Impact of Waste Management on Infectious Disease Control: Evaluating Strategies to Mitigate Dengue Transmission and Mosquito Breeding Sites – A Systematic Review

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Abstract

Background: Dengue, a mosquito-borne viral disease primarily transmitted by Aedes mosquitoes, is a significant global public health concern, particularly in tropical and subtropical regions. Severe cases, including dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS), can be fatal. Recent outbreaks in Bangladesh highlight the disease's escalating threat, with inadequate waste management playing a critical role in mosquito breeding and disease transmission. Methods: This review aims to assess the effectiveness of various waste management techniques, such as gasification, pyrolysis, compaction, and incineration, in reducing the buildup of garbage and, therefore, the spread of mosquito breeding grounds. This review also assesses the waste-derived containers used for storing wastewater, which act as breeding grounds for dengue mosquitoes. This review identifies Aedes aegypti mosquito larvae density in ten dengue-endemic regions. Larval samples were collected from various outdoor containers using dipping methods and analyzed through the Container Index (CI). The CI represents the percentage of containers infested with larvae and indicates the potential for dengue transmission. Results: The review revealed that high CI values in locations such as Dire Dawa, Ethiopia (54%), and Tamil Nadu, India (32.2%) indicated significant risk for dengue transmission. In contrast, a low CI value of 0.15% was observed in Rawalpindi, Pakistan, corresponding with lower dengue incidence. Results showed that poorly managed waste sites, particularly those accumulating stagnant water, contributed to higher CI values. Conclusion: Effective waste management, including proper disposal and reduced breeding grounds, is crucial in mitigating dengue transmission. The review emphasizes the need for improved waste management infrastructure, community involvement, and government-led policy frameworks to control Aedes mosquito populations and reduce dengue outbreaks.

Keywords: Waste management, Dengue transmission, Aedes mosquitoes, Mosquito control, Public health

Significance | This review discusses the direct correlation between inadequate waste disposal and increased dengue transmission, urging sustainable waste management to curb mosquito breeding.

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1. Introduction

Mosquito breeding grounds present significant public health challenges, as they are linked to the spread of mosquito-borne

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infections and contribute to environmental imbalances (Donatus et al., 2022). Mosquito abundance is influenced by factors such as fluctuations in egg-laying patterns and larval overcrowding in water environments (Laursen et al., 2023). The development of mosquito larvae into adult mosquitoes typically requires stagnant water, though certain species can mature even in areas with limited stagnant water (Rodríguez-Mártínez et al., 2023). Uncollected solid waste, such as plastic bottles, tires, broken pots, and cans, accumulates small amounts of rainwater, creating ideal breeding conditions for mosquitoes within 2-3 days (Mihai et al., 2022). Additionally, the accumulation of waste in drainage systems can obstruct water flow, further facilitating mosquito reproduction. Even discarded food remnants attract mosquitoes, providing both breeding grounds and nourishment for adult mosquitoes (Donatus et al., 2022).

The unchecked spread of mosquito populations has aggravated the transmission of diseases such as dengue, chikungunya, malaria, and filariasis, severely impacting human health. In response, a range of chemical insecticides—including dichlorodiphenyltrichloroethane (DDT), organophosphates, permethrin, and dieldrin—has been used to manage mosquito populations (Sajjad & Arif, 2019). However, these chemicals often contaminate water sources such as rivers, ponds, and groundwater, posing significant risks to water quality and public health when consumed for daily use (Islam, 2024; Rai et al., 2020). The extensive application of these insecticides has also led to resistance among mosquito populations and further environmental degradation.

To mitigate these challenges, there is a pressing need to limit chemical insecticide use and explore alternative mosquito control strategies. Researchers have identified several biological control agents, including bacteria, fungi, fish larvae, protozoans, and nematodes, as potential solutions (Ding et al., 2023). Natural compounds, such as juvenile hormone antagonists (JHANs), have also shown promise as safe and effective mosquito insecticides (Hossain et al., 2023b; Park et al., 2022). In addition, insect growth regulators (IGRs) and plant-based extracts are being investigated as environmentally sustainable alternatives (Sankar & Kumar, 2023; Moniruzzaman et al., 2023).

Given the limitations of chemical insecticides, the adoption of environmentally conscious and sustainable methods to control mosquito populations is essential. A key aspect of this approach involves implementing effective waste management procedures to eliminate mosquito breeding grounds and reduce the spread of mosquito-borne diseases.

