Some Field Methods in Medical Ethnobiology

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The authors provide a summary of methods that they have used in their long-term interdisciplinary research that incorporates a series of semi-independent, complementary methods of data collection derived from medical anthropology, ethnobotany, and ethnopharmacology. Discussion begins with the first step in research with human subjects, the acquisition of prior informed consent; they then outline the theoretical postulates underlying their methodological approach. Medical anthropological methods include building databases of ethnoanatomical terms and named health conditions. Ethnoepidemiological surveys can then establish the perceived frequency and cultural salience of the health problems named in the databases. The ethnomedical and ethnobotanical data provide an ethnopharmacopoeia of medicinal plants that become the basis for documentation of the details of selection and preparation and administration or ethnoformulary. The results of these integrated disciplinary studies can be returned to the study population for home use, small-scale local production as cottage industries, and larger commercial production for sustained economic development.

Keywords: *medical ethnobiology; ethnobotany; ethnomedicine; ethnopharmacology*

Our approach to medical ethnobiology—the multidisciplinary scientific study of the folk knowledge and cultural practices embodied in traditional medical systems, with particular emphasis on the uses of natural and biological resources in the maintenance and restoration of normal functioning of human health[1]—is first and foremost anthropological. Ethnomedical systems comprise human belief systems and practices about health and healing.

This article has benefited greatly from the critical comments of four anonymous reviewers. We have attempted to incorporate their positive suggestions wherever possible. Russell Bernard has been supportive throughout the several major revisions that the article has taken from original submission to final form. The diligent copyediting by Carole Bernard has been especially helpful. Finally, we appreciate John Richard Stepp's inviting us to publish a general outline of our medical ethnobiological methods.

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Our anthropological bias leads us to focus holistically on the medical belief system as an integrated system, not as a series of isolated, unrelated beliefs about illnesses and their treatments. In theory, a medical ethnobiological description should strive to encyclopedically represent the cultural knowledge and practices associated with health and healing in a particular society, providing a comprehensive guide for behavior that would be deemed appropriate by members of that society.[2]

The field procedures we discuss here have been part of our long-term research on the medical ethnobiology of the Highland Maya of Chiapas, Mexico (B. Berlin and Berlin 1994, 2000, forthcoming; E. A. Berlin and Jara 1993; E. A. Berlin and Berlin 1996; B. Berlin 1999, 2000; B. Berlin et al. 1999; E. A. Berlin et al. 2000). The use of *some* in our title is deliberate. Given the multidisciplinary nature of medical ethnobiology, a comprehensive discussion of methods drawn from each of its distinct subfields would convert our small article into a large monograph or a broad-ranging survey of the literature more appropriate for an article in *Annual Reviews of Anthropology*. Furthermore, excellent general surveys are found in Browner, Ortiz de Montellano, and Rubel (1988) and Etkin (1993), as well as method-specific articles on some of the procedures we can cover only briefly here (Boster 1994; Cragg, Newman, and Snader 1997; Ryan, Nolan, and Yoder 2000; Werner 2000a, 2000b, 2001, 2002). There also exists a large literature on methods that would be appropriate to medical ethnobiology but that we have not used in our own work, either because of the constraints of our use of population-level surveys or because we lack the necessary expertise (e.g., see Angoff and Barth 1973; Burton and Nerlove 1976; Farnsworth et al. 1985; Elizabetsky 1986; Romney, Weller, and Batchelder 1987; Akerele 1992; Atkinson 1992; Young and Garro 1994; Cragg, Newman, and Snader 1997; Stepp 1999; Mattingly and Garro 2000; and many others).

Our goal here is to present a straightforward description of the major data collection practices we have found productive in our own work. We believe that the methods we discuss, while limited in scope, can provide a firm foundation for more in-depth studies using the many specialized applications we have not covered or have mentioned only in passing. We hope that our omissions of specific procedures used by other researchers will be seen in this light.

Part of the strength of the data-gathering methods summarized here is the production of several quasi-independent yet complementary medical anthropological, ethnobotanical, and ethnopharmacological data sets that allow for a triangulation of information that increases the validity (truthful and logical measures of what we intended to measure), accuracy (qualitative evaluation of the closeness of agreement with truth or fact), and reliability (reproducibility) of our results. Critical to our work is the discovery of patterns of variation that characterizes these interlocking data sets. We are convinced that an understanding of these patterns yields a solid, albeit incomplete, picture of how and why an ethnomedical system actually functions. Finally, while the examples discussed in this article are drawn from our Highland Maya materials, we believe that procedures we describe are applicable to the anthropological study of any traditional, plant-based ethnomedical system.

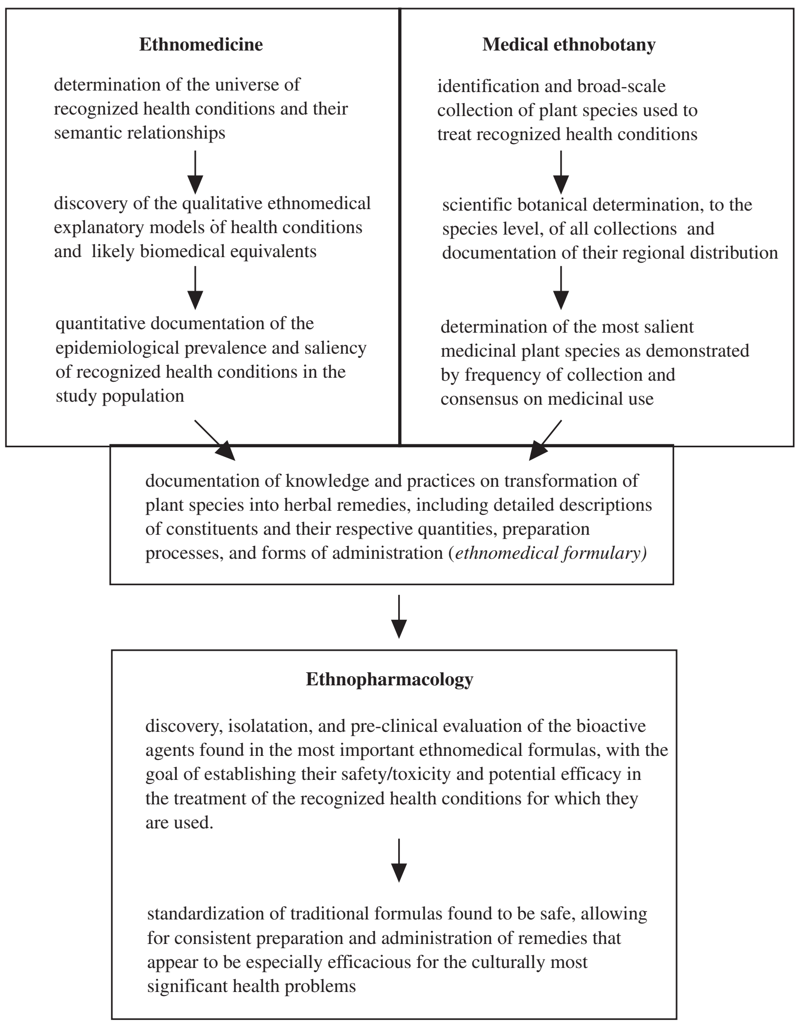
The theoretical assumptions and biases of our approach are made explicit in the following guidelines for research on medical ethnobiology.

- An ethnomedical tradition constitutes an integrated system of cultural beliefs and practices based on concepts of health as a state of normalcy or homeostasis.
- This state of health may be compromised or disrupted by biological, psychological, social, and environmental conditions or events—individually or in combination.
- Disruptions to health may result in disvalued states of well-being that are recognized as disease, illness, infirmity, or dysfunction.
- States of being that represent disruptions to health (diseases, illnesses) are commonly named.
- These named conditions are conceptually organized into categories based on shared similar symptomatology.
- An ethnomedical system aims to effect a return to homeostasis or health through
    1. a body of medical theories and practices that are consistent with societal beliefs on the etiology of illnesses that may be natural or supernatural,[3]
    2. a natural products–based pharmacopoeia that includes a wide range of plant species deemed to have medicinal value in the treatment of illness due to natural causes,
    3. an explicit, publicly known *materia medica* of therapeutic modalities, and
    4. social networks governing the application and transmission of ethnomedical, ethnobotanical, and therapeutic knowledge.

