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Short communication

The role of kinship in knowledge about medicinal plants: evidence for context-dependent model-based biases in cultural transmission?

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ABSTRACT

The similarity in traditional knowledge of medicinal plants was evaluated to draw inferences about the most important models for local knowledge transmission. The following questions were addressed: (1) Do related individuals possess greater similarity in knowledge of medicinal plants than unrelated individuals? (2) Do related individuals of the same generation possess greater similarity in knowledge than do related individuals of different generations? Semi-structured interviews were conducted on the medicinal plants known by the residents of a rural community in western Bahia. Mann-Whitney tests were used to compare Jaccard similarity values between related and unrelated individuals and between relatives of the same generation and relatives of different generations. Related individuals were found to have more similar knowledge than unrelated individuals, and relatives of the same generation were found to have more similar knowledge than relatives of different generations. These findings suggest that there are factors that favor cultural transmission between relatives of the same generation other than just vertical transmission.

Keywords: cultural evolution, cultural transmission, ethnobotany, evolutionary ethnobiology, human ecology

Studies involving the distribution of knowledge on medicinal resources have noted that local medical systems are heterogeneous and that the knowledge is distributed under the main influence of socioeconomic factors such as age, gender and occupation (Hanazaki *et al*. 2000; Quinlan & Quinlan 2007; Silva *et al*. 2011). In general, people tend to know more plants with increasing age (Parveen *et al*. 2007; Silva *et al*. 2011), with exceptions for older ages (See Reyes-García *et al*. 2005). In many communities, remarkably in Brazil, women tend to know a greater amount of medicinal plants than men, especially in the field of exotic and cultivated plants (Torres-Avilez *et al*. 2016). People involved in occupations that promote greater contact with plant resources, such as agriculture, also show to have greater knowledge (Silva *et al*. 2011). However, there are few studies that focus on how the people of the medical system are similar in relation to the repertoire of known plants and which factors lead to greater similarity in groups

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of individuals within the context of intracultural variation (see Araújo *et al*. 2012), which is essential to understand the evolution and structure of these systems.

Investigations on intracultural variation from an analysis of similarity among individuals can access the generating and/or maintaining factors of this variation. There are evidences that people do not copy information randomly, but tend to select certain people as *models* to copy cultural information (Wood *et al*. 2012). This type of strategy is known as *context-dependent model biases* and has been observed in humans and other animals (Mesoudi *et al*. 2013). From these transmission biases based on *models*, people of a group can copy information from certain *models*: such as learning from relatives (kin-based model), from older people (age-based model), from people with higher prestige in the group (prestige-based model) and from persons of a particular gender (gender-based model) (see Rendell *et al*. 2011).

Using the classical models of knowledge transmission proposed by Cavalli-Sforza & Feldman (1981), involving the vertical, horizontal and oblique transmission, based on the learning strategies based on models, we have the following cases: in a community in which knowledge is transmitted mainly by the vertical route (between distinct and related generations), then we can infer that the kin-based model is an important learning bias; if knowledge is transmitted mainly via the oblique route (between distinct and unrelated generations), then the age-based model can be important because younger individuals may be modeling from older generations of unrelated individuals to learn. Finally, if the horizontal route (among individuals of the same generation) is more important in the transmission of knowledge, then the peer-based model may be the predominant learning bias.

The social learning studies show the importance of parental models (kin-based model) in the processes of cultural transmission (see Henrich & Henrich 2010; Salpeteur *et al*. 2015; Kendal *et al*. 2018; Santoro *et al*. 2018). Furthermore, ethnobotanical studies have indicated that the vertical route of transmission of knowledge stands out concerning medicinal plants (Eyssartier *et al*. 2008; Reyes-Garcia *et al*. 2009). However, it is important to consider that parental models may belong to different generations or to the same generation of learners, and we do not know what it can reveal about the phenomenon of information transmission within parental models. To investigate this phenomenon within parental models is a novelty within ethnobiological studies trying to understand the phenomenon of transmission and distribution of knowledge in human groups.

In this scenario, we investigated the variations in the similarities of local ecological knowledge about medicinal plants in a rural community in northeastern Brazil in order to infer on the learning strategies that can direct the transmission of knowledge. For this, we sought to answer the following research questions: (1) Do related individuals present greater similarity of knowledge of medicinal plants than unrelated individuals? (2) Do related individuals of the same generation present greater similarity of knowledge than do related individuals of different generations?