2. Literature Review

Dengue is one of the most prominent mosquito-borne viral diseases affecting humans and has emerged as a significant global public health concern, especially in tropical and subtropical regions. The disease is primarily transmitted through the bite of Aedes mosquitoes (Nakase et al., 2023), which are also known carriers of other viruses, including those responsible for dengue hemorrhagic fever (DHF), dengue shock syndrome (DSS), yellow fever, chikungunya, and Zika virus infection (Gan et al., 2021). While classical dengue fever (DF) typically presents as a mild, flu-like illness, severe cases such as DHF and DSS can be life-threatening. According to Wei et al. (2023), the global burden of dengue is substantial, with approximately 390 million infections and 96 million symptomatic cases annually. Lee et al. (2022) highlighted that dengue is the leading arbovirus impacting human health, causing 100 million symptomatic infections and an estimated 10,000 to 22,000 deaths each year worldwide. However, it is important to note that the actual mortality rate may be higher than reported figures suggest.

Currently, over half of the global population resides in areas conducive to dengue transmission (Nakase et al., 2023). Moreover, recent studies indicate that dengue is no longer confined to urban areas and is increasingly affecting rural populations as well (Khan et al., 2023). The situation in Bangladesh is particularly alarming. According to the World Health Organisation's dengue situation report for Epi-week 34 (21-27 August 2023), Bangladesh has recorded 114,511 cases and 548 deaths, marking the highest number of reported dengue infections and fatalities in the country's history (World Health Organisation, 2023; Sunny et al., 2023). These statistics underscore the escalating threat of dengue in Bangladesh and reflect broader global trends of rising incidence.

As vector-borne diseases like dengue continue to spread, effective mosquito control and public health interventions are critical to reducing the impact of this disease. Dengue's transmission, facilitated by Aedes mosquitoes, not only affects densely populated urban environments but also poses an increasing risk to rural areas (Nakase et al., 2023; Tufael et al., 2024). In light of the growing global prevalence of dengue, comprehensive strategies addressing both urban and rural transmission will be vital in mitigating future outbreaks.

2.1 Current Global Situation Of Dengue

According to Haider et al. (2023), the prevalence of dengue cases in Bangladesh has recently reached its peak, surpassing the levels observed before 2000. Figures 1 to 6 illustrate the facts regarding the occurrence and absence of the dengue virus across five continents: America, Africa, Asia, Australia, and Europe (Brady et al., 2012).

2.2 Dengue Disease And Clinical Management

Dengue is a viral illness that is spread by mosquitoes and results in an abrupt fever and intense joint discomfort. This issue poses a substantial challenge to public health and encompasses an extensive number of clinical manifestations. If severe dengue is not promptly

treated, it can result in substantial morbidity and fatality due to plasma leakage, severe bleeding, or organ failure.

The accessible treatment options for dengue sickness are still restricted and depend on providing supportive care (Palanichamy Kala et al., 2023). The available candidates for dengue vaccine are listed in Table 1.

2.3 Significance Of Climate Change Impact

Each day, an enormous amount of waste, amounting to millions of tons, is generated on a global scale. This waste production plays a substantial role in the rise of global temperatures and is a major contributor to climate change. People often perceive climate change as an intangible global environmental issue, which presents challenges for them to unite around. Nevertheless, garbage is a conspicuous and confined problem that individuals can readily observe and encounter. As per the Intergovernmental Panel on Climate Change (IPCC), the Earth's average temperature has experienced a substantial rise over the past two millennia (IPCC, 2023). Improper waste management methods, such as unregulated incineration, unrestricted dumping, and non-scientific landfilling, also contribute to substantial emissions of greenhouse gases (GHGs), which worsen climate change. Addressing waste management's impact on climate change is critical for achieving sustainable development and protecting the environment.

3.Waste Management and Dengue Control

3.1 Role of Waste In Dengue Vector Breeding

Inadequately constructed landfills and poorly controlled solid waste can attract vectors, such as mosquitoes, resulting in the growth of breeding grounds and the spread of vector-borne diseases, such as dengue. The primary homes of dengue vectors, Aedes aegypti and Aedes albopictus, are mostly artificial containers such as water tanks, flower pots, and discarded tires. These habitats are highly susceptible to climate change. Yasanayake and Zaitchik (2023) showed that Aedes mosquitoes, which transmit dengue, might potentially nest in plastic containers, earthenware, and unused tires. Water quality parameters such as dissolved oxygen, pH, and alkalinity affect dengue vector breeding. These factors, along with the physico-chemical qualities of the water in the breeding habitat, influence the attraction of pregnant mosquitoes to egg-laying. Table 2 presents the results of the principal component analysis (PCA) conducted on the physicochemical properties of several breeding habitats, categorised by container type.

