Journal of Water & Health

Journal of Water and Health Vol 21 No 3, 385 doi: 10.2166/wh.2023.280

Is the presence of mosquitoes an indicator of poor environmental sanitation?

Emmanuel Ajibola Olagunju

Department of Crop and Environmental Protection, Faculty of Agricultural Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria
E-mail: olagunjuemmanuel7@gmail.com

EAO, 0000-0002-2724-0077

ABSTRACT

The World Health Organization has designated mosquitoes as the most lethal animal since they are known to spread pathogen-transmitting organisms. Understanding the many environmental elements that contribute to the spread of these vectors is one of the many strategies used to stop them. If there are mosquitoes around people, it may indicate that there is not an appropriate environmental sanitation program in place in the community or region. Environmental sanitation involves improving any elements of the physical environment that could have a negative impact on a person's survival, health, or physical environment. Keywords containing '*Aedes*,' '*Culex*,' 'Anopheles,' 'dengue,' 'malaria,' 'yellow fever,' 'Zika,' 'West Nile,' 'chikungunya,' 'resident,' 'environment,' 'sanitation,' 'mosquito control,' and 'breeding sites' of published articles on PubMed, Google Scholar, and ResearchGate were reviewed. It was discovered that the general population should be involved in mosquito and mosquito-borne disease control. Collaboration between health professionals and the general population is essential. The purpose of this paper is to increase public awareness of environmental health issues related to diseases carried by mosquitoes.

Key words: disease vectors, environmental sanitation, mosquitoes, mosquito-borne diseases, public health

HIGHLIGHTS

- Effect of environmental sanitation on the spread of mosquitoes
- This study makes recommendations for collaboration between health workers and the public.
- It enhances the need for proper sanitation.
- It creates awareness for the general public.

GRAPHICAL ABSTRACT

INTRODUCTION

In the entire world, mosquitoes have long been regarded as the most hazardous animals. Mosquitoes play a significant role in the spread of several harmful pathogens and parasites, especially arboviruses and protozoa. They serve as a vector for diseases including malaria, dengue, West Nile virus, chikungunya, yellow fever, and Zika virus, which result in hundreds of thousands of deaths each year (WHO 2017). All mosquitoes are members of the family: Culicidae within the order Diptera (flies) of the class Insecta, subfamilies, and genera are found within the family. The mosquito genera *Aedes*, *Culex*, and *Anopheles* (Figure 1) are crucial for the spread of human diseases. There are variations between species and each has specific habitat needs (Dale & Knight 2008). Numerous water environments, both natural and human-made, are inhabited by mosquito larvae. Because of this, some locations, like cemeteries and latrines, frequently function as productive artificial breeding grounds for mosquitoes (González *et al.* 2019). Over 80% of people on the planet are susceptible to a vector-borne illness. The majority of the human-vector-borne disease burden is caused by mosquito-borne diseases (MBDs), which include Zika, dengue, chikungunya, and malaria (Omodior *et al.* 2018; Franklinos *et al.* 2019).

Living organisms such as bacteria, plankton, plants, and animals can be bio-indicators and they can be used to examine the condition of the environment's typical ecosystem. They are engaged to appraise the condition of the surroundings and biogeographic variations that are happening (Parmar *et al.* 2016; Khatri *et al.* 2017). Major mosquito habitats are often located adjacent to community areas, notably residential areas. According to earlier entomological investigations, some dengue vectors have been found in forested spaces (Vezzani *et al.* 2005; Hayden *et al.* 2010), marshy swamps (Sarfraz *et al.* 2012), and brackish lakes (Ramasamy *et al.* 2011; Idris *et al.* 2013). The value of insects in the monitoring and evaluation of environmental contamination was highlighted by Parikh *et al.* (2020).

Due to the environmental conditions, whether indoors or outdoors, residential areas are typically a prospective source for the establishment of breeding sites (Azura *et al.* 2021). The existence of stark disparities, which reduces political attention to enhancing hygienic settings in underdeveloped regions, is a factor driving Zika outbreaks. Residents are always in danger from dengue and malaria, two vector-borne diseases, because of water collection near their homes (Sharma *et al.* 2021). Arbovirus epidemics are widespread issues that result from particular ways in which people interact with their environment (Valle *et al.* 2016).

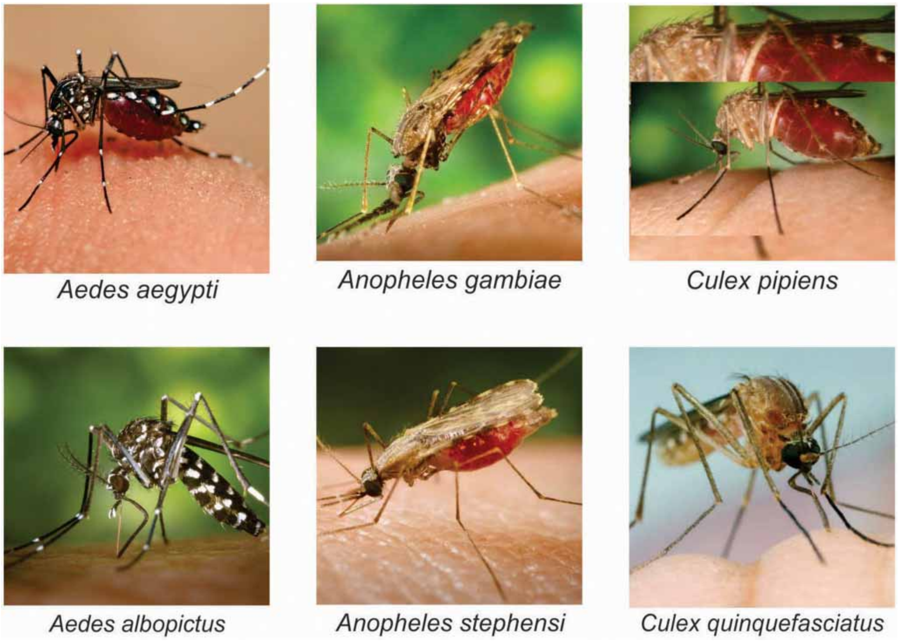

Figure 1 | Identification of some mosquito species.

The abundance and composition of many species of mosquitoes are significantly impacted by the environmental changes (Figure 4) brought on by human activity (Ferraguti *et al.* 2016). Artificial recipients, such as rain catch basins, water storage containers, old tires, flower vases, and tins, have emerged as the primary breeding grounds for invasive species like *Aedes albopictus* and the common yellow fever mosquito *Aedes aegypti* in urban settings. Mosquito hotspots typically develop under ideal circumstances: in areas with lots of breeding habitats, lots of human hosts, and little mosquito control (LaDeau *et al.* 2013). *Ae. albopictus* and *Ae. aegypti* are anthropophilic biting insects that can breed in a range of human-made habitats, including areas with uncontrolled vegetation, rubbish, decaying structures, and insufficient sewerage (Figure 4). Therefore, it is essential for disease vector management and elimination need to comprehend household risk variables that are linked to a decrease in indoor mosquito bites and disease transmission in various contexts (Lwetoijera *et al.* 2013).

Larson *et al.* (2005) reported that urban landscapes frequently receive greater water additions than wild landscapes, which promotes mosquito breeding and survival. For instance, urban mosquitoes exploit human-made objects and structures like abandoned tires and flowerpots that contain water, frequently choosing these artificial breeding locations over ones that are found in nature (Keating *et al.* 2004; Wilke *et al.* 2020). Additionally, human-made bodies of water frequently lack natural mosquito predators. Other aspects of cities that are favorable to mosquitoes include the urban heat island (Townroe & Callaghan 2014; Akhtar *et al.* 2016). Living in the poorest residences in unhygienic environments increases the chances of being exposed to vector-transmitted diseases, it has been discovered that house types and other factors have a profound impact on the incidence of vector-borne diseases (Uttah 2013).

In the past 20 years, there has been a major upsurge in the number of studies examining the relationship between environmental degradation and infectious diseases (Gottdenker *et al.* 2014). Urbanization growth, inadequate or nonexistent drainage facilities, and the disorganized placement of homes and factories in most towns all have an impact on the mosquito population and the severity of dengue transmission. Despite the unfavorable environmental situations brought on by standing pools of water, poor sanitation, and other factors, open-air dumpsites typically serve as significant mosquito breeding grounds (Cruvinel *et al.* 2020).

Most arboviruses are maintained in complex sylvatic cycles that involve mosquitoes and vertebrates that live in forests and are considered reservoirs, such as birds, small mammals, and nonhuman primates. Humans can interfere with those cycles due to their anthropogenic activities and cause the spread of zoonotic diseases, and consequently, viral adaptation can give rise to urban cycles and epidemics. There is mounting proof that certain infectious diseases can be transmitted more easily due to deforestation since it alters the ecology of the vectors (Morris *et al.* 2016; Burkett-Cadena & Vittor 2018).

The impact of poor environmental sanitation on the dispersion and quantity of mosquitoes has not received much attention in the literature. While there have been several programs to educate the public about the connection between poor environmental sanitation and the spread of diseases carried by mosquitoes in developed nations like the USA, there have been relatively few campaigns in developing and undeveloped nations. The objective of this paper is to increase public awareness of the need for public participation in mosquito control and to explore that necessity.

MATERIALS AND METHODS

Publications indexed in PubMed, Google Scholar, and ResearchGate were examined. Included in the list of search keywords are 'mosquito,' '*Aedes*,' '*Culex*,' 'Anopheles,' 'Mosquito-borne diseases,' 'malaria,' 'yellow fever,' 'dengue,' 'West Nile,' 'Zika,' 'chikungunya,' 'environment,' 'sanitation,' 'housing,', 'mosquito control', and 'breeding sites'.

Abstracts were screened and the ones not related to the subject matter were excluded. When the same articles appear in the aforementioned databases, the ones in Google Scholar were retained for further review (Figure 2).

