Investigating the dynamics of cultural mutations in local medicinal plant use in NE Brazil

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Research

Abstract

Background: According to cultural evolution theory (CE), the transmission of cultural information can be subjected to "cultural mutations" (random alteration of information). Cultural mutations can have implications for human culture. However, the contributing factors to the increased/decreased establishment of these processes in local medical systems remain unclear. Thus, we tested the following hypotheses: H1: more conservative transmission modes (vertical transmission) are less prone to cultural mutation; H2: knowledge sharing about a medicinal plant influences the occurrence of cultural mutations in local medical systems; and H3: information on versatile medicinal plants (plants used to treat various ailments) is more likely to undergo cultural mutation in local medical systems.

Methods: To test our hypotheses, we conducted a case study in the Lagoa do Junco community, Santana do Ipanema municipality, Alagoas. The data were collected through semistructured interviews with 120 individuals older than 18 years. Analyses utilized a generalized linear model (GLM) with the binomial and Poisson families.

Results: We found a lower cultural mutation rate for more conservative transmission modes ($p<0.01$). Information about more widely shared medicinal plants was more prone to cultural mutations ($p<0.001$). Versatile medicinal plants are more susceptible to cultural mutations.

Conclusions: Less conservative cultural transmission modes promote greater variation in plant-based medicinal systems. Factors such as information sharing and plant versatility, though important in local medical systems, may have implications for human culture, as exemplified by maladaptive cultural traits, and need assessment in future studies.

Keywords: Cultural evolution, Copy errors, Ethnobotany, Medicinal plants

Background

Local medical systems are characterized by the set of knowledge and practices regarding health and disease management developed by human groups (Bizon 1973). Evidence indicates that social, cultural, biological, and ecological factors can influence the construction of these systems (Molares & Ladio 2014, Johns & Sibeko 2023, Albuquerque *et al*. 2023). Within local medical systems, various resources, including plants utilized for medicinal purposes, prevail in treating diseases. A striking feature of local medical systems is the transmission of information, which is treated as cultural information. Through the transmission of various theoretical and practical knowledge, strategies related to health promotion and disease by different human groups have been developed (Dunn 1976, Kleinman 1978). However, according to "cultural evolution theory" (CE), the transmission of cultural information may occur through unintentional copy errors, which are termed "cultural mutations" (Mesoudi 2011).

During the information transmission process, several factors can influence communication between individuals, resulting in cultural mutations. Among these factors are I) information concealment, in which individuals copy information inaccuracies that they do not perceive; II) incomplete transmission of information, in which only part of the information (of extensive and varied content) is transmitted or assimilated in the minds of individuals; and III) information confusion, in which people transmit probable information instead of suitable information (Arkes 1991, Barkow 1989, Eerkens & Lipo 2005, O'Brien *et al*. 2016).

The occurrence of cultural mutations has implications for human culture and can even be deleterious for some populations. As examples of the effects of cultural mutations, "Maladaptive Cultural Traits" represent adopted behaviors that do not contribute to individuals' adaptation (Barkow 1989). In the local medical system, these behaviors can be represented by plants used for medicinal purposes that do not possess the desired medicinal efficiency (Dantas *et al*. 2020, Pereira *et al*. 2021, Santoro *et al*. 2018).

It is possible that the occurrence of mutations in local medical systems is related to certain situations. For example, some studies have shown that people's knowledge of medicinal plants is more similar to that of their parents than to that of other community members (Brito *et al*. 2019, Santoro *et al*. 2020). In addition, studies have suggested that information transmission from parents to children (vertical route) may function as a more conservative route of information, generating lower rates of change over time than other transmission routes (Cavalli-Sforza & Feldman 1981, Hewlett & Cavalli-Sforza 1986, Reyes-García *et al*. 2009). This would occur because the transmission from parents to children would incorporate changes from one generation to another (Santoro *et al*. 2018), as well as because of the importance people place on information acquired from parents.

On the other hand, other evidence suggests that horizontal (between individuals of the same generation without parental relation) or oblique (between individuals of different generations without parental relation) transmission can promote more varied information and rapid changes (fewer conservative routes). Consequently, variations generated by horizontal and oblique routes promote higher rates of change in cultural evolution (Boyd *et al*. 2011, Mesoudi 2011, Santoro *et al*. 2018). Therefore, it is reasonable to expect that these pathways are more susceptible to cultural mutations. This may occur because the scenarios of the horizontal and oblique pathways may lead to greater acceptance of innovation in information than the vertical pathway (Cavalli-Sforza & Feldman 1981). Additionally, the oblique and horizontal pathways may have a broader scope than the vertical pathway since they allow the transmission of information among all individuals within the same generation and across different generations (Santoro *et al*. 2018), increasing the chances of greater information variation (Boyd *et al*. 2011) and, consequently, alterations in the information (Mesoudi 2011). However, much of what is known about the information associated with transmission routes still exists in studies related to cultural evolution that need to be tested in the context of human populations. Thus, taking the local medical system scenario as a model and seeking to determine the route generating a greater number of mutations, this study proposes to test the following hypothesis: H1: more conservative transmission modes are less prone to cultural mutation, as we expect the vertical route to have a lower frequency of traits with mutations than are the oblique and horizontal routes.

