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Perceived efficiency and local consensus as factors shaping medicinal plant knowledge

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ABSTRACT

Environmental perception goes through physiological, psychological, and cultural filters and can influence the selection and usage of species. Additionally, sharing cultural information is a crucial social strategy for our species' survival. From this standpoint, knowledge that aligns with the local context is typically the most widely "expressed" and/or "replicated" by individuals. Building upon this premise, our objective was to investigate whether knowledge about local medicinal plants is influenced by certain adaptive factors, such as perceived efficacy, perceived availability, and perceived frequency of diseases. The study was conducted with 73 individuals from five rural communities in Vale do Catimbau National Park, Buíque, Pernambuco, Brazil. A free list of medicinal plants and their therapeutic uses was employed. Using these free lists, we employed a salience index to determine consensus within the local diversity. We employed a generalized linear model with a binomial distribution to ascertain whether perceived efficacy, perceived availability, and perceived disease frequency account for the local consensus. Of the three variables analyzed, only perceived efficiency explained the local consensus on the use of medicinal plants ($p < 0.002$). This result indicates that perceived efficiency is the key factor determining the most popular medicinal plant when requested for memory recall, regardless of the perceived availability of the plant or the perceived frequency of diseases it treats. However, looking through the evolutionary perspective, the main question is to understand whether this factor is the only determinant in explaining the nature of the generation of medicinal plants' salience, or if other 'cofactors' of the social-ecological systems act together in an important way to guide this process as well.

Keywords: Evolutionary Ethnobiology; Ethnobotany; Human Ecology; Ecological anthropology; Cultural salience.

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SIGNIFICANCE STATEMENT

This study holds significance in unraveling the complex factors that influence the selection of local medicinal plants, shedding light on the adaptive nature of cultural knowledge transmission. By examining the interplay of physiological, psychological, and cultural filters, the research uncovers how perceived efficiency plays a central role in determining the most prominent medicinal plants, irrespective of their availability or disease frequency. This insight highlights the pivotal role of perceived efficiency in shaping local pharmacopeias.

INTRODUCTION

The perception of nature concerns how individuals perceive the natural world through their senses and can influence the selection of species to become part of their social-ecological systems (Albuquerque et al. 2022). Individual perception undergoes physiological, psychological, and cultural filters, allowing human populations to develop complex medical systems throughout their evolutionary history. For instance, organoleptic properties, like taste, serve as cues for the chemical efficiency of medicinal plants, as taste is often linked to secondary compounds that are effective in treating specific ailments (Medeiros et al., 2015).

The perceived efficacy of a medicinal plant by individuals, for instance, can impact the sharing of information about that plant, given its adaptability in certain contexts. In this context, as outlined by Ferreira Júnior and Albuquerque (2015), these plants can constitute a structural core that represents the most widely used medicinal plants within a local medical system. The popularity of these plants is connected to adaptive factors such as (1) their effectiveness, (2) their availability, and (3) the range of diseases they can treat. In the realm of disease treatment, these factors may be crucial for enhancing the cultural and biological well-being of individuals in a local medical system.

If the most expressed medicinal plants have adaptive characteristics for local medical systems, what factors would support this knowledge distribution?

Some studies have shown that knowledge of medicinal plants in local medical systems is not homogeneously shared by people, characterizing "consensus within diversity" (Barrett 1995; Casagrande 2002; Ferreira Júnior and Albuquerque 2015), wherein few of the known medicinal plants are highly popular, while the majority are little known. In other words, people "express" a specific type of information more often than other types in such systems, and this behavior allows us to examine the possible adaptive factors influencing the achievement of this "consensus." To this end, the present study aimed to verify whether this sharing trend shapes the structure of local knowledge of medicinal plants—an important domain of knowledge para a sobrevivência humana in social-ecological systems.

Based on the key hypothesis put forth by Ferreira Júnior and Albuquerque (2015), we examined whether structural core medicinal plants exhibit adaptive traits that address therapeutic needs in a local medical system. They would represent a "basic kit" of the shared knowledge about medicinal plants that would keep medical systems functioning across space/time, meeting the present and future healing needs of local populations. Theoretically, they would be the most efficient, be available in the environment, deal with the most common local diseases, and if we consider the mnemonic factors in this equation, share organoleptic properties that facilitate social learning, such as perceptual cues like a bitter taste and sweet smell (Casagrande 2002).

Despite the adaptive factors proposed by Ferreira Júnior and Albuquerque (2015) being rooted in the efficiency, actual availability of plants, and the real frequency of diseases within a community, we will employ cognitive/perceptual factors for all variables. As previously mentioned, human perception of natural resources and the surrounding environment is a crucial factor in understanding the utilization and knowledge of medicinal plants (Albuquerque et al. 2015).

Among the significant aspects related to human perception is the perceived efficacy of medicinal plants. Several studies have demonstrated the positive role played by this factor in the selection and utilization of plant resources (Clement et al. 2007; Santos et al. 2018; Tomchinsky et al. 2017). For instance, in the study conducted by Gama et al. (2018), they discovered that perceived efficacy is a significant factor in explaining the popularity of both exotic and native species in the local pharmacopoeia.

Another aspect is associated with resource availability. When assessing perceived availability, discordant evidence exists in the literature. Some studies indicate that perceived availability influences the use of medicinal plants (Gama et al. 2018), while others show that this variable does not exert influence (Santos et al. 2018).

The prevalence of diseases within a system affects the cognitive processing of information about medicinal plants used to treat those diseases (Ferreira Júnior et al. 2019; Silva et al. 2019). Evidence of this phenomenon lies in the fact that therapeutic targets perceived as more frequent are linked to a greater number of medicinal species when compared to less frequent therapeutic targets (Ferreira Júnior et al. 2011; Santoro et al. 2015; Nascimento et al. 2016).

