New evidence regarding the role of previous disease experiences on people's knowledge and learning of medicinal plants and biomedical drugs

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Research

Abstract

Background: What factors influence the knowledge and learning of medicinal plants and biomedical drugs? We investigated this question in a context of intermedicality, exploring previous experiences and the duration of diseases at the individual, family, and community levels.

Methods: We conducted our study in a rural community in Northeast Brazil. We use individual semi-structured interviews to gather information on people's knowledge and learning of medicinal plants and biomedical medications, as well as their prior experiences perceived with diseases at different levels (individual, family, community) and their duration perceived.

Results: The knowledge of medicinal plants can be explained mainly by the previous experience of the disease in the community and the family. For medicinal plant learning in one year, only the previous experience in the community is relevant, but it had a negative influence. Regarding the knowledge of biomedical drugs, we observed positive influence of previous experiences in the family and community and negative influence of the diseases' duration. Finally, none of the predictor variables explained the learning of knowledge of drugs of biomedical origin.

Conclusions: The present study suggests important mechanisms that regulate the knowledge and learning of new treatments (medicinal plants and medicines of biomedical origin) in medical systems.

Keywords: Evolutionary Ethnobiology, previous experience, risk perception, local medical systems, biomedical system.

Background

The human species has adapted bioculturally to illness episodes throughout evolutionary history (Brown 1987, Fabrega 1997). In this case, learning and sharing knowledge and practices for treating illnesses have been important for maintaining health in human populations (Díaz-Reviriego *et al.* 2016, Reyes-García *et al.* 2009, Reyes-García *et al.* 2016). Different medical systems representing the body of knowledge and procedures for the identification, prevention, treatment, and evaluation of therapeutic outcomes have been developed in many human groups in the pursuit of a cure (Kleinman 1978). Among the various medical systems, we can highlight the local (also known as traditional or folk) medical systems, which are found in small local human groups and primarily use medicinal plants, and the biomedical (also known as cosmopolitan or western) medical system, whose main treatment strategy is the prescription of industrialized drugs that are sold on a large scale (Dunn 1976).

These two medical systems can coexist so that the treatments with biomedicine and medicinal plants can complement each other (Giovannini *et al.* 2011, Ndiaye & Sarli 2014). In some cases, to improve treatment, medicinal plants and medicines of biomedical origin are used simultaneously (Nascimento *et al.* 2018). We understand, therefore, that the interactions between the local and the biomedical systems involve hybridization processes (Ladio & Albuquerque 2014) in which treatments from these systems do not have to be mutually exclusive. The study by Santoro and Albuquerque (2021) demonstrates that the presence of modern medicine can contribute to the increase of treatments in a local community, indicating that the two forms of knowledge grow together over time.

Seeking to understand which factors related to diseases can affect knowledge of prevention and cure strategies, some studies have found that the frequency of occurrence can explain the number of resources known to treat them, both of biomedical origin (Santoro & Albuquerque 2021) and local origin, such as medicinal plants and animals (Nascimento *et al.* 2016, Santoro *et al.* 2015). There is also evidence that a community's perception of the frequency of diseases affects learning about new resources for treatment (Santoro & Albuquerque 2021).

These studies have demonstrated that in comparison to other factors, such as the perceived severity, the perceived frequency of the disease is more important in explaining the knowledge of local treatments (Nascimento *et al.* 2016, Santoro *et al.* 2015). The same studies also observed that severity was negatively associated with frequency, which helps to explain the severity's limited significance. In other words, diseases that were considered to be serious may be associated with low risk since they were probably unfamiliar to people in the communities studied. These findings are consistent with research on how people perceive environmental risks, which indicates that adopting mitigation strategies is influenced by prior exposure to the risk-related event (see Wachinger *et al.* 2013). For Wachinger *et al.* (2013), previous experience with risk refers to an event that has already occurred to an individual or other people and resulted in damage. This experience can be classified as either "direct", where the person was exposed to a risky situation, or "indirect", where the person learns about the event from others or from reading the news (Wachinger *et al.* 2013). In this case, studies have demonstrated a link between prior exposure to environmental risks, including floods, volcanic eruptions, tsunamis, and droughts, among others, and the adoption of risk-mitigation actions (Ruin *et al.* 2007, Wachinger *et al.* 2013). In this sense, it is possible to suggest that the behavior in response to health threats is stimulated by the risk perception of the disease (Wang *et al.* 2012), which would be driven by the incidence of the disease rather than necessarily its severity.

In addition, people create an action plan to combat the disease, and while it remains active, an evaluation of the effectiveness of the treatment concerning the disease's progression takes place (Castro *et al.* 2013, Leventhal *et al.* 2016, Wilkinson *et al.* 2009). Therefore, the perception of a disease's duration is another factor that can affect the number of known treatments (see, for example, Tanaka *et al.* 2009). When a disease persists for a very long time, individuals usually look for novel therapies, such as choosing medications of biomedical origin with the possibility of combining them with medicinal plants (Amoroso 2004, Medeiros *et al.* 2016, Nascimento *et al.* 2018). For diseases that have a longer duration in a local medical system, it may be advantageous in this situation to know a larger variety of treatments.

In light of the aforementioned evidence, we can expect that individuals would incorporate information about medicinal plants and medicines of biomedical origin over time, especially for certain diseases, based on factors related to previous experience and the duration of the disease. In this sense, we examined in this study whether previous experience with diseases and their perceived duration can affect people's knowledge of medicinal plants and medicines of biomedical origin. We also looked at how these same factors might impact the knowledge of novel medicinal plants and new medicines of biomedical origin learned by people within a year.

To study the impact of previous experience on knowledge and learning (knowledge of new treatments) in medical systems, we modified the initial categorization of previous experience ("direct" and "indirect"). Based on the multilevel approach presented by Reyes-Garcia *et al.* (2016) and the most recent conceptual synthesis for Ethnobiology (Albuquerque *et al.* 2021), in which processes at different levels have been proposed, we have also chosen to categorize previous experience with diseases into three groups (or levels): (1) previous individual experience (PEI), which refers to the situation in which the disease occurred with the individual in the past; (2) previous family experience (PEF), which considers the experience reported by the individual through illnesses that occurred with people who live in the same residence; and (3) previous experience perceived in the community (PEC), which takes into account the individual's experiences with diseases that occurred with other people in the community who do not belong to his residence.

To the best of our knowledge, we still know very little about the influence of previous experience (considering different levels) and disease duration on the knowledge of treatments in medical systems in hybridization scenarios. Even rarer are the studies that examine the role of previous experience in different levels and the duration of the disease in learning new treatments over time in these systems.

Specifically, this study aimed to investigate whether the factors (1) previous experience with the disease (in the individual, in the family and in the community) and (2) the duration of the disease affect the knowledge and learning of disease treatments with (a) medicinal plants and (b) medicines of biomedical origin. In this sense, we tested the following hypotheses (H1): previous experience (individual, family, and community) and the duration of the disease positively influence the knowledge of disease treatments; (H2) the previous experience (individual, family and community) and the duration of the disease positively influence the learning of new treatments.

Material and Methods

Study area and characterization of participants

This research was carried out in a rural community in the municipality of Casa Nova, located on the margins of BR-235, in the northern region of the state of Bahia, 572 km from the capital Salvador, being part of the Northeast (NE) region of Brazil (Fig. 1). Casa Nova (9 ° 24 '29' 'S, 41 ° 9' 29 '' W) is 9,647.069 km² in length. The region's climate is dry tropical, and "semi-arid", with an average annual rainfall of 485 mm and an average annual temperature of 25.4°C (Cidade Brasil 2020, Prefeitura de Casa Nova 2020, IBGE 2010).

