Revista Brasileira de Farmacognosia 27 (2017) 245–250

Brazilian Journal of Pharmacognosy
REVISTA BRASILEIRA DE FARMACOGNOSIA
www.elsevier.com/locate/bjp

Original Article

The use of different indicators for interpreting the local knowledge loss on medical plants

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ARTICLE INFO

Article history:
Received 2 May 2016
Accepted 11 September 2016
Available online 24 November 2016

Keywords:
Local knowledge
Erosion
Traditional botanical knowledge
Ethnobotany

ABSTRACT

The increasing loss of local ecological knowledge may have negative impacts on the resilience of socio-ecological systems and may also negatively impact bioprospecting efforts, since local ecological knowledge is an important source of information for searching new drugs. Recent studies try to evaluate whether communities are experiencing loss of local ecological knowledge. However, some of them make conclusions which are erroneously based on specific analyses of a single indicator. We propose an integrative analysis of three indicators, namely: number of plants cited by young people and elders, therapeutic choices and people's connectance in terms of medicinal plant learning. The study was carried out in the community of Sucruiuzinho (Bahia, Brazil). We conducted semistructured interviews and a therapeutic recall with 24 local dwellers. We did not find evidence of local ecological knowledge loss in the studied community. Although younger people know fewer plants, they are well connected in terms of knowledge transmission. Moreover, in illness events, young people and adults have similar proportions of choice for plants when compared to allopathy. Concomitant use of the three indicators leads to a more realistic scenario of local ecological knowledge loss than the use of only one of them.

Introduction

It has been argued that local populations around the world are losing their local ecological knowledge (LEK), and this phenomenon primarily affects young people's generations (Benz et al., 2000; Voeks and Leony, 2004; Reyes-García et al., 2013). Several factors appear to account for this change, such as: decrease in biological and cultural diversity (Malthez-Stifel et al., 2012; Sujarwo et al., 2014), modernization (Quilan and Quilan, 2007), urbanization (Teklehaymanot et al., 2007), economic development (Reyes-García et al., 2005) and language barriers (Benz et al., 2000; Zent, 2001). However, the vast majority of works usually evaluates indirectly the processes of knowledge loss, regardless of the current standards of intracultural variability (Zent, 2001).

Several authors suggest that young people's generations are undergoing a process of knowledge loss, from a conclusion based on a single indicator: the number of plant species known by the young people compared to the number of species known by older people. However, an alternative interpretation of this finding is that young people know less plants because they are still in the learning process (Voeks and Leony, 2004; Albuquerque, 2006; Silva et al., 2011; Malthez-Stifel et al., 2012). Thus, an analysis guided only in the amount of known plant species does not allow robust inferences about the process of the knowledge loss.

Another indicator that has been employed to analyze the loss of LEK on medicinal plants is related to therapeutic choices centered on the dichotomy allopathic medicines × medicinal plants. Researchers suggest that access to modern medicines can lead to disinterest of people in learning about medicinal plants of their

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http://dx.doi.org/10.1016/j.bjp.2016.09.006

culture (Quilan and Quilan, 2007; Sujarwo et al., 2014). However, the prevalence of allopathy alone is not necessarily related to loss of LEK. Some medical systems, for example, are plural in terms of healthcare, so that traditional medical systems and Western medicine (biomedicine) coexist (Vandebroek et al., 2004; Soldati and Albuquerque, 2012).

Considering the scenario presented above, that reinforce that a simplistic assessment of the loss of local ecological knowledge can bring inadequate conclusions about a complex phenomenon, this study integrates a set of three indicators to assess the loss of LEK on medicinal plants: number of plants mentioned among young people and elders; therapeutic choices (allopathic or medicinal plants) and young people's connectance in terms of medicinal plant learning. Our third indicator (connectance) is important because it shows how individuals are exchanging medicinal plant knowledge. In this sense, the best of our knowledge, the use of this tool has not been popular among studies about loss of LEK, and has not been used together with the other indicators mentioned above. Connectance calculations are common, for example, in ecological studies about food web patterns (Kondoh, 2013). They are also present in studies that use the concept of social networks (Haselmair et al., 2014). Although the idea of social networks is being increasingly used in ethnobiological research, it is not our aim to deepen theoretical aspects on the subject, but, instead, to use a tool that is also employed in such studies. Such tool will reveal if people are exchanging knowledge or if there are barriers compromising such transmission.