The studies that investigated the routes of the transmission of knowledge are based on self-reported information and that can be influenced by kinship bias, since people tend to indicate the parents as sources of knowledge (see Aunger 2000). Our research proposes a correlational analysis, extremely practical from a methodological point of view, from an analysis of similarity of knowledge on plants among individuals. There are few studies that have conducted an empirical verification of the importance of biases based on models as social learning strategies (see Laland 2004), although recently these researches have been growing (Rendell *et al*. 2011). Even rarer are the works that use this approach in the context of traditional ecological knowledge (see Reyes-García *et al*. 2009; Henrich & Broesch 2011; Salpeteur *et al*. 2015; Soldati *et al.* 2015; Santoro *et al*. 2018). Therefore, the innovative nature of our study relies on the use of similarity in knowledge as a way of inferring on knowledge transmission routes.

The study was conducted in the rural community of Sucruiuzinho that is distant 20 km from the city of Barreiras and is located in the West of Bahia State, northeastern Brazil. The Western Bahia consists of 23 municipalities representing 25 % of the territory of Bahia and corresponds to 80 % of the production of grains in the state (AIBA 2008). The municipality of Barreiras, with the city hall located in the geographic coordinates 12°08'00"S 44°59'00"W, lies 905 km from the state´s capital city, Salvador, and is in an area of 7.859.225 km^2 and altitude of 452 m, with an estimated population of 150.896 inhabitants, of which 13.686 inhabitants are from rural areas (IBGE 2014).

The community was selected as a model to answer the questions developed in this study because it corresponds to a place in which the medical system is still heavily dependent on plants, also presenting ease of access and openness to research. The Sucruiuzinho community consists of 20 houses and 37 residents, including 21 males and 16 females. People with permanent residence in the community and over 10 years old were used as criteria of inclusion for participation in the study. We chose to include people over 10 years old because we observed in the community that children younger than that could have difficulties answering some of the questions of the interview. Therefore, it was an arbitrary choice. We recruited 24 people of both genders, aged over 14 years, given that the range between 10 and 13 years is not represented in the community. Not all residents participated in the survey, either by choice (two people), or not be old enough to participate (six) or were not found repeatedly in their homes (five). Thus, 77.4 % of residents above 10 years participated in the survey. A total of 15 were male while nine were female interviewees. Only two of them were younger than 20 years, while four were between 21 and 40 years old, eight were between 41 and 60 years old and 10 were older than 60 years.

The community lacks health services. The nearest medical center is located in the urban area of the city of Barreiras, requiring the residents to move there for occurrences that are more serious. Every three months the residents receive medical visits, additionally to monthly visits by a health agent who resides in the community. The community has no school services; however, there are municipal transport for the movement of children to carry out their studies.

Residents are engaged mainly in family farming, in which the social division of labor is expressive, with women responsible for household tasks and men for agriculture. The activities performed in the community are animal raising and agriculture, both for subsistence and with poor economic returns, and labor provision for private properties. Animals raised in the community are cattle, pigs and poultry, mainly for local consumption. Residents also grow corn (*Zea mays* L.), beans (*Phaseolus vulgaris* L.), cassava (*Manihot esculenta* Crantz), mango (*Mangifera indica* L.) and orange (*Citrus sinensis* L.), acquiring financial return with the surplus production sold on the open market in Barreiras.

Initially, each participant was asked to sign an informed consent form, which showed the objectives, the research methods and all other explanations about it. The study was approved by the ethics committee on human research of the Faculdade São Francisco de Barreiras (FASB) through the Plataforma Brasil (CAAE: 07488513.4.0000.5026). During the following contacts, in the period from January to May 2014, the free list technique was applied (Albuquerque *et al*. 2014) with participants with the following question: What medicinal plants do you know?. This information was important to obtain the repertoire of known medicinal plants for each participant, which served as basis for the data analysis. We also collected socioeconomic information from each interview.

Additionally, we have built a family tree, placing all community residents, in order to identify the relationships of kinship. The tree started from a consultation with one of the older members of the community and was supplemented with information from other residents.

The technique of guided tour (Albuquerque *et al*. 2014) was performed, in which the cited plants were collected through field trips in close areas with some participants. The collected plants were identified, herborized and deposited in the Herbarium of the Federal University of Western Bahia. Species' identifications were performed by consulting specialists and specialized bibliography.

