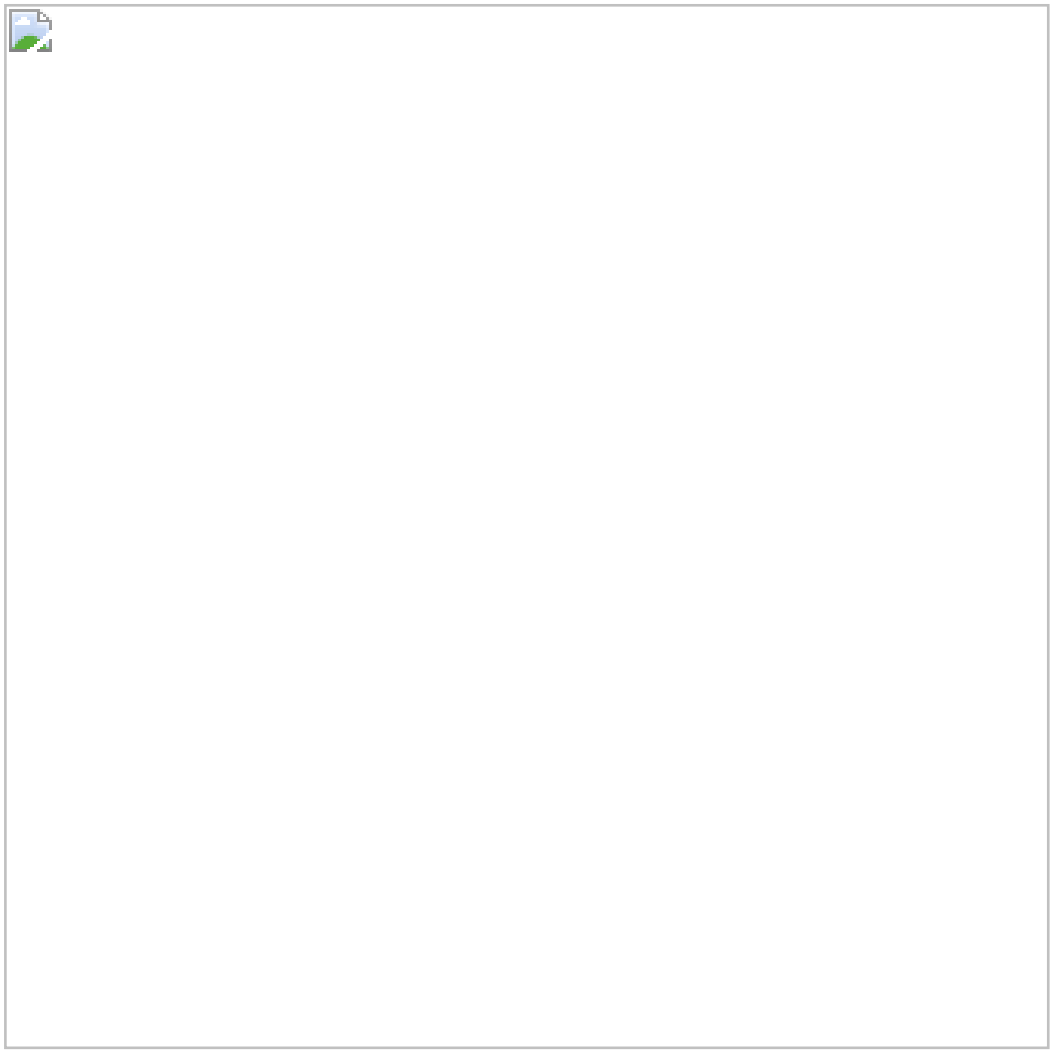

Environmental Management and Sanitation as a Malaria Vector Control Strategy: A Qualitative Cross-Sectional Study Among Stakeholders, Sunyani Municipality, Ghana

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ABSTRACT

BACKGROUND: For centuries malaria infection remains a public health burden globally as well as in the Sunyani Municipality. This exploratory qualitative study aimed to assess the prospects of environmental management and sanitation (EMS) as a malaria vector control strategy among key stakeholders involved in the prevention and control of malaria in Sunyani Municipality, Ghana.

METHOD: We used an exploratory qualitative study and a designed focus group discussion (FGD) guide (with specific research questions) to solicit opinions and/or views among Malaria Control Focal Persons, Environmental Health Officers (Health Inspectors), and Honourable Assembly Members. Data were collected between December 2019 and February 2020. The responses were analyzed according to the specific research questions.

RESULT: Findings from this study shows that high government support and/or political will by investing in environmental sanitation infrastructure, creating the enabling environment for strict enforcement of environmental sanitation bye-laws by Environmental Health Officers/Health Inspectors, effective and efficient collaboration among key stakeholders and organization of communal labor activities is likely to help reduce the majority of the mosquito breeding sites.

CONCLUSION: The prospects of environmental management and sanitation (EMS) as a vector control strategy, look promisingly very high, pertinent, and workable and a likelihood game changer of winning the fight against malaria due to the residual transmission that is happening outdoors. However, EMS can be employed as a supplementary method to the current core vector control methods if the following conditions and bottlenecks are addressed and in place: (a) Effective collaboration among key stakeholders at all levels; (b) Adequate allocation of funds to the Environmental Health and Sanitation Department; (c) Enactment of robust educational campaigns across all educational levels and via different media; (d) Recognition, empowerment, and adequate resourcing of Environmental Health Officers; (e) Adherence to the building regulations to prevent encroachment of natural wetlands; (f) Revision of fees/fines and prosecution of sanitary offenders; (g) Enactment of an Environmental Sanitation Day (ESD), and establishment of the Environmental Health and Sanitation Fund (EHSF).

KEYWORDS: Environmental management and sanitation, malaria vector control, environmental health officers, stakeholders, sunyani municipality, focus group discussion, Ghana

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Introduction

Long-lasting insecticide-treated nets (LLINs) and indoor residual spraying (IRS) are the core malaria vector control tools and interventions in the global fight against malaria recommended by the World Health Organization (WHO).[1] Unfortunately, their effectiveness has been threatened due to the development of insecticide resistance of malaria vectors (female *Anopheles* mosquitoes) and its (malaria vector) behavioral change (outdoor biting and resting) as well as increasing concern as a result of the longstanding ecological effect of

certain insecticides being used.[2] Due to a possible increase in outdoor transmission heightened by the increasing resistance of *Anopheles* species to insecticidal chemistries used on LLINs.[1] In tackling the adverse public health impact of outdoor biting (outdoor resting and feeding) of the *Anopheles* species, additional vector control interventions that target the mosquitoes outside of the home are needed.[1] The growing challenge of insecticide resistance in adult mosquitoes, as well as high levels of outdoor transmission may however lessen the effectiveness of LLINs thereby shifting the problem of control to larval control strategies aimed at preventing the occurrence of adult mosquitoes. In this regard, interventions/strategies that can serve as supplementary methods that would tackle outdoor transmission and insecticide resistance are needed immediately.[3,4]

Globally, controlling malaria by relying on the current core vector control methods (LLINs and IRS) recommended by the World Health Organization (WHO) has proved not to be sufficient because the sustainability of these malaria control strategies has been challenged by the development of resistance as well as increasing worries about the long-standing environmental impact of some insecticides.[2,5] The majority of these malaria cases during 2018 were in the WHO African Region which is 213 million representing 93%.[6]

There were an estimated 241 million malaria cases in 2020 in 85 malaria endemic countries (including the territory of French Guiana), increasing from 227 million in 2019, with most of this increase coming from countries in the WHO African Region.[6] In 2020, malaria deaths increased by 12% compared with 2019, to an estimated 627 000; an estimated 47 000 (68%) of the additional 69 000 deaths were due to service disruptions during the COVID-19 pandemic.[6] About 96% of malaria deaths globally were in 29 countries. Six countries Nigeria (27%), the Democratic Republic of the Congo (12%), Uganda (5%), Mozambique (4%), Angola (3%), and Burkina Faso (3%)—accounted for just over half of all malaria deaths globally in 2020.[6]

