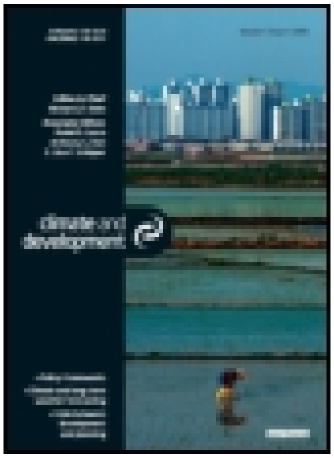

Climate and Development
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tcld20

# Managing health risks in a changing climate: Red Cross operations in East Africa and Southeast Asia

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Published online: 03 Sep 2014.

*Climate and Development*, 2014
http://dx.doi.org/10.1080/17565529.2014.951012

climate and development

RESEARCH ARTICLE

# Managing health risks in a changing climate: Red Cross operations in East Africa and Southeast Asia

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(*Received 25 March 2014; final version received 12 May 2014*)

While climate variability and change affect global patterns of disease, there are few examples of methods that effectively integrate climate into health programming. This study examines a Red Cross Red Crescent pilot project in Kenya, Tanzania, Vietnam, and Indonesia that incorporated climate information and considerations in health operations. Our investigation looks at three elements of programming: baseline community perceptions of climate and health, integration of climate information in operations, and resulting community-level risk reduction behaviour. (1) Through community focus groups, semi-structured interviews, and household surveys, our research reveals that potential health effects of climate variability and change are a key concern at the community level. (2) Project implementors used climate information to design educational materials and health contingency plans to inform *when* and *where* disease prevention activities should be concentrated. This climate-based disease anticipation and improved sharing of incidence data aimed to quickly detect and respond to changing disease patterns in a variable climate. (3) Subsequently, community-level risk reduction behaviour significantly increased in project locations. This pilot is evidence that climate information and considerations can be readily integrated into health programming to account for changing risks, using existing disease prevention techniques to address priority concerns of vulnerable communities.

**Keywords:** vulnerability; disaster risk management; Africa; Asia; community-based adaptation; health; dengue fever; diarrheal disease; forecasts



## 1. Introduction

As anthropogenic influence on the global climate begins to alter average climate and increase climate variability, there is rising concern about how this will affect human health. Already, observed climate change has slowly shifted the range of certain disease vectors and has increased the frequency of extreme weather events (Haines, Kovats, Campbell-Lendrum, & Corvalan, 2006; Intergovernmental Panel on Climate Change [IPCC], 2014; Lindgren, Tällek-lint, & Polfeldt, 2000). As the climate continues to change, risks include further changes to the latitude, elevation, and seasonal distribution of disease vectors and contamination of food and water due to changing patterns of rainfall, temperature, and humidity (Erickson et al., 2012; Gray, Dautel, Estrada-Peña, Kahl, & Lindgren, 2009; Kolstad & Johansson 2011; Moore, Shrestha, Tomlinson, & Vuong, 2012, Paz, Bisharat, Paz, Kidar, & Cohen, 2007).

The literature from the humanitarian and development communities acknowledges this fact and encourages disease prevention programming to take climate change into account (Aalst et al., 2007; Office for the Coordination of Humanitarian Affairs, 2009), but there has been very little action to date. Future patterns of disease will be influenced not only by climate change, but also by non-climate factors and human behaviour, and practitioners are unclear on how to prepare for this uncertainty. Specifically, there are few practical examples of "what to do differently" given climate variability and change; a recent WHO assessment of the peer-reviewed literature on climate and health found a lack of evidence on interventions to reduce health risks due to climate change (Hosking &Campbell-Lendrum, 2012).

This paper examines a pioneering "climate and health" project funded by the Rockefeller Foundation that was the

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first of its kind within the Red Cross Red Crescent Movement, the largest humanitarian organization worldwide. Given the lack of practical information for how to integrate climate into humanitarian programming, this project selected two different diseases with contrasting climate/health interactions: diarrheal disease in Kenya and Tanzania and dengue fever in Vietnam and Indonesia. The project aimed to integrate climate information in traditional health programming interventions to improve response to each disease in the short term as well as to prepare for possible future changes in disease patterns. Technical support from the Red Cross Red Crescent Climate Centre was provided to project implementors from the International Federation of Red Cross and Red Crescent Societies (IFRC) and the Red Cross National Societies. Project components were tailored in each country, but all four incorporated a baseline study on community perception of climate risks and disease, the development and distribution of Information, Education, and Communication (IEC) materials, training for Red Cross volunteers, the development of contingency plans, and an endline survey identical to the baseline.