Given these assumptions and biases, we propose that a comprehensive research program in medical ethnobiology, which treats traditional ethnomedical knowledge and practice as an integrated system, must be comprised of at least three major components: ethnomedicine, medical ethnobotany, and ethnopharmacology (see Figure 1).

The tasks of the ethnomedical component are to document the universe of specific health conditions recognized by the study population and discover the semantic relationships that organize them as a system (the cognitive structure of the system); elucidate the ethnomedical understandings of the cause, course, manifestation, appropriate treatments, and expected outcomes of each health problem (ethnomedical explanatory models) and posit their

FIGURE 1
Flow Chart of Medical Ethnobiological Research



likely biomedical correspondences, making a comparative analysis possible; and determine the prevalence and salience of the health conditions within the population.

The tasks of the medical ethnobotanical component are to collect those plant species identified by native informants as useful in the treatment of the named health conditions elicited by the ethnomedical component and thought to be amenable to treatment by healing plants. This component also provides accurate scientific botanical determinations of the species that comprise the ethnopharmacopoeia, making comparative analysis possible. Based on their frequency of collection and consensus concerning their use for particular health conditions, it will also be possible to determine which medicinal species are the most salient and culturally important for the ethnomedical system as a whole.

The ethnomedical and ethnobotanical components work in concert to document the ethnomedical formulary (*materia medica*). This consists of the knowledge and practices associated with the transformation of individual medicinal plant species into herbal remedies, including detailed descriptions of constituents and their respective quantities, preparation processes, and administration, based on data systematically collected from knowledgeable informants with demonstrated experience in the preparation and administration of each formula.

The ethnopharmacological component then conducts laboratory analyses, guided by earlier ethnomedical and ethnobotanical findings, with the goal of discovering, isolating, and preclinically evaluating the bioactive constituents found in the most important ethnomedical formulas. A long-term goal of this component of the research is to test the safety and toxicity of these formulas and to provide data on their potential pharmacological effects and clinical efficacy in the treatment of the recognized health conditions for which they are used. Ethnopharmacological analysis can also contribute useful data on ways to standardize traditional formulas, allowing for consistent preparation and administration of remedies that appear to be especially efficacious for the culturally most significant health problems.

PRELIMINARY STEPS: PRIOR INFORMED CONSENT TO CONDUCT THE STUDY

The first step of any anthropological research project must, of course, be to obtain the prior informed consent (PIC) of the communities with whom the research is to be conducted. There is a growing body of literature on the complex issues involved in obtaining PIC, particularly in medical ethnobiological research.[4] Previously, this consent process took place at the beginning and during the project, well after funding was received. After we finished an National Institutes of Health (NIH)–funded bioprospecting project that we led in southern Mexico, we recommended that before initiating the project with full funding, funding agencies award at least 1 year of support devoted exclusively to the informed consent process. We understand that this has now become standard policy at the NIH, and we hope that other governmental and nongovernmental funding agencies will follow suit.

The PIC process must be tailored to each specific research project and the context in which the research is to take place, and we will not discuss it further here. However, it should be noted that there is a large body of literature on the subject, to which we have contributed (B. Berlin and Berlin 2003, 2004; E. A. Berlin and Berlin 2004). It is also important that researchers be familiar with the related body of extensive literature concerning intellectual property rights, as all traditional knowledge is, at least in some views, considered to be intellectual property subject to proprietary regulations. These regulations have great import for anthropology as a whole.[5]

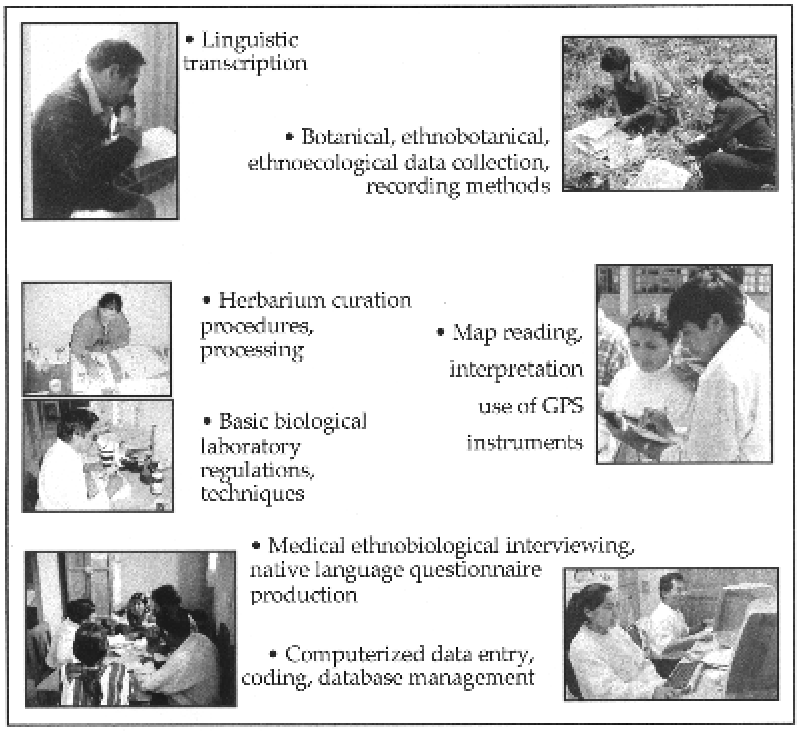
TRAINING LOCAL RESEARCH ASSISTANTS

The scale of data collection envisioned for a comprehensive medical ethnobiological research program is untenable without the support of a cadre of trained field assistants. We have found it feasible and rewarding to train research assistants who are native speakers of the local language(s) of the region where the research will be conducted. This training can be carried out in workshops that contain specific modules on medical anthropological, linguistic, and ethnobiological data-collecting techniques. Some of the most important skills that local research assistants must acquire include the following:

- core field linguistic methods with a focus on accurate linguistic transcription;
- ethnobiological/medical anthropological interviewing skills and native language questionnaire production and testing;
- botanical, ethnobotanical, and ethnoecological data collection and recording methods, including use of global positioning system instruments, map reading, map production, and basic photography;
- herbarium processing priorities and curation procedures;
- basic computer literacy, including word processing and database management; and
- elementary biological laboratory techniques, regulations, and precautions.

Photos of Maya collaborators engaged in a number of these tasks are seen in Figure 2.

FIGURE 2
Training Modules for Native Assistants



NOTE: GPS = global positioning system.

While the efforts involved in training a local field team are great, the rewards cannot be overemphasized. Furthermore, this training often provides native assistants with skills that prepare them for future employment after a particular research project has ended. Specific examples for our personnel include positions as herbarium technicians, botanical illustrators, data entry personnel, field research assistants for other projects, and employment in the local business sector, including some who have garnered sufficient savings to initiate their own small businesses.[6]

ETHNOMEDICAL DATA COLLECTION

Disruptions to health resulting in disvalued states of well-being recognized as disease, illness, infirmity, or dysfunction occur in or on the human body. Preliminary understanding of folk concepts of anatomy and physiology, therefore, are essential to the study of an ethnomedical system. Data on ethnoanatomy can be obtained in numerous ways, most obviously by simply pointing and asking, "What's the name of this?" This can be followed by engaging collaborators in producing their own drawings of the human body, indicating the names of body parts included in each. In addition, informants can be queried about their concepts of anatomy and physiology with the use of simple drawings, three-dimensional models, and commercial anatomical charts. It is important to collect such data independently from both male and female collaborators.

