Assessment of a women-delivered, housewives-centered educational toolkit for household control of *Aedes* mosquitoes in dengue-endemic areas of Taiz city, Yemen: A cluster randomized controlled trial

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Abstract

Aedes mosquitoes are vectors of serious (re)-emerging viral diseases such as dengue, chikungunya and Zika. The global burden of *Aedes*-borne diseases is on the rise, leading to huge outbreaks emerging in different parts of the world. Dengue and chikungunya outbreaks have occurred in Yemen over the past two decades, and the burden of dengue has been reported to get worse as a result of the upheaval and war conditions in this limited-resourced country. Taiz is one of the most afflicted areas with dengue in the country. Therefore, the present project aimed to assess the impact of a women-delivered, housewives-centered educational intervention for the household control of *Aedes* mosquitoes in dengue-afflicted urban settings of Taiz. For this purpose, a cluster randomized controlled trial was conducted in 30 randomly selected clusters of households from a randomly selected district. These clusters were then randomly allocated into two trial groups: an intervention group (15 clusters) where housewives received a women-delivered educational toolkit for the dengue prevention and control and a control group (15 clusters) where the educational toolkit was not delivered. The entomological *Aedes* indices of house index (HI), container index (CI), Breteau index (BI), pupae-per-person/area index (PPI) and pupae-per-household index (PHI) were measured as the outcomes to assess the impact of the women-delivered, housewives-centered educational intervention on the household control of *Aedes* breeding sites compared to pre-interventional baseline indices and to the indices in the control group of the trial. Despite being comparable between both groups of the trial at baseline, HI and BI were lower in the intervention group after the delivery of the dengue educational toolkit compared to the control. The reductions in BI to zero in most clusters of the intervention group compared to the control group support the effectiveness of the dengue educational toolkit under investigation in reducing the

vector breeding sites at the household level. Therefore, there is a need for sustaining the long-term impact of educational campaigns for the household control of *Aedes* vectors to counteract the negative impacts of the ongoing emergency situation and humanitarian crisis in the country.

Keywords: Educational intervention; Household; Housewife; Control; Dengue; Taiz

1. Introduction

Dengue is one of the most important emerging, neglected tropical mosquito-borne diseases associated with serious systemic manifestations and fatal complications. It is caused by five serotypes of dengue virus (DENV) and transmitted by female *Aedes* mosquitoes, mainly *Ae. aegypti*,[1, 2] where infection usually confers a lifelong serotype-specific immunity, but a temporary immunity to other serotypes.[3, 4] Moreover, subsequent infection with a different serotype can lead to more frequent and severe complications. [3, 4] Emerging dengue epidemics in the Middle East in the past two decades raise concerns about the widespread emergence of the disease in this politically unstable region, with reports of dengue fever/ dengue hemorrhagic fever and deaths from the countries of the Arabian Peninsula, including Yemen.[1, 5-9]

In Yemen, one of the poorest and least developed countries afflicted with vector-borne diseases (VBDs), dengue cases and outbreaks attributed to dengue virus serotypes 2 and 3 have been reported from Hodeidah city in the west and Al-Mukalla city in the east, respectively.[5, 6, 8] In Hodeidah, 29% (116/400) of patients with dengue-like illnesses were reported to be infected with DENV, predominantly of serotype 2.[8] Moreover, DENV in Hodeidah was co-circulating with chikungunya virus, which is also transmitted by *Aedes* mosquitoes.[8] Since the start of the political conflicts and war in the early 2010s, the country has been afflicted with an upsurge in suspected dengue as evidenced by an increase of more than 600% of suspected cases in 2016 compared to the same four-month period in 2015 (11,900 *versus* 1755 cases, respectively).[10] The current upheaval in the country has contributed to the emergence of *Aedes*-transmitted diseases, including dengue, as a result of health system collapse and damage, humanitarian crisis and internal population displacement.