Herath et al. observed that abandoned nondegradable items were the most common and predominantly favourable breeding grounds for Aedes mosquitoes in all studied regions of Sri Lanka. This review also showed that water quality has a significant impact on the quantity and dispersion of these mosquitoes. Furthermore, we have observed that Aedes mosquitoes exhibit tolerance towards a diverse set of physicochemical characteristics, suggesting their ability to thrive in many habitats. Simulations revealed that mosquito populations were consistently greater in non-household settings, such as trash and containers affected by rainfall, in comparison to household habitats (Ominski et al., 2022). The results indicate that non-residential settings, such as locations with trash disposal sites, can act as breeding sites for dengue-carrying insects and increase the probability of disease transmission.

3.2 Importance of Waste Reduction In Mosquito Control

Effective waste reduction is crucial in mosquito management since it significantly reduces the transmission of diseases carried by mosquitoes. Efficient waste management can greatly decrease the spread of mosquitoes by eliminating possible breeding sites, such as stagnant water in discarded containers or rubbish heaps. Consequently, this aids in reducing the number of mosquitoes and mitigating the risk of disease transmission. Furthermore, the implementation of waste reduction strategies can significantly reduce the use of hazardous compounds that have the potential to harm both the environment and human well-being. In his work, Cheremisinoff (2003) discusses the pollution problems associated with swine manure and highlights the importance of efficiently controlling odors in the swine business. In order to mitigate the environmental and health consequences, it is imperative to implement waste reduction protocols that encompass the proper disposal and treatment of swine excrement.

Effective management and eradication of garbage, such as municipal solid waste (MSW) and antimicrobial wastewater, can significantly reduce the spread of diseases carried by mosquitoes. In Guanajuato, Mexico, the utilization of controlled incineration techniques for municipal solid waste (MSW) can generate electricity and reduce the dependence on landfills or open dumps (Rubio-Jimenez et al., 2023). Waste minimization plays a crucial role in reducing environmental pollution and promoting public health through mosquito control.

3.3 Management of Solid Wastes

Proper waste management has the potential to destroy dengue habitats and contribute to a reduced rate of temperature increase. The present approach to solid waste management minimises solid waste disposal by decreasing the amount of waste that requires recycling. We employ various techniques to manage solid waste, selecting the most effective one based on the characteristics of the refuse, the available land, and the disposal cost. The techniques for waste management include incineration (Tan et al., 2023), compaction (Mu et al., 2023), pyrolysis (Locaspi et al., 2023), gasification, and composition. These techniques convert plastic waste and biomass into valuable products such as hydrocarbons, fuels, chemicals, and energy. Incineration and compaction are traditional methods that adversely affect the environment and human health. Pyrolysis and gasification are more sustainable alternatives that convert waste into valuable products. Pyrolysis

involves the thermal degradation of waste to produce hydrocarbons and fuels, while gasification converts carbon-containing products into primarily gaseous ones. The author postulates that implementing any one of these techniques, as discussed in the articles by Jafarian et al. (2023; Meng et al. (2023; Pandey et al. (2023), will result in a reduction in the volume of improperly disposed waste within open areas. Therefore, we anticipate that this reduction will indirectly mitigate dengue transmission by reducing stagnant water bodies, which are the primary breeding sites for mosquitoes.

3.4. Determination of the Container Index

This project is an aspect of a global investigation focused on community-based ecosystem management for controlling the dengue vector. A review of insects was carried out to identify the juvenile stages of Aedes aegypti using available scientific literature. The objective was to figure out the density of mosquito larvae by calculating specific indices. The density of Aedes aegypti larvae can be determined via the density flick method described in Table 3. The density of Aedes aegypti larvae is determined based on factors such as the Container Index (CI) derived from Table 4.

Throughout the survey, larvae were gathered from all containers outdoors using various methods, including dipping, pipetting, or using a dipper, which were chosen based on the type and location of the container. Analyzed using the container index (CI), the larval survey findings were examined. The computation of these larval indices relies on the subsequent mathematical equations:

$$Container\ Index = \frac{Number\ of\ Positive\ Container\ Infested}{Total\ Number\ of\ Containers\ Inspected} \times 100$$

4.Discussion

The current review assesses the container index in 10 different places. Table 5 displays the statistics regarding the quantity of containers examined and the quantity of containers affected by infestation at each location.

The container index (CI) in different endemic regions quantifies the frequency of Aedes larvae, providing valuable information on the potential for dengue vector-borne disease transmission. Aedes mosquitoes frequently used the majority of containers observed in the survey locations, making it easy to monitor their presence. Nevertheless, despite the efforts made, larvae remained detected, demonstrating the vector's enduring presence. Greater CI values are associated with a higher chance of disease transmission by mosquitoes. For example, the cities of Dire Dawa in East Ethiopia and Tiruchirappalli district in Tamil Nadu, India, have significantly high CI values of 54 and 32.2, respectively. These values indicate a significant risk of dengue transmission due to the high density of mosquito larvae.