In 2010 in East Africa, diarrheal diseases are estimated to have caused 8.8% of all deaths of children under 5 years, and sanitation-related diseases were responsible for the loss of over 500 disability-adjusted life years per 100,000 people per year in Kenya and Tanzania (Institute for Health Metrics and Evaluation, 2010). Diarrheal disease is related to heavy rainfall, flooding, and drought, all of which increase the probability of contamination or scarcity of water (Ahern, Kovats, Wilkinson, Few, & Matthies, 2005; Effler et al., 2001). Climate change is anticipated to increase the risk of diarrheal diseases by 23% in Equatorial Africa by the end of the century, based on model projections for socio-economic development, temperature, and precipitation (Kolstad & Johansson, 2011).

Research indicates that there are clear links between dengue fever and climate variables, including the El Niño Southern Oscillation, temperature, rainfall, humidity, wind, and hours of sunlight (Focks & Barrera, 2007; Halstead, 2008). These climate factors affect the potential spread of the virus, but are mediated by human attributes, including population density, herd immunity, and creation of breeding sites (Eisen, Beaty, Morrison, & Scott, 2009; Johansson, Cummings, & Glass, 2009; IPCC, 2014). Gross domestic product per capita has also been shown to be negatively associated with the distribution of dengue fever (Aström et al., 2012). Due to this complexity, more research is needed to accurately predict outbreaks based on climate information and develop thresholds for early warning systems (Focks & Barrera, 2007); therefore, surveillance and early detection of dengue cases is particularly important to detect outbreaks as well as changing seasonal or geographical patterns of disease. Of all vector-borne diseases, dengue currently has the fastest increase in incidence and geographic spread (World Health Organization and World Meteorological Organization [WHO &WMO], 2012a), and climate models project over the next century an increased risk of changes to the transmission season and latitudinal and altitudinal ranges of dengue both globally and locally (Aström et al., 2012; Githeko, Lindsay, Confalonieri, & Patz, 2000; IPCC, 2014).

Climate forecasts and projections can be valuable in anticipating disease incidence in both time and space (WHO &WMO, 2012b).The IPCC recommends the development of improved surveillance systems and weather-based early warning systems, increased capacity for response to early warnings, and public education campaigns (IPCC, 2011). Community-based educational interventions to improve sanitation have been shown to spur prevention behaviour for diarrheal diseases (Whaley &Webster, 2011). Although there is a lack of data available on the efficacy of different vector-control strategies for reducing the risk of dengue outbreaks (Ballenger-Browning & Elder, 2009; Heintze, Velasco Garrido, & Kroeger, 2007), research does show that behaviour changes at the community level are likely to reduce the risk of contracting the disease (Castro et al., 2012; Crabtree, Wong, & Mas'ud, 2001; Pai, Hong, & Hsu, 2006).

Given the health risks in the two project regions, this research will examine three aspects of the "climate and health" programming, focusing on the ways in which the inclusion of climate variability and change was used to build on the goals and strategies of health operations. This does not aim to produce rigorous statistical comparisons of techniques, but rather to draw lessons from real-world integration of climate considerations into humanitarian programming, focusing on three aspects:

(1) The view of beneficiaries on the relationship between climate and health.
(2) Integration of climate variability and change into health programming.
(3) Change in disease prevention behaviour in programme areas.

Section 2 outlines the parameters of project implementation and methodology of data collection, followed in Section 3 by results relevant to each of the three components listed above. Section 4 summarizes findings and recommendations for the role of climate in health programming.

## 2. Methods

### 2.1. *Study design*

The ultimate objective of the health risk management project was to reduce disease prevalence rates by: (1) increasing community-level awareness on diseases, prevention techniques, and links with climate change, under the assumption that this would spur more effective preventative action and (2) increasing collaboration between the

Red Cross and national meteorological agencies to improve the use of climate early warning information. In the same vein, the project also aimed to improve collaboration between the Red Cross and local health authorities so that changing patterns or outbreaks of disease are observed and acted on early.

Based on this, the objective of this research paper is to identify the process innovations and behaviours associated with the project itself, drawing lessons learned on actionable climate and health strategies that can be then used at scale. For this component, the Red Cross Red Crescent Climate Centre supervised the use of more rigorous data collection techniques than are otherwise employed in humanitarian programming, and worked with partners to conduct a quantitative and qualitative review after project completion.

### 2.2. *Study sites*

In Kenya, project sites were located in the low-lying alluvial plains of Nyando province, and in Tanzania, in the densely populated coastal Tanga province. Both provinces are vulnerable to endemic malaria, sporadic floods, and outbreaks of diarrheal diseases. In Asia, the target disease was dengue. Project locations encompassed Ho Chi Minh City and Tiền Giang in Vietnam, as well as six Kelurahan (villages) of Jakarta; all areas have high incidence rates of dengue fever.

Each Red Cross National Society designed programme messages and educational information according to standard disease prevention techniques and in response to knowledge levels identified during the baseline survey. In collaboration with local health and meteorological authorities, educational information was also provided about the possible influence of climate on disease patterns. The Red Cross National Societies mobilized community members to take action in their neighbourhood, ranging from local construction of latrines to community-led clean-ups of mosquito breeding grounds.