The same database used for this study was used for a previous investigation aiming to discuss different indicators to interpret the local knowledge loss on medicinal plants (Brito *et al*. 2017). The whole species list can be found in the appendix of the above cited publication.

We considered the scientific names of plants in detriment of vernaculars in the data analysis. We opted for this procedure because it is common for people to assign the same name to different plants, or even different names for the same plant, which may cause noise in the assessment of the similarity in knowledge. Thus, plants not identified to the genus level were excluded from the analysis. We believe, however, that this exclusion has not influenced our findings, since only 8.5 % of species could not be identified to the genus level.

In order to verify whether related individuals have greater similarity of knowledge than unrelated individuals, a binary matrix was created, with the participants as objects and plants as descriptors. Then we calculated a Jaccard similarity matrix among participants (Peroni *et al*. 2014). From this matrix, the obtained similarity values were arranged in two columns: similarity values for related individuals (39 values considering pairs of related individuals) and values for unrelated individuals (237 values considering pairs of unrelated individuals). We applied the Mann-Whitney test to compare the average similarity of knowledge among relatives and non-relatives. We considered the following relationships as being relatives: father, mother, children, siblings, first cousins, uncle and aunts, nephews and nieces, spouse, father and mother in law, and son and daughter in law.

In order to test whether related individuals of the same generation present greater similarity of knowledge than related individuals of different generations, we used the same similarity values obtained from the binary matrix. We organized the similarity values in two columns: values of similarity among related individuals of the same generation (13 values considering pairs of individuals) and another column with values among related individuals of different generations (36 values). In this analysis, we considered individuals of the same generation those who presented a difference of less than 20 years of age between them. We used 20 years of difference because women in this community have children when they are around 20 years old. This information was obtained through informal conversations. Therefore, we considered generation as a gradient and not as static groups to be compared. In addition, we applied the Mann-Whitney test to compare the average similarities between these two data sets.

Our approach has limitations, since we infer about the routes of transmission of knowledge from the similarity in knowledge among individuals. Thus, we do not access the current routes of transmission of knowledge in the community (see Henrich & Broesch 2011). We infer about the routes from which knowledge among individuals were similar. We assume, then, that a greater similarity in knowledge between two individuals may indicate a higher transmission of knowledge among these individuals than between two individuals with low similarity (see Cavalli-Sforza *et al*. 1982 as an example of a similar approach). Nevertheless, we recognize that similarities in knowledge among people can occur due to the greater similarity of experiences lived by them, without necessarily the occurrence of transmission between these people.

A total of 162 medicinal plants were cited by the interviewees. The vast majority (149) were identified to the genus or species level. The most numerous families were Fabaceae (nineteen species), Lamiaceae (nine species), Asteraceae (nine species) and Annonaceae (seven species).

The average similarity is low among the participants ($\bar{X}$ = 0.14 ± 0.07), demonstrating a high heterogeneity of knowledge and/or that people's memories privileged different species. This scenario becomes even clearer when we consider that 52 % of the diversity of medicinal plants cited in the community and identified to species level (132), are known to only one or two people. Related individuals presented higher average similarity than unrelated individuals (Z(U) = 4.11; $p<0.0001$), showing that related individuals are more similar in terms of knowledge of medicinal plants (Tab. 1).

Table 1. Main results of descriptive and inferential statistics based on the similarity values in the knowledge of medicinal plants among residents of Sucruiuzinho community, State of Bahia, northeastern Brazil. X = average, SD= standard deviation.

	Values (X ± SD)
Average similarity among all individuals	0.14 ± 0.07
Average similarity among related individuals	0.18± 0.06
Average similarity among unrelated individuals	0.13± 0.07
Mann-Whitney (related x unrelated)	Z(U)=4.11; p<0.0001
Average similarity among relatives of different generations	0.16± 0.07
Average similarity among relatives of the same generation	0.21± 0.06
Mann-Whitney (relatives of different generations x relatives of the same generation)	Z(U) =2.42; p<0.05

Regarding our second question, we noted that individuals related of the same generation presented on average, higher values of similarity than related individuals belonging to different generations (Z(U) = 2.42; $p<0.05$), which confirms our hypothesis.

