Habitat for Humanity Challenge: Malaria Prevention through Innovations in Home Design or Home Life

Abstract:

For some, a mosquito bite may simply be an itchy nuisance. However, mosquitoes are also carriers of infectious diseases such as Malaria, West Nile virus, and Zika virus. Malaria is the primary concern of this Challenge, as Zika and West Nile viruses have very low prevalence in Kenya. Transmission of vector-borne diseases most frequently occurs within and around the home. Therefore, Habitat for Humanity is searching for solutions to significantly reduce the number of mosquito bites inside the home, thus lowering disease transmission. Solutions should aim to reduce the number of mosquitoes that enter the home and/or modify the behavior of the mosquitoes while inside the home so they can't or don't bite the residents. Furthermore, the solicited solution should have a positive impact on the comfort of residents inside the home.

This is a Reduction-to-Practice Challenge that requires written documentation and proof-of-concept demonstration data if available.

Structure/Image/Logo:

Overview:

Malaria is a life-threatening parasitic disease that is transmitted by infected mosquitoes. According to the Centers for Disease Control and Prevention (CDC), there are an estimated 3.5 million new cases of Malaria and 10,700 deaths per year in Kenya. The main ways to prevent and reduce malarial transmission include the use of insecticide-treated mosquito nets and indoor residual spraying of insecticides. Nets provide protection only if they are used properly and there are growing concerns related to insecticide resistance. Habitat for Humanity is approaching this problem from a different point of view; this Challenge is seeking innovative and cost-effective solutions to retrofit low-income houses with an improved home design or with something that can be done to or in the home to prevent disease transmission.

The submission to the Challenge should include the following:

1. A **detailed description** of the proposed Solution and how it addresses each **Technical Requirement** presented in the Detailed Description of the Challenge. This description should be accompanied by a well-substantiated rationale for the design, annotated drawings, and cost estimates.
2. **Proof-of-concept demonstration data**, if available, showing implementation of the proposed solution.

The Challenge award is contingent upon theoretical evaluation and field demonstration or validation of the submitted Solutions by the Seeker.

To receive an award, the Solvers will not have to transfer their exclusive Intellectual Property (IP) rights to the Seeker. Instead, Solvers will grant to Habitat for Humanity a *non-exclusive license* to practice their solutions and the right to share awarded solutions with other nonprofit and for profit organizations worldwide. **Habitat for Humanity will make awarded solutions freely available to other nonprofit and for profit organizations to help improve the state of low-income housing worldwide.**

Submissions to this Challenge must be received by 11:59 PM (US Eastern Time) on June 7, 2021.
Late submissions will not be considered.

ELIGIBILITY

Employees and interns of Habitat for Humanity International (HFHI), as well as their immediate family members (spouse, parent, child, sibling, and their respective spouses) or persons living in the same household, whether related or not, are eligible to enter the Challenge; provided that they **will not be eligible to receive an award** if their Solution is chosen. In addition, the Solutions of employees and interns of HFHI will fall under HFHI's employment policies and be considered work product of HFHI. **Please note**, employees and interns of Habitat for Humanity Affiliates and independent National Organizations are eligible to enter and receive an award if their Solution is chosen.

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Detailed Description and Requirements:

(Viewable by Solvers who signed user agreement for your Challenge. This and the Project Deliverables section appear on a different webpage from the Abstract and Overview, which is the reason for some duplication of content, for instance, background and award/IP details.)

BACKGROUND

In the areas most affected by mosquitoes, a majority of houses are built with features that don't keep them out (for example, open windows and open eaves), and the disease-causing mosquitoes enter houses through these features. Most houses built by low-income households have either grass thatched roofs or galvanized sheets with open eaves below the roof for additional ventilation. Studies have shown that house eave screening is an effective and promising strategy for reducing indoor vector densities up to 94%, implying that most mosquitoes enter the house through eaves. Where eaves are closed, the temperatures in the house are usually high forcing households to stay outside at night longer and get exposed to mosquito bites. Most families in the rural parts of Kenya do not use screening on eaves, doors, or windows because it is not a common practice and there are no screening solutions available to them from their local material hardware. In addition, the nature of windows installed make it hard to do any screening. Mosquitoes and Malaria are considered health problems and practitioners within the health sector mostly talk about use of insecticide-treated nets as a solution to dealing with mosquitoes and Malaria.