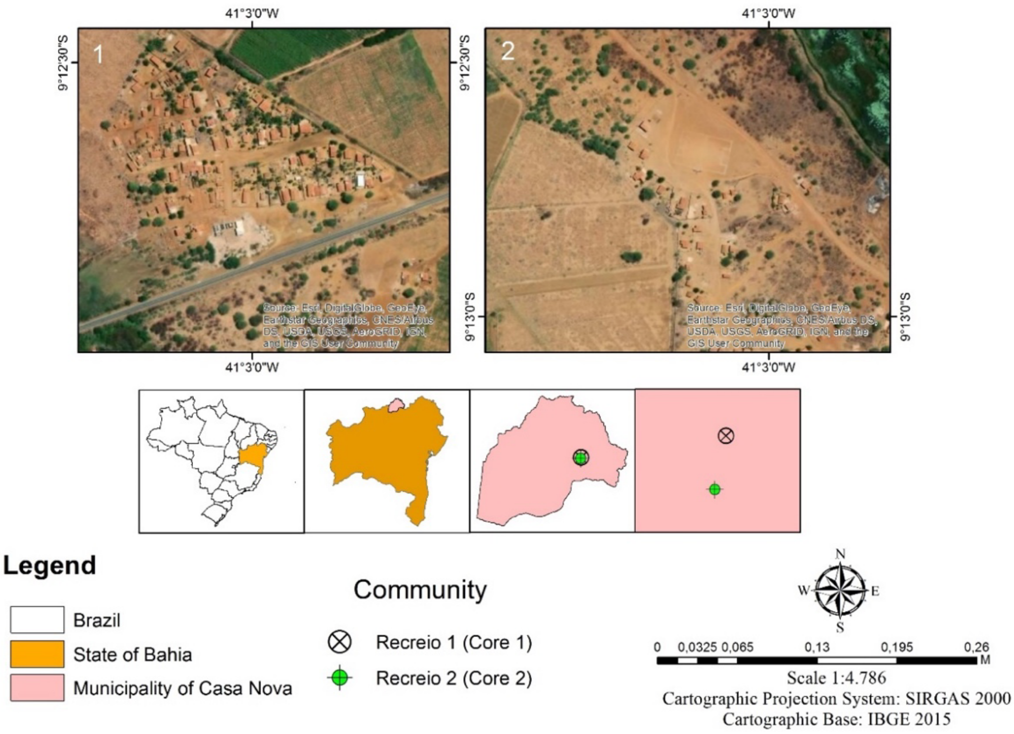

Figure 1. Study area: Recreio community, composed of the Recreio 1 and Recreio 2 nuclei, Casa Nova, state of Bahia (Brazil).

According to the latest Census of the Brazilian Institute of Geography and Statistics (IBGE 2010), the municipality of Casa Nova, in 2010, was composed of 64,944 inhabitants, with 37,543 people residing in the urban area and 27,397 in the rural area (IBGE 2010). The number of people living outside the urban scope and in small rural communities represents approximately 42.2% of the population of the municipality, signaling an expressive workforce in the countryside. The city of Casa Nova stands out for its agricultural production, where "banana", "coco-da-bay", "guava", "lemon", "papaya", "mango", "passion fruit" and "grape" are grown, the latter of which has gained relevance due to the production of wines, attracting tourists to the city's wineries (IBGE 2017).

Regarding the economy, part of the inhabitants of the municipality lives with limited financial resources, as shown by the 2010 IBGE census (IBGE 2010), in which 49.4% of the people had an estimated per capita monthly income of 50% of the minimum wage [that is, R $ 255.00 at the time] (IBGE 2010). In a more recent census, IBGE found that only 9.6% of the population (7,016 people) of Casa Nova worked in formal jobs, with an average salary of 1.6 minimum wages [therefore, R $ 1,499.20, considering that the minimum wage for 2017 was R $ 937.00] (IBGE 2017). The aforementioned data point to a difficulty in obtaining income through formal urban jobs.

For the selection of the study community, the following criteria were considered: the cultivation and use of medicinal plants; proximity to the city; periodic presence of a doctor (every 15 days), thus increasing the chances of people knowing, having access to and using medicines of biomedical origin. In addition, its location close to the BR-235 facilitated the arrival, contact and permanence of the research team in the field for data collection.

The Recreio community represents a rural human group that lives close to the urban center of the municipality of Casa Nova, allowing access to biomedical products and Complementary Alternative Medicine. They are not part of any indigenous group or recognized as a traditional Brazilian community but are the result of years of miscegenation and carry with them important traditional practices that make up their cultural identity, such as the existence of their own local medical system. The community is composed of two nuclei, Recreio 1 (Nucleus 1) and Recreio 2 (Nucleus 2), distant from the urban center of the municipality 9 and 10 km, respectively. The two nuclei are quite integrated, separated only by the BR-235 route, which allows the constant flow of people. In addition, the Association of Rural Workers, community representation, medical assistance and the performance of the community health agent are unified. From an interview with the community health agent, it was registered that the community is composed of 466 people, distributed in 137 homes. We were also informed that the doctor provides care to families at the headquarters of the municipal school only in Recreio 1. In addition, for specialized medical care of urgency and emergency, it is usually necessary to travel to the headquarters of the municipality.

Another important aspect is the socioeconomic situation. The Recreio community has an average income of R$ 631.40, which represents 63% of Brazil's minimum wage in 2019 (R $ 998.00), the year in which data collection was completed. In addition, there is no health post in the community and no basic sanitation, so water is distributed and reserved in cisterns in homes, and there is also no adequate garbage collection, with open sewers. These characteristics can favor the spread of infectious diseases.

Through visits and interviews with local residents, we found that 33.96% of the interviewed residents work for a season in agriculture, in seasonal crops. These people remain employed for approximately 4 months a year, generally performing informal jobs the rest of the year, which creates an unstable social condition for this portion of the population.

Approximately 26% of participants receive assistance from the Federal Government, such as Bolsa Família (income transfer program of the Brazilian government), representing 20.54% of the minimum wage (reaching a maximum of R $ 205.00, if the family is composed of 5 people). Other sources of income involve pensions and / or retirement (30.18% of respondents), in the case of the elderly. Only 9.45% of the participants have formal jobs. Therefore, 60.37% of the population lives in conditions of socioeconomic vulnerability.

As for education, the participants are distributed as follows: 20.78% have no education; 47.16% of people completed only elementary school; 30.18% finished high school and only 1.88% have completed higher education. This indicates that the majority of the adult population of the Recreio community lacks greater opportunities for access and permanence in the formal education system.

Data collection

Initially, we visited the Recreio community for the first contact with the community leader (president of the Rural Association of the community), in order to present the study and its objectives. On this occasion, the leader approved the research in the community. After this stage, a major project, entitled "Knowledge and use of resources in human groups in the Caatinga of Northeast Brazil", of which the present work is part, was submitted and approved by the Research Ethics Committee of the University of Pernambuco (CAAE: 89897518.6.0000.5207). Residents who agreed to participate in the research were invited to sign the Free and Informed Consent Form (ICF), in accordance with resolution 466 of December 12, 2012 from the National Health Council.

