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Ally R. Marotti

University of Arkansas, Fayetteville

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**Methods of Malaria Prevention in Ghana, Africa:
An Exhaustive Literature Review**

Ally R. Marotti

University of Arkansas

Mrs. Agana, MNSc, CNP, APRN and Mrs. Clark, RN, BSN

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Abstract

Ghana, Africa is currently listed among the top fifteen malaria burdened countries across the globe (WHO, 2019). While developed nations around the world have deemed malaria of no concern, third world countries continue to battle rising case and mortality rates each year. The purpose of this literature review is to determine which method of prevention proves most effective against malaria transmission and why recognized prevention methods are lacking in accessibility to the residents of Ghana. Peer-reviewed primary sources published between the years of 2015 and 2021 were utilized in this study. In order to be considered for review, sources located needed to include Ghana, malaria, and mosquito control. The result of this study found that not one malaria prevention method reigns superior amongst others. Additionally, prevention measures remain readily accessible to all residents in Ghana; however, consistent and continued use of these measures remains a sizable issue. A combination of prevention methods alongside measures to ensure continued use is vital in order to effectively reduce and eradicate malaria in Ghana.

**Methods of Malaria Prevention in Ghana, Africa:
An Exhaustive Literature Review**

In sub-Saharan Africa, malaria remains one of the leading and one of the most preventable causes of death. Malaria is a parasitic disease transmitted to humans through the bite of a mosquito (Afoakwah, Deng, et al., 2018, p. 2). Nevertheless, not all mosquitos carry the malaria disease. Ghana is home to the female *Anopheles gambiae* mosquito, the most effective malaria vector and the most difficult vector to regulate (Afoakwah, Nunoo, et al., 2015, p. 2). Alongside the *Anopheles gambiae*, the malaria parasite *Plasmodium falciparum* is widespread throughout Africa and causes the most severe clinical manifestations of the disease (Afoakwah, Nunoo, et al., 2015, p. 2). Ghana, Africa has made great strides in its fight against malaria, decreasing case and mortality rates by 50% and 65% between 2005 and 2015; however, malaria is still considered an endemic disease, accounting for around 30% of Ghana's outpatient attendances and 23% of inpatient admissions. (Shretta et al., 2020, pp. 1-2).

Progress aside, malaria remains a consistent terror in Africa. Ghana kept its listing as one of the top fifteen malaria burdened countries across the globe, after a 5% increase in absolute case numbers from 2017-2018 (WHO, 2019). In correlation with most illnesses treated in the healthcare system, prevention is key in combating this disease. Malaria is deemed non-existent in developed countries around the world, yet prevention efforts against this disease from outside nations have begun to plateau. Numerous studies leave out any mention of or elaboration about this plateau of prevention efforts. Multiple studies and investigations have verified effective measures to prevent malaria transmission decades ago through the use of insecticide-treated nets (ITNs), larvicides, and insect repellent sprays (Atiglo et al., 2018, p. 2). Re-prioritizing these and other methods of prevention in underdeveloped nations, beyond current implementation, is vital

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in helping the residents of Ghana. The purpose of this literature review is to determine which method of prevention proves most effective against malaria transmission and why recognized prevention methods are lacking in accessibility to the residents of Ghana, Africa.

Methods

Study Design

This is an exhaustive literature review of research on Malaria prevention methods for individuals residing in Ghana, Africa.