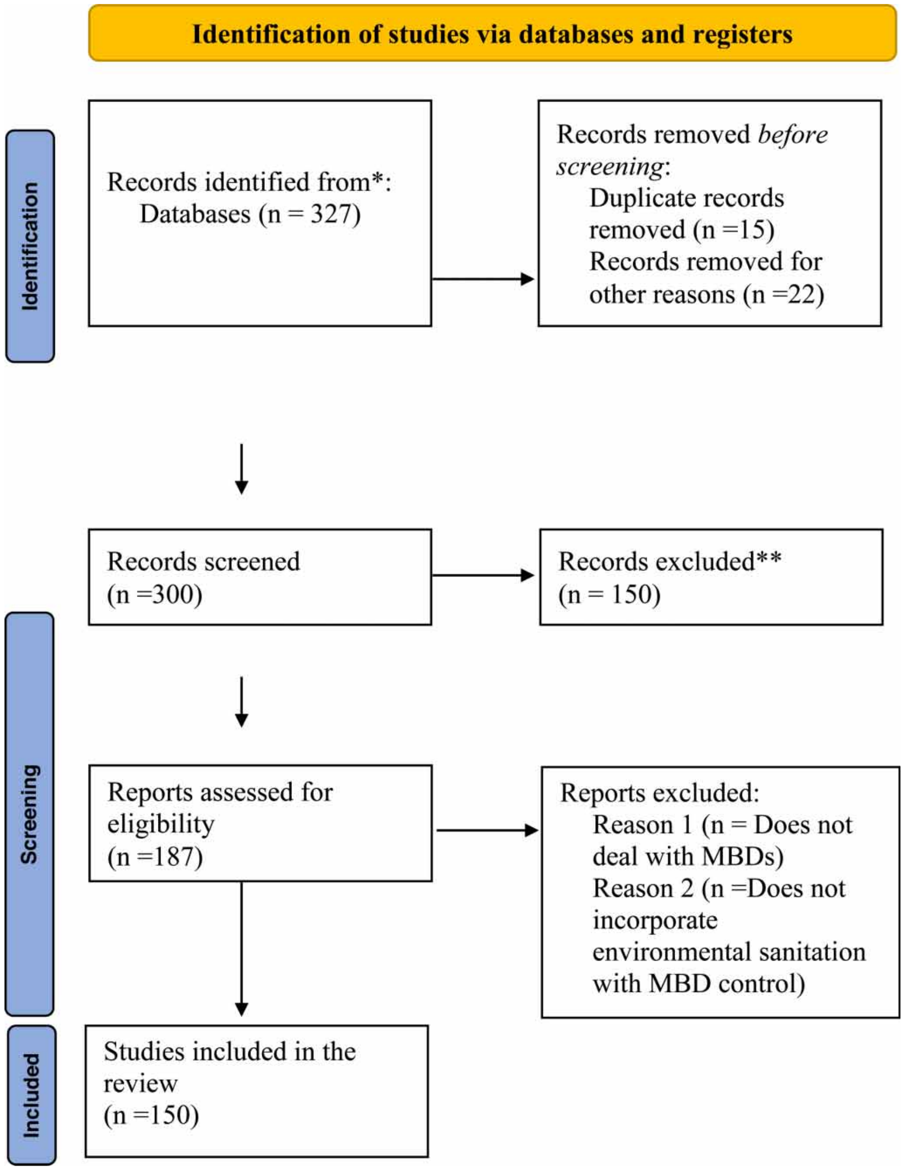

Figure 2 | Selection process.

English was used for the search. Posters, conference abstracts, and short communications were not taken into consideration; only original research works with quantitative analysis and reviews were taken into account. Only open-access papers were reviewed.

The reason behind selecting the databases is that they are relatively simple to use, they allow users to search for a wide variety of materials and they are more up-to-date.

RESULTS

A total of 150 articles met the inclusion criteria and were used for this study. Accordingly, 51 papers were from PubMed, 98 from Google Scholar, and 1 from ResearchGate.

A significant correlation between climate change, temperature, rainfall, landscape, land use, and MBD transmission was found, using the BODMAS procedure, to be 16.6% of these publications.

The three mosquito genera (*Aedes*, *Culex*, and *Anopheles*) and environmental elements such as illegal dumps, water storages, sewage, cemeteries, and human movement were found to be associated with MBDs such as malaria.

The state of housing conditions as a risk factor for encountering MBDs was discussed in 20% of the publications. Artificial containers, tree holes, freshwater ditches, ponds, drains, and gutters as breeding sites for mosquitoes were stated by 26.7% of the publications. Meanwhile, 11.3% of respondents discussed cemeteries as a potential risk for MBDs.

Insects were only recognized as indicators of environmental degradation in 2.7% of the papers. MBD prevention, mosquito transmission dynamics, and the link between nutritional and architectural risk factors were explored by 4.0% of the studies. Another 4.7% of the papers brought up the relationship between locals' exposure to mosquitoes and related ailments and forest degradation/vegetation.

The public's engagement with mosquitoes was only taken into account in 9.3% of the 150 studies included in this study as a potential means of eliminating mosquito breeding sites in residential settings. While 4.7% discussed larviciding as a means to end the transmission of MBDs (Figure 3).

Housing condition

During the 2012 dengue outbreak in Ecuador, poor housing conditions and the percentage of households receiving remittances were the two main risk factors for both the presence and an elevated burden of dengue (Lippi *et al.* 2018). According to Ningsih *et al.* (2016) findings, an indoor cement water tub with well water as the water supply was the most conducive microhabitat for *Aedes* larvae.

As stated by Lwetoijera *et al.* (2013), some house characteristics affect the density of malaria vectors and the danger of disease transmission indoors that goes along with it. Additionally, as stated by Morakinyo *et al.* (2018), improved housing offers a promising way to support a more comprehensive and long-term strategy for combating MBDs.

Homes in underprivileged areas, which are generally in poor conditions such as lack of environmental sanitation, appear to be built in a way that allows for a greater relative humidity and, as a result, a more hospitable environment for adult *Ae. aegypti* mosquitoes. Additionally, there are more breeding locations and environmental factors that can help adult forms of *Ae. aegypti* survive. This results in more water being stored in containers because the piped water supply is inconsistent (Caprara *et al.* 2009). In agreement with other studies, Liu *et al.* (2014) found a link between the prevalence of malaria and housing quality.

Effect of the environment on exposure to mosquitoes

According to Chirebvu *et al.* (2014), homesteads' proximity to mosquito breeding grounds exposed people to mosquito bites. Additionally, the Yibikon *et al.* (2020) investigation discovered that residents who lived close to the breeding location had a higher likelihood of contracting malaria.

While Madewell *et al.* (2019) emphasized the significance of curricula that consider neighborhood-level threats and mitigation plans when advocating for the prevention of vector-borne diseases.

In a study published in 2019, Ngatu *et al.* (Ngatu *et al.* 2019) found that household size, WASH (water, sanitation, and hygiene) status, and rural site were the main factors linked to malaria. This study, which was conducted in Congolese households, revealed a high incidence of malaria in a setting of extreme poverty. Because environmental factors found inside tires are closely linked to larval survival, determining all the factors relevant to species composition will be a significant task for

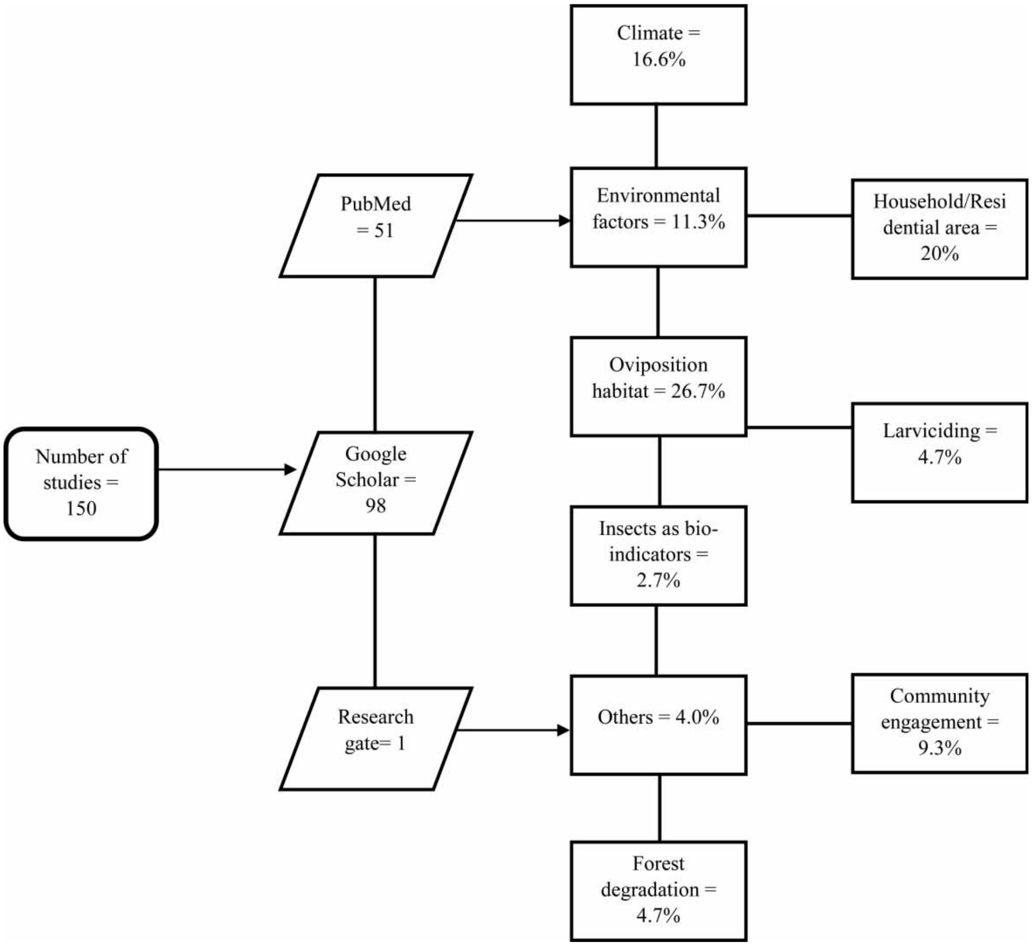

Figure 3 | Workflow (where the percentage (%) refers to the number of publications).

eventually understanding patterns of disease transmission (Yee *et al.* 2010) because tires are anticipated to continue to be a habitat for larvae of disease-carrying mosquitoes soon (Yee 2008).

Additionally, this study found that ineffective waste management was certainly a factor in the probable source of *Aedes* reproduction (Kamari *et al.* 2021). It is anticipated that if these wastes are produced and improperly managed, there will continue to be a risk of increasing mosquito breeding, especially of *Aedes* species. The most significant risk factor for the prevalence and abundance of the arbovirus vectors *Ae. aegypti* and *Ae. bromeliae* at hotel compounds examined in this study (Kampango *et al.* 2021) is the unmanaged solid waste from artificial and natural sources. Therefore, these household wastes should be the primary focus of effective *Aedes* population intervention in tropical nations (Banerjee *et al.* 2013). As reported by Abeyewickreme *et al.* (2012), successful and long-lasting dengue control requires increasing household responsibility for targeted vector treatments.

Alemu *et al.* (2011) stated that living close to possible mosquito breeding sites was positively correlated with the incidence of malaria. This finding suggests that human activity has a significant role in urban malaria, including the establishment of breeding grounds. To reduce malaria morbidity and mortality in the town, it is essential to raise knowledge about the proper use of insecticide-treated nets (ITNs) and to mobilize the community to change the environment. In places where there is a risk of MBDs or where there is a mosquito nuisance, Ensinka *et al.* (2007) recommended that vegetation management, upkeep of the concrete structures, and waste inflow to waste stabilization ponds be enhanced.