The total number of deaths attributable to malaria in 2017 in Ghana was 599 representing a reduction of about 54.6% over 1264 malaria deaths recorded in 2016. Out of these malaria deaths, 327 occurred among children under five (U5) years in 2017 compared to 590 in 2016.[7] In 2016, Ghana recorded 10.4 million suspected malaria cases in its Outpatient departments which denotes a 2.5% increase compared to the same period in 2015. Conversely, there was a reduction in the number of malaria-attributed deaths from 2137 in 2015 to 1264 in 2016 representing a 40.9% reduction. In 2017, the country recorded approximately 10.2 million suspected malaria cases representing about 34% of OPD cases. About 19.0% and 2.0% of total admission and total death respectively were attributable to malaria.[7]

The entire country of Ghana has been declared a high risk for malaria infection. Ghana accounts for 4% of the global malaria burden and in West Africa, 7% of the malaria burden.[8] In 2016, Ghana recorded 10.4 million suspected malaria cases in its Outpatient departments which denotes a 2.5% increase compared to the same period in 2015. Conversely, there was a reduction in the number of malaria-attributed deaths from 2137 in 2015 to 1264 in 2016 representing a 40.9% reduction. In 2017, the country recorded approximately 10.2 million suspected malaria cases representing about 34% of OPD cases. About 19.0% and 2.0% of total admission and total death respectively were attributable to malaria.[7] In 2018, nearly half of all populace at risk of malaria in Africa had protection from the use of insecticide-treated net (ITN), compared to 29% in 2010. Nonetheless, increases in ITN usage is thought to have been stalled ever since 2016.[9]

According to Sherrard-Smith et al[1] in a modeling study which shows that, whilst the ratio of mosquitoes biting indoors has declined, mosquito biting taking place outdoors has amplified by 10% in the year 2018 as compared with the year 2003. The findings from the study forecast an additional 12.2 million malaria cases across the Sub-Saharan Africa (SSA) region yearly, even with an anticipation of 100% coverage with the current malaria vector control tools that can be achieved.[1] The possible reasons for the alteration in mosquito behaviors could be a result of mosquitoes biting earlier in the evening and avoiding the LLITNs which people sleep under during the night, and perhaps that householders are staying outdoors longer in the evening.[1]

Environmental management is the altering of the environment to avoid or reduce vector proliferation to prevent human-vector-pathogen contact through the destruction, changing, eliminating, or salvaging of empty receptacles providing conducive environment developmental stages of the mosquito vector such as eggs, larvae, pupa, and adult whereas these activities must form the backbone of vector control[10] Environmental Management is in 3-folds namely: Environmental Modification: permanent carnal alterations to reduce vector larval habitats for example, consistent network water supply to communities as well as domestic connections. Environmental Manipulation: momentary changing/altering of vector habitations concerning the controlling of receptacles including regular draining and housekeeping by washing water-storage containers, flower pots, desilting of gutters, hiding or discarding empty lorry tires to prevent accumulation of water, recovering or appropriate disposal of discarded containers and tires. Modification and Manipulation: human habitat and behavioral changes as well as activities to shrink human–vector contact, that is, fixing mosquito screening on windows and doors as well as other entrances and use of mosquito nets during sleeping time either day/night time.[10]

The environmental management of malaria vectors could be an operational means for malaria control. Ever since the unearthing of the *Anopheles* mosquitoes in malaria transmission over 100 years ago, malaria control professionals have

acknowledged the significance of altering mosquito larval habitats to lessen or eliminate malaria transmission. Elimination of habitats or alteration efforts have been incorporated into general programs to shrink the abundance of all mosquitoes and targeted more projects of species sanitation focused on the primary malaria vectors. The concept of modifying vector habitat to discourage larval development or human contact is generally termed environmental management (EM).[11]

Interestingly, in East Asia and the Pacific, during the 1900s malaria was controlled in several fragments of the region by employing environmental management (EM) as a vector control strategy. Environmental management is termed as the modification and manipulation of the environment or both, serving as breeding grounds, to lessen malaria transmission by killing local malaria mosquito vectors. However, to employ this strategy one must understand the habitats of the mosquito species involved to be successful.[2]

There are indications environmental measures should be given increasing prominence, anthropogenic or man-made causes (such as reasonably preventable breeding sites, stagnant waters, uncovered water receptacles, encroachment, and settlement on swampy/marshy areas) should have man-made solutions, about 40% is the estimated proportion of *Anopheles* mosquito breeding sites (and malaria cases) which could be eliminated through environmental management (EM).[12] Strategies such as screening of doors and windows to prevent mosquitoes from entering buildings as well as environmental changes like engineering projects to limit or remove mosquito breeding sites such as draining marshes, swamps, and other areas mosquitoes may laid their eggs, that is, efforts known as species sanitation that seeks to control both the larval stages of the mosquitoes and the adults.[11]

By 1984, the development of immature stages of (breeding) *Anopheles funestus* had almost disappeared from Accra as a result of the loss of natural habitats such as ponds, swamps, marshes, tree holes and resting places (trees and shrubs), as well as the adoption of mosquito control measures (screening of houses, aerosol spraying of insecticides, use of coils, control of domestic water containers (by covering receptacles with lid, removal and /or proper disposal where possible), and intermittent larvicidal campaigns with kerosene and dichloro-diphenyl-trichloroethane (DDT).[13]

Controlling the mosquitoes that transmit the malaria infection by tackling the Anophelines larval stage is an essential element of malaria control program globally through eliminating the breeding sites by way of source reduction, which is attacking the larval habitats as well as incorporating adult vector control measures, could greatly help this fight. This study was carried out to assess the prospects of Environmental Management and Sanitation (EMS) as a vector control strategy to control malaria mosquitoes outside/outdoor among stakeholders (since EMS seems to be an effective, workable, and communally conventional vector control strategy) to reduce drastically the transmission of malaria.

Materials and Methods

Profile of the study area

Sunyani Municipality is one of the 27 districts in the Brong-Ahafo region (now Bono Region) in the southern part of Ghana. The Sunyani Municipal Assembly covers a total land area of 506.7 km^2. It is located at the heart of the Bono Region lying between latitudes 70 20′N and 70 05′N and longitudes 20 30′W and 20 10′W. The monthly temperatures vary between 23°C and 33°C with the lowest around August and the highest around March and April. The average rainfall is 88.99 cm. The district experiences 2 wet seasons with the main rainy season between March and September and the minor season from October up to December. The relative humidity averaging between 75% and 80% during the rainy seasons and below 70% during the dry seasons is ideal for luxurious vegetative growth. Sunyani Municipality falls largely within the moist–semi-deciduous forest vegetation zone. The Sunyani Municipality has a total population of 123 224 made up of 61 610 males and 61 614 females. The Municipality is predominantly urban with more than 8 out of every 10 persons living in urban areas.[14,15]

Focus group discussions (FGD)

Study design and stakeholder selection. This study was conducted in the Sunyani Municipality in the Bono Region of Ghana between the periods of December 2019 and February 2020. Three (3) key stakeholders were involved: (a) Malaria Control Focal Persons, (b) Environmental Health Officers, and (c) Honourable Assembly Members. These stakeholders have a role to play in malaria prevention and control either directly (Health Professionals) or indirectly (Assembly Members).

The Malaria Control Focal Persons was selected from the Regional Disease Control and Surveillance Unit of the Ghana Health Service. This group included a Disease Control Officer serving as the Regional Malaria Control Focal Person for the National Malaria Control Programme (NMCP), Ghana Health Service. The Environmental Health Officers/Health Inspectors group included Environmental Health Officers and Environmental Health Assistants from the Environmental Health and Sanitation Department of the Sunyani Municipal Assembly of the Ministry of Local Government and Rural Development (MLGRD). The group of Honourable Assembly Members included Assembly Members from New Dormaa, New Dormaa East, Yawhima, and Asuakwa electoral areas of the Sunyani Municipal Assembly (SMA), MLGRD.