This study was carried out in two stages, and, for its realization, we invited all residents aged 18 years or over to participate in the study. In the first stage, carried out from March to July 2018, 69 people accepted to participate in the research and were interviewed through semi-structured interviews. With each participant, we applied the free list technique (Ladio & Molares 2014), in which they were invited to list all known medicinal plants. Subsequently, we used the supplementary reading back technique, that is, we read all the plants mentioned, in order to help the participant to remember additional plants that he knows and had not yet mentioned (Brewer 2002). From the plants mentioned, we asked which disease each plant was indicated for treatment, and if the participant knew biomedical drugs that also treated each disease mentioned. If the answer to this last point was positive, we invited the participant to list the biomedical drugs known for the disease, and then we applied the reading back technique to the list of biomedical drugs already mentioned (Brewer 2002).

In the second stage, 16 people gave up or were not found during the field visits. In total, 53 participants were interviewed individually, 38 women and 15 men, aged between 19 and 94 years. In this step, carried out between March and July 2019, we used the data previously collected to build a specific protocol on the interviewees' previous experience in three categories (individual, family and community) for each disease mentioned by them in step 1. At this point, the participants were free to remove or add any treatment they forgot to mention in the first stage, which was important for updating their individual lists. Still at this stage, data were collected on the knowledge of new plants and medicines of biomedical origin, after a one-year interval between the two stages, for each disease.

In this second stage, the questions involved: "how much did the disease occur with the interviewee in the last year?" to collect information about previous individual experience. Then, we asked how much each disease occurred in the family context, in the last year. For this question, we list the people who live with the interviewee and ask about the frequency of occurrence of the disease in each of the family members (except the participant). Only the interviewee answered about the frequency of the disease in each family member. Through this approach, we obtained information on the frequency of occurrence of diseases for 172 people, due to data related to the family, since the families of the Recreio community have an average of 3 members.

Finally, we questioned how much each disease occurred in the community in the last year, reflecting the experience that the participant had with the disease based on what was observed in the community, with people who do not belong to the interviewee's family. For questions about previous experience, the answers were recorded on a Likert scale (Linkert 1932), with (0) for "it did not occur", (1) for "it occurred few times", (2) for "more or less" and (3) for "it happened many times". At this stage, we also investigated the perceived duration of the disease, asking "how long does someone get cured from this disease?" For this last question, we consider the answers in days.

To collect data on learning new plants in the last year (see Sousa *et al.* 2016 for the importance of recent use in free lists), we asked "in the last year, did you learn any new plants to treat this disease? If so, which one?". And, to quantify the learning of medicines of biomedical origin, we asked "in the last year, did you learn any pharmacy medicine to treat this disease? If so, which one?". We note the names of the new medicinal plants and the new medicines of biomedical origin learned in the last year for each disease. We know that learning is a complex process from which skills and knowledge are developed, behaviors and values are modified and acquired. In this study, we use this word in a more limited scope, referring only to the appearance of a new item in the treatment of a disease. For example, learning will be measured when new biomedical drug or previously unknown medicinal plants become known.

During data collection, we strive to preserve the information obtained during the interviews from the point of view of the local logic. According to Ryan (1998), we used the information about signs and symptoms provided by the interviewee, to the detriment of biomedical criteria and descriptions, to identify diseases and classify them as chronic and acute. In this sense, still based on Ryan (1998), we consider as chronic the diseases that the participants claimed that it is not possible to achieve a cure within 1 year; those that the participants did not know how to inform the duration time; and diseases that have their symptoms controlled only with the uninterrupted use of biomedical drugs, or through surgery, for example, hypertension, nervousness, diabetes, heart problems, kidney problems and stroke. Following the same reasoning, non-chronic diseases are all those that the informants were able to inform the duration of the disease and that lasted less than 1 year, for example, flu, fever, headache and stomach pain and indigestion. Therefore, we adopted parameters similar to those used by Ryan (1998), however, as we remain in the field for a long time, we extended the period for the definition of chronic diseases from 3 weeks (the period used by Ryan 1998) to up to 1 year.

It is also important to highlight that the term "therapeutic targets" was used for this manuscript instead of diseases, since the definitions and symptoms described by the participants were considered. In this way, we understand that, sometimes, people treat symptoms as “diseases” and, in these cases, we do not know which disease is linked to the indications of the participants, such as in the work of Santoro *et al.* (2015). The delimitation of the study in relation to the choice of the local point of view to record the therapeutic targets was important to test our hypotheses, since the factors linked to the previous experience and the duration of the disease involve the participant's perception of the events of diseases. The same logic was applied to the medicinal resources listed by participant. We recorded popular names for both medicinal plants and drugs of biomedical origin for each participant. We took care to individualize each item listed for the participant (plant or medicine of biomedical origin), clarifying doubts directly with him, when necessary, if two or more names referred to the same plant or medicine of biomedical origin.

Data analysis

To assess whether previous experience and duration of the disease affect knowledge of medicinal plants and medicines of biomedical origin, in addition to knowledge of new treatments (plants and medicines of biomedicine) in 1 year, we used General Linear Models (GLM), Poisson family. We considered as dependent variables: (1) the number of medicinal plants known for each disease per participant; (2) number of biomedical drugs known for each disease per participant; (3) number of new medicinal plants known in a year for each disease per participant; and (4) number of new biomedical drugs known in one year for each disease per participant. As independent variables, we used: (1) previous experience with the disease in the individual, measured on a scale of 0-3; (2) previous experience with the disease in the family (scale 0-3); (3) previous experience perceived in the community (scale 0-3); and (4) duration of the disease, measured in days. This last variable was subjected to a base 10 logarithmic transformation, due to the scale discrepancy in relation to the other variables. For the variable frequency of occurrence in the family, we only considered the greatest frequency value derived from the participant’s response to a particular disease. For instance, if a participant reported that only two family members had the disease in a previous year, and that it had “occurred a few times” in one and “happened many times” in the other, we would only consider that the disease had occurred frequently (value 3 on the scale) in the family.

It is important to note that chronic diseases have symptoms that are too long or are rarely cured (Poureslami *et al.* 2017, Rheault *et al.* 2021), such as cancer, vascular diseases, diabetes, and chronic lung diseases, among others (Hajat & Stein 2018, Wang *et al.* 2016). Since the present study aims to investigate whether perceived characteristics of diseases can interfere with the knowledge of medicinal plants and medicines of biomedical origin, it was necessary to consider only acute diseases for testing the hypotheses, since chronic diseases have a time of very long duration, which could bias the data of the participants associated with the perceived previous experience and the perceived duration of the disease. In this case, for chronic diseases, some participants did not know how to inform the duration, since it tends to be long, and it is difficult to achieve a cure.

We submitted the data to verify the assumptions for linear models in the following sequence: (1) Shapiro-Wilk test to verify the normality of the data distribution, in which we observed that all variables showed non-normal distribution; (2) Bartlett test to ascertain the homogeneity of the variances, and (3) Spearman's correlation test to assess whether the predictor variables are correlated, being verified that the Previous Experience in the Community (PEC) and Previous Individual Experience (PEI) are positively correlated ($rho = 0.3844356$; $p = 3.391e-14$), as well as PEC and Previous Family Experience (PEF) ($rho = 0.3368892$; $p = 4.675e-11$), in addition to PEI and PEF ($rho = 0.2774632$; $p = 8.025e-08$). We also observed that PEF and disease duration time (DDT) have a negative correlation ($rho = -0.1221622$; $p = 0.02$). That is, all the predictive variables associated with the frequency of occurrence of the disease (Previous Experience), at the three levels, are significantly correlated, so they were used in separate models.