Information Sources and Search Strategy

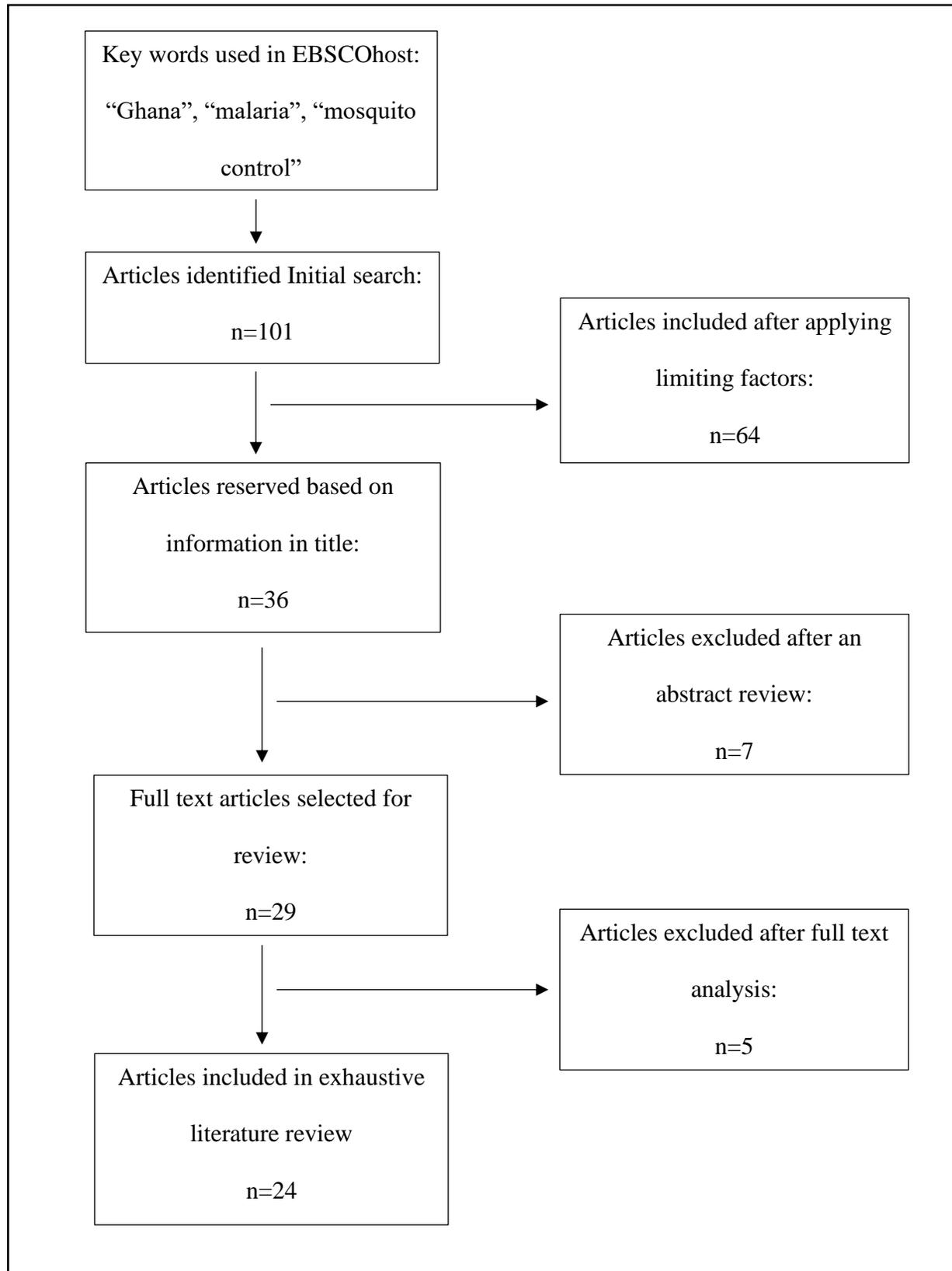
An informational Boolean Phrase search was conducted from June of 2020 to February of 2021 using the EBSCOhost database. A multitude of search terms were utilized including: (a) Ghana; (b) malaria; and (c) mosquito control. The search yielded 101 results, most being relevant to this literature review.

Eligibility Criteria

To further narrow the search, the previous 101 results were reduced to only include peer reviewed articles, articles published between 2015 and 2021, articles that included an abstract and full text, and articles written in the English language. This exclusion criteria led to a total of 64 journal articles. 28 of the 64 articles were eliminated due to redundancies and unrelated information in the article's title. Unrelated information such as prevention measures in other countries, mosquito ecology, individual immunity factors, and bloody analysis studies. Seven other articles were excluded after abstract evaluation revealed a sole focus on financials. Lastly, five more articles were eliminated after a full text analysis determined data and statistic information excluded a majority of certain populations in Ghana. Conclusively, 24 sources were selected for this exhaustive literature review and are illustrated in Figure 1.

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Figure 1: *Data Extraction/Inclusion and Exclusion Diagram*



