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Use of Network Centrality Measures to Explain Individual Levels of Herbal Remedy Cultural Competence among the Yucatec Maya in Tabi, Mexico

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Abstract

Common herbal remedy knowledge varies and is transmitted among individuals who are connected through a social network. Thus, social relationships have the potential to account for some of the variation in knowledge. Cultural consensus analysis (CCA) and social network analysis (SNA) were used together to study the association between intracultural variation in botanical remedy knowledge and social relationships in Tabi, Yucatan, Mexico. CCA, a theory of culture as agreement, was used to assess the competence of individuals in a domain of herbal remedies by measuring individual competence scores within that domain. There was a weak but positive association between these competence scores and network centrality scores. This association disappeared when age was included in the model. People in Tabi, who have higher competence in herbal remedies tend to be older and more centrally located in the herbal remedy inquiry network. The larger implication of the application of CCA and SNA for understanding the acquisition and transmission of cultural knowledge is also explored.

Keywords

cultural consensus analysis; social network analysis; intracultural knowledge variation; medicinal plant remedies; Yucatan

Introduction

Across the world, people use local plants as remedies for illness. Knowledge of these remedies varies, and there is a long tradition of research to measure this variation. Some researchers compare variation in local, individual knowledge with etic ecological data (Begossi 1996; Ghimire et al. 2004; Stepp 1999; Zarger and Stepp 2004), whereas others compare knowledge across members of a cultural group (Friedman et al. 1986; Johns et al. 1990; Phillips and Gentry 1993; Trotter and Logan 1986). The most powerful method for the latter is cultural consensus analysis (CCA), a theory of culture that specifies the conditions under which agreement among informants about a cultural domain equals knowledge about that domain (Romney et al. 1986). CCA is widely used to assess this agreement in knowledge within domains of ecological knowledge (Reyes-García et al. 2007).

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In groups that are dominated by subsistence agriculture, traditional ecological knowledge and skills tend to be acquired through participation in daily life (Gaskins 1999; Hunn 2002; Zarger 2002b). Typically, knowledge about herbal remedies is acquired through observation and participation in illness treatment and in discussions about how to cure illnesses (Casagrande 2002; Prince et al. 2001). In general, children begin learning traditional ecological knowledge around the age of 2 and they continue to acquire information until the age of 14, which is when most children reach basic adult proficiency (Stross 1973; Zarger 2002a; Zarger and Stepp 2004). Some people, of course, become more proficient by continuing to learn about medicinal plants into adulthood (Anderson 2003; Phillips and Gentry 1993), but there tends to be a large body of generalized knowledge that is shared by all adults (Casagrande 2002).

Traditional methods of learning may be hampered by language loss, shifts from subsistence agriculture to non-land-based production activities, increased amounts of classroom education, and the presence of biomedical health care (Maffi 2005; Ohmagari and Berkes 1997; Voeks and Leony 2004). Increased inconsistencies in the quantity and quality of traditional learning opportunities can arrest acquisition of knowledge (Boster 1991) and result in more variation in traditional ecological knowledge within a group (Ghimire et al. 2004).

In the last decade, researchers have shown that relationships between people—that is, aspects of their social networks—may in part explain variation in knowledge (Atran et al. 2002; Casagrande 2002; Ross 2002; Vandebroek et al. 2004). The idea is that social networks are the structure through which socially acquired knowledge is transmitted and that, therefore, people in different positions within the social network may have access to different information. This, in theory, should result in patterned variation in knowledge (D'Andrade 1995). In the work reported here, I test the hypothesis that individual medicinal plant knowledge is positively associated with an individual's structural position within the herbal remedy inquiry network in Tabi, Yucatan, Mexico. It turns out that the association between knowledge and network centrality is weak and trumped by age when attribute variables are included in the model, but I focus here on the method for assessing this relationship and the implication of the method for understanding the acquisition of cultural knowledge.

Study Location

The study took place in 2007 in Tabi, a village in the central part of the state of Yucatan, Mexico. Tabi is a rural subsistence farming community with 698 people living in 122 households. The majority of adults attended school but just 26% have finished sixth grade and 30% are illiterate. Most of the villagers are bilingual in Yucatec Maya and Spanish (89%) and the rest are monolingual in Maya (9.5%) or in Spanish (1.5%). Catholicism is the most common religion in Tabi (46%), but increasing numbers of people are joining Protestant churches (34%) or are choosing to have no religious affiliation. Changes in the treatment of common illnesses are also occurring. Families are increasingly using pharmaceuticals prescribed in the state-run health care clinic in Tabi, but herbal remedies continue to be the most common treatment method for frequently occurring illnesses. Access to and use of modern services, such as the health care clinic by residents of Tabi and evidence that they are embracing new forms of knowledge (rising religious conversion and bilingualism) made it an ideal place to study variation in medicinal plant remedy knowledge among adults.

