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Empowering Environmental Health Officers for Malaria Control in Nigeria

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Abstract
The over a century old mosquito-malaria theory which posits that malaria is transmitted from human to human through mosquito bites is already an established fact. But the certainty that greeted this discovery is yet to be matched with a breakthrough in malaria eradication. To date, malaria poses one of the greatest challenges to public health, particularly in sub-Saharan Africa. For Nigeria, in spite of 15 years Roll Back malaria programme, it remains a risk factor for about 97% of the population, accounting for 25%–40% of all outpatient clinic visits, and between 20% and 50% of all hospital admissions in the country. This paper aimed at examining the environmental determinants and control of malaria, and the role of Environmental Health Officers in the process. Review of relevant literature and historical records were undertaken drawing much from unique experiences in the Unites States in the control of mosquito population through habitat management and the roles of Environmental Health Officers in the process. Results indicate habitat management in which Environmental Health Officers play active roles as the most sustainable malaria control strategy. The paper therefore recommends habitat management for the control of mosquito population and the empowerment of Environmental Health Officers for ensuring citizen participation and compliance with environmental rules and regulations for sustainable malaria control in Nigeria.

Autonomisation des agents de santé environnementale pour le contrôle du paludisme au Nigeria

Résumé
La théorie des moustiques et du paludisme, existant de plus d'un siècle, qui postule que le paludisme se transmet d'humain à humain par les piqûres de moustiques, est déjà un fait établi. Mais la certitude qui a accueilli cette découverte doit encore être associée à une percée dans l'éradication du paludisme. À ce jour, le paludisme constitue l'un des plus grands défis en matière de santé publique, en particulier en Afrique subsaharienne. Pour le Nigéria, malgré un programme antipaludique de 15 ans, il reste un facteur de risque pour environ 97% de la population,

représentant entre 25% et 40% de toutes les visites en clinique externe et entre 20% et 50% de toutes les admissions hospitalières dans le pays Cet article visait à examiner les déterminants environnementaux et le contrôle du paludisme, ainsi que le rôle des agents d'hygiène du milieu dans le processus. L'examen de la littérature pertinente et des documents historiques ont été entrepris à partir des expériences uniques aux États-Unis dans le contrôle de la population de moustiques grâce à la gestion de l'habitat et le rôle des agents d'hygiène. Les résultats indiquent une gestion de l'habitat dans laquelle les agents d'hygiène jouent des rôles actifs en tant que stratégie de lutte antipaludique la plus durable. Le document recommande ensuite la gestion de l'habitat pour le contrôle de la population de moustiques et l'habilitation des agents de santé environnementale pour faire respecter la participation des citoyens et le respect des règles et réglementations environnementales pour un contrôle durable du paludisme au Nigeria.

Introduction

There is a direct connection between the physical environment and malaria prevalence in Nigeria. Any environment that harbours indiscriminate open and uncovered/unprotected pools of water would have provided breeding grounds for mosquitoes. Most countries that made significant progress towards eradicating malaria did so by first paying attention to the environmental conditions that usually led to the multiplication of mosquitoes (WHO, 2010).

The World Health Organisation (WHO) clearly made a very strong argument for the need to refocus global attention on the environment in which Environmental Health Officers will play significant roles as the best approach to the control of malaria (WHO, 1989). The UN agency reported that environmental management for the control of mosquito vectors of disease almost disappeared with the development of chemical insecticides.

After the Second World War, the use of such insecticides, especially as residual house sprays, was very efficacious in controlling mosquitoes and mosquito-borne diseases that little or use was made of biological and physical methods of mosquito control. However, starting with *Culex molestus* initially and *Anopheles sacharovi* in Greece, mosquitoes of economic and public health importance began to develop resistance to insecticides and this slowed the advances made by chemical control alone. Furthermore, environmental concern over repeated applications of insecticides for pest or vector control has contributed to a decrease in the development of new public health insecticides.

The recent oil price increases have narrowed the economic feasibility of repeated insecticide applications. At the same time, the development and extended availability of skilled manpower and efficient excavating and earth-moving equipment increased the feasibility of applying large-scale environmental management measures for mosquito control. The need to develop integrated strategies including both old and new methods of mosquito control is now widely accepted. Environmental management measures constitute an effective component of such strategies.

