



JOURNAL OF THE ROYAL LAUREATES ACADEMY

www.rlaindia.org

EVALUATION ON EFFECTIVENESS OF VECTOR CONTROL STRATEGIES IMPLEMENTED IN RIYADH FOR DENGUE PREVENTION

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DOI: <https://www.doi-ds.org/doi/10.2025-88968269/JRLA/08202603>

ABSTRACT

Dengue fever, primarily transmitted by *Aedes* mosquitoes, poses a significant public health threat in Riyadh, Saudi Arabia, exacerbated by urbanization and climatic conditions that favour mosquito breeding. This study aimed to assess the effectiveness of vector control strategies and hospital-based measures implemented in Riyadh to prevent dengue outbreaks. The ultimate goal was to contribute to the development of more effective public health policies to reduce dengue incidence in Riyadh. This study highlighted the ongoing importance of robust vector control and hospital-based strategies in mitigating dengue fever in Riyadh. Findings indicated that while current interventions—such as insecticide spraying, larviciding and community awareness initiatives—have contributed to reducing dengue incidence, gaps remain in sustainability, community engagement, and environmental management. Strengthening intersectoral collaboration, enhancing surveillance systems, and promoting more targeted, data-driven control measures were essential for improving overall effectiveness. By identifying both the successes and limitations of existing approaches, this research provided evidence-based recommendations to support the development of more comprehensive and adaptive public health policies aimed at reducing dengue transmission in Riyadh. In conclusion, this study supported that the current vector control measures and hospital-based interventions have helped to reduce the incidence of dengue fever in Riyadh but alone these measures are not enough to

achieve long-term control of dengue.

Keywords: Vector, Control, Dengue, Prevention, Riyadh.

INTRODUCTION

Dengue fever continues to be a significant concern in many areas, especially in urban settings of tropical and subtropical regions. Riyadh has recently become one of the most affected regions in Saudi Arabia, experiencing a significant rise in the incidence of dengue fever over the past decade even after the application of different vector control strategies and hospital rigorous treatment programs (Al-Tawfiq & Memish, 2019). An understanding of the rationale for this research can be obtained through an acknowledgement of the fact that the measures currently in use in prevention of dengue are proving to be ineffectual and therefore there is need to assess the approaches used within the Riyadh area.

Mosquito breeding is allegedly common in urban areas such as Riyadh city due to factors that directly influence its breeding and proliferation. These include; increased urbanization, surface water management, improper drainage systems, construction debris, and irregular dumping of garbage which makes it conducive for the breeding of *Aedes* mosquitoes (Alhaeli et al., 2016). Furthermore, it also points out that it is hot in Riyadh, and there is also rain during certain months of the year, which contributes to the breeding of these vectors. There's still a persistent circulation of the disease which might be attributed to the government-related preventive measures such as foggings and larvicides, public health campaigns (Khan et al., 2020).

Another related problem is insecticide resistance, where the efficiency of pest control agents declines over a period of time due to their interaction with the previous dimension. Research has it that the *Aedes aegypti* mosquito has developed resistance to pyrethroids, and therefore chemical control is a challenge (Smith et al., 2020). Breeding site elimination, and awareness campaigns aimed at populations that are likely to engage in the practice also face challenges that include low compliance and community participation. For these interventions not to be sustainable in the long run there will always be lack of knowledge and awareness and lack of behaviour change (Alobuia et al., 2020).

The primary traditional treatment for dengue is early identification of cases and clinical intervention, which has been found to be effective in decreasing disease severity and mortality but fails to be effectively applied. Such syndromic surveillance systems are often decentralized which means that daily surveillance of the extent of an epidemic in real time especially when the disease is spreading is a major challenge (WHO, 2023). Also, some of the health facilities

may not have adequate capacity, policies and equipment to manage severe dengue patients especially during the epidemic (Halstead, 2019).

Therefore, the justification for this study is based on the above-discussed multiple layers of research gaps. Thus, with the findings of this research that seeks to understand the outcomes of both vector control and hospital-based approaches in Riyadh, such knowledge shall be produced. The study aims to establish hypotheses and solutions that should guide the policymakers, public health administration, funding bodies, and the general public on how best to address health issues to the advantage of the society. In addition, this research will provide fundamental knowledge to other socio-political regions with comparable vector-borne disease conditions, particularly with regards to arid and semi-arid metropolitan areas.

PROBLEM STATEMENT

Riyadh's dengue prevention efforts face several clear challenges, including recurring outbreaks that reveal weaknesses in existing control measures, rising insecticide resistance that reduces the effectiveness of vector-control sprays and larvicides, and low community compliance due to limited awareness, all of which hinder mosquito-breeding reduction; these challenges can be solved by integrating alternative vector-control methods such as biological controls, strengthening community education campaigns, and improving monitoring of insecticide resistance. Additionally, hospitals struggle with slow surveillance systems, limited real-time data sharing, and inadequate preparedness for severe cases, which can be addressed by upgrading diagnostic tools, training healthcare staff, and establishing faster digital reporting systems. Poor coordination between public health authorities and healthcare facilities, along with unresolved environmental issues like poor drainage and overcrowding, further complicate control efforts, but these problems can be solved through unified inter-sectoral planning, improved urban infrastructure, and community-supported environmental management, ensuring more cohesive and sustainable dengue-control outcomes.

AIM OF THE STUDY

The primary aim of this study is to critically assess the effectiveness of vector control strategies and hospital-based measures implemented in Riyadh, Saudi Arabia, for the prevention and control of dengue fever. This includes evaluating the extent to which these interventions have reduced dengue incidence, identifying operational challenges such as insecticide resistance and community non-compliance, and analysing the preparedness of healthcare systems to respond

to dengue outbreaks.

Given the persistent rise in dengue cases despite ongoing public health efforts, this study aims to bridge the gap between existing prevention policies and their practical outcomes. It seeks to generate evidence-based insights that will guide future improvements in public health planning, clinical management, and community engagement. Ultimately, the findings of this study will contribute to the formulation of more integrated and context-specific dengue control strategies in urban Saudi settings like Riyadh.