Building upon these pieces of evidence, we aim to investigate the correlation between these three variables and the popularity of medicinal plants.

We will use our results with those available in the literature to answer some fundamental questions about the influence of these individual perceptual factors in the direct knowledge of medicinal plants. Thus, in the present study, we tested three hypotheses: (H1) the perceived efficiency of medicinal plants positively affects their local importance, whereby we expected that (P1) plants mentioned first most frequently and by most people (as measured by cultural salience) would show the highest overall perceived efficiency in treating various diseases; (H2) the perceived availability of medicinal plants positively affects their local importance, whereby we expected that (P2) plants mentioned first most frequently and by most people (as measured by cultural salience) exhibit the greatest overall perceived availability in the local environment; and (H3) the perceived frequency of diseases in the community positively affects the local importance of medicinal plants, whereby we expected that (P3) plants mentioned first most frequently and by most people (as measured by cultural salience) treat the highest number of diseases with overall high perceived frequency.

MATERIAL AND METHODS

Characterization of the study area

The present study was performed in Vale do Catimbau National Park (PARNA do Catimbau; 8°3254.2" S 37°1449.6" W), Integral Protection Conservation Unit of the state of Pernambuco, Northeast Brazil (ICMBio 2016). The park boundaries were established on December 13, 2002, covering an area of 62,294.14 ha, encompassing the municipalities of Pernambuco, namely, Ibimirim, Tupanatinga, and Buíque (ICMBio 2016). The park has a semiarid tropical climate with a Caatinga ecosystem (Brazilian savanna). The mean annual temperature is 23°C, and the mean annual precipitation is 486–975 mm, with rainfall concentrated between March and July (Specht et al. 2019). Despite being a completely protected conservation unit and inhabitation being prohibited by Brazilian law, at least 17 small communities live in this region. This situation has generated a series of sociopolitical conflicts related to the legality of these local communities and their land use rights (Specht et al. 2019). The residents of these communities live in a subsistence regime, with small plantations of beans and corn, and raise livestock, such as goats, chickens, and cattle, for consumption and sale. The nearest village and main entrance to the park is Vila do Catimbau, with approximately 2,240 inhabitants (Silva et al. 2020).

There is no health post inside the park; thus, any minor or routine emergency care must be performed at the Family Health Post in Vila do Catimbau. Severe or overly complex emergencies are managed in neighboring cities. There are no schools inside the park, but the city government provides school buses to transport children to an elementary school in Vila do Catimbau. Some families in this region have government assistance and receive basic food baskets, education, and free medical assistance provided by the nongovernmental organization, Amigos do Bem (www.amigosdobem.org), whose infrastructure is located at the park entrance. This organization is responsible for educating all children inside the park and assisting local populations through national and international donations.

Finally, PARNA do Catimbau is the second largest archeological park in the country, with evidence of human population and natural resource use dating nearly 6,000 years ago (Rufino et al. 2008). It is located 285 km from Recife, the state capital of Pernambuco (Castro et al. 2016).

The present study was performed in five communities residing in the interior of the park, namely, Igrejinha, Muquém, Túnel, Açude Velho, and Dor de Dente (figures 1 and 2). All communities studied have similar housing characteristics, live under subsistence, water scarcity, and depend on natural resources for survival. According to data from the Family Health Post of Vila do Catimbau, Igrejinha had approximately 112 residents, Muquém had 38 residents, Túnel had six residents, Açude Velho had 17 residents, and Dor de Dente had 13 residents (n = 186) (figure 2). We interviewed 39 people (age >18 years) in Igrejinha, 25 in Muquém, four in Túnel, three in Açude Velho, and two in Dor de Dente, totaling 73 residents. It is important to note that despite the official data, fieldwork identified many closed residences and nonlocalized residents, which must have reduced the total possible "n" of residents of the locality, at least at the time of our field research.

Ethical and legal aspects

We contacted the head of the Vila do Catimbau Family Health Center, which provides primary health care to all residents of the park, to gain access to general information and the total number of residents of each community studied and to explain the objectives of the study. We also spent several weeks building rapport with local communities. Following this, all people over 18 years of age who agreed to participate in the study were instructed to sign the informed con-