CCA in Tabi

CCA was used to determine if there was one common culture of herbal remedy knowledge in Tabi and to measure the individual variation in agreement of botanical remedies. I used free listing, a simple technique where participants are asked to list items within one cultural domain, to identify a list of culturally salient items for use in the CCA questionnaire (Borgatti 1996b; Weller and Romney 1988). Initially, I had intended to ask the participants to list all the medicinal plants they knew and then use the list of plants as a prompt to determine the illnesses they were used to treat. However, when pretesting this method in a nearby community, I found that participants invariably told me not just the name of the plant but also the illness it treated and any other plants that were included in the preparation of the remedy. Thus, my focus shifted from medicinal plants, which is typical in medical ethnobotanical studies (see Reyes-García et al. 2007 for a review), to herbal remedies.

In Tabi, I asked 30 women and 10 men of varying ages from different households to free list all the herbal remedies they knew. I used ANTHROPAC (Borgatti 1996a) to analyze the data. The 40 informants produced a total of 650 unique remedies, with one remedy listed 20 times and 562 listed just once. Questionnaires for consensus analysis require at least 20 items to obtain a stable estimate of individual competence (Weller 2007), so I selected 21 remedies that were mentioned at least twice as the basis for the questions in the consensus exam. The 21 illness-remedy combinations are shown in Table 1; they consist of one remedy for each of the most commonly reported illnesses (with the exception of diarrhea, which had such a large number of remedies that I decided to keep two) and varied in frequency to help capture any variation in knowledge that existed within the community. The questions were in the form: “Can *plant x* cure *illness y*?” in which I substituted the various plants and corresponding illness names for *plant x* and *illness y*, respectively. The expected answer to each of the 21 questions was “yes” as all the remedies were reported in the free-listing exercise.

I also included 22 more “remedies,” which I created by matching commonly used medicinal plants with common illnesses in unique combinations. I constructed these remedies because CCA is sensitive to the proportion of yes responses (Weller 2007; see Table 2). The plant-illness complexes I generated were not known as remedies in the literature on Yucatec Maya medicinal plants nor were they reported in the free list exercise in Tabi. Thus, the expected answer to each of the 22 created remedies was “no.”

I administered the 43-question instrument (shown in Table 3) to 116 people in different households. From my ethnographic research, I learned that, although most health care decisions were made jointly by the adults in each household, one person, the household expert on remedies, was most likely to be consulted when someone fell ill. In collecting the data, I asked for a nomination of the household expert and interviewed that person. If more than one expert was nominated, or if none were, I selected at random the person to be interviewed. There were 122 people nominated. Three chose not to participate and three were removed from the sample because of indications that they provided false information during the interview.

Respondents had the option of answering “yes,” “no,” or “uncertain” for each question. During the interviews, I encouraged people who were unsure of the answer to guess because CCA operates under the assumption that a respondent will guess if they are uncertain (Romney et al. 1986). However, there were several cases where participants would not guess, so I marked their responses as uncertain and simulated guessing by coin toss (Weller 2007).

The data were analyzed using UCINET, which has routines for social network analysis (SNA) and for CCA (Borgatti et al. 2002). To test for response bias in the consensus analysis, I ran both the multiple choice and the covariance models and then compared the scores from the two models (Weller 2007). The difference between the two models is that the proportion of matching responses between individuals is corrected for guessing at different levels. The correlation coefficient was .97 ($p < .01$), indicating little difference in competence values between the two models and limited response bias. I use the competence values from the covariance model in the remainder of the analyses because it was designed to be used with dichotomous (yes–no) responses.

The first step of the CCA is the calculation of the proportion of matches between all pairs of participants with a statistical adjustment for guessing (Borgatti 1996b). Then, a minimum residual factor analysis is applied to the corrected matches (Romney et al. 1986). Finally, the CCA uses Bayes's Theorem to estimate the correct answers to the set of questions.

There are three assumptions in the model: (1) Informants share a common culture; (2) Informants answer the exam questions independently of one another; and (3) All exam questions are of equal difficulty (Romney et al. 1986). It is reasonable to believe that the assumptions are not violated when (1) the values in the first factor of the residual factor analysis are all positive; (2) they account for at least three times the variation in the data as compared to the second factor (the ratio was 14.64 for the Tabi data); and (3) all other factors are comparatively small and reduce slowly in size. Table 4 shows the data from Tabi did not violate the assumptions of the analysis. In addition, the data met the criterion for avoiding the sensitivity of CCA to greatly unequal proportions of yes and no responses with 51% affirmative responses to the questions in the questionnaire (Weller 2007).