Due to the absence of specific antiviral agents or licensed vaccines against dengue,[11] its prevention and control depends mainly on vector control measures targeting immature and adult stages of the vectors such as eliminating environmental and man-made breeding habitats in and near households, proper solid waste disposal, use of appropriate larvicides and adulticides, personal protection and community mobilization.[1] Because Aedes species also serve as the vectors of other arboviral diseases such as chikungunya, yellow fever and Zika,[12, 13] effective and sustainable control of dengue and other VBDs necessitates community education and engagement in various vector control activities as part of multisectoral. approaches to the integrated control of emerging arboviral diseases and outbreaks. This strategy can be enhanced through community- and household-directed educational interventions to change the knowledge, attitudes and practices of household members. In this regard, community education has been shown to be more effective than insecticide spraying alone in reducing mosquito breeding habitats.[14] Several entomological indices have been developed for assessing the impact of household vector control interventions. The most commonly used indices include house index (HI): percentage of houses infested with larvae and/or pupae, container index (CI): percentage of water-holding containers with larvae and/or pupae, Breteau index (BI): number of *Aedes*-infested containers per 100 houses, pupae-per-household index (PHI): number of pupae per 100 houses, and pupae-per-person index (PPI): number of pupae (a proxy of adult mosquitoes) per number of people in the community.[1, 15] One of the innovative approaches to the surveillance and control of *Aedes* mosquitoes is the use of ovi-larvicidal (OL) traps.[16] For surveillance purposes, the OL index measures the percentage of positive traps that reflect the distribution of *Aedes* mosquito population.[16]

Increasing women's participation in vector control activities should be highly encouraged in developing countries, where women could be actively recruited in educating their local communities.[17] Women demonstrate willingness, motivation and well organization in the management of the targeted operations when given the opportunity.[18-20] In Yemen, involving women in the education of their counterpart housewives should be assessed for its impact on *Aedes* vector control at the household level in urban areas with previous history of dengue outbreaks. Such women-delivered, housewives-centered approach should be assessed in the country for several reasons including: 1) Housewives spend most of their time at home, making them the ideal recipients of health education messages with high response rates; 2) Women volunteers can easily access to the households and communicate with housewives according to the sociocultural norms of the Yemeni community, making them the ideal health educators; 3) Housewives hold the responsibilities for household activities related to indoor and outdoor vector breeding such as waste disposal, gardening and domestic water storage, etc.; 4) Housewives are more concerned about the health of their children and family members and save no efforts to protect them from dengue; 5) Women are more likely to stay longer in the community compared to men who are most commonly farmers, fishermen and day workers, spending almost of their time outside the community/households.

Besides the feasibility of their roles in the cost-effective and sustainable control of household *Aedes* vectors in endemic areas of the country, women involvement can contribute to the achievement of the UN Sustainable Development Goal 5 to "*Achieve gender equality and empower all women and girls*".[21] Therefore, the present project aims to assess the impact of a women-delivered, housewives-centered educational

intervention on household control of *Aedes* mosquitoes in urban settings with history of dengue outbreaks in Taiz city.

2. Methodology

2.1. Study design, clustering and random allocation of clusters

This cluster randomized controlled trial (cRCT) was conducted in Taiz city, a city located on the Red Sea at the coordinates of 14°48' N and 42°75' E, with baseline and post-intervention cross-sectional surveys of entomological indices (Figure 1). Because dengue outbreaks and increased density of *Ae. aegypti* have been reported during winter, this cRCT was implemented between October and November 2019 during dengue transmission season.

Al Mudhafar district was randomly selected from the three districts of Taiz city known to be endemic for dengue. This district combines sub-districts, and each sub-district combines zones. Therefore, each zone was considered one cluster. Because clusters do not necessary have the same number of houses (the cluster size), those with less than 50 houses were combined with neighboring clusters. All clusters in the district were listed, and 30 homogeneous clusters of at least 17 households each were selected using simple random sampling technique, leaving buffer zones of houses between the clusters to prevent the effects of close proximity on the outcomes of the intervention as a result of the circulation of the health education messages between the clusters. Fifteen clusters were then randomly allocated into the intervention and control groups of the study.