Study procedures and data collection. This was an exploratory qualitative study and four (4) moderated focus group discussions (by the use of a focus group discussion guide with specific research questions) were conducted in different locations in the study area. Focus groups were stratified according to age that is, 20-35 years and 36-45 years or older with mixed sex, consisting of 4 groups in each stratum, making 12 participants in all. Each

Focus group lasted 35 to 50 minutes and were conducted in English and the local language Twi (for the Environmental Health Officers, Regional Malaria Focal Persons, and Honourable Assembly Members respectively). The FGD for the Environmental Health Officers and Regional Malaria Focal Persons took place at the staff common room of the Environmental Health and Sanitation Department, Sunyani Municipal Assembly whilst that of the Honourable Assembly Members took place outside in New Dormaa electoral area. Participants were asked open-ended questions on their views of the specific questions below:

Specific research questions. The study sought to answer the following specific research questions:

1. Where do mosquitoes breed?
2. What are the causes or factors contributing to mosquito breeding in the municipality?
3. Do you think settlement (ie, building houses and living) around natural swampy/marshy areas contributes to malaria prevalence in the communities? (explain)
4. What types of vector control strategies/methods/interventions do you employ in the prevention and control of malaria in the Sunyani municipality?
5. What supplementary or alternative anti-malaria prevention and control method will you recommend for households in the municipality?
6. Who are some of the stakeholders (institutions, departments/organizations, etc.,) you are working with as change agents for malaria prevention and control in the municipality?
7. Do you organize any radio/TV discussions about the prevention and control of malaria in the municipality? If yes, (how often and at what time)
8. Robust educational campaigns on environmental management and sanitation would go a long way in the prevention and control of malaria. To what extent do you agree with this? (explain)
9. Do you think the enforcement of environmental sanitation bye-laws will make community members clean their environment to help prevent mosquitoes from breeding? (explain)
10. Please explain how high government support/political will towards environmental management and sanitation would ensure the prevention and control of malaria?
11. What challenges do you face with regards to malaria prevention and control in the Sunyani municipality?

Focus group discussions (FGD) guide (questionnaire) design

This study adopted the focus group discussions (FGD) guide (questionnaire) from previous exploratory qualitative studies relative and relevant to this topical area where open ended questions were used to allow respondents to elaborate upon their responses, whilst the researchers were able to seek clarification from the respondents on their responses and this helps the researchers to gather more information on the various questions or topics.

Content validation

Content validity is the extent to which research items to be considered in a FGD guide (questionnaire) are to entirely represent the theoretical construct the item is designed to measure or assess.[16] The researchers who are experts and familiar with the construct that the FGD guide is designed to measure evaluated the content validity of the FGD guide in this study. The team ascertained whether the items in the FGD guide could sufficiently measure the construct intended to instigate as well as whether the items are appropriate to measure the objects of the study. Among the items evaluated were; whether the FGD guide questions were clear and easy to answer by the respondents, the questions adequately covered all the topical areas of environmental management and sanitation (EMS) as a malaria vector control strategy, whether the FGD guide is deficit of key questions on EMS, the usability of the FGD guide by future researchers and whether there are items in the FGD guide that could violate the privacy of the respondents among others.[17]

Pre-testing

Prior to the conduct of the focus group discussion (FGD) with the key stakeholders in the study area, the FGD guide developed was pre-tested on a small sample of about 5 to 10 respondents in November, 2019 among similar category of key stakeholders (ie, National Malaria Control Focal Persons, Environmental Health Officers and Hon. Assembly Members) in the Tano North Municipality, adjacent to the Sunyani Municipality with the same demographic characteristics.[16,18,19] This pre-testing of the FGD guide gave the researchers the opportunity to ascertain whether there was a confusion and/or ambiguous questions about any of the items as well as if respondents had any suggestions to probably improve upon the items. The FGD guide was revised by the researchers after a thoroughly review of the responses of the participants during the pre-testing, before finalizing the final draft FGD guide and administered to the stakeholders (participants).[20]

Sample size determination. This study adopted code saturation and meaning saturation to determine the sample size (where code saturation, is defined as the point when no additional issues are identified in data and the codebook has stabilized whilst meaning saturation, is also defined as the point at which it is fully understood the issues identified had no further insights or nuances found)[21] to select 16 focus group discussions. Unfortunately, however, due to the Coronavirus (COVID-19) pandemic and its restrictions on human

Table 1. Gender distribution of the participants of the focus group discussions.

STAKEHOLDER GROUP	MALES	FEMALES	TOTAL
Health Professionals	4	4	8
Honourable Assembly Members	4	0	4
Total	8	4	12

movement in March 2020, the researchers could not reach the set target. According to Guest et al,[22] when it comes to averaging the chronological, as well as randomized order of focus groups, 2 to 3 focus groups, are deemed to be sufficient to record 80% of themes, this includes the most dominant themes whilst 3 to 6 groups for 90% of themes when it comes to homogenous study population using a semi-structured discussion guide.

Ethical consideration. The Committee on Human Research Publication and Ethics (CHRPE), School of Medical Sciences, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana *(CHRPE/AP/143/20)* approved the study. Individual informed consent was sought from participants (signed CHRPE participants' consent forms) before each focus group discussion commenced. Participants were informed of the study procedures, risks, and benefits and provided written consent to take part in the focus group discussions and for the audio recording.

An official letter seeking approval from the study site as well as the notification was sent to the Regional Director of Health Services (RDHS), the Regional Environmental Health and Sanitation Officer (REHO), The Municipal Director of Health Services (MDHS), and the Municipal Environmental Health and Sanitation Officer (MEHO). The aforementioned Offices offered verbal approval and their full support for the research work to be carried out in the study area which is under their jurisdiction.

Data processing and analysis. The responses were analyzed according to the specific research questions. The audio recordings were transcribed verbatim into a data recording book and later typed into Microsoft Word version 2016. Responses from the participants (stakeholders) were summarized and supported by quotation marks.

Results

In all, 12 people participated in the FGD discussions across the stakeholder groups, 8 of them were males whereas 4 were females. The lack of gender balance among the participants is due to the Coronavirus (COVID-19) pandemic restriction of movement in Ghana which prevented the researchers from contacting the rest of the participants. The demographic characteristics of the FGD participants are presented in Table 1 above.

Responses and /or opinions of key stakeholders involved in and/or concerned with malaria prevention and control in the study area are presented with regard to the FGD guide questions enumerated in the specific research questions above.

Participants' knowledge of breeding sites of mosquitoes in the Sunyani Municipality

The health professionals (Malaria Control Focal Persons and Environmental Health Officers) and Honourable Assembly Members expressed their views and deliberated on the breeding sites of mosquitoes in the Sunyani Municipality when they were all asked this question. Natural and anthropogenic (man-made) conditions and breeding sites were the major topical areas that came up among all the participants. The health professionals stated that:

> *"The female Anopheles mosquitoes breed in clear, relatively clean waters, not fast flowing stagnant waters. Also, in rice fields and pools of water when it rains in our homes, female Anopheles mosquitoes will breed there"* (Malaria Control Focal Person).

> *"They normally breed in stagnant waters. However, Anopheles mosquitoes breed in stagnant waters that are clean. Poor sanitation. "Living in an untidy environment"* (Environmental Health Officer I, Environmental Health and Sanitation Department, EHSD).

On the part of the Honourable Assembly Members, they indicated that mosquitoes breed in a variety of places and many reasons account for or bring about their breeding in the communities. However, they could not indicate where the female *Anopheles* mosquito that serves as a vector for the transmission of the *Plasmodium Falciparum* that causes malaria infection breed. An Honourable Assembly Member stated:

> *"Mosquitoes breed on leaves of trees that accumulates water in bushy areas around our houses when you fetch water and you leave the water uncovered for a long time of which the water is clean"* (Honourable Assembly Member III).

Participants' knowledge on causes or factors contributing to mosquitoes breeding in the Sunyani Municipality

The health professionals indicated that both natural conditions and man-made causes and factors are responsible for mosquito breeding in the Municipality. One health professional stated that:

> *"When you have empty gallons, empty cans, when you have a bit of depression of land, it can easily collect clean water, which will aid the breeding of the female Anopheles mosquitoes. Our rainfall pattern (rain season and dry season), humidity, climate, and temperature all aid the development of the female Anopheles mosquitoes from the pupa to the adult stage"* (Regional Malaria Control Focal Person, Sunyani).

Another health professional indicated that:

"Improper drainage systems" (Environmental Health Officer IV, EHSD).

One Honourable Assembly Member stated:

> *"Filthy environment (poor environmental sanitation) for instance when our communal refuse container is full, emptying it becomes so difficult and a challenge"* (Honourable Assembly Member I).