As with any medical system that does not include surgical intervention, the detail and specificity of knowledge of the exterior body will generally be greater than that of the internal organs. In our Maya material, we have determined that internal organ systems are named and identified according to their perceived function. Detailed elicitation on body parts may reveal cultural beliefs about organs that have no apparent equivalent in biomedical anatomical concepts (see discussion of the organ *me'winik* [mother of man] in E. A. Berlin and Jara 1993; E. A. Berlin and B. Berlin 1996; see also Adams 2004).

Concurrent with building a database on ethnoanatomy and physiology, we aim to establish an initial inventory of named health conditions or diseases in the folk system. One of the most productive native language questions to discover is "What are the names of all of the kinds of health problems that you know?" Development of these disease name inventories is the most efficient entry into the system, especially when they are collected independently from many informants.

If literacy is a problem, informants' responses can be recorded for later transcription. Preserving the order of elicitation of terms may be useful in establishing salience, based on the assumption that the more salient conditions will be named first. This can also suggest possible semantic groupings of health conditions that can be confirmed or rejected by other grouping techniques.

Preliminary lists of illness names are likely to contain expressions that mark categories of differing levels of specificity. Treating each term as the name of a concept that may possibly include named subclasses, one can inquire of each, "What are all of the kinds of ____?" "Are there any other kinds of ____?" "Is ____ a kind of ____?"

In addition to hierarchical relations of class inclusion, some categories of illness may be recognized as semantically similar to other categories of the same rank (e.g., hay fever and asthma, measles and chicken pox). Initial groupings of this type can be elicited by questions such as "To what other health problems is ____ similar?"

Somewhat more formal field procedures for determining possible conceptual relationships between and among health conditions include pile sorts and triad tests. In the former, names of conditions previously generated are transcribed on cards, and respondents are asked to sort them into separate piles based on their similarity and to provide explanations as to why they are grouped as they are ("Why are the health conditions in this pile related to one another?"). This task is most easily carried out with literate respondents who can read the names of the conditions. Triad tests require respondents to group the two most similar of a set of three conditions (or the most distinctive of the set of three). Both literate and nonliterate respondents can participate in triad tests. For nonliterate respondents, the investigator can state the names of three conditions and ask which two of the three are most similar or least similar to the other two.[7]

DISCOVERING THE MEANING OF RECOGNIZED HEALTH CONDITIONS

At this stage of the research, one will have some basic hypotheses that illness names A, B, C . . . n refer to recognized health conditions and that these conditions are grouped into one or more major categories based on perceived similarities and differences in them. Discovering the ethnomedical meanings of these named conditions is based on in-depth ethnomedical elicitation sessions, analysis of native language texts, survey questionnaires to elicit ethnomedical explanatory models, and clinical observations that lead to hypotheses about how named folk conditions might correspond to diseases/health conditions recognized in Western biomedicine.

ETHNOMEDICAL EXPLANATORY MODELS QUESTIONNAIRES

Arthur Kleinman (1980, 1988) first proposed the use of medical explanatory models. We have built on his work by developing Maya ethnomedical explanatory models questionnaires in close collaboration with our local native language–speaking assistants. The survey instrument must be translated and back translated in the local language, and the validity of the questions (whether the answers reflect the question one intended to ask) should be reviewed periodically. Interview responses should be recorded in the local language. These can be transcribed at the time of the interview or they can be audio- or videotaped for more accurate documentation and subsequent translation into the major language used for analysis (usually that of the investigator). The primary native language data must be archived and stored on electronic media that will be easily available for reanalysis by current and future researchers.

Our structured interviews for elucidating ethnomedical explanatory models of recognized health conditions consist of a series of basic questions about the following variables.

- Ultimate cause: *Why* did you get sick or why did *you* get sick?
- Proximate cause: This may consist of a series of contributory or risk factors or events that could cause someone to become ill.
- Onset: Is the onset rapid or gradual? Might it develop from another condition or as a complication of another condition?
- Signs: How does it look, feel, or smell to persons other than the patient?
- Symptoms: What are the sensations and indicators that only the patient perceives?
- Normal course or natural history: What is the normal progression of the condition if left untreated?
- Complications: Does the condition sometimes worsen and perhaps transform into another condition?
- Prognosis: What is the expected outcome of this condition?
- Ecology of occurrence: Is it associated with conditions of the biological environment or psychosocial environment?
- Special groups affected: Who gets it (age, gender, ethnicity)?
- Treatment: How can it be made better or cured?
- Options for healing resources: Who can treat or cure it?
- Special precautions during treatment: Are there any special dietary or behavioral restrictions that must be observed during and after treatment?

An example of the Highland Maya ethnomedical explanatory model for *ch'ich' tza'nel* (bloody diarrhea), based on the fundamental questions listed above, can be seen in E. A. Berlin and Berlin (1996:187–204).

Explanatory models interviews may be conducted with individuals or focus groups. The former yields higher quality data in that an individual response is an integrated global description of a given health problem. Individual interviews can be conducted with a large number of informants over a wide geographic area. The focus group process allows the researcher to develop a composite of consensus. Care must be taken to ensure that a leader does not emerge and stifle discussion of alternative views. The interview sample must be representative of the designated study population or subpopulation. Selection of individuals for interview should be made on the basis of an established set of criteria such as age, gender, social roles, place of residence, and language group, to mention a few relevant characteristics (see Bernard 1999 for a comprehensive survey).

NARRATIVES AND TEXTS IN THE LOCAL LANGUAGE

Local language illness narratives[8] and texts can lend richness to the quality of the data and understanding of the full cultural meanings of health problems. In a context in which local assistants can write, they can be guided by a general set of native language questions or by a standard format for discussion of health conditions that provide semistructured descriptions of health conditions and their treatment.

In addition to their value as qualitative data, native language texts can also open the door to discussion of topics that might ordinarily be socially sanctioned if discussed openly in face-to-face interviews. Women's problems, for example, were underreported in our ethnoepidemiological data. One condition responsible for female infertility (based on reports from Tzeltal-speaking collaborators from the municipality of Tenejapa) is known as *buluk' sit*, a term that also refers to a large caterpillar. In the course of producing native language texts on general health problems, we discovered that informants say that this condition is due to the caterpillar's entering a woman's vagina where it consumes her husband's semen, preventing conception. Social constraints hindered face-to-face discussion of the condition; however, several versions were produced in written format, including case examples.

ETHNOMEDICAL GLOSSARIES

The development of native language glossaries can provide insights about the most salient characteristics of ethnomedical conditions. The purpose of the glossary is to generate one or two sentence statements about the key distinguishing characteristics of each health condition (see E. A. Berlin et al. 2000). Questions such as "If one suffers *cha'lam tzotz ta sitil*, how do you know that this is what it really is?" lead to concise one-sentence definitions that provide clues to the illnesses' major distinguishing features. In this particular example, *cha'lam tzotz ta sitil* has been defined in Tzeltal Maya as *jun chamel banti ya xchi' xcha'lamul stzotzil sitil* (a disease in which a second layer of hair begins to grow on the eyelid). This glossary provides clues to the biomedical correspondence of the disease, which in this case was shown to be late-stage trachoma as confirmed by clinical data (see below).

CLINICAL DATA

Much can be learned by clinical evaluations of actual cases and by interviewing informants about relevant ethnomedical diagnostic criteria during standard medical examinations. If a member of the research team is trained in clinical medicine or nursing (as is the case with one of us, E. A. B.), examination of cases is especially useful for biomedical interpretation of health conditions. Even when the research group includes a specialist with a medical background, it is useful to establish a cooperative relationship with local health officials who can serve as consultants on the project. Such contacts may also allow for access to statistical reports on the number of patients seen in clinics in the region and the reported diagnostic categories observed for common illnesses. Clinics usually have a summary record with this information for use in periodic reports to the appropriate state and national agencies.[9] Sometimes clinic personnel are willing to use a standardized data collection form provided by the medical anthropologist that can be a source of additional information on health and illnesses in the clinic context. In our research, such data have provided insights into the presentation of symptoms by Maya patients and have significantly aided in developing a better understanding of the ethnomedical-biomedical correspondences of health conditions.