A minimum sample size of 517 households was required for each group of the trial based on the following parameters: an expected reduction in *Aedes* entomological indices from 60% to 45%, a statistical power of 80%, a significance level of 5% and an

intra-cluster correlation coefficient (ICC) of 3%, as recommended for cRCTs.[22] Buildings with apartments were considered one house in the first stage of selection, and one apartment was randomly selected by a second simple random. For households with multiple housewives, one housewife was randomly selected. Housewives refusing to participate or who had undergone health education about dengue or whose residence in the household is temporary were excluded and replaced by those of their next households.

2.2. Baseline entomological surveys

Entomological surveys were conducted in the household clusters of both groups of the trial to assess HI, CI, BI, PPI and PHI at baseline. These indices of vector density were measured by a team of highly-qualified entomologists according to standard methodologies and guidelines.[1, 15, 23]

2.3. Educational toolkit intervention

A dengue educational toolkit pre-designed and provided by the Ministry of Public Health and Population was delivered to women in the household clusters of the intervention group with respect to coverage of household water containers and removal of outdoor artificial deposits.

Fifteen educated women (teachers, healthcare workers, etc.) were selected after being trained on the delivery of the educational toolkit and evaluated by the research team to be the health educators for the housewives the intervention group, one for each cluster. The educational toolkit was delivered through house visits in the first week of the intervention after the baseline survey.

2.4. Post-intervention entomological surveys

Post-intervention entomological surveys were conducted in all households included in the intervention and control groups of the cRCT using the same methods for the baseline surveys one month after implementing of the educational intervention.