Participants' opinions on whether settlement and living around natural swampy/marshy areas contributes to malaria prevalence in the community

On this subject, all the participants expressed the same or very similar opinions, however none of the participants mentioned the different species (types) of *Anopheles* mosquitoes who breed in natural swampy/marshy (either *Anopheles gambiae*, *Anopheles* funestus, etc.). As pointed out by the health professionals:

> *"Of course, living in or around swampy/marshy areas have an effect on the prevalence of malaria. Because there is the breeding of the female Anopheles mosquito which will bite you and transmit the malaria infection"* (Regional Malaria Control Focal Person, Sunyani).

> *"Yes, when water stands virtual at swampy areas, it breeds Anopheles mosquitoes, which bite nearby residents and contributes to malaria prevalence."* (Environmental Health Officer I, EHSD).

The Honourable Assembly Members shared their personal experiences with regards to how they had had mosquito bites whilst working or staying around natural swampy/marshy areas when responding to this subject. One Honourable Assembly member passionately stated:

"*Yes, the swampy/marshy areas help in the breeding of mosquitoes more. I am saying this because, I have a farm near a swampy area, and mosquitoes do bite me more often when I visit the farm*" (Honourable Assembly Member I).

Responses on types of vector control strategies being employed by the national malaria control program and other stakeholders in the prevention and control of malaria

There were diverse views from the stakeholders on the types of vector control strategies being employed in the prevention and control of malaria in the municipality. It was evident that the national malaria control program (NMCP) employed multiple strategies and do not rely on only one method when it comes to malaria prevention and control as a national agency responsible for fighting the deadly disease. These multiple strategies range from preventive to chemotherapeutic. A stakeholder working with the NMCP stated that:

> "*Distribution of long-lasting insecticides treated nets (LLINs) in schools, continuous distribution (every day) at antenatal clinics (ANC) registrants (pregnant women) and Mass net distribution. Also, larviciding (to reduce the larval population of the female Anopheles mosquitoes) collaboration with Zoomlion (a private waste management company) and the Environmental Health Division of the Metropolitan, Municipal and District Assemblies (MMDAs)"* (Regional Malaria Control Focal Person, Sunyani).

Interestingly, one participant was optimistic about the potential and the prospects of additional methods/ tools being explored by the NMCP in the region as the game changer in malaria control, especially among children under five (U5). This is what the participant pointed out:

> *"Malaria vaccine piloting implementation program started last year (2019) in Brong-Ahafo, Volta, and Central regions of Ghana. We give children up to 6 months-24 months of the malaria vaccine to prevent malaria infection"* (Regional Malaria Control Focal Person, Sunyani).

On the other hand, the environmental health officers mentioned the need for community members to regularly clean their immediate environment as means of eliminating mosquito breeding sites to reduce the larval population of the vector. One participant from the group indicated that:

> *"Good environmental management by flushing or draining relatively clean stagnant waters, weeding the environment, desilting of choked gutters, management of discarded car tires and cans from accumulating rain water that breeds mosquitoes"* (Environmental Health Officer IV, EHSD).

The Honourable Assembly Members, they agreed with the health professionals most especially the malaria control focal person in that, the use of integrated vector management (IVM), where multiple strategies are deployed will help in the fight against the infection though they mentioned about employing environmental management (EM) measures as indicated by the Environmental Health Officers. One Honourable Assembly Member stated that:

> *"The common type of mosquito control strategy is the use of the mosquito nets (LLITNs/ITNs) and keeping our environment clean to ensure there is always good environmental sanitation, by eliminating breeding sites like stagnant waters"* (Honourable Assembly Member I).

The health professionals mentioned various methods being employed including larviciding. They did not mention what larviciding is and what is used in this. However, one person from the Honourable assembly members group describes an experience he has heard about the biological control of the mosquito larvae. The participant said that:

> *"I have learned it somewhere that stagnant waters, when we pour dirty oil or kerosene on its surface, it prevents the breeding of mosquitoes, by making the surface of the water heavy."* (Honourable Assembly Member III).

Opinions on supplementary or alternative anti-malaria prevention and control methods for households in the municipality

Discussion on the supplementary or alternative anti-malaria prevention and control methods, the stakeholders unanimously mentioned the adoption of environmental and social interventions and/or measures by engaging and involving community

members, opinion leaders and everyone at all levels of the society and that, they believed this act will likely help to eliminate majority of potential mosquito breeding sites. However, one participant highlighted the need to also use mosquito repellents by residents as personal protection. This is what a Malaria Control Focal Person pointed out:

> *"Environmental management (EM) via social and behavior change communication (SBCC). Because, people have to take care of their environment by preventing stagnant waters, empty cans, and cover our water receptacles to prevent mosquitoes from breed there"* (Regional Malaria Control Focal Person, Sunyani).

Further, one stakeholder belonging to the health professionals group indicated that: *"Proper environmental management and sanitation measures (flushing of rain water, covering of water receptacles and barrels at home). Since the mosquitoes need water to multiply, preventing water from accumulating/stagnating will help to eliminate or prevent mosquito breeding sites"* (Environmental Health Officer IV, EHSD).

Another stakeholder belonging to the health professionals group said the *"Use of mosquito repellents"* (Environmental Health Officer V, EHSD).

Responses on stakeholders' national malaria control program, environmental health and sanitation department, and Honourable assembly members work with in the municipality for malaria prevention and control

There were very diverse stakeholders and/or participants of this focus group discussion that have been working within the study area. Both local and international development partners are working in close collaboration with NMCP and EHSD in their malaria prevention and control mandate. On one hand, it was noted that the NMCP has a very good working collaboration with international development partners (DPs) and local non-governmental organizations (NGOs) than the other stakeholders (EHOs and Honourable Assembly Members). One participant pointed that:

> *"Key stakeholders NMCP works with in the region are development partners such as World Health Organization (WHO) 2). United Nations Children's Fund (UNICEF) 3). United States Aid (USAID) as well as Non-governmental organizations (NGO) such as Impact Malaria, Franko initiative – Tano South, Providence Club - Jaman South, Community Youth Development–Kintampo, Rural People's Foundation – Nkoranza south"* (Regional Malaria Control Focal Person, Sunyani).

Participants of the Environmental Health group emphasized that they work with the local authorities at the grassroots and semi-national level, health authorities, private sector waste management companies, and local religious bodies who have initiated their activities (to involve its members in clean-up exercises to ensure communities are clean at all times). One participant noted that:

> *"We work with Honourable Assembly Members, Non-Governmental Organizations (NGOs) and Churches such as the Church of Pentecost (COP), through the environmental care campaign (ECC)"* (Environmental Health Officer II, EHSD).

Another participant of this group mentioned that:

> *"Zoomlion Ghana Limited, National Youth Authority (NYA) and Ghana Health Service (GHS)"* (Environmental Health Officer I, EHSD).

On the other hand, the Honourable Assembly Members intimated that they also work with the hierarchy of the traditional leaders of the communities, households (residents) of the local communities, and other identifiable bodies or organizations located or present in the communities for developmental purposes. One participant of this group stated that:

> *"We work with the Chiefs and Unit Committee members. Because you cannot do anything in the community without informing the Chiefs. The community members/individuals, Pastors, Religious Leaders, etc. are some of the institutions or people we work with to ensure our communities are clean"* (Honourable Assembly Member I).

A major issue that came up during the various FGDs and that was agreed upon by all the participants was the issue of collaboration among the stakeholders most especially the NMCP and Honourable Assembly Members. It was evident that the participants who have key roles to play in the fight against malaria through their various duties and responsibilities felt that, the stakeholders are not fully working together but rather are carrying out parallel activities devoid of each other to a very large extent. This is what one participant has to say:

> *"Though we need to improve on our collaboration. Many of our collaboration has been with the Environmental Health Officers/Health Inspectors for instance during World Malaria Day (WMD)" (Regional Malaria Control Focal Person, Sunyani).*

Another participant emphasized that:

> *"There is an inadequate collaboration between the national malaria control programme (focal persons), the Community Health Nurses, and the Environmental Health Officers/Health Inspectors"* (Honourable Assembly Member I).