Additionally, the more times people transmit information to others, the more susceptible these pieces of information will be to random changes (Mesoudi 2011, Santoro *et al*. 2018). For example, person "A" tells information to person "B", and they transmit it to person "C"; however, the information arrives at "C" with some alteration. In other words, the process is similar to that of the game Chinese whispers (Santoro *et al*. 2018) or the telephone game (Camargo *et al*. 2021), as the information transmitted can be altered in each person's mind (Laland & Brown 2011). Considering the possibility of reconstructing the information in the minds of individuals, in this study, we also assessed the following hypothesis: H2:

Knowledge sharing about a medicinal plant influences the occurrence of cultural mutations in local medical systems. A priori, our expectation is that more widely shared biocultural traits have a greater frequency of mutations.

Moreover, "causal mismatch" (Henrich & Mcelreath 2003) or "effect generalization" are also factors that can assist in understanding the generation of cultural mutations. The ability of versatile therapeutic potential plants (i.e., those with different disease symptoms) can contribute to the occurrence of cultural mutations. This is because the versatility of the medicinal uses of a plant can lead individuals to use it without understanding how, for what, or why certain species work, increasing the chances of transmitting altered information. In effect generalization, individuals associate information with other existing information. Therefore, in the case of versatile medicinal plants, people can make different information associations, increasing the chances of cultural mutations. Thus, considering the implications of the versatility of the use of medicinal plants, we also tested the hypothesis that H3: Information on versatile medicinal plants is more likely to undergo cultural mutation in local medical systems. Our expectation is that biocultural traits with greater versatility in medicinal use have a greater frequency of mutations.

Materials and Methods

Study Area

This study was conducted in the Lagoa do Junco community, located in the municipality of Santana do Ipanema in the state of Alagoas, Northeast Brazil (Dantas *et al*. 2020). The municipality of Santana do Ipanema is in the mesoregion of the Alagoan Sertão, 207 km from the state capital, Maceió, and has a population of 48,232 inhabitants (IBGE 2021). The Lagoa do Junco community consists of 63 families, housing a total of 188 individuals. The community is situated in an area with caatinga vegetation, which is a type of seasonally dry tropical forest. Community members engage in extractive activities, such as collecting firewood and medicinal resources, on this vegetation. The region's climate is semiarid, with an irregular rainfall distribution concentrated over a period of four to five months (Lopes *et al*. 2005).

Within the community, there are educational, medical, commercial, and religious establishments. Additionally, the Lagoa do Junco Community is characterized by a strong tradition of using and commercializing medicinal plants (Dantas *et al*. 2020, Pereira *et al*. 2021). Furthermore, community members possess significant expertise in medicinal plants and often have lower incomes, a common situation in other areas of Northeast Brazil (Magalhães *et al*. 2022, Sousa *et al*. 2022, Oliveira *et al*. 2017), which is why they frequently resort to medicinal plants to address their health concerns. The strong history of using and selling medicinal plants prompted us to select this community for our study.

