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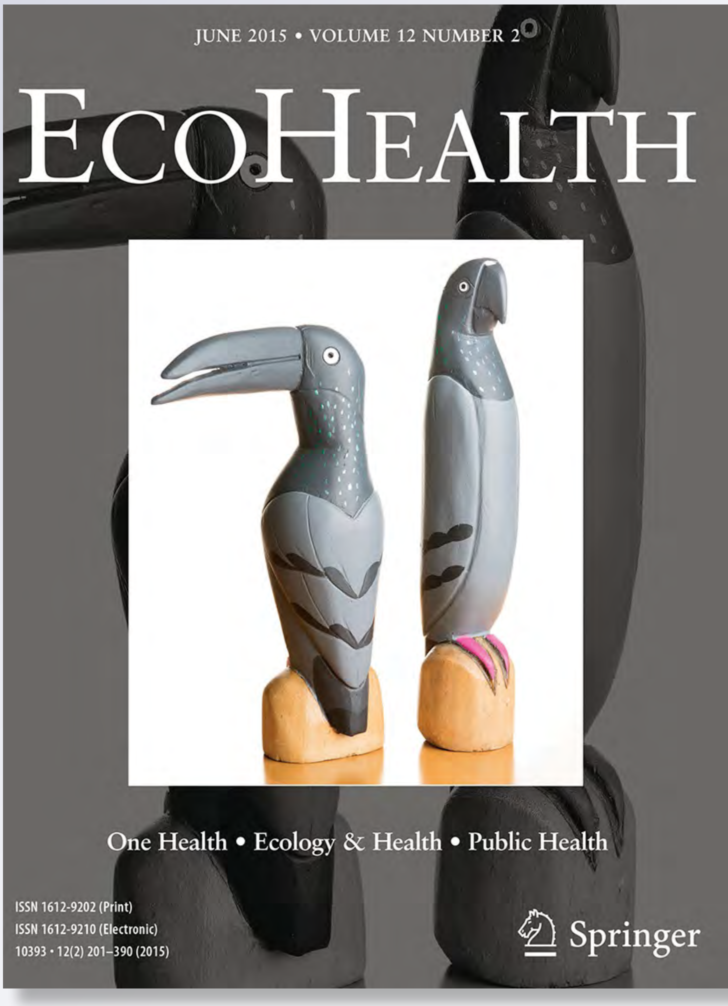

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Original Contribution

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Strengthening Ecohealth Practice Throughout Conservation Science and Capability Approach

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Abstract: Adaptive management and ecohealth frameworks were developed for malaria elimination in Amerindian riparian communities of Venezuela. These frameworks were developed as a strategy to capture, organize, and communicate connections among key factors related to local malaria complex systems. Important causal relationships between social, economic, and environmental stressors which are determinant of malaria were identified at different levels and assumptions that guide interventions are offered, based on available scientific knowledge and input from stakeholders. Drawing on our experience of action research committed to the health of Amerindian populations and conservation of areas with biodiversity value, the authors provide lessons to strengthen the practice of an ecohealth approach. First, conservation targets were considered as a way to achieve sustainable human well-being rather than as a consequence of well-being. Second, the effectiveness and sustainability of technical solutions generally proposed for malaria control depend largely on individual knowledge, attitudes, and practices. Hence, it is necessary to look at the real opportunities of choices that Amerindian people have for attaining a life without malaria, and therefore pay attention to local capabilities, needs, and freedom to choose. The ecohealth approach can benefit from the capability approach, and we explain why.

Keywords: malaria, Ye'kwana, Sanema, Caura, ecohealth, adaptive management, capability approach, Guiana Shield

INTRODUCTION

Malaria is a major health problem in the Amazon region, where it accounts for more than 80% of all cases in the American Region (PAHO 2012). The main problems facing Amerindian communities in the region include poverty, illiteracy, unemployment, lack of land and territory, and high morbidity from preventable causes (PAHO 2002). In remote forested areas with Amerindian populations in southern Venezuela, the loss in quality of life is exacerbated by the gradual degradation of the ecosystem, over

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exploitation of natural resources (agriculture, timbering, gold mining), and changes in traditional settlement patterns (Miranda et al. 1998; Bevilacqua et al. 2002; Bevilacqua et al. 2006).

This region has been classified for more than 50 years as affected by elusive malaria, due to the difficulties inherent in geographic access and the presence of dwellings with limited or no walls for residual spraying with DDT used by the Venezuelan Malaria Eradication Program (Gabaldon 1983). By the late 1990s, community-based epidemiological surveillance and malaria control measures were implemented (Bevilacqua et al. 2009). Despite these efforts malaria cases in Bolivar State raise from 4998 cases in 2001 to 65,980 in 2013 (MPPS 2002, 2013), currently representing 89.1% of all reported malaria cases in Venezuela. National and Bolivar State epidemiological records do not publish any data on malaria trends in Amerindian populations.

Some studies explain variations in malaria prevalence in the southern region of Venezuela as a consequence of budget reductions for program activities and control, increased mining activity, population migration to endemic areas, exophilic behavior of mosquito vectors, and remote frontiers where malaria control activities are difficult to implement (Sandoval de Mora 1997; Moreno et al. 2007). Few studies investigated malaria transmission in southern Venezuelan Amerindian communities, and most such studies have taken place in the State of Amazonas (Magris et al. 2007a, b). Southern Venezuela is not environmentally uniform, and given the vast differences in geomorphology, drainage patterns, and economic, social, and cultural diversity between eco-regions, findings in one area cannot be generalized to the rest of it.