Figure 1: An open eave

Figure 2: A typical low-income house in Kenya

Many rural houses in Kenya lack ceilings and the roof is visible indoors. Most avoid ceilings because it is expensive to install. The presence of ceilings, however, has an effect similar to closing the eaves.

Figure 3: House with mud floor and open ceiling

Windows and doors are also key entry points for mosquitoes. Most rural homes in Kenya have tiny windows, with both windows and doors made out of jointed wood with gaps in between the wood planks and between the door and floor. These are ideal entry points for mosquitoes. Windows help enhance ventilation and regulate temperatures inside the house, while also reducing the accumulation of carbon dioxide, an indicator utilized by mosquitoes to locate a potential host.

One of the problems of traditional houses in Kenya is that they are too hot. A majority are made from mud, bricks or cement blocks that heat up during the day and radiate heat at night, making the houses hot and stuffy at night. A hot bedroom at night is not conducive for sleeping under a bed net (it has been shown that bed nets create a warmer microclimate around the area they are in use) and is the primary reason that people will not use a net at night. Increasing the size and number of windows helps lower temperatures and enhance ventilation but also creates more open space for mosquito entry. Generally, screening halves the amount of air flowing into and out of the house through the opening. Therefore, to maximize airflow, both windows and doors should be large to allow in enough air and with screening to restrict mosquito entry. Most households close windows at night to prevent mosquito entry but more importantly to protect against burglars. Eaves and ceilings are left open to enhance ventilation at night when windows and doors are closed. This is why eaves are the primary mosquito entry points in majority of houses in Kenya. The recommended window area is at least 10% of the floor area and a window should be positioned on a wall parallel to either a door or another window for optimal cross ventilation.

Figure 4: Pastoralist house with no windows

Figure 5: Grass thatched house without windows


Figures 6 and 7: Rural house with plastered walls & steel & glass windows

MOSQUITO PROBLEM

Mosquitoes are the leading disease-causing vector in Kenya and are responsible for transmission of Malaria, Chikungunya, Zika, yellow fever, rift valley fever and lymphatic filariasis among other diseases. In Kenya, about 70% of the population is at risk of Malaria with the burden being realized more in the riparian ecosystems. The disease is seasonal in semi-arid areas, but a recent study indicated that Malaria is also perennial in low altitude areas. Since the turn of the millennium, a concerted campaign of Malaria control has halved the proportion of those infected with Malaria parasites in Africa. Malaria, however, continues to be a major drain on the health in the continent as 93% of the global Malaria burden occurs in sub-Saharan Africa (WHO. 2019 *World Malaria Report 2019)*. In 2018, there were still 213 million cases of Malaria and 380,000 Malaria-associated deaths in sub-Saharan Africa, and it is becoming clear that the current arsenal of weapons that include insecticide-treated bed nets, indoor residual spraying, ongoing efforts to test a Malaria vaccine, and prompt and effective treatment with antimalarials is insufficient to achieve Malaria elimination from the region, including Kenya. Among the many health benefits, improved housing, by reducing mosquito house entry and hence biting, can be an additional tool to help achieve Malaria control and elimination, and reduce the opportunities for re-emergence after elimination.

STRATEGY FOR A SOLUTION

Malaria is caused by a single-celled parasite of the genus Plasmodium. This parasite is transmitted to humans most commonly through mosquito bites. The most effective way to prevent Malaria is to prevent mosquito bites. This is best achieved by blocking the mosquitoes from entering the home (so the home becomes a 'protected area') and by creating an indoor environment in which mosquitoes don't bite the people inside the home.

Current solutions to prevent mosquito bites depend on wearing additional clothing and/or using insecticide-treated mosquito netting. Both approaches will make the user feel warmer, thus many people will forego protection in favor of comfort during the night time hours when mosquitoes are most active. Other solutions depend on the use of insect repellent. Solutions in these areas are not within the scope of this Challenge.