While many barriers to behaviour change are out of the control of the individual in developing countries (i.e. service provision), in this case, we targeted actions that were within the ability of the average household in the target area. This included activities such as covering water containers and using bed nets, which are widely available in each region. In the case of latrine coverage, we specifically made available the technical training to construct latrines from locally available materials, so that this would not be a barrier to behaviour change in Kenya and Tanzania.

### 2.3. *Data collection*

For the categories outlined below, we used a mixed methods approach combining qualitative and quantitative approaches to data collection.

#### 2.3.1. *Community understanding of climate and health*

We held semi-structured interviews with individual key informants which provided a rich understanding of current perceptions around climate and health and a framework to design quantitative surveys. While those interviews are not analysed here, we conducted eight focus group discussions with participants disaggregated by gender and age. These results are considered here, and presented in Table 2.

Cross-sectional surveys of household heads were carried out before and after programme implementation in all countries, with a response rate of nearly 100% (Table 1). In Vietnam and Indonesia, respondents were selected through cluster sampling from a sampling frame of all clusters in the targeted administrative regions. Households were selected randomly from a list of households in each cluster. In Kenya and Tanzania, the sampling frame consisted of all villages in each administrative unit of the project. As there were no lists of households, the project team used the Expanded Programme on Immunization method to select a random direction by spinning a pen at the centre of a map of one village per administrative unit, and counted all houses on the line of the pen, using a random number to identify the first sample house. This was treated as a simple random sample (see limitations

Table 1. Description of survey and population demographics.

| | Baseline date | Endline date | Baseline sample | Endline sample | Respondents with no formal education (baseline) % (95% CI) | Common livelihoods |
|---|---|---|---|---|---|---|
| Kenya | October 2010 | July 2012 | 400 | 400 | 15% (11.5–18.5) | Sale of crops, small-scale trade |
| Tanzania | May 2011 | December 2012 | 469 | 448 | 11% (8.2–13.8) | Small-scale trade, sale of crops, paid employment |
| Vietnam | October 2010 | April 2011 | 405 | 418 | 1.2% (0.3–2.1) | Small trading, hired labour, farming, civil servant |
| Indonesia | November 2011 | November 2012 | 397 | 400 | 1% (0–2) | Home-makers, private sector employees, micro-entrepreneurs |

Table 2. Observed historical climate changes in project locations.

| Kenya[a] | Tanzania | | Vietnam | | Indonesia | |
|---|---|---|---|---|---|---|
| Changes to seasons, irregular rainfall | More drought | 77.2% (73.4–81) | Weather has changed | 84.2% (79.2–89.2) | Weather has changed | 86.3% (79.4–93.3) |
| Increased incidence and severity of floods | Rainy season finishes earlier | 76.8% (73–80.6) | Hotter temperatures[b] | 59.1% (52.5–65.7) | Hotter temperatures[b] | 75.4% (68.7–82.2) |
| Increased incidence and severity of drought | Hotter environment | 65.5% (61.2–69.8) | Seasons have changed | 77.6% (70.9–84.2) | Seasons have changed | 83.1% (75.9–90.3) |
| | | | Hotter temperatures in dry season[c] | 49.8%[c] (42.9–56.7) | Hotter temperatures in dry season[c] | 60.8% (51.8–69.8) |
| | | | Rainy season starts earlier[c] | 34.7% (27.4–41.9) | Rainy season starts earlier[c] | 11.6% (5.2–17.9) |
| | | | Rainy season starts later[c] | 25.3% (18.2–32.3) | Rainy season starts later[c] | 17.9% (9.6–26.3) |

[a]Information from focus group discussions.
[b]Of those who thought weather had changed.
[c]Of those who thought seasons had changed.

for further discussion). Pre- and post-samples were independently drawn.

Surveys assessed community perceptions of climate variability and change, of links between climate and disease, and of local disease prevention. Survey translations were reviewed and pilot tested and were administered by trained interviewers who secured informed consent and anonymity of respondents. In order to not bias responses, interviewers did not read out answer alternatives to survey questions aloud during survey administration.

#### *2.3.2. Operations and programming*

With regard to project techniques, we examined the use of climate information in health promotion activities. We conducted a qualitative review of project documents and contingency plans to examine the types of activities conducted, triggers for carrying out these activities, and partners involved.

#### *2.3.3. Data analysis of disease prevention behaviour*

To examine community perceptions of the relationship between climate and health, we calculated prevalence estimates and 95% confidence intervals from responses to the quantitative survey questions. SPSS and Microsoft Excel were used for the Kenya and Tanzania data. SAS (Research Triangle Institute, Research Triangle Park, NC, USA) was used for Vietnam and Indonesia to account for clustered sampling and survey weights where relevant; survey weights were normalized, and pre- and post-samples were comparable in demographic characteristics (i.e. gender and occupation).

