An ecosystem approach to human health and the prevention of cutaneous leishmaniasis in Tumaco, Colombia

Una propuesta de ecosistemas para la salud humana y la prevención de leishmaniasis cutánea en Tumaco, Colombia

Carlos A. Rojas [1]

[1] *Centro Internacional de Entrenamiento e Investigaciones Médicas. AA 5390, Cali, Colombia. cideim@cali.cetcol.net.co*

Abstract *A study was conducted during 1996-1997 in 20 villages of Tumaco, Colombia, to evaluate the effectiveness of personal protective measures against cutaneous leishmaniasis (CL). The intervention was effective, but the high costs of the preventive measures and the lack of a more holistic approach hampered the intervention's sustainability. This paper analyzes the results using an ecosystem approach to human health. Using this approach, we found that CL has been present in the study area for a long time and affects farmers and those living closest to the forest. The forest constitutes the habitat for insect vectors (sandflies) and parasite reservoirs (wild mammals). Four spatial scales were identified in this ecosystem: residential, village, regional, and global. From the ecosystem perspective, three interventions are proposed to prevent CL in the 20 villages: improve housing construction, organize village housing in clusters, and make diagnosis and treatment of CL more accessible. The design and implementation of these interventions require active involvement by people with the disease (village inhabitants) and decision-makers (local authorities).*
Key words *Cutaneous Leishmaniasis; Prevention and Control; Insect Vectors; Ecosystems*

Resumen *Durante 1996-1997 se realizó un estudio en 20 veredas de Tumaco, Colombia, para evaluar la efectividad de medidas de protección para leishmaniasis cutánea (LC). La intervención fué efectiva, sin embargo, los altos costos de las medidas de protección y la falta de una propuesta más holistica no permitieron sostener la intervención. Los resultados de este estudio son analizados en este artículo usando una propuesta de ecosistemas para la salud humana. Usando esta propuesta, vemos que LC ha estado presente en la zona de estudio por mucho tiempo y que afecta a agricultores y a aquellos que vivien cerca del bosque. El bosque constituye el hábitat para los insectos vectores (sandflies) y los reservorios del parásito (mamiferos salvajes). Cuatro escalas espaciales fueron identificadas en este ecosistema: residencia, vereda, región y global. Desde la perspectiva de la propuesta de ecosistemas, se proponen tres intervenciones para prevenir LC en estas 20 veredas: mejorar la construcción de las residencias, organizar las residencias en conglomerados, y hacer más accesibles el diagnostico y el tratamiento de LC. Estas intervenciones requerirán la participación activa de aquellos que sufren la enfermedad (habitantes de las veredas) y de aquellos que pueden tomar decisiones al respecto (autoridades locales).*
Palabras clave *Leishmaniasis Cutánea; Prevención y Control; Insectos Vectores; Ecosistemas*

Introduction

Control of cutaneous leishmaniasis (CL) in the Americas has been restricted principally to case management (WHO, 1990; Desjeux, 1996). Nevertheless, diagnosis and treatment are both challenging. Accurate diagnosis is based on laboratory techniques and requires trained personnel and adequate equipment (Escobar et al., 1992). Treatment is also expensive, requires parenteral administration, and has frequent adverse effects (Herwaldt & Berman, 1992). To evaluate the effectiveness of personal protective measures in preventing CL transmission, a randomized community trial was conducted during 1996-1997 (Rojas & Becerra, 1994). The study was conducted in 20 rural villages in Tumaco, Department of Nariño, in southwestern Colombia. Cutaneous leishmaniasis due to *L. (V.) panamensis* (89%) and *L. (V.) braziliensis* (11%) is endemic in this area (Saravia et al., 1998).

The study was conducted by the *Centro Internacional de Investigaciones Médicas* – CIDEIM, and the *Centro de Investigaciones Multidisciplinarias en Desarrollo* – CIMDER, two Colombian nongovernmental research institutions. We combined the expertise of the two institutions to develop a control strategy for CL through community participation. The study was proposed as the next logical stage in a series of epidemiological studies on CL conducted by CIDEIM in Tumaco and sponsored by the International Development Research Center – IDRC of Canada (Weigle et al., 1986, 1993; Travi et al., 1988). The study constituted part of the leishmaniasis global control network launched by the Canadian agency in 1994.