The epidemics in Dire Dawa City, Ethiopia, and Chennai district, Tamil Nadu, India, highlight the considerable public health problem presented by dengue fever (Assefa Tufa et al., 2023; Chander et al., 2022). The occurrence of these outbreaks can be attributed to causes such as the accumulation of stagnant water, inadequate waste management, and sewage, which provide favourable conditions for the proliferation of Aedes mosquitoes. The low confidence interval (CI) observed in Rawalpindi, Pakistan (0.15) indicates a relatively low number of larvae, which aligns with the decrease in dengue incidence observed between 2007 and 2017 (Rubianti et al., 2018).

5.Challenges and Barriers

5.1 Socioeconomic Factors Affecting Waste Management

Socioeconomic factors significantly impact waste management. Factors such as human resources, education level, training programmes, conflicts, and government restrictions influence waste management in different regions. Furthermore, Velis et al. (2022) attributed the variation in cities' performance in managing municipal solid waste (MSW) to socioeconomic development indicators such as GDP, social progress index, and corruption perception index. Socioeconomic features such as gender, age, education, income, and marital status influence participants' waste collection involvement in the informal waste management sector. Economic and social activities, including industrial activity, income per capita, and population growth, contribute to environmental pollution by generating garbage. The correlation between waste management and economic growth differs among nations. While certain countries exhibit a favourable correlation between the practice of material recycling and the advancement of their economies, other countries do not demonstrate the same relationship. In order to mitigate these effects, it is advisable to establish effective waste management systems, including the implementation of trash sorting and recycling practices. Furthermore, it is critical to provide incentives for the collection and sorting of recyclable, non-biodegradable garbage. By examining and implementing solid waste management strategies adopted by other nations, it is possible to reduce trash and enhance recycling, resulting in improved socioeconomic results.

5.2 Infrastructure Limitations in Waste Collection and Disposal

The lack of adequate facilities for trash collection and disposal poses a significant difficulty, particularly for developing nations. The limitations include insufficient garbage collection coverage, poor waste sorting at the source, disruptions in the transportation chain, and limited disposal facility capacity. The waste collection problem necessitates a meticulous examination of factors such as truck capacity, journey time, distance constraints, and variable and constant expenses. Moreover, the process of gathering solid waste

Table 1. Current Vaccine Candidates for Dengue Prevention (Source: Sandrasegaran, 2016)

Vaccine type	Developer	Process	Progress
Live, attenuated chimeric (recombinant)	Acambis/Sanofi Pasteur	Insertion of genes coding for DENV structural proteins into a yellow fever virus (17D) backbone.	Phase III tetravalent—leading candidate
	Centre for Disease Control (CDC)/Inviragen	Insertion of serotype genes into serotype II (DENV2 PDK53) DNA backbone.	Phase II monovalent
	National Institutes of Health (NIH)/University of Maryland	Insertion of serotype II and III genes into safer, more immunogenic serotype I and IV DNA backbone. Live attenuated DENV Delta-30 mutation	Phase I tetravalent
Live, traditionally attenuated	Walter-Reed Army Institute of Research (WRAIR)/GlaxoSmithKline (GSK)	Attenuation achieved by growing the virus in cultured cells and selecting strains	Phase II tetravalent; technical issues
	Mahidol Institute/Sanofi Pasteur		Phase II tetravalent
Inactivated	GSK	Viruses cultured and killed	Phase I tetravalent
Subunit	Hawaii Biotech	Viral immunogenic envelope is combined with viral non-structural protein antigens to produce recombinant 80% E subunit vaccine	Phase I tetravalent
DNA	WRAIR	Dengue prM-E DNA vaccine incorporating membrane and envelope genes into a plasmid vector	Phase I monovalent