In assessing changes to disease prevention behaviour in the population, we compare proportions of the population self-reporting certain behaviours before and after the programme was completed. Statistically significant results are marked with asterisks (*) in the following section, allowing for a very conservative estimate of statistical significance compared to simply using overlapping confidence intervals.

## 3. Results

### 3.1. *Community understanding of climate and health*

The way in which community members perceive climate variability and change can influence their motivation to engage in public health programmes and should be taken into account when choosing how to communicate prevention of climate-influenced diseases. In all four countries, most respondents (60–80%) indicated that they were familiar with the concept of climate change (Figure 1), and community members articulated that they have already experienced changes to seasonal and weather patterns, extreme events, and increased temperatures (Table 2). In

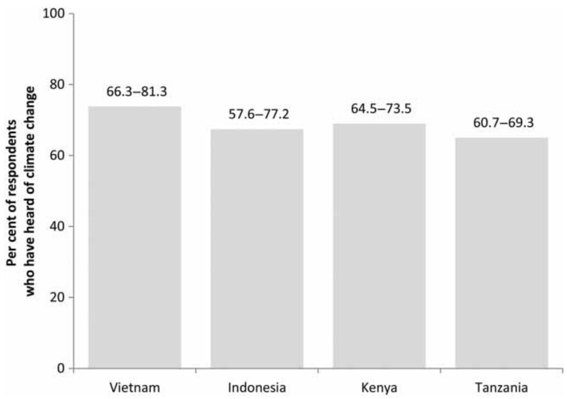


Figure 1. General awareness of the concept of climate change by country.

Kenya, questions about observed climate changes were posed to gender-disaggregated focus group discussions in each project location; Table 2 reflects the qualitative answers stemming from those discussions.

With regard to people's perception on the links between seasonal variability and health, in East Africa, people perceive the prevalence of both diarrheal diseases and malaria to be significantly higher in the rainy seasons than the dry seasons (Table 3). Because both project areas experience endemic malaria, educational materials as part of this project included information on malaria in addition to diarrheal disease. In Southeast Asia, 77.4% (70.9–83.9) of respondents in Vietnam and 53.5% (42.9–64.2) in Indonesia reported that dengue is presently most common during the rainy season.

In Tanzania, respondents were asked to name which health issues they expect to be affected by climate change; diarrheal diseases (81%) and malaria (67.2%) were the most commonly named (Table 4).

Similarly, in Southeast Asia, most respondents believe that climate change will affect health (79% Vietnam and 70% Indonesia), including dengue fever specifically (55.3% Vietnam and 51% Indonesia). When asked about the mechanism by which climate change will affect dengue fever, the most common answers were that more rainfall will increase the breeding of mosquitoes (90.0% Vietnam and 36% Indonesia). A man in a Ho Chi Minh City focus group stated quite simply: "Dengue fever is caused by rains. And changes in the weather and climate have effects on dengue fever" (Table 5).

In all four countries, people expected that climate change will cause disease and health effects. Across the board, most respondents mention rainfall: in both East African countries, respondents were concerned about variable rainfall and drought; in Southeast Asia, variable rainfall and storms, hurricanes, and typhoons were mentioned most frequently. In Vietnam, a women's focus group in Ho Chi Minh City stated "climate change in recent years means natural disasters, flood, and drought". Most respondents identified plausible climactic impacts and effects on livelihoods, livestock, and crops.

### 3.2. *Integration of climate into health programming*

The main activity of this project was to raise community-level awareness on climate and health, both the link between climate and disease as well as methods for effectively preventing illness and managing it. IEC materials were developed specific to this project, addressing the primary concerns of survey respondents as well as corroborating or correcting widely held beliefs on climate and health. In all four countries, the IEC materials included information on the effects of climate change that can be expected in the target region, including the concept of increased uncertainty. Specific links between climate and disease, when applicable, were explained through simple diagrams and text in the local language. All materials also included information on intervention measures to prevent the spread of disease in a changing climate, based on existing health risk reduction best practices, such as use of latrines for diarrheal disease.

Following up on the educational materials, a key component of this project was the creation of a climate-informed "contingency plan" by each Red Cross National Society. Contingency plans consist of a set of scenarios that organize and anticipate the flow of resources during a disaster (IFRC, 2012). As contingency planning is a fairly standard practice in disaster management circles, planning encouraged collaboration and integration between health and disaster management specialists within the National Societies implementing this project. The four results are compared below to identify points of departure in the inclusion of climate information (Table 6).