We compared the models constructed from the Δi AIC (Akaike Information Criteria) and the weight of each model, in order to compare the values of Delta AIC (Δi) to define which models best describe the variation of the response variables, considering even a null model (Mazerolle 2004, Santos *et al.* 2020). The criterion adopted to select the important models is based on the Delta AIC values (Δi) found, selecting those that present the least loss of information, when compared to the best model, from the following scale: Δi <2 indicates that the model is highly relevant; Δi between 3 and 7 informs that the model has less solid evidence; and Δi> 10 points to an excessively uncertain model (Mazerolle 2004, Santos *et al.* 2020). All analyzes were performed using the R version 3.6.1 program (Mazerolle 2004, Santos *et al.* 2020) with a significance level of 5%.

Results

In total, the participants indicated 153 ethnospecies (average of 11.87 per participant), 133 drugs of biomedical origin (average of 6.24), to treat 82 diseases (average of 1.54). The most cited diseases were "flu" (influenza), mentioned by 79.24% of the interviewees, followed by "belly pain" (47.16%), "arterial hypertension" and "indigestion" (both with 41.50%), in addition to "nervousness" (anxiety) (32.07%). Many of the most cited diseases were also indicated by respondents with higher values of previous experience in the last year, such as "flu" (influenza, 134 episodes of the disease), "belly pain" (abdominal and pelvic pain, 127 cases), "fever" (49 cases), "indigestion" (dyspepsia, 38 cases) and "arterial hypertension" (35 cases). The total number of episodes of the disease in the community listed above exceeds the number of participants, as they include individual episodes and cases in the participants' family. For all levels studied, we found that flu and belly pain are the most common illnesses perceived in the last year. We insert a list of therapeutic targets, plants and medicines of biomedical origin cited by participants in supplementary information (SI-Table 4).

The diseases that presented a greater number of medicinal plants were (a) "flu", with 52 medicinal plants indicated for its treatment, the most indicated plant being ***hortelã*** (mint) with 18 mentions; (2) belly pain, with 44 plants mentioned, with the "umburana de cheiro" being recommended by most people (11); (3) indigestion, 21 plants indicated for treatment with ***umburana de cheiro*** being the most cited; (4) fever, with 19 plants mentioned, wherein ***eucalipto*** (eucalyptus) and ***hortelã*** (mint) were the most mentioned (11 times); (5) injury, with 18 plants indicated, with the ***mastruz*** being indicated 5 times for treatment.

The diseases that presented the highest number of biomedical drugs indicated were (1) influenza: with 25 biomedical drugs known for treatment, with ***syrup*** (generally used as an expectorant, with several syrups of different compositions and brands) the most indicated (15 indications) ; (2) belly pain: 17 biomedical drugs mentioned, with 8 indications for ***Sonrisal®*** (acetyl salicylic acid, sodium carbonate, citric acid and sodium bicarbonate); (3) headache (headache) with 14 biomedical drugs indicated, with ***Anador®*** (dipyrone) and ***Dipyrone*** being the most indicated, with 8 indications each; (4) Injury: 14 medications and 4 indications of a healing pomade (the participants were unable to provide the trade name) and (5) fever: 8 medications indicated, ***Dipyrone*** was the most cited biomedical drug, with 15 indications. We would like to point out that in this study we consider a new biomedical drug when it is mentioned with a different name. For example, we know that ***Dipyrone*** and ***Anador®*** correspond to the same active principle, but they are cited in different ways, as they are marketed under different names (sold by different laboratories). When we deal with the learning of new biomedical drugs, this can also reflect the learning of a new medicine with the same active principle of a previously known medicine.

Regarding the learning of new medicinal plants and biomedical drugs in one year (2018 to 2019), 51 medicinal plants were learned, with an average of 0.96 among the participants, and the diseases with the highest number of plants learned were "flu" and "belly pain", with 9 and 6 plants, respectively. During this period, 50 biomedical drugs were learned (0.94 on average), with "flu" and "headache" being the diseases with the highest number of biomedical drugs learned, 6 and 5 biomedical drugs, respectively.

Does previous experience and duration of the disease affect the knowledge and learning of medicinal plants?

The results follow the model comparison criterion based on the Delta AIC (Δi) values, that is, only the important models will be detailed in this section. We show the tables with all models tested in Supporting information. The best models to explain the behavior of the MP variable involve Model 1 (Δi = 0) and Model 3 (Δi = 2.4). Model 2 and the null model presented Δi> 10, being very uncertain to explain the MP variable. These results are shown in Table 1. In addition, we verified in models 1 and 3 that only the variables PEC and PEF positively and significantly explain the knowledge of medicinal plants, as well as PEC involves a more important factor than PEF, because model 1 has less information loss and more weight than model 3. The supporting information presents graphs that illustrate the results found (Figures 1-4).

Table 1. GLM Model 1 for knowledge of medicinal plants (response variable), the independent variables being the previous experience in the community and the duration of the disease, and Model 3 for knowledge of medicinal plants (response variable) having previous experience in the family as an independent variable.

Model 1				
Coefficients				
Estimate	**Std.**	**Error**	**z value**	**Pr(>|z|)**
(Intercept)	0.56681	0.08153	6.952	< 3.60e-12 ***
Previous experience in the community	0.12828	0.02782	4.611	4.01e-06 ***
Duration of the disease	-0.03045	0.06607	-0.461	0.645
Dispersion parameter for Poisson family taken to be 1				
Null deviance: 318.28 on 361 df		AIC: 1192.6		
Residual deviance: 296.68 on 359 df		Number of Fisher scoring iteractions: 5		
Model 3				
Coefficients				
Estimate	**Std.**	**Error**	**z value**	**Pr(>|z|)**
(Intercept)	0.58606	0.04766	12.297	< 2e-16 ***
Previous experience in the family	0.13127	0.03100	4.234	2.3e-05 ***
Dispersion parameter for Poisson family taken to be 1				
Null deviance: 318.28 on 361 df		AIC: 1195		
Residual deviance: 301.07 on 360 df		Number of Fisher scoring iteractions: 5		

* Significance code: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '' 1.

Our data indicate an increase in the number of plants known for the disease, as the previous perceived experience of these diseases in the community (PEC) and in the family increases (PEF). We also observed that the PEI and DDT variables did not significantly explain the knowledge of medicinal plants.

Regarding the learning of new medicinal plants in one year, we observed that the most important model is model 1 (Δi = 0), given that the others assume very high Δi values and very low weights (Supporting information). In this sense, we show in Table 2 the results of M1.

Table 2. GLM Model 1 for the Learning of Medicinal Plants in one year, with independent variables being the previous experience in the community and the duration of the disease.

Coefficients				
Estimate	**Std.**	**Error**	**z value**	**Pr(>|z|)**
(Intercept)	-1.3256	0.2857	-4.641	3.47e-06 ***
Previous experience in the community	-0.3612	0.1384	-2.609	0.00907 **
Duration of the disease	-0.5264	0.2940	-1.790	0.07340 .
Dispersion parameter for Poisson family taken to be 1				
Null deviance: 318.28 on 361 df		AIC: 1192.6		
Residual deviance: 296.68 on 359 df		Number of Fisher scoring iteractions: 5		

* Significance code: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '' 1.

Our findings indicate that only the PEC variable is significant (p <0.05) to explain the learning of medicinal plants in the period of one year. However, this relationship is negative, that is, diseases perceived with a greater previous experience in the community (PEC) in the previous year, tend to have less medicinal plants learned over the course of a year (Supporting information). The PEI, PEF and DDT variables did not significantly explain the LMP variable.

