

Housing improvement: a novel paradigm for urban vector-borne disease control?

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As the world's population crosses the 7.4 billion mark and urban areas become humanity's dominant landscape, there is a pressing need for strategically planning for future population growth in light of current trends in social inequality, accelerated climate change, extreme poverty and (re)emerging infectious diseases. On 25 September 2015, world leaders meeting at the United Nations Sustainable Development Summit adopted the 2030 Agenda for Sustainable Development:¹ a blueprint for humanity's future rooted in a set of 17 Sustainable Development Goals (SDGs). This Agenda, which extends the original eight Millennium Development Goals through the 21st century, now includes SDGs addressing human rights, climate change, overexploitation of natural resources and sustainable urban growth.¹ In including urbanization as a major SDG, world leaders have officially recognized the relevance of cities as catalyzers for current and future development. By 2050, it is estimated that more than 6.5 billion people (two-thirds of the human population) will live in urban areas.² Thus, improving human health, reducing poverty and promoting sustainable development will be strongly tied to transforming the way urban spaces are built and how countries mitigate the impacts of climate change and address issues of poverty and infectious disease propagation.

Housing type (i.e., the physical structure together with the materials and construction style that make up a human habitation) has been linked to negative health outcomes for a myriad of communicable diseases.^{3–6} As such, it is not surprising that housing improvement has been considered as a foundational public health intervention.⁴ Improving housing and livelihoods can have dramatic collateral public health benefits against vector-borne diseases (VBDs). In the USA, window screening was indirectly attributed as an important contributor to the elimination of malaria⁷ and, more recently, the presence of house screens and use of air conditioning explained the reduced incidence of dengue in the US-Mexico border.⁸ Similar effects have also been

observed in less developed rural settings, particularly with respect to malaria and leishmaniasis.^{9,10} However, for tropical urban VBDs, the consideration of housing improvement has been historically marginalized due to the lack of clinical evidence supporting its epidemiologic impact and the high costs involved (which may lead to low intervention coverage).

In the light of the current Zika epidemic and the potential for re-emergence of yellow fever, urban vector control, particularly targeting *Aedes aegypti*, finds itself in the spotlight. The limited effectiveness of current methods of urban vector control (e.g., ultra-low volume spraying, source reduction, aerial spraying) and the rapid propagation of insecticide resistance are pushing for new paradigms for *Aedes*-borne disease mitigation.¹¹ Improving housing by screening doors and windows is gaining terrain as an appealing tool for integrated vector management, particularly in areas where multiple VBDs overlap.¹² Improving housing by providing a reliable piped water supply could reduce the proliferation of aquatic habitats for vectors such as *Ae. aegypti* that favor domestic water storage containers for oviposition.

Randomized controlled trials (RCTs) performed in Mexico demonstrated that using long-lasting insecticide treated nets (LLIN) to screen doors and windows in urban areas can significantly reduce *Ae. aegypti* indoor abundance in an area dominated by high resistance to pyrethroids (Figure 1) at an estimated intervention cost of US\$80 per house.^{13,14} The evidence generated by these studies contributed to the growing body of evidence for the use of window screening to protect houses from *Ae. Aegypti*.¹⁰ Despite this positive prospect, there is still need for further RCTs specifically quantifying the long-term effectiveness of screening and other house modifications (measured with epidemiological endpoints and over multiple years) and, ultimately, the context within which such approaches can be scaled-up. Unfortunately, funders have not seen the value of supporting such large-scale and costly trials.