The results of Hasnan *et al.* (2017) suggest that the *Aedes* mosquito's breeding habitat is influenced by the local environment, such as stagnant water. The dengue disease outbreak can be permanently stopped by improving environmental conditions (Hasnan *et al.* 2017).

Kibret *et al.* (2018) reported that water level management could be used to suppress malaria mosquitoes in big reservoirs. Lower mosquito larval abundance is correlated with faster water drawdown rates, which ultimately lowers the risk of malaria for populations of people living near reservoirs. The study by Souza *et al.* (2017) shows how a straightforward storm drain modification can significantly reduce water retention and, as a result, have an impact on *Ae. aegypti* larval numbers.

Community engagement

A crucial component of any vector control program's surveillance should be how the community views a vector and the risk of disease transmission it carries (Juarez *et al.* 2021). Brown *et al.* (2021) concluded that understanding people's perceptions of mosquito abundance may permit improved management practices for mosquito populations.

Adeleke *et al.* (2013) concluded that the state government must maintain environmental sanitation and management to lower the incidence of MBDs. Additionally, residents should be made aware of mosquito breeding grounds and the necessity of getting rid of them. To prevent diseases, control the population, and stop the vector spread to urban areas in southern regions, Ruggerio *et al.* (2021) came to the same conclusion that governments and the community needed to be included in an active health strategy and a sustained commitment.

DISCUSSION

Currently, 6.01 billion people reside in places where the *Ae. aegypti* mosquito can spread disease (Ryan *et al.* 2019). Despite the circumstance that environmental sanitation is an essential component of mosquito nuisance prevention, little research has been done to-date on the connection between mosquito abundance, diversity, and disease transmission risk and how these factors relate to environmental sanitation at the household level.

Understanding the environmental influences underlying the circulation, abundance, and species composition of mosquito vector species – factors that eventually regulate the dispersal of vector-borne pathogens and play an important role in explaining the risk of pathogen transmission – will help us better understand the complexities of MBD risk (Lambin *et al.* 2010). For reproduction, mosquitoes require access to standing water. Using the neighborhood as the aggregate unit, vegetation coverage was positively associated with dengue in 2008–2009. At the more precise 'block of home' aggregation scale, it was associated with decreased incidence.

At both extensive and fine scales, shrubs and trees may have a sway on the spatial distribution and abundance of *Culex* larvae. At the neighborhood-level, the main street tree genus may have significant effects on larval production. For example, neighborhoods with great concentrations of oak trees may have lower mosquito populations because the tannins in oak leaves are toxic to mosquito larvae and pupae (Rey *et al.* 2000). Because they serve as resting places for both adult mosquitoes and the birds that serve as their blood meal hosts, trees and shrubs play a role in local mosquito dispersal by inducing gravid females to oviposit in neighboring catch basins and other nearby aquatic environments (Gardner *et al.* 2013). In Panama, Boshell discovered in 1940 that a forest with minor tree removal allowed for the capture of more Haemagogus mosquitoes (Bates 1944). The idea that differing leaf species in the aquatic environment affect mosquito production and longevity of the subsequent adult stage was supported by Muturi *et al.* (2012)'s study.

According to Brown *et al.* (2008), vegetation cover, demographic traits, and the layout of residential areas are all associated with adult *Culex* mosquito numbers and infection prevalence (Ruiz *et al.* 2004). A mosquito disposal route to community areas is provided by vegetation between the community area and the mosquito breeding place (Azura *et al.* 2021). When summer temperatures are high, the presence of plants helps prevent mosquito larva development, boosting survivability in an otherwise hostile environment (Yee 2008; Yang *et al.* 2019). Unkempt vegetation can also give male and female mosquitoes food supplies (such as plant sap, nectar, or honeydew) and resting places (Zhao *et al.* 2020). As stated by Castro *et al.* (2010), there was a favorable correlation between vegetation and the presence of mosquito larvae.

Artificially creating water sources has a cost in that it makes it more likely that mosquitoes will reproduce and spread diseases. The construction of dams, the creation of artificial wetlands, and agricultural irrigation are just a few examples of how changes to water resources may enhance mosquito reproduction and affect the spread of diseases linked with it (Jardine *et al.* 2008). The volume of water, containers' size, site, container color, vegetation cover, water chemical characteristics, water surfaces size, material type, solar exposition, temperature, organic matter, detritus, micro-organisms, and intra- and inter-specific competition, among other things, all play a role in the choice of vessels or survivorships of larvae or pupae in culicids (Vezzani 2007; Getachew *et al.* 2015; Rey & Lounibos 2015). By drastically reducing the number of larvae that will eventually become adults, larval management is an effective method of lowering mosquito concentrations (Adeleke *et al.* 2008).

By destroying habitats, polluting the ecosystem with nutrients, and using agrochemicals, humans are changing the environment at previously unheard-of rates (Figure 4). This has lately been postulated to function as a possibly important driver of disease-vectoring mosquito species that pose a risk to human and animal health (Schrama *et al.* 2020).

Given that mature *Aedes* and *Culex* mosquitoes, such as *Ae. aegypti*, can disperse up-to several meters, González *et al.* (2019) emphasized the significance of cemeteries as centers with large densities of vector species.

Urbanization is a factor that may surge the quantity of *Aedes* mosquito-favored habitats, resulting in a rise in *Aedes* mosquito density and survival, particularly in residential areas (Saleeza *et al.* 2011). Even after adjusting for socioeconomic inequalities and preventive behaviors, this analysis of the risk variables for malaria in young children reveals that urbanization and housing materials, such as house screening and ceiling installation, may have some role in reducing risk (Liu *et al.* 2014).

The northeastern regions of Brazil were plagued with *Aedes* in January 2016, so the Brazilian government dispatched more than 200,000 soldiers there. In a big effort to stop the spread of this mosquito and show the administration's involvement in the Zika problem, the troops went from family to family, scattered insecticides, and made an effort to eradicate potential breeding sites for *Aedes* (Löwy 2017).

Wetlands have profuse inhabitant and wandering bird and mosquito populations coinciding in space and time (BØgh *et al.* 2007; Ezenwa *et al.* 2007), building them vital ecosystems for the enzootic cycles of West Nile Virus transmission (Roiz *et al.* 2015).

Increases in the trash and other rubbish (Figure 4), which are more prevalent in low-income areas and act as mosquito breeding grounds, may be related to the association between income and perceptions of mosquitoes as a problem (LaDeau *et al.* 2013). One of the most effective predictors of whether people convey mosquitoes as a problem is how filthy they think their communities are. Trash and waste are breeding grounds for mosquitoes in many metropolitan areas, which increases their population (LaDeau *et al.* 2013; Wilke *et al.* 2020).

Limitations

First off, this topic is not sufficiently geographically represented (Table 1), which would have given it a more accurate context. Second, there is a lack of specificity about an environmental sanitation-related MBD and its vector.

Recommendations

The breeding behaviors of mosquitoes, particularly *Ae. aegypti* and *Ae. albopictus*, must be thoroughly understood to manage mosquitoes in residential settings. The use of plastic, polystyrene containers, such as cups and bottles, and tin cans are becoming more frequent in modern communities. The number of containers available for mosquito breeding may grow as a result of improper disposal (Figure 4) or littering of these materials (Azura *et al.* 2021). Proper disposal methods for these materials must be applied.

Adding water crystals to flower vases can prevent water from stacking up. Vases can also be treated with a specific substance that transforms water into a gel to keep flowers fresh and inhibit mosquito growth (González *et al.* 2019). Through

Figure 4 | Image modified from Akpeli (2019).

Table 1 | A table containing all the countries/regions of the publications reviewed in this paper (review articles are not included in this table as they are more generic in nature)

Region/Country	Number of publications	References
Afghanistan	1	Azimi *et al.* (2020)
Argentina	1	Ruggerio *et al.* (2021)
Australia	2	Russell *et al.* (2009), Sweeney *et al.* (2007)
Botswana	1	Chirebvu *et al.* (2014)
Brazil	12	Wilke *et al.* (2017), Souza *et al.* (2017), Caprara *et al.* (2009), Cruvinel *et al.* (2020), Vicente *et al.* (2017), Dutra *et al.* (2015), Fuller *et al.* (2017), Childs *et al.* (2019), Parra *et al.* (2022), Dorvillé (1996), Löwy (2017), Leandro-Reguillo *et al.* (2015)
Burkina Faso	1	Bonnet *et al.* (2020)
Canada	1	Rakotoarinia *et al.* (2022)
China	2	Ran *et al.* (2020), Chen *et al.* (2020), Wang *et al.* (2022)
Colombia	1	Chaparro *et al.* (2017)
Congo	1	Ngatu *et al.* (2019)
Cyprus	1	Drakou *et al.* (2020)
Dominican	1	González *et al.* (2019)
Ecuador	4	Heydari *et al.* (2017), Lippi *et al.* (2018), Ryan *et al.* (2019), Asigau & Parker (2018)
Ethiopia	5	Abate *et al.* (2013), Alemu *et al.* (2011), Ayele *et al.* (2012), Mereta *et al.* (2013), Getachew *et al.* (2015), Kibret *et al.* (2018)
France	1	Thuilliez *et al.* (2014)
Ghana	2	Owusu-Sekyere *et al.* (2016), Kudom (2015)
Guatemala	1	Madewell *et al.* (2019)
India	4	Banerjee *et al.* (2013), Arunachalam *et al.* (2012), Sharma *et al.* (2021), Parikh *et al.* (2020)
Indonesia	8	French *et al.* (2021), Ningsih *et al.* (2016), Yibikon *et al.* (2020), Tomia *et al.* (2022), Sasmita *et al.* (2021), Chandra *et al.* (2021), Sari (2021), Daswito & Samosir (2021)
Iran	1	Soleimani-Ahmadi *et al.* (2014)
Italy	1	Roiz *et al.* (2011)
Kenya	5	Mwangangi *et al.* (2012), Lutomiah *et al.* (2016), Obala *et al.* (2015), Dida *et al.* (2015), Carlson *et al.* (2004)
Laos	1	Hiscox *et al.* (2013)
Malaysia	8	Kamari *et al.* (2021), Dom *et al.* (2016), Hasnan *et al.* (2017), Dickin *et al.* (2013), Wong *et al.* (2015), Sairi *et al.* (2016), Azura *et al.* (2021), Dom *et al.* (2013)
Mexico	1	García-Rejón *et al.* (2011)
Netherlands	1	Boerlijst *et al.* (2019)
New Caledonia	1	Zellweger *et al.* (2017)
Nigeria	5	Bamidele *et al.* (2012), Adeleke *et al.* (2013), Adekunle & Sam-Wobo (2021), Fatunla *et al.* (2022), Morakinyo *et al.* (2018)
Papau New Guinea	1	Gul *et al.* (2021)
Rwanda	1	Habyarimana & Ramroop (2020)
Saudi Arabia	1	Aziz *et al.* (2012)
Sierra Leone	1	Bah (2020)
South Africa	2	Cornel *et al.* (2018), Schrama *et al.* (2020)
Spain	2	Ferraguti *et al.* (2016), Roiz *et al.* (2015)
Sri Lanka	2	Ensinka *et al.* (2007), Abeyewickreme *et al.* (2012)