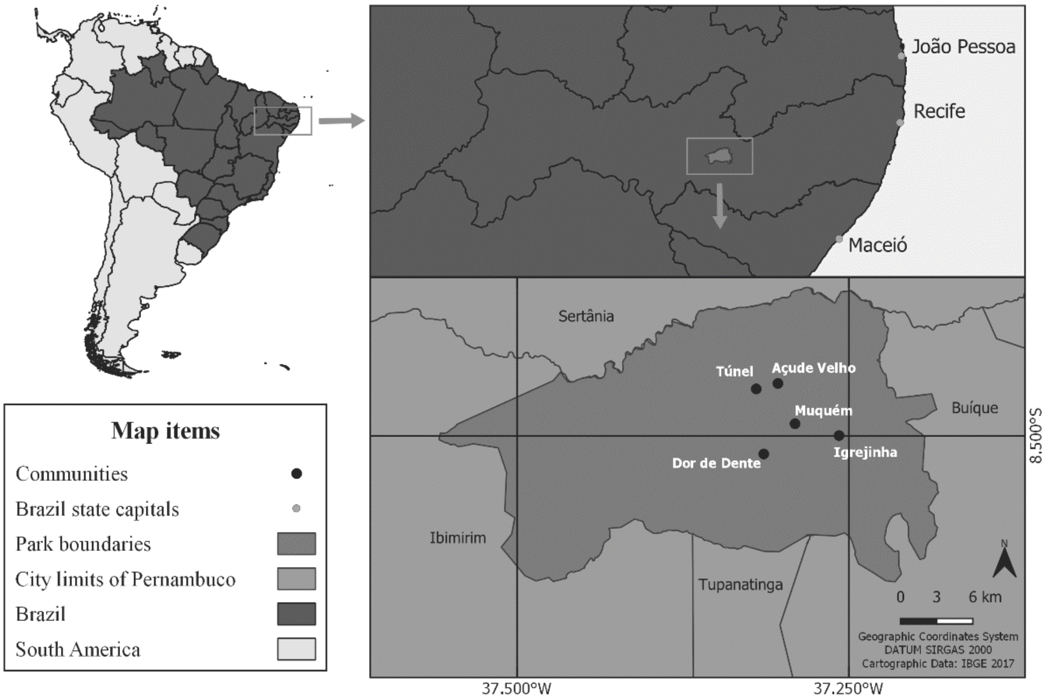

Figura 1. Map of Vale do Catimbau National Park boundaries and location of the studied communities.

sent form, by the current legislation of the Ministry of Health and Universal Declaration of Human Rights (Resolution 466/12 of the National Health Council, see Brasil 2012), which legally protects the identity of study participants and sharing of information collected. The study proposal was submitted to and approved by the Research Ethics Committee of the University of Pernambuco (CAAE: 89887817.6.0000.5207).

Collection of ethnobotanical data

The fieldwork was carried out over two periods. The first was from January 2017 to November 2017, involving a broad joint effort by the associated researchers from the National Institute of Science and Technology in Ethnobiology, Bioprospecting, and Nature Conservation (https://www.inctethnobio.com/), the Laboratory of Ecology and Evolution of Social-ecological Systems (https://www.evoethnobio.com). The second fieldwork was from January 2019 to April 2019. All interviews were conducted in Portuguese, the native language of both participants and researchers. The first period was dedicated to gaining the trust of local populations, and the second period to data collection. Two-stage interviews were conducted to test our hypotheses. In the first stage, we made individual free lists of medicinal plants (Albuquerque et al. 2019a; Bernard 2006) through one question only "Which plants serve as a remedy that you know?" This procedure allowed us to record the order in which medicinal plants were mentioned by each person. Then, for each plant recalled, we asked the informant to indicate the respective therapeutic targets. Since the concept of disease in local communities is not always consistent with that established by international biomedical organizations, we considered "therapeutic targets" according to the emic perception of diseases (Santoro et al. 2015). As explained by Santoro et al. (2015), *"therapeutic targets can refer to symptoms such as fever and coughing or to a set of symptoms that constitute a more complex condition such as influenza."*

The second stage of the interview was based on a Likert scale—a psychometric test in which people specify their level of agreement on a particular study question, typically as numerical values (Likert 1932). In this stage, we sought to measure the informants' perceptions of our three study variables (plant efficiency, availability, and disease frequency) using a metric scale from 1 to 10For each plant mentioned in the free list, we inquired with the informant about their overall perceived effectiveness, ranging from 1 (not very efficient) to 10 (highly efficient), in treating various therapeutic targets. Additionally, we asked about the overall perceived presence of these plants

Figura 2. (1) House in the Igrejinha community, PARNA Catimbau. The construction method is common throughout the study area and includes the use of clay and wood to create houses (Photo: Clara Assis). (2) Access road to the Dor de Dente community, PARNA Catimbau. Highlight indicates the grazing of goats belonging to the residents (Photo: Temoteo Luiz). (3) Dry cauldron of rainwater reserve in the Igrejinha community, PARNA do Catimbau (Photo: André Santos).

in the local environment, using a scale of 1 (scarce/not available) to 10 (abundant/very common). For each disease cited, we asked the participants about the overall perceived frequency of its occurrence in the community from 1 (little/infrequent) to 10 (very frequent).

It is important to point out that despite using the term perceived efficiency, we consider all the synonyms used in the scientific literature such as efficacy, effectiveness, etc. as equivalent terms. Conceptualizing efficiency is not a simple task and we prefer to skip the semantics arguing that it reflects a concept that explains the individual cognitive measure of calculating the perceived cost/benefit of medicinal plants, in matters of disease treatment.

Data analysis

The challenge in this study was to define as objectively as possible the information that would represent the structural core, as defined by Ferreira Junior and Albuquerque (2015). As the plants at the structural core are the most popular ones, we decided to measure the "local popularity" of the plants through a cultural salience index, calculated using cognitive analysis of the frequency of recall and ordering position of the responses to the free list (Quinlan 2005). However, the cultural salience index is a numerical continuum, and any attempt to define, without any pragmatic criteria, the items that should be part of the "structural core" or "nonstructural core" would be completely subjective, affecting the results of our analysis. Therefore, to determine these categories statistically and objectively, we used the salience threshold proposed by Chaves et al. (2019), as described below.

Chaves et al. (2019) compared free lists and saliences randomly generated in a statistical environment using the Monte Carlo method, considering a null analysis scenario with real-time free lists and saliences obtained in the field. For the null scenario generated to have the same characteristics as the real-time scenario, hypothetical free lists were generated from the same number of informants, the same number of items cited by the population, and the same average number of citations per free list obtained through the interviews (Chaves et al. 2019).

Finally, 1,000 random lists and their respective salience values were generated under these conditions. The "real" salience values calculated with the items collected based on free lists *in situ* were compared with the salience values obtained through the positions and frequency of citations under the null scenario. Using this statistic, "real" salience values stand out significantly from those expected under the null scenario, and there may be items with higher or lower salience values than those expected by chance. Accordingly, as suggested by Chaves et al. (2019), all medicinal plants with a less than 5% probability of occurrence in the top salience positions were considered significant and placed at the structural core. All other plants below this list were considered satellite plants for the classification criteria only (Table 1).