Malaria transmission is a result of a dynamic interaction between the pathogens, the vectors, and the human host, in the context of a heterogeneous environment, natural and anthropogenic landscapes, and time scale (Patz et al. 2000, 2004; Vittor et al. 2006). The concept of frontier malaria to characterize transmission in settlement areas of the Amazonian region has been proposed (Sawyer 1989; Sawyer and Sawyer 1987) to address the challenges of local control. Castro et al. (2006) pointed out limitations in the spatial and temporal dimensions of the frontier malaria concept, and suggest that malaria risk can be better characterized with analytical models linked to social, economic, environmental, demographic, and ethnographic information, in both temporal and spatial dimensions.

There are reasons to think that the increase in malaria prevalence in southern Venezuela is due to the lack of a systemic approach to human and natural ecosystems health in the malaria program, as has been proposed in some Amazonian countries. So there is an urgent need to develop analytical models of malaria risk that include and describe determinants that exacerbate the emergence of the disease. In this study, we describe the development of a conceptual model that combines adaptive management (Holling 1978; Gilioli and Baumgärtner 2007; Rehr et al. 2012) and ecohealth (Nielsen 2001; Waltner-Toews 2001; Charron 2012a, b) approaches to address a long-term action research intervention to eliminate local malaria among Amerindian communities in the Caura River Basin of Venezuela.

The paper is divided into three parts. Part 1 develops the conceptual framework that reflects our understanding of the interaction between the social, economic, and environmental dimensions of malaria transmission (ecohealth), and also describes causal relationships between factors identified for adaptive management pertinent to the malaria program. Part 2 summarizes the results of our research aimed at understanding malaria determinants in Amerindian communities. Part 3 highlights key findings and constrains to fight malaria in the study area, and poses two fundamental questions that arose during this review: Has the Ecohealth approach limitations to solve the problems of malaria through public policy? Can adaptive management and the capability approach conceptual bases contribute to inform health policy, particularly from Ecohealth approach, applied to the case of malaria in Amerindian communities?

Conceptual Framework

Two conceptual frameworks were developed with three objectives: (1) to focus on the causal relationships and identify key environmental, social, cultural, and economic factors relevant to human well-being and malaria; (2) to implement interventions with a systemic approach to human health and adaptive management, and use this information to learn what works and what does not work for elimination of local malaria, and (3) to aid in identifying long-term operational research program to help address local life without malaria.

Adaptive Management Framework

The complex nature of the ecological and socioeconomic dimensions closely involved in malaria transmission limits the applicability of traditional experimental approaches. Moreover, dealing with environmental risk factors to human health and interactions between individuals and communities on multiple scales calls for an adaptive management approach, as has been suggested in conservation biology (Meffe and Carroll 1997). Adaptive management is a continuous process of data acquisition, processing, and model development to improve knowledge and decision-making for a wide range of applications (Comiskey et al. 1999). It is an iterative process of robust decision making in the face of uncertainty, with the aim of reducing uncertainty over time via system monitoring. The procedure, initially developed by Holling (1978) for forestry management, was further developed as an approach to natural resource management (Walters 1986; Rose and Cowan 2003; Nicols et al. 2007; Meffe and Carroll 1997). The approach has been extended to ecosocial systems (Gunderson et al. 1995; Waltner-Toews et al. 2003; Gilioli and Baumgärtner 2007).

Adaptive management was applied in the early 1990s to understand the interactions between social issues and the state of the environment, to identify lessons learned across development projects (OECD 1994), and to link environmental risk factors to human health (Corvalán et al. 1999). Since then, the approach has evolved into the Driving force–Pressure–State–Impact–Response (DPSIR) framework, which has been widely used to integrate socioeconomic factors to environmental planning purposes, for the sustainable use and management of natural resources (EEA 2005), and to integrate public health issues with environmental health (Yee et al. 2012). By 2004, a common set of Open Standards for the Practice of Conservation (OPSPC) and guidelines had been developed to apply adaptive management to best practices for conservation project design, management, and monitoring (CMP 2013).

Building on these backgrounds, we develop a conceptual framework to improve the effectiveness and efficiency of the Bolivar State Malaria Program, to strengthen the practice of ecohealth in remote Amerindian territories, and address riparian forest conservation.