ETHNOEPIDEMIOLOGY SURVEY

Systematic application of the preceding methods will produce an inventory of health conditions and a qualitative understanding of their meaning based on an analysis of ethnomedical explanatory models and, when possible, clinical observations. Such data also provide some suggestions on the relative salience or importance of particular health conditions. However, none of these data give quantitative information on the actual prevalence of these conditions in the study population. Data of this sort can best be obtained through retrospective ethnoepidemiological surveys with the purpose of establishing general patterns of disease.

Our Maya collaborators conducted ethnoepidemiological surveys in fourteen municipalities of the Highland Maya region. Interviews were carried out with heads of five households from twenty hamlets in each of the fourteen municipalities. We aimed to gather data from households in as many diverse ecological settings as possible.

The interview instrument we developed was built around a standard, three-generation genealogy chart, with the first generation representing male and/or female heads of household or ego(s). First-generation male and/or female heads are the target interviewees. In these surveys, all recent self-defined illness events are recorded for all household members as well as modes of treatment. Deceased persons of any generation are noted, as well as the attributed cause of death.[10] An example of ethnoepidemiological data for one household in the Tzotzil-speaking municipality of Chamula is seen in Figure 3.

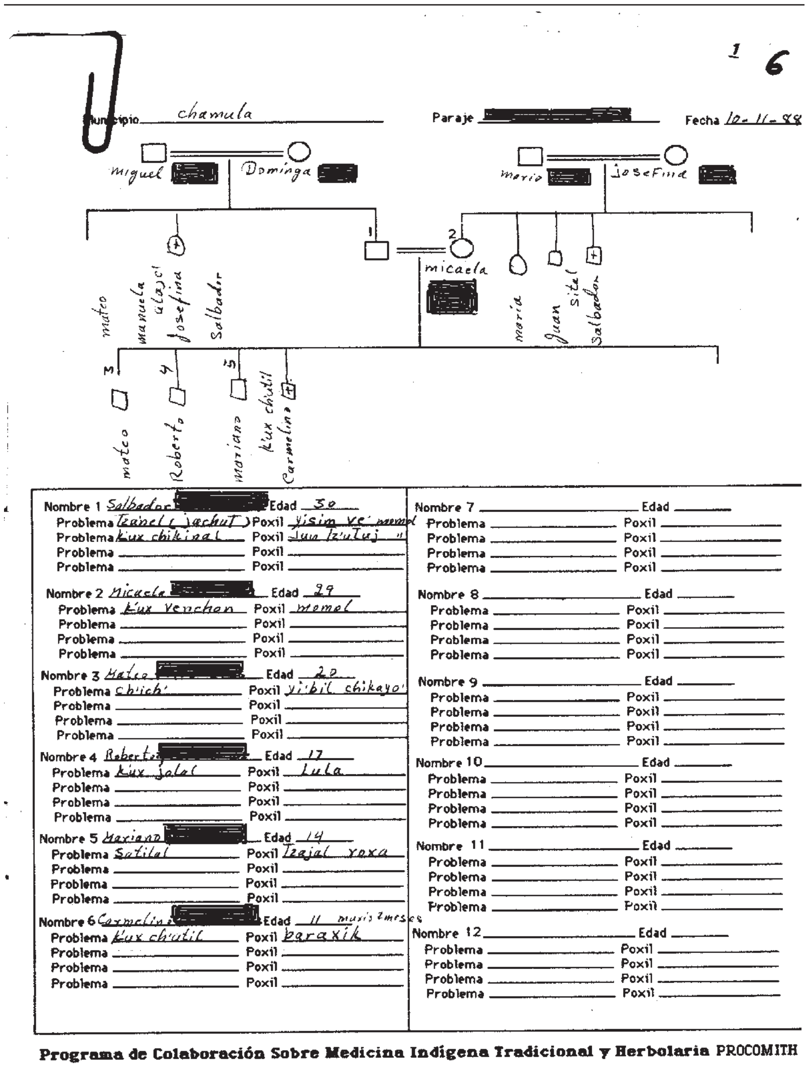
Ethnoepidemiological prevalence is demonstrated by noting the relative frequency of reports of diseases and the number of reports within the general class of conditions (derived from the tests of similarities among health conditions). These can be compared with clinical data from local, state, and regional epidemiological reports, when such statistics are available. The goodness of fit will depend on the accuracy of survey reports and on social and cultural variation in conditions for which biomolecular medical care is sought. A comparison of our own ethnoepidemiological survey results with those of the State of Chiapas regional health department (data for 1985) is seen in Figure 4.

Figure 4 reveals a striking similarity in the relative frequency of health problems in the two independent data sets. In both cases, gastrointestinal problems are by far the most frequent illnesses reported, followed by respiratory conditions. Illness reports based on recall are comparable to those based on actual clinic visits, at least for the most important health conditions.

Nonetheless, it is important to be aware that retrospective epidemiological surveys are subject to reporting bias, and there are a variety of usually well-known factors that can produce bias. We have noted the following:

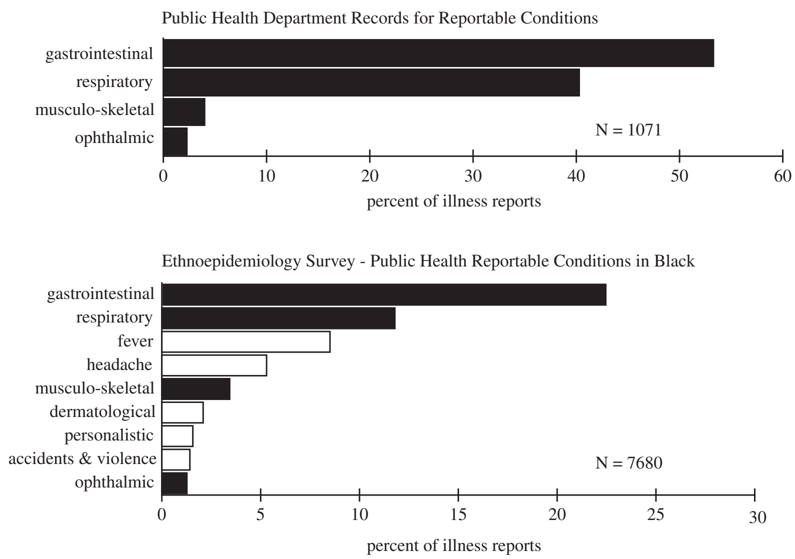
- Recall bias results in underreporting that may come from inaccuracy of recall. Generally speaking, the longer the time period since the illness event, the greater the recall bias.
- Saliency bias may result in overreporting of conditions that carry greater cultural significance.
- Ubiquity bias may result in underreporting of conditions that occur so frequently that they are not notable for mention.[11]

FIGURE 3
Example of Data Sheet from an Ethnoepidemiology Survey



- Social value bias can also affect rates of self-report of specific conditions when a health problem or its causes are socially sanctioned.

FIGURE 4
Comparison of Frequency of Ethnoepidemiology Illness Reports and Local Public Health Reports (Data for 1985)



In cases in which reporting bias is greater, an awareness of cultural norms alerts the researcher, and appropriate measures can be taken to supplement the survey data.

MEDICAL ETHNOBOTANY

The first priority of the ethnobotanical component is to develop an inventory of names for plant species used in the treatment of the recognized health conditions established earlier in the medical anthropological component of the research project. A question can be developed roughly glossed as "If one can treat diarrhea with plants, what are the names of each plant used to treat it?" When these preliminary inventories of plant names of medicinal species are elicited from large numbers of informants, they are useful guides in ethnobotanical collecting. If, after several months, species named as part of the initial inventories have not been collected, special efforts can be made to find them.

ETHNOBOTANICAL COLLECTING SURVEY

All required local, national, and international collecting permits should be obtained and in place prior to the initiation of the botanical collection surveys. Equally important are the arrangements that must be made with collaborating botanists for accurate and timely scientific determinations of the ethnobotanical collections. Ideally, a botanical collaborator working directly with the project should provide these determinations. It is essential that determinations be accurate and reliable as these are critical for any future biological assay work.