All four plans identified seasonal disease peaks in endemic areas, and organized disease prevention activities on a seasonal basis. At least three types of activities are defined: on-going activities, activities to be carried out during the "low" disease season, and activities for the

Table 3. Per cent of respondents noting the presence of different diseases during the specified season.

| | Kenya | | Tanzania | |
|---|---|---|---|---|
| | Rainy | Dry | Rainy | Dry |
| Diarrheal diseases | 95.7% (93.7–97.7) | 85.7% (82.3–89.1) | 84.2% (80.9–87.5) | 50% (45.5–54.5) |
| Malaria | 100% (100–100) | 97.6% (96.1–99.1) | 88.5% (85.6–91.4) | 76.5% (72.7–80.3) |

Table 4. Per cent of respondents expecting climate change will affect health issues in Tanga, Tanzania.

| | |
|---|---|
| Diarrhoea | 81% (77.4–84.6) |
| Malaria | 67.2% (63–71.4) |
| Respiratory diseases | 14.7% (11.5–17.9) |
| Heart disease | 10.3% (7.5–13.1) |
| Influenza | 3% (1.5–4.5) |
| Heat stress | 9.8% (7.1–12.5) |
| Cancer | 3.2% (1.6–4.8) |
| Dengue | 1.1% (0.2–2) |

"high" season, when prevalence rates increase and larger outbreaks are more likely. A combination of disease incidence rates and climate factors was used to define different action "brackets". All plans included partnerships with and between local institutions, the most common being meteorological departments, ministries of health, and local community-based organizations.

Rainfall is used as a contingency planning tool in two ways. In Tanzania and Indonesia, seasonal rainfall is used as an indicator of *when* to carry out activities, and is used to alter the calendar: for example, calling volunteer meetings earlier when the season start date is predicted to be earlier. Rainfall can also be used to inform *where* to intervene. In Vietnam, rainfall forecasts are used to adjust activities in space, for example, targeted clean-ups of mosquito breeding sites in areas forecasted to receive rainfall. This is similar in Kenya, when short-term rainfall forecasts trigger local activity in preparation for floods.

In Kenya, traditional early warning signs for flooding, such as observations of the environment, were included to encourage community action alongside scientific forecast-based alerts. In Tanzania, water purification materials were put on a seasonal distribution cycle in light of rainfall characteristics, and in Vietnam, a system was instituted to reciprocally share disease prevalence data on a timely basis with the Health Department. Data sharing is key to improving disease surveillance, enabling early and targeted response. Indonesia included a unique category of actions to be carried out post-peak of dengue, with an aim to prevent recurrence.

### 3.3. *Community disease prevention behaviour in project locations*

In Kenya and Tanzania, educational aspects of the climate and health project focused on community and individual level behaviours that would reduce the risk of diarrheal disease, particularly basic hygiene and spatial segregation of waste from work and play areas through the use of latrines. While latrines were not provided by the project, the educational interventions taught community members techniques for constructing latrines from locally available materials, and both countries saw a statistically significant increase in latrine coverage.

Community members in Kenya were more likely to treat their drinking water after the project, although in Tanzania this indicator remained fairly static, perhaps due to economic restrictions. Significantly more community members in both locations indicated that they receive early warning information for floods after project completion; Kenya increased from 68.6% to 86.5%, and Tanzania from 52.3% to 81.0%. In Tanzania, significantly more respondents indicated after the project that, during flooding, their latrines would still be usable. At the inception of the project, more than 95% of respondents washed their hands and did not dip their hands in their water source; therefore these were not included in measuring change after the programme.

Both Kenya and Tanzania also included education on malaria prevention, as this was identified as a seasonal risk by community members. Ownership of mosquito nets increased significantly in both Kenya (84.8–99.5%) and Tanzania (77.6–96.7%) after the programme was completed. In Kenya, nets were distributed, but in Tanzania, they were not, as they were considered to be widely available (Tables 7 and 8).

In Vietnam and Indonesia, the climate and health project focused solely on dengue fever prevention: strategies for reducing mosquito habitats; prevention from getting bitten; and recognizing the need to seek care. Community-level activities in Indonesia were delayed due to several disasters in the region and internal restructuring within the Indonesia Red Cross; therefore, fewer activities were implemented in this country than in the others. In Table 9, the change in behavioural indicators for Indonesia is less than that of Vietnam, with none of the indicators reaching statistical significance.

In Vietnam, a number of actions to reduce mosquito habitat increased with statistical significance from the baseline to the endline of this project, including preventing water stagnation, covering water containers, and regularly cleaning water containers. Indonesia saw a non-significant

Table 5. Expectations for the effects of climate change on health in Southeast Asia.

| | Vietnam | Indonesia |
|---|---|---|
| Believe that climate change will affect health | 79.0% (71.5–86.5) | 69.9% (59.6–80.3) |
| Believe that climate change will affect dengue fever | 55.3% (46.1–64.5) | 51.0% (42.4–59.6) |
| Expect dengue will increase due to more mosquito breeding sites from more rain | 90.0% (85.6–94.4) † | 47.5 (35.4–59.6)[a] |

[a]Of those who thought climate change would increase dengue.