Does previous experience and duration of the disease affect knowledge and learning of drugs of biomedical origin?

We observed that the best model to explain the knowledge of biomedical medicines is model 1 (Δi = 0), followed by model 3 (Δi = 2.3). In addition, models 2 and null were discarded due to their Δi values much greater than 0 (Supporting information). In sequence, Table 3 and 4 shows the results obtained from model 1 and 3.

About previous experiences, models 1 and 3 showed that the high perception of the occurrence of the disease in the community (PEC, see Figures in SI) and in the family (PEF, see Figures in SI) significantly increases the number of known biomedical drugs. About the duration of the disease (DDT), Model 1 demonstrates that it is a significant factor (p <0.05), but negatively influences the knowledge of biomedical drugs of biomedical origin, that is, as the duration of the disease increases, the knowledge of biomedical drugs decreases. However, considering our Spearman correlation analyses, in which PEF and DDT are inversely correlated, this last result (inverse relationship between DDT y known biomedical drugs) may be an indirect consequence of the positive relation between PEF and biomedical drugs knowledge and the negative correlation between PEF and DDT. Finally, we observed that the learning of new drugs of biomedical origin in one year was not explained by any of the independent variables used in this study.

Table 3. GLM Model 1 for the Knowledge of Biomedical Medicines, the independent variables being the previous experience in the community and the duration of the disease.

Coefficients				
Estimate	**Std.**	**Error**	**z value**	**Pr(>|z|)**
(Intercept)	0.08806	0.12167	0.724	0.469185
Previous experience in the community	0.15434	0.04173	3.699	0.000217 ***
Duration of the disease	-0.48907	0.11497	-4.254	2.1e-05 ***
Dispersion parameter for Poisson family taken to be 1				
Null deviance: 450.04 on 361 df		AIC: 889.49		
Residual deviance: 414.70 on 359 df		Number of Fisher scoring iterations: 5		

* Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘’ 1.

Table 4. GLM Model 3 for the Knowledge of Biomedical Medicines, with the independent variable being the previous experience in the family.

Coefficients				
Estimate	**Std.**	**Error**	**z value**	**Pr(>|z|)**
(Intercept)	-0.36832	0.07605	-4.843	1.28e-06 ***
Previous experience in the family	0.25644	0.04470	5.737	9.61e-09 ***
Dispersion parameter for Poisson family taken to be 1				
Null deviance: 450.04 on 361 df		AIC: 891.84		
Residual deviance: 419.06 on 360 df		Number of Fisher scoring iterations: 5		

* Significance code: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘’ 1.

Discussion

Our findings demonstrated that knowledge of treatments based on biomedical medications as well as medicinal plants is influenced by the participant's previous experience with the disease occurring in the community and the family. Additionally, the duration of the disease had an inverse effect on the knowledge of biomedical drugs, although this finding may be due to the influence of other factors, especially the negative relationship between the duration of the disease and previous experience with the disease by family members. On the knowledge of medicinal plants, we did not find the same influence on the duration of disease. Additionally, our findings demonstrate that the individual previous experience with a disease is unrelated to the knowledge of medicinal plants and medicines of biomedical origin.

As shown by Santoro *et al.* (2015) and Nascimento *et al.* (2016), there is a greater knowledge of treatments in the medical systems oriented to the treatment of diseases that are considered by people as more frequent, which may explain how our findings relate to the role of the disease’s frequency. In this regard, the work of Tanaka et al. (2009) provided theoretical models that demonstrated how the frequency of disease can affect how much information is shared about it. In this instance, the higher the frequency of the disease the greater the number of people who can share treatment information. As a result, our research’s findings suggest a process that may be connected to previous experience with the disease as perceived at the community and family level, which may help to explain why local medical systems focus their treatments on diseases that are seen to be very common.

The results show that the events of the disease in the community (previous experience in the community) and at home (experience in the family) may be more relevant to people's knowledge of treatments than the occurrence of the disease with the individual (previous individual experience). This is possible as a result of the disease that affects numerous members of the family and the community frequently, increasing the chances for people to discuss their experiences and share knowledge about treatments.

Culture can be viewed as a cumulative system of collective inheritance, according to Reyes-García *et al.* (2016), which is related to our finding, since the PEF and PEC factors interfere with the knowledge of medicinal plants and biomedical medicines. Our result illustrates behavior associated with collective adaptation in the knowledge of disease treatment (Reyes-García *et al.* 2016). Perhaps, the necessity to treat common diseases has influenced how knowledge about treatments is constructed (Ladio & Lozada 2004, Nascimento *et al.* 2018, Santoro *et al.* 2015). It is interesting to highlight the fact that research studies that dealt with the influence of the frequency of occurrence, measured it from methodologies that considered a collective perspective (Nascimento *et al.* 2018, Santoro *et al.* 2015, Santoro & Albuquerque 2021). Gathering our evidence, we can conclude that a phenomenon that occurs on a collective level affects knowledge at the individual level.

The findings of our study regarding the knowledge of medicines of biomedical origin demonstrated that the same mechanism (namely, collective previous experience with diseases) that influences the knowledge of medicinal plants also influences the knowledge of biomedicine treatments. Our findings may support the idea that treatment knowledge develops through social interactions in a human population (Santoro *et al.* 2018) and this knowledge is not restricted to the family, it is also shared with friends (van't Klooster *et al.* 2016) and members of the local community. In addition, the need to communicate knowledge about treatments that have a high adaptive value due to use is created through family interaction between people of different generations in the context of coping with diseases, which is a behavior that benefits memory (Brito *et al.* 2019).

In addition to previous experience, studies have revealed that the duration of the disease may be significant to the sharing of therapeutic information (Tanaka *et al.* 2009). However, the relationship between disease duration and the increase in the number of known treatments was not observed in our results involving medicinal plants. Instead, we observed that the duration of the disease is inversely related to the knowledge of pharmaceuticals. We must offer a potential explanation for this evidence, even though this result may be a result of the interaction between our variables, reflecting an indirect relationship rather than an inverse direct association between, in particular, DDT and biomedical knowledge.

In this sense, as the disease progresses, people can associate medicinal plants with medicines of biomedical origin (Dræbel & Gueth Kueil 2014, Nascimento *et al.* 2018) since survival becomes threatened (Wilkinson & Whitehead 2009). Therefore, the greater the duration, the greater the opening to industrialized treatments, so that the integrated use of the two medical systems can represent a strategy to favor the cure (Langdon 2004, Soldati & Albuquerque 2012). Since biomedical drugs are specific in their actions, a disease that lasts a long time allows people to understand which biomedical drugs work and which do not, allowing people to stay with only those who treat the disease. An individual can experiment with many treatments during a rapid event of a disease, but this disease quickly ends its "natural" cycle, leading the individual to assume that all medications used have been effective. Such an example can be attributed to a phenomenon called causal mismatch, generating a misjudgment that attributes the cure of a disease to an inefficient treatment, thus giving rise to maladaptive traits (Abbott & Sherratt 2011, Arkes 1991, Greene 1998). In short, the few known industrialized biomedical drugs are sufficient to cure diseases that medicinal plants sometimes cannot treat. Thus, we think that the "causal mismatch" may be less likely to occur in diseases with a longer duration and with treatments that have a more specific activity, such as biomedical drugs, which may lead to a decrease in the number of biomedical drugs known for these diseases.