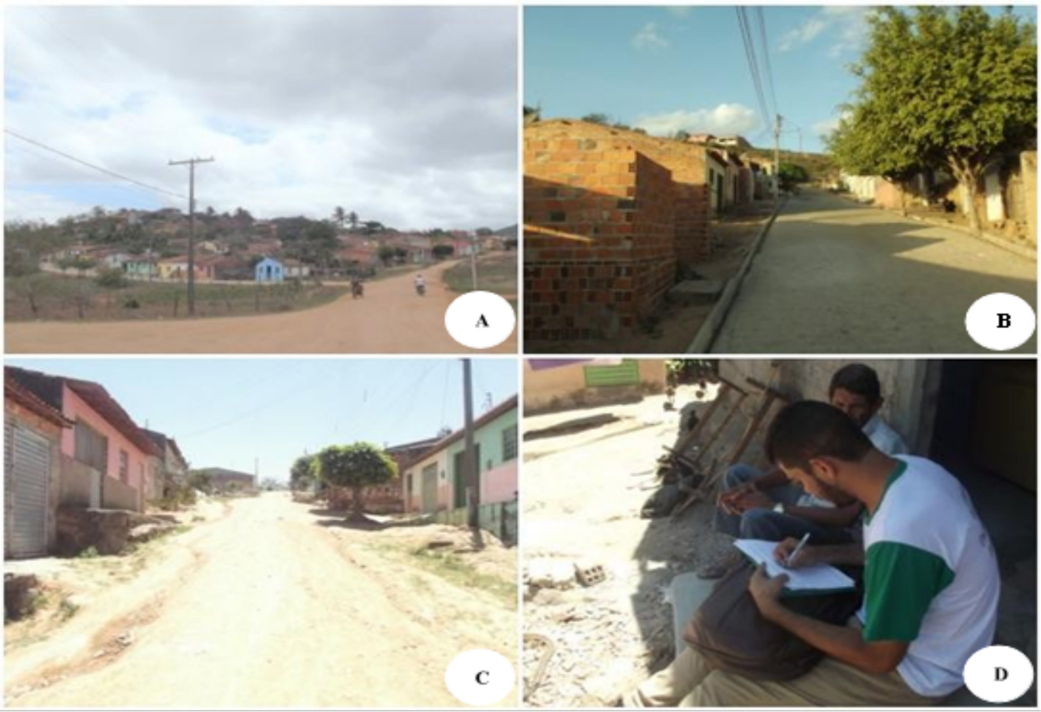

Figure 1**.** Lagoa do Junco Community, Santana do Ipanema municipality, Alagoas, Brazil. A. An overall view of the community. B. Street 1 of the community. C. Street 2 of the community. D. Conducting semistructured interviews with one of the community members**.**

Ethical and legal aspects

Data collection adhered to the guidelines of the Resolution (466/12) from the National Health Council for Research Involving Human Subjects, with the approval of the Ethics in Research Committee (CEP) of the University of Pernambuco-UPE, which granted the following approval number: CAAE: 97380918.9.0000.5207. Furthermore, the study was also conducted with registration from the National System for the Management of Genetic Heritage and Associated Traditional Knowledge-SISGEN under the number AB5C935 for accessing associated traditional knowledge. All participants willing to participate in this study were invited to sign the Free and Informed Consent Term (TCLE). Additionally, for botanical material collection, we used proof of registration from the Authorization and Information System in Biodiversity - SISBIO, under the number 64841-1, as recommended for collections carried out outside Conservation Units.

Verification of Cultural Mutations

The data for this study were collected between 2018 and 2019. Patients were diagnosed with medicinal plants by local residents older than 18 years (representing 82% of the adult population), for a total of 120 participants. The data were collected in two separate phases. In the initial phase, we employed the free-listing technique (Albuquerque *et al*. 2014), inviting all individuals to list plants known or used by them medicinally (**Supplementary Material).** Semistructured interviews were subsequently conducted (Albuquerque et al. 2014) to gather information about each plant mentioned by the respondents. Furthermore, semistructured interviews were also used to identify transmitting individuals (those who passed on information about medicinal plants in the local medical system) and learning individuals (those who learned information about medicinal plants in the local medical system) (Dantas *et al*. 2020). For instance, during the interviews, for every plant mentioned by respondents, we posed the following inquiries: 1) For which diseases or ailments is this plant indicated? 2) Which part/parts of the plant is used in treatment? 3) From whom did you acquire this knowledge?

After conducting the semistructured interviews, the information (considered biocultural traits) of the transmitting individuals was analyzed and compared with the information from the learning individuals of the local medical system to pinpoint potential instances of cultural mutations (Albuquerque *et al*. 2014). In this analysis, information about the same plant used by the learning individual and the information transmitter was taken into account. Information or a biocultural trait was deemed a mutation when 1) the therapeutic target (disease) indicated by a learning individual was different from what the information transmitter had indicated or 2) the plant part used by the learner was different from the information transmitter (Albuquerque *et al*. 2014).

Classification of Cultural Mutations or Guided Variation (second data collection phase)

Information alteration can occur unintentionally (cultural mutation) or intentionally (guided variation) (Mesoudi 2011). To ascertain whether the changes in information between individuals were truly unintentional (mutation), a new data collection phase was undertaken. This stage involved conducting fresh semistructured interviews solely with the learning and transmitting individuals who, in the first data collection phase, presented potential cultural mutation cases.

For this stage, each learning and transmitting individual in the local medical system was reminded of the information they had previously mentioned during the initial interviews. Subsequently, after jogging their memory, a series of inductive questions were posed, such as the following: 1) Days ago (first phase), you mentioned using plant *X* to cure disease *Y*. However, can this plant also be used to treat other types of diseases? If yes, which ones? 2) Have you used this plant to cure another disease in the past? If so, which? 3) Have you ever suggested this type of plant to someone to cure a different disease? If so, which? 4) Days ago, you mentioned using part *X* of this plant. However, can other parts of the plant be used as well? If so, which? From these questions, it was possible to determine whether the changes in information within the medical system between transmitting and learning individuals were random (cultural mutation) or intentional (guided variation). Here, is a hypothetical scenario for better illustration:

During the initial stage of the semistructured interviews, individual "A" mentioned using leaves from the “aroeira” plant to alleviate headaches and learning about this practice from individual "B," a resident of the community. When we interviewed individual "B," they also confirmed using the “aroeira” plant for headaches but specified using the bark, not mentioning the use of leaves as reported by individual "A." Upon concluding the initial data collection and analyzing the interviews, we identified a discrepancy in information between the two participants. However, we did not ascertain whether this difference was an r cultural mutation or a guided variation.