This research proposal aims to fill theoretical and methodological gaps with regard to the proposal of three indicators that can be decisive for the detection of loss of LEK (number of known species, therapeutic choices and connectance in terms of medicinal plant learning). Therefore, it can be useful in future researches aimed at documenting this phenomenon more accurately.

Making an accurate evaluation of LEK loss is important since such knowledge commonly increases the resilience of socio-ecological systems (Ferreira Júnior et al., 2015). Furthermore, the increasing loss of local ecological knowledge may have negative impacts on bioprospecting efforts, since LEK is an important source of information for searching new drugs (Heinrich, 2008).

Materials and methods

Study area

We tested our proposal in the community of Sucruiuzinho, placed in the municipality of Barreiras, state of Bahia, Northeastern Brazil (Fig. 1). It is located 20 km from the center of Barreiras. Barreiras is 905 km far from Bahia's capital, Salvador (IBGE, 2010). The municipality has an extension of 7859.225 km^2 and altitude of 452 m, with an estimated population of 150,896 inhabitants, 13,686 of them in rural areas (IBGE, 2010). The city is characterized by its average annual temperature of 24.3 °C with average annual rainfalls varying from 1100 mm to 1200 mm (SEI, 2007).

Sucruiuzinho has twenty households and 37 residents (21 male and 16 female). The community is placed in a rural area and has no health centers, schools or basic sanitation. The nearest health center is located in the center of Barreiras. However, the community residents receive visits from a doctor each three months as well as monthly visits of the local health agents.

Data collection

The initial contact with community members was performed with the assistance of a member of the neighboring community (Sucruiu), which participated in previous studies developed by our team. We explained the study aims to the community members and those who accepted to participate were invited to sign the Free and Informed Consent Term, where the goals and methods of the research were exposed as well as the possibility of returning in the house of those who were interested in contributing to the research. This research proposal was submitted and accepted by the ethics committee in research with human beings through the Plataforma Brasil (CAAE 07488513.4.0000.5026).

During the following visits, we conducted 24 semi-structured interviews (Albuquerque et al., 2014). Our study design included people with permanent residence in the community and over 10 years. Therefore, 24 people from 14 to 83 years-old participated, considering that the interval between 10 and 13 years was not represented in the community. Not all residents participated in the survey, as two people refused; six were not old enough to participate, and five were not found even after several attempts. We chose a small community, since it facilitates connectance analysis of medicinal plant learning which will be described below. Therefore, we interviewed a total of 63% of the residents (77% of those old enough to participate) in order to identify which medicinal plants are known (indicator 1), besides collecting socioeconomic data. After this step, the therapeutic recall was performed. We named "therapeutic recall" the adjustment of the recall 24 h commonly used in ethnobiological studies (Albuquerque et al., 2014). This technique aimed at analyzing: (a) The self-reported illness events suffered by the interviewee in the last year; (b) and for each illness event, if the respondent made use of allopathy or medicinal plants. This methodological step generated data that has been analyzed as the indicator 2 of knowledge loss between generations, as it was related to therapeutic choices.

Afterwards, in order to analyze how connected are the youngers to the community in terms of medicinal plant learning (indicator 3), a list with the names of all people in the community was presented to the respondents. They were invited to indicate the individuals in the list from whom they have learnt about medicinal plants, as well as those individuals to whom they have actively taught. This methodological procedure carries a risk of bias, since the teaching and learning events were all based on the informant's memory. Thus, we tried to reduce this methodological bias as follows: when the respondent x claimed to have learned about plants from a respondent y and respondent y did not mention to have transmitted knowledge to the respondent x, the information about the transmission of knowledge from x to y was considered, thus increasing the reliability of the information.