There is, then, one common culture of herbal remedy knowledge in Tabi, and the first factor values represent individual competence scores for that knowledge. The competence scores range from .08 to .95 (Table 5) with an average of .64 ($SD = .20$). The large range in competence scores and the relatively large standard deviation show that there is quite a bit of variation in agreement about herbal remedies across households in Tabi.

SNA in Tabi

To determine the botanical remedy inquiry network, I asked each of the 116 participants (the same individuals who responded to the CCA questionnaire) the following: “Have you asked *person x* about herbal remedies?” substituting for *person x* the names of each of the 115 other participants. This question was designed to elicit a whole network. I used this approach, rather than one based on personal networks, so that I could calculate individual measures of each person's centrality in the information exchange network within Tabi. From these data, I produced several overall measures of network structure and a visualization of the network using UCINET and NetDraw, respectively. As shown in Figure 1, the graph was unconnected. There was one main component of 96 individuals connected to each other either directly or indirectly and 18 isolates who neither inquired about botanical remedies nor were asked about them by others in the community.

Some measures of network structure for Figure 1 are shown in Table 6. The density was low (.02, $SD = .13$), meaning there were few ties between people through which information could flow. The fragmentation score—the proportion of nodes that cannot reach each other—was .29, showing that the proportion of individuals who can reach each other was relatively high (.71). Most of those connections, however, were not mutual (they were initiated with one individual), indicated by the extremely low reciprocity value (.03). In general, the overall measures of network structure indicated a lack of cohesion in this network.

I assessed individual position within the network using degree and betweenness, two measures of centrality. I did not calculate closeness centrality, another commonly used measure, because degree centrality and closeness centrality were highly related ($r = .95$, $p < .01$, $N = 116$). Degree centrality is a measure of distance between nodes in a network and is both easy to interpret and definable for unconnected graphs.¹

I measured degree centrality using the method reported by Freeman (1979), where degree is the number of nodes (people) adjacent to a given node in a nondirected graph (a graph consisting of reciprocal ties). In directed graphs (a graph consisting of nonreciprocal ties), such as the one produced using the data from Tabi, the in-degree of a focal node is the number of ties (which represent the relationships between people) received by that node and the out-degree is the number of ties initiated by the focal node. The mean in-degree in the herbal remedy inquiry network was 2.11 (SD = 3.09), with a range from 0 to 19. These statistics indicate that participants were asked by few of the other 115 respondents about herbal remedies. The in-degree network centralization score, a measure of hierarchy in centrality measures where the closer the centralization scores is to 100% the more unequal the centrality scores are in different positions of the network, was 14.81% (Freeman 1979; Wasserman and Faust 1994).

Out-degree had the same mean (2.11), but a larger standard deviation (5.53) and a wider range (0–37); these results indicate that participants were inquiring about botanical remedies with few other respondents. Out-degree showed evidence of greater hierarchy than in-degree, with an out-degree centralization score of 30.60%. Two people in the network visualization, nodes 17 and 101, stood out as having particularly high out-degree, which explains the larger standard deviation, range, and centralization score as compared to in-degree (Figure 1). Further interviewing with those individuals revealed that one was seeking new treatment options for a difficult-to-cure illness contracted by her husband and the other was interested in becoming a healer.

Betweenness centrality, the second gauge of individual position, is a measure of the extent to which the individual is located between various other individuals in the network (Scott 2000). There are several ways to measure betweenness centrality in UCINET. One way is node betweenness, which is based on the proportion of times a node falls along geodesics (the shortest path between two nodes; Freeman 1979). Another is flow betweenness, which is based on all paths, not just the geodesics (Freeman et al. 1991). I selected flow betweenness because it is a better measure of how information actually flows.