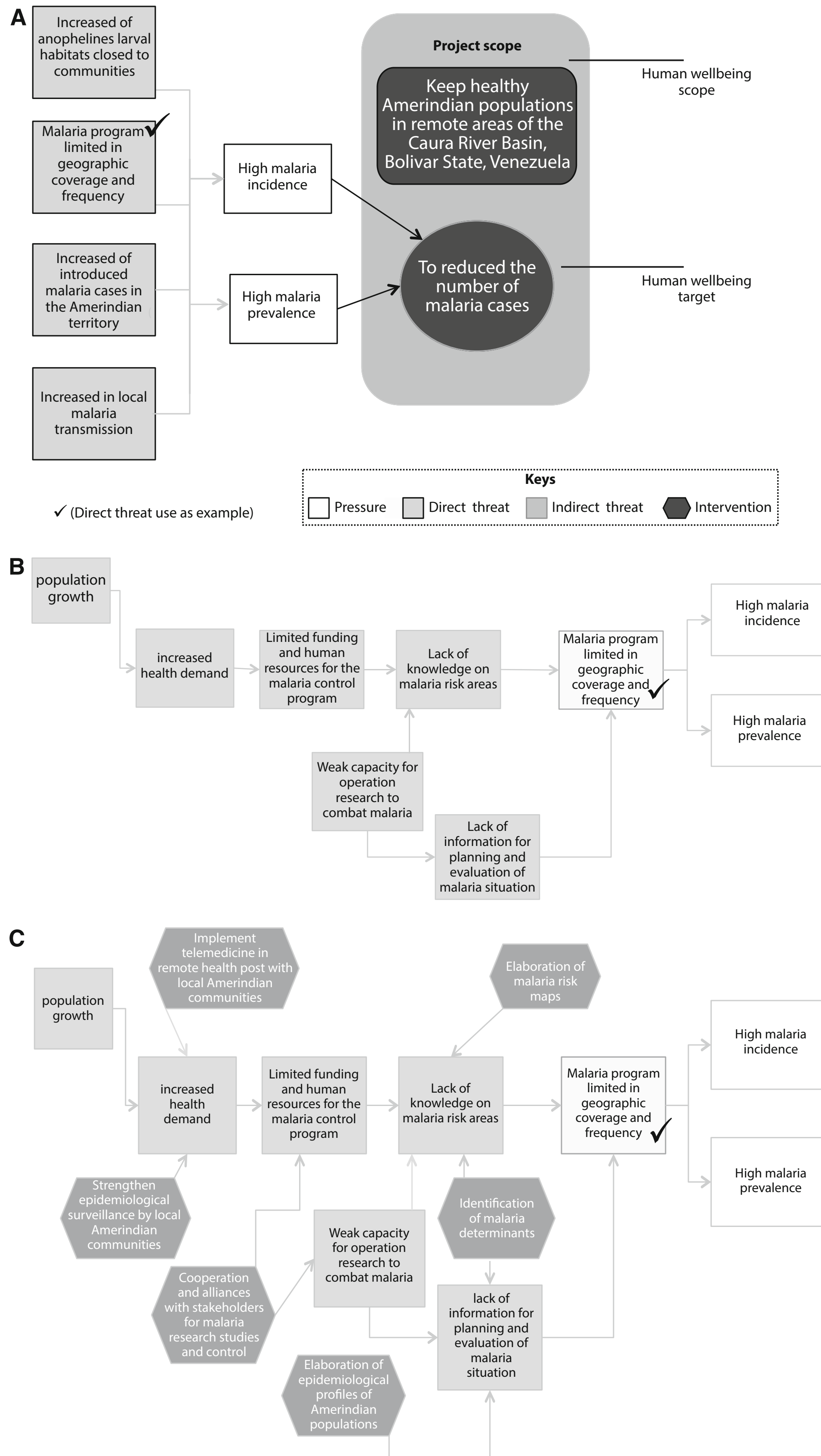
The framework was developed by a team of experts in conservation biology, human geography, epidemiology and entomology, local health care agents, and community leaders. The construction of the framework starts identifying the project's geographic scope (what the team sought to achieve), and the human well-being target, as a common base for setting goals, carrying out actions and measuring effectiveness (Figure 1A). Then, direct threats that degraded or prevented the human well-being target were identified. Based on a situation analysis, the team establishes main hypothetical cause-and-effect relationships between the key factors that we believe drive the direct threats and ultimately influence the human well-being target (Figure 1B). The next step was to identify which factors offered opportunities for intervention, and identified the ones that can best be leveraged to achieve project goals (e.g., increased agricultural and mining activities). Once key interventions were prioritized, a set of potential strategies that addresses these intervention points was generated and then those with the greatest potential to achieve the project's target were selected (Figure 1C). Finally, the team selected the best set of strategies from among the existing alternatives (e.g., studies of dynamic changes in ecosystems and their relations with epidemiological events), and drew assumptions on how the strategies would contribute to achieving the human well-being goals.

Figure 2 shows a synthesis of the entire conceptual model. Based on the OSPC tool (CMP 2013), we developed a chain of result tool to depict these assumptions, in a causal progression from expected short- to long-term intermediate results that lead to longer-term results (not shown in this paper).

Ecosystem Health Approach Framework

The ecosystem approach to health or "ecohealth" (Nielsen 2001; Waltner-Toews 2001) focuses on the interactions between biophysical, sociocultural, and economic environments or dimensions where disease occurs. These interactions can be analyzed from different hierarchy levels or scales such as the individual, community, region, country, and international level (Riach 2004). In the context of vector-borne diseases, the biophysical dimension is important for the presence, reproduction, and survival of the vector and the etiologic agent, while the sociocultural and economic dimension are relevant for human–vector contact and transmission (Campbell-Lendrum and Molyneux 2005).