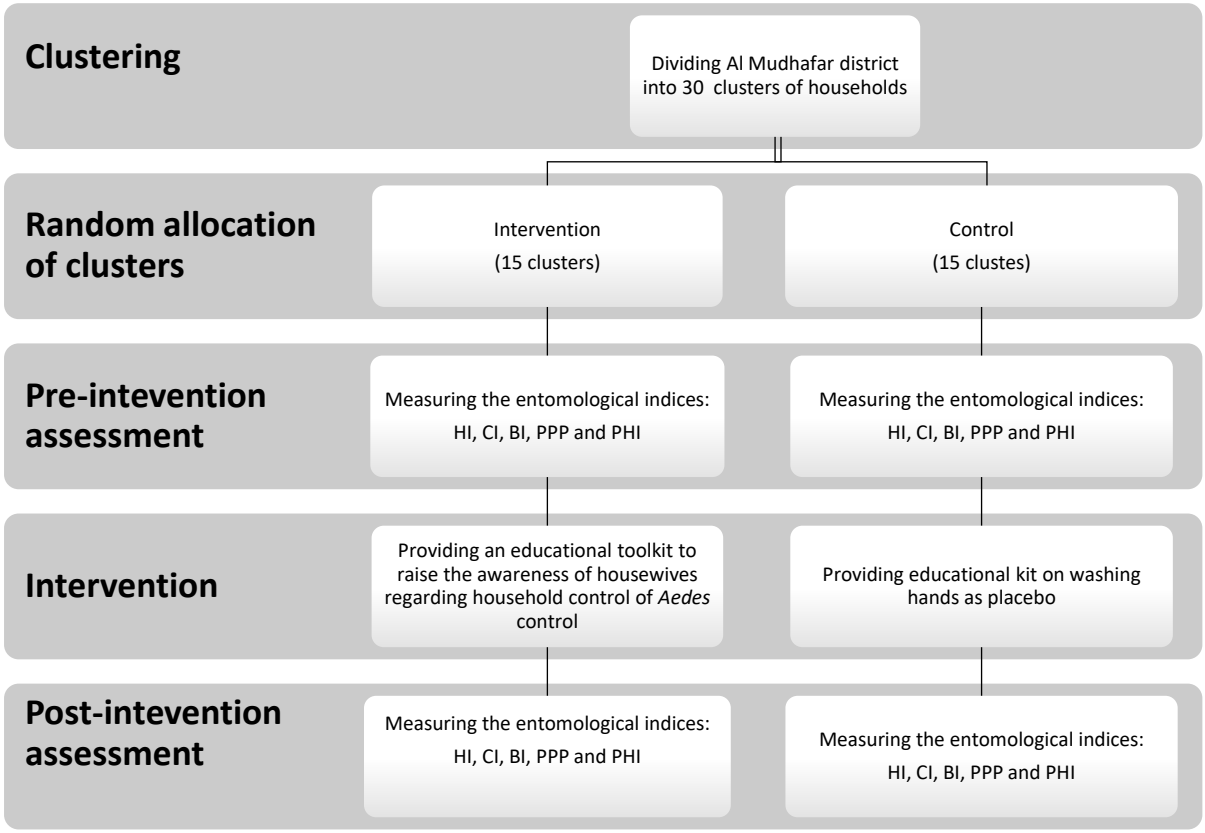

Figure 1. Flowchart of the cRCT of a dengue educational toolkit among housewives in Al Modhafar district, Taiz governorate, Yemen in 2019

2.5. Data analysis

Data were coded using the numbers of the cluster and households to preserve the anonymity of the study participants. Coded data were then dually entered, verified and analyzed using the IBM SPSS Statistics version 22.0 (IBM Corp., Armonk, NY, USA). Household *Aedes* indices were calculated as percentages according to well-established formulas and used as the outcomes to estimate the effectiveness of the educational

intervention in the household control of *Aedes* vectors. Pre- and post- interventional *Aedes* indices were analyzed and compared between the clusters of the interventional and control groups of the trial.

2.6. Ethical considerations

The proposal of the present project was reviewed and approved by the Research Ethics Committee of the Faculty of Medicine and Health Sciences, University of Science and Technology, Sana'a, Yemen. Participation of women educators and housewives was on a voluntary basis, and written informed consent was obtained from housewives after explaining the objectives and methods of data collection. However, verbal informed consent was obtained from illiterate housewives because the trial does not have clinical or medical implications, asking them for a thumb impression on the printed consent. The confidentiality of personal information was assured.

3. Results

3.1. Characteristics of the trial clusters

This study included 391 houses with 2615 inhabitants in 17 intervention clusters and 255 houses with 1557 inhabitants in 15 control clusters. Baseline entomological surveys were conducted in all intervention and control clusters, while post-intervention surveys were conducted in all control clusters and 16 intervention clusters, where one cluster was not surveyed at the end of the intervention. All larvae collected in the baseline survey were identified as *A. aegypti.*

3.2. Entomological outcome measures

The baseline survey showed variations in the entomological indices between the individual clusters of the intervention and control groups and between intervention and control groups (Table 1). In the baseline survey, HI and CI were about the same in intervention and control groups. However, BI, PHI and PPI were higher in the intervention group than the control group (Figure 1). In contrast, post-intervention indices of HI, CI and BI were lower in the intervention group compared to the control (Figure 2)

Table 1. Entomological indices in the intervention and control arms for assessing an educational toolkit for *Aedes* household control in Al Modhafar district, Taiz, Yemen (2019)