Participating villages were selected on the basis of CL prevalence, accessibility, and willingness to participate. The intervention included: deltamethrin-impregnated bed nets, a repellent (DEET 20% and permethrin 0.5%), treatment of tree trunks (sandflies' resting sites) with whitewash, and health education. Intervention measures were delivered to all the inhabitants in 10 randomly selected villages. The remaining 10 villages comprised the control group. The strategy designed by CIMDER to promote community participation included: an initial assessment of the degree of community organization and participation in each village, the organization of meetings aimed to encourage participation in the project, training of volunteers (educational outreach workers), and involvement of local health institutions in project activities.

A survey was conducted prior to the intervention, and participants susceptible to infection and disease were identified. Information about known risk factors for CL was collected, and insect species potentially involved in transmission as well as their resting sites near residences were identified. The 20 villages were followed for one year (1996-1997), during which incident CL cases were detected and use of intervention measures was monitored.

Ten new cases of CL were confirmed in the intervention group and 23 in the control group, producing a risk ratio (RR) of 0.42 (95% CI: 0.14-1.26). The intervention had a greater effect in preventing CL in children < 10 years old, those living on the village periphery, and in villages ≥ 200 inhabitants. No adverse effects were reported with any of the personal protective methods, and adherence was higher for use of bednets than for repellent (Rojas, 1999).

Tumaco

Tumaco is a port on the Pacific Ocean with approximately 120,000 inhabitants. Fifty percent of this population live in the urban area (an island connected to the continent by a bridge). The rest of the Tumaco population lives in the rural area, which is comprised of small villages located along rivers or along the paved road connecting Tumaco to the rest of Colombia. Tumaco's population is predominantly black (95%). The rest are indigenous (2%) and white (3%). Only those living in the rural area of Tumaco are exposed to CL transmission, because the urban area lacks the ecological conditions necessary for vectors and reservoirs to survive.

The main economic activity in the 20 participating villages is subsistence farming. However, fishing is an important activity in those villages located near the sea, and laboring on the oil palm plantations is becoming the main source of income for those who have sold their land to these companies. Most of the rural inhabitants live in poverty with inadequate sanitary conditions. There is no electricity or sewage system, water has to be fetched in buckets from nearby creeks, and most houses lack latrines.

A few villages have health posts, none of which has a permanent staff. A physician and nurse from the Tumaco hospital visit the health posts every one or two weeks for some two hours to see patients from that village and those located nearby. However, CL patients are not attended during these visits, and they have to be seen at the hospital in urban Tumaco. Although people are not required to pay for CL diagnosis and treatment, they do have to cover their own travel expenses. Besides the costs of transportation and meals, patients lose their wages on that day. In the case of children with CL, one or both parents usually take the child to the hospital.

Socioeconomic and ecological history of cutaneous leishmaniasis in Tumaco

Cutaneous leishmaniasis appears to have been present in Tumaco since remote times. Archeological findings of pre-Colombian pottery (200 BC-350 AD) show people with skin and mucosal lesions compatible with CL. A socio-anthropological study conducted in the 1950s identified CL as one of the diseases affecting Tumaco inhabitants (West, 1957). In addition, one of the earliest epidemiological reports on CL in Colombia refers to the disease in this area of the country (Werner & Barreto, 1981).

Socioeconomic variables related to CL in Tumaco can be divided into three groups. The first includes village-related variables: level of community participation, number of inhabitants, and CL prevalence in that community. The second group includes residential variables: building materials facilitating access by sandflies (thatched roofs and bamboo walls), proximity to the forest, and location on the village periphery. The third group includes human activities that increase exposure to sandflies in the forest, which in decreasing order of importance are farming, lumbering, and hunting.

Ecological variables related to CL are the proximity of the forest and changes in climatic conditions. The forest allows parasite reservoirs (wild animals) and sandflies to reproduce and interact. In addition, people continue moving to less altered parts of the forest (upstream in the river basin), where they clear the forest to farm the land. These activities have been associated with CL outbreaks. Rainfall changes in recent years due to the El Niño phenomenon have affected agricultural practices and may have altered the forest's ecological characteristics and therefore vector and reservoir behaviors.