To test our hypotheses, we submitted a data-generalized linear model (GLM) analysis with a binomial distribution. The response variable, called "list of saliences," was a categorical variable with two levels, namely, "structural core" and "satellite plants," as described above, following the salience threshold analysis proposed by Chaves et al. (2019). As predictor variables, data on the perceived efficiency and availability of a plant and the perceived frequency of the diseases it treats were collected individually using a Likert scale. The purpose of this analysis was to verify whether these three predictors affected the increased odds of medicinal plants being at the "structural core". Scale scores from 0 to 10 were inputted into the analysis as absolute numbers for perceived plant efficiency and availability, as well as perceived disease frequency. All analyses were performed in R 3.5.2 (R Core Team 2018), and $p < 0.05$.

RESULTS

We recorded 96 known plants from 73 local individuals. Following the salience and statistical threshold analysis proposed by Chaves et al. (2019), we characterized the first 19 plants as the "structural core" ($p < 0.05$) and the remaining 77 as "satellite plants" (Table 1). Figure 3 shows a typical consensus within the diversity curve of 96 remembered medicinal plants structured by salience. Figure 4 also shows a classic "consensus within the diversity" curve for the first 38 plants. We made this cutout of 38 plants (19 structural core and 19 satellite plants) for didactic/illustrative purposes, also because the next 39 satellite plants became increasingly idiosyncratic. Tables 2 and 3 show the scientific names, salience values, average perceived effectiveness, and average perceived availability of the 19 plants in the structural core and the first 19 satellite plants, respectively. The average perceived efficacy and perceived availability of the structural core plants were 8.52 and 6.65, respectively, and those of the satellite plants were 7.45, and 7.05, respectively.

Tabela 1. Structure of knowledge about medicinal plants of the 73 residents of the communities Igrejinha, Muquém, Túnel, Açude Velho and Dor de Dente, communities located inside the Vale do Catimbau National Park, Buíque, Pernambuco, Brazil, after statistically cutting the salience list.

Salience order	Local name	Salience	'p' value
Structural core (19 plants)			
1	ameixa	0.5478	0.0000
2	quixaba	0.3557	0.0000
3	aroeira	0.3187	0.0000
4	jatobá	0.2697	0.0000
5	papaconha	0.1975	0.0000
6	bássimo	0.1797	0.0000
7	bom nome	0.1707	0.0000
8	mastruz	0.1667	0.0000
9	imburana de cambão	0.1503	0.0000
10	erva cidreira	0.1443	0.0001
11	babosa	0.1399	0.0004
12	angico	0.1391	0.0005
13	sassafrás	0.1369	0.0006
14	mororó	0.1332	0.0009
15	alcansus	0.1318	0.0009
16	quebra faca do sertão	0.1307	0.0011
17	imburana de cheiro	0.1303	0.0011
18	algaroba	0.1172	0.0056
19	juá	0.1128	0.0081
Satellite plants (77 plants)			
20	capim santo	0.0830	0.0936
21	baraúna	0.0807	0.1098
22	caju roxo	0.0776	0.1339
23	hortelã	0.0731	0.1781
24	jurubeba	0.0598	0.3538
25	arruda	0.0557	0.4253
26	federação	0.0530	0.5251
27	pau d'arco roxo	0.0484	0.4395
28	velame	0.0474	0.4210
29	catingueira	0.0427	0.3355
30	jenipapo	0.0423	0.3289
31	eucalipto	0.0410	0.3069
32	jurema preta	0.0405	0.2987
33	alecrim	0.0389	0.2711
34	pinhão brabo	0.0347	0.2068
35	jucá	0.0276	0.1139
36	piranha	0.0267	0.1039
37	pau de leite	0.0246	0.0841
38	alento	0.0237	0.0765
39	rabo de raposa	0.0229	0.0702
40	umbuzeiro	0.0215	0.0596
41	capeba	0.0195	0.0463
42	mandacaru	0.0195	0.0463
43	maracujá do mato	0.0187	0.0419
44	canzenzo	0.0178	0.0372
45	melancia	0.0178	0.0372
46	carrapixo de boi	0.0170	0.0331
47	pau d'arco	0.0168	0.0324

Salience order	Local name	Salience	'p' value
48	sambacaité	0.0160	0.0293
49	mulungu	0.0148	0.0254
50	moita de mulher	0.0144	0.0239
51	boldo	0.0137	0.0215
52	goiaba	0.0137	0.0215
53	alfavaca	0.0123	0.0166
54	quebra pedra	0.0123	0.0166
55	manjirioba	0.0118	0.0151
56	biratanha	0.0114	0.0136
57	manjericão	0.0111	0.0129
58	marmeleiro	0.0107	0.0118
59	japicanga	0.0105	0.0114
60	chumbinho de areia	0.0103	0.0109
61	canelinha	0.0100	0.0103
62	cabeça de nego	0.0098	0.0099
63	coqueiro	0.0096	0.0094
64	cambuim	0.0093	0.0086
65	ouricuri	0.0091	0.0084
66	feijão brabo	0.0090	0.0083
67	folha miúda	0.0090	0.0083
68	canafistula	0.0088	0.0079
69	pau ferro	0.0084	0.0072
70	cana de macaco	0.0068	0.0043
71	coroa de frade	0.0065	0.0041
72	vassourinha	0.0065	0.0041
73	louco	0.0060	0.0035
74	facheiro	0.0059	0.0034
75	espada	0.0057	0.0032
76	maracujá	0.0057	0.0032
77	melão de são caetano	0.0057	0.0032
78	andu	0.0055	0.0031
79	caiubinha	0.0055	0.0031
80	manjirioba	0.0055	0.0031
81	mijo de ovelha	0.0047	0.0022
82	beladona	0.0046	0.0021
83	romã	0.0043	0.0019
84	pau d'arco branco	0.0029	0.0009
85	jiquiri	0.0027	0.0009
86	maçaranduba	0.0027	0.0009
87	batata de purga	0.0026	0.0008
88	erva doce	0.0025	0.0008
89	marcela	0.0023	0.0008
90	abacate	0.0022	0.0007
91	araçá	0.0021	0.0006
92	pega pinto	0.0014	0.0003
93	sucupira	0.0014	0.0003
94	cabuci	0.0011	0.0002
95	caroá	0.0011	0.0002
96	amargoso	0.0007	0.0001