Considering the six principles of ecohealth approach (Charron 2012a, b), we developed the ecohealth framework for the prevention and control of malaria in Amerindian populations in the Caura River basin (Figure 3). Malaria in riverine communities is described in terms of the interaction between environmental, sociocultural, and economic factors at the individual, home, community, and river basin scales. At each scale, we considered factors that influence


A
Increased of anophelines larval habitats closed to communities
Malaria program limited in geographic coverage and frequency
Increased of introduced malaria cases in the Amerindian territory
Increased in local malaria transmission
High malaria incidence
High malaria prevalence
Project scope
Keep healthy Amerindian populations in remote areas of the Caura River Basin, Bolivar State, Venezuela
To reduced the number of malaria cases
Human wellbeing scope
Human wellbeing target
✓ (Direct threat use as example)
Keys
Pressure
Direct threat
Indirect threat
Intervention
B
population growth
increased health demand
Limited funding and human resources for the malaria control program
Lack of knowledge on malaria risk areas
Malaria program limited in geographic coverage and frequency
High malaria incidence
High malaria prevalence
Weak capacity for operation research to combat malaria
Lack of information for planning and evaluation of malaria situation
C
population growth
Implement telemedicine in remote health post with local Amerindian communities
increased health demand
Limited funding and human resources for the malaria control program
Elaboration of malaria risk maps
Lack of knowledge on malaria risk areas
Malaria program limited in geographic coverage and frequency
High malaria incidence
High malaria prevalence
Strengthen epidemiological surveillance by local Amerindian communities
Cooperation and alliances with stakeholders for malaria research studies and control
Weak capacity for operation research to combat malaria
Identification of malaria determinants
lack of information for planning and evaluation of malaria situation
Elaboration of epidemiological profiles of Amerindian populations

◀ **Fig. 1.** Step-by-step construction of the adaptive management causal framework of malaria in Amerindian communities of the Caura River basin, Bolívar State, Venezuela. **A** Human well-being scope and target, pressure, and direct threat, **B** example of indirect threat, **C** example of interventions.

the persistence of malaria, and identified and measured a set of variables to study the interaction between each dimension and the occurrence of malaria. Thus, the interaction between environmental and economic dimensions results in land use and vegetation cover change, whereas the interaction between environmental and sociocultural factors results in malaria transmission dynamics. At the intersection of the sociocultural and economic dimensions, the result is the public health care system. The ecohealth framework provided an overview of the process of disease causation, thereby helping to identify the most effective scale and dimensions for intervention efforts aimed at controlling or preventing disease outbreaks (e.g., individual, household, etc.).

Field Study

Given the multidimensional and multiscale nature of the ecosystem approach to health, no single methodology can be devised to capture all the data relevant to malaria events, nor is it possible to devise a decision support framework that can be used to build agreement around a preferred health intervention, especially among decision makers and multiple stakeholders who have different objectives and beliefs regarding malaria issues. The levels of analysis required, and consequently the methodologies needed, depend on the question being addressed in this study: what are the social, cultural, economic, and environmental determinants of malaria from the individual to the landscape scale? The following is a descriptive summary of the methods used in the study area.

Geographical, Geopolitical, and Ethnic Context

The project is located in the Caura River basin (45,336 km^2), in Bolivar State, southern Venezuela, as previously described (Bevilacqua and Ochoa 2001; Machado-Allison et al. 2003; Rosales et al. 2003). The Caura River is located in the heart of the Guiana Shield Eco-Region, which covers 250 million hectares and extends from Venezuela, Guyana, Suriname, and French Guiana and is confluent with the ecologically associated areas of northern Brazil and southwestern Colombia (Figure 4).

The Guiana Shield contains the largest uninterrupted primary tropical forests on earth, and is characterized by a uniquely high level of biodiversity and human cultural diversity, with at least 100 Amerindian cultures spread throughout. The Caura River basin has been inhabited by indigenous peoples since the earliest historical records, which date back to early Spanish contact in the mid sixteenth century (Perera 2003). Today the basin is the traditional habitat of two vigorous Amerindian peoples, the Ye'kwana, a Carib-speaking people, and the Sanema group (northern Yanomami). In common with most other peoples of the Amazon and Orinoco basins, the Ye'kwana and Sanema have mixed economies based on hunting, gathering, shifting cultivation, and the use of forest products for construction, medicines, food, and other material purposes (Colchester et al. 2004).

For over 18 years, the Venezuelan Association for the Conservation of Natural Areas (ACOANA) focused on biodiversity conservation and healthy communities along the Caura River basin, which gave us a thorough knowledge of the environmental, sociocultural, and economic dynamics of the region. In 1997–1998, we assisted the Amerindian Organization of the Caura Basin (KUYUJANI) with a general situation analysis of major health problems, and in 2003 we cooperated with KUYUJANI (26 communities, approximately 2340 people) to develop a conservation plan for traditional Amerindian territories (Bevilacqua et al. 2006). Our studies on malaria in the Caura River basin started in 2005 with the *Wesoichay* Project (*wesoichay:* malaria in the Ye'kwana language) at the request of KUYUJANI, encouraged by previous participatory action research that lead to considerable learning and community mobilization based on the Ye'kwana people's own well-being goals. At that time, a multidisciplinary and local community team, already working on a baseline malaria research agenda (financed by the Venezuelan Ministry of Science and European Delegation in Venezuela), applied for a seed grant from International Development Research Centre (IDRC-Canada) to focus on the ecohealth approach to the study of malaria and deforestation. Below we describe the methods used on this IDRC-project.