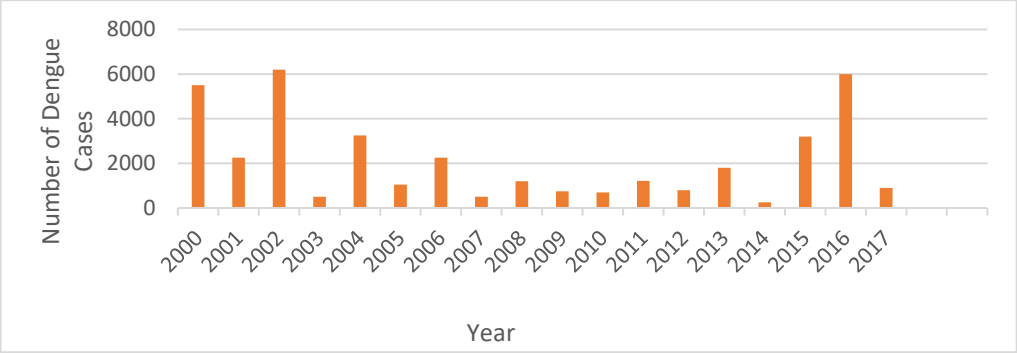

Figure 1. Number of dengue cases reported by Control Room, DGHS, Bangladesh

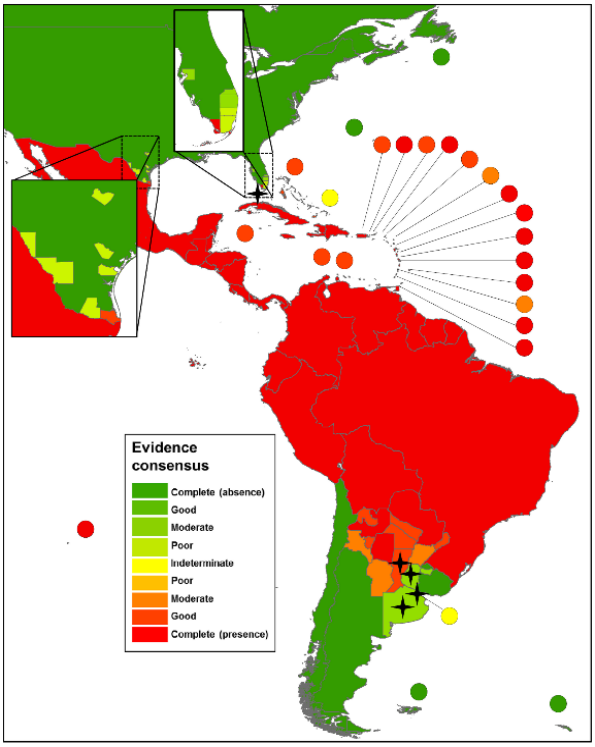

Figure 2. Evidence consensus on dengue virus presence and absence in America

Table 2. Water quality parameters of dengue vector mosquito breeding container types (mean ± SE). Source: (Herath et al., 2024).

Container type	Total dissolved solid (mg/L)	Free ammonia (mg/L)	Total alkalinity (mg/L)	Total iron (mg/L)	Chloride (mg/L)	pH
AC refrigerators	522 (±278)	0.082 (±0.02)	100.7 (±30.5)	0.29 (±0.1)	632 (±528)	6.7 (±0.23)
Bamboo stump	98 (±3)	0.08 (±0.001)	79.5 (±7.5)	0	0	9.4 (±0.5)
Clay plot	124.2 (±14.1)	0.076 (±0.03)	116.8 (±17.2)	0.04 (±0.02)	30.6 (±19.4)	7.78 (±0.52)
Covering items	115.7 (±32.2)	0.28 (±0.26)	96.7 (±57.8)	0.4 (±0.1)	0	7.06 (±0.2)
Discarded degradable	168.7 (±5.91)	0.271 (±0.24)	89 (±25.9)	0.12 (±0.01)	0	7.02 (±0.4)
Discarded nondegradable	186 (±12.3)	0.152 (±0.04)	119 (±6.76)	0.13 (±0.02)	0	7.47 (±0.3)
Gutters	226.8 (±12.2)	1.64 (±0.35)	150.4 (±24.2)	0.56 (±0.14)	0	7 (±1.64)
Commodes and cisterns	60 (±12.7)	0.59 (±0.47)	38 (±13.9)	0.075 (±0.02)	27.5 (±4.79)	7.35 (±0.17)
Ornamental flower pots	1172 (±423)	0.1 (±0.01)	136.4 (±39.4)	0.12 (±0.07)	60 (±8.22)	7.94 (±0.41)
Slab	166 (±6.22)	0.16 (±0.01)	98.14 (±9.98)	1.37 (±0.24)	0	6.98 (±0.13)
Tyres	1547 (±374)	0.084 (±0.004)	182.8 (±36.2)	0.1 (±0.04)	171 (±50.2)	8.82 (±0.03)
Water storage barrels	189.9 (±35.8)	0.08 (±0.02)	126.5 (±43.4)	0.15 (±0.12)	95.5 (±15.4)	7.86 (±0.26)

Table 3. Aedes aegypti larva density according to (WHO, 2000)

Density flick	Larva density
6-9	High density
2-5	Medium density
1	Low density

Table 4. Density larva of Aedes aegypti base indicators (WHO, 2000).