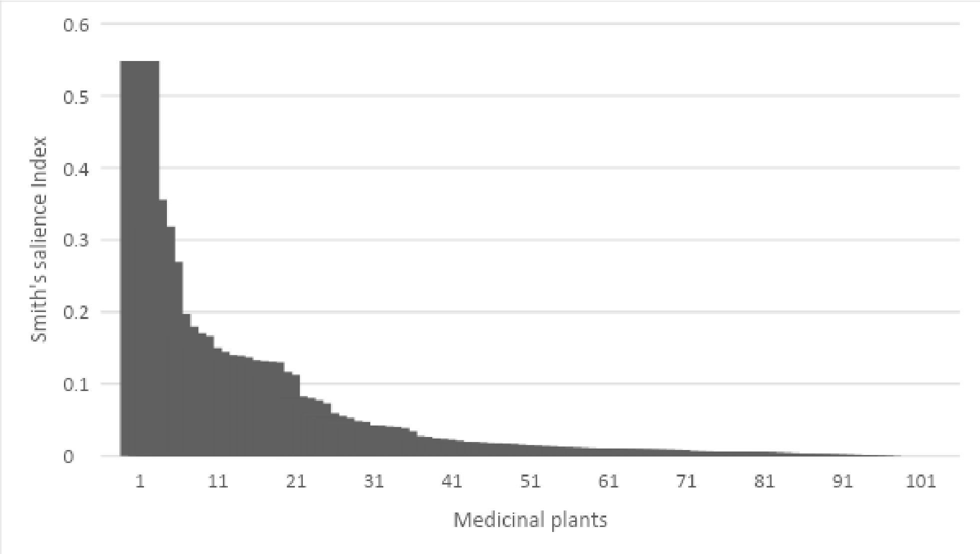

Figura 3. Distribution of salience of all medicinal plants (n = 96) recalled by the 73 residents in the communities Igrejinha, Muquém, Túnel, Açude Velho and Dor de Dente, located inside the Vale do Catimbau National Park, Buíque, Pernambuco, Brazil.

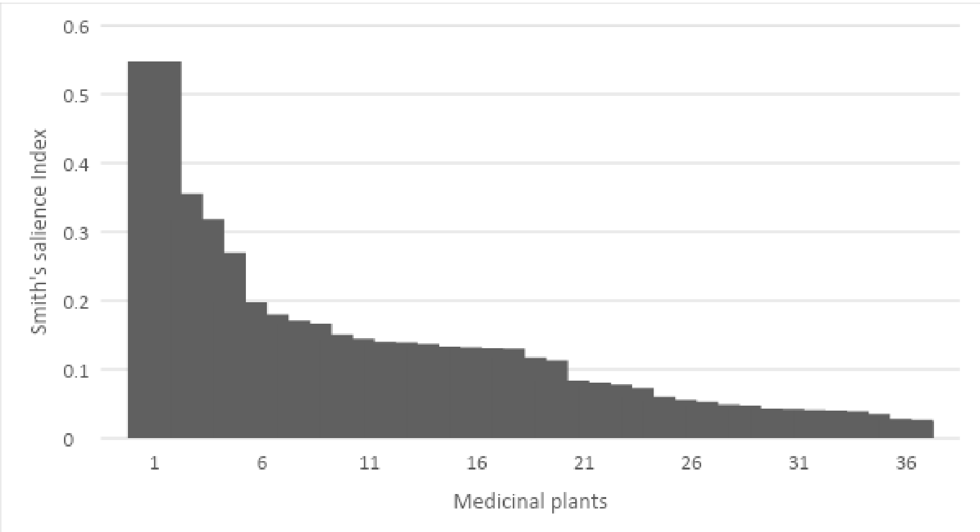

Figura 4. Projection of the first 38 medicinal plants (19 from the structural core and 19 from the satellites) most remembered by the 73 residents of the communities of Igrejinha, Muquém, Túnel, Dor de Dente and Açude Velho, communities located inside the Vale do Catimbau National Park, Buíque, Pernambuco, Brazil. We made this cutout of 38 plants for didactic/illustrative purposes.

Tables 4 and 5 show the distribution of the knowledge of these first 38 plants regarding their therapeutic indications, the popular name of each plant, total recall in the free lists, total therapeutic indications, the main therapeutic indications (most remembered per plant), and the total number of recalls of these main indications.

Of the three hypotheses analyzed in this study, only the perceived efficiency of a medicinal plant increased the probability of it being at the structural core ($p = 0.002$). In contrast, the perceived availability of a medicinal plant ($p = 0.772$) and perceived disease frequency ($p = 0.86111$) did not affect the composition of the structural core (most important local medicinal plants) (Table 6).

Tabela 2. Local name, scientific name, ranking of salience, an average of perceived efficacy and average of perceived availability of the 19 plants belonging to the structural core category of knowledge about medicinal plants from the communities of Igrejinha, Muquém, Túnel, Dor de Dente and Açude Velho, communities located inside the Vale do Catimbau National Park, Buíque, Pernambuco, Brazil. *not fertile materials. **identified locally. *** Plant not found. IPA: Herbarium Dárdano de Andrade-Lima.