The objective of environmental management for vector control is the reduction of the abundance of dangerous species. Past experience with mosquito vectors of the disease has shown that each species has defined geographical distribution zones and occurs in large numbers only in certain breeding sites with identifiable combinations of physical, chemical and biological characteristics. Environmental management measures thus depend on the fullest understanding of mosquito ecology and population dynamics as well as of mosquito-borne disease epidemiology. Studies on vector habitats must, therefore, be intensified in order that the attack may be made on sound bases.

An important concept is that of "species

sanitation". This term, as applied to malaria control, means that attention should be directed primarily to local *Anopheline* mosquitoes known to be the principal transmitters of malaria. There are about 150 species of these potential malaria vectors in the world; only some 30 of them are considered to be important malaria vectors, and of the 30, only a few will occur locally in any given geographical area (WHO, 1989). What could appear as an almost impossible task of controlling all Anopheline mosquitoes is thus narrowed down to a reasonably attainable goal.

How successfully man can intervene in the readjustment of habitats depends upon how wellscientific inquiry in the field defines the key factors that regulate mosquito population and favour the breeding of one kind of mosquito but not that of another. The vector control workers thus must explore the possibility of economic application of these principles so that the activities such as water impoundments, irrigation, hydroelectric generation and other man-made works, which are liable to become mosquito breeding places, may benefit man without producing an undue abundance of vectors (WHO, 1989).

Nevertheless, environmental management measures are not intended to replace other methods and techniques applied to control vector-borne diseases but rather to complement these and provide for the development of "integrated control" strategies.

Social and Economic Burden of Malaria in Nigeria

The basic science and accompanying theory for measuring and modeling malaria borne pathogen transmission developed slowly from 1877 when Manson showed that mosquitoes transmit filarial worms (Service, 1978; Manson, 1878). Mosquitoes were then implicated in the transmission of malaria in 1897 (Ross, 1897), yellow fever in 1900 (Cleaveland, 2001), and dengue fever in 1906 (Bacroft, 1906). Hundreds of pathogen species are now known to be mosquito-transmitted (Cleaveland, 2001), including 38 of clinical significance in humans (Hay, 2013).

The relentless global attention focus on causes of malaria and its control is not without strong reasons. For Nigeria, despite 15 years' efforts towards its eradication, it still remains a major problem, a risk factor for about 97% of the Nigerian population (US Embassy in Nigeria, 2011). It is a major cause of morbidity and mortality and a major public health problem with a prevalence rate of infection of 919/100,000 (DFID, 2012). Furthermore, malaria accounts for 25%–40% of all outpatient clinic visits and between 20% and 50% of all hospital admissions in Nigeria. It also contributes 30% to 40% of childhood mortality and 11% of maternal mortality in the country, confirming the fact that children and pregnant women are the most vulnerable to the scourge of malaria (National Population Commission, 2013). All these exert drain on the country's economy, costing an estimated 132 billion Nigerian Naira (approximately US$ 835 million) annually on prevention, treatment, and loss of income due to inability to work, and the country contributes a quarter of Africa's malaria burden(DFID, 2012). According to UNDP at the close of the MDGs regime, as a major public health problem in Nigeria, malaria accounts for more cases and deaths than any other country in the world. Indeed, instead of reduction, malaria cases have been on the rise during the period 1998-2014 (UNDP, 2015).

There are two approaches to the control of malaria, preventive and curative, but the effectiveness of the two are affected by behavioural factors (UNDP/World Bank/WHO, 2003, Ojurongbe et al., 2014; Okeke and Okafor, 2008). Children and pregnant women, in particular, are the most vulnerable to malaria. The focus on behavioural factors is crucial because, in spite of 15 years' efforts towards rolling back malaria under the Millennium Development Goals (MDGs) regime, it still remains one of the leading causes of death among children and pregnant women in Nigeria (NBS, 2014). Two ways by which malaria can be prevented among pregnant women and children are through the use of bed-nets and indoor residual sprays (IRS). But available figures indicate that the use of bed-nets among both under-five children and pregnant women