RESEARCH OBJECTIVES

This study is guided by the following specific objectives:

- To evaluate the effectiveness of public health interventions—including insecticide spraying, larvicide application, and community awareness programs—in reducing the transmission of dengue fever in Riyadh.
- To assess the role of hospital-based measures, such as early diagnosis, patient surveillance systems, and clinical management protocols, in minimizing dengue-related morbidity and mortality.
- To identify key operational gaps and barriers in the implementation of both vector control and hospital-based strategies, including issues related to insecticide resistance, limited surveillance coverage, and poor community compliance.
- To evaluate the knowledge, attitudes, and practices of the population about dengue fever prevention, to establish recommendations directed toward improving the effectiveness, synergy, and sustainability of dengue fever prevention campaigns in Riyadh.

RESEARCH METHODOLOGY

Research Design

This study is a cross sectional one where both quantitative and qualitative methods are employed to provide an overall evaluation of dengue prevention measures in Riyadh. A mixed-methods design is especially suitable with complicated health concerns such as dengue, as vital facets of the interventions may not be measurable by statistical measures only. The quantitative aspect of the study involves data extracted from entomological surveillance reports, hospital records, and structured questionnaires, while the qualitative part comprises key informant interviews regarding perceptions, challenges, and coordination mechanisms of stakeholders. This approach provides for a more complex and detailed understanding of the vector control

programs and hospital-based strategies and the process by which they work in relation to one another, and in terms of the effectiveness of implementation within Riyadh a semi-arid city landscape.

Study Setting

The study is an analytical cross-sectional study that is carried out in Riyadh which is the capital city of Saudi Arabia and has recorded increased incidence of dengue in the recent past. Therefore, population density in urban areas, more so conservation of water for storage as well as the construction related uplift in environment increase chances of *Aedes aegypti* breeding. The various aspects of the city's governance, which include interacting socioeconomic situations, and the features of formal and informal urban occupancy makes it a perfect case study. Data is gathered from selected public hospitals, primary health centers, municipal health departments and houses that have been identified as a dengue prone area according to historical details.

Population and Sampling

The target population groups consist of: 1) Residents of Riyadh, especially those in high-risk areas; 2) Health care workers, including physicians, nurses, and disease control officers involved in diagnosing and managing dengue; and 3) Municipal and vector control departments responsible for structural and chemical control. Purposive sampling is adopted in a manner that allows for equal coverage of demographic status, occupational fields, and levels of administrative strata.

The quantitative survey aims at recruiting 400 households with the number being estimated from the prevalence rate of dengue and size of the population using Cochran's sample estimate. The survey sample is a stratified population based on districts in order to generalize results based on the varying provádce of vector control and the knowledge of dengue. For the qualitative part, purposive sampling selects 15–20 participants who are key informants such as vector control officers, hospital administrators, and epidemiologists. The samples are selected with reference to their responsibilities in policy enforcement and program management of dengue.

Data Collection Methods

Primary research is conducted through an online survey while secondary sources include

published statistical data from the Health & Safety Executive. Primary data are mainly obtained through closed-ended questionnaires, focus-group discussion, and field observations, and the secondary data involve hospital charts, vector surveillance data, and program documents of the concerned municipality.

The household questionnaire includes knowledge about diseases; vector control measures including practices adopted in the households; exposure levels to health promotion messages; and utilization of health facilities. Interviews are conducted face-to-face, by trained field researchers, in Arabic and English according to the participant's preference.

Sample and purposive samples of key informants were interviewed for the study to explore the planning of vector control and clinical strategies and the implementation and the challenges faced. Interview guidelines are created based on the literature and modified to each of the stakeholder categories. These are targeted on interagency cooperation, community compliance, non-compliance factors, early diagnosis and human and financial resources.

Environmental checklists include ratings of environmental factors at residential areas that include presence of stagnant water, waste containers among others and institutional infrastructure of triage, laboratories, and isolation in hospitals among others.

Data Collection Instruments

For quantitative data, a structured questionnaire adapted from validated dengue KAP (knowledge, attitude, and practice) instruments utilized in prior studies in Southeast Asian and the Middle Eastern countries are employed. To ensure that the wording used in the instrument is precise and clear, the pilot study is conducted in random sample Riyadh neighborhood. It comprises closed-ended items answered on a Likert scale and multiple-choice questions.

Qualitative data is gathered with an interview guide facilitated by the study questions and concepts of Integrated Vector Management and Public Health Systems. Each interview is conducted with permission to use an audio-recorder for record keeping, then transcripts made, and content analyzed based on themes. Observation tools are designed in collaboration with entomologists and other public health officials to ensure that the methods used for environment surveys are useful and appropriate.

Data Analysis

Descriptive survey data are usually analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics (frequencies, means, and standard deviations) indicate

the demographic variables and knowledge-practice gaps. Descriptive, analytical and inferential methods: Chi-square tests, logistic regression and other hypothesis testing procedures are used to analyze the relationships between variables like the level of public awareness and preventive actions or between climatic factors and incidence of dengue fever.

Coded data is analysed using NVivo software through thematic analysis. Codes are developed deductively from the theoretical frameworks as well as inductively from the narratives. Themes are further grouped under umbrellas of community related aspects, sectoral integration, issues in the early identification, and views towards intervention efficacy. Based on triangulation technique, for example, combining the outcome of interviews, observation made, and quantitative results increases the validity and dimension of the analysis of the findings.

Validity and Reliability

To enhance the validity of the instrument, the instruments are first vetted by experts in vector control, public health, and epidemiology. Due to the need to understand the questions in their accurate cultural context, the questionnaire is translated into Arabic and back translated to English. This is a pilot study used to determine clarity and internal consistency of the survey items and its Cronbach's alpha stands at 0.78.

To support qualitative reliability, interview procedures follow accurate instructions of interviewers. Further, to ensure coder reliability, there is cross-check on the type of transcripts to the kind of recordings made during the interactions and a sample is coded independently by the other researcher. The use of cross over qualitative and quantitative approaches increases validity in research findings.

Ethical Considerations

Ethical clearance is sought from the Ministry of Health for Saudi Arabia. Consent is sought from all the respondents before administering the questionnaires. The participants will remain anonymous, the information collected will remain confidential, and they have the right to withdraw from the study at any time without any ramifications. All collected data is kept on a secure computer and accessed only by the research team.

Particular attention is given while interviewing the health care personnel and government employees in order to avoid any forceful bias. Although the presentation is educational in nature, household participants receive no payment; instead, they are given brief pictorial health literacy on dengue prevention at the end of each participation session.