Botanical collecting should be carried out over as broad a geographic area as possible, during at least one complete flowering season, preferably many more, by several collecting teams made up of trained native ethnobotanists. Members of collecting teams will recruit knowledgeable local informants who accompany them on daily collecting forays. These informants are charged with identifying medicinal species for collection and for providing relevant information on their medicinal uses.

All collections must be made following standard botanical field procedures (excellent guides can be found in Alexiades and Sheldon [1996] and Martin [2004]). It is essential to produce botanical voucher specimens that conform to the highest standards, taking particular care to collect examples of species in flower and/or fruit. Sterile specimens are useless and will generally be discarded by botanists asked to identify them.

Preprinted field notebooks can be used to record ethnobotanical as well as botanical information for all collections. As in the ethnomedical component of the research, ethnobotanical data must be transcribed in the local language. In addition to including standard botanical data, at least the following ethnobotanical information should be noted:

1. local name(s) of the plant,
2. health condition(s) that the plant is said to treat,
3. plant part(s) employed in preparation of herbal medication,
4. other plants or substances used as admixtures in the prepared prescription and relevant plant parts used,
5. specialized collection requirements considered necessary for the plant to be effective (e.g., time of day or night, season),
6. complete methods of preparation,
7. complete modes of administration,
8. quantities (based on native system of measurement) of all ingredients used,
9. dosage (with special consideration for age, gender, health condition of patient),

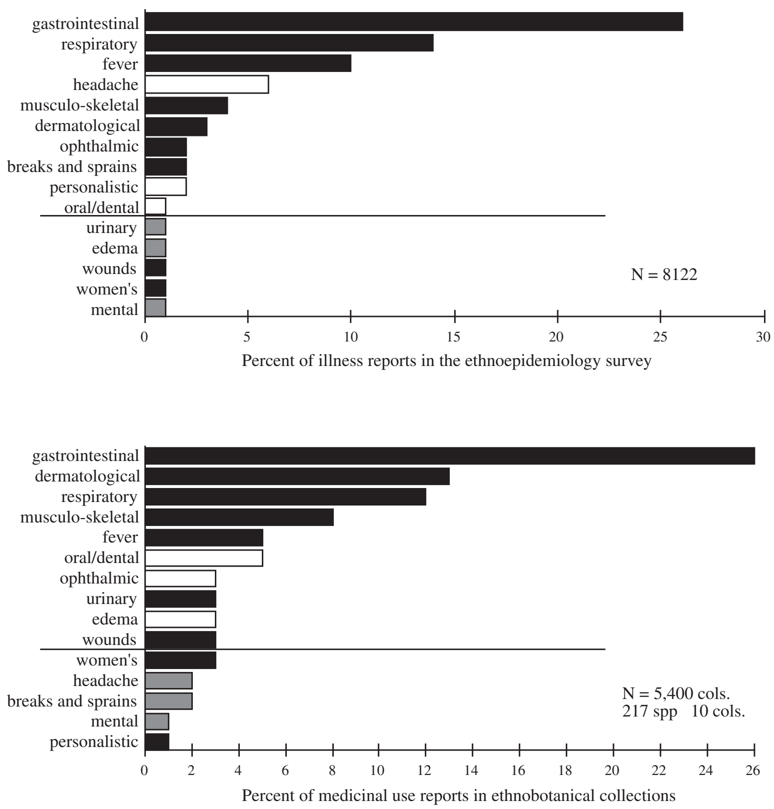
10. presumed curative principles of each constituent (often organoleptic properties),
11. desired effect produced by each ingredient,
12. duration of treatment, and
13. special behavioral requirements to be observed by the patient during treatment (dietary constraints, restrictions on regular activity).

Plant specimens, with their associated botanical and ethnobotanical information, should be mounted and labeled and ideally housed in a local herbarium where they can be made available for study. It is common to make collections in multiple sheets (usually, five to seven). The first set is generally designated for a local, state, or country herbarium; other duplicate sets are distributed to national and international herbaria on the basis of previously established exchange arrangements. Specimens sent to specialists for determination remain with the specialist who, in return, provides the collector with a proper determination of the species. Unicate collections should remain at the local herbarium, except when they must be sent to a specialist for determination. In such cases, a scanned image of the specimen should be made and kept with the local collection.

It is highly desirable to collect the same species multiple times in different localities with different informants. The greater the number of ethnobotanical collections made in distinct localities with different native informants, the more reliable one's generalizations on the distribution of species throughout the region and the greater one's confidence in determining which species have greatest medicinal importance. A single collection of a medicinal plant is essentially useless from a medical ethnobotanical perspective. If an ethnomedical system is based on the extensive use of herbal remedies, there are no important medicinal plant species so rare as to be located only once in a broad-ranging collecting program. In a similar vein, the views of a single informant are equally as uninformative if that informant is the only person, among hundreds of subjects, who claims that species X is a remedy for health condition Y.[12]

A broad-based collecting program of medicinal plants, with numerous informants over a broad geographic area and through a full flowering season, will result in a large set of botanical collections representing many hundreds of species. Our database of nearly 10,000 collections reveals an inventory of more than 1,708 species in 767 genera of 158 botanical families. Nonetheless, many of these species are represented by only 1 or 2 collections. Only 271 species in 43 families have been collected over a wide area and are represented by ≥10 collections. Many of these species are widely distributed throughout Latin America and the Caribbean. Where they are reported as

FIGURE 5
Comparison of Frequency of Ethnoepidemiology Illness Reports and Illness Use Reports from Ethnobotanical Collections



NOTE: The ten most frequently reported health conditions are indicated above the vertical line in each profile. Black bars indicate those health conditions that appear in both profiles. White bars indicate those health conditions not among the top ten in the other figure. Gray bars indicate those conditions found only in the top ten of the opposing figure. Seven conditions occur in the top ten of both profiles. Ubiquity of minor skin infections results in underreporting of dermatological problems in the ethnoepidemiology survey data.

medicinal, their primary uses are similar to those of the Highland Maya (for the theoretical implications of this finding, see B. Berlin and Berlin forthcoming).

The distribution of medical use responses for these common and widespread species allows one to draw important inferences about their relative salience in the treatment of recognized health conditions. As shown earlier, ethnoepidemiological data on Highland Maya medicine indicate the high salience of a small number of major health problems. The ethnobotanical collections support this conclusion, as can be seen by comparing the patterns observed in the epidemiological survey with the distribution of medical use responses linked with our ethnobotanical collections (Figure 5).

The ten most frequently reported health conditions are indicated above the vertical line in each profile in Figure 5 (A, ethnoepidemiology survey; B, ethnobotanical collections profile). Black bars indicate those health conditions that appear in both profiles. White bars indicate those health conditions not among the top ten in the corresponding profile. Gray bars indicate those conditions found only in the top ten of the corresponding profile. The similarity in distribution of responses in the two data sets is quite high. Seven major health conditions occur in the top ten illness classes of both profiles. Five of six most frequently reported conditions occur in both data sets, more than two-thirds of all reported health conditions—gastrointestinal, respiratory, dermatological, musculo-skeletal, and fever. It is likely that ubiquity bias results in underreporting dermatological problems in the ethnoepidemiology survey data.

The diversity of patterns of medical use responses from the botanical collections shows distinctive use profiles, as can be inferred by the level of informant agreement about what conditions a particular species is used to treat. As a working hypothesis, it is reasonable to propose that the greater the number of independent collections of a particular species showing the same medicinal use, the greater the importance of that species in the treatment of the associated health condition (see also L. Trotter et al. 1983; R. T. Trotter et al. 1983; R. T. Trotter and Logan 1986, who have used comparable measures to indicate potential pharmacological importance of particular species).