(*Continued.*)

Table 1 | Continued

Region/Country	Number of publications	References
Tanzania	9	Bousema *et al.* (2010), Chaki *et al.* (2009), Castro *et al.* (2010), Okumu *et al.* (2012), Mng'ong'o *et al.* (2011), Dida *et al.* (2015), Mauti *et al.* (2015), Lwetoijera *et al.* (2013), Liu *et al.* (2014)
The Americas	1	Gardner *et al.* (2018)
The Gambia	1	Fillinger *et al.* (2009)
Uganda	2	Musoke *et al.* (2013), Snyman *et al.* (2015)
United Kingdom	2	Sinka *et al.* (2020), Golding *et al.* (2015)
United States of America	17	Yee *et al.* (2010), Walton *et al.* (2013), Metzger *et al.* (2011), Richards *et al.* (2008), Moreno-Madrinan & Turell (2017), Bauhoff & Busch (2020), Muturi *et al.* (2012), LaDeau *et al.* (2013), Becker *et al.* (2014), Juarez *et al.* (2021), Lizzi *et al.* (2014), Samson *et al.* (2015), Gardner *et al.* (2013), Chaves *et al.* (2011), Nguyen *et al.* (2012), Brown *et al.* (2021), Moller-Jacobs *et al.* (2014), Wilke *et al.* (2020), Muturi *et al.* (2011), Stone *et al.* (2012)
Venezuela	1	Grillet *et al.* (2010)
Vietnam	1	Toan *et al.* (2015)
Zanzibar	1	Kampango *et al.* (2021)
Zimbabwe	1	Macherera *et al.* (2017)

home repair and screening, current treatments with environmental management and socioeconomic development can be combined to offer a noninsecticidal, complementary method of enhancing resistance to mosquito bites (Baragatti *et al.* 2009; Graves *et al.* 2009).

Debris removal and routine inspection, when done continuously, minimize breeding in such places, as does the application of larvicide, the removal of surface waters from productive sites, adjusting the water level along the shoreline, and flooding areas where mosquitoes lay their eggs in the soil.

Anti-vector interventions like ITN and indoor residual spraying (IRS) should be made available to communities at risk to scale up the malaria program, together with the deployment of recurring WASH initiatives in residential areas (Maitland 2016). This could potentially result in effective malaria control (Ngatu *et al.* 2019). To reduce human-vector interaction, it is crucial to promote the proper use of long-lasting insecticidal nets at adult stages. This, along with community-level health promotion education that teaches people how to control mosquitoes, will help communities prevent the spread of disease (Mwangangi *et al.* 2012). Communities should be taught environmental management techniques such as draining and filling during the immature stages. They may also utilize larvicides like *Bacillus thuringiensis* var. Israelensis, which primarily targets *Anopheline* and *Culicine* habitats, as larvicides. Additionally, the *Aedes* populations will be controlled by sealing the water storage containers inside the dwellings and properly discarding containers inside the homesteads (Mwangangi *et al.* 2012).

To establish long-term control of malaria, the focus should be placed on eliminating mosquito breeding areas in the community. Health education regarding malaria control should be reinforced, particularly through the training and retraining of community health volunteers (Bamidele *et al.* 2012). To reduce *Ae. aegypti* populations, community involvement through sensitization, public awareness of the disease, and the best practices of water preservation and disposal of tires and containers would be crucial (Lutomiah *et al.* 2016).

In sub-Saharan Africa, housing quality is a significant risk factor for malaria in a variety of transmission environments. The gradual development of African housing in conjunction with socioeconomic progress should be viewed as having a significant potential to lower malaria transmission and as a promising approach to help the continent achieve and maintain malaria elimination over the long term (Tusting *et al.* 2017). By hindering host-seeking behavior, elevating homes on stilts can also decrease mosquito house entry (Hiscox *et al.* 2013).

Coagulation–flocculation technology was suggested as a novel strategy for a long-lasting, minimally disruptive solution to mosquito control by Ran *et al.* (2020). In the laboratory, chlorine-free tap water was treated with polyaluminum chloride. The oviposition fondness of *Culex pipiens,* the emerging mosquito eggs, and the survival amount of mosquito larvae were observed, and the pupa population was recorded on a daily basis. This method could efficiently kill early-stage larvae instars by reducing the amount of food available to larvae.

CONCLUSION

Poor sanitation is the main factor promoting the presence of mosquitoes in a location. The environmental factors of a place, such as vegetation cover, waste and tire disposal, housing conditions, and poor sewage and garbage disposal, affect whether mosquitoes are more or less likely to spread. Although there are additional factors outside environmental sanitation that affect the presence or absence of these disease vectors, such as climate change, migration, and insecticide resistance, this paper does not cover them all.

To stop the proliferation of mosquitoes, residents, the general public, and health professionals must collaborate. Maintaining good environmental sanitation will aid in reducing mosquito populations and the illnesses they carry.

Through environmental management, reducing aquatic habitats (breeding sites) decreases the spread of MBD, the appearance of host-seeking mosquitoes, and the time needed for vectors to find oviposition sites (Gu *et al.* 2006). Communities would be safer from MBDs if integrated vector and pest management strategies successfully incorporated environmental changes as a method of controlling pests (Lizzi *et al.* 2014).

FUNDING

This work was funded by the author's resources.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

Abate, A., Degarege, A. & Erko, B. 2013 Community knowledge, attitude and practice about malaria in a low endemic setting of Shewa Robit Town, northeastern Ethiopia. *BMC Public Health* **13**, 312.

Abeyewickreme, W., Wickremasinghe, A. R., Karunatilake, K., Sommerfeld, J. & Kroeger, A. 2012 Community mobilization and household level waste management for dengue vector control in Gampaha district of Sri Lanka; an intervention study. *Pathogens and Global Health* **106**, 8.

Adekunle, O. N. & Sam-Wobo, S. O. 2021 Assessment of endophilic mosquitoes and parity status as continuous means of lymphatic filariasis transmission in selected communities, Ondo State, Nigeria. *FUW Trends in Science & Technology Journal* **6** (2), 458–462.

Adeleke, M. A., Mafiana, C. F., Idowu, A. B., Adekunle, M. F. & Sam-Wobo, S. O. 2008 Mosquito larval habitats and public health implication in Abeokuta, Ogun State, Nigeria. *Tanzania Journal of Health Research* **10** (2), 103–107.

Adeleke, M. A., Adebimpe, W. O., Hassan, A. O., Oladejo, S. O., Olaoye, I., Olatunde, G. O. & Adewole, T. 2013 Larval habitats of mosquito fauna in Osogbo metropolis, Southwestern Nigeria. *Asian Pacific Journal of Tropical Biomedicine* **3** (9), 673–677.

Akhtar, R., Gupta, P. T. & Srivastava, A. K., 2016 Urbanization, urban heat island effects and dengue outbreak in Delhi. In: *Climate Change and Human Health Scenario in South and Southeast Asia* (Akhtar, R., ed.). Advances in Asian Human-Environmental Research; Springer, Cham, Switzerland, pp. 99–111.

Akpeli, A. O. 2019 *Poor Environmental Sanitation*. Available from: https://dutable.com/2019/01/31/poor-environmental-sanitation/

Alemu, A., Tsegaye, W., Golassa, L. & Abebe, G. 2011 Urban malaria and associated risk factors in Jimma Town, south-west Ethiopia. *Malaria Journal* **10**, 173.

Arunachalam, N., Tyagi, B. K., Samuel, M., Krishnamoorthi, R., Manavalan, R., Tewari, S. C., Ashokkumar, V., Kroeger, A., Sommerfeld, J. & Petzold, M. 2012 Community-based control of *Aedes aegypti* by adoption of ecohealth methods in Chennai City, India. *Pathogens and Global Health* **106** (8), 488–496.

Asigau, S. & Parker, P. G. 2018 The influence of ecological factors on mosquito abundance and occurrence in Galápagos. *Journal of Vector Ecology* **43** (1), 125–137.

Ayele, D. G., Zewotir, T. T. & Mwambi, H. G. 2012 Prevalence and risk factors of malaria in Ethiopia. *Malaria Journal* **11**, 195.

Azimi, A. N., Dente, S. M. R. & Hashimoto, S. 2020 Social life-cycle assessment of household waste management system in Kabul City. *Sustainability* **12**, 3217.

Aziz, A. T., Dieng, H., Ahmad, A. H., Mahyoub, J. A., Turkistani, A. M., Mesed, H., Koshike, S., Satho, T., Salmah, M. R. C., Ahmad, H., Zuharah, W. F., Ramli, A. S. & Miake, F. 2012 Household survey of container breeding mosquitoes and climatic factors influencing the prevalence of *Aedes aegypti* (Diptera: Culicidae) in Makkah City, Saudi Arabia. *Asian Pacific Journal of Tropical Biomedicine* **2** (11), 849–857.

Azura, F., Dom, N. C. & Camalxaman, S. N. 2021 Environmental assessment and infestation level of the dengue vectors at residential area in Puncak Alam, Selangor. *Journal of Sustainability Science and Management* **16** (1), 120–128.

Bah, M. S. 2020 *The Relationship Between Malaria Status in Under-Five Children and Some Household Demographic, Socioeconomic and Environmental Factors Associated with the Disease in Sierra Leone*. *Public Health Theses*.

Bamidele, J. O., Ntaji, M. I., Oladele, E. A. & Bamimore, O. K. 2012 Community participation in malaria control in Olorunda local government area, Osun State, southwestern Nigeria. *African Journal of Infectious Diseases* **6** (2), 24–28.

Banerjee, S., Aditya, G. & Saha, G. K. 2013 Household disposables as breeding habitats of dengue vectors: linking wastes and public health. *Waste Management* **33**, 233–239.

Baragatti, M., Fournet, F., Henry, M. C., Assi, S., Ouedraogo, H., Rogier, C. & Salem, G. 2009 Social and environmental malaria risk factors in urban areas of Ouagadougou, Burkina Faso. *Malaria Journal* **8** (1), 13.