Methods

For individual, home, community, and basin scale, at environment, sociocultural, and economic dimensions

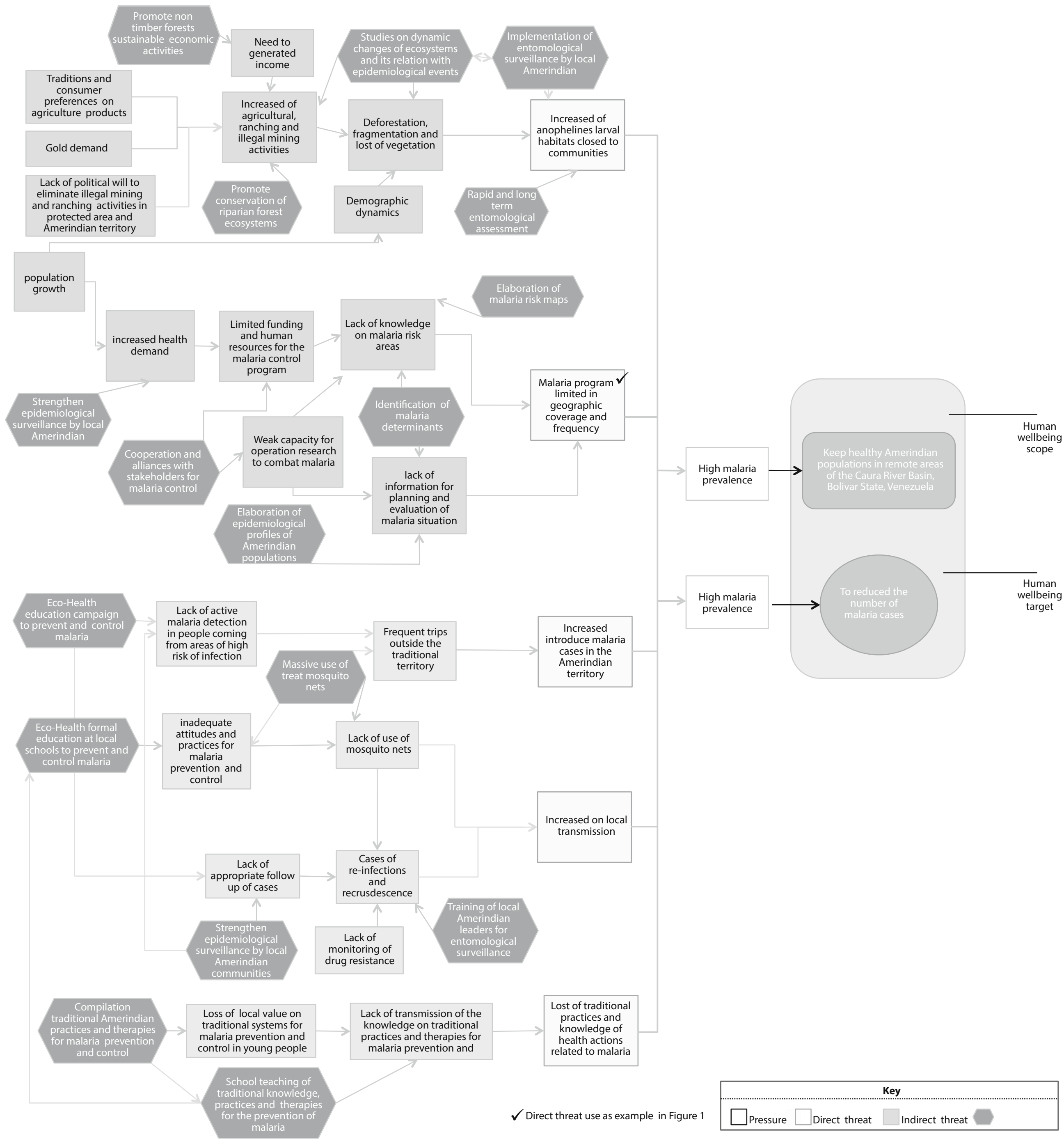


Figure 2. Adaptive management causal frameworks for malaria elimination in Amerindian communities of the Caura River basin, Bolívar State, Venezuela.

(Figure 3), standard research methods were used for data collection. Table 1 shows the variables recorded at each scale.

Environmental data: Available records for rainfall and temperature were obtained from 6 pluviometric and 2 climatological stations in the study area. The hydrological, landscape, topographic form, and altitudinal data were obtained from a digital terrain Caura model of the Shuttle Radar Topography Mission developed for the study (Medina et al. 2011).