Medicinal use diversity (or level of agreement as to medicinal use) can be calculated by a number of measures commonly used in plant population ecology to evaluate species diversity (Yule 1924/1944; Zippi 2003). The Yule index is useful because of its sensitivity in differentiating use profiles of species with the same or similar number of collections and the same or similar number of uses. The standard formula of the index (Y) is

$$Y = N^2/\sigma\, n_i(n_i - 1),$$

where N is the total number of botanical collections for a given species and n_i is the number of collections associated with a particular medicinal use. Low

Yule values indicate strong agreement as to use (low levels of diversity/variation among respondents), while high values indicate weak agreement (high levels of diversity/variation among respondents). Figure 6 shows the use profiles for three medicinal plant species, *Tagetes lucida* (Asteraceae), *Rhus terebinthifolia* (Anacardiaceae), and *Lobelia laxiflora* (Campanulaceae).

In Figure 6, the x-axis represents medicinal uses and the y-axis represents number of collections. *T. lucida*, represented by fifty-one collections, shows a tightly patterned medicinal use profile of just eight uses in which informants strongly agree on the primary importance of the species as a remedy for gastrointestinal conditions. There is little agreement on the remaining uses mentioned. Accordingly, *T. lucida* shows a low Yule value of 2.34.

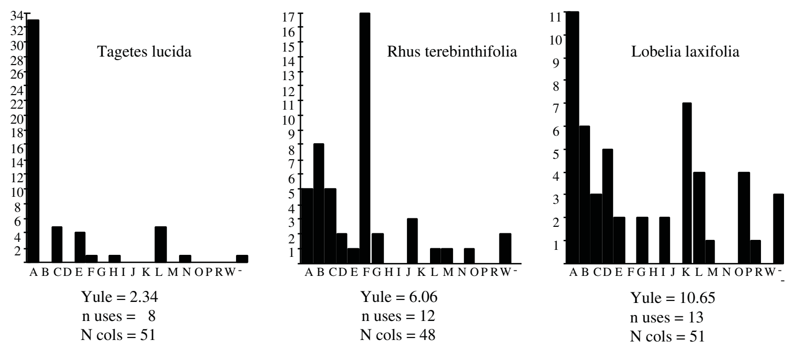
By comparison, despite similar numbers of collections (forty-eight and fifty-one) and numbers of uses (twelve and thirteen), *R. terebinthifolia* and *L. laxiflora* are distinguished by markedly divergent Yule values (6.06 and 10.65). The use profile for *R. terebinthifolia* shows that its principal use is as a remedy for a mouth condition. There is much less agreement as to the particular illness conditions treated with remedies derived from *L. laxiflora*.

Yule values for medicinal plants used to treat specific health conditions let one prioritize those species most likely to show bioactivity in future laboratory studies that will be carried out in the ethnopharmacological component of the research. In the examples just cited, it can be predicted that *T. lucida* is more likely to show significant bioactivity than is *L. laxiflora*, as can be inferred from the distinctive patterns of informant diversity about the specific uses of these two species. Our preliminary laboratory studies support this hypothesis (Meckes et al. 1995; Tortoriello et al. 1995).

CONFIRMATION OF SPECIES' USE RELIABILITY: THE "TRAVELING HERBARIUM"

A broad-ranging ethnobotanical collecting effort led by trained indigenous collaborators and assisted by local informants is limited by the numbers of informants who can be interviewed. For practical considerations, only one or two local assistants can participate in daily collecting trips, identify medicinal species, and provide information about their medicinal uses. Collectors can partially address this problem by working with a local assistant for a specified period, followed by a different assistant from the same locality. In this fashion, small sets of collections will be produced by a number of local collaborators. No individual assistant, however, will have seen the complete set of collections.

FIGURE 6
Comparison of Use Profiles and Yule Values for Three Species with Similar Numbers of Collections



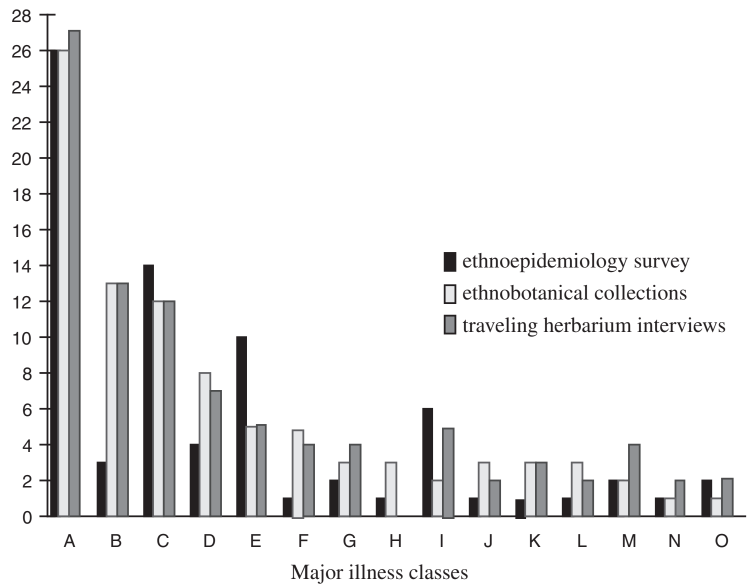
NOTE: Illness codes: A = gastrointestinal; B = dermatological; C = respiratory; D = body pain; E = fever; F = oral/dental conditions; G = eye infections; H = urinary tract infections; I = headache; J = edema; K = wounds; L = women's conditions; M = sprains and broken bones; N = mental conditions; O = magical; P = earache; R = "golpe"; W = evil eye; – = unknown.

Even when large numbers of collections are made, this data-collecting strategy cannot provide the breadth of ethnobotanical information that can be obtained from interviewing a large number of people on the medicinal uses of the same set of plant species, which, for practical reasons, is best represented by those species that have the broadest distribution and have been collected most frequently. Specimens of these plants can then be affixed to standard botanical mounting paper that has been cut to fit an 8.5 × 11–inch three-ring notebook. The portable specimens can be sealed in clear plastic covers and taken into the field where they can easily be used in interviews with large numbers of informants who have not participated in the earlier collecting efforts. We have referred to this ethnobotanical survey instrument as a "traveling herbarium."

The questionnaire accompanying the traveling herbarium should contain the same set of queries used in ethnobotanical collection procedures. In this manner, we interviewed 123 informants (men and women) from distinct ecological zones in fourteen municipalities, providing a rich database composed of more than twenty-eight thousand records.

These data can then be compared to the medicinal use patterns obtained from the ethnomedical, ethnoepidemiological, and ethnobotanical databases (see Figure 7). As can be seen in Figure 7, interview results from the traveling herbarium confirm the observed patterns in prior independent data sets.

FIGURE 7
Comparison of Frequency of Illness Reports from Three Databases



NOTE: Illness codes: A = gastrointestinal; B = dermatological; C = respiratory; D = body pain; E = fever; F = oral-dental conditions; G = eye infections; H = urinary tract infections; I = headache; J = edema; K = wounds; L = women's conditions; M = sprains/broken bones; N = mental conditions; O = magical.

Likewise, the Yule scores obtained for levels of informant consensus from the collections database show the same pattern as those derived from the medical use responses elicited for these same species in the traveling herbarium materials (see Table 1).

ETHNOMEDICAL FORMULARY

It is well known by anthropologists and ethnobotanists, and increasingly recognized by natural products chemists, that the mode of preparation and administration are often crucial variables in determining pharmacological efficacy. As Brun and Schumacher (1987:224) concluded, "We are of the opinion that the most reliable information about the relationships between plants and diseases are to be found in the prescriptions, which are also regarded by the herbalists themselves as the essence of the tradition."

TABLE 1
Comparison of Yule Values for Three Species from Two Databases

	Traveling Herbarium			*Collections Database*		
Species	*Responses*	*Uses*	*Yule Index*	*Collections*	*Uses*	*Yule Index*
Tagetes lucida	165	14	2.38	51	8	2.34
Rhus terebinthifolia	159	14	5.05	48	12	6.06
Lobelia laxiflora	141	17	8.39	51	13	10.65

Preparation methods may influence the chemical composition of an herbal remedy. For example, infusion (steeping in water) and boiling release water-soluble constituents, distillation and condensation (boiling with a cover then plunging into cold water) evaporate elements that may react to produce a different substance with new chemical properties, and tincturation (infusing in alcohol) releases tannins. Preparation methods may also affect bioavailability (the degree to which a medicinal constituent can be absorbed and made available for its intended purpose), pharmacokinetics (absorption, distribution, and metabolism), and pharmacodynamics (action or effect) of medical ethnobotanicals.