Or results also show that as the disease has greater previous experience perceived in the community it results in a limited amount of learning in a single year. We believe that people form their therapeutic repertoires for diseases with greater previous experience and with greater occurrence in the community, favoring therapeutic safety for these diseases and, in this sense, reducing the learning of new treatments over time. In other words, diseases that are already well known, in which people have many previous experiences, already have their therapeutic framework consolidated, and learning with new resources is not so necessary. On the other hand, people need to learn new treatments for diseases they have little previous experience with.

Although knowledge of medicinal plants is influenced by previous experiences, the same does not happen with the learning of new information about other type of resources, as biomedical drugs. We can speculate that the learning of biomedical drugs can occur in other ways that are unrelated to previous experience. As they are external resources to the local medical system, it is possible that their learning takes place in specific events of contact with the biomedical system, whether through conversations during visits to urban pharmacies or television advertisements, among other possible learning pathways.

It is interesting to note that our study is associating previous experience with learning new medicinal resources, but the experience may also be influencing other forms of learning about the treatment, as more efficient forms of preparation and administration, resignifications, alternative uses, etc. It is also important to emphasize that our results refer to a period of one year, between one data collection and another. Our time range may have limited the capacity of our study to capture the learning strategies. At this point, it is worth considering that despite the short time of the study, we observed a close number of new drugs of biomedical origin known in one year (50 new biomedical drugs), when compared to the number of new medicinal plants (51 new plants). In addition, we observed from the general results that plants and medicines of biomedical origin were indicated mainly for the two diseases most cited among the participants, so biomedicine has become an integral part of the community's medical system, which allows the expansion of the possibilities of treatments available to treat diseases (Nascimento *et al.* 2018, Soldati & Albuquerque 2012), in this case, important diseases. Regarding the learning of new medicinal plants and medicines of biomedical origin, it is still necessary that future studies extend and prolong the duration of the research, to better understand the dynamics of what drives the learning of treatments in medical systems.

Finally, our findings have limits to be projected for the local system studied as a whole, since only a part of the local residents agreed to participate in the study, although we invited all residents over 18 years old to participate in the research. However, we were able to interview local specialists, recognized by residents as experts in treatments and who help residents in the treatment of their illnesses. In this case, our findings may reveal how the investigated factors shape the knowledge of plants and medicines of biomedical origin at the individual level, considering an important part of people who live in a rural community in a context of intermedicality.

Intermedicality involves the interaction between the local system (including knowledge of treatments related to medicinal plants and animals, prayers, healing rituals, among others) and biomedical knowledge and practices in the same human group (Greene 1998, Soldati & Albuquerque 2012). Considering that the knowledge and learning of treatments involving the two medical configurations can be influenced by different factors, it is interesting that future studies consider the greatest number of possible factors to verify at which points the two systems converge and at which points they diverge, enabling a greater understanding of the dynamics of intermedicality in medical systems.

Conclusions

Our findings suggest that knowledge of resources from the two medical configurations responds in a similar way to previous experiences. Also, the collective experiences are more relevant than the individual experience, emphasizing the importance of the collective levels for knowledge of treatments. Furthermore, we observed that the duration of the disease does not influence the repertoire of medicinal plants and negatively affects the repertoire of medicines of biomedical origin. However, this last find must be analyzed with caution, given the interaction between our variables. If the negative interaction is explanatory, a relatively small repertoire can cope with curing the symptoms of prolonged illnesses, without the need to know many biomedical drugs.

The smaller the previous experience, the greater the need to learn new medicinal plants. The same does not occur with the learning of industrial biomedical drugs. Therefore, the learning about new biomedical information follows a different logic than the learning about plants, perhaps industrial drugs are learned in opportunistic events of contact with biomedicine, or television advertisements, for example. This result may also be masking a phenomenon that could be seen in a longer period of time.

The present study suggests important mechanisms that regulate the knowledge and learning of new treatments (medicinal plants and medicines of biomedical origin) in medical systems.

Declarations

Ethics approval and consent to participate : This study was submitted and approved by the Research Ethics Committee of the University of Pernambuco (CAAE: 89897518.6.0000.5207). Participants signed the Free and Informed Consent Form (ICF), in accordance with resolution 466 of December 12, 2012 from the National Health Council.

Consent for publication: Not applicable

Availability of data and materials : The authors have made available the results of the statistical models and graphics in supplementary file.

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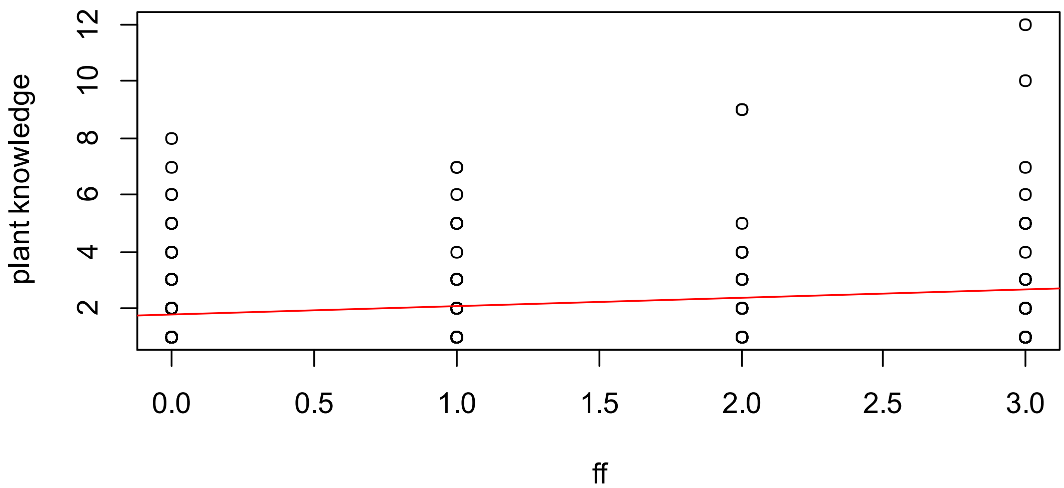
Supporting information

(1A)

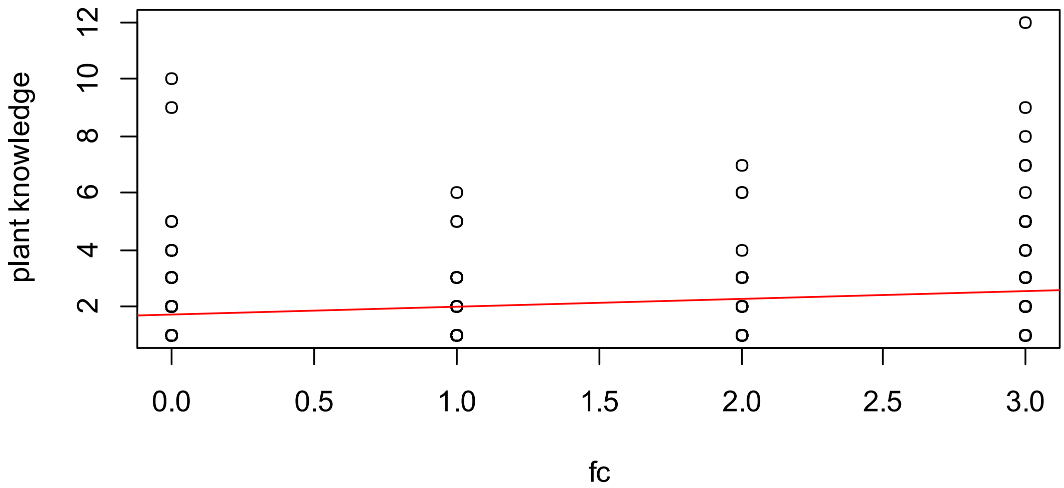
SI-Table 1. Nested models and null model, based on values of AIC, Delta AIC (Δi), degrees of freedom (df) and weight, considering the effect of the variables Previous Individual Experience (PEI), Previous Family Experience (PEF), Previous Community Experience (PEC) and Disease Duration Time (DDT) in knowledge of Medicinal Plants (MP), in the Recreio community, Northeast Brazil.