There is a relationship between the socioeconomic and ecological characteristics associated with CL. Housing located closer to the forest or on the village periphery is more likely to be built with materials that facilitate access by sandflies. Such homes are inhabited by poorer village families who work in farming, are unable to move their families to urban Tumaco, and lack the economic means to upgrade their housing. This type of exposure especially increases the risk of children under 5 years acquiring CL. In addition, lower level of community participation in a given village is related to higher CL prevalence and a larger proportion of residences located on the periphery. Homes located on the village outskirts are spaced farther apart, making communication between neighbors less frequent, decreasing opportunities for interaction among inhabitants, and affecting the level of village organization and participation.

Defining an ecosystem

Our study's primary focus was the village, but the study area could be defined as an ecosystem containing four spatial scales: residential, village, regional, and global. These scales relate to each other as follows: study participants live in households; a group of households constitutes a village; the villages are located on the Pacific Coast of Colombia; and the region is influenced in turn by global changes (see Table 1).

On a spatial scale, residential characteristics and the forest interact at the residential level. The location of homes and the forest interact both at the same level and at the village level, since they affect community organization and CL prevalence. In addition, occupational variables and the forest interact at the village and regional levels. On a temporal scale, residential variables and the forest interact on a daily basis. Occupational variables and the forest interact on a weekly basis because people do not work on the farms every day.

The system includes both people with CL (children < 5 years, farmers, and community leaders) and those without the disease but who are involved in disease treatment and prevention (field health workers, local and national health authorities, researchers, funding agencies, and the international community) (see Table 2).

People with CL are in a less favorable situation (less educated and poorer) and lack the power to change the system. One might think that farmers could change their occupational behavior, upgrade their family housing, or build their houses farther away from the forest. However, there are limited job alternatives in the region, and small farmers own limited amounts of land and cannot afford to upgrade their housing.

Men and especially those with more schooling and wealth appear to be the ones who benefit from the way the system is organized. Women's impact on the system is at the more external levels (regional and global), where they have the same power as men to make de-

Table 1

Cutaneous leishmaniasis in Tumaco, Colombia: ecological dimensions of the ecosystem.

Dimension (scale)	Identification of relevant environmental variables	Definition of ecosystem relationships among variables	Disease related to ecosystem context?	Impact of intervention related to ecosystem context?
Residential	Distance to the forest. Borders on the forest. Housing materials. Residence located on the village periphery.	Housing built of bamboo and thatch is more likely to be located closer to the forest. Residences located on the village periphery, border on the forest, and are more likely to be isolated.	Residences located on the village periphery or close to the forest are less protected from sandflies. Bamboo walls and thatched roofs increase the chances for sandflies to enter the residence.	Replace bamboo and thatch with building materials that block sandfly entry. Install screens on windows and doors. Relocate families who live on the village periphery.
Village	Residential clustering. Level of community organization. Number of inhabitants. Prevalence of *Leishmania* infection in children < 5. Geographical location. Time since village settled.	Based on the level of clustering, villages can be classified as nuclear or dispersed. Nuclear villages tend to be more organized and have better community participation. Nuclear villages have a lower prevalence of *Leishmania* infection in children < 5.	When houses are scattered, people need to cross the forest more often to visit others or to participate in community activities.	Relocate families living on the village periphery and promote nuclear villages.
Regional	Vegetation pattern. Rainfall. Temperature. Presence of transmission foci.	The Pacific Coast of Colombia is characterized by high temperatures and heavy rainfall throughout the year, with tropical rain forest vegetation. The local population is primarily black, sharing a similar culture with the study area in Tumaco.	This region is appropriate for the coexistence of insect vectors and wild animals (parasite reservoirs). Individuals are at greater risk if their farms are located in the middle of the forest or they have to enter the forest for any reason.	Generate job alternatives that avoid people having to enter the forest.
Global	Weather changes (*El Niño, La Niña*). Global warming. Global economic crisis.	Rainfall patterns have changed in the study area. This affects agricultural practices and people's behavior. Poverty is further increasing in poor countries. Government health care budgets are decreasing. Reduction in activities to control transmission of vector-borne diseases.	Changes in the rainfall pattern affect insect breading patterns and CL transmission. The disease primarily affects people in poor countries. Poor countries lack the resources to invest in CL prevention.	Stop global warming. Redesign government health care policies. Recruit more help from the international community

Table 2

Cutaneous leishmaniasis in Tumaco, Colombia: actors in the ecosystem.