Route of administration can also be a major factor in determining the efficacy of herbal preparations, a point made years ago by Elizabetsky (1986). An example is noted by Albers-Schönberg and colleagues (1997), in which "an herb that was proven to have therapeutic benefit in a local setting did not exhibit effectiveness in the laboratory until the researchers incorporated local healers' methods of delivery (oral ingestion) into their testing procedures." This finding is explained by Mukherjee (2002:66), who suggested that "natural compounds are often metabolized in the digestive tract; that is they act like pro-drugs," which must undergo transformation in the body before becoming active.

The bioavailability of a medicinal may also be affected by the route of administration. The most common route of administration of folk medicinals is oral. However, while enzymatic, bacterial, or pH environment of the gastrointestinal system may have positive effects as mentioned above on the chemical composition of some preparations, they may be destructive to others. Topical, intradermal (abrasion, injection), rectal, or respiratory (inhalation) application may preserve or alter the rate of drug uptake and metabolism as well as have an effect at the site of administration.

An aspect of ethnomedical practice that has been relatively neglected in medical ethnobiological studies is the behavioral prescriptions and proscriptions the patient must observe (see Maya ethnomedical explanatory model questionnaire). The most common prescription is bed rest. At a minimum, physiological processes can be directed toward healing rather than production of energy for physical activities. Bed rest may also include specific injunctions against leaving the dwelling. Some medicines produce phototoxic reactions (harm during ultraviolet light exposure). Dietary restrictions are also common. Presence, characteristics (e.g., acidity, fat content), and quantity of food in the gastrointestinal system can influence drug absorption, metabolism, and excretion.

Given the importance of these aspects of ethnoformulary, we have developed an elicitation protocol that allows us to record preparation procedures according to traditional Maya natural products formulas. As a first step in data collection, we employ a two-part, standardized but open-ended, Maya-language questionnaire. Interviews begin with the elicitation of all of the treatments that the consultant knows and has personally prepared (part 1). Data include

1. the name of each species used in treatment,
2. the collection number of the herbarium voucher identifying the plant, and
3. the order of preference in which the informant would use the treatments if all were equally available.

Part 2 of the interview proceeds to data concerning each treatment named in the first segment.

All ingredients are listed, and the following data are collected on each ingredient:

1. local name;
2. scientific name;
3. healing strength (expressed on a five-point scale), organoleptic properties (color and odor, five-point scale), and flavor (three-point scale);
4. any other distinguishing characteristics (produces foam, caustic);
5. properties (milky sap, ash, resin);
6. effect produced by the ingredient (in the body or on the illness);
7. quantity added;
8. part(s) used;
9. whether the ingredient is obligatory or optional in the formula;
10. ecological habitat (forest, garden, trailside, etc.);
11. growing range (hot, temperate, cold country);
12. time of availability (seasonality);
13. preferred time of harvest (diurnal, lunar phases);
14. special conditions of harvest (ritual or practical);
15. preliminary preparation of each substance (washing, heating, grinding);
16. containers for preparation (if special, e.g., clay pots, leaves);

17. manner in which ingredients are mixed (icons serve as reminders of possible significant forms): order of mixture (before/after water boils, in distilled liquor), form (chopped, sprinkled, whole), prepared in (cold water, boiled, distilled, plunged in cold water), preparation time (minutes boiled, time of day);
18. to whom remedy is administered (age, gender, life stage);
19. mode of administration (drunk, rubbed, bathed, steamed, etc.);
20. dosage (cup, handful, drops, native measures if relevant);
21. special diet required (prescriptions/proscriptions); and
22. special behavior required (bed rest, avoid sun, steambath).

While this instrument is a good guide, it should be adapted to local needs and use patterns. Developing the ethnoformulary instrument is a cooperative venture between the researcher and representatives of the local culture and will likely require repeated field testing and modification. Audio-visual recording of formulary preparation can provide a valuable record for specialists (e.g., natural products chemists) to analyze for possible insights missed by ethnographers and their local collaborators.

ETHNOPHARMACOLOGY

The final stages of the medical ethnobiological study of a plant-based ethnomedical system incorporate specialists in the relatively new field of ethnopharmacology.[13] There is broad variation in the degree of sophistication in incorporation of ethnomedical information and anthropological expertise by ethnopharmacologists. We cannot address with any authority the laboratory methods of ethnopharmacology, nor is there space here to present an adequate review of the field. Our discussion is limited to what we envisage to be a productive interface between ethnomedicine and medical ethnobotany, on the one hand, and ethnopharmacology, on the other, with the goal of providing a holistic anthropological description of a traditional ethomedical system (refer again to Figure 1).

Ethnopharmacological research differs from phytopharmacology and pharmacognosy only to the extent to which it relies on *ethno*medical information. No widely accepted definition of the field exists, but one widely cited is that of Bruhn and Homstedt (1981:406): "Ethnopharmacology deals specifically with the remedies employed by various cultures." It is the "interdisciplinary scientific exploration of biologically active agents traditionally employed or observed by man . . . [based on] the observation, identification, description and experimental investigation of the ingredients and the effects of such indigenous drugs." Data resulting from the ethnobotanical component of the work described above can be used as a guide for ethnopharmacologists in determining which species represent the most likely candidates to show significant bioactivity. The ethnomedical data provide clear indications of therapeutic expectations that can guide pharmacological laboratory analysis (e.g., for analgesic or antibiotic activity, neurological or metabolic effects). Thus, the recognized health conditions (ethnomedicine) and the primary species used to treat those health conditions (medical ethnobotany) form the primary data for the ethnopharmacologist. Exemplary work that contributes to this approach is that of Heinrich and his colleagues (see especially Frei et al. 1998; Leonti et al. 2001; Leonti, Sticher, and Heinrich 2002; Leonti et al. 2003).

One problem that anthropologists often face is developing collaborative ties with laboratories and scientists who have the interest and ability to carry out the specific assays for the kind of pharmacological effects the folk system suggests. To some extent, this is compensated for by the development of rapid throughput screening techniques—assays of a large number of plant species for many different kinds of pharmacological activities in a short period of time. These may include the specific therapeutic responses predicted by the ethnomedical system plus a number of other pharmacological properties. However, it is critical to ensure that the ethnomedically predicted or expected pharmacological effect is included in the testing process.

The combination of plant species (and sometimes other substances) in the ethnomedical formulary provides a more sophisticated (and challenging) basis for the ethnopharmacological evaluation process that is several steps beyond the single plant or single compound assay. Laboratory science was, until recently, the limiting factor in such analysis. Single plants normally have a complex series of chemical compounds. Traditional laboratory approaches previously aimed to isolate one target compound for testing. It is now possible to analyze multicomponent formulas. Confirmation of the pharmacological properties of these multicomponent formulas attests to the scientific basis of ethnomedical systems.[14]

It is true that ethnomedical products have undergone sustained pragmatic testing and are therefore likely to produce the predicted effect in laboratory analysis. It is also true, however, that long-term cumulative effects are not likely to be immediately detectable solely on the basis of experience and/or there is no easy way to establish a link between a health problem and a phytomedicinal administered months or years previously. Ethnopharmacological evaluation can play an important role in determining safety and toxicity, as well as pharmacological efficacy. It can also guide standardization of dosage.

Finally, medical anthropologists, medical ethnobotanists, and ethnopharmacologists can potentially meld their research findings to explore ways to make their results available to the local populations with whom they have worked. While the scope of this theme is well beyond the present article, it should be noted that the use of herbal remedies that have been shown to be safe and efficacious can be promoted in place of expensive patent or over-the-counter medicines. Also potentially desirable is local production of pharmacologically effective medicinal plants in home gardens and community plots, especially if, as for the Highland Maya, these species are not normally cultivated. Some species may show promise for commercial production, either for local or regional markets as raw materials or processed as tinctures, oils, and salves for the natural products medicines market. There is also potential for local production and sale in bulk for commercial purposes or even commercial production of herbal medicines and nutritional supplements for sustained economic development. The discovery of novel compounds may even be pursued for development of new pharmaceuticals.