Bates, M. 1944 Observations on the distribution of diurnal mosquitoes in a tropical forest. *Ecology* **25**, 159–170.

Bauhoff, S. & Busch, J. 2020 Does deforestation increase malaria prevalence? Evidence from satellite data and health surveys. *World Development* **127**, 104734.

Becker, B., Leisnham, P. T. & LaDeau, S. L. 2014 A tale of two city blocks: differences in immature and adult mosquito abundances between socioeconomically different urban blocks in Baltimore (Maryland, USA). *International Journal of Environmental Research and Public Health* **11**, 3256–3270.

Boerlijst, S. P., Trimbos, K. B., Van der Beek, J. G., Dijkstra, K. D. B., Van der Hoorn, B. B. & Schrama, M. 2019 Field evaluation of DNA based biodiversity monitoring of Caribbean mosquitoes. *Frontiers in Ecology and Evolution* **7**, 240.

BØgh, C., Lindsay, S. W., Clarke, S. E., Dean, A., Jawara, M., Pinder, M. & Thomas, C. J. 2007 High spatial resolution mapping of malaria transmission risk in the Gambia, West Africa, using LANDSAT TM satellite imagery. *American Journal of Tropical Medicine and Hygiene* **76** (5), 875–881.

Bonnet, E., Fournet, F., Benmarhnia, T., Ouedraogo, S., Dabiré, R. & Ridde, V. 2020 Impact of a community-based intervention on *Aedes aegypti* and its spatial distribution in Ouagadougou, Burkina Faso. *Infectious Diseases of Poverty* **9**, 61.

Bousema, T., Drakeley, C., Gesase, S., Hashim, R., Magesa, S., Mosha, F., Otieno, S., Carneiro, I., Cox, J., Msuya, E., Kleinschmidt, I., Maxwell, C., Greenwood, B., Riley, E., Sauerwein, R., Chandramohan, D. & Gosling, R. 2010 Identification of hot spots of malaria transmission for targeted malaria control. *The Journal of Infectious Diseases* **201** (11), 1764–1774.

Brown, H., Diuk-Wasser, M., Andreadis, T. & Fish, D. 2008 Remotely sensed vegetation indices identify mosquito clusters of West Nile virus vectors in an urban landscape in the northeastern United States. *Vector-Borne Zoonot* **8**, 197–206.

Brown, J. A., Larson, K. L., Lerman, S. B., Cocroft, A. & Hall, S. J. 2021 Resident perceptions of mosquito problems are more influenced by landscape factors than mosquito abundance. *Sustainability* **13**, 11533. https://doi.org/10.3390/su132011533.

Burkett-Cadena, N. D. & Vittor, A. Y. 2018 Deforestation and vector-borne disease: forest conversion favors important vectors of human pathogens. *Basic and Applied Ecology* **26**, 101–110.

Caprara, A., de Oliveira Lima, J. W., Marinho, A. C. P., Calvasina, P. G., Landim, L. P. & Sommerfeld, J. 2009 Irregular water supply, household usage and dengue: a bio-social study in the Brazilian Northeast. *Cadernos de Saúde Pública* **25** (1), 125–136.

Carlson, J., Keating, J., Mbogo, C. M., Kahindi, S. & Beier, J. C. 2004 Ecological limitations on aquatic mosquito predator colonization in the urban environment. *Journal of Vector Ecology* **29** (2), 331–339.

Castro, M. C., Kanamori, S., Kannady, K., Mkude, S., Killeen, G. F. & Fillinger, U. 2010 The importance of drains for the larval development of lymphatic filariasis and malaria vectors in Dar es Salaam, United Republic of Tanzania. *PLoS Neglected Tropical Diseases* **4** (5), e693.

Chaki, P. P., Govella, N. J., Shoo, B., Hemed, A., Tanner, M., Fillinger, U. & Killeen, G. F. 2009 Achieving high coverage of larval-stage mosquito surveillance: challenges for a community-based mosquito control programme in urban Dar es Salaam, Tanzania. *Malaria Journal* **8**, 311.

Chaparro, P. E., Molina, K., Alzate, A., Padilla, J., Arévalo-Herrera, M. & Herrera, S. 2017 Urban malaria transmission in a non-endemic area in the Andean region of Colombia. *Memórias do Instituto Oswaldo Cruz, Rio de Janeiro* **112** (12), 797–804.

Chaves, L. F., Hamer, G. L., Walker, E. D., Brown, W. M., Ruiz, M. O. & Kitron, U. D. 2011 Climatic variability and landscape heterogeneity impact urban mosquito diversity and vector abundance and infection. *Ecosphere* **2** (6), 70.

Chandra, E., Johari, A., Syaiful, S. & Fahri, S. 2021 Alternatives to improve mosquito eradication behavior: a systematic review. *Journal of Research Development in Nursing & Midwifery* **18** (2), 53–59.

Chen, X., Wu, T., Liang, J. & Zhou, L. 2020 Urban mosquito management administration: mosquito (Diptera: Culicidae) habitat surveillance and questionnaire survey in Wuhan, Central China. *PLoS ONE* **15** (5), e0232286.

Childs, M. L., Nova, N., Colvin, J. & Mordecai, E. A. 2019 Mosquito and primate ecology predict human risk of yellow fever virus spillover in Brazil. *Philosophical Transactions of the Royal Society B* **374**, 20180335.

Chirebvu, E., Chimbari, M. J. & Ngwenya, B. N. 2014 Assessment of risk factors associated with malaria transmission in Tubu Village, Northern Botswana. *Malaria Research and Treatment* **2014** (6), 403069.

Cornel, A. J., Lee, Y., Almeida, A. P. G., Johnson, T., Mouatcho, J., Venter, M., De Jager, C. & Braack, L 2018 Mosquito community composition in South Africa and some neighboring countries. *Parasites & Vectors* **11**, 331.

Cruvinel, V. R. N., Zolnikov, T. R., Obara, M. T., de Oliveira, V. T. L., Vianna, E. N., do Santos, F. S. G., de Oliveira, K. C. & Scott, J. A. 2020 Vector-borne diseases in waste pickers in Brasilia, Brazil. *Waste Management* **105**, 223–232.

Dale, P. E. R. & Knight, J. M. 2008 Wetlands and mosquitoes: a review. *Wetlands Ecology and Management* **16**, 255–276. doi:10.1007/s11273-008-9098-2.

Daswito, R. & Samosir, K. 2021 Physical environments of water containers and *Aedes* sp. larvae in dengue-endemic areas of Tanjungpinang Riau. *BKM Journal of Community Medicine and Public Health* **37** (1), 13–19.

Dickin, S. K., Schuster-Wallace, C. J. & Elliott, S. J. 2013 Developing a vulnerability mapping methodology: applying the water-associated disease index to dengue in Malaysia. *PLoS ONE* **8** (5), e63584.

Dida, G. O., Gelder, F. B., Anyona, D. N., Abuom, P. O., Onyuka, J. O., Matano, A. S. Adoka, S. O., Kanangire, C. K., Owuor, P. O., Ouma, C. & Ofulla, A. V. O. 2015 Presence and distribution of mosquito larvae predators and factors influencing their abundance along the Mara River, Kenya and Tanzania. *Springer Plus* **4**, 136.

Dom, N. C., Ahmad, A. H. & Ismail, R. 2013 Habitat characterization of *Aedes* sp. breeding in urban hotspot area. *Procedia – Social and Behavioral Sciences* **85**, 100–109.

Dom, N. C., Madzlan, M. F., Yusoff, S. N. N., Ahmad, A. H., Ismail, R. & Camalxaman, S. N. 2016 Profile distribution of juvenile *Aedes* species in an urban area of Malaysia. *Trans R Soc Trop Med Hyg* **110**, 237-245.

Dorvillé, L. F. M. 1996 Mosquitoes as bioindicators of forest degradation in southeastern Brazil, a statistical evaluation of published data in the literature. *Studies on Neotropical Fauna and Environment* **31** (2), 68–78.

Drakou, K., Nikolaou, T., Vasquez, M., Petric, D., Michaelakis, A., Kapranas, A., Papatheodoulou, A. & Koliou, M. 2020 The effect of weather variables on mosquito activity: a snapshot of the main point of entry of *Cyprus*. *International Journal of Environmental Research and Public Health* **17**, 1403.

Dutra, H. L. C., dos Santos, L. M. B., Caragata, E. P., Silva, J. B. L., Villela, D. A. M., Maciel-de-Freitas, R. & Moreira, L. A. 2015 From lab to field: the influence of urban landscapes on the invasive potential of Wolbachia in Brazilian *Aedes aegypti* mosquitoes. *PLoS Neglected Tropical Diseases* **9** (4), e0003689.

Ensink, J. H. J., Mukhtarb, M., van der Hoekcd, W. & Konradsen, F. 2007 Simple intervention to reduce mosquito breeding in waste stabilisation ponds. *Transactions of the Royal Society of Tropical Medicine and Hygiene* **101**, 1143–1146.

Ezenwa, V. O., Milheim, L. E., Coffey, M. F., Godsey, M. S., King, R. J. & Guptill, S. C. 2007 Land cover variation and west Nile virus prevalence: patterns, processes, and implications for disease control. *Vector-Borne and Zoonotic Diseases* **7**, 173–180.

Fatunla, O. A. T., Olatunya, O. S., Ogundare, E. O., Fatunla, T. O., Babatola, A. O., Adeniyi, A. T. & Oyelami, O. A. 2022 Malaria prevention practices and malaria prevalence among children living in a rural community in southwest Nigeria. *Journal of Infection in Developing Countries* **16** (2), 352–361.

Ferraguti, M., Martinez-de la Puente, M. J., Roiz, D., Ruiz, S., Soriguer, R. & Figuerola, J. 2016 Effects of landscape anthropization on mosquito community composition and abundance. *Scientific Reports* **6**, 29002.

Fillinger, U., Sombroek, H., Majambere, S., van Loon, E., Takken, W. & Lindsay, S. W. 2009 Identifying the most productive breeding sites for malaria mosquitoes in the Gambia. *Malaria Journal* **8**, 62.

Franklinos, L. H. V., Jones, K. E., Redding, D. W. & Abubakar, I. 2019 The effect of global change on mosquito-borne disease. *The Lancet Infectious Diseases (Auckland)* **19** (9), e302–e312.

French, M. A., Barker, S. F., Taruc, R. R., Ansariadi, A., Duffy, G. A., Saifuddaolah, M., Agussalim, A. Z., Awaluddin, F., Zainal, Z., Wardani, J., Faber, P. A., Fleming, G., Ramsay, E. E., Henry, R., Lin, A., O'Toole, J., Openshaw, J., Sweeney, R., Sinharoy, S. S., Kolotelo, P., Jovanovic, D., Schang, C., Higginson, E. E., Prescott, M. F., Burge, K., Davis, B., Ramirez-Lovering, D., Reidpath, D., Greening, C., Allotey, P., Simpson, J. A., Forbes, A., Chown, S. L., McCarthy, D., Johnston, D., Wong, T., Brown, R., Clasen, T., Luby, S. & Leder, K. & the RISE consortium 2021 A planetary health model for reducing exposure to faecal contamination in urban informal settlements: baseline findings from Makassar, Indonesia. *Environment International* **155**, 106679.