15-49 years never reached 20% during the period, 2003-2013 (NDHS, 2003, 2008 and 2013). Indoor use of IRS has also been very low. In 2013, for example, the States in Nigeria with the highest percentages of IRS in Nigeria were reported as Jigawa (15 percent), Yobe (10 percent), and Nasarawa (6 percent). This is not encouraging given that the goal is for at least 80 percent of the targeted population to use appropriate preventive measures by 2020 (NDHS, 2013), just three years away. Furthermore, the MDGs end-point Report indicated the deployments of ineffective strategies, which include emphasis being put more on curative than preventive, low utilisation of treated bed-nets as the reasons for the ever increasing case of malaria in Nigeria (UNDP, 2015). These indicate that the use of bed-nets and IRS still remains very relevant even under the SDGs. Another problem is delay in seeking for malaria treatment, even as the source of treatment also matters a lot. These make the understanding of the determinants of the use of bed-nets and indoor residual spraying, as well as treatment-seeking behaviour highly imperative for the control of malaria in Nigeria.

The objective of this paper, therefore, is to demonstrate the critical role of Environmental Health Officers in the control of malaria control in Nigeria.

Mosquito-Malaria Theory

Mosquito-malaria theory (or sometimes mosquito theory) was a scientific theory developed in the latter half of the 19th century that solved the question of how malaria was transmitted. The theory basically proposed that malaria was transmitted by mosquitoes, in opposition to the centuries-old medical dogma that malaria was due to bad air, or miasma. The first scientific idea was postulated in 1851 by Charles E. Johnson, who argued that miasma had no direct relationship with malaria (Johnson, 1851; Hempelmann and Krafts, 2013). Although Johnson's hypothesis was forgotten, the arrival and validation of the germ theory of diseases in the late 19th century began to shed new lights (Manson, 2002). When Charles Louis Alphonse Laveran discovered that malaria was caused by a protozoan parasite in 1880, the miasma theory began to subside (Nye, 2002).

An important discovery was made by Patrick Manson in 1877 that mosquito could transmit human filarial parasites (Chernin, 1983). Inferring from such novel discovery Albert Freeman Africanus King proposed the hypothesis that mosquitoes were the source of malaria (Cook, 1994). In the early 1890s, Manson himself began to formulate the complete hypothesis, which he eventually called the mosquito-malaria theory. According to Manson malaria was transmitted from human to human by a mosquito. The theory was scientifically proved by Manson's confidant, Ronald Ross in the late 1890s. Ross discovered that malaria was transmitted by the biting of specific species of mosquito. For this Ross won the Nobel Prize for Physiology or Medicine in 1902. Further experimental proof was provided by Manson who induced malaria in healthy human subjects from malaria-carrying mosquitoes. Thus the theory became the foundation of malariology and the strategy of control of malaria (Cox, 2010).

The Philosophy of Mosquito Control

The underlying philosophy of mosquito control is based on the fact that the greatest control impact on mosquito populations will occur when they are concentrated, immobile and accessible. This therefore calls for the focus of attention on habitat management and the control of the immature stages before mosquitoes emerge as adults, thereby reducing the need for widespread pesticide application in residential areas.

To best appreciate this strategy requires the understanding of the ecology of mosquitoes (Figure 1). Adult flying mosquitoes often rest in tall grass and shrubbery, but they cannot develop there. All mosquitoes need water to complete their life cycle. Some mosquitoes lay their eggs in standing water where they hatch in just a day or two. Other mosquitoes may lay their eggs in old tires, tin cans, or other water-holding containers. The eggs may remain unhatched for

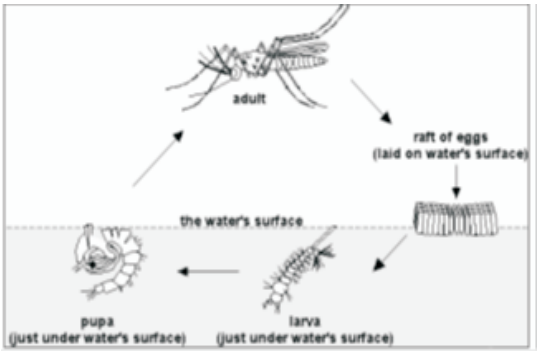

Figure 1: Mosquito Life Cycle:
Source: http://www.state.nj.us/health/cd/documents/faq/mosquito_checklist.pdf

weeks or even months until they are covered with water.