Cluster name	Baseline survey					Post-intervention survey				
	HI (%)	CI (%)	BI (%)	PPI	PHI	HI (%)	CI (%)	BI (%)	PPI	PHI
Intervention group										
Al-Sakaneyah	47.1	36.1	76.5	135.3	13.6	0.0	0.0	0.0	0.0	0.0
Berarah	52.9	22.0	64.7	47.1	8.9	5.9	2.4	5.9	0.0	0.0
Wadi Al- Qadhy - Al Tharbah	41.2	14.9	82.4	141.2	19.8	-	-	-	-	-
Al-Dar	41.2	38.3	105.9	170.6	24.0	0.0	0.0	0.0	0.0	-
Al-Sakaneyah	52.9	59.4	111.8	194.1	27.3	5.9	1.0	5.9	0.6	1.0
Berarah	47.1	20.0	88.2	1647.1	261.7	0.0	0.0	0.0	0.0	0.0
Wadi Al- Qadhy	58.8	25.9	129.4	123.5	18.1	0.0	0.0	0.0	0.0	0.0
Al-Domainah	58.8	42.4	82.4	705.9	107.1	0.0	0.0	0.0	0.0	0.0
Al-Dar	41.2	39.5	100.0	323.5	44.7	0.0	0.0	0.0	0.0	0.0
Dar Al-Serah	47.1	36.1	76.5	1005.9	138.5	8.8	0.0	0.0	0.0	0.0
Wadi Al-Masal	44.1	17.6	47.1	0.0	0.0	5.9	0.0	0.0	0.0	0.0
Al-Mehsab	64.7	69.6	94.1	1367.6	258.3	0.0	0.0	0.0	0.0	0.0
Al-Modhaffar-Ein Al-Hady	73.5	41.7	117.6	579.4	96.1	0.0	0.0	0.0	0.0	0.0
Naqeel Al hofar	38.2	18.3	70.6	382.4	66.0	0.0	0.0	0.0	0.0	0.0
Al-Dohhy	55.9	49.0	141.2	597.1	77.2	0.0	0.0	0.0	0.0	0.0
Beer basha	64.7	40.8	170.6	1235.3	170.7	0.0	0.0	0.0	0.0	0.0
Al-Manakh	64.7	42.9	123.5	970.6	175.5	5.9	2.2	5.9	0.0	0.0
Control group										
Al-Domainah	41.2	38.5	58.8	88.2	13.5	11.8	1.8	11.8	0.0	0.0
Al-Jamaah-Amad	23.5	8.1	35.3	0.0	0.0	5.9	1.3	5.9	0.0	0.0
Al-Nosaireiah	64.7	48.8	117.6	176.5	27.8	0.0	0.0	0.0	0.0	0.0
Bab Musa	58.8	30.0	88.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Al- Moror	35.3	31.0	52.9	676.5	102.7	5.9	0.9	5.9	0.0	0.0
Madenat Al-Noor	47.1	44.1	88.2	764.7	123.8	17.6	4.9	17.6	0.0	0.0
Al- Bab Al-Kabeer	47.1	30.2	111.8	0.0	0.0	17.6	4.5	29.4	0.0	0.0
Al-Maidan	11.8	6.1	11.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Al-Matar	47.1	52.4	129.4	194.1	32.7	0.0	0.0	0.0	0.0	0.0
Al-Daery	64.7	45.7	94.1	470.6	65.6	0.0	0.0	0.0	0.0	0.0
Al-Jameah	47.1	21.4	70.6	0.0	0.0	5.9	1.2	5.9	0.0	0.0
Al-Haseb	47.1	41.9	105.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Jawlat Al-Moroor	82.4	52.4	129.4	1470.6	198.4	5.9	0.0	0.0	0.0	0.0
Al-Dhohrah	17.6	13.7	41.2	352.9	59.4	0.0	0.0	0.0	0.0	0.0
Al-Tamaddod	41.2	20.5	47.1	705.9	129.0	0.0	0.0	0.0	0.0	0.0

HI, house index; CI, container index; BI, Breteau index; PHI, pupae-per-household index; PPI, pupae-per-person index