One of our findings was the high heterogeneity in the knowledge of medicinal plants. This finding is not different from the observed by several studies, which show that in medical systems knowledge is hardly shared among people, that is, most of the known plants is mentioned by one or a few persons (Barrett 1995; Hopkins & Stepp 2012; Santoro *et al*. 2015), and a smaller group of species present shared and widespread knowledge. This high heterogeneity can be generated by some factors that we list below. These factors should not be thought of as mutually exclusive, they might act together:

The first factor is the vertical transmission of knowledge. If this route is important, as suggested here, there may be a greater heterogeneity of knowledge in a human group because the information is transmitted within households, with no diffusion of information among groups. This type of transmission of knowledge is highly conservative, which hinders the diffusion of innovations to the other members of a group (Cavalli-Sforza & Feldman 1981; Boyd & Richerson 1995; Hewlett *et al*. 2011; Kendal *et al*. 2018).

Second, one of our findings suggests that related people of the same generation may exchange more information about medicinal plants among themselves. According to the models of cultural transmission, a higher transmission of information among peers may lead the system to a greater homogenization and may allow more easily the transmission of maladaptive characters (Cavalli-Sforza & Feldman 1981; Hewlett *et al*. 2011). However, we observed a high overall heterogeneity among community informants, although more related people have knowledge that is more similar. This can be related either because the information remains in families and are not widespread in the community, or can also be related to individuals who copy differentiated information from each other. For example, even if two people have learned a lot from the same local knowledgeable individual, or a relative of the same generation, they may have acquired different elements of knowledge from this individual. This may be linked to the need of individuals (they appealed to the knowledgeable individual to treat different diseases) and the different times of observation of the daily life of the knowledgeable individual. This means that even in a community where there is a large flow of information, it is possible to achieve a high heterogeneity in knowledge among individuals. Thus, using the same sources in terms of knowledge acquisition does not guarantee similarity (Fig. 1).

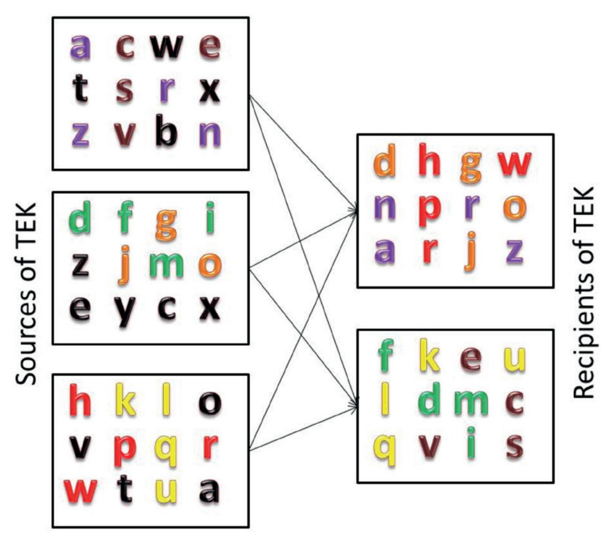

Figure 1. Representation of a situation in which access to the same sources of traditional ecological knowledge does not lead to the similarity among recipients. The letters represent different medicinal plants. Even accessing the same sources, there is no similarity among recipients, showing a bias of context-dependent transmission.

The third factor is our limited capacity to store in memory information about the environment leads to the selection of a small set of information that have adaptive value to store in memory (Nairne *et al*. 2007; 2008). This may explain, in a certain way, the reason we find a large number of medicinal species that is known to few people (low similarity). Here we can use the same argument raised earlier: each individual goes through different experiences in relation to diseases, and thus store in memory the information of greater adaptive value in face of that lived experience. This means that along with the above explanations, a high heterogeneity could be expected, since our species can not store in memory a large amount of information present in the medical system.

Finally, we should not reject that methodological artifacts amplify the heterogeneity found in this and other studies, since at the time of interview people do not remember all the plants they know. In this sense, others can remember the plants omitted for some in the interviews and vice versa, which would overvalue the differences among people.

Even with a high overall heterogeneity in knowledge, we can find groups of individuals that are more similar than others in the knowledge of plants. In this case, the data support the hypothesis that related individuals are more similar than unrelated individuals in the knowledge of medicinal plants. The fact that our hypothesis was corroborated may reveal an important component in the structure of local medical systems, the learning by parental models (kin-based model), supporting the findings of other researchers (Eyssartier *et al*. 2008; Reyes-García *et al*. 2009). This parental bias of learning can be associated with a behavior observed in children who tend to copy more information from relatives during childhood (Hewlett *et al*. 2011), and that may extend into adulthood (see Laland 2004; Henrich & Broesch 2011).