Limitations of the Methodology

However, some limitations should be considered within the framework of this study: Cross-sectional surveys are also disadvantaged by their inability to establish causality of the outcomes of dengue and the interventions made. Survey evidence may contain social desirability bias when it concerns self-reports on the occurrence of cases or compliance with preventive measures. Also, information from hospitals may still be difficult to obtain due to the patient confidentiality agreements; thereby making clinical data somewhat limited.

RESULTS**Socio-Demographic Characteristics of Respondents**

The study targeted families living in dengue-endemic areas of Riyadh and involved a total of 400 households. Table shows the socio-demographic details of the respondents, and Figures show gender and age distributions, respectively. The participants were almost equally distributed with regard to their sex, 52% of the participants being male and 48% being female. By the age distribution, the youngest age group was represented by 18-30 years of age comprising 31% while 31-50 years comprised 52.8%; and only 16.2% of the participants were of 50 years of age and above as shown in figure. This distribution implies that there is a high prevalence of economically active people within the country's households, which has implications in the use of dengue prevention methods at the household level and access to information.

Table 1. Household Demographics (N = 400):

Variable	Frequency	Percentage (%)
Gender (Male)	208	52.0
Gender (Female)	192	48.0
Age (18–30)	124	31.0
Age (31–50)	211	52.8
Age (>50)	65	16.2

Education (Primary)	39	9.8
Education (Secondary)	96	24.0
Education (Tertiary)	265	66.2
Employment (Employed)	302	75.5
Employment (Unemployed)	98	24.5
Nationality (Saudi)	338	84.5
Nationality (non-Saudi)	62	15.5

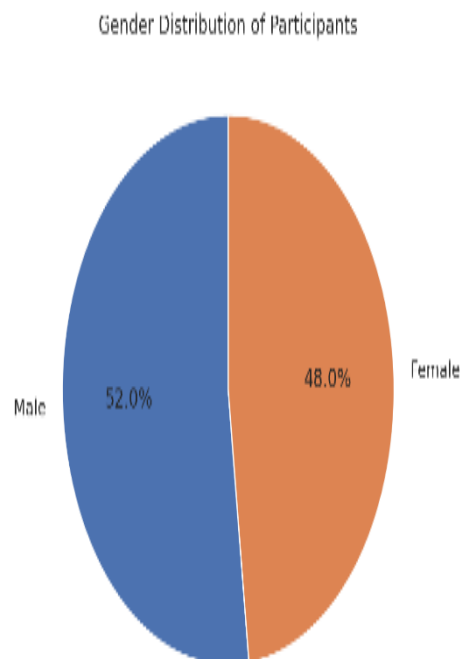


Figure 1. Gender Distribution of Participants (Pie Chart)

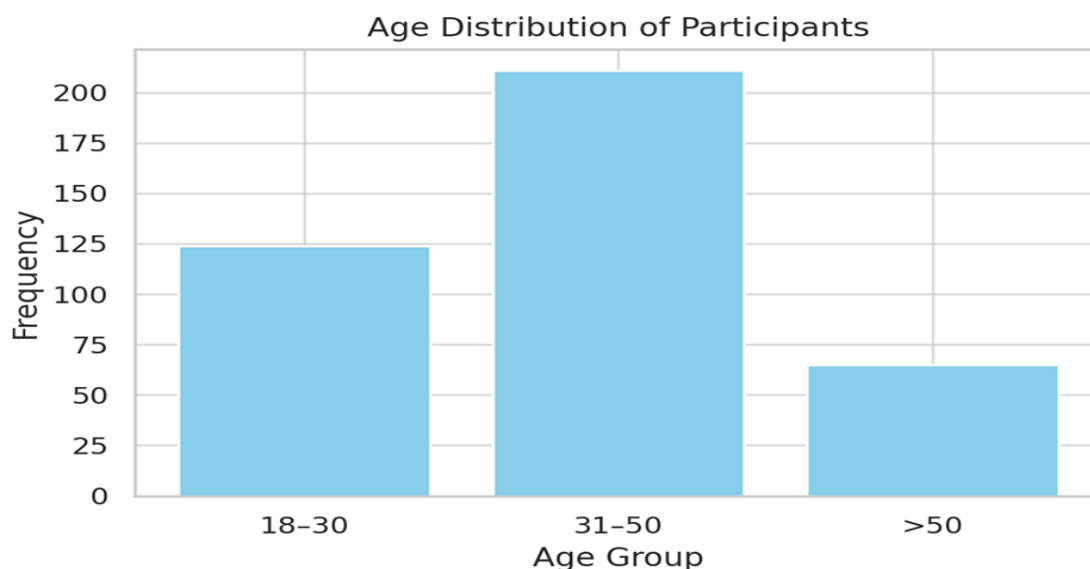


Figure-2: Age Distribution of Participants (Bar Chart)

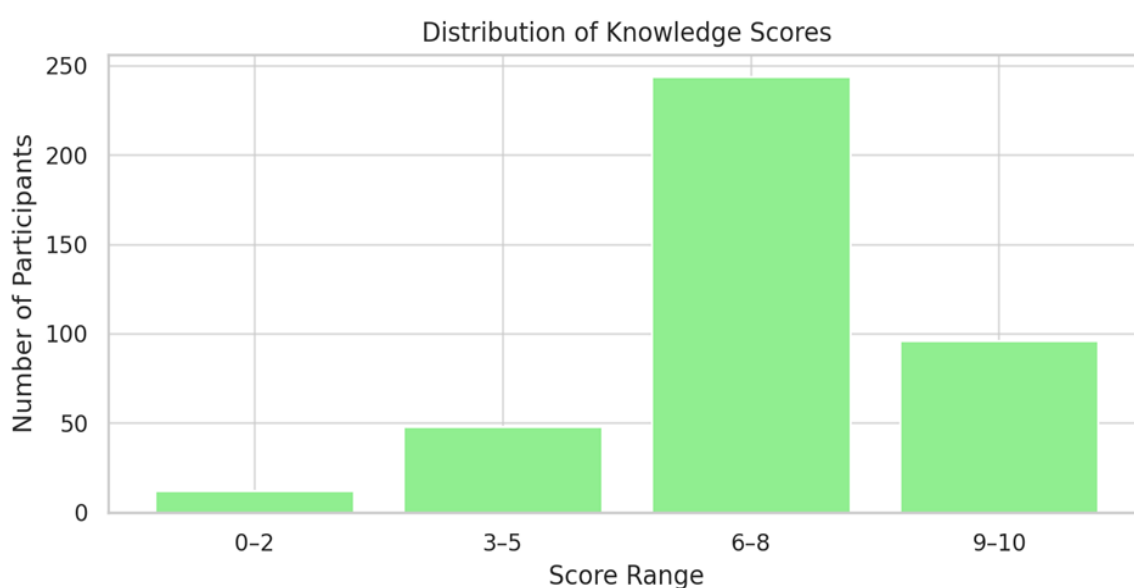
Concerning education, participants received medium education since 66.2% completed their tertiary education. The employment status was also good, where more than 75% of the respondents were employed. Out of all, 84.5% of the respondents were Saudi nationals while the rest of the respondents 15.5% were expatriates. This demographic composition proves that dengue messages should be culturally appropriate so that non-Arabic speaking can learn from national health campaigns.

