net reported in this study was non-existent and incomparable to the national average household LLIN ownership and use of 69% and 37.2% (44.3% vs. 11% in Lagos) respectively reported in the 2015 Nigeria Malaria Indicator Survey [31] and 60.6% and 43.2% (29.3% vs. 12.8% in Lagos) respectively reported in the 2018 National Demographic Health Survey [32]. Similarly, the use of LLIN reported in the study is lower than the 20.6% [7] and 27.9% [33] reported in earlier studies among mothers of children under five years in Ogun State and 31.5% among same group in Lagos State [34]. The none use of LLINs in this study is disturbing because the respondents and their households were unavoidably exposed to mosquito bites at a time that transmission of malaria is highest, that is, during the rainy season between April and November [16] within which the survey period July/August was.

The main reason that "it was hotter sleeping under LLIN" which all respondents studied gave for not using LLINs was similar to one of the reasons for not using treated mosquito nets reported in a study among same group of women in Lagos and the 2018 National Demographic Health Survey which were lower at 7.5% [34] and 14.0% [32] respectively. This finding to a large extent corroborates the World Health Organisation's statement that climate change is one of the challenges impeding malaria elimination [5] because the increased environmental heat it causes evident in documented increasing trend in the annual mean temperature in Lagos State [35] and confirmed by respondents in the study discourages the use of LLINs as an effective tool for malaria prevention thereby increasing the people's vulnerability to mosquito bites and then malaria and its health and financial consequences. Health education on the benefits of LLIN as the most cost-effective and efficacious method of preventing malaria and reducing malaria-related deaths to zero

and the implications of its non-use because of hot weather conditions when mosquitoes are more active need to be relentlessly intensified in the communities.

The rising trend in the non-use of LLINs due to hot weather condition over the years from 4.0% [8] and 7.5% [34] in 2013, 14.0% [32] in 2018 in earlier studies to 100.0% in this study perhaps explains the increased rate at which increased ranges of temperature which is a key aspect of climate change has continued to discourage LLIN use across Nigeria particularly in the Lagos environment. This affirms the fears and concerns of Costello *et al.*, [1] that the achievements made so far in malaria control could be stalled and reversed by climate change.

The above is imperative given that climate change is predicted to increase malaria transmission, [30] 97% of the population in Lagos is at risk of malaria, [5] the high entomological inoculation rate of 12 to 145 infective bites per person per year [36] and malaria being a major contributor to maternal, child and infant mortality in Nigeria [32]. Knowing that there is high prevalence of malaria in the study communities as evident in Table 3 and all respondents interviewed in this study reported increased malaria cases in their households over the last 5 years with cases of malaria episodes among their household members in the past month preceding the survey, it is suggested that the LGA Malaria Control Programme managers develop and implement locally appropriate community and advocacy strategies to promote and increase the ownership and use of LLINs.

It is encouraging to note that television and newspapers/magazines/journals were sources through which most respondents reported accessing adequate and appropriate information about climate change. Television and newspapers/magazines as visual electronic and print media with wide spread appeal and large audiences make them suitable for promotion of messages about issues. It is evident that having previous climate change information from these sources had a positive effect on the high awareness of climate change among the respondents.

Given that about 60% of Lagos residents regularly listen to the radio (Adeneye, pers. comm.) and the World Health Organisation [37] reported that women in Nigeria and Kenya considered radio as an important medium for receiving health information and that radio programmes have the advantage of being accessible to all family members, through which information is thereafter shared, referred to and discussed, we suggest the increased use of the radio for the dissemination of the information promoting awareness about climate change, human activities that promote it and its consequences even though very few of the women interviewed mentioned radio as their source of climate change information as evident (Figure 4).

The use of schools, vocational skills centres and Information, Education and Communication (IEC) materials such as posters could in addition be used as complementary effective channels of information dissemination on climate change and its influence on malaria. These sources could perhaps be effectively used as a launch pad to continuously disseminate information on climate change and its health aspects to the public. Knowing that school-based peer education programs can potentially reach a large number of children in settings such as Lagos where school enrolment is high and the structured school environment is conducive to sending educational messages to youth, offering a potential captive audience for environmental and health programs such as climate change and malaria. In-school children in schools for example could be educated and



trained as agents and advocates of change on climate change risks, adaptation and mitigation and maternal and child health consequences of malaria in the communities as successfully implemented in reproductive health and HIV/AIDS programs [38] and political and decision-making processes for community development [39]. The content and presentation of targeted information for specific audience segment in the population should however be in local languages, which the communities should easily comprehend and relate to without any ambiguity. This becomes important given the increasing recognition of the important role of culture as a factor associated with health and health behaviours, as well as a potential means of enhancing the effectiveness of health communication in addressing public health problems.

The main limitation of this pilot study is the small sample size from one part of Lagos State. Nonetheless, the limitation does not underestimate the validity of the findings of this study. Given the concerns about the paucity of evidence of community knowledge and perception of climate change and its effects on health, the results of this preliminary study is expected to be useful as a baseline for a larger study with adequate sample size that is more representative of the population of the State needed to provide more generalizable findings. This is important if the SDG targets to combat malaria and climate change and its impacts [10] as well as the target of WHO Global Technical Strategy for Malaria 2016-2030 of eliminating malaria in at least 35 countries by 2030 [9] are to be realized in the studied communities Lagos particular and Nigeria in general.

Drawing from the findings of this preliminary study offers potential avenues for advocacy for integrated policy development across sectors to take account of the effects of climate variability and change on health particularly malaria. The consideration of incorporating climate and health interactions in planned and ongoing community development programs as a 'One Health' approach to effectively tackle climate change and health particularly malaria in local environmental and health management planning and implementation is suggested. The advocated 'One Health' approach is in line with the World Health Organisation's resolution WHA61.19 at its Sixty-first World Health Assembly where Member States were urged "to develop health measures and integrate them into plans for adaptation to climate change as appropriate and to strengthen the capacity of health systems for monitoring and minimizing the public health impacts of climate change through adequate preventive measures, preparedness, timely response and effective management of natural disasters" [40].

### Conclusion

It is apparent that high knowledge of climate change with some misconceptions about its cause and perception of its likelihood of affecting human health particularly as it relates to increased vulnerability to malaria in the communities have been established by the study. In addition, despite reported high malaria episodes, low use of LLINs for malaria prevention was found in the population studied. This preliminary study showed that successfully improved knowledge and perception of climate change can only be achieved if the gap in knowledge is bridged and the poor perception is corrected. Public health education therefore needs to be intensified in the communities, targeting women with children under five years old, emphasising the health effects of climate change particularly as it impact on malaria and the benefits of owning and using LLINs regardless of the weather conditions for improved health outcomes

in the household. The study provides useful evidence-based information for delivering and strengthening culturally acceptable, cost-effective and sustainable programmes designed to mitigate and adapt to climate change challenges and control malaria particularly in Amuwo Odofin LGA of Lagos State and the country at large.

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### Authors' contributions

This work was carried out with contributions from all authors. AKA conceived the study and wrote the protocol. Authors AKA, ASJ, TSA and MAM were involved in the design of the study; the data collection was overseen by AKA. AKA performed the statistical analysis and interpretation of the data and AKA wrote the first draft of the manuscript. Authors AKA and MAM managed the literature searches. AKA, ASJ, TSA and MAM read and approved the final manuscript.

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