Given this life cycle, therefore, environmental Health Officers work is to ensure the interruption of the habitats and life cycle of local mosquitoes, as anywhere water collects for longer than one week represents an opportunity for mosquitoes to reproduce. It should be noted that while the anopheline malaria causing mosquitoes breed largely in clean water, the culicine specie can breed in polluted water (Wadinga, 2016). The understanding of the mosquito life cycle clearly indicates the practical possibility of source control.

The critical importance of the role of environmental health workers is demonstrated by the fact that the use of pesticides for mosquito control is considered a temporary form of control. Since it is unreasonable to expect to completely eliminate the next generation by treating the current generation, the process may have to be repeated time and again. This is true for chemical treatment of both immature and adult populations of mosquitoes. By contrast, source reductionthat prevents mosquito development can be a permanent form of control, perhaps requiring limited maintenance from time to time.

However, Integrated Mosquito Management (IMM) has long been advocated (WHO, 1989). It is the use of all appropriate technological and management techniques that brings about an effective degree of mosquito prevention and suppression in a safe, cost-effective, and environmentally sound manner. The major components of integrated mosquito management are:

* Source reduction
* Biological control
* Larviciding
* Adulticiding
* Public education

All of these control methods should be based on surveillance data to determine need and timing of interventions.

Literature Review

Due to its health and economic burdens, the source control of malaria through habitat management for controlling mosquito population has received scholarly attention for quite some time. A systemic reviews of strategies for malaria vector control (Thevasagayam, 1985; Steve *et. al*., 2004; Hanson et. al., 2004;Poopathis and Tyagi, 2006) indicated the use of integrated approach as very important, but with recommendations for much attention paid to environmental management reinforced with continuous monitoring and feedback, as well as enlisting community participation, co-ordination of the functioning of different departments involved directly or indirectly in preventing mosquito breeding habitats. All through the literature, the crucial roles played by Environmental Health Officers in environmental management for control of mosquito population are strongly emphasised. It is in this regard that the call for revitalization of the Environmental Health Officers role becomes very crucial. Their roles are seen to be very vital in the overall health care system that the Environmental Health Officers Registration Council of Nigeria (EHORECON) was established by an Act in 2002. The Act states the work of Environmental Health Officers as cutting across pest control services, industrial cleaning services, waste collection and disposal services, sewage collection and disposal services, air quality, and very crucially -sanitary inspection (EHORECON, 2002).

Environmental Health Officers are primarily helpful in source reduction of mosquito population. Since many mosquitoes breed in standing water, source reduction can be as simple as ensuring emptying water from containers

around the home which homeowners can accomplish, removal of unused plastic pools, old tires or buckets, by clearing clogged gutters and repairing leaks around faucets; by regularly (at most every 4 days) changing water in birds' barths; and by filling or draining puddles, swampy areas, and tree stumps. Ensuring that such mosquito breeding areas are eliminated can be an extremely effective and permanent way to reduce mosquito populations without resorting to insecticides (Wikipedia: https://en.wikipedia.org/wiki/Mosquito_control).

The work of Debra (2004) provided important tips for mosquito control which highlights the crucial role Environmental Health Officers can play. It reveals that mosquitoes can reproduce in as little as two tablespoons of water, and under ideal breeding conditions, that small amount of water only needs to exist for a mere 5 days for adult mosquitoes to develop. In the light of this, simple steps that can eliminate mosquito breeding on property or in the compound are suggested as follows:

- Eliminate all unnecessary sources of standing water on your property. This includes old tires, tin cans, bottles, buckets, unused swimming pools, or anything that can hold even the smallest amount of water.
- Clean clogged gutters and remove standing water under or around structures. Check around faucets and air conditioner units and repair leaks or eliminate puddles that remain for several days.
- Do not let water accumulate in the saucers of flowerpots, cemetery urns or pet dishes for more than two days.
- Change the water in birdbaths and wading pools at least once a week.
- Cover boats and wheelbarrows with a tarp or store them upside down.
- Fill in holes or depressions on your property that hold water.
- Drain water from pool covers and tarps covering equipment, etc.
- Increase water movement in ponds, water gardens, and pools.