To investigate whether this change was a cultural mutation or intentional variation, we conducted new interviews (second stage of data collection) with individuals "A" and "B." During this phase, we posed the following question to individual "A”:

"A few days ago, you mentioned using the leaves of the "aroeira" plant to alleviate headaches. However, have you ever used or do you currently use other parts of the "aroeira" plant for this purpose? If yes, which ones?" Individual "A" then disclosed that they had previously used the bark of the "Aroeira" plant to treat headaches, but despite the suggestion to use the bark, they now preferred the leaves because of their "better taste." In the interview with individual "B," we asked, "In addition to using the bark, have you ever recommended to someone else another part of the "aroeira" plant for treating headaches?" Individual "B" stated that they had always used only the bark of the "Aroeira" plant for this purpose and had consistently recommended solely the use of the bark.

In this context, we confirmed that the information change was a guided variation, as individual "A" consciously adapted the information, preferring the leaves of the "aroeira" over the suggested bark by individual "B." However, if individual "A" had asserted during the interview that they had always used and continue to use only the leaves of the "aroeira" plant to treat headaches, without mentioning or being aware of the use of the bark, we would consider this a cultural mutation, indicating a spontaneous deviation in information without evidence of intentional alteration.

Botanical Material Collection and Identification

We employed the guided-tour technique (Albuquerque *et al*. 2014) for collecting plant species. Following the semistructured interviews, each participant was invited to display the medicinal plants they had at their homes or nearby homes. A total of 39 species were documented. Botanical material from these species was collected for identification by specialists, and the specimens were deposited at the Agronomic Research Institute of Pernambuco (IPA).

Data analysis

To test our hypotheses, we employed a generalized linear model (GLM) using R software version 3.4.3 (2017). The acquisition and categorization of information transmission modes were conducted through the analysis of specific questions posed during the initial data collection with the individuals included. For instance, at the commencement and conclusion of semistructured interviews, participants were asked various questions, including the following:

1. How old are you?
2. Who are your relatives in the community?
3. From whom did you acquire knowledge about medicinal plants?
4. Is this person a relative of yours?
    - If yes, specify the degree of the relationship (uncle, aunt, mother, father, grandmother, grandfather, cousin, etc.).
    - If not, what is the nature of your relationship with this person (friend, neighbor, etc.)?

These questions allowed us to analyze information from all the transmitting and learning participants in the local medical system. Ultimately, we categorized transmission as vertical when information was passed from parents to children, horizontal when information was exchanged among individuals of the same generation, and oblique when information was shared between individuals of distinct generations without a familial connection.

The relationship between the versatility and popularity of medicinal plants (measured by citation frequency) was assessed using simple linear regression.

To assess whether H1: more conservative transmission modes are less prone to cultural mutation occurrence, we created a spreadsheet recording informant names and all the cultural traits (plant+ part of the plant used in treatment+ disease indicated for treatment) mentioned by them. In addition to the cultural traits mentioned by informants, "1" was assigned if the information had mutated, or "0" was assigned if it had not. Additionally, we noted the cultural trait transmission mode (vertical, horizontal, or oblique). Finally, we used a generalized linear model (GLM) with a binomial family, considering the dependent variable as the mutation variable and the independent variable as the individual learning factor.

To test H2, that the sharing of knowledge about a medicinal plant influences the occurrence of cultural mutations in local medical systems, we designed a spreadsheet recording all the plants mentioned by the informants. In addition to each plant name, we added the number of people who mentioned information about each plant. Furthermore, in another column, we assigned the number of times a mutation occurred for each species (e.g., "1" for one mutation associated with a species and "2" for two mutations associated with a species). We then utilized a generalized linear model (GLM) using the Poisson family, considering the independent variable as the number of people citing each plant and the dependent variable as the number of times a cultural mutation occurred for each plant.

To test whether H3: Information about versatile medicinal plants is prone to greater cultural defects in local medical systems, the relative importance (RI) index of plant species was first calculated as per Bennett & Prance (2000), where versatile species have more medicinal properties and body systems. The following formula was used: RI = NSC+NP, where RI = relative importance, NSC = number of body systems and NP = number of properties. The following formulas were used for calculating NSCs and NPs: 1) NSC=NSCE÷NSCEV, where NSCE is the number of body systems treated by a particular species and NSCEV is the number of body systems treated by the most versatile species; 2) NP=NPE÷NPEV, where NPE is the number of medicinal functions attributed to a particular species and NPEV is the total number of medicinal functions attributed to the most versatile species. After calculating the relative importance index, we designed a spreadsheet noting the names of all the plants mentioned by the informants. In addition to each plant name, we added the RI value of the plant, and in addition to the RI value, we added the number of times a mutation occurred for each species (e.g., "1" for one mutation case linked to a species and "2" for two mutation cases linked to a species). We then used a generalized linear model (GLM) employing the Poisson family, considering the independent variable as the RI value of each plant and the dependent variable as the number of times a cultural mutation happened for each plant.