Local name	**Scientific name**	**Voucher Herbarium**	**Salience rank**	**Avg perc effectiv**	**Avg perc availab**
ameixa	*Ximenia americana* L.	*	0.5478	9.09	8.58
quixaba	*Sideroxylon obtusifolium* (Humb. ex Roem. & Schult.) T.D. Penn.	*	0.3557	8.87	5.06
aroeira	*Myracrodruon urundeuva* Allemão	*	0.3187	8.19	5.45
jatobá	*Hymenaea courbaril* L.	IPA 91630	0.2697	9.16	7.08
papaconha	*Pombalia arenaria* (Ule) Paula-Souza	IPA 91628	0.1975	9.62	8.71
bássimo	*Myroxylon peruiferum* L.f.	**	0.1797	8.81	6.22
bom nome	*Maytenus cf. opaca* Reissek	IPA 91614	0.1707	9.08	8.66
mastruz	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	IPA 91613	0.1667	8.43	5.06
imburana de cambão	*Commiphora leptophloeos* (Mart.) J.B.Gillett	IPA 91627	0.1503	9.33	8.81
erva cidreira	*Lippia alba* (Mill.) N.E. Br	**	0.1443	7	6.25
babosa	*Aloe vera* (L.) Burm. F.	**	0.1399	8.62	7.86
angico	*Anadenanthera colubrina* var. cebil (Griseb.) Altschul	IPA 91649	0.1391	7.5	4.87
sassafrás	-	***	0.1369	9.5	5.43
mororó	*Bauhinia acuruana* Moric.	IPA 91660	0.1332	7.1	7.9
alcansus	*Periandra mediterranea* (Vell.) Taub.	IPA 91648	0.1318	8.3	3.88
quebra faca do sertão	*Croton* sp.	*	0.1307	7.9	5.2
imburana de cheiro	*Amburana cearensis* (Allemão) A.C. Sm.	*	0.1303	8.4	5.21
algaroba	*Prosopis juliflora* (Sw.) DC	IPA 93440	0.1172	8.35	8.92
juá	*Ziziphus cotinifolia* Mart.	IPA 91676	0.1128	8.78	7.35
		Arithmetic average		8.52	6.65

Tabela 3. Local name, scientific name, ranking of salience, average of perceived efficacy and average of perceived availability of the first 19 plants belonging to the satellites category of knowledge about medicinal plants from the communities of Igrejinha, Muquém, Túnel, Dor de Dente and Açude Velho, communities located inside the Vale do Catimbau National Park, Buíque, Pernambuco, Brazil. *not fertile materials. **identified locally. *** Plant not found. IPA: Herbarium Dárdano de Andrade-Lima.

Local name	Scientific name	Voucher Herbarium	Salience rank	Avg perc effectiv	Avg perc availab
capim santo	*Cymbopogon citratus* (DC.) Stapf	*	0.0830	5.14	7.28
baraúna	*Schinopsis brasiliensis* Engl.	*	0.0807	8.8	8.1
caju roxo	*Anacardium occidentale* L.	IPA 93683	0.0776	7.9	8.6
hortelã	*Mentha* sp.	*	0.0731	8.71	4.85
jurubeba	*Solanum paniculatum* L.	IPA 91633	0.0598	8.2	7.4
arruda	*Ruta graveolens* L.	*	0.0557	5.75	7
federação	*Acanthospermum hispidum* L.	IPA 91626	0.0530	6.2	7.8
pau d'arco roxo	*Tabebuia* sp.	*	0.0484	8.62	7.75
velame	*Croton micans* Sw.	IPA 91638	0.0474	9.5	7.75
catingueira	*Senna rizzini* Irwin & Barneby	IPA 91636	0.0427	7.66	8.66
jenipapo	*Tocoyena formosa* (Cham. & Schltdl.) K.Schum.	IPA 91681	0.0423	6.5	6.75
eucalipto	*Eucalyptus* sp.	*	0.0410	9.16	8
jurema preta	*Mimosa tenuiflora* (Willd.) Poir.	*	0.0405	5.75	7
alecrim	*Lippia origanoides* Kunth	IPA 91612	0.0389	6	6.75
pinhão brabo	*Jatropha molíssima* (Pohl) Baill.	IPA 91659	0.0347	9	6.4
jucá	*Caesalpinia férrea* Mart.	**	0.0276	8	3.5
piranha	*Guapira laxa* (Netto) Furlan	*	0.0267	9.33	6
pau de leite	*Sapium argutum* (Müll.Arg.) Huber	IPA 93499	0.0246	6.5	9.5
alento	-	***	0.0237	5	5
		Arithmetic average		7.45	7.05

Tabela 4. Local name, number of people who mentioned the plant, total therapeutic indications, main therapeutic indication, and total number of main indications of the 19 medicinal plants belonging to the structural core category of knowledge of the 73 residents of the communities of Igrejinha, Muquém, Túnel, Dor de Dente and Açude Velho, communities located inside the Vale do Catimbau National Park, Buíque, Pernambuco, Brazil.

Local name	**Total citation number**	**Number of therapeutic indications**	**Main therapeutic indications**	**Total main indications**
ameixa	42	53	inflammation	29
quixaba	30	36	inflammation	18
aroeira	28	31	inflammation	13
jatobá	28	32	anemia	10
papaconha	19	24	catarrh	9
bássimo	17	23	flu	8
bom nome	17	17	kidneys	12
mastruz	16	25	flu	6
imburana de cambão	16	18	flu	5
erva cidreira	16	19	bellyache	6
babosa	10	16	worms	2
angico	16	22	inflammation	3
			blood	3
			veterinary	3
sassafrás	16	17	gastritis	4
mororó	17	19	cough	5
alcansus	15	16	cough	10
quebra faca do sertão	13	16	bellyache	6
imburana de cheiro	17	19	cough	9
algaroba	13	15	inflammation	11
juá	15	19	flu	6
Total	361	437		178

Tabela 5. Local name, number of people who mentioned the plant, total therapeutic indications, main therapeutic indication, and total number of main indications of the first 19 medicinal plants belonging to the satellite category of knowledge of the 73 residents of the communities of Igrejinha, Muquém, Túnel, Dor de Dente and Açude Velho, communities located inside the Vale do Catimbau National Park, Buíque, Pernambuco, Brazil.