It is certain that these measures will require regulatory and legal frameworks for ensuring public enforcement and compliance, and without doubt, the Environment Health Officers are crucial in the whole process. This position was strongly echoed by the University of Florida (2009), which habitat management can give rise to permanent mosquito control but will require effective and empowered Environmental Health Officers. It cited ……..the United as the country that paid the greatest attention to mosquito control with massive support that it was referred to as 'mosquito control movement'. In the United States, the discovery that mosquitoes could transmit pathogens opened a new chapter in the story of the relationship between mosquitoes and human beings. Until 1871, no medical textbook identified any disease that could be transmitted by an insect (Howard, 1923), but once the connection was established, it generated great citizen movement for the control of mosquito population, thus the name 'mosquito movement'.

An in-depth examination of the US mosquito movement is important to show the importance of mosquito population control through habitat management, the critical importance of government support and the role of the Environmental Health Officers in the process.

The American anti-mosquito movement moved through three distinct phases in the twentieth century: a mechanical control era 1900–1942; a chemical control era 1942–1972; and, an integrated mosquito management era 1972 to the present. As the second decade of the 21st century neared its conclusion, advocates of mosquito control faced a daunting array of challenges ranging from emerging pathogens and invasive species to the lack of support for research and opposition from increasingly vocal critics who believe mosquito control was in conflict with protecting the environment. The control of mosquitoes in the USA went through three phases; chemical, mechanical and integrated eras (Gordon, 2016).

The mechanical era of mosquito control (1900-1942) drew impetus from the Gorgas's success in Havana and his later work in Panama. In 1901, a group of well-to-do residents of South Orange, New Jersey (USA) formed a village improvement society motivated by the desire to reduce the mosquito menace through ditching and draining and the limited use of oil as larvicide that were shown to be effective (Smith, 1904). In 1912, Smith and his allies

won the support of Woodrow Wilson, New Jersey's governor, for the passage of the first law authorizing the creation of mosquito abatement districts. Smith's work proved a model for advocates of mosquito control in California in 1905. During the next 20 years, mosquito control programs based on ditching and draining with the limited application of oil were launched in a number of US states such as Florida, Utah, and Illinois.

Florida's anti-mosquito campaign bears particular note because advocates of mosquito control built their campaign around the effort to control the population of pathogen bearing mosquitoes. Florida had long been plagued with outbreaks of yellow fever and dengue fever. Notable advances in mosquito control took place in the 1920s with the establishment of experimental station for the control of mosquitoes by the United States Department of Agriculture (USDA). The USDA researchers explored different means of controlling mosquitoes.

In 1925, the first test using an airplane to distribute Paris Green was performed, an emerald green arsenite, as a larvicide against anopheline mosquitoes. At the same time, United States Public Health Service (USPHS) entomologists continued their research on different species of mosquitoes' flight ranges and different strategies for eliminating malaria in the Southeast. Unfortunately, in 1927, but the Great Depression provoked tremendous changes within the anti-mosquito movement. The economic downturn forced the leaders of the anti-mosquito movement to temper their optimism and reconsider their objectives. Prospects for mosquito control dimmed as the depression worsened, until the coming of President Franklin Roosevelt's era who buoyed hopes for sustaining mosquito control.

In spite of the tremendous progress made during this period, an attack against the mosquito movement emerged because the problem was limited to 14 southern states (Williams, 1935). Some claimed that the "federal emergency support of malaria and pest mosquito control ditching was but the most recent assault on the nation's water resources" and that it was a "government-sponsored racket" (Vogt, 1937). The movement also faced opposition from wildlife advocates and fishermen (Price, 1938).

The anti-mosquito movement underwent radical changes in the 1940s and 1950s which marked the chemical era. Late in 1942, the Orlando researchers made a revolutionary breakthrough, especially with the discovery of the insecticidal properties of DDT, which marked the beginning of a new epoch in mosquito control. DDT's low cost, potency, persistence, and efficacy as both a larvicide and adulticide revolutionized mosquito control. Field tests in early 1943 confirmed DDT's potency against lice, mosquito larvae, and adult mosquitoes. In May 1943, Neocide, the Orlando laboratory's formulation of a DDT louse powder, was added to the list of approved pesticides. The first shipments of Neocide reached North Africa in the late summer to take care of German prisoners in North Africa. The discovery of DDT's efficacy sparked a dramatic expansion of the Unites States Department of Agriculture Orlando laboratory's mission.