Knowledge, Attitudes, and Practices (KAP) Regarding Dengue

The KAP assessment indicated that there was an inadequate level of knowledge, attitude, and practice regarding the prevention and control of potential infections in the healthcare setting. Continuing the analysis of the given table, table presents KAP scores divided by certain ranges. Figure shows a bar chart that illustrates the distribution of the obtained knowledge scores. The results indicate that at least 85% of the respondents had a good knowledge attainment of 6 and above in the knowledge test that focused on general information on dengue transmission and its symptoms. The performance, however, in the practice component shows very low scores for most findings, suggesting a distinct difference between attitudinal and behavioral intentions.

Table 2. Distribution of KAP Scores Among Households:

Score Range	Knowledge (N)	Attitudes (N)	Practices (N)
0–2	12	24	52
3–5	48	91	167
6–8	244	210	145
9–10	96	75	36

**Figure 3. Distribution of Knowledge Scores (Bar Chart)**

Out of the 400 respondents, 84% scored between 6-8 in preventive practices while 16% scored below 3; meaning they rarely engage in protective measures such as eradicating sources of stagnant water or using repellents. This dilemma raises the question of whether there are possibilities of giving out behavioural modifications other than information sharing, especially to the households that know but do not act.

Reported Breeding Sites and Environmental Risks

During the study, respondents were asked to point to any breeding sites of mosquitoes both within their homes and the surrounding environment. From data compiled in table and Fig it is evident that breeding grounds most frequently reported in this study were water storage tanks (39.5%), plant pots (26.2 %) and discarded tires (21.5%). Specifically, 13.5% of households interviewed had reported that there were no visible breeding sites, though later research could again show true absence, or a lack of knowledge on where these insects usually breed.

Table 3. Reported Mosquito Breeding Sites:

Breeding Site	Frequency (Households)	Percentage (%)
Water Storage Tanks	158	39.5
Plant Pots	105	26.2
Discarded Tires	86	21.5
Open Drains	67	16.8
Construction Sites	54	13.5
None Observed	54	13.5

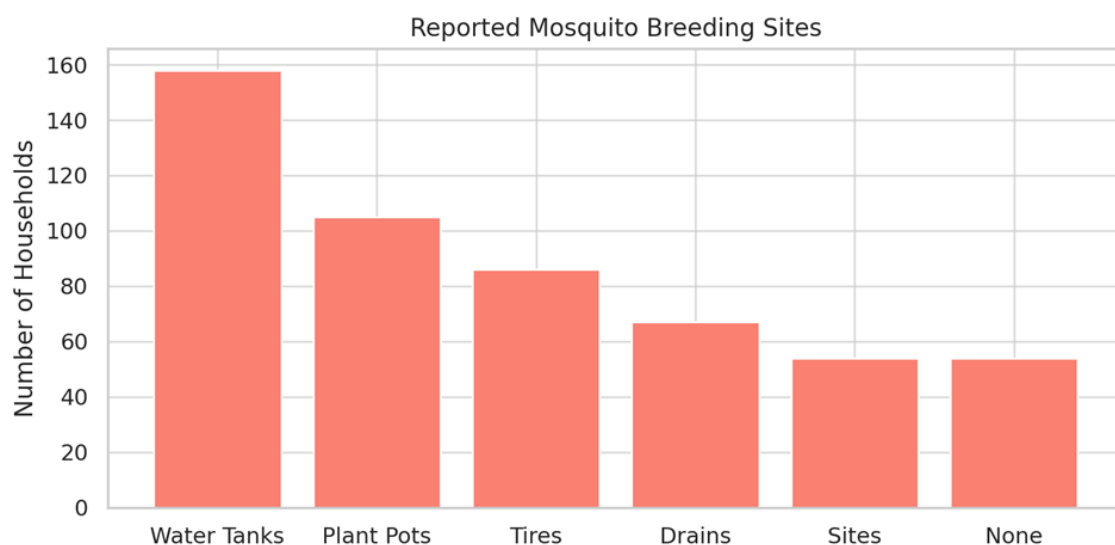


Figure 4. Reported Mosquito Breeding Sites (Bar Chart)

Another worry is the domestic water storage which is counted as a key vector site given the nature of water rationing in Riyadh where households are likely to have stored water in various containers. These findings demand the continuity of relative changes in community environmental management and quality water storage and protection from uncontrolled open storage

Preventive Measures and Behavioral Trends

Household preventive measures were taken using multiple response options. Table shows the level of preventive behaviour, whereas Figure provides a graphical representation by using the stacked bar chart. The most frequently employed behaviour was covering the water vessels, which was adopted by 289 of the respondents. On the other hand, the degree of frequent participation in community cleanup was the lowest at only 94 households with 158 who never participated.