Results

Table 1: Data Extracted from Articles Included for Review

Study	Study Purpose	Subjects	Findings
Afoakwah, Deng, & Onur (2018)	Investigate the association of different malaria interventions and malaria infection percentages among Ghanaian children under five years of age.	2,449 Ghanaian children 6 months to 59 months old tested for malaria via rapid diagnostic test (RDT).	Insecticide-treated net: 44.97% RDT malaria prevalence. Indoor residual sprayed room (IRS): 36.50% RDT malaria prevalence. Children's mothers with a secondary education level and above plus Insecticide-treated net 25.80% RDT malaria prevalence.
Afoakwah, Nunoo, & Andoh (2015)	Investigate the effectiveness of insecticide-treated bed nets (ITN) and mortality rates in Ghanaian children under five years of age.	3,839 Ghanaian children under five years of age; sourced from the Ghana Demographic and Health Survey.	Mortality rates of Ghanaian children under the age of five who sleep under ITNs is 18.80% lower compared to mortality rates of Ghanaian children who do not sleep under ITNs.
Ahorlu et al. (2019)	Investigate and understand the gap between access to and use of ITNs in Ghana.	174 Ghanaian participates across three separate sites within Ghana.	Heat and Ghana's dry season proved to be the greatest deterrents in using ITNs. While the recent loss of a loved one to malaria proved to be the greatest motivator to use ITNs.

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<p>Atiglo et al. (2018)</p>	<p>Investigate community member's willingness to support malaria interventions in urban and poor Ghana.</p>	<p>768 individuals from three densely populated communities in urban Accra, Ghana.</p>	<p>Perceived community cohesion was associated with lower odds while being considered a migrant and help-seeking from neighbors were associated with higher odds of supporting malaria interventions.</p>
<p>Briët et al. (2017)</p>	<p>Investigate if the introduction of small solar powered fans will increase ITN use in Ghana.</p>	<p>83 households in Accra, Ghana, split randomly into three groups.</p>	<p>Supplying one fan per household seemed to increase ITN usage in Accra, Ghana households over a 10 month study by 90-100%.</p>
<p>Coleman et al. (2017)</p>	<p>Study malaria reduction in Northern Ghana after 7 years of IRS.</p>	<p>Individuals residing in three separate regions in Northern Ghana (Savelugu Nanton, Tolon Kumbungu, and Tamale Metropolis).</p>	<p>IRS application significantly impacted entomological indicators of malaria transmission by 68% to 72.3%.</p>
<p>Darko et al. (2019)</p>	<p>Investigate socio-demographic determinants associated ownership and use of long lasting insecticide treated nets (LLINTs).</p>	<p>394 pregnant women in Wa Municipality of Ghana.</p>	<p>82.2% of women owned LLINTs and 69.3 actually utilized their LLINTs.</p>

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<p>Dery et al. (2016)</p>	<p>Study <i>Anopheles gambiae</i> susceptibility to insecticides prior to IRS introduction in 11 districts in Ghana.</p>	<p>22 to 25 female <i>Anopheles gambiae</i> mosquitos.</p>	<p>Malathion effectively killed <i>Anopheles gambiae</i> in seven districts, fenitrothion in three districts, and propoxur in one district. Organophosphate insecticide was effective in all eleven districts.</p>
<p>Ernst et al. (2017)</p>	<p>Investigate ITN ownership and use in social contacts is associated with uptake of ITNs for prevention in Ghana pregnant women.</p>	<p>300 pregnant women seeking antenatal care in an urban hospital.</p>	<p>78% reported owning ITNs, 61% of the 78% reported using the ITN the previous night. The study concluded interpersonal influence appears to have a modest impact on ownership and use of ITNS.</p>
<p>Gakpey et al. (2016)</p>	<p>Investigate strategies towards LLINs attainment distribution.</p>	<p>All residents in Ghana.</p>	<p>LLINs that are given should come with hanging and installation assistance. More use comes with this theory.</p>
<p>Gogue et al. (2020)</p>	<p>Investigate the impact of IRS on malaria incidence reports over three years.</p>	<p>Individuals residing in Northern, Upper East, and Upper West Regions of Ghana.</p>	<p>Northern Region: 40% malaria incidence reduction over three years. Upper East Region: IRS was disbanded in 2015. This caused a malaria increase of 485%. In districts where IRS was not disbanded, a 35% malaria incidence reduction was seen. Upper West Region: Remained high throughout all three years of</p>

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			observation. An 80% to 93% incidence rate, believed to be attributed to IRS disbandment.
Hogarh et al. (2016)	Investigate mosquito coil application and associated self-reported health issues in Ghana.	480 households across four districts in Ghana.	Applied mosquito coil incidence rate: 86.3%. No mosquito coil application incidence rate: 72.4% Application of mosquito coils did not reduce malaria incidence rate.
Jaeger et al. (2016)	Investigate if small solar powered net fans will increase net use.	23 key informant interviews of Ghana Residents.	Fan use improved overall comfort inside the ITNs and positively improved net usage.
Kanmiki et al. (2019)	Investigate socio-economic and demographic disparities in ownership and use of ITNs.	3,993 Ghanaian women between 15 and 49 years old in seven districts of the Upper East region of Ghana.	Disparities between ownership and use were discovered to be due to wealth, occupation, religion, and district of residence. Individuals in wealthier districts were 74% more likely to own and use ITNs, while individuals in less wealthy districts were 33% less likely.
Kim et al. (2019).	Explore consumer preferences of middle-class Ghanaians for LLINs.	78 Ghanaians (51 adults, 27 boarding school students).	A more convenient way to hang the LLINs, more comfortable sleeping arrangements inside the LLINs, and