Finally, in May 1945, the Orlando laboratory and the Rockefeller Foundation launched a major experiment in Mexico. The researchers treated a group of villages with high malaria indexes with DDT. Four months after the application, there was nearly a complete eradication of adult mosquitoes within the treated buildings. The mosquito larvae in rice fields, which were adjacent to the village, dropped 90%(Bishopp, 1945).

But several entomologists expressed reservations about DDT calling for restraint and warned of DDT's potential harm to wildlife, a fear that triggered the search for a repellent that would be effective and harmless to wildlife. Fueled by the availability of DDT and, later, by the subsequent discovery of other powerful chemical toxicants, the anti-mosquito movement experienced spectacular growth during the two decades following World War II. The chemical era of mosquito control was marked by an explosion of new mosquito control programmes from the Gulf Coast to the Pacific Northwest of USA. But the use of DDT and reliance on chemical control agents which sparked the spectacular growth of mosquito control in the post-War era became the source of the public's disenchantment with mosquito control in the turbulent 1960s. The remarkable thing is that at the beginning of the insecticide era, many of

the leaders of the mosquito crusade cautioned against an over-reliance on DDT (Gray, 1949). In 1972, a newly created Environmental Protection Agency (EPA) banned the use of DDT, thus making way for the integrated mosquito management.

In the three phases of malaria control in the United States, source control (habitat management) of mosquito population was key, and throughout the mosquito movement period, Environmental Health Officers, (called by various nomenclatures in the US) played crucial roles, particularly with regard to citizen participation, environmental rules enforcement and compliance.

Declining Importance of Environmental Health Officers in Malaria Control Process in Nigeria

Since the roll back malaria started in 2002, the strategies were:- early diagnosis and prompt treatment; use of insecticides treated bed nets and mosquito control. Note that mosquito control comes last, yet total elimination of malaria depends on it. With little or no control, small, medium and large cities in Nigeria are virtual breeding grounds for mosquitoes, turning them into cities of mosquitoes. Yet the critical importance of Environmental Health Officers (EHOs) in the control of mosquito population has a long history of success in Nigeria during the colonial era (Sani, 2017):

> *In the 19th century, the colonial masters who executed the sanitary duties of our environment in Nigeria were known as sanitary inspectors while the African/ Nigerians attached to them were known as sanitary attendants. These attendants acted as aides to their masters to discharge various sanitary inspection activities like marking of tall trees, service of abatement notice etc. under their masters' directives and close supervision.*
>
> *As time went on these sanitary attendants were given more responsibility such as routine sanitary inspection, collection of water samples, survey for breeding places of mosquitoes, as well as acting as guides and interpreters.*
>
> *During the early 20th century, with improved educational background, these attendants gathered enough experience from their colonial masters, they were assigned duties such as cutting down tall trees that were close to the residential buildings, identification of infectious disease cases, disinfection and disinfestations, liaison between the colonial masters and villagers, verification of notices issued by their colonial masters [sanitary inspectors], retention of daily, weekly and monthly returns*

In spite of their increasing importance over the years, the present status of EHOs in Nigeria is described by Sani (2017) as follows:

> *With all the roles they have played, now the story is different. The profession is dying and being painted or branded as olden days' profession and has nothing to offer in the health sector by some other health professionals. Even though a federal ministry was created and other agencies of the environment, yet they cannot perform to the expectation due to poor structures that incorporate environmental health officers in most or all departments and nonchallant attitude of our governments.*

Today, the country suffers from acute shortage of Environmental Health Officers (EHOs). This is clearly shown in Table 1 below. At 150million people in 2012, only Abuja the Federal Capital Territory met half of the World Health Organisation (WHO) recommendation of 1 EHO to 8000 people.