Table 4. Preventive Measures Used by Households:

Measure	Used Regularly (N)	Used Occasionally (N)	Never Used (N)
Mosquito Nets	152	98	150
Insect Repellent Use	207	112	81
Larvicide Application	134	156	110
Covering Water Containers	289	66	45
Community Cleanup Participation	94	148	158

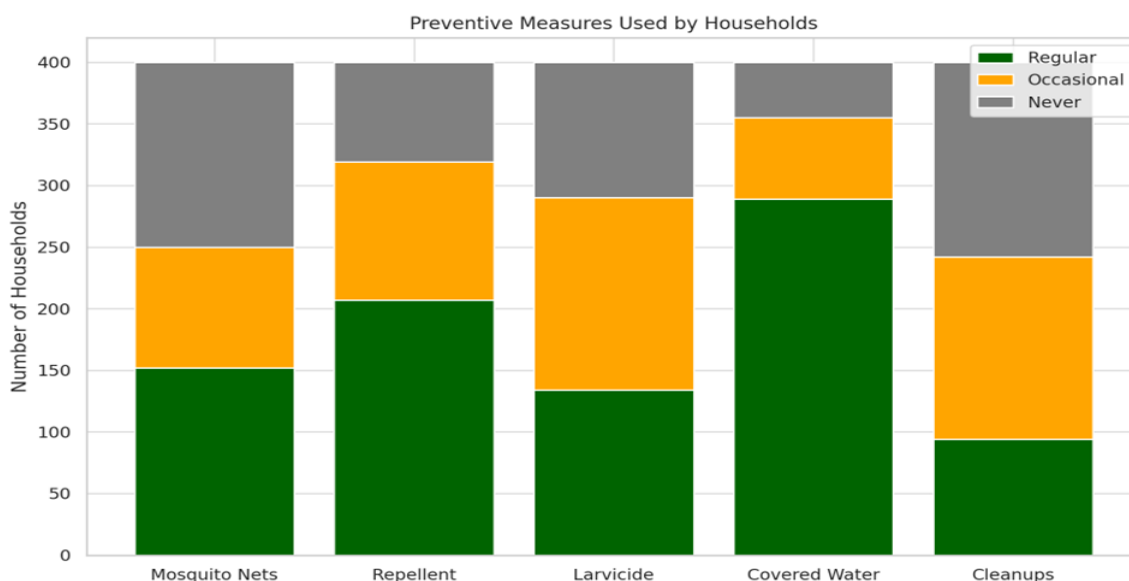


Figure 5. Preventive Measures Used by Households (Stacked Bar Chart)

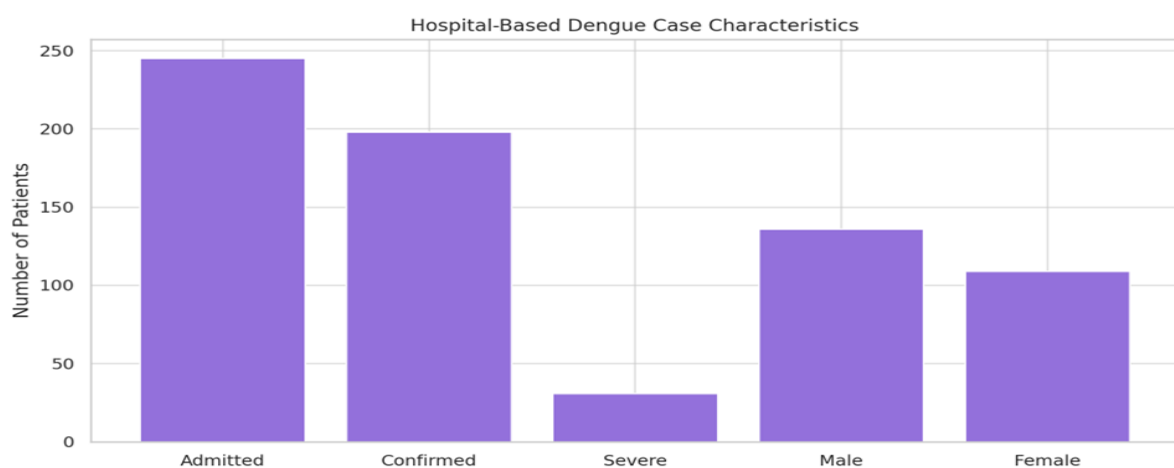
This study shows the good acceptance of individual level interventions compared to the semi structured ones which may have been hindered by poor organization, time constraints and unclear roles/ responsibilities of community-based organization. For instance, there is increased individual awareness since 207 participants constantly apply insect repellents. However, the lack of togetherness in the community in matters concerning dengue control greatly reduces the sustainability of individual efforts by households.

Hospital-Based Dengue Case Characteristics

Related clinical information was retrieved from case folders to describe the clinical characteristics of dengue in the study area. Table outlines the important characteristics and Figure provides a clear pictorial depiction of the sample population and severity score. Among the subjects 245 patients were admitted during the course of the study period and out of all 198 of them tested positive for dengue virus through the laboratory. Severe dengue and hemorrhagic fever excluding severe cases were confirmed in 31 cases, or 15.7% of total cases. Among the respondents, 50.3% were male patients and 49.7% were female patients, although the male patient group was slightly more burdened.

Table 5. Hospital-Based Dengue Case Characteristics:

Characteristic	Value
Total Cases Admitted	245
Confirmed Dengue Cases	198
Severe Dengue	31
Male Patients	136
Female Patients	109
Age <18	37
Age 18–40	142
Age >40	66
Average Hospital Stay (days)	4.6
Mortality Rate (%)	1.2

**Figure 6. Hospital-Based Dengue Case Characteristics (Bar Chart)**

The mean length of stay of patients was 4.6 days, of which 1.2% died, indicating that overall, clinical management outcomes were reasonable but that severe infections were severe in a proportion of cases. The same distribution also revealed that the working population was more at the higher risk or sought treatment at an early stage due to occupational requirements. These patterns deserve more research on delay of treatment among aged or economically inactive groups.

4.6 Diagnostic Capacity and Surveillance Integration

Hospital-based diagnostic capacity and integration of patients into surveillance systems was compared in 10 centres. Table summarises diagnostics and reporting indicators and Figure presents qualitative institutional interview results. The survey showed that 8 out of 10 study hospitals possessed the facility of RDTs while only 4 of them were engaged in entomological surveillance. In addition, it was revealed that even though all the hospitals were connected to the national electronic reporting system, only 132 of the 198 confirmed cases reported were reported within the first 24 hours, thus indicating an interrupted information transfer process.