Models	AIC	Δi	df	weight
Model 1: (MP ~ PEC + DDT)	1192.6	0.0	3	0,76
Model 2: (MP ~ PEI + DDT)	1209.4	16.8	3	<0,001
Model 3: (MP ~ PEF)	1195	2.4	2	0,23
Null model	1345.3	152.7	2	<0,001



SI-Figure 1. Representative graph of the number of known medicinal plants (Knowledge of Medicinal Plants) according to the predictor variables, Previous Experience in the Family (ff) (Figure 2A) and Previous Experience in the Community (fc) (Figure 2B), in the community Recreio, Northeast Brazil.

(1B)

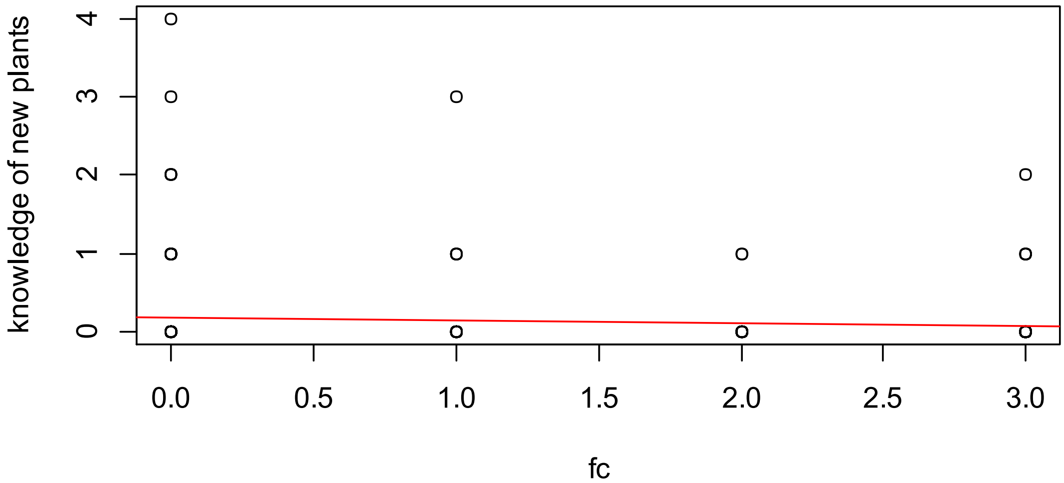


SI-Figure 2. Representative graph of the number of medicinal plants learned (learning of medicinal plants) in a year, according to the predictor variable Previous experience in the Community (fc).

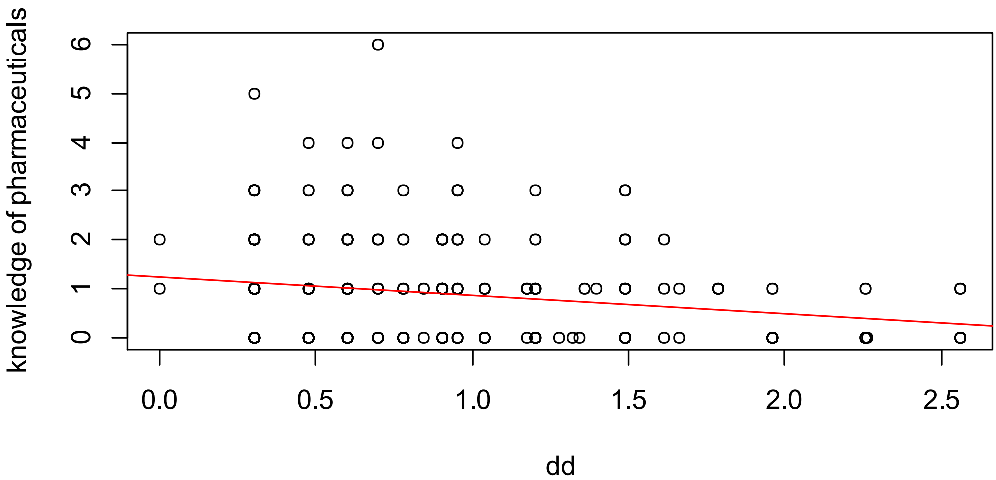
SI-Table 2. Nested models and null model, based on AIC values, Delta AIC (Δi), degrees of freedom (df) and weight, considering the effect of the variables Previous Individual Experience (PEI), Previous Family Experience (PEF), Previous Experience in the Community (PEC) and the Duration of the Disease (DDT), in relation to the dependent variable Learning of Medicinal Plants (LMP) in one year, in the Recreio Community, Northeast Brazil.

Model	AIC	Δi	df	weight
Model 1: (LMP ~ PEC + DDT)	292.98	0.0	3	0,904
Model 2: (LMP ~ PEI + DDT)	299.28	6,3	3	0,039
Model 3: (LMP ~ PEF)	301.86	8,8	2	0,011
Null model	453.69	160,7	2	<0,001

(3A)



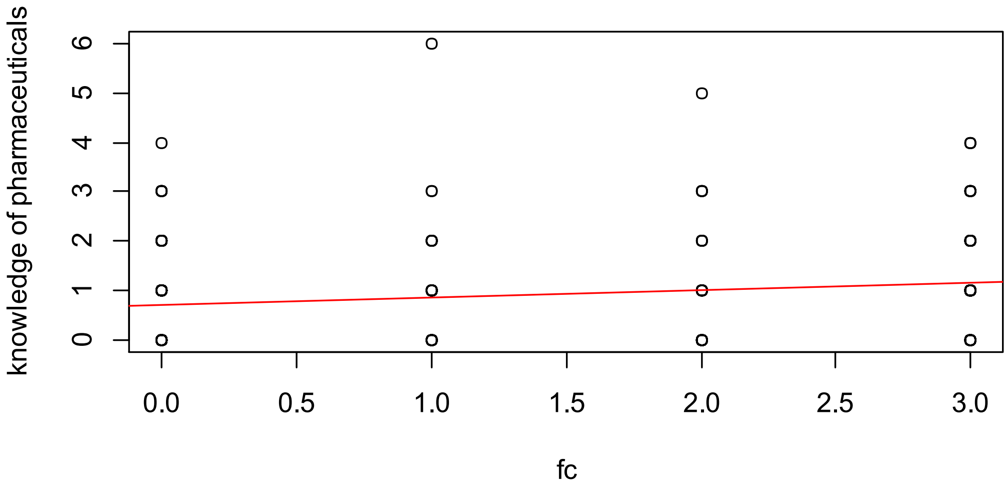
(3B)