Fuller, T. L., Calvet, G., Estevam, C. G., Angelo, J. R., Abiodun, G. J., Halai, U.-A., De Santis, B., Sequeira, P. C., Araujo, E. M., Sampaio, S. A., de Mendonca, M. C. L., Fabri, A., Ribeiro, R. M., Harrigan, R., Smith, T. B., Gabaglia, C. R., Brasil, P., de Filippis, A. M. B. & Nielsen-Saines, K. 2017 Behavioral, climatic, and environmental risk factors for Zika and Chikungunya virus infections in Rio de Janeiro, Brazil, 2015-16. *PLoS ONE* **12** (11), e0188002.

García-Rejón, J. E., Loroño-Pino, M. A., Farfán-Ale, J. A., Flores-Flores, L. F., López-Uribe, M. P., Najera-Vazquez, M. D. R., Nuñez-Ayala, F., Beaty, B. J. & Eisen, L. 2011 Mosquito infestation and dengue virus infection in *Aedes aegypti* females in schools in Mérida, México. *American Journal of Tropical Medicine and Hygiene* **84** (3), 489–496.

Gardner, A. M., Anderson, T. K., Hamer, G. L., Johnson, D. E., Varela, K. E., Walker, D. E. & Ruiz, M. O. 2013 Terrestrial vegetation and aquatic chemistry influence larval mosquito abundance in catch basins, Chicago, USA. *Parasites & Vectors* **6**, 9.

Gardner, L. M., BoÂta, A., Gangavarapu, K., Kraemer, M. U. G. & Grubaugh, N. D. 2018 Inferring the risk factors behind the geographical spread and transmission of Zika in the Americas. *PLoS Neglected Tropical Diseases* **12** (1), e0006194.

Getachew, D., Tekie, H., Gebre-Michael, T., Balkew, M. & Mesfin, A. 2015 Breeding sites of Aedes *aegypti*: potential dengue vectors in Dire Dawa, East Ethiopia. *Interdisciplinary Perspectives on Infectious Diseases* **1**, 706276.

Golding, N., Nunn, M. A. & Purse, B. V. 2015 Identifying biotic interactions which drive the spatial distribution of a mosquito community. *Parasites & Vectors* **8**, 367.

González, M. A., Rodríguez Sosa, M. A., Vásquez Bautista, Y. E., Diéguez Fernández, L., Borge de Prada, M., Guerrero, K. A. & Alarcón-Elbal, P. M. 2019 Micro-environmental features associated to container-dwelling mosquitoes (Diptera: Culicidae) in an urban cemetery of the Dominican Republic. *Revista de Biología Tropical* **67** (1), 132–145.

Gottdenker, N. L., Streicker, D. G., Faust, C. L. & Carroll, C. R. 2014 Anthropogenic land use change and infectious diseases: a review of the evidence. *Ecohealth* **11** (4), 619–632.

Graves, P. M., Richards, F. O., Ngondi, J., Emerson, P. M., Shargie, E. B., Endeshaw, T., Ceccato, P., Ejigsemahu, Y., Mosher, A. W. & Hailemariam, A. 2009 Individual, household and environmental risk factors for malaria infection in Amhara, Oromia and SNNP regions of Ethiopia. *Transactions of the Royal Society of Tropical Medicine and Hygiene* **103** (12), 1211–1220.

Grillet, M.-E., Barrera, R., Martínez, J.-E., Berti, J. & Fortin, M.-J. 2010 Disentangling the effect of local and global spatial variation on a mosquito-borne infection in a neotropical heterogeneous environment. *American Journal of Tropical Medicine and Hygiene* **82** (2), 194–201.

Gu, W., Regens, J. L., Beier, J. C. & Novak, R. J. 2006 Source reduction of mosquito larval habitats has unexpected consequences on malaria transmission. *Proceedings of the National Academy of Sciences of the United States of America* **103**, 17560–17563.

Gul, D., Rodríguez-Rodríguez, D., Nate, E., Auwan, A., Salib, M., Lorry, L., Keven, J. B., Katusele, M., Rosado, J., Hofmann, N., Ome-Kaius, M., Koepfli, C., Felger, I., Kazura, J. W., Hetzel, M. W., Mueller, I., Karl, S., Clements, A. C. A., Fowkes, F. J. I., Laman, M. & Robinson, L. J. 2021 Investigating differences in village-level heterogeneity of malaria infection and household risk factors in Papua New Guinea. *Scientific Reports* **11**, 16540.

Habyarimana, F. & Ramroop, S. 2020 Prevalence and risk factors associated with malaria among children aged six months to 14 years old in Rwanda: evidence from 2017 Rwanda malaria indicator survey. *International Journal of Environmental Research and Public Health* **17**, 7975.

Hasnan, S. N. A., Dom, N. C., Latif, Z. A. & Madzlan, F. 2017 Surveillance of *Aedes* mosquitoes in different residential types in central zone of Shah Alam, Selangor. *Asian Pac J Trop Dis* **7** (6), 930–938.

Hayden, M. H., Uejio, C. K., Walker, K., Ramberg, F., Moreno, R., Rosales, C. & Janes, C. R. 2010 Microclimate and human factors in the divergent ecology of *Aedes aegypti* along the Arizona, US/ Sonora, MX border. *EcoHealth* **7** (1), 64–77.

Heydari, N., Larsen, D. A., Neira, M., Ayala, E. B., Fernandez, P., Adrian, J., Rochford, R. & Stewart-Ibarra, A. M. 2017 Household dengue prevention interventions, expenditures, and barriers to *Aedes aegypti* control in Machala, Ecuador. *International Journal of Environmental Research and Public Health* **14**, 196.

Hiscox, A., Khammanithong, P., Kaul, S., Sananikhom, P. & Luthi, R. 2013 Risk factors for mosquito house entry in the Lao PDR. *PLoS ONE* **8** (5), e62769.

Idris, F. H., Idris, A., Usman, S. N. & Ramasamy, S. R. 2013 Detection of *Aedes albopictus* pre-imaginal stages in brackish water habitats in Brunei Darussalam. *Journal Vector Ecology* **38** (1), 197–199.

Jardine, A., Cook, A. & Weinstein, P. 2008 The utility of mosquito-borne disease as an environmental monitoring tool in tropical ecosystems. *Journal of Environmental Monitoring* **10**, 1409–1414.

Juarez, J. G., Garcia-Luna, S. M., Medeiros, M. C. I., Dickinson, K. L., Borucki, M. K., Frank, M., Badillo-Vargas, I., Chaves, L. F. & Hamer, G. L. 2021 The eco-bio-social factors that modulate *Aedes aegypti* abundance in South Texas border communities. *Insects* **12**, 183.

Kamari, I. Z., Dom, N. C., Aziz, M. Y., Shafie, F. A. & Ishak, A. R. 2021 Larval surveillance and habitat characterization of dengue vectors in Tangkak, Johor, Malaysia. *Serangga* **26** (3), 89–98.

Kampango, A., Furu, P., Sarath, D. L., Haji, K. A., Konradsen, F., Schioler, K. L., Alifrangis, M., Saleh, F. & Weldon, C. W. 2021 Risk factors for occurrence and abundance of *Aedes aegypti* and *Aedes bromeliae* at hotel compounds in Zanzibar. *Parasites Vectors* **14**, 544.

Keating, J., Macintyre, K., Mbogo, C. M., Githure, J. I. & Beier, J. C. 2004 Characterization of potential larval habitats for anopheles mosquitoes in relation to urban land-use in Malindi, Kenya. *International Journal of Health Geographics* **3**, 9. doi:10.1186/1476-072X-3-9.

Khatri, N., Tyagi, S. & Rawtani, D. 2017 Rural environment study for water from different sources in cluster of villages in Mehsana district of Gujarat. *Environmental Monitoring and Assessment* **190** (1), 10. doi:10.1007/s10661-017-6382-8.

Kibret, S., Wilson, G. G., Ryder, D., Tekie, H. & Petros, B. 2018 Can water-level management reduce malaria mosquito abundance around large dams in sub-saharan Africa? *PLoS ONE* **13** (4), e0196064.

Kudom, A. A. 2015 Larval ecology of *Anopheles coluzzii* in Cape Coast, Ghana: water quality, nature of habitat and implication for larval control. *Malaria Journal* **14**, 447.

LaDeau, S. L., Leisnham, P. T., Biehler, D. & Bodner, D. 2013 Higher mosquito production in low-income neighborhoods of Baltimore and Washington, DC: understanding ecological drivers and mosquito-borne disease risk in temperate cities. *International Journal of Environmental Research and Public Health* **10**, 1505–1526.

Lambin, E. F., Tran, A., Vanwambeke, S. O., Linard, C. & Soti, V. 2010 Pathogenic landscapes: interactions between land, people, disease vectors, and their animal hosts. *International Journal of Health Geographics* **9** (54), 1–13.

Larson, E. K., Grimm, N., Gober, P. & Redman, C. 2005 The paradoxical ecology and management of water in the phoenix, USA metropolitan area. *Ecohydrology & Hydrobiology* **5**, 287–296.

Leandro-Reguillo, P., Thomson-Luque, R., Monteiro, W. M. & de Lacerda, M. V. G. 2015 Urban and architectural risk factors for malaria in indigenous Amazonian settlements in Brazil: a typological analysis. *Malaria Journal* **14**, 284.

Lippi, C. A., Stewart-Ibarra, A. M., Muñoz, A. G., Borbor-Cordova, M. J., Mejía, R., Rivero, K., Castillo, K., Cárdenas, W. B. & Ryan, S. J. 2018 The social and spatial ecology of dengue presence and burden during an outbreak in Guayaquil, Ecuador, 2012. *International Journal of Environmental Research and Public Health* **15**, 827.

Liu, J. X., Bousema, T., Zelman, B., Gesase, S., Hashim, R., Maxwell, C., Chandramohan, D. & Gosling, R. 2014 Is housing quality associated with malaria incidence among young children and mosquito vector numbers? Evidence from Korogwe, Tanzania. *PLoS ONE* **9** (2), e87358. doi:10.1371/journal.pone.0087358.

Lizzi, K. M., Qualls, W. A., Brown, S. C. & Beier, J. C. 2014 Expanding integrated vector management to promote healthy environments. *Trends in Parasitology* **30**, 8.