The low mean betweenness score of 6.88 (SD = 33.45) indicates that participants were situated between few pairs of people. The distribution of betweenness scores showed that the majority of participants (83.62%) did not lie along any paths between pairs of participants and two individuals stood out with extremely high betweenness scores (219.17 and 260.50) as compared to the rest of the respondents. The betweenness network centralization index was 1.95%. The low mean betweenness score, the large percentage of

¹Although closeness centrality cannot be measured for unconnected graphs, several solutions of varying desirability are used in practice. When using Freeman's "sum of geodesics distances" approach, UCINET recodes the infinite distances between unconnected points as the number of nodes, which is one more than any possible path in a network. This approach is difficult to defend because it creates a finite measure for a distance that is infinite. Another work-around is to extract the main component and only run the closeness centrality analysis on that component. This method is more desirable, especially for graphs that are mostly connected, but it is still problematic because data are excluded. The two most preferred methods, because of their applicability to datasets with varying levels of connectivity, are the "sum of reciprocal distances" or Valente-Foreman's "average of reverse distances" (Valente and Foreman 1998). Unlike Freeman's approach, which sums the geodesics and then takes the reciprocal (Freeman 1979), both of these approaches take the reciprocal of the geodesics, which allows the closeness of unconnected nodes to be represented by 0 because it follows the convention that 1 divided by infinity is 0. I used the sum of reciprocal distances to calculate the closeness centrality values I employed to assess the relationship between degree and closeness.

actors with a betweenness score of 0, and the extremely low network centralization index indicates that there was not much opportunity for brokering of herbal remedy information in this network.

Testing the Association of Consensus Scores and Network Scores

I tested the hypothesis that greater individual herbal remedy knowledge, as measured by agreement, is positively associated with the positions of individuals within the botanical remedy inquiry network by running regressions using permutation tests among degree and betweenness scores and competence scores from the consensus analysis.² The correlation between competence and in-degree scores was weak, but positive, and significant ($r = .28$, $p < .01$, $N = 116$; Table 7). So, people in Tabi who have high competence scores tend to be asked by more of their co-villagers about remedies than those who have low competence scores. This association is also apparent in the network visualization; nodes that represent individuals with higher competence and in-degree scores are located toward the center of the graph (Figure 1). Nodes 4, 38, 49, and 57 further demonstrate this association because they all have relatively high in-degree and competence scores. These nodes also show that the herbalists (nodes 38, 49, and 57) obtained lower competence scores than individuals who were knowledgeable about herbal remedies but were not considered specialists (node 4). These findings exhibit the shaman effect—that is, when the competence scores of people with highly specialized knowledge differs noticeably from those of the general public (Bernard 2006).

There was no significant relationship between competence scores and out-degree ($r = -.14$, $p = .15$, $N = 116$) or between competence scores and betweenness ($r = 0$, $p = 1.00$, $N = 116$). Betweenness and in-degree scores were not associated ($r = .05$, $p = .45$, $N = 116$) and a moderately positive relationship was observed between betweenness and out-degree scores ($r = .54$, $p < .01$, $N = 116$). Therefore, people who asked many individuals about botanical remedies tended to be intermediaries within the medicinal plant remedy inquiry network. The results from the correlation between competence and in-degree scores support the hypothesis that individual herbal remedy knowledge is positively associated with an individual's structural position within the herbal remedy inquiry network, whereas the results from the correlation with betweenness did not support the hypothesis.

I further tested the connection between social relationships and cultural knowledge with a multiple regression, using competence score as the dependent variable and various individual attributes—including network position scores—as independent variables. Attribute variables that have been shown to influence individual knowledge levels in different contexts and for which I had data are age, distance traveled from current residence, lifestyle score from a Guttman scale (Guttman 1944 and see Guest 2000 for a description of how to create a Guttman scale), relative economic prosperity (also from a Guttman scale), gender, literacy, religion, and preference for herbal remedies as compared to pharmaceuticals.

The ANOVA results in Table 8 show that the variation described by the model was not due to chance ($F = 3.34$, $p = .04$, $N = 116$). The linear correlation between the observed competence scores and the model predicted values was moderate ($r^2 = .26$, $N = 116$), with

²Permutation tests are ideal for hypothesis testing with relational variables because they are adaptable to all classical statistical tests and are applicable to situations where the observations are not independent, sampling is not random, and the distribution is unknown (Borgatti 2000). There are several steps to the permutation test (Borgatti et al. 2002). First, a standard regression analysis is performed. Next, UCINET randomly permutes the rows in the data matrix and reruns the regression, this step is repeated a designated number of times (1,000 is the default), and the results are recorded. Last, the significance of the coefficients is determined by calculating the proportion of random permutations that have a result as extreme as the coefficients in the original regression.

26.1% of the variation in competence scores explained by the variables included in the model. The association between competence scores and all of the other variables was masked by age ($B = .01, p < .01, N = 116$). Thus, individual network position, as measured by in-degree and betweenness, does not explain any variation in medicinal plant remedy knowledge across households in Tabi after controlling for the individual attributes. In particular, age and in-degree are positively associated ($r = .48, p < .01$), which suggests that, as generally expected, the trend in Tabi is that older people are both the most knowledgeable and the most centrally located in the network.