Responses of participants on whether Radio/ Television discussions are organized on environmental management and sanitation for prevention and control of malaria

The Malaria Control Focal Person indicated that the NMCP embarked on social and behavior change communication (SBCC) via different media platforms available at its disposal and during these activities, sensitization of residents on proper sanitation and/or cleanliness and a healthy environment are included in their discussion. A participant from NMCP stated that:

"We do organize radio and TV discussions on malaria control during the weekends besides given education in the community and we do educate the community on environmental management and sanitation they must practice preventing mosquitoes from breeding" (Regional Malaria Control Focal Person, Sunyani).

Environmental Health Officers also agreed that they carry out media discussions on malaria prevention and control in the community and always advocate for the need for community members to keep their environment clean (including desisting from creating and /or removal of stagnant waters) to prevent the proliferation of mosquito breeding sites. One participant from this group stated that:

"Yes, we organize it (radio and TV discussions) twice a week in the morning and in the evening at a cost" (Environmental Health Officer I, EHSD).

On the contrary, the Honourable Assembly Members (HAMs) indicated that they engage in radio discussions a couple of times a year but has never had the opportunity to visit a TV station for a discussion on malaria control. Interestingly, the HAMs stressed that they embarked on malaria prevention and control activities via the local religious organizations present in their electoral areas. One HAM stated:

"I also use the churches and mosques to educate my community members about malaria control. For radio discussion/ education, we do it twice a year but for the churches and mosques is an ongoing activity that we have been doing more often." (Honourable Assembly Member II).

Responses of participants on whether robust educational campaigns are organized on environmental management and sanitation for prevention and control of malaria

The stakeholders unanimously agreed that instituting robust educational campaigns by NMCP, Government and relevant bodies both at the community level, organizational and formal institutional levels will go a long way in the fight against the disease. One participant indicated that:

"Robust educational campaigns, starting from our basic schools to the universities on environmental management and sanitation concerning malaria control, will go a long way. Because Zero malaria starts with you, everyone has a role to play in our fight to eradicate malaria in Ghana once and for all" (Regional Malaria Control Focal Person, Sunyani).

In the same vein, another participant indicated that:

"I think is very good to start educating our children on environmental management and sanitation (EMS) from nursery primary to the university level, this is because the practice of proper sanitation will be inculcated or instilled in them when they complete school and will be practicing good environmental sanitation in their houses and communities" (Honourable Assembly Member IV).

Further, another participant indicated the need to embark on frequent and timely educational campaigns in the communities due to forgetfulness among individuals. This is what the participant has to say:

"People are somehow aware of environmental sanitation but continuous education will help, through the development of jingles that would be used during educational programs/campaigns and being played on television (TV) and radio stations as well as local information centers" (Environmental Health Officer IV, EHSD).

Interestingly, a participant called on Central and Local Government authorities to institute an annual nationwide ceremonial day to commemorate and promote environmental hygiene and sanitation (cleaning) activities in the communities to remove mosquito breeding sites and hideouts. As indicated by the participant:

"Government should set aside a day for Environmental Sanitation Day (ESA), to compliment the Malaria Day but educating people about environmental management and sanitation with regards to the prevention and control of Malaria" (Environmental Health Officer VI, EHSD).

Opinions on whether enforcement of environmental sanitation bye-laws will make community members clean their environment to help prevent mosquitoes from breeding

Unanimously, all the stakeholder groups agreed that enforcement of environmental sanitation bye-laws by Health Inspectors (Environmental Health Officers), is likely to help win the fight through the removal of mosquito breeding sites thereby reducing its larval populations and densities.

In the era of "Tankas" (Town Council or Health Inspectors) during the colonial days, their routine premises inspections and abatement of nuisances (such as indiscriminate wastewater and solid waste disposal and growth of weeds on premises) as well prosecution of sanitary offenders were very helpful in the prevention and control of most diseases of public health concern. One participant stated:

"If environmental sanitation bye-laws are being enforced, of course, malaria and a broad range of other public health conditions/diseases will be eliminated. For instance during the era of "tankas (health inspectors). It takes a lot of willingness and commitment to enforce the environmental and sanitation bye-laws. Also, the galamsey (illegal mining) creates a lot of breeding sites. We need a lot of political, social commitment and all of us on board." "If environmental and sanitation bye-laws are being enforced, of course, there will be fewer breeding sites for mosquitoes, especially the female Anopheles mosquitoes, once there are fewer breeding sites, it is likely there will be fewer cases of malaria. Once there are fewer malaria cases, we will not spend much funds/money on malaria. These funds will serve as money that can be used for other things. Once there is less malaria, we do not have to spend money buying ACTs, ITNs, insecticides, larvicides, etc. it has a broader benefit" (Regional Malaria Control Focal Person, Sunyani).

A major issue that came up which was important to the Environmental Health Officers and Honourable Assembly Members was poor attendance and participation in communal

labor activities by residents as well as low court fines for sanitary offenders. They believed these reasons are stumbling blocks to the effective and strict enforcement of the environmental sanitation bye-laws. One participant indicated that:

> *"As an Honourable Assembly Member, when there is time for communal labor, some people decide to participate whilst others too refused to participate, which has been the trend. This is happening because the Assembly's environmental sanitation bye-laws are not being implemented strictly. Every community member can dispose of their refuse/garbage anywhere (indiscriminately) to litter the environment. However, if the environmental sanitation bye-laws are being strictly enforced and thereby punishing offenders, it will serve as a deterrent to others"* (Honourable Assembly Member II).

> *"There is indiscipline among community members of late. This has led to a vast decline in the commitment and zeal of community members towards communal labor compared to the olden days, when we were children"* (Honourable Assembly Member III).

Similarly, other participants indicated that:

> *"The court fines are too small. The amount offenders pay as court fines are very small and this does not discourage community members from committing sanitary offenses in the community. Therefore, we are pleading for the court fines to be reviewed and increased to a reasonable amount that would be huge and difficult to pay and I believed this will discourage community members from committing sanitary offenses. This approach is likely to change the behavior of the people in the community and the results on environmental sanitation will be massive"* (Honourable Assembly Member IV).

> *"The charges or penalties given to sanitary offenders will compel a lot of them to do the right thing because when one got to know that they will be fine hugely, therefore, the charges and fines must be high, and currently the fines are very small"* (Environmental Health Officer IV, EHSD).

> *"Yes, at times, when there is a communal labor in the community, some refuse to participate and when you prosecute them, the rest will comply, so the next time, there are doing another communal labor because of that person who was prosecuted, the others will join"* (Environmental Health Officer I, EHSD).

Another interesting issue that came up during the discussion was the benefits of visibility in communities, empowerment, and adequate resourcing of Health Inspectors (Environmental Health Officers) with regard to having a clean, serene, and conducive environment free of filth in our communities. One participant indicated that:

> *"Tankas (Town Council or Health Inspectors) must be empowered and resourced to help us get our communities back to proper environmental sanitation standards as compared to the olden days. We must start engagement with our Municipal Chief Executives (MCEs), maybe they (MCEs) are not aware of the plight of the Health Inspectors and their work is nothing to write home about. We need to remind the MCEs"* (Honourable Assembly Member I).

Another participant stated that:

> *"If there are laws, and the laws are enforced by Health Inspectors (Environmental Health Officers), by hearing the presence of these Officers in the community, you could see people running and putting things or their house in order. Therefore, if these laws are strictly enforced, nobody will be reminding community members to clean their environment" (Honourable Assembly Member II).*

Opinions on how high government support/political will toward environmental management and sanitation would ensure the prevention and control of malaria

All the stakeholder groups agreed that high government support/political will toward environmental management and sanitation as a tool to help in the prevention and control of malaria in the communities. They stressed that if the Government (central government and its authorities at all levels) eschew gross political interference in the performance of the duties and responsibilities of Health Inspectors (Environmental Health Officers) in the enforcement of the environmental sanitation bye-laws, it will greatly benefit the communities and the country at large. As one participant from the NMCP said:

> *"If the government supports environmental management and sanitation, it is likely to go a long way to help reduce malaria cases or burden, the amount /funds for malaria control and has a rippling effect. With high government support, if we can enforce the environmental sanitation bye-laws, to ensure good environmental sanitation in our communities, majority of mosquito breeding sites will be prevented, reduced or eliminated"* (Regional Malaria Control Focal Person, Sunyani).