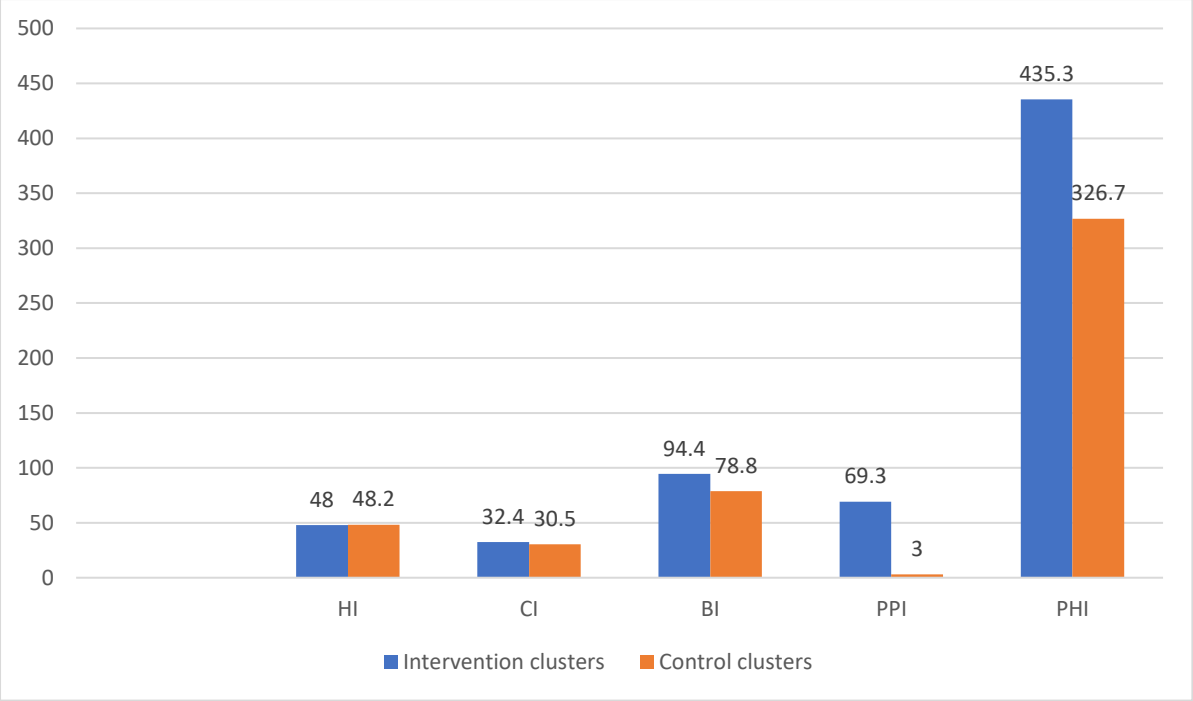

Figure 1. Baseline entomological indices in intervention and control groups. HI, house index; CI, container index; BI, Breteau index; PHI, pupae-per-household index; PPI, pupae-per-person index

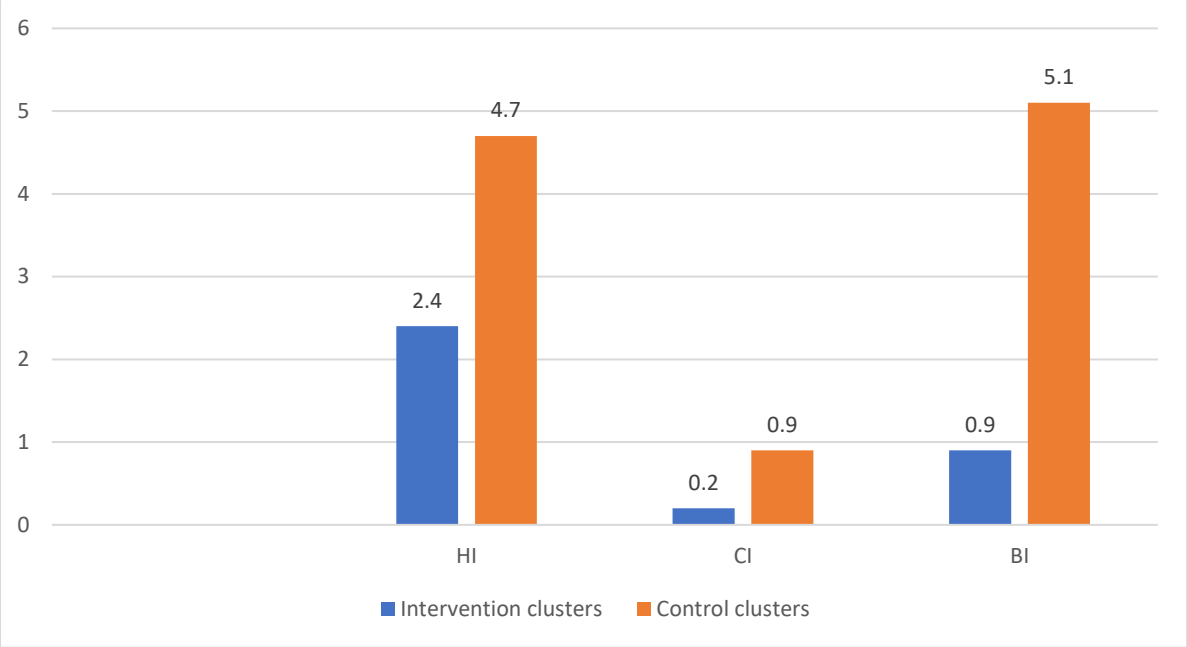

Figure 2. Post-intervention entomological indices in intervention and control groups. HI, house index; CI, container index; BI, Breteau index