Results

We found a significant relationship between plant popularity and usage versatility ($F=98.48$, $p<0.01$). The cultural mutation rate was lower for vertical transmission than for oblique or horizontal transmission ($p<0.01$), and information about widely shared medicinal plants was more prone to cultural mutations ($p<0.001$). Additionally, versatile medicinal plants are more susceptible to cultural mutations ($p<0.001$), confirming our expectations (Table 1).

Table 1. Generalized linear model with binomial and Poisson families showing 1) the association between different cultural transmission routes and the occurrence of cultural mutations, 2) the association between a greater amount of shared medicinal plant information and the occurrence of cultural mutations, and 3) the association between the versatility of medicinal plant usage and the occurrence of cultural mutations.

GLM (Hypothesis 1)				
I estimated	**Std. Error**	**Z Value**	**Pr(>|z|)**	**AIC**
Intercept -2.4342	0.1844	-13.203	<2e-16***	545.93
Road comparison vertical with horizontal	0.8845	0.2704 3.272	0.00107**	
Road comparison vertical with oblique	0.7896	0.2768 2.853	0.00433 **	
GLM (Hypothesis 2)				
I estimated	**Std. Error**	**Z Value**	**Pr(>|z|)**	**AIC**
Intercept -1.160902	0.270975	- 4.284	1.83e-05 ***	100.9
Quote 0.042747	0.003621	11.806	< 2e-16 ***	
GLM (Hypothesis 3)				
I estimated	**Std. Error**	**Z Value**	**Pr(>|z|)**	**AIC**
Intercept -2.2560	0.3762	-5.997	2.01e-09 ***	113.06
RI 2.5520	0.2328	10.963	< 2e-16 ***	

The most frequently mentioned transmission route was vertical, with a total of 397 biocultural traits and 32 cultural mutations. The horizontal route had a total of 177 biocultural traits with 31 mutations, and the oblique route had 173 biocultural traits with a total of 28 mutations.

Discussion

Do more conservative modes of transmission have lower tendencies for cultural mutations?

Our findings support the prediction that vertical transmission can act as a more conservative route for accessing cultural information than can other transmission pathways (Cavalli-Sforza & Feldman 1981, Hewlett & Cavalli-Sforza 1986, Reyes-García *et al*. 2009). Several factors may contribute to this. First, parent-to-child transmission typically results in changes accumulating from one generation to the next (Santoro *et al*. 2018), whereas oblique and horizontal pathways facilitate the sharing of cultural traits among all individuals within and across generations (Mesoudi 2011). This might amplify information diversity (Boyd & Richerson 2011) and, in turn, the emergence of cultural mutations.

Relevant studies in evolutionary psychology, particularly those associated with adaptive memory, suggest that over time, human memory systems have evolved to better retain information deemed crucial from an adaptive perspective (Nairne & Pandeirada 2008, Nairne *et al*. 2008, Nairne *et al*. 2007, Nairne *et al*. 2009, Nairne *et al*. 2012). Thus, in the community we studied, knowledge acquired from parents (vertical transmission) might be perceived as more important and, therefore, better retained and transmitted with fewer errors than information obtained through other transmission routes. The emphasis individuals place on parentally acquired knowledge could be attributed to various factors, such as family traditions, parental care involving the use of medicinal plants since childhood (Eyssatier *et al*. 2008, Henrich 2011, Santoro *et al*. 2020), and viewing parents as primary local role models for cultural information (Wood *et al*. 2012). The extent to which these factors influence perceived importance and the occurrence of cultural mutations needs further evaluation to better understand the conservative nature of vertical transmission.

Another reason why vertical transmission may yield fewer cultural mutations is its dominance over oblique and horizontal transmission in local medical systems (Santoro *et al*. 2020). Individuals often learn through vertical channels more than oblique and horizontal channels. This preference was evident in our study and has been highlighted in other research concerning medicinal plants in various local medical systems (Brito *et al.* 2019, Santoro *et al*. 2020). Consequently, frequent events may affect how we prioritize specific details in memory and cultural transmission (Sachs *et al*. 2017, Scheideler *et al*. 2017, Silva *et al*. 2022).

Furthermore, some studies suggest that information provided by exemplary individuals (those perceived as vast reservoirs of knowledge or skill in cultural contexts) tends to be more widely transmitted and memorable than that from other sources (Henrich 2009, Jiménez & Mesoudi 2020). Moreover, evidence implies that the more often people replicate information from a model, the less likely they are to experience copying errors (Schillinger *et al*. 2015). In our research, parents were most frequently cited as information sources, indicating that within the community we examined, parents are considered paramount in acquiring local knowledge. This perception could stem from the inherent trust in parental advice or the ease of accessing information from parents. Therefore, this trust may lead to better retention of cultural traits linked with vertical transmission, subsequently resulting in fewer cultural mutations. However, further studies are needed to confirm this observation.