One participant from the Honourable Assembly Members group emphasized that:

> *"Government and its officials at the national, regional, district, local and community levels must allow Environmental Health Officers (EHOs) or Health Inspectors to work by desisting from politically interfering in their work"* (Honourable Assembly Member I).

Environmental Health Officers argued that the country cannot achieve high standards of environmental sanitation without adequate budgetary allocation to the Environmental Health and Sanitation Department (EHSD) coupled with the sad phenomena of diverting funding (inadequate though) allocated to the department to other areas, and that prevents the funds from even getting to them. As indicated by one participant:

> *"In every Municipality or District, there is an amount apportioned to sanitation as government support. Ironically, Government support that comes to the Environmental Health and Sanitation Department (EHSD) does not reach us. Because since we are under the Local Government when the money (allocation to EHSD) is paid to your assembly, the amount which is supposed to be disbursed to environmental health and sanitation (water and sanitation, and waste management inclusive), EHSD has the highest allocation but unfortunately it (allocated funds) does not reach us."* (Environmental Health Officer VI, EHSD).

On the other hand, a participant from the Honourable Assembly Members group strongly supported the call by the EHOs and indicated:

> *"Government must make readily available financial resources to support community sanitation projects or infrastructure. Also, the MMDAs must provide more information centers in the community and support EHOs to educate community members on environmental management and sanitation."* (Honourable Assembly Member II).

Honourable Assembly Members also fiercely argued that Government must show greater interest and commitment to the development of the communities by supporting the creation of an enabling environment for healthy living. As one participant postulated:

> *"Government should be very committed to environmental management and sanitation with the same zeal that they do commit to political activities in the community and the country"* (Honourable Assembly Member I).

Majority of the stakeholders passionately called on the central Government and MMDAs to construct proper drainage systems and strictly supervise road infrastructure projects awarded to construction firms or contractors, and ensure the specifications are adhered to. As one participant opined:

> *"Construction of proper drainage systems in the communities by Central Government and Assemblies to ensure adequate draining of stormwater and wastewater (grey) in the communities to prevent the breeding of mosquitoes"* (Honourable Assembly Member IV).

Another participant emphasized that:

> *"When given contracts to road contractors by the MMDAs, they should ensure that the roads are constructed with proper drainage systems."* (Environmental Health Officer IV, EHSD).

Opinions on challenges facing stakeholders in malaria prevention and control

Malaria Control Programmes also faces challenges. Diverse challenges were being faced and expressed by the various stakeholder groups. On one hand, the national malaria control programme (NMCP) highlighted inadequate financial support, limited access to LLITNs by community members, and poor attitudes of residents (community members) with regard to ownership and usage of the LLITNs. As indicated by a participant from this group:

> *"Funding challenges due to Ghana's attainment of middle-income country status which has therefore resulted in the cessation of funding from some development partners (DPs). Non-patronage of LLITNs by communities. Access and use of mosquito nets (LLITNs) is a challenge. People give all manner of excuses such as the net is hot when you sleep under it. However, education has been ongoing, when we can create an effective barrier between us and the mosquitoes, we will have a very long way to go. Behavioral attitudes, sometimes some use the bed net (LLITNs) as a fence for their backyard garden and other activities. Continuous social and behavior change communication (SBCC), surely, we will get there."* (Regional Malaria Control Focal Person, Sunyani).

The Honourable Assembly Members also emphasized how lack of funding is undermining the performance of their duties. As one participant stressed:

> "*Lack of funds or financial resources is a major challenge we face. Sometimes, there is a need to see Zoomlion workers (a private company) come and spray (disinfest) your community for you but due to financial resources, we cannot carry out any initiative to help our communities. Even at times after communal labor, it is good to at least give an ice kenkey(mashed kenkey) to the community members who participated during the activity as a form of motivation but this gesture we cannot do because it all bores down to funds"* (Honourable Assembly Member I).

The Environmental Health Officers, stated emphatically that, political interference, lack of educational materials (teaching and learning) to carry out health education and promotion activities in the community, lack of means of transportation, and recognition by government authorities as the key challenges they (EHOs) are facing in the course of performing their duties. As indicated by the participants of this group:

> *"Political interference is one of our major challenges. When you go to the community and you issue an abatement notice, the offender may have a favor from the Assembly member or any political figure, he/she will try to take the notice to such person Member before getting to you"* (Environmental Health Officer IV, EHSD).

Also, *"Teaching aids is a challenge. If you are going to conduct education on malaria, you will need some teaching materials, which are not available"* (Environmental Health Officer IV, EHSD).

> *"At times when we are going to the communities to embark on educational talks on malaria prevent and control, even lorry fare or transportation is a problem, vehicles or means of transport is a problem too"* (Environmental Health Officer III, EHSD).

> *Further, "Lack of recognition as Health Officers in charge of Environmental Health and Sanitation in Ghana is a major challenge to us"* (Environmental Health Officer I-VII, EHSD).

Discussion

This study explored the knowledge and opinions of key stakeholders on the prospects of environmental management and sanitation (EMS) as a malaria vector control strategy. The stakeholders' discussion focused on EMS as a supplementary or alternative malaria prevention and control strategy amid insecticide resistance and vector behavior change.

The findings show considerable agreement across the stakeholders on stagnant water being the main breeding site for mosquitoes. The health professionals indicated stagnant waters that are relatively clean as well as rice fields, and pools of water are where *Anopheles* (female) mosquitoes breed whereas the Honourable Assembly Members identified leaves of trees that

accumulate water in bushy areas around our houses, uncovered water receptacles and polluted waters. These responses are consistent with findings from other studies which stated that larval habitats such as impermanent, standing, or slowly moving water under a shadow are known breeding sites of *Anopheles*.[2] While principal sites ensue year-round and tend to be connected with the stream system in a deep forests, mosquito habitats can include freshwater wetlands (swamps, flood plains, riverine forests, and swamp forests), mangroves, and coastal wetlands (lagoons, estuaries, and tidal mudflats).[23] However, they differ in nature with regards to the season where there are stream beds, pools connected with streams, or meanders of slow-moving streams in the dry season.[24,25] The malaria epidemic might emanate as result of the development of dams, and irrigation schemes, which alter the local environment and subsequently the preceding ecological balance.[26] It is noted that *Anopheles* breeds in wells near houses in certain areas all over the year even when densities of these wells are declined in the dry season[27] and secondary larval habitats occur in the rainy season and can be found closer to human settlement at the forest fringe such as shallow, temporary, shaded water-holding depressions and in long marshy areas (swamps).[28]

Environmental factors such as rainfall, humidity, and temperature have been mentioned by the health professionals while mainly poor sanitation (presence of empty gallons, empty cans, and plastic containers) and lack of drainage systems were considered the main factors contributing to mosquitoes breeding addressed as the main factors that were raised by the Honourable Assembly Members. This agrees with a study by Kyi,[29] which indicated that moderate, warm temperatures, high humidity, and wetlands/swampy areas within the tropical zones serve as environmental conditions and factors that provide a readily available receptive environments which is responsible for mosquito breeding and proliferation and malaria transmission differs seasonally due to mosquito populations' densities during these periods. According to Obsomer et al,[26] the commonest causative element in malaria epidemics is abnormal climatological settings which alter the environmental balance between human hosts and parasites. The breeding sites (place of laying of eggs) of mosquitoes is influenced by many environmental factors such as climatic conditions which includes temperature, rainfall, vegetation, salinity and turbidity of the water, the size of the breeding habitat, and the amount of sunlight.[30] The ability of mosquito larvae to survive depends on the temperature of the larval habitats which could impact larval development, pupation rate and time.[31] Discrepancy in respect of rainfall patterns as well as changes in seasons (dry and rainy) is noted to influence the presence of larval habitats and its proliferation.[32] Landscape features such as topography, land cover, and land use influence the formation, distribution, and microclimate conditions of larval habitats, which in turn influence the distribution of adult Anopheles vectors.[33,34] Bugoro et al,[35] in a study demonstrated that, the presence and abundance *Anopheles farauti* larvae were influenced by environmental factors (ie, floating filamentous algae, aquatic emergent plants, sun exposure, salinity and rainfall) within the large streams and a good understanding these parameters will allow for targeted cost effective implementation of source reduction and larviciding to supplement the core malaria vector methods IRS and LLINs.