Local name	Total citation number	Number of therapeutic indications	Main therapeutic indications	Total main indications
capim santo	13	14	bellyache	3
baraúna	10	12	flu	4
			cough	4
caju roxo	11	12	inflammation	6
hortelã	6	10	catarrh	3
			cough	3
jurubeba	8	10	flu	4
arruda	6	6	therapeutic bath	2
			general pain	2
federação	8	9	fever	3
pau d'arco roxo	9	9	cancer	2
			general pain	2
velame	6	6	wound	2
			blood	2
catingueira	6	6	bellyache	1
			fortifying	1
			geriatric medicine	1
			nerves	1
			prostate	1
jenipapo	4	5	articulation pain	2
			limb twisting	2
eucalipto	7	8	fever	5
jurema preta	6	6	wound	3
alecrim	6	6	therapeutic bath	1
			herbal smoker	1
			general pain	1
			flu	1
			lung	1
pinhão brabo	5	5	snake bite	3
jucá	3	5	inflammation	2
piranha	2	3	contraceptive	1
			bone pain	1

Local name	Total citation number	Number of therapeutic indications	Main therapeutic indications	Total main indications
			veterinary	1
pau de leite	4	5	therapeutic bath	1
			lump	1
			itch	1
			blood	1
			veterinary	1
alento	3	3	flu	1
			worms	1
			veterinary	1
Total	123	140		80

Tabela 6. Results of the binomial generalized linear model. Estimated regression parameters, standard errors, “z” values, “p” values, and effects of predictors (“perceived efficiency” and “perceived availability”) on the categorical response variable “list of saliences” comprising two levels (“structural core” and “satellite plants”) are indicated. Effects of predictor variables on increasing the odds of a medicinal plant being at “structural core” are shown.

	Estimate	**Std. Error**	**z value**	**Pr(>|z|)**
(Intercept)	-0.508715	0.581363	-0.875	0.38155
Perceived efficiency	0.161005	0.052948	3.041	0.00236*
Perceived availability	-0.011491	0.039676	-0.290	0.77210
Perceived disease frequency	0.007804	0.044603	0.175	0.86111

DISCUSSION

Overall, our findings suggest that the perception of efficacy is a crucial factor that influences the formation of the structural core of medicinal plants. The perception of the availability and perception of the frequency of diseases does not. The important point of this work is to understand the reason for the behavior according to the logic of the distribution of the salience of medicinal plants and the social-ecological factors that may be involved in this process. Casagrande (2000; 2002) was a pioneer in this line of analysis in ethnobotany in local medical systems and argued that it is not so simple to determine why a plant becomes widely known as medicinal, as this depends on influences related to the quality of the plant (e.g., organoleptic properties), individual cognition, social factors, and factors that concentrate cultural transmission, such as time and disease prevalence. However, it is perceived effectiveness, above all, that is fundamental for remembering, acquiring, and disseminating knowledge that the plant in question is effective in altering culturally recognized harmful symptoms (Santos et al. 2018; Gama et al. 2018; Medeiros 2013; Casagrande 2002:93).

Previous studies have examined the impacts of a medicinal plant’s efficacy on its selection and utilization, relying on the presence of potentially active secondary compounds for medicinal purposes (Araújo et al. 2008; Khafagi and Dewedar 2000; Omar et al. 2000; Slish et al. 1999), and people’s perceived efficiency of plant resources and their implications for medical systems (Clement et al. 2007; Gama et al. 2018; Santos et al. 2018). These studies offer the following assumptions: not every plant perceived as efficient by individuals to treat diseases contains bioactive compounds to cure diseases (Araújo et al. 2008), and perception of efficiency is a fundamental variable in establishing the use of medicinal plants (Clement et al. 2007). As few studies directly analyze the relationship between cultural salience and the perception of efficiency, we will show below how this variable can act in several mechanisms of the local medical systems before focusing directly on the main question.

Clement et al. (2007) examined the impacts of perceived efficacy on the decisions of residents of the islands of Trinidad and Tobago to utilize plants for treating their illnesses. They found that 86% of individuals who employed medicinal plants believed in their effectiveness in disease treatment, providing a rationale for their usage.

In another study conducted by Santos et al. (2018), they explored the local medical behaviors of a community in Canabrava, located in the municipality of Barreiras, Bahia, Northeast Brazil. The study assessed whether the frequency of medicinal plant use for treating two common local diseases was influenced by three factors: perceived efficacy, ease of acquisition, and taste. They showed that the average use of medicinal plants for both diseases was influenced by a single factor: the perceived efficiency of plants. Gama et al. (2018) verified whether perceived efficiency, taste, and perceived availability influenced the decision to use exotic or native plants to treat four local targets (namely, cancer, flu, general inflammation, and hypertension).

They demonstrated that perceived efficacy was the most significant factor in explaining people’s choice to use both exotic and native plants. These findings highlight the predominant influence of perceived efficacy on modulating the behavior of self-medicating with plants, compared to other factors. Taken together, these reports add to the evidence from our study. Our results indicate that the most popular plants to the local population are always perceived as the most efficient. This finding is important for ethnobiology because it demonstrates that despite being context-dependent, the local importance (as measured by the cultural salience) of medicinal plants is explained by the perceived efficiency, reinforcing the arguments of Casagrande (2002).