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			more sensible LLINs were found to increase overall net usage.
Mensah et al. (2020)	Individual and Community factors associated with bed net use two years after mass distribution.	Residents in Sunyani West district of Ghana.	Ownership was at 78.93% while usage was 55.95%. Health education that emphasizes everyone is susceptible to malaria can improve usage.
Monroe et al. (2015)	Investigate if outdoor activities increase residual transmission of malaria.	182 individuals across 24 houses in Ghana's Northern and Upper West Regions.	42% of the individuals reported sleeping outside during the night. 65% reported owning a bed net with only 17% using the net at any time during the night.
Pwalia et al. (2019)	Investigate high insecticide resistance intensity and low success rates of LLINs in Accra, Ghana.	Three-to-five day old adult <i>Anopheles gambiae</i> mosquitos from Opeibea Accra, Ghana.	The <i>Anopheles gambiae</i> were resistant to all insecticides tested with very low mortality observed. The bio-efficacy of pyrethroid LLINs ranged from 2.2% to 16.2% mortality, the PBO LLIN had 73% mortality.
Ricotta et al. (2019)	Study determinants of bed net use, including household and environmental.	11,835 Ghanaian Surveys from the Ghana Demographic and Health Survey (DHS) and the 2018 Malaria Indicator Survey (MIS).	Findings reported that living in a rural area, low financial status, no access to electricity in the household, high temperatures, and amount of individuals residing in the household all negatively affected net usage.

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<p>Riveron et al. (2016)</p>	<p>Investigate insecticide resistance in the major malaria vector in Southern Ghana.</p>	<p>Adult Anopheles mosquitos from Obuasi and Adawukwa in Southern Ghana.</p>	<p>Mosquitos collected from both regions showed a high resistance to insecticide classes such as pyrethroids and carbamates yet remained fully susceptible to organophosphates.</p>
<p>Shretta et al. (2020)</p>	<p>Estimate the risk of declining funding for malaria treatments and prevention methods.</p>	<p>No subjects: A compartmental transmission model was developed to estimate the impact of a range of malaria interventions between 2018 and 2030.</p>	<p>Malaria elimination in Ghana is expected to cost 961 million between 2020 and 2029. The elimination of malaria is estimated to prevent 85.6 million cases and around 4,468 deaths, it is also predicted to prevent 2.2 billion in health system expenditures.</p>
<p>Suuron et al. (2020)</p>	<p>Explore facilitators and barriers to acceptability and community uptake of IRS in a highly endemic region of Ghana.</p>	<p>101 Ghana individuals in high endemic regions.</p>	<p>Barriers: A dislike of insecticide sprays, inadequate information, religious and cultural beliefs, false perception about effectiveness, and unprofessional conduct of IRS spray operators. Facilitators: Perceived effectiveness in its malaria reduction, incidental benefits, respect for authority, training and capacity building, and sensitization activities.</p>

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While each journal article provides information essential to preventing the transmission of malaria, it is obvious to the eye there is not one single prevention measure that outshines the latter. Instead, a combination of insecticide-treated bed nets (ITNs), transmission education, indoor residual spraying (IRS), etc. is needed in Ghana. For example, Afoakwah, Deng, et al. (2018) concluded IRS to be the most efficient malaria vector control method. However, Afoakwah, Nunoo, et al. (2015) discussed how ITNs have proven to halt the transmission of malaria and other insect transmitted infections, while boosting Ghana's economy. All measures considered, the largest issue Ghana and other malaria burdened countries face is consistent and continued use of these methods. As stated in Gogue et al. (2020), the suspension of IRS in the Upper East Region of Ghana lead to a 485% increase in malaria incidences between 2014 and 2017. However, efforts to persuade the continued use of these methods can and have been implemented. Briët et al. (2017) stated how providing small, solar powered fans to improve comfort while sleeping inside ITNs increased individual usage, thereby decreasing incidence rates. Each method alone produces a positive result, yet real change occurs when merged together. Transmission education alongside ITN use decreased disease transference percentages by half compared to ITNs alone (Afoakwah, Deng, et al., 2018, p. 5). Joint use is vital, one method alone does not suffice in the eradication of malaria.