Data analysis

To analyze the first indicator of knowledge loss between generations, we used a simple linear regression to assess the relationship between age and number of known plants. These data were subjected to a square root transformation to fit in a normal distribution. Then we performed a similar analysis considering the knowledge on plants of people up to 50 years old (12 people in total), since we observed a posteriori a stability in plant knowledge of people from that age group.

The citations for different therapeutic choices (allopathic, plants and both) when informants faced health problems, our second indicator, were compared between age classes through Fisher Extract. Three age groups were considered: class a (between 14 and 36 years) (six people), class b (between 37 and 59 years) (eight people) and class c (between 60 and 83 years) (ten people). More age classes were not adopted in this study because of the limited number of people in the community, what would lead to classes with small values and a possible statistical bias. We interpret that a higher proportion of citations for allopathic among younger people could be related to knowledge loss. The limits of age classes within the

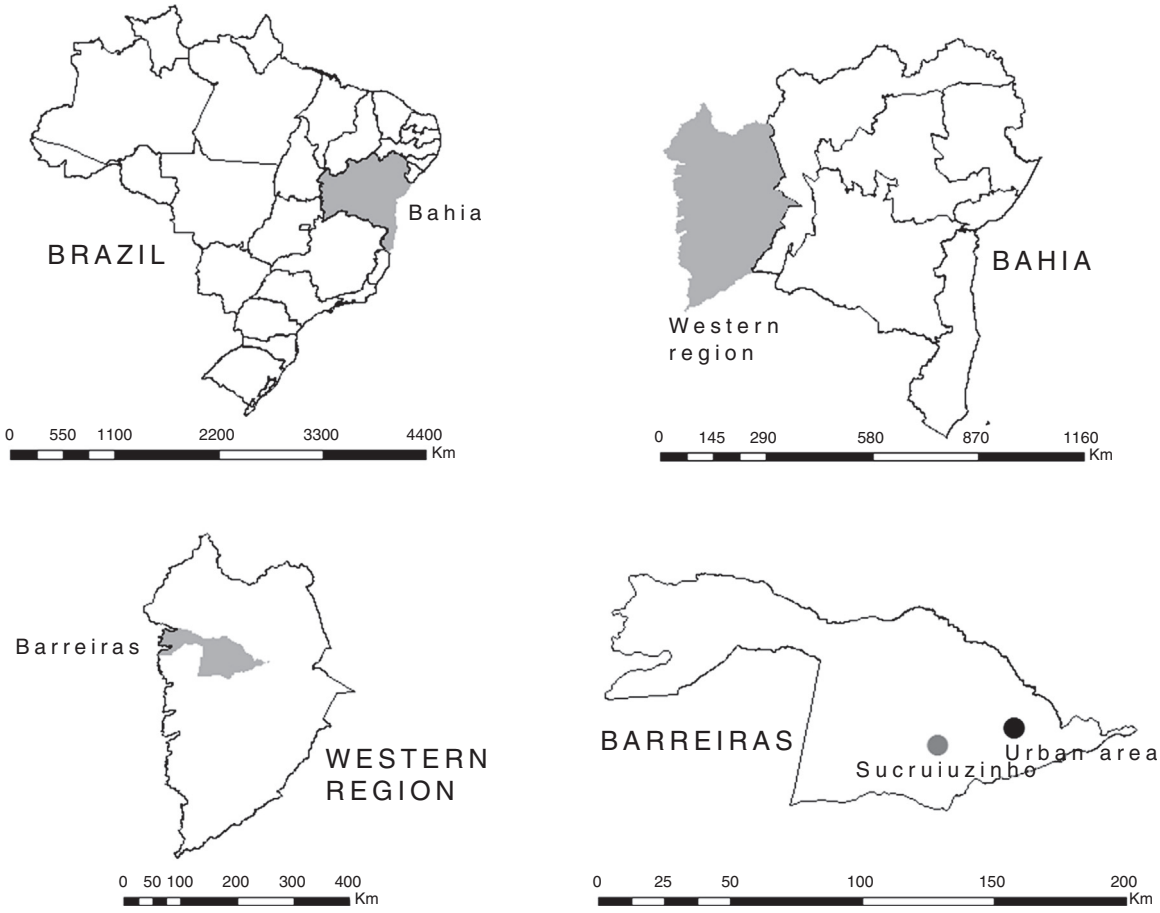

Fig. 1. Location of the community of Sucruiuzinho, municipality of Brreiras, State of Bahia, northeastern Brazil.

age groups were based on the extent of the age of the youngest to the oldest divided into the three classes.

The third indicator was measured by calculating the connectance for each person in terms of medicinal plant learning (number of people in the community from whom the respondent learnt about medicinal plants/total number of respondents − 1) so that larger connectance indicate that the person acquires knowledge with a larger number of people. Thus, connectance values can range from 0 (the respondent did not learn from anyone) to 1 (the respondent learned from all others in the community). This