Table 6. Characteristics of contingency plans incorporating climate information.

| | Kenya | Tanzania | Vietnam | Indonesia |
|---|---|---|---|---|
| On-going activities | Awareness creation on hygiene; hazard review | Monitor forecasted season start date | Visit at-risk families in areas with new cases; refresher trainings; hazard review | Monitor forecasted season start date |
| Pre-peak-season activities | Strengthen flood gates, clean water channels, de-silt rivers, stockpile water purifiers, treat drinking water, clean mosquito breeding grounds, dispose of waste, fortify latrines and homes, hand-washing campaigns | Volunteer meeting about rainfall forecasts prior to advent of rainy season, clean local environment, distribute treated bed nets and water purifiers, sanitation campaigns | Monitor caseload, rainfall and forecasts to identify areas to preposition materials and train volunteers; recruit/maintain volunteers, awareness campaigns, sustain vector-control activities | Monitor rainfall forecasts and caseload, warn communities on surveillance and prevention activities, spread larvicides, sanitation campaigns |
| Peak-season activities | Open water channels and ponds, review disaster response activities | Check that treated bed nets are hung, people with symptoms are going to clinic, water/sanitation education | House-to-house education and guidance, share case information, strengthen breeding ground elimination | Monitoring, surveillance, and case analysis; mobilize funds, ambulance and medicines |
| Partners | Provincial government, Local Committee, Meteorological Department | Meteorological Service, Health Department | Department of Health, People's Committee, local associations | Health Office, local administration, regional hospitals, community organizations |
| Unique components | Incorporate traditional early warning signs when mobilizing community | Seasonal calendar for non-food-item distribution | Health data shared reciprocally with health department | Post-epidemic activities to prevent recurrence and accelerate recovery including M&E |

Note: M&E, monitoring and evaluation.

increase in preventing water stagnation and making sure water containers are covered. With regard to managing the risk of being bitten by mosquitoes, self-reported behaviour in Vietnam increased significantly after the programme was completed. This included an increase in use of bed nets at night and during the day, as well as mosquito repellents and electrocutors.

## 4. Discussion and conclusions

### 4.1. *Community understanding of climate and health*

Research about community perceptions of climate change in the USA, Canada, and Europe shows that respondents tend to rank health implications of climate change as an unlikely or unimportant effect, or are unable to name specific health risks of climate change (Berry, Clarke, Pajot, Hutton, & Verret, 2009; Bord, Fischer, & O'Connor, 1998; Leiserowitz, 2005, 2007; Lorenzoni & Pidgeon, 2006). In contrast, the majority of respondents in Kenya, Tanzania, Vietnam, and Indonesia believe that climate change will have negative repercussions on human health; climate and health programming in these areas is likely to be well received. People already associate climate with health outcomes as they observe seasonal variability of health issues within their communities; therefore, information on health actions can reduce concerns and anxiety about future climate change.

### 4.2. *Integration of climate into health programming*

Given such widespread interest in the climate–health connection, this project generates a replicable approach to adjust health programming to incorporate climate information and an awareness of changing risks. Community-level action to prevent climate from exacerbating health outcomes need not be substantially different from the action that combats present-day health risks. However, climate information can inform *where* and *when* these actions should take place through climate-informed contingency planning, and also for how long. Through partnerships with meteorological departments and health departments, implementing partners were able to share information about rainfall, temperature, and disease incidence to tailor health interventions in each season. Although these contingency plans did not set explicit intra-seasonal thresholds of climate variables for instigating action, the partnerships with existing organizations and resource centres enabled practitioners to navigate the complex relationship between climate, immunity, and human behaviour that affects incidence of disease. It is vital for humanitarian organizations to liaise with *local* experts on disease and climate who understand the context and can advise on opportunities and limitations of using climate information for public health action.

Table 7. Self-reported behavioural indicators in Kenya.

| | Baseline | Endline |
|---|---|---|
| Receive early warning information for floods** | 68.5% (63.9–73.1) | 86.5% (83.2–89.8) |
| Treat water before drinking** | 89.4% (86.4–92.4) | 97.5% (96–99) |
| Have a latrine in household** | 88.1% (84.9–91.3) | 99% (98–100) |
| Have a bathroom in household** | 88.3% (85.2–91.4) | 96.5% (94.7–98.3) |
| Dispose of garbage in a garbage pit** | 36.4% (31.7–41.1) | 52% (47.1–56.9) |
| Have a mosquito net** | 84.8% (81.3–88.3) | 99.5% (98.8–100.2) |

*Items for which a two-tailed *t*-test is significant at the 0.05 level.
**Items significant at the 0.0014 threshold given Bonferroni correction for family of tests $n = 35$.

Table 8. Self-reported behavioural indicators in Tanzania.

| | Baseline | Endline |
|---|---|---|
| Receive early warning information for floods** | 52.3% (47.8–56.8) | 81% (77.3–84.7) |
| Treat water before drinking | 49.2% (44.7–53.7) | 49.3% (44.6–54) |
| Have a latrine in the household** | 84% (80.7–87.3) | 92.6% (90.2–95) |
| Use a latrine yourself** | 94.7% (92.7–96.7) | 99% (98.1–99.9) |
| During flooding can still use latrine** | 91.5% (89–94) | 99.1% (98.2–100) |
| Latrine is in proper use** | 91.4% (88.9–93.9) | 98.3% (97.1–99.5) |
| Have a mosquito net** | 77.6% (73.8–81.4) | 96.7% (95–98.4) |

*Items for which a two-tailed *t*-test is significant at the 0.05 level.
**Items significant at the 0.0014 threshold given Bonferroni correction for family of tests $n = 35$.