We suggest that the process of learning about medicinal plants may be favored among related individuals of the same generation. Observe in what situations this route of transmission is favored may be important to target future research. In this case, we can hypothesize several possible conditions that may lead to favor the learning strategy of relatives of the same generation, for example, from differences in disease incidence among the different generations (see Chung *et al*. 2009; Silva *et al*. 2011). In this case, certain diseases may present a higher frequency of occurrence among young people and they can learn about plants from each other, increasing the copy events among young individuals. In turn, other diseases may have high frequency in older generations and that can increase the copy events among individuals of those generations. This may suggest that an increase in the transfer of information among related individuals of the same generation may be associated with needs and experiences shared among individuals of the same generation and the same family. It has a highly adaptive value, in the sense that mainly the medical system information that is put into practice is stored in memory.

Since our findings about the greater similarity among relatives of the same generation supported the observed in the literature, we also suggest that the role of learning among individuals of the same generation should be investigated in future research, in other real situations, following the recent trend of studies on social learning (see Rendell *et al*. 2011), to verify the role of kin-based model learning bias in other contexts. Finally, future studies could benefit from mixing approaches for the identification of the most important routes of knowledge transmission. Therefore, self-reported information could be compared to the similarities of knowledge (as proposed in our study) in order to provide a more precise picture of the reality.

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References

AIBA- Associação de Agricultores e Irrigantes da Bahia. 2008. Anuário da Região Oeste da Bahia/ Safra 2013/2014. Santa Cruz do Sul, Gazeta Santa Cruz.

Albuquerque UP, Ramos MA, Lucena RFP, Alencar NL. 2014. Methods and techniques used to collect ethnobiological data. In: Albuquerque UP, Cunha LVF, Lucena RFP, Alves RRN. (eds.) Methods and techniques in ethnobiology and ethnoecology. Springer, New York. p: 15-37.

Araújo TAS, Almeida ALS, Melo JG, *et al*. 2012. A new technique for testing distribution of knowledge and to estimate sampling sufficiency in ethnobiology studies. Journal of Ethnobiology and Ethnomedicine 8: 11. doi: 10.1186/1746-4269-8-11

Aunger R. 2000. The life history of culture learning in a face-to-face society. Ethos 28: 445-481.

Barrett B. 1995. Herbal knowledge in Nicaragua's Atlantic Coast: consensus within diversity. Journal of Community Health 20: 403-421.

Boyd R, Richerson PJ. 1995. Why does culture increase human adaptability. Ethnology and Sociobiology 16: 125-143.

Brito CC, Silva TC, Albuquerque UP, *et al*. 2017. The use of different indicators for interpreting the local knowledge loss on medical plants. Revista Brasileira de Farmacognosia-Brazilian Journal of Pharmacognosy 27: 245-250.

Cavalli-Sforza LL, Feldman MW 1981. Cultural transmission and evolution: A quantitative approach. Princeton, Princeton University Press.

Cavalli-Sforza LL, Feldman MW, Chen KH, Dornbusch SM. 1982. Theory and observation in cultural transmission. Science 218: 19-27.

Chung HY, Cesari M, Anton S, *et al*. 2009. Molecular inflammation: Underpinnings of aging and age-related diseases. Ageing Research Reviews 8: 18-30.

Eyssartier C, Ladio AH, Lozada M. 2008. Cultural transmission of traditional Knowledge in two population of North- Western Patagonia. Journal of Ethnobiology and Ethnomedicine 4: 25. doi: 10.1186/1746-4269-4-25

Hanazaki N, Tamashiro JY, Leitão-Filho HF, Begossi A. 2000. Diversity of plant uses in two *Caiçara* communities from the Atlantic Forest coast, Brazil. Biodiversity and Conservation 9: 597-615.

Henrich J, Broesch J. 2011. On the nature of cultural transmission networks: evidence from Fijian villages for adaptive learning biases. Philosophical Transactions of the Royal Society B: Biological Sciences 366: 1139-1148.

Henrich J, Henrich N. 2010. The evolution of cultural adaptations: Fijian food taboos protect against dangerous marine toxins. Proceedings of the Royal Society B: Biological Sciences 277: 3715-3724.

Hewlett BS, Fouts HN, Boyette AH, Hewlett BL. 2011. Social learning among Congo Basin hunter-gatherers. Philosophical Transactions of the Royal Society B: Biological Sciences 366: 1168-1178.

Hopkins AL, Stepp JR. 2012. Distribution of herbal remedy knowledge in Tabi, Yucatan, Mexico. Economic Botany 66: 249-254.