Container Index (CI)	Density flick
1	1
3-5	2
6-9	3
10-14	4
15-20	5
21-27	6
28-31	7
32-40	8
41+	9

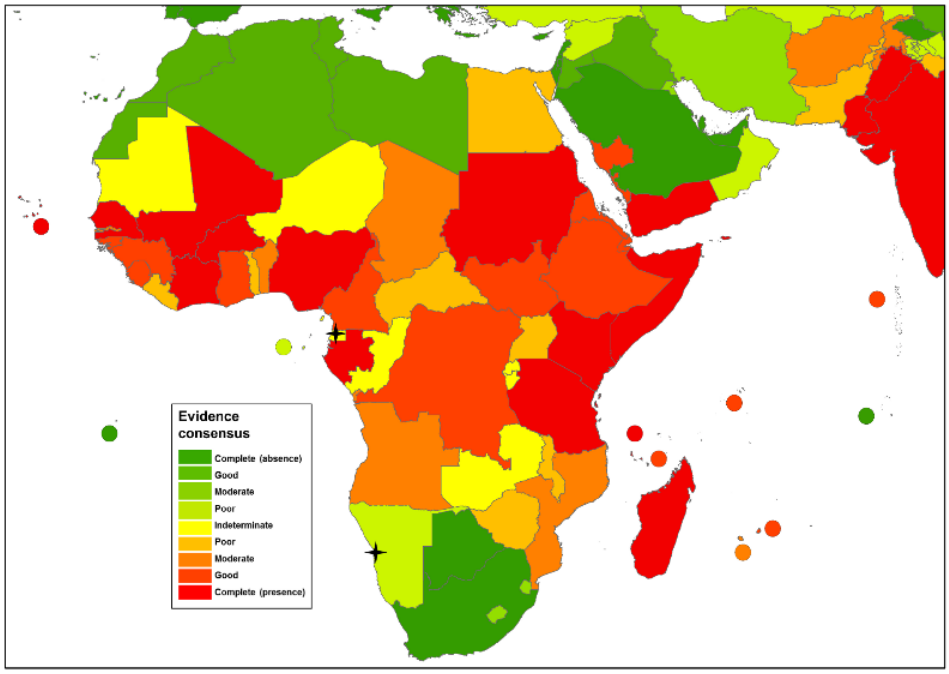

Figure 3. Evidence consensus on dengue virus presence and absence in Africa

Table 5. Mosquitoes identified from larvae collected from containers in review areas.

Location (City Name)	Total Number of Container Inspected	Total Number of Container Infested	Container Index	Reference
Tiruchirappalli district, Tamil Nadu, India	118	38	32.2	Rajesh et al., (Rajesh et al., 2013)
Dire Dawa, East Ethiopia	750	405	54	Getachew et al., (Getachew et al., 2015)
Kolkata, West Bengal, India	6150	1307	21.25	Banerjee et al., (Banerjee et al., 2013)
Kepong, Kualalum Pur, Malasiya	2067	227	10.98	Rahim et al., (Rahim et al., 2021)
Semarang, Central Java, Indonesia	659	39	5.92	Yuliawati et al., (Yuliawati et al., 2020)
Trujillo, Venezuela	12564	1023	8.14	Lenhart et al., (Lenhart et al., 2022)
Medan, North Sumatra, Indonesia	519	60	11.56	Siregar et al., (Siregar et al., 2016)
Langkat, North Sumatera, Indonesia	594	14	2.36	Siregar et al., (Siregar et al., 2016)
Banten, Indonesia	2575	400	15.53	Prasetyowati et al., (Prasetyowati et al., 2018)
Rawalpindi, Pakistan	10008037	14985	0.15	Mukhtar et al., (Mukhtar et al., 2018)