index can show if the younger are still learning about medicinal plants in the community, although it does not provide information on the intensity and nature of such learning. In addition, it considers only current and internal relations of knowledge transmission, disregarding other people's information (*e.g.* people from neighboring communities or former community members).

After the calculation we performed a simple linear regression to test whether age influences connectance. If the regression results are not significant, it will indicate that the youngest are not less connected than the elders in terms of medicinal plant learning.

Results

General findings

The community cited a total of 162 medicinal plants (Appendix). 149 were identified to the genus or species level and thirteen could not be identified. The most important families in terms of number of species were Fabaceae (nineteen species), Lamiaceae (nine species), Asteraceae (nine species) and Annonaceae (seven species).

Indicator 1: age × number of known plants

There was no overall relationship between age and number of known plants ($R^2 = 0.11$; $p > 0.05$). However, as can be seen in Fig. 2, when the regression analysis considered only people up to 50 years (Fig. 3), we found a strong and significant relationship between age and number of plants ($R^2 = 0.50$; $p < 0.01$).

Indicator 2: age × therapeutic choices

Therapeutic plurality is similarly common in all age classes. Thus, there were no differences in the proportions of citation for 'plants', 'allopathic' or 'both strategies' when facing an illness event

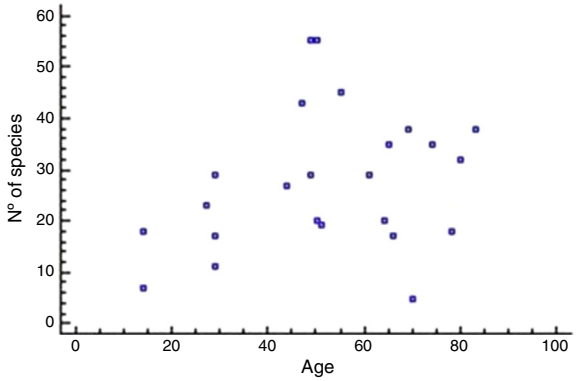

Fig. 2. Relationship between age and number of medicinal plants known by residents of Sucruiuzinho community, Barreiras, Bahia, Brazil.

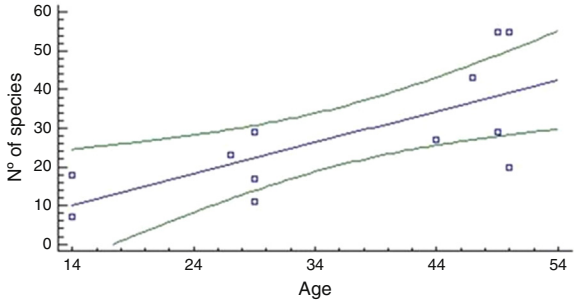

Fig. 3. Relationship between age and number of medicinal plants known by residents up to 50 years in the Sucruiuzinho community, Barreiras, Bahia, Brazil.