Discussion

To this day, malaria remains one of the most preventable leading causes of death in sub-Saharan Africa. All articles utilized in this exhaustive literature review emphasize the impact single and conjoined prevention methods have on decreasing malaria morbidity and mortality.

Afoakwah, Deng, et al. (2018) explored a multitude of prevention factors that influenced malaria infections in Ghanaian children under the age of five years old. Afoakwah, Nunoo, et al.

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(2015) investigated the effects of ITN usage and mortality rates in Ghanaian children, also under the age of five years old. While the focus of this literature review pertains to malaria prevention regardless of age, Afoakwah, Deng, et al. (2018) established how malaria incidence rates can be reduced by more than half when two or more prevention measures are used simultaneously, and Afoakwah, Nunoo, et al. (2015) established how the correlation between parent education about transmission and household income directly affect mortality rates. On the other hand, Briët et al. (2017) provided a new perspective to help reduce transmission by correlating net usage and comfort:

Insecticide-treated nets (ITNs), including long-lasting insecticidal nets (LLINs), have been credited with the highest number of malaria cases averted since the year 2000.

However, ITNs are ineffective if they are not being used. (p. 2)

By introducing small, solar powered fans for sleeping comfort, ITN usage grew exponentially amongst the study's included subjects (Briët et al., 2017, p. 9). Gogue et al. (2020) explored the impact of IRS in three separate regions across Ghana, spanning three years. This exploration showcased a 40% reduction in malaria cases reported to public health facilities in the Northern Region of Ghana (Gogue et al., 2020, p. 9).

Strengths and Limitations

Afoakwah, Deng, et al. (2018) and Afoakwah, Nunoo, et al. (2015) limited their study's findings by only focusing on children under the age of five years old. Additionally, Afoakwah, Deng, et al. (2018) limited their study even further due to their data demonstrating associations in trends rather than confirmed effectiveness. Like any illness or disease, certain factors affect susceptibility. Afoakwah, Deng, et al. (2018) and Afoakwah, Nunoo, et al. (2015) strengthened

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their article's arguments by including financial income, the possibility of weakened immune systems, household size, and children's order of birth in their statistical analysis.

Briët et al. (2017) limited their study by not being able provide definitive evidence that providing fans increases ITN usage, a larger study is needed in order to prove this research's impact in Ghana. Although the article is built on associations of data, it does include multiple strengths. While other articles note a lack of ITN usage in their findings, most fail to elaborate on or discuss ways to combat the issue. Briët et al. (2017) has brought forward an important and well researched solution that can help increase overall usage by improving comfort measures.

Research findings in Gogue et al. (2020) were limited when certain regions included in the study disbanded IRS treatments throughout a multitude of districts. Treatments were proving effective in the first year of the study; however, after secession of treatments, incidence numbers spiked, and overall data became skewed. Limitations aside, the overall findings in Gogue et al. (2020) reveal the effectiveness of IRS against malaria if used persistently.

Conclusion

When researching the malaria endemic in Ghana, it is challenging to avoid its correlation to the current global pandemic of COVID-19. Although difficult to compare an endemic to a pandemic, factors including response time and transmission prevention remain the same. The Coronavirus halted the world in March of 2020, yet one year later vaccine administrations and prevention measures are phasing lives back to a sense of normalcy. Developed countries around the globe have made malaria a nonexistent threat for decades, yet the death toll in countries such as Ghana continue to rise each year. The same level of determination used to fight COVID-19 is needed in helping eliminate malaria across all endemic regions. This plateau of malaria prevention leaves residents in affected areas even more susceptible to becoming a part of a

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statistic. “Our progress against malaria is impressive. But vigilance remains a critical ingredient to protect the health of all people” (Frieden, 2013).

Upon conclusion of this literature review, there is not one prevention method that stands alone as most effective in combating malaria. Articles that provided statistics on a combination of multiple prevention measures resulted in the lowest incidence rates. So, combining efforts to increase consistent usage with ITNs, IRS, and transmission education, malaria in Ghana could become a burden no longer. Countries around the globe are returning to normalcy after COVID-19. Ghana, alongside other malaria stricken countries, require assistance beyond current implementation in order obtain a sense of freedom from a disease that should have been contained long ago.

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