Table 9. Self-reported behavioural indicators in Vietnam and Indonesia.

| | Vietnam | | Indonesia | |
|---|---|---|---|---|
| How do you eradicate the breeding sites of mosquitoes? | Baseline (% and 95% CI) | Endline (% and 95% CI) | Baseline (% and 95% CI) | Endline (% and 95% CI) |
| Preventing water stagnation** | 64.4 (56.8–72.0) | 87.5 (82.3–72.0) | 49.2 (41.8–56.7) | 55.3 (45.5–65.0) |
| Covering water containers** | 50.8 (42.0–59.6) | 81.1 (75.2–86.9) | 10.9 (4.3–17.4) | 19.8 (9.0–30.5) |
| Regularly clean water containers** | 46.5 (42.0–51.8) | 67.7 (60.9–74.5) | 49.0 (41.0–57.0) | 31.5 (24.1–38.9) |
| Cleaning of garbage and trash* | 40.1 (30.8–49.5) | 54.8 (47.3–62.2) | 40.2 (32.9–47.4) | 36.8 (27.6–45.9) |
| How do you prevent getting bitten by mosquitoes? | Baseline | Endline | Baseline | Endline |
| Mosquito spray | 69.8 (61.9–77.8) | 76.8 (68.4–85.2) | 57.6 (47.8–67.4) | 66.0 (58.0–74.0) |
| Mosquito bed net at night* | 63.9 (55.4–72.4) | 75.6 (67.9–83.2) | 4.5 (1.7–7.4) | 3.5 (1.0–5.5) |
| Mosquito bed net for daytime sleeping | 54.39 (45.4–63.4) | 66.4 (58.7–74.1) | 1.8 (0.4–3.2) | 5.0 (0.3–9.7) |
| Mosquito bed net for working/doing homework** | 1.94 (0.68–3.2) | 10.86 (5.9–15.7) | – | – |
| Window and door screens** | 5.6 (2.8–8.4) | 16.4 (9.5–23.2) | 4.0 (1.3–6.8) | 7.8 (3.3–12.3) |
| Mosquito repellent and cream* | 28.0 (20.3–35.6) | 40.8 (33.1–48.5) | 65.9 (58.0–73.8) | 56.5 (48.8–64.2) |
| Wear long-sleeved clothes** | 25.3 (17.9–32.6) | 51.1 (42.9–59.4) | 1.51 (0–3.3) | 2.8 (0.5–5.0) |

*Items in Vietnam for which a chi-square test is significant at the 0.05 level.
**Items in Vietnam significant at the 0.0014 threshold given Bonferroni correction for family of tests $n = 35$.

Planning humanitarian and development health interventions along a seasonal calendar has precedent elsewhere; research shows that incorporating seasonality of disease patterns into prevention efforts can enable health practitioners and community members to concentrate efforts at the most effective times to prevent transmission. This makes interventions likely to be more cost-effective and successful (Altizer et al., 2006; Eisen et al., 2009; Khazeni, Hutton, Garber, Hupert, & Owens, 2009; Vazquez-Prokopec, Chaves, Ritchie, Davis, & Kitron, 2010). The recent IPCC report acknowledges the seasonality of this disease and the efficacy of scaling up control measures prior to the peak season (IPCC, 2014). In fact, Luz, Vanni, Medlock, Paltiel, and Galvani (2011) show that insecticide-based mosquito control can be counterproductive in reducing dengue incidence if applied equally over the course of a year, because over-application can cause insecticide resistance in mosquitoes and loss of immunity in the population before a renewed outbreak.

The two diseases examined in this project required different techniques to monitor and respond to the threat of an outbreak, and preparing for the possible effects of climate change on dengue fever is particularly challenging. First, it is still unclear how climate change might influence seasonal patterns and affect which populations are most at risk for contracting dengue, because of the number of complex factors influencing transmission. Second, there are no operational seasonal climate-based early warning systems in operation for dengue fever. In light of these challenges, public health practitioners and community-based organizations can adapt by keeping their "ear to the ground" and implementing strong surveillance mechanisms and programmes to share incidence data to quickly detect any changes in disease patterns. This applies during an epidemic or outbreak, but also generally, to ensure that agencies working to prevent dengue are aware of any longer term seasonal or geographic shifts in disease patterns.