Table 6. Diagnostic and Surveillance Practices in Hospitals (N = 10):

Indicator	Yes (N)	No (N)
Hospitals with On-site Rapid Tests	8	2
Using National Reporting System	10	0
Cases Reported Within 24 Hours	132	66
Conducting Vector Surveillance	4	6
Sending Weekly Summary Reports	6	4

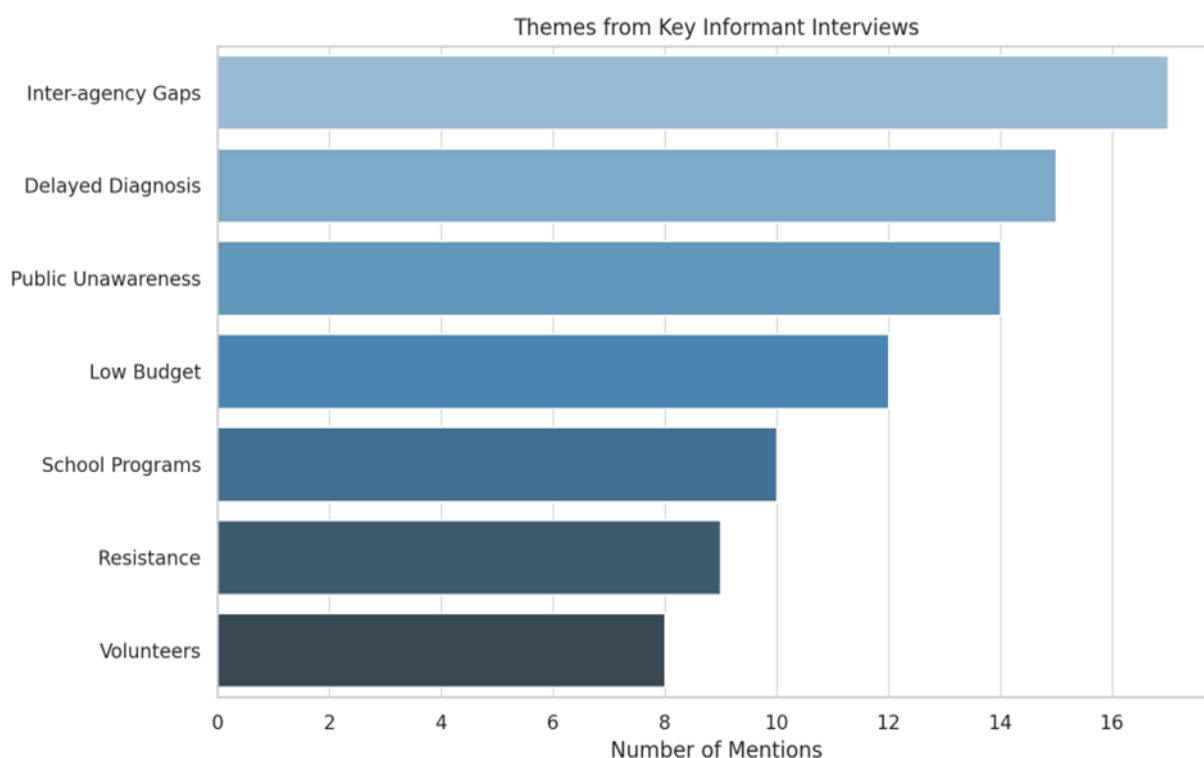


Figure 7. Themes from Key Informant Interviews (Horizontal Bar Chart)

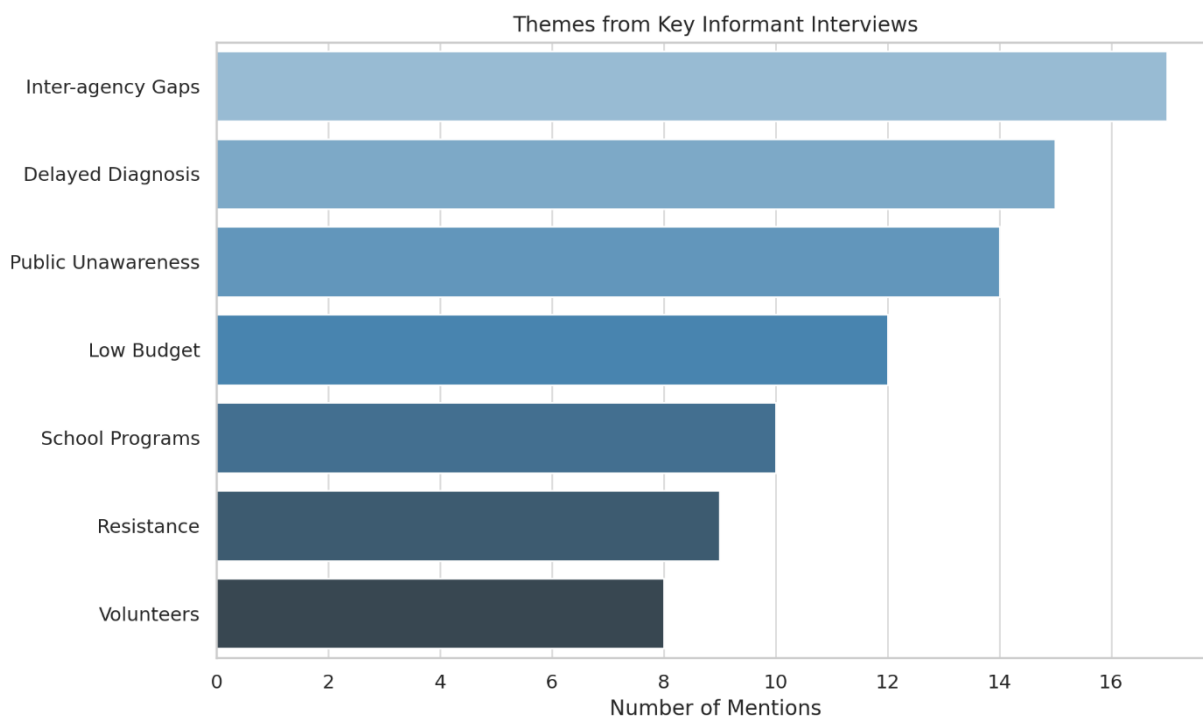
This breakdown in immediate reporting may possibly lead to delays in activating the vector control response in the affected neighbourhoods. The low number of hospitals conducting their own vector surveillance is also telling of a lack of link between clinics and service providers and the environmental health department. These findings suggest that it is necessary to establish standard ways of frequent data sharing and determine processes of cooperation with other organizations to contain rapid outbreaks.

Themes from Key Informant Interviews

20 key informants enhanced the operational issues and systematic factors revelations. Table presents the most cited themes with the results presented in the form of pie chart in figure. The one which was mentioned most often was the lack of integrated cooperation with other institutions/personnel (17 interviews) and delayed clinical diagnostics and lack of publicity of breeding sites.