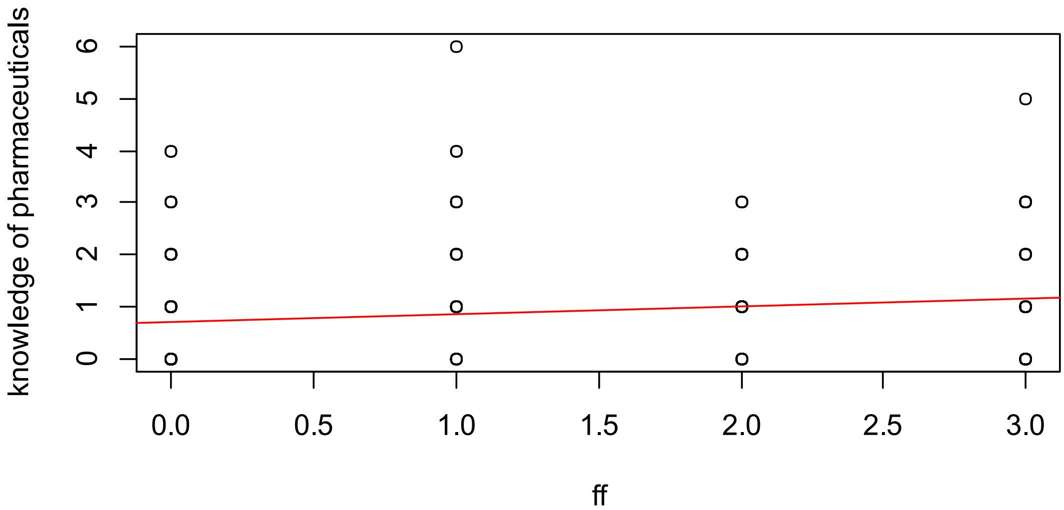


SI-Figure 3. Graphs representative of the number of known biomedical drugs (knowledge of pharmaceuticals), according to the predictive variables Duration of Disease Duration (dd) (Figure 3A) and Previous Experience in the Community (fc) (Figure 3B).

SI-Table 3. Demonstration of the analysis of nested models and the null model, based on values of AIC, Delta AIC (Δi), degrees of freedom (df) and weight, considering the effect of the variables Individual Previous Experience (PEI), Previous Experience Family (PEF), Previous Experience in the Community (PEC) and the Duration of the Disease (DDT), in relation to the dependent variable Knowledge of Biomedical Medicines (BM), in the Recreio community, Northeast Brazil.

Model	AIC	Δi	df	weight
Model 1: (BM ~ PEC + DDT)	889.49	0.0	3	0.7550
Model 2: (BM ~ PEI + DDT)	898.43	8.9	3	0.0086
Model 3: (BM ~ PEF)	891.84	2.3	2	0.2364
Null model	1039.6	150.1	2	<0.001





SI-Figure 4. Graph representing the number of known biomedical drugs (knowledge of pharmaceuticals), according to the predictor variable Previous Experience in the Family, in the Recreio community, Northeast Brazil.

SI-Table 4. List of therapeutic targets, medicinal plants and biomedical drugs, cited by respondents, study carried out in the Recreio community, Northeastern Brazil.

Alvos terapêuticos	Plantas medicinais	Medicamentos Biomédicos
abortion	acerola	hydrogen peroxide
allergy	agrião	alodipine
anemia	aipim	ambroxol
appendicitis	alecrim-de-canteiro	amitritine
arthrosis	alecrim-do-mato	amoxicillin
asthma	alface	ampicillin
bronchitis	alfazema	analgesic
healing after surgery	algaroba	antibiotic
cancer	algodão	anti-inflammatory
uterine cancer	alho	apevitin®
phlegm	alumã	apracur®
circulation problems	ameixa	acetylsalicylic acid
itch	amora	atroveran®
cholesterol	anador	azithromycin
baby colic	angico	benegrip®
menstrual cramps	arnica	berotec®
congestion	aroeira	bezentacil®
constipation in the eye	arruda	sodium bicarbonate
convulsion	aveloz	biotonic
heart problems	babosa	buclina®
stroke	barbatimão	buscopan®
dysentery	batata-de-tiú	cariban®
diabetes	batata-inglesa	calcitran®
gynecological disease	beringela	natural tranquilizer
belly ache	beterraba	captopril
headache	boa-noite	sedavan®
toothache	boldo	cephalexin
stomachache	boldo-amargo	celecrim
earache	bononi	cicatricure®
back pain	braúna	simvastatin
joint pain	cabelo-de-milho	clonazepam
body ache	caju	ciprofloxacin hydrochloride
pain in the foot of the belly	camará	loperamide hydrochloride
chest pain	camomila	corticotem
kidney pain	cana	losartan
nausea	canela	diazepam
discharge	canelinha	diclofenac
winepress	caninana	dimethicone
lack of appetite	cansanção-branco	dipyrone
fever	bananeira	doralgina
wound in the uterus	capim-santo	dorflex®
wound	caraibeira	doril®
liver problems	casca-da-banana	dramim®
bone fracture	catingueira	elixir
boil	cebola-branca	imosec®
gases	cenoura	emulsion
gastritis	chapéu-de-couro	estomazil®
the flu	chuchu	expec®
bleeding	coco	expectrim
indigestion	coentro	figatil®
infection	couve	fluoxetine
urinary infection	cravo	frectrin
infertility	crista-de-galo	gardenal®
throat inflammation	endro	gastrol®

insomnia	erva-cidreira	gelol®
malaise	erva-doce	glicamim®
evil eye	eucalipto	glifage®
stuffy nose	favela	gripazil
teething	feijão-de-corda	hydrochlorothiazide
nervousness	folha-santa	ibuprofen
ovary problems	gameleira	hydrochlorothiazide
hit	gengibre	infectrin®
kidney stone	gergilin	insulin
post childbirth	girassol	iodine
high pressure	goiaba	lacto-purga®
liver problem	hortelã	luftal®
blood problem	hortelã-miuda	magnesium
problem in the uterus	insulina	maracujina®
kidney problem	jamelão	melhoral®
prostate problem	jatobá	meracillin
pus	juazeiro	metformin
regulate menstruation	jurema-preta	merthiolate®
cold	jurubeba	nimesulide
dryness	laranja	multigrip®
rheumatism	leite-de-banana	nervocalm®
hoarseness	limão	novalgina®
measles	losma	omeprazole
sinusitis	malva	ouvidonal®
child fright	malva-branca	paracetamol
cough	malva-santa	ginger tablet
worm	malvão	mint tablet
redness	mamão	petivit®
wart	mameleiro	ointment
vomit	mamona	vaginal ointment
	mandacaru	pressomede®
	manga	promil®
	manjericão	ranitidine
	manjericó	rifocina®
	maracujá-do-mato	salbutamol
	marcela	celestamine®
	marcela	cibalena®
	marmeleiro	sinvax®
	mastruz	ciprofloxacin
	melancia	sonrisal
	melão-de-são-caetano	ferrous sulphate
	milindro	tandene®
	miroró	terramicina®
	mostarda	tylenol®
	muçambé	tretex®
	mulatinho	valsartan
	mulungú	vick®
	noni	voltaren®
	noz-moscada	syrup
	pai-pedro	
	papaconha	
	pau-branco	
	pau-brasil	
	pau-d'arco	
	pau-ferro	
	pepino	
	pereiro	

pichuri
pimenta
pimenta-do-reino
pimenta-malagueta
pinha
pinhão-roxo
pitanga
ponta-fina
pruma
quebra-faca
quebra-pedra
quiabo
quina-quina
quixabeira
romã
rosa vermelha
salgueiro
são-gonçalo
semente-de-abobora
sena
seriguela
sete-dores
sete-misturas
tamarindo
tangerina
timbaúba
tipi
trançagem
truquia
umburana de cambão
umburana-de-cheiro
umburuçu
umbuzeiro
uva
vaselina
vassourinha-de-nossa-
senhora
velame
vick