Vegetation types and land cover data: Landsat 7 ETM + 30 m × 30 m resolution images were interpreted

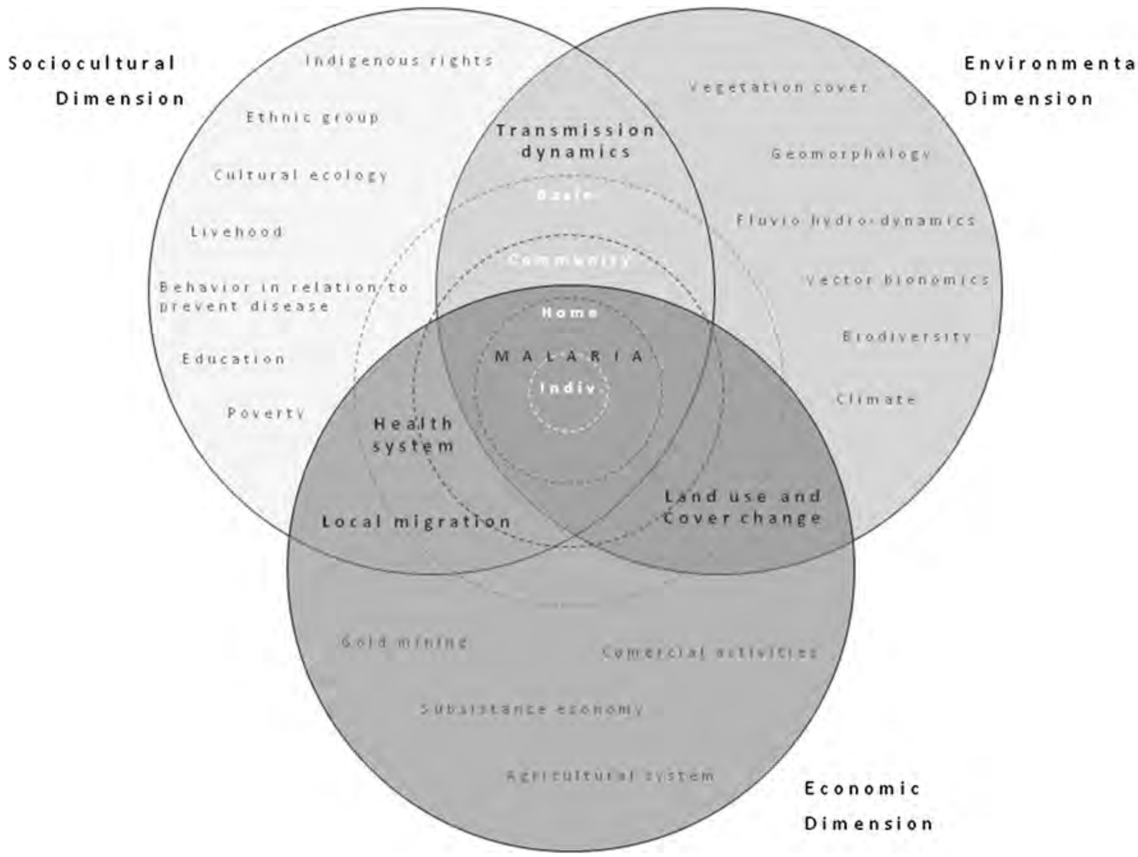


Figure 3. Ecohealth model of malaria transmission in riverine communities of the Caura River basin, Bolívar State, Venezuela. Factors identified in each dimension are shown, as well as the resulting effects on the interception of dimensions.

Figure 4. Regional location of the Caura River Basin (outlined in *black*) within the Guiana Shield in Venezuela.

Table 1. Type of Variables Recorded Within each Dimension at the Individual/Home, Community, and Basin Levels in Amerindian Riverine Communities of the Caura River Basin, Bolivar State, Venezuela.

Data	Scale		
	Individual home	Community	Basin
Environmental			
Temperature			✔
Rainfall			✔
Hydrology			✔
Landscape / site form			✔
Altitude			✔
Slope			✔
Vegetation type		✔	✔
Land cover		✔	✔
Larval habitats		✔	
Anopheline species diversity		✔	
Anopheline abundance		✔	
Parity		✔	
Incriminated vectors		✔	
Biting activity		✔	
Entomological inoculation rate		✔	
Sociocultural			
Age	✔		
Sex	✔		
Ethnic group	✔		
Type of work	✔		
Type of dwelling	✔		
Number travels per month	✔		
Level of education	✔		
Health post		✔	
Size and structure of population		✔	
Time of residence	✔	✔	
Search for health assistance	✔		
Behavior to prevent disease	✔		
Knowledge and practice about malaria	✔		
Economic			
Agricultural system	✔	✔	
Main economic activity	✔	✔	
Hunting	✔		
Fishing	✔		
Forest products exploitation	✔		
Mining	✔		
Economical status	✔		
Epidemiology of malaria			
Number of cases	✔	✔	✔
Number of cases by age	✔	✔	✔
Number of cases by sex	✔	✔	✔
Annual parasite index			✔
Plasmodium species	✔	✔	✔

within a buffer with a 5-km radius centered on each of the 26 communities analyzed, and were validated in the field (Medina et al. 2011).

Entomological data: Longitudinal studies were conducted in three selected villages in the Lower Caura River Basin. Larval habitats were characterized according to Rubio-Palis et al. (2010). Female adults were collected, identified, dissected for parity, and kept dry over silica gel until assayed by ELISA to identify *Plasmodium* spp circumsporozoite protein (Rubio-Palis et al. 2013). Further entomological surveillance was carried out by local leaders trained and supervised by the research team, with continuous follow-up by indigenous authorities in two Amerindian villages (Lower and Upper Caura).

Epidemiological malaria data: Historical epidemiological information (1995–2012) was provided by the 13 malaria health posts located in the communities, run by trained Amerindians nurses and/or microscopists supervised by the Society for Endemic Disease Control and the Indian Health Care (CENASAI). Consolidated data for the whole Basin were provided by the Institute of Public Health of Bolivar State. Data available included name, age, probable place of infection, and results of the parasitological diagnosis (results will be published elsewhere).