Löwy, I. 2017 Leaking containers: success and failure in controlling the mosquito *Aedes aegypti* in Brazil. *American Journal of Public Health* **107** (4), 517–524.
Lutomiah, J., Barrera, R., Makio, A., Mutisya, J., Koka, H., Owaka, S., Koskei, E., Nyunja, A., Eyase, F., Coldren, R. & Sang, R. 2016 Dengue outbreak in Mombasa City, Kenya, 2013 ± 2014: entomologic investigations. *PLOS Neglected Tropical Diseases* **10** (10), e0004981.
Lwetoijera, D. W., Kiware, S. S., Mageni, Z. D., Dongus, S., Harris, C., Devine, G. J. & Majambere, S. 2013 A need for better housing to further reduce indoor malaria transmission in areas with high bed net coverage. *Parasites & Vectors* **6**, 57.
Macherera, M., Chimbari, M. J. & Mukaratirwa, S. 2017 Indigenous environmental indicators for malaria: a district study in Zimbabwe. *Acta Tropica* **175**, 50–59.
Madewell, Z. J., Sosa, S., Brouwer, K. C., Juárez, J. G., Romero, C., Lenhart, A. & Cordón-Rosales, C. 2019 Associations between household environmental factors and immature mosquito abundance in Quetzaltenango, Guatemala. *BMC Public Health* **19**, 1729. https://doi.org/10.1186/s12889-019-8102-5.
Maitland, K. 2016 Severe malaria in African children: the need for continuing investment. *The New England Journal of Medicine* **375**, 2416–2417.
Mauti, G. O., Mauti, E. M. & Kowanga, D. K. 2015 Evaluation of malaria spread in relation to poor environmental conditions at Kibaha District (Tanzania). *Journal of Scientific and Innovative Research* **4** (5), 203–206.
Mereta, S. T., Yewhalaw, D., Boets, P., Ahmed, A., Duchateau, L., Speybroeck, N., Vanwambeke, S. O., Legesse, W., De Meester, L. & Goethals, P. L. M. 2013 Physico-chemical and biological characterization of anopheline mosquito larval habitats (Diptera: Culicidae): implications for malaria control. *Parasites & Vectors* **6**, 320.
Metzger, M. E., Harbison, J. E. & Hu, R. 2011 Discovery of vector mosquitoes (Diptera: Culicidae) in newly installed above- and belowground stormwater treatment systems in San Diego County, California. *Journal of Medical Entomology* **48** (6), 1136–1144.
Mng'ong'o, F. C., Sambali, J. J., Sabas, E., Rubanga, J., Magoma, J., Ntamatungiro, A. J., Turner, E. L., Nyogea, D., Ensink, J. H. J. & Moore, S. J. 2011 Repellent plants provide affordable natural screening to prevent mosquito house entry in tropical rural settings – results from a pilot efficacy study. *PLoS ONE* **6** (10), e25927.
Moller-Jacobs, L. L., Murdock, C. C. & Thomas, M. B. 2014 Capacity of mosquitoes to transmit malaria depends on larval environment. *Parasites & Vectors* **7**, 593.
Morakinyo, O. M., Balogun, F. M. & Fagbamigbe, A. F. 2018 Housing type and risk of malaria among under five children in Nigeria: evidence from the malaria indicator survey. *Malaria Journal* **17**, 311.
Moreno-Madrinan, M. J. & Turell, M. 2017 Factors of concern regarding Zika and other *Aedes aegypti*-transmitted viruses in the United States. *Journal of Medical Entomology* **54** (2), 251–257.
Morris, A. L., Guégan, J. F., Andreou, D., Marsollier, L., Carolan, K., Le Croller, M., Sanhueza, D. & Gozlan, R. E. 2016 Deforestation-driven food-web collapse linked to emerging tropical infectious disease, *Mycobacterium ulcerans*. *Science Advances* **2** (12), e1600387.
Musoke, D., Karani, G., Ssempebwa, J. C. & Musoke, M. B. 2013 Integrated approach to malaria prevention at household level in rural communities in Uganda: experiences from a pilot project. *Malaria Journal* **12**, 327.
Muturi, E. J., Kim, C.-H., Alto, B. W., Berenbaum, M. R. & Schuler, M. A. 2011 Larval environmental stress alters *Aedes aegypti* competence for Sindbis virus. *Tropical Medicine and International Health.* **16** (8), 955–964.
Muturi, E. J., Allan, B. F. & Ricci, J. 2012 Influence of leaf detritus type on production and longevity of container-breeding mosquitoes. *Environmental Entomology* **41** (5), 1062–1068.
Mwangangi, J. M., Midega, J., Kahindi, S., Njoroge, L., Nzovu, J., Githure, J., Mbogo, C. M. & Beier, J. C. 2012 Mosquito species abundance and diversity in Malindi, Kenya and their potential implication in pathogen transmission. *Parasitology Research* **110**, 61–71.
Ngatu, N. R., Kanbara, S., Renzaho, A., Wumba, R., Mbelambela, E. P., Muchanga, S. M. J., Muzembo, B. A., Leon-Kabamba, N., Nattadech, C., Suzuki, T., Oscar-Luboya, Wada, K., Ikeda, M., Nojima, S., Sugishita, T. & Ikeda, S. 2019 Environmental and sociodemographic factors associated with household malaria burden in the Congo. *Malaria Journal* **18**, 53.
Nguyen, A. T., Williams-Newkirk, A. J., Kitron, U. D. & Chaves, L. F. 2012 Seasonal weather, nutrients, and conspecific presence impacts on the southern house mosquito oviposition dynamics in combined sewage overflows. *Journal of Medical Entomology* **49** (6), 1328–1338.
Ningsih, F., Zakaria, I. J. & Hasmiwati 2016 The microhabitat preferences of mosquito genus *Aedes* (Diptera: Culicidae) in Padang, West Sumatra, Indonesia. *International Journal of Mosquito Research* **3** (5), 36–40.
Obala, A. A., Mangeni, J. N., Platt, A., Aswa, D., Abel, L., Namae, J. & O'Meara, W. P. 2015 What is threatening the effectiveness of insecticide-treated bednets? A case-control study of environmental, behavioral, and physical factors associated with prevention failure. *PLoS ONE* **10** (7), e0132778.
Okumu, F. O., Moore, J., Mbeyela, E., Sherlock, M., Sangusangu, R., Ligamba, G., Russell, T. & Moore, S. J. 2012 A modified experimental hut design for studying responses of disease-transmitting mosquitoes to indoor interventions: the Ifakara experimental huts. *PLoS ONE* **7** (2), e30967.
Omodior, O., Luetke, M. C. & Nelson, E. J. 2018 Mosquito-borne infectious disease, risk-perceptions, and personal protective behavior among U.S. international travelers. *Preventive Medicine Reports* **12**, 336–342.
Owusu-Sekyere, E., Attakora-Amaniampong, E. & Aboagye, D. 2016 Wealth, health, and inequality: households exposure to environmental hazards. *Geography Journal* **2016** (1), 1–9.
Parikh, G., Rawtani, D. & Khatri, N. 2020 Insects as an indicator for environmental pollution. *Environmental Claims Journal*. doi:10.1080/10406026.2020.1780698.

Parmar, T. K., Rawtani, D. & Agrawal, Y. K. 2016 Bioindicators: the natural indicator of environmental pollution. *Frontiers in Life Science* **9** (2), 110–118. doi:10.1080/21553769.2016.1162753.

Parra, M. C. P., Lorenz, C., Dibo, M. R., de Aguiar Milhim, B. H. G., Guirado, M. M., Nogueira, M. L. & Chiaravalloti-Neto, F. 2022 Association between densities of adult and immature stages of *Aedes aegypti* mosquitoes in space and time: implications for vector surveillance. *Parasites & Vectors* **15**, 133.

Rakotoarinia, M. R., Blanchet, F. G., Gravel, D., Lapen, D. R., Leighton, P. A., Ogden, N. H. & Ludwig, A. 2022 Effects of land use and weather on the presence and abundance of mosquito-borne disease vectors in a urban and agricultural landscape in Eastern Ontario, Canada. *PLoS ONE* **17** (3), e0262376.

Ramasamy, R., Surendran, S. N., Jude, P. J., Dharshini, S. & Vinobaba, M. 2011 Larval development of *Aedes aegypti* and *Aedes albopictus* in peri-urban brackish water and its implications for transmission of arboviral diseases. *PLoS Neglected Tropical Diseases* **5** (11), e1369.

Ran, L.-X., Sheng, H.-M., En, L.-P., Yu, L.-X. & Bing, X. 2020 Coagulation-flocculation: a potential application for mosquito larval source management (LSM). *Acta Tropica* **213**, 105748.

Rey, J. R. & Lounibos, P. 2015 Ecología de *Aedes aegypti* y *Aedes albopictus* en América y transmisión de enfermedades (Ecology of *Aedes aegypti* and *Aedes albopictus* in the Americas and disease transmission). *Biomédica* **35** (2), 177–185.

Rey, D., David, J. P., Cuany, A., Amichot, M. & Meyran, J. C. 2000 Differential sensitivity to vegetable tannins in planktonic crustacea from alpine mosquito breeding sites. *Pesticide Biochemistry and Physiology* **67**, 103–113.

Richards, S. L., Ghosh, S. K., Zeichner, B. C. & Apperson, C. S. 2008 Impact of source reduction on the spatial distribution of larvae and pupae of *Aedes albopictus* (Diptera: Culicidae) in suburban neighborhoods of a piedmont community in North Carolina. *Journal of Medical Entomology* **45** (4), 617–628.

Roiz, D., Neteler, M., Castellani, C., Arnoldi, D. & Rizzoli, A. 2011 Climatic factors driving invasion of the tiger mosquito (*Aedes albopictus*) into new areas of Trentino, Northern Italy. *PLoS ONE* **6** (4), e14800.

Roiz, D., Ruiz, S., Soriguer, R. & Figuerola, J. 2015 Landscape effects on the presence, abundance and diversity of mosquitoes in Mediterranean wetlands. *PLoS ONE* **10** (6), e0128112. doi:10.1371/journal.pone.0128112.

Ruggerio, C. A., Querejeta, G. A., Conicelli, K. B. & Lombardo, R. J. 2021 Integration of municipal state, society and university efforts for sanitary risk prevention associated with *Aedes aegypti* mosquito in the metropolitan area of Buenos Aires, Argentina. *Tropical Medicine and International Health* **26** (7), 789–799.

Ruiz, M. O., Tedesco, C., McTighe, T. J., Austin, C. & Kitron, U. 2004 Environmental and social determinants of human risk during a West Nile virus outbreak in the greater Chicago area, 2002. *International Journal of Health Geographics* **3**, 8.