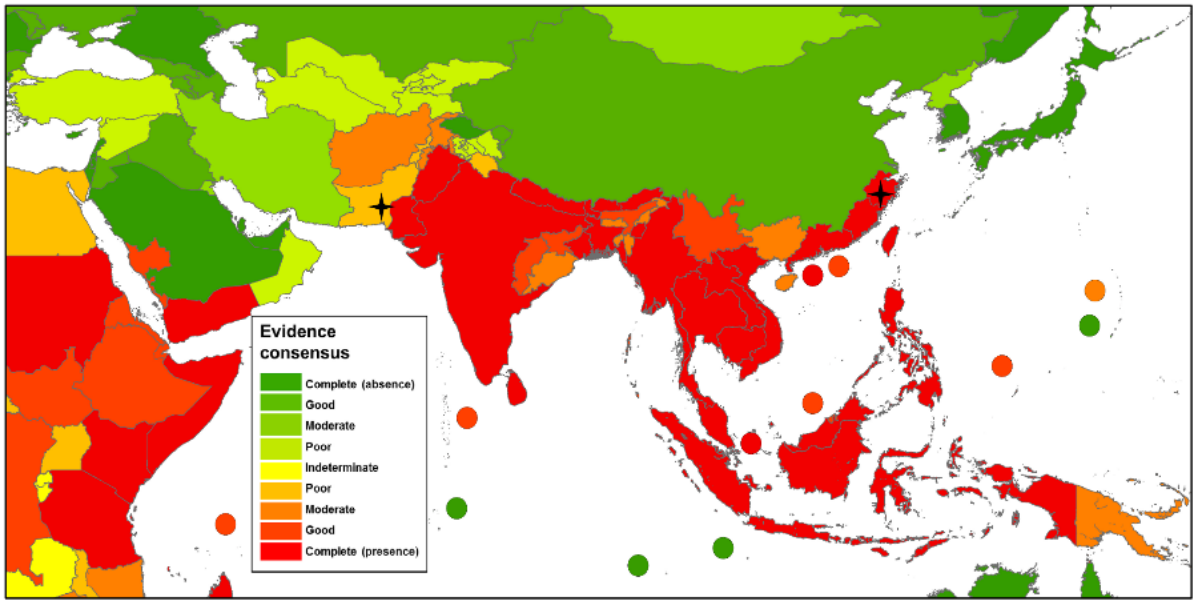

Figure 4. Evidence consensus on dengue virus presence and absence in Asia

incurs significant costs, and the placement of garbage receptacles and the timing of collection are essential considerations.

Infrastructure constraints in waste collection and disposal encompass issues such as limited coverage in waste collection and low rates of recyclable material recovery. Additionally, there are high costs associated with selective waste collection, an inadequate number of partnerships, and insufficient efforts focused on environmental education and promoting selective waste collection. There are also problems with the system's lack of government oversight, the fact that trash isn't separated properly at the source, problems with the logistics of selective collection, unfair distribution of trash by cooperatives, the fact that collectors are often not paid enough, and the fact that cooperatives and public agencies have resources that aren't being used to their full potential. These restrictions impede the sustainability and effectiveness of garbage collection systems, necessitating enhancements in management, transparency, stakeholder integration, public education, improved working conditions, and compensation for waste collectors.

6 Policy Implications and Recommendations

6.1 Policy Frameworks For Integrating Waste Reduction In Dengue Control Programs

Initiatives for dengue control can incorporate waste reduction through policy frameworks. Conventional methods of vector management, such as eliminating breeding grounds or physically lowering mosquito populations, are becoming less successful due to pesticide resistance and logistical difficulties. International experiences have demonstrated the necessity of engaging families and communities in efforts to decrease breeding sites and deploy advanced techniques such as biological management and physical control of sources. Multiple studies have examined policy frameworks for incorporating waste reduction into dengue control initiatives. Sharma et al. introduced an extensive framework for monitoring dengue disease. This framework combines several data sources, methods for visualisation, disease status assessment, and prediction analysis (Sharma et al., 2023). Arham et al. (2018) highlighted the significance of employing a comprehensive research strategy that integrates ecosystem-based health methods, adaptive management, and community engagement in decision-making processes for the purpose of managing dengue illnesses. Lin et al. carried out a community-based integrated intervention in Guangzhou, China. The intervention resulted in a notable decrease in the number of mosquitoes and reported cases of dengue. This review emphasises the usefulness of an integrated programme for controlling dengue. Tissera et al. (2016) examined the redesign and strategic planning of Sri Lanka's dengue-control program. They proposed the creation of a dedicated dengue-control unit and the implementation of improved vector control measures as part of their policy framework for dengue control.

Promoting recycling as a component of dengue prevention requires a comprehensive strategy that encompasses laws, community engagement, integrated vector control, cross-sector collaboration, and methods to monitor and analyse the situation. Governments can limit the impact of dengue transmission and protect public health in vulnerable populations by creating comprehensive policy frameworks that address the socio-environmental factors influencing the spread of the illness.

6.2 Role Of Government And Non-Governmental Organizations

The government has carried out many measures to regulate the spread of dengue on a global scale. The measures encompass training healthcare professionals, assessing national guidelines on case management, enhancing dengue services, augmenting bed capacities in hospitals, reinforcing mass awareness campaigns, guaranteeing the availability of diagnostic kits, offering diagnostic services at reduced rates, and fostering collaboration with city corporations, municipalities, and other agencies. The Bangladeshi government has stressed the importance of coordination, collaboration, and partnership across all relevant ministries and agencies, with the Ministry of Health and Family Welfare taking the lead. Additionally, the government has consistently worked to improve surveillance, vector management, community involvement, and monitoring and evaluation throughout the year (Hossain et al., 2022). In addition, the government has implemented many steps to address the occurrence of dengue, which include campaigns for controlling the vectors. However, experts consider the vector control initiatives in Bangladesh inadequate and recommend the implementation of enhanced techniques (Kayesh et al., 2023).