Table 1: Population by State and the Recommended Number and Licensed Environmental Health Officers (EHOs)

State	2012 Population*	WHO Recommendation (1 EHO to 8000 people)	Number of Licensed Environmental Health Officers as at 3rd May, 2017**	Number of Licensed EHOs as Percentage of WHO Recommendation
Abuja	1698781	212	115	54.2
Abia	3437308	430	2	0.5
Adamawa	3840217	480	1	0.2
Akwa Ibom	4713800	589	47	8.0
Anambra	5046947	631	5	0.8
Bauchi	5621049	703	9	1.3
Bayelsa	2059107	257	7	2.7
Benue	5138531	642	13	2.0
Borno	5038824	630	3	0.5
Cross River	3494820	437	58	13.3
Delta	4967962	621	14	2.3
Ebonyi	2629820	329	31	9.4
Edo	3906007	488	60	12.3
Ekiti	2898015	362	11	3.0
Enugu	3947649	493	20	4.1
Gombe	2857042	357	4	1.1
Imo	4744619	593	33	5.6
Jigawa	5268227	659	2	0.3
Kaduna	7385303	923	13	1.4
Kano	11357050	1420	13	0.9
Katsina	7008495	876	NA	NA
Kebbi	3934003	492	3	0.6
Kogi	4003468	500	13	2.6
Kwara	2857420	357	10	2.8
Lagos	11009520	1376	215	15.6
Nasarawa	2258266	282	16	5.7
Niger	4777488	597	11	1.8
Ogun	4531494	566	12	2.1
Ondo	4180848	523	57	10.9
Osun	4127793	516	8	1.6
Oyo	6141895	768	27	3.5
Plateau	3873590	484	8	1.7
Rivers	6280212	785	36	4.6
Sokoto	4472948	559	NA	NA
Taraba	2772190	347	2	0.6

* Source: NBS: http://www.nigerianstat.gov.ng/report/490
**Source: Environmental Health Officers Registration Council of Nigeria (2017)

It is against this background that there have been repeated calls for the re-introduction of EHOs in Nigeria. A few of such calls are reproduced below:

> *The Director-General, Voice of Nigeria, Mr. Osita Okechukwu, has called for the reintroduction of sanitary inspectors in schools to curb the spread of preventable diseases. Okechukwu made the call when the National Coordinator and Chief Executive Officer of the Nigeria Centre for Disease Control (NCDC), Dr. Chikwe Iheakweazu, paid him a visit on Friday in Abuja – (http://www.authorityngr.com/2017/03/D-G-calls-for-reintroduction-of-sanitary-inspectors-in-schools/).*

> *The Rivers State Environmental Sanitation Authority has concluded plans to re-introduce house to house sanitary inspection. Speaking at a one-day stakeholders forum on waste management in Port Harcourt, the chairman of the Rivers State Environmental Sanitation Authority, Mr. Isoboye Jack noted that there is need to re-introduce house to house sanitary inspection to actualize its target of restoring Port Harcourt City to its Garden City Status (http://www.thenewswriterng.com/?p=3677).*

> *Piqued by the perceived increasing poor sanitary habits of the residents of the 27 local councils in Imo State, the state government has announced the reintroduction of Rural Sanitary Inspection. Governor Rochas Okorocha said the decision would help in averting diseases and keeping the environment safe. Sanitary inspection was a system adopted in the 60s, 70s, and part of 80s in the state by which health officials would inspect peoples' compounds instantaneously. If any compound was found filthy, appropriate fines and sanctions were awarded (https://guardian.ng/news/imo-reintroduces-sanitary-inspectors-in-rural-areas/).*

Conclusion and Recommendations

It is now a foregone conclusion that the past 15 years' effort at rolling back malaria did very little to significantly change the tragic story of the pandemic in Nigeria. This has largely been attributed to the adoption of wrong strategies that placed little or no attention to the control of mosquito population in residential areas through habitat management. The roles of Environmental Health Officers in this regard have also been degraded over the years in spite of their importance in this direction during the colonial era. Yet, countries in which significant efforts were made towards eradicating malaria did so largely through habitat management targeted at controlling mosquito population, with vital roles played by Environmental Health Officers. Therefore, to achieve sustainable malaria control in Nigeria, the paper recommends the following:

i) Habitat management policies and programmes targeted at wiping out mosquito breeding grounds in residential areas be put in place;
ii) Environmental Health Officers (EHOs) must be re-introduced / empowered by Government at all levels with appropriate legislations to ensure citizen participation and compliance with environmental rules and regulations;
iii) Government should ensure compliance with the World Health Organization minimum requirement of 1 EHO to 8000 people;
iv) Public enlightenment on the importance of community participation and compliance with environmental rules and regulations for wiping off mosquito population should be embarked upon;
v) Environmental research and surveillance be embarked upon on continuous basis for ensuring mosquito-free residential areas.