Discussion

This article demonstrates that network centrality can be used to account for some variation in shared knowledge. The use of relational variables, such as network centrality measures, to describe knowledge variation need not replace traditional attribute variables (e.g., age, gender, and literacy). Instead, relational data should be viewed as another type of data that can be used, in addition to attribute data, to better understand intracultural knowledge variation. By combining attribute and relational data, I was able to determine that older people in Tabi were more knowledgeable about medicinal plants and were sought out for herbal remedy advice by more people than were younger members of the community.

The results from this analysis have implications for improving our understanding of acquisition of cultural knowledge and for measuring knowledge acquisition networks. Most traditional ecological knowledge and skills in rural areas are acquired through situational learning and unsolicited advice between people who interact on a daily basis. The remedies reported in the consensus exam in this study were likely acquired through these means. However, the network question I asked focused on learning through direct questioning. This discrepancy in how cultural knowledge is typically acquired, and the method used here to approximate the network used for knowledge acquisition, may explain why the amount of variation explained by the centrality measures is so low. Perhaps the inclusion of centrality measures from networks created from questions designed to capture nonexplicit learning might further explain variation in competence scores. Specifically, questions created to capture the frequency and duration of contact and communication between individuals, kinship ties, and physical proximity could be included in the predictive model by comparing and incorporating data from kinship, geographical, and interaction networks.

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Figure 1.

Herbal remedy inquiry network of Tabi. The nodes are the individuals in the network and the lines represent the relationship between them. The arrow indicates the direction of the relationship: Individuals with arrows pointed toward them were asked about herbal remedies and the individuals who asked about herbal remedies are located at the beginning of the arrow. The size of the nodes indicates the magnitude of the individual's competence score: The larger the node, the higher the competence score. Shading represents in-degree: The darker the shading, the greater the in-degree of the node. In-degree is the number of individuals who have asked the participant about herbal remedies. The spring-embedded graphic theoretical layout was used.

Table 1
Remedies in the Cultural Consensus Questionnaire Mentioned at Least Twice in the Free List

Remedy #	Illness in Remedy			Plant in Remedy	
	English Gloss	Spanish Gloss	Maya Name	Scientific Name	Common Name
1	Acne	Granos	Mejen chuchun	<i>Momordica charantia</i> L.	Chiquita
2	Asthma	Asma	K'aak'as se'en	<i>Gossypium hirsutum</i> L.	Tz'intaman
3	Canker sores	Fogajies	K'aak'	<i>Jatropha curcas</i> L.	Sikilte
4	Colic	Cólico	Ch'ot nak'	<i>Urena baccifera</i> (L.) Gaudich. ex Wedd.	Ortiga
5	Cough	Tos	Saasa' kaal	<i>Persea americana</i> Mill.	Aguate
6	Diarrhea	Diarea	Waach' k'aja'al	<i>Callicarpa acuminata</i> Kunth	Puk'in
7	Diarrhea	Diarea	Waach' k'aja'al	<i>Manilkara zapota</i> (L.) van Royen	Zapote
8	Dysentery	Disentería	K'iik' nak'	<i>Hylocereus undatus</i> (Haw.) Britton & Rose	Pitajaya
9	Ear ache	Dolor de oído	K'iinan xikin	<i>Origanum vulgare</i> L.	Orégano de castilla
10	Eye pain	Dolor de ojo	K'iinan ich	<i>Ocimum basilicum</i> L.	Albahaca
11	Gas	Aire en el estómago	U yik'al nak'	<i>Allium schoenoprasum</i> L.	Cebollina
12	Headache	Dolor de cabeza	Chi'ibal pool	<i>Manfreda petkinil</i> R. Orellana, L. Hern. & G. Carnevali	Petzkinil
13	Itchy skin	Comezón	Saak'	<i>Trichilia hirta</i> L.	K'ulinsiis
14	No lactation	No lactación	Mina'an u k'abu yim	<i>Enidoscolus aconitifolius</i> (Mill.) I. M. Johnston	Chaya
15	Parasites	Bichos en el estómago	U yik'el u nak' maak	<i>Dysphania ambrosioides</i> (L.) Mosyakin & Clements	Epazote
16	Snake bite	Mordedura de serpiente	Chi'ibal kaan	<i>Carica papaya</i> L.	Chi'ich' puut
17	Splinter	Espina	K'iix	<i>Tabernaemontana amygdalifolia</i> Jacq.	Utzupek'
18	Stomach fever	Calentura en el estómago	Chokuil nak'	<i>Plantago major</i> L.	Llantén
19	Toothache	Dolor de muela	K'iinan koj	<i>Argemone mexicana</i> L.	Kardo santo
20	Vomit	Vómito	Xej	<i>Artemisia vulgaris</i> L.	Sisin
21	Warts	Verrugas	Ax	<i>Croton humilis</i> L.	Ik'aban