Russell, T. L., Kay, B. H. & Skilleter, G. A. 2009 Environmental effects of mosquito insecticides on saltmarsh invertebrate fauna. *Aquatic Biology* **6**, 77–90.

Ryan, S. J., Carlson, C. J., Mordecai, E. A. & Johnson, L. R. 2019 Global expansion and redistribution of *Aedes*-borne virus transmission risk with climate change. *PLOS Neglected Tropical Diseases* **13** (3), e0007213.

Sairia, F. A. M., Dom, N. C. & Camalxaman, S. N. 2016 Infestation profile of *Aedes* mosquitoes in multi-storey buildings in Selangor, Malaysia. *Procedia, Social and Behavioral Sciences* **222**, 283–289.

Saleeza, S. N. R., Norma, R. Y. & Sofian, M. 2011 Mosquitoes larval breeding habitat in urban and suburban areas, Peninsular Malaysia. *World Academy of Science, Engineering and Technology* **5** (10), 599–603.

Samson, D. M., Archer, R. S. & Alimi, T. O. 2015 New baseline environmental assessment of mosquito ecology in northern Haiti during increased urbanization. *Journal of Vector Ecology* **40**, 1.

Sarfraz, M. S., Tripathi, N. K., Tipdecho, T., Thongbu, T., Kerdthong, P. & Souris, M. 2012 Analyzing the spatio-temporal relationship between dengue vector larval density and land-use using factor analysis and spatial ring mapping. *BMC Public Health* **12** (1), 853.

Sari, K. R. Y. 2021 Determinant factors to the existence of *Aedes aegypti* mosquito in the working area of Ubud I Health Center Gianyar Regency, Bali. *The Indonesian Journal of Public Health* **16** (1), 101–111.

Sasmita, H. I., Neoh, K.-B., Yusmalinar, S., Anggraeni, T., Chang, N.-T., Bong, L.-J., Putra, R. E., Sebayang, A., Silalahi, C. N., Ahmad, I. & Tu, W.-C. 2021 Ovitrap surveillance of dengue vector mosquitoes in Bandung City, West Java Province, Indonesia. *PLoS Neglected Tropical Diseases* **15** (10), e0009896.

Schrama, M., Hunting, E. R., Beechler, B. R., Guarido, M. M., Govender, D., Nijland, W., van't Zelfde, M., Venter, M., van Bodegom, P. M. & Gorsich, E. 2020 Human practices promote presence and abundance of disease-transmitting mosquito species. *Scientific Reports* **10**, 13543. https://doi.org/10.1038/s41598-020-69858-3.

Sharma, M. L., Lal, M., Verma, R. & Kaur, H. 2021 A cross-sectional study of health-related issues in relation to housing environment in a rural area of Amritsar, Punjab. *National Journal of Physiology, Pharmacy and Pharmacology* **11** (2), 227–231.

Sinka, M. E., Pironon, S., Massey, N. C., Longbottom, J., Hemingway, J., Moyes, C. L. & Willis, K. J. 2020 A new malaria vector in Africa: predicting the expansion range of *Anopheles stephensi* and identifying the urban populations at risk. *PNAS* **117** (40), 24900–24908.

Snyman, K., Mwangwa, F., Bigira, V., Kapisi, J., Clark, T. D., Osterbauer, B., Greenhouse, B., Sturrock, H., Gosling, R., Liu, J. & Dorsey, G. 2015 Poor housing construction associated with increased malaria incidence in a cohort of young Ugandan children. *American Journal of Tropical Medicine and Hygiene* **92** (6), 1207–1213.

Soleimani-Ahmadi, M., Vatandoost, H. & Zare, M. 2014 Characterization of larval habitats for anopheline mosquitoes in a malarious area under elimination program in the southeast of Iran. *Asian Pacific Journal of Tropical Biomedicine* **4** (1), S73–S80.

Souza, R. L., Mugabe, V. A., Paploski, I. A. D., Rodrigues, M. S., Moreira, R. S. D., Nascimento, L. C. J., Roundy, C. M., Weaver, S. C., Reis, M. G., Kitron, U. & Ribeiro, G. S. 2017 Effect of an intervention in storm drains to prevent *Aedes aegypti* reproduction in Salvador, Brazil. *Parasites & Vectors* **10**, 328.

Stone, C. M., Jackson, B. T. & Foster, W. A. 2012 Effects of plant-community composition on the vectorial capacity and fitness of the malaria mosquito *Anopheles gambiae*. *American Journal of Tropical Medicine and Hygiene* **87** (4), 727–736.

Sweeney, A. W., Beebea, N. W. & Cooper, R. D. 2007 Analysis of environmental factors influencing the range of anopheline mosquitoes in northern Australia using a genetic algorithm and data mining methods. *Ecological Modelling* **203**, 375–386.

Thuilliez, J., Bellia, C., Dehecq, J.-S. & Reilhes, O. 2014 Household-level expenditure on protective measures against mosquitoes on the island of La Réunion, France. *PLOS Neglected Tropical Diseases* **8** (1), e2609. doi:10.1371/journal.pntd.0002609.

Toan, D. T. T., Hoat, L. N., Hu, W., Wright, P. & Martens, P. 2015 Risk factors associated with an outbreak of dengue fever/dengue haemorrhagic fever in Hanoi, Vietnam. *Epidemiology and Infection* **143**, 1594–1598.

Tomia, S., Hadi, U. K., Soviana, S. & Retnani, E. B. 2022 Density of eggs and larvae of *Aedes* spp. and the characteristics of their larvae habitat in endemic dengue area in Ternate City. *Malaysian Journal of Medicine and Health Sciences* **18** (5), 138–143.

Townroe, S. & Callaghan, A. 2014 British container breeding mosquitoes: the impact of urbanisation and climate change on community composition and phenology. *PLoS ONE* **9**, e95325. doi:10.1371/journal.pone.0095325.

Tusting, L. S., Bottomley, C., Gibson, H., Kleinschmidt, I., Tatem, A. J., Lindsay, S. W. & Gething, W. P. 2017 Housing Improvements and malaria risk in Sub-Saharan Africa: a multi-country analysis of survey data. *PLoS Med* **14** (2), e1002234.

Uttah, E. C. 2013 House types and demographic risk factors for sustained endemic filariasis in south – eastern, Nigeria. *Pacific Journal of Medical Sciences* **11** (2), 12–21.

Valle, D., Pimenta, D. N. & Aguiar, R. 2016 Zika, dengue and chikungunya: challenges and issues. *Revista do Sistema Unico de Saude do Brasil* **25** (2), 419–422.

Vezzani, D. 2007 Review: artificial container-breeding mosquitoes and cemeteries: a perfect match. *Tropical Medicine & International Health* **12** (2), 299–313.

Vezzani, D., Rubio, A., Velazquez, S. M., Schweigmann, N. & Wiegand, T. 2005 Detailed assessment of microhabitat suitability for *Aedes aegypti* (Diptera: Culicidae) in Buenos Aires, Argentina. *Acta Tropica* **95** (2), 123–131.

Vicente, C. R., Herbinger, K.-H., Cerutti, J. C., Malta, R. C., de Souza, A. C. A. & FroÈschl, G. 2017 Determination of clusters and factors associated with dengue dispersion during the first epidemic related to *dengue virus* serotype 4 in VitoÂria, Brazil. *PLoS ONE* **12** (4), e0175432.

Walton, W. E., Popko, D. A., Van Dam, A. R. & Merrill, A. 2013 Distribution of *Culex* species in vegetation bands of a constructed wetland undergoing integrated mosquito management. *Journal of the American Mosquito Control Association* **29** (1), 69–73.

Wang, T., Fan, Z.-W., Ji, Y., Chen, J.-J., Zhao, G.-P., Zhang, W.-H., Zhang, H.-Y., Jiang, B.-G., Xu, Q., Lv, C.-L., Zhang, X.-A., Li, H., Yang, Y., Fang, L.-Q & Liu, W. 2022 Mapping the distributions of mosquitoes and mosquito-borne arboviruses in China. *Viruses* **14**, 691.

WHO 2017 *Vector-Borne Diseases*. World Health Organization (WHO), Geneva. Available from: https://www.who.int/news-room/fact-sheets/detail/vector-bornediseases (accessed 16 January 2018).

Wilke, A. B. B., de Carvalho, G. C. & Marrelli, M. T. 2017 Microgeographic population structuring of *Culex quinquefasciatus* (Diptera: Culicidae) from São Paulo, Brazil. *Journal of Medical Entomology* **54** (6), 1582–1588.

Wilke, A. B. B., Beier, J. C. & Benelli, G. 2020 Filariasis vector control down-played due to the belief the drugs will be enough – not true!. *Entomologia Generalis* **40**, 15–24. doi:10.1127/entomologia/2019/0776.

Wong, L. P., Shakir, S. M. M., Atefi, N. & AbuBakar, S. 2015 Factors affecting dengue prevention practices: nationwide survey of the Malaysian public. *PLoS ONE* **10** (4), e0122890.

Yang, L., Turo, K. J., Riley, C. B., Inocente, E. A., Tian, J., Hoekstra, N. C., Piermarini, P. M. & Gardiner, M. M. 2019 Can urban greening increase vector abundance in cities? The impact of mowing, local vegetation, and landscape composition on adult mosquito populations. *Urban Ecosystems* **22**, 827–839.

Yee, D. A. 2008 Tires as habitats for mosquitoes: a review of studies within the eastern United States. *Journal of Medical Entomology* **45** (4), 581–593.

Yee, D. A., Kneitel, J. M. & Juliano, S. A. 2010 Environmental correlates of abundances of mosquito species and stages in discarded vehicle tires. *Journal of Medical Entomology* **47** (1), 53–62.

Yibikon, L., Rantetampangb, A. L., Pongtiku, A., Tingginehe, R. M., Makaba, S. & Ruru, Y. 2020 The risk factors associated with malaria incidence in the Elelim Public Health Center in Yalimo District, Papua Province. *International Journal of Sciences: Basic and Applied Research (IJSBAR)* **53** (1), 119–142.

Zellweger, R. M., Cano, J., Mangeas, M., Taglioni, F., Mercier, A., Despinoy, M., Menkes, C. E., Dupont-Rouzeyrol, M., Nikolay, B. & Teurlau, M. 2017 Socioeconomic and environmental determinants of dengue transmission in an urban setting: an ecological study in NoumeÂa, New Caledonia. *PLoS Neglected Tropical Diseases* **11** (4), e0005471. https://doi.org/10.1371/journal.pntd.0005471.

Zhao, J., Tang, T. & Wang, X. 2020 Effects of landscape composition on mosquito population in urban green spaces. *Urban Forestry & Urban Greening* **49**, 126626.

First received 28 October 2022; accepted in revised form 16 February 2023. Available online 1 March 2023