Does sharing knowledge about a medicinal plant influence the occurrence of cultural mutations in local medical systems?

Our data suggest that more widely shared information about medicinal plants is more prone to cultural mutations. According to certain premises of cultural evolution, when specific information undergoes repeated transmission, the probability of an error surges. The more individuals relay information, the more susceptible they become to random modifications (Mesoudi 2011, Santoro *et al*. 2018). This phenomenon arises because as information circulates, each recipient may alter it slightly in their mind (Laland & Brown 2011). Thus, public dissemination can muddle information since individuals might convey probable information instead of the precise, intended data (Barkow 1989).

A prime illustration of this is the "Chinese Whispers" game (Santoro *et al*. 2018) or "Telephone" (Camargo *et al*. 2021). Here, participants form a line or circle, and the first player shares a message, whispering it into the ear of the next person, thereby passing the information from one individual to another. Ultimately, the final participant announces their received message, contrasting it with the original (Utami & Rahmawati 2018). These games inevitably alter the initial message through transmission, mirroring the concept of cultural mutations in cultural evolution.

The propensity for widely shared medicinal plant information to be susceptible to cultural mutations might explain why redundant studies uncover a greater number of redundant medicinal plants for frequently targeted therapies (Santoro *et al*. 2015).

Redundant medicinal species are those with identical functions, such as several species used to treat the same ailment (Santoro *et al*. 2015). Common therapeutic targets are those with high incidences throughout the year, such as colds, headaches, and fever. Thus, in local medical systems, some species might become redundant due to cultural mutations. For instance, in one scenario, Person A informs Person B that a particular plant cure headaches. However, Person B might assimilate this as the plant cures colds instead of headaches, as initially conveyed. In another instance, Person C tells Person D that a specific plant remedies diarrhea. However, Person D might assume that the plant treats colds and not diarrhea, as first suggested. In these examples, although the medicinal plants differ and were recommended for distinct ailments, cultural mutations made them redundant in the system. Both now serve the same medicinal function (curing colds). We did not investigate the relationship between species redundancy and cultural mutations in this work, but we believe this topic is an intriguing avenue for future research.

Conversely, our findings contrast with those of several archaeological studies probing the emergence and transmission of copying errors. For instance, via a laboratory experiment with human groups, Acerbi & Tennie (2016) explored how the frequency of shared artifact information might influence cultural transmission fidelity. Contrary to our findings, they discerned that the more participants shared artifact details, the likelier the faithful transfer of cultural information. This discrepancy might arise because artifact information is less intricate than other resource information, leading to easier memorization compared to that of other resources, such as plants. Thus, a connection might exist between information sharing and the onset of cultural mutations, contingent on the content transmitted by humans. This relationship warrants further exploration in future studies.

Are versatile medicinal plants more susceptible to cultural mutations in local medical systems?

As anticipated, we found a link between the versatility of medicinal plant usage and the incidence of cultural mutations. We believe several factors contribute to this difference in incidence in local medical systems. One such factor is "causal mismatch" (Henrich & McElreath 2003). As versatile medicinal plants are recommended for various health issues, individuals might struggle to remember the exact function(s) of the plant species relayed via cultural transmission.

Additionally, individuals might be associating prior information before passing it to a new person, potentially leading to a generalization of effects before transmission. Trust in the therapeutic potential of a versatile plant might prompt them to form various information associations, heightening the chances of cultural mutation. For example, an individual might be informed that Plant *X* cures colds, diarrhea, and headaches. However, the recipient might use Plant *X* to remedy migraines, either because they equate migraines and headaches to the same bodily system or because they perceive similar symptoms. Consequently, the individual might rely on another plant *X* that remedies colds, diarrhea, and migraines, diverging from the original information and thus resulting in a cultural mutation (Dantas *et al*. 2020).

Moreover, studies on copying errors tied to cultural transmission highlight that information content variation can significantly influence cultural information fidelity (Acerbi & Tennie 2016). Therefore, as versatile medicinal plants can be used for multiple symptoms, when compared to less versatile ones, information variation for the former might foster a greater occurrence of cultural mutations. It is also worth noting the potential mutual influence between cultural mutations and plant versatility. As versatile medicinal plants can cause cultural mutations, these mutations could also enhance the versatility of certain plant species. For instance, in a local medical system, a cultural trait might indicate that Plant *X* cures colds and diarrhea. However, during transmission, one individual might convey that Plant *X* remedies headaches and colds. The recipient, assimilating the mutated information, will use the plant for a new ailment (headaches). If this mutation is relayed to others in the local medical system, Plant *X's* therapeutic versatility can increase, making understanding of these medical systems intricate. Initially, versatility leads to increased mutation, enabling cultural evolution even when based on inefficacious information and potentially increasing the pressure on the collection of some plant species. These mutations might subsequently be linked to new data, suggesting previously unused plants for specific therapeutic purposes and further exacerbating collection pressure. Thus, regarding medicinal resources, cultural evolution and mutations might exacerbate species conservation issues, contingent on the plant part used and collection frequency and intensity.