Table 7. Themes from Key Informant Interviews (N = 20 Interviews):

Theme	Times Mentioned
Inadequate Inter-agency Coordination	17
Delayed Diagnosis in Clinics	15
Public Unawareness of Breeding Sites	14
Insufficient Budget for Vector Control	12
Success of School Awareness Programs	10
Resistance to Insecticides	9
Underutilization of Community Volunteers	8

**Figure 8. Themes from Key Informant Interviews (Horizontal Bar Chart)**

A number of informants pointed out that vector control was not adequately funded and not

effectively linked with hospital-level dengue case management. On the other hand, community-based school dengue awareness programmes were said to be effective especially in addressing the issues to do with children's knowledge and behavior. This thematic content resonates with prior research done on the on knowledge- practice and elucidates more systematic issues such as vertical programme structures, poor engagement with communities, and absence of identified responsibility.

Association between KAP Levels and Dengue Incidence

Last of all, the implication of KAP levels within households and reported dengue incidences was done. Table shows the cross tabulation while figure displays the distribution of cases of dengue based on KAP knowledge, attitude, and practices. It was found out that 38 of 105 households with low KAP scores reported having at least one reported dengue case. On the other hand, 128 households in the high KAP set /score group reported dengue incidents in the past.

Table 8. KAP Scores vs. Dengue Incidence in Households:

KAP Level	Households with Dengue (N)	Households without Dengue (N)	Total Households
Low	38	67	105
Moderate	24	143	167
High	7	121	128

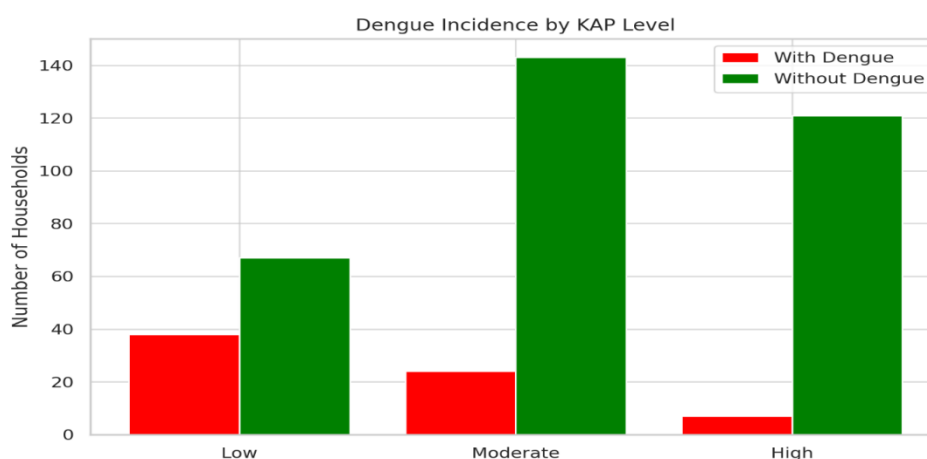


Figure-9: Dengue Incidence by KAP Level (Grouped Bar Chart)

This clearly indicates that there is an inverse relationship between public health literacy and dengue prevalence in the region in question. It has been ascertained that knowledge and the right practices can help to limit the spread of disease within the household. However, 24 reported cases were from the moderate KAP group which means that partial or inconsistent behaviour is still dangerous in causing transmission. This underscores the importance of strengthening tertiary behavior change interventions through repeated involvement, feedback and organizational support mechanisms.

DISCUSSION

Interpretation of results related to the objectives

This study wanted to check out how effective public health interventions really are. It also took a close look at the role that hospital-based measures play in all this. We spotted some operational gaps along the way. Then there was the part about assessing community knowledge and their everyday practices. In the end, the goal was to come up with evidence-based recommendations that could boost the overall efficacy of the system. The findings all point to how multifaceted public health responses tend to be. They really highlight those key areas where targeted improvements are needed.

Effectiveness of Public Health Interventions and Incidence Data

Evaluation of the effectiveness of public health measures used in dengue control efforts shows that integrated approaches, including vector control, environmental, and community participation, have produced the most durable results. Insecticide spraying, especially space spraying or fogging, can quickly suppress *Aedes* adults in an outbreak setting; however, available evidence shows this to be a transitory and time-, context-, and resistance-pattern-dependent strategy. Application of larvicide, especially in the form of *Bacillus thuringiensis israelensis* (Bti) and Pyriproxyfen, has reduced larval indices significantly and proved efficient when used regularly in high-risk larval breeding sites (Boyce et al., 2013).

Community awareness and behavior change programs are critical in this respect, especially because a large number of breeding sites have been found to exist within households. Studies have shown that dengue vector indices and interventions can be greatly reduced in a sustained manner through a focus on household container control, education on protection methods, and community mobilization efforts (Al-Muhandis & Hunter, 2011). Evidence accumulated from various studies on integrated vector management in dengue-endemic areas confirms that a combination of different methods such as chemicals and biological control methods in addition

to community-led efforts can bring far more effective reductions in vector transmission indices than other methods used alone (Bowman et al., 2016).

Assessing the role of hospital -based measures

Hospital-based measures play a central role in mitigating severe dengue outcomes by improving early detection, clinical management, and case reporting. Enhanced triage systems and standardized clinical protocols—such as those outlined in the WHO dengue management guidelines—have been shown to significantly reduce case-fatality rates through timely identification of warning signs and rapid initiation of fluid management. Implementation of dengue diagnostic tools, including NS1 antigen tests and rapid hematology monitoring, improves clinical decision-making and enables earlier classification of patients at risk of severe disease.

Strengthening hospital surveillance systems is equally important, as timely reporting of confirmed cases supports public health authorities in initiating outbreak response measures and allocating resources effectively. Studies in endemic regions have shown that improved hospital-based reporting correlates with faster detection of transmission clusters and more efficient vector control deployment (Runge-Ranzinger et al., 2014). Additionally, staff training and capacity-building initiatives—covering clinical management, infection prevention, and patient education—have been associated with reductions in dengue-related complications and more consistent adherence to treatment protocols. Collectively, these hospital-based interventions form a critical pillar of dengue control strategies by directly reducing severe disease outcomes while supporting broader public health response systems.

Effectiveness of Current Vector Control Strategies

Currently, the control measures regularly practiced in Riyadh are chemical control with an emphasis on fogging using pyrethroid insecticides. However, the ongoing presence of *Aedes* mosquitoes in household facilities despite their frequent treatment with insecticides imply that there are some constraints of this strategy. Like in other cities such as Dhaka and Muscat, the fogging has limited impact on the indoor or sheltered breeding areas and is effective only with adult mosquitoes. This ineffectiveness may be magnified by existing ignorance of insecticide resistance which however has been reported in the neighbouring countries of Saudi Arabia.