There was a consensus among all the participants, on settlement around wetlands (swampy or marshy areas) area could significantly contribute to malaria prevalence in the community because *Anopheles* species such as female *Anopheles gambiae, Anopheles* funestus, etc. breeds in these areas). This findings agrees with a study conducted by Hinne et al[36] in Ghana, shows that swamps and furrows ranked the most prolific larval habitats of *Anopheles* mosquitoes in the Sahel savannah zone during the dry and rainy seasons, respectively whilst larval habitat types were influenced by the presence of larvae as well as larval density. Also, the land-use type affected the presence of *Anopheles* larvae whereas vegetation cover influenced larval density. Further, the researchers concluded that, the abundance of Anopheles breeding habitats and larvae were influenced by anthropogenic activities and therefore the involvement of community members whose actions and activities turned to produce larval habitats to participate in larval source management including habitat manipulation with the aim of stopping mosquito breeding is paramount for malaria prevention and control.[36]

According to Celli,[37] aside from genetic adaptation, the most common human strategy for limiting malaria infections historically was geographic and avoiding mosquito breeding sites such as swampy areas and clean stagnant waters. Avoiding malaria is the reason that the United States Congress and Supreme Courts had a summer recess to avoid Philadelphia and Washington DC during the months when malaria was most common; similarly, communities of British in Colonial India moved to Hill stations in summer believing them to be healthier than lower elevations. Larvae of *Anopheline* species can be found in a wide diversity of habitats, ranging from small, temporary pools and puddles to large and more permanent water bodies. The aquatic life cycle of *Anopheles* species starts when a gravid female mosquito deposits her eggs on or very near the water in swampy areas or around stagnant waters.[38] Complementary interventions might be suitable in a particular situation, for example, larval source management in situations where mosquitoes' aquatic habitats are insufficient, immovable as well as visible.[39]

On the types of vector control strategies employed in the Municipality, according to the Regional Malaria Focal Person, Sunyani, the National Malaria Control Programme (NMCP) employed integrated vector management (IVM) (ie, use of, prompt and effective case management (test, treat, and track), Intermittent preventive treatment for pregnant women (IPTp) (Sulphadoxine pyrimethamine (SP), LLITNs, IRS, and larviciding/bio-control). It was noted that the NMCP has started a

piloting programme implementation on malaria vaccine among children up to 6 to 24 months. The Environmental Health Officers and Honourable Assembly Members called on community members to consider taking responsibility for cleaning their environment to eliminate mosquito breeding sites and advised community members to use LLITNs and IRS. Interestingly, the Honourable assembly members stressed the need to employ local biological control methods such as the pouring of dirty oil or kerosene on the surfaces of stagnant waters to prevent mosquito breeding and larvae survival. The development of biological control agents such as natural enemies and organisms pathogenic to the larval and adult stages such as the use of kerosene has helped to reduce the larval populations.[3]

The participants highlighted 3 supplementary or alternative options as an anti-malarial prevention method. The use of social and behavior change communication (SBCC), strengthening the previous environmental management (EM) options, and social mobilization (communal labor) of the local community to embark on clean-up exercises (to remove mosquito breeding sites). These opinions or suggestions of the participants corroborated with findings of research conducted in urban Tanzania where the majority of participants stressed the importance of environmental management to remove mosquito-breeding sites as the most effective strategies for controlling outdoor-biting mosquitoes and malaria.[40] Except intermittent preventive treatment of pregnant women, IPTp (currently the use of sulfadoxine-pyrimethamine was mentioned), other important and sensitive supplementary or alternatives methods such as mass drug administration for the general population, gene drive technology (ie, genetically modified mosquitoes), and biological control methods such as the use of *Bacillus thuringiensis var. israelensis (Bti)* as a novel biological control agent for malaria and its vector control in the community that was mentioned by another research study from Tanzania[41-43] were not mentioned by the participants of this current study. This could be due to either the lack of knowledge and/or the non-availability of such options in our study area. The majority of the participants unanimously agreed extra efforts and additional interventions are required other than the current interventions to reduce the burden of malaria, which was consistent with findings from malaria endemic areas of Africa.[44] One of the missing links regarding the implementation of environmental management and sanitation as a vector prevention and control mechanism was the recognition that different types of mosquitoes might have different habitats for breeding as stated in Finda et al.[45] For malaria eradication to succeed, all elements in the transmission cycle must be sufficiently targeted, taken into consideration with the current vector control tools where only indoor- and late-biting, and indoor-resting vectors are tackled. However, there is a gap in protection, not only before sleeping time but also for people that remain outdoors during the night. A specific mosquito behavior assuring its vectorial status is only relevant concerning specific human behavior and the relation people have with their surrounding environment. According to Durnez and Coosemans,[46] larval control must be included as part of the integrated vector management (IVM) programs on the condition that malaria elimination remains the ultimate goal whilst the prominence of larval interventions has newly re-claimed consideration in malaria control.[47] Ferguson et al[48] indicated that other tools not relying on the host-vector contact (such as larval control and environmental sanitation measures) can supplement ITNs and IRS as they are not specific for indoor biting and indoor resting mosquito populations.

The participants mentioned that they worked with local and international organizations and institutions such as development partners, non-governmental organization, and government agencies who are responsible for malaria control as well as religious bodies who have demonstrated a keen interest in environmental care or cleanliness, and traditional and opinion leaders (Chiefs and Unit Committee). These views expressed by the respondents rightly corroborate with the findings of a similar study conducted in Rwanda where the participants considered the involvement of various stakeholders as key to success in malaria elimination, including stakeholders at the national level, community grassroots level, and partnership between the national and local level as well as other community.[49] According to National Malaria Control Programme,[7] a project that was implemented based on processes of mass education and stakeholders engagement and involvement was very successful with some modest achievements (ie, 60, 200 audiences were reached in 172 remote communities, 90 schools and 43 Districts from 10 Regions in Ghana) where major stakeholders in the health sector such as Community Health Workers, District Health Officers, Honourable Assembly Members, Traditional Authorities, the Clergy, and Teachers to use a single platform to address social and behavioral change against the burden of malaria among community members.

Despite stressing the important of stakeholder collaboration, it was noted in the current study that there was lack of effective collaboration among the stakeholders especially National Malaria Control Programme (NMCP), Environmental Health Officers (EHOs), and Honourable Assembly Members (HAMs) that is serving as a major challenge against fighting malaria. In most malaria-endemic countries, there is lack of effective collaboration among local experts such as public health officers, medical entomologists and engineers from different sectors to plan, implement, monitor, and evaluate control interventions including conducting health impact assessments (HIAs).[50,51]

The stakeholders stressed the importance of robust educational campaigns on environmental management and sanitation on different media platforms and educational levels from nursery through to universities. It was noted that stakeholders organize discussions on malaria control and educate the community on environmental management and sanitation on

radio/TV, in churches, mosques, and information centers. This was consistent with findings from a study conducted in Tanzania which focused on the effectiveness of mass behavior change communication (BCC) campaigns on the importance of environmental management and sanitation as the main tool for sustainable, community-led malaria control[52]. According to National Malaria Control Programme,[7] community radio stations were used, whereby some of them had a listening audiences beyond the selected districts which were used for mass education on malaria prevention and control in local languages. However, this helped the team to reach the audience who could not come to see the cinema shows during the mass education campaign. According to Ingabire et al[49] in a study conducted in Rwanda, participants expressed the need for repeated intensive education with a focus on malaria prevention methods, malaria symptoms, and correct use of bed nets, the benefits of indoor residual spraying, and hygiene and environmental cleaning. A study conducted by Ahmed and Isaac in the Volta Region of Ghana, recommended sensitizing or educating the inhabitants as well as the general public on sanitation in basic schools to create some level of awareness as well as strengthening and equipping the Municipal Assembly in the area by the Government would help ensure frequent monitoring and regulate waste management in the area.[53]