CONCLUSIONS

In this article, we have presented a summary of the primary methods we have personally tested and used in our work on the medical ethnobiology of the Highland Maya. The work involves three major components: ethnomedicine, medical ethnobotany, and ethnopharmacology. Our research aims to be holistic, focusing on medical knowledge and practice as an integrated system, not as a series of isolated, unrelated beliefs about illness(es) and their treatments or on the pharmacological constituents of particular medicinal species. This view is consistent with our bias on the nature of what constitutes an adequate ethnography, namely, the encyclopedic codification of the knowledge required to behave in a culturally appropriate fashion in some particular society, a view of cultural description that still remains central to anthropologists engaged in long-term fieldwork today.

Of course, no comprehensive medical ethnobiological description of a complete ethnomedical system has yet been produced that satisfies this criterion of adequacy. Our own efforts to provide a sketch of the medical ethnobiology of Highland Maya knowledge of gastrointestinal conditions, using the methods that we have outlined here, resulted in a monograph of nearly six hundred pages (E. A. Berlin and Berlin 1996). To cover the remaining health conditions with equal detail would require several additional volumes, and work on one of them is currently under way. Nonetheless, we believe that descriptions of complete ethnomedical systems are feasible. The methods we have outlined here aim to shed some light on what such descriptions would entail and how one might go about collecting the basic data on which they might be built.

Notes

1. Recent studies of traditional, small-scale societies reveal sophisticated ethnomedical systems that promote the maintenance and reestablishment of health, often employing a complex ethnopharmacopia of plant-derived remedies. The ethnomedical formulary of medicinal plants (*materia medica*) described in these studies is commonly based on an astute understanding of human anatomy, physiology, and the healing properties of plants on human bodily function. Several recent examples that address at least some of these topics include Fleuretin and Pelt (1982), Davis and Yost (1983), Browner (1985), Elvin-Lewis (1986), Dos Santos and Fleuretin (1991), Anderson (1993), Longuefoss and Nossin (1993), Brett (1994), Abdel-Malek et al. (1996), Johannes (1996), Carlson et al. (1997), Frei et al. (1998), Leonti et al. (2001), Casagrande (2002), Pieroni et al. (2002), and Leonti et al. (2003); the work of Bastien (1983, 1987, 1989, 1992) is probably the most comprehensive of these.

2. Our ethnographic biases are traced to the ethnoscientific tradition of the new ethnography that began in the late 1950s (see Conklin 1954; Goodenough 1957; Frake 1962; Romney and D'Andrade 1964; D'Andrade 1995; the latter has a good history of some of the major themes of this vision of anthropological fieldwork). Although much has changed in this tradition over the past four decades, the fundamental premise that ethnography should aim to codify the knowledge required to generate culturally appropriate behavior in some particular society, first stated explicitly by Goodenough (1957), continues today with much vigor.

3. The maintenance or reestablishment of a state of health is dependent on events and interactions in two separate realities: the natural, usually visible, reality that follows predictable physical norms (naturalistic conditions) and another, frequently nonvisible reality that relates to extranatural phenomena (personalistic conditions; Foster and Anderson 1978). The participation of a health condition in the naturalistic system is based primarily on immediately apparent signs and symptoms (e.g., *ch'ich' tza'nel* [bloody diarrhea], recognized by the presence of frank blood in the stool and severe pain in the lower abdomen). Naturalistic conditions are normally treated with medicinal plants. Diagnosis of personalistic conditions is based on retrospective presumption of etiologic agent (e.g., *jme'tik jtatik*, literally, our ancestral mothers and fathers, resulting from an inadvertent encounter with these ancestral spirits). Diagnosis and treatment of personalistic conditions frequently involve the intervention of healers with special powers who normally use remedies that require ceremonial healing rituals and special prayers (see Guiteras-Holmes 1961; Holland 1963; Metzger and Williams 1963; Silver 1966a, 1966b; Fabrega 1970; Fabrega, Metzger, and Williams 1970; Fabrega and Silver 1970, 1973; Harman 1974). Our own research has focused on the naturalistic aspects of Maya medicine, but we recognize that the knowledge and practices associated with both naturalistic and personalistic healing must be incorporated into any complete ethnomedical description.

4. Prior informed consent (PIC) requirements are well established and follow the stipulations outlined in the Protection of Human Subjects Office of Human Relations Program Title 45 of the Code of Federal Regulations, part 46. Additional specific requirements may be established

by the Institutional Review Board of the investigator's home institution. The significance of this topic can be seen from the hundreds of sites devoted to PIC from a cursory search of the World Wide Web. Additional sources that focus on PIC in matters of access to biological resources can be found in the references cited in Anaya (1996), Pan America Health Organization (1996), Posey and Dutfield (1996), ten Kate and Laird (1999), Svarstad and Dhillion (2000), and Laird (2002). The relevant sections of the Convention on Biodiversity are articles 15 and 8(j).

5. We refer the reader to the American Anthropological Association statement by Clark and Kingsolver at the association Web site (www.aaanet.org/committees/ethics/bp5.htm) and the Declaration of Belém at the Web site of the International Society of Ethnobiology (www.guallart.dac.uga.edu/ISE). The latter posts a statement on ethics and a partial list of relevant publications on these topics.

6. Some exceptional examples include Nicolás Hernández Ruíz (Tzotzil, municipality of San Andrés Larráinzar) who became the first indigenous member of the Mexican Society of Botanical Illustrators. Alonso Méndez Girón (Tzeltal, municipality of Tenejapa) became a brigade leader for the Mexican national botanical survey for Chiapas during the 1980s. Pedro Pérez Conde (Tzeltal, municipality of Tenejapa) publishes a bilingual newspaper column in *Cuarto Poder*, a daily newspaper in the state's capital, Tuxtla Gutiérrez. Feliciano Gómez Sántiz (Tzeltal, municipality of Oxchuc) won a state prize for a historical treatise on his home municipality.

7. A useful manual describing these general methods has been recently published by Norbert Ross (2003) and is highly recommended. Data resulting from all of these methods are commonly analyzed today with AnthroPac, a software application developed by Steve Borgatti and now part of the tool kits of most anthropologists; see www.analytictech.com/ and www.analytictech.com/apacdesc.htm.

8. Kleinman's (1988) discussion of the use of illness narratives is highly relevant to this topic. See also Young and Garro (1994).

9. Summary reports ensure patient confidentiality; however, if patient information is to be viewed by the investigator, it is necessary to acquire the patient's PIC.

10. This is similar to the genogram sometimes used by family practice physicians.

11. We are not aware of prior reference in the literature to this type of bias.

12. Walter and Memory Lewis's (personal communication) work among the Aguaruna Jívaro of Amazonas, Peru, contradicts this claim, at least as a universal principle. They note that they have discovered one plant species with active pharmacological properties known only to a single informant. The health conditions or particular species in question have not been published.

13. Over the past thirty years, ethnopharmacology has become a well-established academic discipline with an extensive body of literature. See the International Society of Ethnopharmacology's official journal *Ethnophamarmacology*, and for some indication of the broad scope of the field, see www.ethnopharmacology.org/; www.ethnopharmacologia.org/, the site of the French society of ethnopharmacology; and membres.lycos.fr/ethnopharma/thesociety.html, the site of the European Society of Ethnopharmacology. In addition, Heinrich and Gibbons (2001) provide a useful window to the nature of the discipline.

14. It will be claimed by some that demonstrating the scientific bases of folk medical systems need not be a concern of practitioners of medical ethnobiology. This may be partially true. Nonetheless, recognizing that the ethnobiological knowledge of traditional peoples conforms in many respects to basic scientific principles is an empirical generalization that merits emphasis, especially when prejudice and ignorance suggest that folk knowledge is nonsense, a stubbornly persistent bias.

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