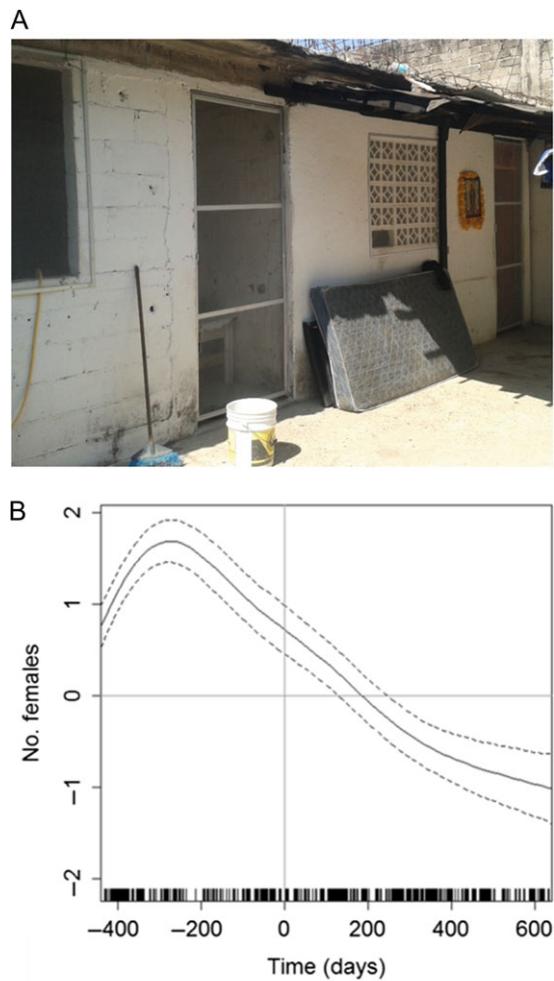


Figure 1. (A) The long-lasting insecticide-treated screens (Duranet®) mounted on aluminium frames and fixed to windows and external doors of houses in Acapulco, Mexico. (B) Predicted effect of screening on the abundance of female *Aedes aegypti* (using a generalized additive mixed-effects model) and the time since installation. Horizontal line shows the area of no difference between treatment and control houses, and vertical line the time when screens were installed. When values in the y-axis are negative, it means that there is a protective effect of screening. Figure adapted with permission.¹³

Proving quantitative evidence of the significant health benefits of an intervention can pave the road for cutting-edge innovations in materials and delivery and produce measurable impacts in disease burden (e.g., LLINs for malaria).

To be scalable, housing improvement interventions must be engineered to be durable and cost-effective. In the case of screening, there is need for innovation in the development of screen material that is both durable and can retain insecticidal effect over the long term. Simple ways to firmly attach screening material to door and window frames that are highly variable in size, shape and construction material could lead to reductions in intervention costs and facilitate installation. In Mexico, we have been using aluminum frames with excellent performance for over five years, making the initial investment in durable frames cost-effective over the period a house remains protected.

Cost and logistics for mass-deployment are often cited as factors that preclude large-scale housing improvements for the protection against VBDs. Particularly in urban areas, such approaches can consider public-private partnerships. For example, the large market base for screening could lead to opportunities for employment and business creation, which could significantly drive down the cost per house. We are currently scaling up interventions in Merida, Mexico, by screening 1000 contiguous houses. Material costs were reduced by 12% by purchasing aluminum directly from an importer rather than from a retailer. The role of public policy is also key. Housing codes can be adapted to require screens and a reliable piped water supply, which will be particularly important for public housing units and new constructions. Given the societal and public health value of improved housing, government agencies can also partner to finance housing improvements in vulnerable areas within cities where risk of VBDs is high (a spatially targeted delivery approach). External donors and non-governmental organizations can strengthen partnerships and provide initial capital for research and development. Ultimately, housing improvements stand the greatest likelihood of long-term success when implemented together with other effective vector-control interventions as part of an integrated vector management strategy.¹²

The time has come to realize the full potential of housing improvement as a key tool for successful integrated vector management in urban areas. We acknowledge the many challenges associated with housing improvement as a novel paradigm for urban VBD control. Yet, this long-term approach can reach beyond VBDs to address structural problems impacting multiple aspects of urban health and, at the same time, bring the world closer to the SDG's target for safe, resilient and sustainable urban growth.

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