IBGE – Instituto Brasileiro de Geografia e Estatística. 2014. Estatística. http: //www.ibge.gov.br. 20 Aug. 2018

Kendal RL, Boogert NJ, Rendell L, Laland KN, Webster M, Jones PL. 2018. Social learning strategies: Bridge-building between fields. Trends in Cognitive Sciences 22: 651-665.

Laland KN. 2004. Social learning strategies. Learning & Behavior 32: 4-14.

Mesoudi A, Laland KN, Boyd R, *et al*. 2013. The cultural evolution of technology and science. In: Richerson PJ, Christiansen MH. (eds.) Cultural evolution: Society, technology, language, and religion. Cambridge, MIT Press.

Nairne JS, Pandeirada JNS, Thompson SR. 2008. Adaptive memory: The comparative value of survival processing. Psychological Science 19: 176-180.

Nairne JS, Thompson SR, Pandeirada JNS. 2007. Adaptive memory: Survival processing enhances retention. Journal of Experimental Psychology: Learning, Memory, and Cognition 33: 263-273.

Parveen BU, Roy S, Kumar A. 2007. Traditional uses of medicinal plants among the rural communities of Churu district in the Thar Desert, India. Journal of Ethnopharmacology 113: 387-399.

Peroni N, Araújo HFP, Hanazaki N. 2014. Ecological methods in ethnobotanical and ethnobiological research: Using diversity measurements and richness estimators. In: Albuquerque UP, Cunha LVFC, Lucena RFP, Alves RRN. (eds.) Methods and techniques in ethnobiology and ethnoecology. Springer, New York. p: 397-412.

Quinlan MB, Quinlan JR. 2007. Modernization and medicinal plant knowledge in a Caribbean horticultural village. Medical Anthropology Quarterly 21: 169-192.

Rendell L, Fogarty L, Hoppitt WJE, Morgan TJH, Webster MM, Laland KN. 2011. Cognitive culture: theoretical and empirical insights into social learning strategies. Trends in Cognitive Sciences 15: 68-76.

Reyes-García F, Vadez V, Byron E, *et al*. 2005. Market economy and the loss of folk knowledge of plant uses: estimates from the Tsimane' of the Bolinvian Amazon. Current Anthropology 46: 651-656.

Reyes-García V, Molina JL, Broesch J, *et al*. 2009. Cultural transmission of ethnobotanical knowledge and skills: an empirical analysis from an Amerindian society. Evolution and Human Behavior 30: 1-12.

Salpeteur M, Patel H, Balbo AL, *et al*. 2015. When knowledge follows blood. Kin groups and the distribution of traditional ecological knowledge in a community of seminomadic pastoralists, Gujarat (India). Current Anthropology 56: 471-483.

Santoro FR, Ferreira Júnior WS, Araújo TAS, Ladio AH, Albuquerque UP. 2015. Does plant species richness guarantee the resilience of local medical systems? A perspective from utilitarian redundancy. PLOS ONE 10: e0119826. doi: 10.1371/journal.pone.0119826

Santoro FM, Nascimento ALB, Soldati GT, Ferreira Júnior WS, Albuquerque UP. 2018. Evolutionary ethnobiology and cultural evolution: opportunities for research and dialog. Journal of Ethnobiology and Ethnomedicine 14: 1. doi: 10.1186/s13002-017-0199-y

Silva FS, Ramos MA, Hanazaki N, Albuquerque UP. 2011. Dynamics of traditional knowledge of medicinal plants in a rural community in the Brazilian semi-arid region. Revista Brasileira de Farmacognosia 21: 382-391.

Soldati GT, Hanazaki N, Crivos M, Albuquerque UP. 2015. Does environmental instability favor the production and horizontal transmission of knowledge regarding medicinal plants? A study in southeast Brazil. PLOS ONE 10(5): e0126389. doi: 10.1371/journal.pone.0126389

Torres-Avilez W, Medeiros PM, Albuquerque UP. 2016. Effect of gender on the knowledge of medicinal plants: Systematic review and meta-analysis. Evidence-Based Complementary and Alternative Medicine 2016: 6592363. doi: 10.1155/2016/6592363

Wood LA, Kendal RL, Flynn EG. 2012. Context-dependent model-based biases in cultural transmission: children's imitation is affected by model age over model knowledge state. Evolution and Human Behavior 33: 387-394.