Actors	Economic status	Level of schooling	Gender	Decision-making power	Scale of activity
Children < 5 years	Very low	Not applicable (NA)	Not an issue	No	Residential
Farmers	Very low	Initial elementary	Mainly men	Yes/No	Residential village
Community leaders	Low	Elementary or part of high school	Traditionally men, but more women becoming involved	Yes/No	Village
Health extension workers	Low-Middle	High school	Mainly men	Yes/No	Residential village
Local health authorities	Low-Middle	High school College	Traditionally men, but more women becoming involved	Yes	Village
National health authorities	Middle-High	College Graduate school	Not an issue	Yes	Regional
Researchers	Middle-High	Graduate school	Not an issue	Yes	Residential village
Funding agencies	High?	Graduate school	Not an issue	Yes	Global
International community	NA	NA	NA	Yes	Global

cisions. Although women are becoming more involved as community leaders, traditionally this role has been played by men.

How might this ecosystem be managed to improve human health ?

Sustainable interventions that take into account the socioeconomic and ecological context of the ecosystem and all the actors involved should be designed and implemented. Appropriate use of budgets by national and local health institutions would make a dramatic impact on this ecosystem. A change in people's attitudes would increase the possibility that those with decision-making power would consider those with unmet basic needs and take steps to help them.

The importance of Pacific Coast farmers for Colombia's economy should be recognized and addressed by government and society. Inhabitants of the 20 villages continue to be exposed to the forest, and this situation is unlikely to change in the future. For these people, their land is probably their only possession, while most have strong ties to it because it has belonged to their families for generations. In addition, farming is what they know best and enjoy doing, and moving to another ecosystem (like a city) would mean having to learn a new job and life style.

Improved housing and relocation would decrease the risk of CL, especially for children < 5 years. Some changes have occurred in recent years because of interventions by governmental and nongovernmental organizations with housing improvement programs. One of these programs has provided families with galvanized roof tiles to replace the traditional thatched roofs. Another program has fostered residential relocation, promoting the clustering of residences along with improved housing conditions. However, the impact of these programs on CL transmission and other health-related outcomes remains to be evaluated.

Housing materials that facilitate access by sandflies could also allow the entry of malaria vector mosquitoes. In other words, housing improvements could have a simultaneous protective effect against leishmaniasis and malaria. Malaria has a higher incidence rate compared to CL and is associated with high morbidity and mortality in the study area.

Villages would benefit by adopting a nuclear pattern (clustered residences), not only reducing the risk of CL but also fostering greater community participation and village development, based on our experience in the study area. Residential clustering, although beneficial from a CL standpoint, would raise some problems for the villages. Diseases transmitted by direct human-to-human contact (childhood eruptive diseases, tuberculosis, etc.) and those associated with poor sanitation (diarrhea) are more common in clustered than dispersed populations (Pimentel et al., 1998).

Diagnosis and treatment of CL should be available on a more timely and routine basis, and patients should not have to travel to urban Tumaco. A clinical prediction rule for CL diagnosis was developed with patients from Tumaco and could constitute an alternative to traditional parasitological diagnosis (Weigle et al., 1993). The algorithm was also adapted and used by community health volunteers and primary health care providers in Tumaco with good results (Collazos & Rojas, 1995). Regarding treatment, since 1994 CIDEIM has conducted a series of workshops in Tumaco to train community health volunteers in the administration and supervision of CL therapy, thus allowing administration at the village level by certified personnel.

Village inhabitants should be actively involved in this process. If government funds are unavailable or insufficient to cover the cost of the solutions, nongovernmental organizations and international agencies should be involved. Local researchers with experience in this issue should be consulted and involved in the design and evaluation of any new intervention.