Habitat for Humanity is looking for a different approach. First, we are seeking ideas that could keep mosquitoes largely out of a Kenyan home by focusing on building elements through which mosquitoes enter the house. This will minimize the number of potential disease vectors entering the house and biting residents. Second, for the mosquitoes that successfully enter the home, we are soliciting ideas for how to distract or hinder the mosquitoes, so they don't bite the residents of the home. The solution could try to attract the mosquitoes away from the people. Or it could try to segregate the mosquitoes from the humans (like a net that does not create a warmer microclimate). Or it could try to make the indoor temperature cooler so that people will want to use insecticide-treated mosquito nets. Or it could try to trick the mosquito by lowering carbon dioxide and body odor levels so it cannot locate a host to bite. Or you can think of another idea that would achieve the objective.

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THE CHALLENGE

Habitat for Humanity desires a solution to dramatically reduce the number of mosquito bites for a typical family. Solutions related to home design must address the multiple avenues of entry (e.g. eaves, ceiling, windows, doors) used by mosquitoes to enter a home. Solutions related to changes in home life must change the dynamics that cause a mosquito to bite a family member once the mosquito is in the home. A submitted solution should do nothing to increase the indoor temperature of the home or create discomfort for any resident.

Note: Generally, the solution should aim at creating a balance between improving the indoor environment (enhanced ventilation, thermal comfort, and enough light) and keeping out mosquitoes. In addition, it should give households a sense of security while in the house, especially at night. This should be achieved through but not limited to design propositions and material/solutions specifications for the building elements mentioned above. The solution can be constructed or non-constructed.

Habitat for Humanity is primarily interested in solutions that meet the following **Technical Requirements**.

Must have:

1. Design/Solution is compatible with a low-income house for a typical Kenyan family
    - Utilizes locally available materials/solutions and/or materials that can be supplied by local vendors or improved from existing materials
    - Maintains cultural sensitivity and borrows from current/traditional housing forms and practices generally acceptable among Kenyans
    - Retrofitting of an existing house with material cost not exceeding 200 USD for a 36 square meter house with three rooms (sitting room and two bedrooms)
    - Should not depend on electricity, as a majority of target homes do not have electric power, though long-life battery power is acceptable.
2. Low maintenance and highly durable with a life span of 10+ years
3. Low tech and easy to install by fundis (local Kenyan laborers with limited construction experience); should not take more than a week to retrofit a house using the solution (for construction/architectural solutions)
4. Adaptable to different styles of Kenyan homes as described in the figures above
5. Conforms to the Kenyan building code (for construction/architectural solutions)

Nice to have:

1. Addresses inclusivity and social impact
2. Promotes sustainability

Project Deliverables: *(Viewable by Solvers who signed user agreement for your Challenge)*

Submissions should include the following:

1. **Detailed description** of the design solution and **rationale** as to how the proposed Solution addresses each **Technical Requirement**. This should include the design philosophy along with material specifications, instructions for installation, and predicted overall performance.
2. **Detailed drawings** including, but not limited to the following:
    a. Well annotated plans, elevations, and sections if and where necessary
    b. Shop drawings for the different elements of the proposed design [e.g. openings (eaves, doors, and windows); floors; ceilings; roofs]
    c. Annotated sketches where necessary
3. **Cost estimate** for the proposed design containing:
    a. Material specifications for all components to be used
    b. Material quantities and their respective costs
4. Proof-of-concept demonstration data, if available, showing implementation of the proposed solution as well as demonstrating its ability to meet the **Technical Requirements** as outlined above.

The Seeker may wish to partner with the Solver at the conclusion of the Challenge. Solver should describe their expertise and include a statement indicating their interest in this opportunity.

The proposal should not include any personal identifying information (name, username, company, address, phone, email, personal website, resume, *etc*.) or any information the Solvers may consider as their Intellectual Property they do not want to share.

The Challenge award is contingent upon theoretical evaluation and field demonstration or validation of the submitted Solutions by the Seeker. If multiple proposals meet all the **Technical Requirements**, the Seeker reserves the right to award only the solution which they believe will be the easiest to install at the lowest cost.

To receive an award, the Solvers will not have to transfer their exclusive IP rights to the Seeker. Instead, Solvers will grant to Habitat for Humanity a *non-exclusive license* to practice their solutions and the right to share awarded solutions with other nonprofit and for profit organizations worldwide. **Habitat for Humanity will make awarded solutions freely available to other nonprofit and for profit organizations to help improve the state of low-income housing worldwide.**

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