Sociocultural and economic data: Data were obtained from interviews of focus groups (local indigenous nurses, epidemiologists, school teachers, and other local leaders), the council of elders, and community dialogs in which both women and men participated. For individual, household, and community data collection, informed consent was obtained and local indigenous monitors were trained to use the census and questionnaire instrument designed for the study (Bevilacqua et al. 2009).

Major Findings

The major findings of this research project are summarized in Table 2, organized in terms of the dimensions and scale analyzed according to the ecohealth conceptual framework.

Discussion

This paper represents our efforts to fill the gap created by the lack of a systemic approach to human and natural ecosystems health in the Guiana Shield in Venezuela. It is the first study that uses an ecohealth approach to understand malaria prevalence in remote Amerindians population living in riparian forests. From its inception, the project built on multi-stakeholder participation, especially with Ye'kwana communities (health workers, local traditional leaders, and women). The project was implemented as a collective learning experience that involved academics, malaria program personnel, community leaders, and conservationists.

The OSPC tool was used to organize research data, a task associated with uncertainties, assumptions, intervention options, and objectives to be aligned for a strategy of relevant knowledge and information. This tool was useful to map the complex web of factors related to malaria, to drive intervention in key issues, and to learn from adaptive management. Use of the OSPC tool in human health projects is uncommon. In the logic of the OSPC conservation project, human well-being is achieved as a result of reaching biodiversity conservation targets, and consequently maintaining ecosystem services (CMP 2013). For example, fishery-based livelihoods would be a human well-being target in a project that aimed to conserve ichthyofauna resources for biodiversity and sustainable human use. Instead, in our framework, the conservation targets (e.g., to promote conservation of riparian forest ecosystems or promote sustainable economic activities in non-timber forests) are considered a way to achieve human well-being, rather than a consequence of well-being, based on the assumption that reducing deforestation will reduce the increase in anopheline larval habitats and at the same time reduce human–vector contact and prevent malaria transmission (Figure 2). Environmental sustainability is one of the challenges of ecohealth approach, and its intervention should be an integral part of ecohealth action plan, and not just a task for environmentalist and conservation biologist. Adaptive management and conservation science provide ways to the ecohealth approach to achieve welfare, as a result of biodiversity conservation actions. With this approach, we encourage the use of conservation targets as key interventions and an integral part of sustainable health agendas through an ecohealth approach.

Settlement change, transformation of landscapes, population growth, loss of cultural heritage, migration, and the emergence of illegal gold mining have modified the health challenges faced by Ye'kwana people. The conceptual frameworks developed describe the relation between drivers of malaria risk in the study area. Like other infectious disease-related health problems (Bazzani and Wiese 2012), the ecology and transmission of malaria in Amerindian communities in forested areas is linked to interactions

Table 2. Major Findings of the Research Project Within Each Dimension at the Individual, Home, Community, and Basin Levels in Amerindian Riverine Communities of the Caura River Basin, Bolivar State, Venezuela.

A. Environmental dimension

River basin scale

1. Natural environmental condition promotes reproduction of vector: temperature, precipitation hydrogeomorphological-vegetation interactions in the riverine corridor (flood pulses, spatial variations in water availability, nutrient supply, erosion, and overbank sediment deposition)
2. Map risk of malaria shows that the Caura River riparian corridor and its tributaries are areas at risk of malaria, with a gradient of low to high risk from south to north to the mouth on the Orinoco River
3. The most efficient vector specie of the Amazon basin is present: *Anopheles darlingi* (positive for *P. vivax* 210 and 247 CS protein)
4. A diversity complex of several vector species is present, whose abundances are higher in deforested habitats (*An. albitarsis F, An. nuneztovari s.l., An. oswaldoi B, and An. Triannulatus*)
5. Biting activity is different as report for the rest of the country, *An. darlingi and An. nuneztovari* activity is higher before 10 pm, so risk of getting malaria is higher in hrs when people are unprotected outdoors
6. The risk of infective bites/person/year (entomological inoculation rate) is higher in Sanema people

B. Sociocultural dimension

River basin scale

1. Malaria cases in the Amerindian territory increase from 80 in the 1995 to 2811 in the year 2010

Community scale

2. Recent colonization (less than 10 years) increased by 92% the risk of getting malaria
3. High incidence of malaria is correlated with communities with less original forest cover and higher agriculture areas (*active and abandoned*) within 5 km radio buffer
4. 49% of malaria cases within the Amerindian territory are reported from six communities

Home level

5. Home in dwelling without proper walls and screening is at higher risk

C. Economical dimension

Individual and Home level

1. No significant difference of getting malaria between gender
2. The risk is 132% higher of getting malaria in people older than 23 years
3. Additional activity from salaried jobs *(Teacher, nurses, and microscopist)* increased the risk of getting malaria by 257%
4. Persons performing activities of gathers products in the forest increase the risk of getting malaria by 208%
5. Ethnic group different from Ye'kwana (*Sanema and criollos*) has 132% of risk of getting malaria
6. Monsquito nets in regular conditions with an index of less than 0.4 have 29% of risk of getting malaria
7. Travels outside its community (*mainly to the municipality capital and/or state capital*) increased the risk of getting malaria by 153%

among several factors, especially deforestation, human–vector contact behaviors (i.e., travel to risk areas, main economic activities), and the presence of several species of mosquito vectors, including the most efficient vector in the entire Amazon region (*Anopheles darlingi*). Considering the extend of risk areas of malaria transmission in the Caura River Basin (Medina et al 2011), the effectiveness and sustainability of technical solutions identified for suppression of local malaria depend largely on individual knowledge, aptitudes, and practices at home and community level. An intervention frequently used to reduce prevalence of malaria will not work as expected unless individuals, families, and communities understand ‘‘who needs to do what'' in order to transform the complex web of factors that keep malaria in their territories.