Research implications

Certain aspects of the CL transmission cycle in the study area remain unknown, like the wild animal species serving as reservoirs for the parasite, whether domestic animals could be reservoirs, and the location of vector breeding sites. Future studies on CL should focus more on aspects related to vector biology and behavior to establish a connection with the socioeconomic and ecological factors already identified.

Another characteristic of CL transmission in the Tumaco area is clustering of cases by household, as observed in some villages during the study. Although this may only represent the effect of a common source of exposure to the parasite, it could also suggest human-to-human transmission. Anthroponotic CL transmission has been documented in the Old World (Tayeh et al., 1997) but not in the New World. If this is happening in the study area, it is probably connected with some of the socioeconomic characteristics already identified.

Interventions to prevent CL transmission should combine scientific work and Participatory Action Research (PAR). The scientific work will provide the means to quantify the impact of such interventions using indicators like disease incidence. The number of cases in children < 5 years would be a good outcome indicator to assess the effect of housing improvement or residential relocation. The information generated from scientific work could be used to promote sustainable health and empower communities.

PAR could help provide a more complete picture of communities and the ecosystems of which they are a part. This approach provides input from all actors in the ecosystem and bolsters the community's confidence in researchers and funding agencies. Scales or instruments to assess community organization and achievements allow community members and outsiders to evaluate the overall impact of systemic intervention.

Baseline multidisciplinary studies should be conducted to identify other ecosystem variables amenable to intervention. Based on such information, study hypotheses should be proposed and pilot studies designed to test them. Such studies should involve multidisciplinary teams including community participation experts, anthropologists, ecologists, entomologists, botanists, economists, epidemiologists, health educators, physicians, geographers, botanists, social communicators, local health workers, and community representatives.

Geographical Information Systems (GIS) are powerful analytical tools. However, their use is limited by the availability of magnetic maps and satellite images. One very relevant type of analysis to be conducted with this technology would be to relate residential and village variables with vegetation (forest). Cost-effectiveness analysis and measurement of health-related quality of life are also important outcomes that should be considered to evaluate the impact of new interventions against CL.

Right from the beginning, communities should be invited to participate in any research project that involves them. Leaders selected by their own communities should be invited and consulted during the planning meetings. When community involvement is delayed, it can lead to resentment and may not generate any type of interest on the people's part. Health might not be the most important priority for such communities, i.e.; they may be more interested in other outcomes such as access to electricity or better schools. Although these responses might not be what researchers interested in health outcomes would expect from the community, they would be an indicator that people are seriously considering the project and are beginning to believe that things can change. This is an important part of the participatory process. Later on, funding agencies, researchers, and the community can meet to negotiate project outcomes.

Conclusions

The ecosystem approach to human health is more comprehensive and coherent than previous approaches. Our integrated disease control model based on social participation was ecosystem-oriented because it considered different actors and identified variables at different spatial levels. However, we did not outline all the possible links and feedback loops between these variables. Doing this would have helped us to anticipate some of the problems we faced later with the intervention's sustainability.

The community participation strategy we used allowed us to approach the study communities, understand what they know and think about CL, become accustomed to the local culture and include these aspects in our educational materials, increase participants' adherence to the intervention, and involve local health institutions in project activities. However, our intervention was not sustainable without the researchers' technical support and IDRC's financial support. An approximation like the one proposed by the ecosystems approach might have produced sustainable results.

Communities should be involved from the beginning. Ideally, they should take part in identifying both the problem and potential solutions. They also should be involved in monitoring the intervention and assessing various outcomes. Involving all the system's actors is a challenge. Affected communities can be willing to adopt the new intervention, but the same is not necessarily true for local and national health institutions, especially if they do not perceive a direct benefit for them. They can also be reluctant to involve the communities in this process.

Sustaining the ecosystem approach is a challenge. Since the approach is new, the system's different actors require time to get used to it and adopt it as an approach of their own. Therefore, in order to be sustainable a systemic intervention should have short-term outcomes that encourage people to continue in the project.

Acknowledgements

I am grateful to Jaime Becerra, and Alba Lucia Morales (CIMDER), to Rafael Tovar and Wilson Cortés (CIDEIM), and to Kristen Weigle (University of North Carolina at Chapel Hill). The study and the manuscript preparation was supported by the International Development Research Center of Canada (IDRC).