Remedies in the Cultural Consensus Questionnaire Created to Counteract the Sensitivity of the Analysis to the Proportion of Positive Responses

Table 2

Remedy #	Illness in Remedy			Plant in Remedy		
	English Gloss	Spanish Gloss	Maya Name	Scientific Name	Common Name	
22	Acne	Granos	Mejen chuchun	<i>Jatropha gaumeri</i> Greenm.	Polmolche'	
23	Asthma	Asma	K'aak'as se'en	<i>Crescentia cujete</i> L.	Jicara	
24	Canker sores	Fogajies	K'aak'	<i>Mentha × pipertia</i> L.	Hierba buena	
25	Colic	Cólico	Ch'ot nak'	<i>Citrus limonia</i> Osbeck	Limón país	
26	Cough	Tos	Saasa' kaal	<i>Cissampelos pareira</i> L.	Pepektun	
27	Diarrhea	Diarea	Waach' k'aja'al	<i>Schoepfia schreberi</i> J.F. Gmelin	Sak beek	
28	Dysentery	Disentería	K'iik' nak'	<i>Maclura tinctoria</i> (L.) D. Don ex Steud.	Moraz	
29	Ear ache	Dolor de oído	K'iinan xikin	<i>Pluchea carolinensis</i> (Jacq.) G. Don	Chalche'	
30	Evil eye	Mal de ojo	K'aak'as ich	<i>Punica granatum</i> L.	Granada	
31	Eye pain	Dolor de ojo	K'iinan ich	<i>Spondias purpurea</i> L.	Cirucla	
32	Fever	Calentura	Chokuil	<i>Cymbopogon citratus</i> (DC. ex Nees) Stapf.	Zacate de limon	
33	Gas	Aire en el estómago	U' yik'al nak'	<i>Tecoma stans</i> (L.) Juss. ex Kunth	K'an lool	
34	Headache	Dolor de cabeza	Chi'ibal pool	<i>Lippia graveolens</i> Kunth	Orégano país	
35	Itchy skin	Comezón	Saak'	<i>Antigonon leptopus</i> Hook. & Arn.	Flor de Santiago	
36	No lactation	No lactación	Mina'an u k'abu yim	<i>Heliotropium angiospermum</i> Murray	Nema ax	
37	Parasites	Bichos en el estómago	U' yik'el u nak' m'ak	<i>Solanum lycopersicum</i> L.	Tomate	
38	Snake bite	Mordedura de serpiente	Chi'ibal kaan	<i>Ximenia americana</i> L.	Napche'	
39	Splinter	Espina	K'iix	<i>Citrus aurantium</i> L.	Naranja agria	
40	Stomach fever	Calentura en el estómago	Chokuil nak'	<i>Thevetia gaumeri</i> Hemsley	Akitz	
41	Toothache	Dolor de muela	K'iinan koj	<i>Euphorbia gaumeri</i> Millsp.	Weech xiw	
42	Vomit	Vómito	Xej	<i>Abelmoschus moschatus</i> Medik.	Viperol	
43	Warts	Verrugas	Ax	<i>Ocimum campechianum</i> Mill.	Kakaltun	