Despite the mobilization of the community to build health post, to support the training of nurses and microscopists, and to run epidemiological surveillance and treatment administration, malaria cases continue to rise. The main findings (Table 2) show that there are favorable environmental conditions for vector breeding, and many economic and cultural factors that promote the human–vector contact. There are also institutional constraints like limited funding and human resources for the malaria control program, lack of information for planning and evaluation of malaria situation, and individual constraints like inadequate attitudes and practices for malaria prevention and control, and lack of use of mosquito nets (Figure 1C), which affect opportunities of local people to live without malaria. The diversity of malaria drivers (Figure 3), at individual, household and community level, raise the question: have the Ye'kwana their own choice to live with malaria or are deprived of capabilities to life without malaria?

Logical framework developed from the ecohealth perspective does little to clarify this question, since it focuses primarily on general dimensions (externalities) link to the disease and not on the alternative available to choose from, to reach wellness at individual level. It is necessary to look at the real opportunities of choices that Amerindian people have for attaining a life without malaria, and therefore pay attention to that local capabilities.

From the point of view of Sen's Capability Approach (Sen 1985, 1999, 2000, Hernández and Escala 2011), if a person lives in a world of limits on their freedoms (e.g. poverty), it is deprived of capabilities (understood as the opportunity for a person to choose between options for reaching a certain achievement) to function and live the life they want. Do not have alternatives to choose from to reach their wellness. The loss of liberty may be due to the presence of inadequate opportunities (e.g., absence of basic freedoms such as being well nourished, escape premature death, and be able to avoid preventable diseases).

In the adaptive management framework (Figure 1C), several instrumental freedoms—called economic facilities and social opportunities from Sen's approach—are clearly identified at the institutional level (budget, equipment, malaria detection, operational research) and individual level (education, mosquito net, trips outside the community). Those are one of the instrumental freedoms of Sen's approach, whose absence impacts the ability of people to seek their welfare. Sen considers that economic unfreedom can breed social unfreedom, just as social or political unfreedom can also foster economic unfreedom. He, therefore, proposed the development process as an extension of human freedom, and that social arrangements should aim to expand the capabilities of people to achieve what they value being and doing in their lives.

The elimination of malaria is multidimensional, and to tackle it from development as freedom involves removing those obstacles to address malaria control. The ecohealth approach pays attention to the overall needs of the community and the Amerindian territories to fight malaria, but contributes little to address that different people need different resources, income and assets to achieve the same level of welfare, within individual, household, and community level.

The capability approach helps us to identify the likelihood that two persons will have very different substantial opportunities even when they apparently have exactly the same set of means or tools. This can mean the difference between success and failure of a malaria intervention. For a variety of reasons, as discussed by Sen (1990), differences in the capability to function can arise even when the same set of personal means is available: (a) physical and social heterogeneity among persons (e.g., malaria vulnerability, gender differences); (b) variations in non-personal resources (e.g., the quality of local health care assistance, social cohesion of the community, traditional cultural continuity), (c) environmental diversity (e.g., climatic conditions, malaria risk areas, exposure to past malaria epidemics), and (d) different relative social position (e.g., clothing, mosquito netting, housing, frequent traveling).

The application of the capability approach in Amerindian communities implies pay attention to cultural issues, human diversity and consider who they are and who they want to be, and should be. We propose the cultural freedoms as called by Hernández and Escala (2011) a new pillar of ecohealth approach. The capability approach assigns substantial value to the freely and reasoned action of individuals and groups in search of what they value, which is called the Agency: the process that allows people to consider various alternatives for action and consequently act on what interests most (Sen 1985, 1999).

In the adaptive management framework (Figure 1C), we consider a variety of action strategies built from the multiplicity of participants and its various views. The proposed instrumental freedoms undoubtedly affect the expansion of the capabilities of people, and some have been implemented by the malaria control program (e.g., social opportunities and economical facilities) and have allowed the control of malaria in communities since its early stages (Bevilacqua et al. 2009). Continuous increase of malaria in remote areas calls us to turn the gaze toward other Sen's instrumentals freedoms (e.g., political freedoms, transparency guarantees and protective security, and cultural freedom), to inform policy from the ecohealth approach, and to improve good health, basic education, and cultural continuity, as an alternative path to fight malaria. Each of these distinct types of rights and opportunities helps to advance the general capability of a person, and will impact on the welfare. In our opinion, the ecohealth approach can benefit from work through the promotion of these distinct but interrelated instrumental freedoms. It is the subject of further studies that demonstrates the effectiveness of this theoretical proposal.

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