People's participation in community cleanup was significantly low with less than a quarter of the respondents participating in the activity frequently. This reflects operational as well as

motivational challenges. There are better results achieved by community-based approach if sustained by boost, incentives, and community led supervision. Such efforts, though, seem scattered and not well coordinated and ingrained into the daily fabric of the citizens of Riyadh. The lack of neighbourhood-level coordination bodies or participatory structures perhaps makes the community forget their roles and responsibilities in environmental management.

Thus, the current strategy of vector control seems to be somewhat weak or rather piecemeal. This raises an apprehension that DDT spraying, with apparently inadequate attention to larval source reduction, environmental sanitation and biocontrol, lacks a measure of sustainable effectiveness. These findings call for a shift in speaking about the vector to imply something that can be integrated, inclusive of the community and mindful of resistance.

Gaps in Clinical and Surveillance Systems

Among the questions identified in the course of the study was one that pointed to delays in reporting dengue cases within the mentioned hospitals. While all the participating hospitals reported the acute cases through the national electronic reporting system, only 69% of the confirmed reports were submitted within the first 24 hours. This is concerning especially in regions with high incidence of dengue since rapid healthcare response is required to curb further spread of the outbreak. Similar problems are evident in urban India and Nigeria where due to lack of proper integration and insufficient diagnostic training the outbreak alerts are delayed and effectiveness is less.

By comparing these data with hospital-based information about dengue patients, it was noted that a considerable share of such individuals was within the economically active age range of 18-40 years and 15.7% of them had severe symptoms. This demonstrates that dengue's impact is not only on the health sector of different countries but also on the productivity of the workforce affected by the disease. However, this case fatal rate of 1.2% remains low despite being grouped among COVID-19 complications because the following are examples of under-reporting: private facilities and delayed admission or presentation among vulnerable persons. These practices support the need for enhanced triaging, early warning indicators, and effective training within clinical care and tertiary health centres.

However, out of the 10 surveyed hospitals, only a few were engaged in entomological surveillance, indicating a lack of synergy between what clinician's witness and what those in charge of disease control and elimination do. The lack of interconnectivity between the hospitals, epidemiological units, and vector control teams results in fragmented responses.

According to the analysis of experiences in Indonesia and Peru, hospital-vector interaction can enhance the outbreak response by cutting the numbers of cases. This way, the efforts put into controlling dengue in Riyadh are rather defensive and non-discrete.

Stakeholder Perceptions and Institutional Barriers

Interview with the key informants provided the richness of information to survey and hospital findings which are more quantitative. For instance, there were consistent mentions of the areas of poor coordination between the Ministry of Health and the municipalities together with environmental agencies. Lack of funds, blurred responsibilities, and lack of coordination between leaders were among the frequently mentioned difficulties. They are not exclusive to KSA, as other research on dengue governance in Pakistan also highlighted that lack of coordination and bureaucratic silos hinder efficient management of dengue.

Another common issue that speakers pointed out was the insufficiency of resistance monitoring at the regional level. Some of the informants' concerns included there was the continued use of insecticides without feedback from surveillance results. This lack of adaptive management is a consequence of a substantive lack in entomological capacity, as suggested in other emerging cities like Ethiopia and Nepal: underdeveloped vector surveillance hampered the evolution of the strategy.

However, school programmes were deemed useful by everyone as it was understood that these were useful in creating awareness and preventive measures especially by the younger generation. Nevertheless, these shifts are still relatively small-scale and do not include involvement of parents, thus failing to target household performances. Lack of optimal use of trained community workers was also reported, the study highlighted that even though CHW have much potential, their programmes were often relegated to the background and replaced with a top-down approach.

Altogether, the opinion-based evidence corroborates the numerical analysis results and indicates more profound systemic challenges that prevent integrated dengue control in Riyadh, from organizational, workflow inefficiency to inadequate community participation.

CONCLUSION

In conclusion, the findings of this study indicate that dengue prevention in Riyadh is challenged by a complex array of factors, spanning both behavioral and environmental, as well as more systemic issues. While good levels of knowledge and dengue awareness correlate with reduced

levels of dengue in, or around, homes, there remain substantial differences between what Riyadh's residents know about dengue, and what they actually do to protect themselves from it, namely with regard to sustained approaches such as sound water storage practices. An environmental analysis suggests that *Aedes aegypti* larval breeding areas remain widespread in Riyadh through the use of urban water, construction materials, poor storage practices, or through ineffective efforts to suppress by means of fogging.

An analysis of the hospital-based studies indicates that there is a lack of speed in terms of the time taken for the diagnosis of dengue cases, that there is a lack of reporting of dengue cases, that there is a lack of coordination between the hospitals and vector control departments, and that there is no real-time surveillance. When taken together, it is evident that Riyadh is faced with a dengue control situation that is limited by a lack of translation of dengue prevention information into practice, lack of infrastructure, and a lack of coordination between dengue control services.

In sum, this study contributes significantly to academic research and public health practice, especially for the Gulf development and semi-arid urban environments.

First, it offers one of the most extensive overviews of dengue prevention in Riyadh, a city that is not commonly analyzed in the literature on vectors' borne diseases in Middle Eastern areas. Previous studies conducted in KSA have focused mainly on Jeddah and Makkah and the coastal and religious factors that define public health in these areas. This paper fills a gap in the national knowledge on dengue by comparing inland dynamics of urbanization and future infrastructure and water developments influencing disease transmission.

Second, it provides a new approach for integrating IVM and PH Systems, suggesting how an operationalist and a systemic perspective can be beneficial to complement each other. By adopting the dual theoretical framework, both the micro-actions and patterns and the macro-structures that are conducive to the spread of communicable diseases were investigated, and it is a model that can be used in other cities that are facing similar problems.

Third, it fills the methodological gap in many previous studies as it used both quantitative and qualitative data in the research design. Thus, the use of both quantitative and qualitative data allowed for data triangulation and added richness to the analysis with the help of several key stakeholders' interviews that shed light on the political, financial, and practical challenges of dengue control.

In this regard, the study adds to the existing body of dengue literature in order to understand how non-tropical urban arid landscapes that are becoming more prevalent in the developing

world pose challenging risk landscapes for Aedes-borne diseases.

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