4. Discussion

The present trial assessed an educational intervention on the removal of indoor and outdoor mosquito-breeding sites as a control strategy delivered to housewives in a dengue-endemic area of Taiz city compared to controls. Although HI and CI were comparable between both groups of the trial at baseline, these indices were lower in the intervention group after the delivery of the dengue educational toolkit to women compared to the control. Furthermore, the delivery of the dengue educational toolkit led to a higher reduction the BI in the intervention group compared to the control despite being higher in the intervention group at baseline. The low post-intervention BI, being zero in most clusters, in the intervention group compared to those at baseline and in the control group indicates that the intervention was successful in greatly reducing the vector larval infestation. It is noteworthy that the BI is considered one of the most

sensitive early warning signals for dengue outbreaks and in low infestation areas prone to outbreaks.[24, 25]

The post-intervention reductions in the entomological indices in the present trial indicates the feasibility and effectiveness of engaging Yemeni housewives in endemic areas in dengue control via the delivery of the dengue educational toolkit to encourage them remove *Aedes* breeding sites through covering household water containers and elimination of outdoor artificial deposits. Women represent one of the most influential stakeholders to combat vector-borne diseases, including dengue, when mobilized to control such diseases as part of community-based vector control.[26] Several community-based programs have been proven to be effective in reducing the density of *Aedes* vectors through raising awareness among communities as evidenced by RCTs,[14, 27-33] particularly when integrated with other control interventions.

This study underlines the importance of delivering regular educational toolkits on the household control of vector breeding sites to housewives in endemic areas and integrating this approach to existing dengue control interventions. It is to be noted that educational interventions can reduce *Aedes* breeding sites more effectively than insecticide-based interventions.[14] The present study focused on housewives as key contributors for the household control of *Aedes* breeding sites for several reasons, including their longer home stays that make them ideal recipients of health education messages with high response rates, their responsibility for household activities related to indoor and outdoor vector breeding such as waste disposal, gardening and domestic water storage, etc. and their role in protecting the health of the family members. The involvement of housewives, as an important feminine component of the community, in the control of dengue and other VBDs can maintain the cost-effective sustainability of control measures at the household level. On the other hand, the present study recruited

female educators because of their easy access to houses in a conservative community with strict socio-cultural traditions besides moving forwards towards the achievement of the Sustainable Development Goals related to gender equality and empowerment of women.[21]

This intervention was directed to the control of *Aedes* vectors at the household level through the active participation of housewives as the key householders involved in activities that could impact the vector density. Houses and their vicinities constitute a primary setting for the transmission of VBDs, including dengue.[34] In such settings, more acceptability and compliance to control interventions as well as greater impact could be achieved through their delivery by women and household adoption by housewives.

Although the present intervention showed short-term effects in reducing *Aedes* breeding sites and dengue vector density, the sustainability of such intervention in the long-run has to be evaluated through long-term studies, considering multiple factors that could play roles in its impact. Therefore, it is recommended to sustain the effectiveness and broaden the extent of such interventions in reducing vector density through refresher educational campaigns, preferably through community health workers and volunteers after coordination with the programmes they are already working with such as the Nutrition Programme. This is particularly important because of the impact of the ongoing conflicts on the control activities of VBDs. Moreover, this will contribute to prevent outbreaks with other *Aedes*-borne diseases such as chikungunya.

5. Conclusions

Women engagement in the education of housewives proves to be an effective intervention for the removal of indoor and outdoor *Aedes* breeding sites. This implementation of such an approach can lead to significant reductions in the percentages of households infested with the larval stages of the vector as well as in the percentages of water-holding containers infested with such stages at the household level. The reductions in BI to zero in most clusters of the intervention group support the effectiveness of the dengue educational toolkit under investigation in reducing the vector breeding sites at the household level. Therefore, there is a need for sustaining the long-term impact of educational campaigns for the household control of *Aedes* vectors to counteract the negative impacts of the ongoing emergency situation and humanitarian crisis in the country.

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