References

COLLAZOS, C. & ROJAS, C. A., 1995. *Use of a Clinical Prediction Rule for the Auto-Diagnosis of Cutaneous Leishmaniasis by Affected Communities*. Final Report. Cali: World Health Organization Program on Social Economical Research.

DESJEUX, P., 1996. Leishmaniasis. Public health aspects and control. *Clinics in Dermatology*, 14:417-423.

ESCOBAR, M. A.; MARTINEZ, F.; SMITH, S. & PALMA, G., 1992. American cutaneous and mucocutaneous (tegumentary) leishmaniasis: A diagnostic challenge. *Tropical Doctor*, 22(Sup. 1):69-78.

HERWALDT, B. L. & BERMAN, J. B., 1992. Recommendations for treating leishmaniasis with sodium stibogluconate (pentostam) and review of pertinent clinical studies. *American Journal of Tropical Medicine and Hygiene*, 46:296-306.

PIMENTEL, D.; TORT, M. & D'ANNA, L., 1998. Ecology of increasing disease. Population growth and environmental degradation. *Bioscience*, 48:817-826.

ROJAS, C. A. & BECERRA, J., 1994. *Design and Evaluation of a Strategy to Prevent Infectious Diseases in the Pacific Coast of Colombia Based on Social Participation and Using Cutaneous Leishmaniasis as a Model*. Study protocol. Cali: International Development Research Center.

ROJAS, C. A., 1999. *Evaluation of a Multifaceted Intervention to Prevent the Transmission of American Cutaneous Leishmaniasis in Colombia*. Ph.D. Thesis, Chapel Hill: Department of Epidemiology, School of Public Health, University of North Carolina.

SARAVIA, N. G.; SEGURA, I.; HOLGUIN, A. F.; SANTRICH, C.; VALDERRAMA, L. & OCAMPO, C., 1998. Epidemiologic, genetic, and clinical associations among phenotypically distinct populations of *Leishmania* (Viannia) in Colombia. *American Journal of Tropical Medicine and Hygiene*, 59:86-94.

TAYEH, A.; JALOUK, L. & AL-KHIAMI, A. M., 1997. *A Cutaneous Leishmaniasis Control Trial Using Pyrethroid-Impregnated Bednets in Villages Near Aleppo, Syria*. WHO document No. WHO/LESIH/97.41. Geneva: World Health Organization.

TRAVI, B. L.; MONTOYA, J.; SOLARTE, Y.; LOZANO, L. & JARAMILLO, C., 1988. Leishmaniasis in Colombia I: Studies on the phlebotomine fauna associated with endemic foci in the Pacific Coast region. *American Journal of Tropical Medicine and Hygiene*, 39:261-266.

WEIGLE, K. A.; SARAVIA, N. G.; DE DAVALOS, M.; MORENO, L. H. & D'ALESSANDRO, A., 1986. *Leishmania braziliensis* from the Pacific Coast region of Colombia: Foci of transmission, clinical spectrum and isoenzyme phenotypes. *American Journal of Tropical Medicine and Hygiene*, 35:722-731.

WEIGLE, K. A.; ESCOBAR, M.; ARIAS, A. L.; MARTINEZ, F. & ROJAS, C. A., 1993. A clinical prediction rule for American cutaneous leishmaniasis in Colombia. *International Journal of Epidemiology*, 21:548-558.

WEIGLE, K. A.; SANTRICH, C.; MARTINEZ, F.; VALDERRAMA, L. & SARAVIA, N. G., 1993. Epidemiology of cutaneous leishmaniasis in Colombia: A longitudinal study of the natural history, prevalence, and incidence of infection and clinical manifestations. *Journal of Infectious Diseases*, 168:699-714.

WERNER, J. K. & BARRETO, P., 1981. Leishmaniasis in Colombia, a review. *American Journal of Tropical Medicine and Hygiene*, 30:751-761.

WEST, R., 1957. *The Pacific Lowlands of Colombia*. Baton Rouge: University of Louisiana.

WHO (World Health Organization), 1990. *Control of Leishmaniasis*. WHO Technical Report Series 793. Geneva: WHO.