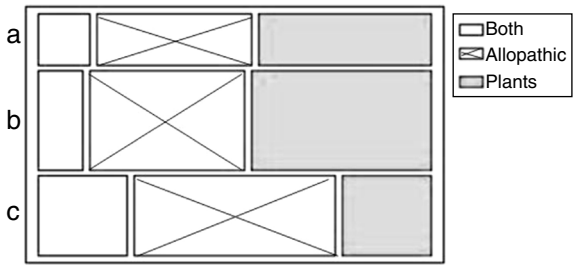

Fig. 4. The therapeutic choices accessed from the therapeutic recall conducted with residents of the Sucruiuzinho community, Barreiras, Bahia, Brazil. (a) Between 14 and 36 years old, (b) between 37 and 59, and (c) between 60 and 83 years. The height of the bars is the number of respondents in each class and the width of the bars indicates the citations to each therapeutic choice.

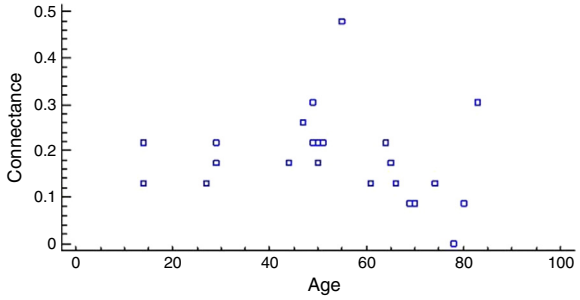

Fig. 5. Relationship between age and medicinal plant learning connectance by residents of Sucruiuzinho community, Barreiras, Bahia, Brazil.

($p > 0.05$) (Fig. 4). In the last age class we saw a small tendency for a greater use of allopathic, although differences to the other classes were not statistically significant.

Indicator 3: age × connectance

Young people are well integrated in terms of medicinal plant learning, as it is evident they are going through learning events. The connectance values for the young people (respondents in age class 1) varied between 0.1304 and 0.2173, being similar or superior to some older members of the community for which connectance values ranged from 0.2173 and 0.3043.

There were no significant differences between young and older people in terms of learning connectance ($R^2 = 0.04$; $p > 0.05$), which means that either young or older people have experienced learning events with other community members (Fig. 5).

Discussion

Regarding the difference of knowledge between young people and the elders indicated here and by some authors (Reyes-García et al., 2005; Quilan and Quilan, 2007; Silva et al., 2011; Malthez-Stifel et al., 2012), there are some possible interpretations to this phenomenon: (1) young people know less because they may not have had time to learn and experiment as much as the elders (Voeks and Leony, 2004; Albuquerque, 2006), and (2) the elders may have been affected by a greater diversity of diseases throughout their lives (Henrich and Broesch, 2011) and therefore accumulated a larger plant repertoire. Thus, the relationship between age and number of cited plants alone does not allow us to make inferences on knowledge loss in a community, but may indicate that the knowledge tends to be transmitted and accumulated gradually, except in communities where this knowledge is quickly passed in early learning stages, as will be exemplified below.

When we evaluate the three indicators together, we can state that there is no local knowledge loss in the community, since the younger use medicinal plants and allopathic in the same proportion as the elders, what characterizes a plural medical system (Vandebroek et al., 2004; Giovannini et al., 2011). In addition, young people are connected to the community as any other member in terms of medicinal plant learning, what can strengthen the argument that a lower amount of plants cited by young people is a natural process. When knowledge on useful plants is restricted to a group due to the interruption of the transmission mechanism, then the risk of loss becomes much larger (Albuquerque and Andrade, 2002).