Table 3

Cultural Consensus Questionnaire

1	Does <i>Momordica charantia</i> L. cure acne? ¿Chiquita cura granos? ¿Chiquita ku tz'akik wa mejen chuchun?
2	Does <i>Gossypium hirsutum</i> L. cure asthma? ¿Tz'intaman cura asma? ¿Tz'intaman ku tz'akik wa k'aak'as se'en?
3	Does <i>Jatropha curcas</i> L. cure canker sores? ¿Siklite' cura fogajes? ¿Siklite' ku tz'akik wa k'áak'?
4	Does <i>Urera baccifera</i> (L.) Gaudich. ex Wedd. Cure colic? ¿Ortiga cura cólico? ¿Laal ku tz'akik wa ch'ot nak'?
5	Does <i>Persea americana</i> Mill. cure cough? ¿Aguacate cura tos? ¿Oon ku tz'akik wa saasa' kaal?
6	Does <i>Callicarpa acuminata</i> Kunth cure diarrhea? ¿PuK in cura diarrea? ¿PuK in ku tz'akik wa waach' k'aja'al?
7	Does <i>Manilkara zapota</i> (L.) van Royen cure diarrhea? ¿Sapote cura diarrea? ¿Ya'a ku tz'akik wa waach' k'aja'al?
8	Does <i>Hylocereus undatus</i> (Haw.) Britton & Rose cure dysentery? ¿Pitajaya cura disentería? ¿Pitajaya ku tz'akik wa k'iik' nak'?
9	Does <i>Origanum vulgare</i> L. cure ear ache? ¿Orégano de castilla cura dolor de oído? ¿Orégano de castilla ku tz'akik wa k'i'inan xikin?
10	Does <i>Ocimum basilicum</i> L. cure eye pain? ¿Albahaca cura dolor de ojo? ¿Albahaca ku tz'akik wa k'i'inan ich?
11	Does <i>Allium schoenoprasum</i> L. cure gas? ¿Cebollina cura aire en el estómago? ¿Cebollina ku tz'akik wa u yik'al nak'?
12	Does <i>Manfreda petskinil</i> R. Orellana, L. Hern. & G. Carnevali cure a headache? ¿Petzkinil cura dolor de cabeza? ¿Petzkinil ku tz'akik wa chi'ibal pool?
13	Does <i>Trichilia hirta</i> L. cure itchy skin? ¿K'ulinsiis cura comezón? ¿K'ulinsiis ku tz'akik wa saak' wiinkila?
14	Does <i>Cnidioscolus aconitifolius</i> (Mill.) I.M. Johnston cure lack of lactation in new mothers?

- ¿Chaya cura cuando se seca la leche de una mamá?
 ¿Chay ku tz'akik wa mina'an u k'abu yiim un tul kooel yanu chambal?
- 15 Does *Dysphania ambrosioides* (L.) Mosyakin & Clemants cure parasites?
 ¿Epazote cura bichos?
 ¿Epazote ku tz'akik wa u yik'el u nak' máak?
- 16 Does *Carica papaya* L. cure snake bite?
 ¿Papaya del monte cura mordedura de serpiente?
 ¿Ch'iich' puut ku tz'akik wa chi'ibal kaan?
- 17 Does *Tabernaemontana amygdalifolia* Jacq. remove a splinter?
 ¿Utzupek' saca una espina?
 ¿Utzupek' ku joosik wa k'i'ix?
- 18 Does *Plantago major* L. cure stomach fever?
 ¿Llantén cura calentura en el estómago?
 ¿Llantén ku tz'akik wa chokuil nak'?
- 19 Does *Argemone mexicana* L. cure toothache?
 ¿Kardo santo cura dolor de muela?
 ¿Kardo santo ku tz'akik wa k'i'inan koj?
- 20 Does *Artemisia vulgaris* L. cure vomit?
 ¿Sisin cura vómito?
 ¿Sisin ku tz'akik wa xej?
- 21 Does *Croton humilis* L. cure warts?
 ¿Ik'aban cura verrugas?
 ¿Ik'aban ku tz'akik wa ax?
- 22 Does *Jatropha gaudieri* Greenm. cure acne?
 ¿Polmolche' cura granos?
 ¿Polmolche' ku tz'akik wa mejen chuchun?
- 23 Does *Crescentia cujete* L. cure asthma?
 ¿Jicara cura asma?
 ¿Luuch ku tz'akik wa k'aak'as se'en?
- 24 Does *Mentha × piperita* L. cure canker sores?
 ¿Hierba buena cura fogajes?
 ¿Hierba buena ku tz'akik wa k'aak'?
- 25 Does *Citrus limonia* Osbeck cure colic?
 ¿Limón país cura cólico?
 ¿Limón país ku tz'akik wa ch'ot nak'?
- 26 Does *Cissampelos pareira* L. cure a cough?
 ¿Pepektun cura tos?
 ¿Pepektun ku tz'akik wa saasa' kaal?
- 27 Does *Schoepfia schreberi* J.F. Gmelin cure diarrhea?
 ¿Sak beek cura diarrea?
 ¿Sak beek ku tz'akik wa waach' k'aja'al?
- 28 Does *Maclura tinctoria* (L.) D. Don ex Steud. cure dysentery?
 ¿Moraz cura disentería?