Notably, simple linear regression analysis indicated a relationship between the popularity and versatility of the medicinal plants in our study. These findings suggest that the more popular plants in the local medical system also exhibit a greater incidence of cultural mutation due to their versatility. Thus, we posit that the versatility of medicinal plants allows for greater variation in the information available for the most popular plants, favoring a higher mutation rate for these resources.

Conclusion

This study is among the pioneers highlighting cultural mutations within human populations based on medicinal plant use. Our findings reinforce the cultural evolution theory and showcase that knowledge transmission about medicinal plants plays a pivotal role in spawning mutations in local medical systems.

Additionally, our study has significant implications for understanding local medical systems and the ethnobotanical domain. For instance, our data demonstrate that learning about medicinal plants from parents may reduce errors compared to learning from others. Thus, if parental learning minimizes errors due to its conservative nature, it becomes imperative for future studies to discern whether vertically obtained information offers greater adaptive value for human cultures than information from other transmission routes.

Furthermore, although plant versatility is deemed essential in ethnobotanical studies, our findings reveal that this characteristic might also have negative adaptive value due to its propensity to amplify cultural mutations. Versatility in medicinal use might contribute to poorly adapted traits in local medical systems, a concept requiring comprehensive exploration in subsequent studies. For instance, in bioprospective studies in which plants are selected based on versatility, species with maladapted cultural traits might be chosen. Hence, our study's findings pave the way for innovative research on medical systems, aiming to decipher the evolutionary factors culminating in poorly adapted trait accumulation in medical systems and assessing the ramifications of cultural mutations for human populations. It is necessary for studies of this nature to be conducted in a greater number of communities with plant use traditions to ensure robust generalizations.

Limitations

Given that cultural mutation studies in medical systems are incipient, potential methodological limitations might skew our findings, such as informant memory constraints and nonlinearity in learning. For example, an individual might learn about a plant from Person *X* and to increase their knowledge about another plant use with Person *Y*. However, during interviews, the informant might only recall Person *X*, their primary knowledge source, introducing bias in recording the information's transmission route (whether vertical or not). Considering that knowledge can be obtained from multiple sources, we propose that subsequent cultural mutation studies employ methods or strategies to sidestep such biases.

Depending on social-ecological context, cultural learning might be far more intricate than mere person-to-person transmission regarding a medicinal plant. Although adaptive thinking is based on learning and experience, people may continue using inefficient plants to treat illnesses because there may be a delay in people's perception of the efficiency of the medicinal use of a given plant, as also highlighted by Tanaka *et al*. (2009). Furthermore, sometimes using a plant may work for one person and not work for another. Therefore, it is possible to continue to use plants that are not effective at treating certain diseases. Although there is a relationship between versatility and the frequency of mutations, this relationship must be considered with caution, as there may be other factors not considered in this study that influence this relationship.

Declarations

List of abbreviations: EC: Cultural evolution; IBGE: Brazilian Institute of Geography and Statistics; TCLE: Informed consent form; GLM: Generalized linear model; IPA: Agronomic Research Institute of Pernambuco; CEP: Research Ethics Committee; RI: relative importance index; NSC: Number of Body Systems; NP: Number of properties; NSCE: Number of body systems treated by a particular species; NSCEV: Number of body systems treated by the most versatile species; NPE: Number of medicinal functions attributed to a particular species; NPEV: Total number of medicinal functions attributed to the most versatile species.

Ethical Approval and Participant Consent: The study was submitted and approved by the Research Ethics Committee of the University of Pernambuco under registration number CAAE: 97380918.9.0000.5207. It was also registered with the National System for the Management of Genetic Heritage and Associated Traditional Knowledge-SISGEN, under the number AB5C935, and the Authorization and Information System in Biodiversity- SISBIO, under the number: 64841-1, as suggested for collections carried out outside Conservation Units. All the participating individuals were informed of the purpose of this study and were asked to sign the informed consent form.

Consent for Publication: Not applicable.

Availability of Data and Materials: The data generated by this study are available upon request.

Competing interests: The authors declare no conflicts of interest.

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Author Contributions: Janilo Italo Melo Dantas conducted the fieldwork, statistical analysis, and manuscript writing. André Luiz Borba do Nascimento contributed to the statistical analysis and manuscript writing. Taline Cristina da Silva contributed to the writing of the manuscript. Ulysses Paulino Albuquerque and Elcida de Lima Araújo participated in the study's conception, analysis, and manuscript writing.

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Supplementary Material: List of medicinal plants used by the Lagoa do Junco community in the Municipality of Santana do Ipanema-Alagoas, Brazil.