### 4.3. *Disease prevention behaviour in project locations*

After the climate and health project, disease prevention behaviours increased in all project communities. Such risk reduction behaviours and programme interventions are not necessarily different than what would have been done without a consideration of climate variability and change; instead, educational interventions promoted best practices in disease prevention through an explanation of the relationship between climate and health. Increased community-level disease prevention at the right places and the right times is key to combatting the effects of climate change and climate variability. As climate change might alter current seasonal or geographical patterns of disease, the contingency plans also enable practitioners to "expect the unexpected" and have a plan of response in place.

### 4.4. *Implications*

Based on these results, practitioners in developing countries should be aware of the common local concern that climate change will cause negative health effects. Programming that addresses this concern by empowering community members with actions to reduce the possible negative effects of climate change is likely to be well received, as community members are aware that rainfall and temperature are associated with local disease incidence and are already observing changes in their local climate. While recognizing that disease incidence is not only perfectly predicted by climatic variables but is also influenced by other factors, the climate–health connection should be integrated into traditional health educational materials.

It is important to note that respondents were overwhelmingly concerned that climate change would cause an increase in existing endemic diseases; very few expected that a changing climate will introduce entirely new risks. Given this, if climate change is expected to increase the geographical range of a disease, health practitioners should consider educational activities to alert the susceptible population, who might otherwise focus on their vulnerability to known disease patterns.

Adaptation to climate change in health programming should also take into account projections of increasing climate uncertainty. Increases in activity to prevent disease will ultimately serve to benefit those involved, although it is not always clear how the climate will ultimately affect disease patters. This approach can be considered "no-regrets", as improved community and organizational level preparedness will combat factors other than climate change that also increase disease risk.

### 4.5. *Limitations*

Translating the term "climate change" into local languages can pose particular challenges, because the use and understanding of the term can differ between countries. In our study, survey enumerators often needed to explain the term as defined by the IPCC, as several respondents took "climate change" to mean the change that takes place from one season to the other.

In Tanzania and Kenya, there might have been a sampling bias towards households in smaller villages in rural wards which could have affected our estimates and confidence limits. (The number of households selected in each ward was proportional to ward size. In rural wards one village was selected at random and all households in that ward were sampled from that village.) In the future, it would be ideal to carry out a similar study including a control group to gather further information as to the effectiveness of health interventions.

### 4.6. *Directions for future research*

More research is needed to substantiate the results of this initial study. While this paper focused on four countries carrying out different health interventions, it did not seek to primarily evaluate climate/health intervention methods. Such evaluations are lacking in the literature (Heintze et al., 2007, Hosking & Campbell-Lendrum, 2012), and further quantitative research could enable practitioners to understand which activities are the most successful and cost-effective. In particular, more information is needed on the efficacy of different methods to prevent dengue fever outbreaks and seasonal peaks.

Further research to quantify any reduced disease prevalence that resulted from increased community knowledge and action would aid in estimating the effectiveness of project techniques. The extent to which greater understanding of climate information corresponds with greater disease prevention in individuals should also be investigated to aid in programme development, and best practices in climate–health partnerships should be ascertained through follow-up and evaluation of the permanency and evolution of the relationships developed during this project.

Research should also evaluate the longevity and long-term impacts of contingency planning, particularly the efficacy of these plans during and after extreme events that could cause a disaster. To further expand the contingency plan approach, researchers should develop methodologies to select thresholds of climate variables (temperature and precipitation) that would be accurate triggers for humanitarian action against disease. At the moment, there are few, if any, operational early warning systems for dengue fever in the world, and research into climate thresholds coupled with disease incidence could be relevant both at the institutional level, to spur interventions and programming, and also at the community level, to spur mobilization and action. Based on future research, humanitarian organizations should be able to pre-emptively take action before a disease outbreak, greatly increasing the ability to save lives and livelihoods.

### 4.7. *Conclusion*

Seasonal climate variability has always impacted health, and given that climate change will affect seasonality and climate extremes, there is a need to develop programming that can respond to climate variability and change. Preliminary conclusions from our study indicate that there is merit in including climate considerations in health programming, and that the following two components respond to a widespread concern about climate change and health: the integration of basic climate information in health educational materials and the use of climate information to inform the location and timing of health interventions. This should be combined with better surveillance to detect changing patterns of climate sensitive diseases. Such programming is likely to increase community-level preventative behaviour in a way that will increase resilience to climate change, regardless of its future manifestation in any given locality.

## Acknowledgements

This study has been partly funded with funding from the Rockefeller Foundation. The authors thank Sabine Marx at the Center for Research on Environmental Decisions (CRED), Columbia University, for introducing us to the method of Mental Model Interviews, and for her help with the development of survey instruments. The authors also thank Sheila Chemjor and Robertus Sulistyo of the International Federation of Red Cross and Red Crescent Societies, Kennedy Mulama and Linnet Oballa of Kenya Red Cross, Renatus Mkaruka of Tanzania Red Cross, Dewi Ariyani of Indonesia Red Cross, Bryan Moy, Scott Wood, Jennifer Bream, and Lindsay Bouton.

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