Various countries, including Bangladesh, have applied a community-based approach (CBA) to manage vectors and promote individual behaviour change (Chowdhury & Haque, 2012). Nevertheless, the community-based approach (CBA) has predominantly been unsuccessful as a result of a lack of awareness and consideration of the fundamental needs and viewpoints of the local community members. As a result, it is critical to involve non-governmental groups and community-based organizations in dengue control efforts to cater to the local people's unique needs and viewpoints.

6.3 Strategies for Sustainable Waste Management Practices

Efficient approaches to maintaining sustainable waste disposal practices include trash reduction, recycling, and waste material utilization. Adopting a circular waste management paradigm that prioritises closing the loops and achieving sustainable development goals can help promote environmental sustainability. This model encourages waste reduction by optimizing the use of resources and ensuring they yield maximum value. This model involves the creation of durable items, facilitating their repair and

remanufacturing, and ultimately recycling materials for further use in the production process.

Collaboration among stakeholders is crucial for efficiently closing the loops in waste management. Governments, organisations, communities, and individuals all have crucial responsibilities in implementing sustainable practices. Policies and regulations play a crucial role in trash reduction and recycling efforts, while businesses can use environmentally friendly manufacturing processes and packaging designs. Community engagement and education initiatives have the potential to enhance public understanding of the significance of waste segregation, suitable recycling methods, and conscientious consumption practices.

7 Future Directions

7.1 Emerging Technologies For Waste Reduction And Dengue Control

There is a need to invent technology that can efficiently tackle both trash reduction and dengue control. Given the mounting difficulties in waste management and the mounting environmental demands, it is becoming increasingly evident that achieving a state of Zero Waste is crucial. Adelaide, Australia, and San Francisco are exemplary Zero Waste towns that have effectively implemented waste management techniques. These strategies involve utilizing legislation, innovative programs, and community engagement to redirect substantial amounts of waste away from landfills.

Zero Waste projects not only promote environmental sustainability, but also provide economic advantages by decreasing the necessity for constant resource replenishment. The Zero Waste Alliance (ZWA) helps to carry out Zero Waste projects in various communities and industries (Alliance, 2013).

Integrating developing technology with proactive waste management and public health policies is crucial for addressing environmental concerns and enhancing community well-being. Additional review and cooperation are necessary to progress towards a Zero Waste future and effectively combat diseases such as dengue.

7.2 Areas for Further Research and Collaboration

Potential avenues for additional investigation and cooperation in waste reduction and dengue management comprise the necessity of engaging the community in efforts to diminish breeding grounds and enhance home hygiene. For dengue control, technological advancements are critical for minimizing waste. Although current research focuses primarily on urban zero-waste systems, future studies must investigate comprehensive waste reduction solutions for several other waste streams. In addition, tools such as the Green City Index, which evaluates environmental performance based on different variables, including waste management, provide essential data for policymakers and stakeholders in supporting sustainable practices (Siemens, 2012). Nevertheless, there is a need for research on the efficacy of community mobilisation in reducing dengue vector reproduction at the home level. Furthermore, more research is needed to develop more cost-effective and simplified waste management systems. Finally, it is imperative to foster cooperation among governments, communities, and researchers in order to effectively tackle these research shortcomings and improve waste reduction and dengue control efforts.

8 Conclusion

The global incidence of dengue is significant, and it is a growing barrier for public health authorities and policymakers. If no action is taken in the future, there is a possibility of substantial dengue epidemics occurring. Dengue exerts a significant influence, affecting millions of individuals annually through infection. Efforts to prevent dengue involve the creation of vaccinations, although their effectiveness against all dengue virus serotypes is currently restricted. To effectively tackle the issues that arise from dengue, a range of actions are required, such as establishing surveillance systems, conducting public awareness campaigns, and conducting research on the correlation between dengue and environmental factors. Improving the scientific foundation for conducting evaluations of control techniques and their impacts is crucial to effectively mitigating this increasingly prevalent global threat. We expect that evaluating the current distribution and burden of dengue risk will aid in achieving the goal of reducing the spread of vector-borne diseases like dengue. Globally, there would be a significant rise in the occurrence of dengue. Therefore, public health officials must equip themselves adequately to handle anticipated surges in dengue transmission.

The authors of this review aim for their work to serve as an enlightening and motivating resource for a diverse range of individuals. This endeavour aims to strengthen the efforts of experienced professionals, up-and-coming researchers, instructors, and students. Due to the urgent and increasing concerns about the influence of inappropriate waste disposal on dengue fever epidemics, it is critical to maintain and progress research in this area.

Author contributions

Original draft preparation was conducted by S. The manuscript was reviewed and edited by F.B.M.S., M.A.A., A.H., M.S.A., M.J.I., M.M.H., D.S., M.S.R., S.S.D., and M.H. All authors have read and approved the final version of the manuscript for publication.

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Competing financial interests

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