Popular name	Scientific name	Botanical Family	Voucher	Relative Importance
Aroeira	*Myracrodruon urundeuva* (M.Allemão) Engl.	Anacardiaceae	Dantas. JIM 929563	1.54
Seriguela	*Spondias purpurea L.*	Anacardiaceae	Dantas. JIM 92947	0.29
Babosa	*Aloe vera* (L.) Burm. f.	Asparagaceae	Dantas. JIM	1.52
Grajaú	*Fridericia chica* (Bonpl.) L.G.Lohmann	Bignoneaceae	sterile	0.29
Umburana	*Commiphora leptophloeos* (Mart.) J.B.Gillett	Burseraceae	Dantas. JIM 92951	0.94
Rabo de Raposa	*Harrisia adscendens* (Gurke)Britton e Rose	Cactaceae	Dantas. JIM 93420	0.58
Muçambê	*Tarenaya spinosa* (Jacq.) Raf.	Cleomaceae	Dantas. JIM 92702	0.58
Pratudo	*Kalanchoe crenata* (Andrews) Haw.	Crassulaceae	Dantas. JIM 92699	2
Bom Nome	*Monteverdia rigida* (Mart.) Biral	Celastraceae	Dantas. JIM 92952	0.58
Melão de São Caetano	*Momordica charantia* L.	Cucurbitaceae	Dantas. JIM 92696	0.29
Pião Roxo	*Jatropha gossypiifolia* L.	Euphorbiaceae	Dantas. JIM 92700	0.29
Quebra Pedra	*Phyllanthus amarus* Schumach. & Thonn.	Euphorbiaceae	Dantas. JIM 92956	0.29
Carrapateira (Mamona)	*Ricinus communis* L.	Euphorbiaceae	Dantas. JIM 92705	0.67
Hortelã da Folha Pequena	*Mentha villosa* Huds.	Lamiaceae	Dantas. JIM 92949	1.43
Sambacaitá	*Mesosphaerum pectinatum* (L.) Kuntze	Lamiaceae	Dantas.JIM 929562	0.87
Manjericão	*Ocimum americanum* L.	Lamiaceae	Dantas. JIM 92948	1.23
Hortelã da Folha Grande	*Plectranthus amboinicus* (Lour.) Spreng.	Lamiaceae	Dantas.JIM 929560	1.81
Boldo	*Plectranthus ornatos* Codd.	Lamiaceae	Dantas.JIM 949561	1.34
Alecrim	*Rosmarinus officinalis* L.	Lamiaceae	Dantas. JIM 949510	1.05
Mororó	*Bauhinia cheilantha* (Bong.) Steud.	Fabaceae	Dantas.JIM 92953	0.76
Jatobá	*Hymenaea courbaril* L.	Fabaceae	Dantas.JIM	0.58

			93419	
Catingueira	*Poincianella pyramidalis* (Tul.) L.P.Queiroz	Fabaceae	Dantas. JIM 92944	0.58
Angico	*Anadenanthera colubrina* var. *cebil* (Griseb.) Altschul	Fabaceae	Dantas. JIM 92955	1.05
Tamarindo	*Tamarindus indica* L.	Fabaceae	Dantas. JIM 92701	0.29
Mulungú	*Erythrina velutina* Willd.	Fabaceae	Dantas. JIM 92959	0.47
Romã	*Punica granatum* L.	Lythraceae	Dantas.JIM 92697	0.87
Acerola	*Malpighia emarginata* Dc.	Malpighiaceae	Dantas. JIM 92945	0.29
Hibisco	*Hibiscus rosa-sinensis* L.	Malvaceae	Dantas. JIM 92707	0.29
Pitanga	*Eugenia pitanga* L.	Myrtaceae	Dantas. JIM 92703	0.29
Goiabeira	*Psidium guajava* L.	Myrtaceae	Dantas. JIM 92706	0.29
Capim Santo	*Cymbopogon citratus* (DC.)Stapf	Poaceae	Dantas. JIM 929564	1.34
Juazeiro	*Sarcomphalus joazeiro* (Mart.) Hauenschild	Rhamnaceae	Dantas. JIM 92698	0.67
Noni	*Morinda citrifolia* L.	Rubiaceae	Dantas. JIM 93422	0.38
Pé de Limão	*Citrus* sp.	Rutaceae	Dantas. JIM 92708	0.29
Laranjeira	*Citrus aurantium* L.	Rutaceae	Dantas. JIM 92954	0.96
Quixabeira	*Sideroxylon obtusifolium* (Roem. & Schult.) T.D.Penn	Sapotaceae	Dantas. JIM 92946	0.96
Pimenta	*Capsicum frutescens* L.	Solanaceae	Dantas. JIM 93421	0.58
Erva Cidreira	*Lippia alba* (Mill.) N.E.Br. ex Britton & P.Wilson	Verbenaceae	Dantas. JIM 92704	1.90
Testa de Touro	*Kallstroemia tribuloides* (Mart.) Steud.	Zygophyllaceae	Dantas. JIM 92950	0.29