- ¿Moraz ku tz'akik wa k'iik' nak'?
- 29 Does *Pluchea carolinensis* (Jacq.) G. Don cure ear ache?
¿Chalche' cura dolor de oído?
¿Chalche' ku tz'akik wa k'i'inan xikin?
- 30 Does *Punica granatum* L. cure evil eye?
¿Granada cura mal de ojo?
¿Granada ku tz'akik wa k'ak'as ich?
- 31 Does *Spondias purpurea* L. cure eye pain?
¿Ciruela cura dolor de ojo?
¿Le Abloo ku tz'akik wa k'i'inan ich?
- 32 Does *Cymbopogon citratus* (DC. ex Nees) Stapf. cure fever?
¿Zacate de limón cura calentura?
¿Zacate de limón ku tz'akik wa chokuil?
- 33 Does *Tecoma stans* (L.) Juss. ex Kunth cure gas?
¿K'an lool cura aire en el estómago?
¿K'an lool ku tz'akik wa u yik'al nak'?
- 34 Does *Lippia graveolens* Kunth cure headache?
¿Orégano país cura dolor de cabeza?
¿Orégano país ku tz'akik wa chi'ibal pool?
- 35 Does *Antigonon leptopus* Hook. & Arn. itchy skin?
¿Flor de Santiago cura comezón?
¿Flor de Santiago ku tz'akik wa saak' wiinkila?
- 36 Does *Heliotropium angiospermum* Murray cure lack of lactation in new mothers?
¿Nema'ax cura cuando se seca la leche de una mamá?
¿Nema'ax ku tz'akik wa mina'an u k'abu yiim un tul kooel yanu chambal?
- 37 Does *Solanum lycopersicum* L. cure parasites?
¿Tomate cura bichos?
¿P'ak ku tz'akik wa u yik'el u nak' máak?
- 38 Does *Ximenia americana* L. cure snake bites?
¿Napche' cura mordedura de serpiente?
¿Napche' ku tz'akik wa chi'ibal kaan?
- 39 Does *Citrus aurantium* L. remove a splinter?
¿Naranja agria saca una espina?
¿Pak'al ku joosik wa k'i'ix?
- 40 Does *Thevetia gaumeri* Hemsley cure stomach fever?
¿Akitz cura calentura en el estómago?
¿Akitz ku tz'akik wa chokuil nak'?
- 41 Does *Euphorbia gaumeri* Millsp. cure toothache?
¿Weech xiiw cura dolor de muela?
¿Weech xiiw ku tz'akik wa k'i'inan koj?
- 42 Does *Abelmoschus moschatus* Medik. cure vomit?
¿Viperol cura vómito?
¿Viperol ku tz'akik wa xej?

43 Does *Ocimum campechianum* Mill. cure warts?

¿Kakaltun cura verrugas?

¿Kakaltun ku tz'akik wa ax?

Table 4

Cultural Consensus Model Fit Measures

Factor	Value	Percentage of Variance Explained	Ratio
1	51.56	88.10	14.64
2	3.52	6.00	1.03
3	3.42	5.80	

Table 5

Descriptive Statistics for Individual Measures

	Number of Participants	Mean	Std Dev	Minimum	Max
Competence scores	116	.64	.20	.08	.95
In-degree	116	2.11	3.09	0	19
Out-degree	116	2.11	5.53	0	37
Betweenness	116	6.88	33.45	0	260.50

Table 6

Aggregated Network Measures

Whole Network	
Density	.02
Fragmentation	.29
Reciprocity	.03

Table 7

Correlations Based on Permutation Tests between Individual Relational Measures and Competence Scores

		In-degree	Out-degree	Betweenness
Competence scores	<i>R</i>	.28	−.14	0
	<i>p</i> value	<.01	.15	1.00
In-degree	<i>R</i>		−.09	.05
	<i>p</i> value		.24	.45
Out-degree	<i>R</i>			.54
	<i>p</i> value			<.01

Note: $N = 116$.

Table 8

Multiple Regression Analysis Based on a Permutation Test

Model Summary		r^2 .26			
ANOVA		F 3.34	p .04		
Coefficients	Unstandardized B	Standardized B	Proportion as Large	Proportion as Small	Proportion as Extreme
Constant	.36	.00	1.00	.00	1.00
In-degree	.01	.09	.22	.78	.46
Betweenness	.00	-.05	.69	.32	.66
Age	.01	.48	.00	1.00	.01
Distance traveled	.00	-.16	.91	.09	.16
Lifestyle score	.01	.04	.39	.61	.76
Economic prosperity score	-.02	-.12	.89	.11	.26
Female	.05	.13	.12	.88	.24
Literacy	.04	.09	.26	.74	.50
Catholic	.01	.03	.42	.58	.86
Protestant	-.01	-.03	.58	.42	.83
Herbal remedy preference	.02	.05	.36	.64	.73

Note: $N = 116$.