The age-influenced increase in the number of plants up to 50 years was similar to that observed by Reyes-García et al. (2005). The main difference between their study and ours is that they found a decline in knowledge after a certain age (55) and in our case knowledge stabilized for 50 years or more. Additionally, in a work on medicinal plants performed in a rural community in Northeastern Brazil, Silva et al. (2011) reported that the most knowledgeable age group was precisely the 59–68 years old, with a decline in knowledge after that age range. These findings reinforce the argument that there is a tendency of self-reported knowledge stabilize or decline after a certain age (Ayantunde, 2008). This can be explained by the assumption that our synapses are strengthened or weakened by new stimuli, experiences and actions, which enables us to learn throughout life, but after a certain age the formation of new synaptic connections become more rare and we have difficulties in retaining new data in memory (Friedrich and Preiss, 2006).

Our findings related to therapeutic choices are similar to those found by Ceolin et al. (2011), which show that most participants involved in his research, when faced with illness events, make use of both medicinal plants and formal health services. Medical pluralism in the context of some local populations can be explained by different factors, including the frequent contact with the influential urban area (Giovannini et al., 2011) the perception of some diseases as incurable by biomedicine, such as the "spirit" disease, "evil eye" or other "culture bound syndromes" (Amorozo, 2004; Vossen et al., 2014); and increased economic power of some populations (Quilan and Quilan, 2007). Furthermore, the use of traditional medicine and biomedicine can increase the amplitude of therapeutic choices that human population uses, increasing the range of possible solutions for the treatment of diseases (Ryan, 1998; Bhasin, 2007). Thus, this set of factors justifies the therapeutic choices and again weakens the argument about the knowledge loss, demonstrating that this knowledge can be hybridized (Soldati and Albuquerque, 2012).

The finding concerning learning connectance has shown that young people behave like the elders for this parameter. However, although learning behavior is similar, we also observed that young people do not teach about medicinal plants the same way elders do, what can be expected since people often seek for the most experienced when they want information on medicinal plants.

Box 1: Simulation of possible scenarios considering different behaviors of the indicators of knowledge loss on medicinal plants.

Scenarios	Combinations	Interpretation
Knowledge loss	Situation A: - Less knowledge of young people - Greater use of allopathic by young people - Young people with less learning connectance	Breaks in transmission and abandonment of traditional practices
	Situation B: - Less knowledge of young people - Greater use of plants or both (plants and allopathic) by young people - Young people with less learning connectance	Breaks in the transmission from elders to young people may cause the knowledge of young people to stabilize in the early stages of life, so that when they reach adulthood, this generation may know fewer plants than the last adult generation
Without knowledge loss	Situation C: - Less knowledge of young people - Greater use of plants or both (plants and allopathic) by young people - Young people with equal or more learning connectance	Gradual learning
	Situation D: - There are no differences in knowledge regarding the age - Greater use of plants or both (plants and allopathic) by young people - Young people with equal or more learning connectance	Knowledge transmitted at an early stage
Without current knowledge loss, but with susceptibility to future loss	Situation E: - Less knowledge of young people - Greater use of allopathic by young people - Young people with equal or more learning connectance	Preference for allopathic may limit the traditional pharmacopoeia to specific disease (and plants), affecting the transmission of knowledge about plants before employed for purposes now dominated by official medicine
	Situation F: - There are no differences in knowledge regarding the age - Greater use of plants or both (plants and allopathic) by young people - Young people with less learning connectance	Improbable scenario, but that may indicate susceptibility to future loss
	Condition G: - There are no differences in knowledge regarding the age - Greater use of allopathic by young people - Young people with less learning connectance	Improbable scenario, but that may indicate susceptibility to future loss
	Situation H: - There are no differences in knowledge regarding the age - Greater use of allopathic by young people - Young people with equal or more learning connectance	Preference for allopathic may limit the traditional pharmacopoeia to specific disease (and plants), affecting the transmission of knowledge about plants before employed for purposes now dominated by official medicine

The possible combination of behaviors for the three indicators led us to propose different scenarios for interpreting knowledge loss (Box 1). In this case, the interaction between indicators may lead to three possible scenarios about knowledge loss. In scenario 1 we simulate two situations in which knowledge loss is more likely to occur: (a) young people know less about plants than the elders; their therapeutic choices are mostly based on allopathic, and they are not learning about medicinal plants with other community members (condition with very high chances of loss); or (b) young people know less plants than elders, their therapeutic choices are based on the use of plants (or both plants and allopathy), and they are not learning about medicinal plants with other community members (local botanical knowledge of young people will remain based on a small set of plants) (Box 1: A and B).