References

Bancroft T.L. 1906. On the aetiology of dengue fever. The Australasian Medical Gazette. 25:17–18.

Chernin, E. 1983. "Sir Patrick Manson's studies on the transmission and biology of filariasis". Reviews of Infectious Ddiseases. 5 (1): 148–66.

Cleaveland S, Laurenson M.K., Taylor L.H. 2001. Diseases of humans and their domestic mammals: pathogen characteristics, host range and the risk of emergence. Philos Trans R Soc Lond B Biol Sci. 356:991–9.

Cox, Francis E.G 2010. "History of the discovery of the malaria parasites and their vectors". Parasites & Vectors. 3 (1): 5. doi:10.1186/1756-3305-3-5. PMC 2825508 . PMID 20205846.

Debra J.H. 2004. Tips for Mosquito Control. Avaialble online: http://livestocktrail.illinois.edu/uploads/horsenet/papers/tips%20for%20mosquito%20control.pdf.

Environmental Health Officers Registration Council of Nigeria (EHORECON): 2002. Environmental Health Officers (Registration, etc) Act 11 of 2002. Available online: http://www.ehorecon.gov.ng.

Environmental Health Officers Registration Council of Nigeria 2017. Available online: http://www.ehorecon. gov.ng/List-of-Licensed-EHOs.

Hanson K, Goodman C, Lines J, Meek S, Bradley D, Mills A. 2004. The economics of malaria control interventions. Global Forum for Health Research: Helping Correct the 10/90 GAP.

Hay SI, Battle KE, Pigott DM et al. 2013. Global mapping of infectious disease. Philos Trans R Soc Lond B Biol Sci 368:20120250.

Hempelmann, E; Krafts, K 2013. "Bad air, amulets and mosquitoes: 2,000 years of changing perspectives on malaria". Malaria Journal. 12 (1): 232. doi:10.1186/1475-2875-12-232. PMC 3723432 . PMID 23835014.

Howard, L.O. 1923. A Fifty-Year Sketch-History of Medical Entomology; Annual Report of the Smithsonian Institution: Washington, DC, USA.

Johnson, Charles E. "An Address before the Medical Society of North Carolina, at Its Second Annual Meeting, in Raleigh, May 1851". Documenting the American South. the University Library, The University of North Carolina at Chapel Hill. Retrieved 22 April 2014.

Manson P. 1878. On the development of Filaria sanguinishominis, and on the mosquito considered as a nurse. J Linn Soc Lond 1878;14:304–11.

Manson, P (2002) [1900]. "Experimental proof of the mosquito-malaria theory. 1900". The Yale Journal of Biology and Medicine. 75 (2): 107–12. PMC 2588736 . PMID 12230309.

Nye, E.R 1991. "Ronald Ross: discoverer of the role of the mosquito in the transmission of malaria.". The New Zealand Medical Journal. 104 (919): 386–7.

Poopathi S. and Tyagi B.K. 2006. The Challenge of Mosquito Control Strategies: from

Primordial to Molecular Approaches. Biotechnology and Molecular Biology Review 1 (2), pp. 51-65. Available online at http://www.academicjournals.org/BMBR.

Ross, R. 1896. "Observations on Malaria Parasites made in Secunderabad, Deccan.". British Medical Journal. 1 (1831): 260–1. doi:10.1136/bmj.1.1831.260. PMC 2406240 . PMID 20755993.

Ross R. 1897. On some peculiar pigmented cells found in two mosquitoes fed on malarial blood. Br Med J. 2:1786–8.

Service MW. 1978. A short history of early medical entomology. J Med. Entomol. 14:603–26.

Steve L.; Matthew K.; Enis B. and Robert B. 2004. Environmental Management for Malaria Control in the East Asia and Pacific (EAP) Region. HNP Discussion Paper, 29255.

Thevasagayam E.S. 1985. Environmental management in mosquito control. Southeast Asian Journal of Tropical Medicine and Public Health 16:149-152.

US Embassy in Nigeria 2011. Nigeria Malaria Fact Sheet. Available online: http://photos.state.gov/libraries/nigeria/231771/Public/December-MalariaFact Sheet2.pdf.

WHO 1982. Manual on Environmental Management for Mosquito Control with Special Emphasis on Malaria Vectors. WHO Offset Publication No. 66.