The findings showed considerable agreement amongst participants on the importance of law enforcement regarding environmental and sanitation bye-laws in the prevention and control of malaria. The stakeholders stressed that even if the law exists, the lack of implementation or enforcement would not encourage or force people to keep their environment clean thereby removing mosquito breeding sites to prevent and control malaria transmission in the community. However, among the reasons given by the stakeholders as to why there seems to be a difficulty in the enforcement of environmental sanitation bye-laws are (a) Political interference, (b) Lack of commitment and political will from government, (c) Indiscipline, (d) Low charges/fines and non-prosecution of sanitary offenders, and (e) Lack of empowerment and inadequate resourcing of the Health Inspectors (EHOs). According to Sangoro et al[42] a major issue voiced out by all stakeholder groups in a similar qualitative study was the lack of clear regulations and enforcement on environmental management (EM) regulations though EM look like a malaria prevention method which is not supported by the law although it seems to be cost-effective method. Environmental management and sanitation (EMS) interventions could be implemented because a higher chance of exposure from outdoor biting can occur in breeding sites known for female *Anopheles* mosquitoes that are left without any intervention supported by law enforcement.[54] Law enforcement may support the implementation and sustainability of EMS for malaria control as a supplementary tool against malaria, by reducing overall vector populations including those that may bite outdoors.[55] The importance of law enforcement regarding Environmental management and sanitation interventions is vital during summer times, when a great proportion of people are forced to spend more time outdoors because of higher temperatures.[56] The finding of this study regarding law enforcement practice was different from other findings from eastern Rwanda, where a community-based initiative where local communities were engaged in monthly community clean-up activities or works aimed at destroying mosquito-breeding sites around homes was successfully implemented. This activity was then promoted and maintained to regulate environmental conditions at the community level and later was found to have help in the reduction of the malaria disease burden.[57]

One interesting finding of this study was the issue of the high government support/political will. The majority of the stakeholders believed that the government has not been giving enough support and political will in the allocation of funds for the prevention tasks as well as the inclusion of the prevention tasks in the objective of projects that are under way such as road projects. The stakeholders emphasized that central and local government authorities must avoid political interference to allow the Health Inspectors to strictly enforce the environmental sanitation bye-laws. Environmental Health Officer stressed that there is allocation of funds (though inadequate) to the EHSD but the funds are not reaching the intended purpose (them). The Government support was addressed as funds and supports were not only inadequate but also adequate and being misused. As indicated by Sande et al in a study conducted in Zimbabwe,[58] lack of capacity building mainly due to lack of human resources and inadequate infrastructure is the main reason put forward for the little government support for malaria prevention and control. According to Dr. Margaret Chan, a former Director General of WHO, *"Recent progress on malaria has shown that, with adequate investments and the right mix of strategies, remarkable results could be achieved if strong political commitment and expanded financing are in place."*[59]

There were many challenges raised regarding the stakeholders' collaboration in malaria prevention and control in the Sunyani Municipality. The stakeholders were many but their actual integration was restricted at the Regional level. It was characterized by seasonal involvement mostly on occasions such as "World Malaria Day" and "environmental care campaigns" but the involvement was relatively stronger at the lower level where the community significant others such as Chiefs and Unit Committee Members, Pastors, Religious Leaders are included in the malaria prevention and control tasks. It was also stressed that the collaboration between the Malaria Control Focal Persons and concerned professionals at the grass root level is very poor. The issue of inadequate financial support, access to LLINs by community members, and poor attitudes of residents (community members) with regard to ownership and usage were described as key challenges. Lack of reliable funding opportunities for mosquito control operations and the lack of initiatives to apply leverage in support of mosquito control by other government and community agencies are common

problems being faced with malaria control in Africa, the Middle East, and the Americas.[60] Further, findings from this study highlighted political interference, lack of educational materials (teaching and learning) to carry out health education and promotion activities in the community, lack of means of transportation, and recognition by government authorities were outlined as part of the challenges being faced by the various stakeholders (especially the EHOs and HAMs) in the fight against malaria in the Municipality. According to Lemon et al,[61] deterioration of public health infrastructure, lack of adequate funding, lack of adequate training and training models, over-specialization in the biomedical sciences, driven by emerging technology and emphasis on the basic sciences, and bureaucratization were identified as key bottlenecks affecting finding lasting solutions for vector-borne disease (VBDs). However, for a successful implementation of malaria control programs, the National Malaria Control Programmes must address these bottlenecks.

This weak integration and /or involvement was identified as one of the threats to the strategy of malaria prevention and control in sub-Saharan Africa in addition to weak advocacy and inadequate promotion.[62,63] According to a study conducted by Nganga et al in western Kenya, stakeholder collaboration in the management of malaria prevention and control programs should not only target the prevention and control of malaria, rather it shall integrate other vector-borne diseases to maximize the outcome.[64] An innovative country-driven response, dubbed High burden to high impact has been launched in Mozambique in November 2018. This new line of attack is presently under implementation and driven by 11 nations that are malaria endemic and carries the highest burden of the infection i.e., Burkina Faso, Cameroon, the Democratic Republic of the Congo, Ghana, India, Mali, Mozambique, Niger, Nigeria, Uganda and the United Republic of Tanzania). Important fundamentals of this novel approach include (1) Political will to reduce the toll of malaria, (2) Strategic information to drive impact, (3) Better guidance, policies, and strategies, and (4) a coordinated national malaria response.[65] In addition, maintaining high coverage levels will require effective distribution approaches aimed at strengthening all routine delivery mechanisms and improving integration with other disease programs where appropriate. Increased decentralization of decision-making and budgeting will facilitate strengthened community participation in the delivery of interventions.[66]

The study had limitations. Due to the Coronavirus (COVID-19) pandemic and its restrictions on human movement in March 2020, the researchers could not reach the set target sample size of conducting 16 focus group discussions as well as causing a gender balance bias (recorded more males than females) among the participants.

Conclusions

Due to current documented reports of malaria vector behavioral change (outdoor biting and resting) and insecticides resistance that seems to help malarial vectors to evade the core vector control methods (LLINs and IRS), alternative vector control interventions are needed to further reduce malaria transmission. Findings from this study shows the prospects of environmental management and sanitation (EMS) as a vector control strategy and/or supplementary option that would help in the fight against malaria due to the residual transmission that is happening outdoors.

However, EMS could be employed as a vector control strategy and/or supplementary option if the following conditions and bottlenecks are addressed and in place: (a) Effective collaboration among key stakeholders such as National Malaria Control Programme (NMCP), Environmental Health and Sanitation Department (EHSD), Honourable Assembly Members (HAMs), Non-Governmental Organizations (NGOs), Private Sector, Traditional Leaders, and Religious Bodies; (b) High Government (central and local) support and political will through the adequate allocation of funds to the Environmental Health and Sanitation Department (with a dedicated account to reach them) and Honourable Assembly Members (HAMs); (c) Enactment /instituting of robust educational campaigns across all educational levels and via different media (Radio/TV, Information Centres, Churches, and Mosques) on environmental management and sanitation; (d) Recognition, empowerment, and adequate resourcing of Health Inspectors (Environmental Health Officers) to effectively and efficiently enforce the environmental sanitation bye-laws to ensure residents remove or eliminate mosquito breeding sites; (e) Adherence to settlement away (building and living around) from natural wetlands (swampy/marshy) where there are high *Anopheles* mosquito population densities; (f) Revision of fees/charges/fines and strict prosecution of sanitary offenders and reinforcement of communal labor exercises; and (g) Enactment /instituting Environmental Sanitation Day (ESD), adequate provision of sanitary infrastructure (proper drainage systems), and the establishment of the Environmental Health and Sanitation Fund (EHSF).

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Author Contributions

Conceptualization, SYAB, EA and SOK; methodology, SYAB, EA, SOK and JYWD; validation EA, SOK and JYWD;

formal analysis (verbatim transcription), SYAB and JYWD; data curation, EA, SOK and GGK; writing original draft preparation, SYAB, EA, SOK, JYWD, NCD and GGK; writing review and editing, EA, SOK, JYWD, NCD and GGK; supervision, EA and SOK; project administration, SYAB; funding acquisition, SYAB, EA and SOK. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

Not applicable.

Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki and School of Graduate Studies, KNUST, and approved by the Committee on Human Research Publication and Ethics, School of Medical Sciences, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana with protocol code *CHRPE/AP/143/20*.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study. However, written informed consent has been obtained from the participants to publish this paper.

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