This hypothetical scenario may be real as drivers of knowledge loss act concomitantly. For example, the loss of biological diversity is already identified as a limiting factor in the repertoire of medicinal plants of young people (Malthez-Stifel et al., 2012; Sujarwo et al., 2014) and, moreover, in some contexts, the young people tend to be more susceptible to the choice of allopathic treatment of diseases (Quilan and Quilan, 2007).

In scenario 2 we simulate two situations in which there is no actual loss of LEK, as follows (a) young people know less about plants than elders; their therapeutic choices are based on the use of plants (or both plants and allopathy), and they are connected in terms of medicinal plant learning. In such case we can expect that the fewer plants known by the young people are the result of gradual knowledge transmission and that there is not a loss of current knowledge, as is the case of the findings of this study. Another possibility within the scenario 2 is that (b) age does not influence medicinal plant knowledge; young people's therapeutic choices are based on the use of plants (or both plants and allopathy), and they are connected in terms of medicinal plant learning. Based on this model, we can say that knowledge about plants is passed in the early stages (Box 1: C and D).

The scenario 3 here proposed consists of four situations when loss of current knowledge may not be occurring, but indicators point future vulnerability to knowledge loss. For example, (a) young people know less about medicinal plants than elders; their therapeutic choices are based on allopathy, and they are connected in terms of medicinal plant learning. This condition denotes certain vulnerability in the system, since learning may be restricted to few plants that still play a role in young people's healthcare. In another model (b) for this scenario there is no difference in knowledge regarding age; young people have their therapeutic choices based on the use of plants (or both plants and allopathy), but they are weakly connected to the community in terms of medicinal plant knowledge. Such model also indicates a future vulnerability in knowledge, since interruptions in medicinal plant learning process may prevent natural and gradual acquisition of new information, bringing knowledge to stabilize in the early stages.

Finally, there are still two situations when the knowledge of young people and elders are similar; young people choose more allopathic than medicinal plants, even if they are connected to the community in terms of medicinal plant learning (c) or not (d), these scenarios are configured in a system without loss of current knowledge, but still vulnerable to future knowledge loss, because the lack of knowledge application can lead to forgetfulness (Box 1: E–H).

Final considerations

In the studied community there is no evidence of knowledge loss or of threats to its maintenance. Young people know less about plants than elders (up to 50 years) because the learning process occurs gradually.

We recommend that future studies consider a joint assessment of the factors proposed here, in order to avoid inadequate conclusions based on indicators that, used in isolation, may not lead to an accurate representation of the studied reality.

The study has the following limitation: since we dealt only with internal community networks, we cannot tell if there are differences between the youngest and the eldest in terms of external learning (learning with people from other regions). Therefore, the result that showed no difference in terms of learning networks is only valid for internal learning and we think future studies could also investigate learning outside the studied communities

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

Authors' contributions

CCB contributed in fieldwork and wrote the first version of the MS, TCS made a critical reading and considerably changed the MS, UPA made a critical reading and considerably changed the MS, MAR made a critical reading and considerably changed the MS, WSFJ made a critical reading and considerably changed the MS, FNB contributed in fieldwork and helped writing the fist version of the MS, EMCN co-directed the Masters dissertation of the first author, PMM idealized the study and directed the Masters dissertation of the first author.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgments

The authors thank Universidade Federal da Bahia for the grant given to the last author. They thank CAPES for the fellowship given to the first author. The authors also thank Universidade Federal do Oeste da Bahia for funding the MS translation. Special thanks are given to all members of Sucruiuzinho, who kindly accepted to be interviewed.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.bjp.2016.09.006.

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