Taking the empirical evidence from the studies of Casagrande (2000), Santos et al. (2018), and Caetano et al. (2019) and our results, the present study allows us to realize at least two new hypotheses regarding the performance of perceived efficiency in forming the structural core or consensual structure of medicinal plants through an evolutionary perspective. We assume that maintaining salient medicinal plants through time that are also perceived as more efficient for the treatment of diseases would be an adaptive advantage both at the individual and population level because it would optimize the treatment of diseases.

Nonetheless, ethnobotanical literature has highlighted that the cultural significance of medicinal plants is also linked to their practical everyday utilities (Quinlan 2005; Sousa et al. 2016). Therefore, the increase in the popularity of a medicinal plant might be connected to recent medical challenges. For instance, in our study (Sousa et al. 2022), conducted over two years within the same five communities under examination here, we discovered that the structural core changed over time. This challenges the notion that the core functions as a static "basic kit" and underscores its significantly more dynamic and flexible nature compared to the initial belief held by some of us (Ferreira Júnior and Albuquerque 2015).

As mentioned earlier, our results allow us to consider two hypothetical paths. The first suggests that perceived efficiency could be the sole vital variable in shaping consensus within the diversity structure and determining which plants are most frequently used or remembered in the fundamental strategies of local medical practices. However, factors like usage frequency (Casagrande 2002), taste, and prevalence in vegetation (Casagrande 2002; Gama et al. 2018) might also elucidate the selection of medicinal plants concurrently with perceived effectiveness. Therefore, caution is needed when asserting the determinism of perceived efficacy in influencing the utilization and knowledge of medicinal plants, as implied by hypothesis 1. This is because other contextual and socio-ecological factors can sometimes lead individuals within the system to choose a resource based on its availability more than its perceived efficacy.

Our second hypothetical path suggests that perceived efficiency is an important variable, influencing the salience of information and people's behaviors about medicinal plants, but other perceptive and space/time factors are relevant as 'cofactors'. This hypothesis is more parsimonious than the first one because it includes organoleptic and sociocultural learning about plant resources and the space/time context generating salience at the time of data collection. However, despite being parsimonious, this hypothesis creates an obstacle: What would be the other cofactors, and what spatial/temporal contexts can influence the formation of salience?

Based on the assumption that maintaining the salience of culturally perceived information as more efficient and available would be an adaptive population strategy since it would maximize the energetic entry of local medical systems, we can argue that the social-ecological theory of maximization, proposed by Albuquerque et al. (2019b), can be favorable to the logic of hypothesis 2, where, in n-dimensional space of variables that make up a local social-ecological system, the structure of the distribution of knowledge about medicinal plants must be maximized by several variables, such as availability and taste; however, perceived efficiency would be the main one. Of course, several factors can act as 'salience generators', other than the perceived efficiency during free lists, such as visual stimuli at the time of the interview (Miranda et al. 2007), the frequency of use or prototypicality of plant resources, as shown in the studies by Casagrande (2000; 2002), or the floristic environment of the region (Saslis-Lagoudakis et al. 2012; 2014). Because perceived efficiency still seems to be the structuring factor in ordering the recall of information about people's medicinal plants, it is necessary to test hypothesis 2 and properly discuss the limits of its dominance.

Thus, we believe that future studies that seek to investigate hypothesis 2 should understand that in addition to perceived efficacy, there are fundamental 'salience-generating' cofactors for the distribution of current local knowledge, perceptual/organoleptic, and space/temporal factors. The perceptual factors are those referring to memory and social learning, where the organoleptic and sociocultural mnemonic clues of knowledge about medicinal plants would guide the selection and cultural transmission, for example, bitter taste, efficiency, salient colors, local importance, hot/-cold classification, etc.(see Casagrande 2002).

In the literature, the ecological availability of a resource significantly influences how societies use and/or know plants (Dai et al. 2017; Gonçalves et al. 2016; Ladio et al. 2007; Saslis-Lagoudakis et al. 2014; 2012). It is argued that the most common plants in the environment would eventually influence their importance t and use by people (Phillips and Gentry 1993; Gonçalves et al. 2016); However, when it comes to plants used for medicinal purposes, availability seems not to be a particularly crucial factor (Gonçalves et al. 2016). In our findings, we did not identify any correlation between salience and the perceived availability of medicinal plants in the environment, which aligns with the results observed by Santos et al. (2018).

It's worth noting that, on the contrary, this outcome could reflect the fact that we didn't measure the "actual" availability of plants within social-ecological systems based on the assessment of phytosociological parameters or observations of backyards and the storage of medicinal plants in people's homes Thus, future studies on the structural core of medicinal plants should address this question by investigating whether the "real" availability of plant resources is related to their popularity.

Regarding the hypothesis of the perceived frequency of diseases, we expected that more people would use a single or a certain set of plants to treat a disease they perceived as being more frequent, which would favor the popularity of these plants. Since a more recent episodic context of a medicinal treatment would make the plant more "active" in memory for recall (see Sousa et al. 2016), we believe that this factor would influence the plant's salience due to simple general cognitive factors for recall, such as the recency or primacy effect. However, our results showed that the perceived frequency of diseases did not affect the formation of cultural salience. This finding contradicts reports in the literature regarding the importance of the perceived frequency of diseases in the formation and sharing of knowledge of medicinal plants and treatments (Ferreira Júnior et al. 2011; Nascimento et al. 2016; Santoro et al. 2015).

For instance, Ferreira Junior et al. (2019) argued that under fixed environmental conditions of social-ecological systems (i.e., conditions under which medical systems stably evolve through the *principle of regularity*), the human mind would be biased toward prioritizing sharing and/or remembering medical treatments for more frequent diseases. This was not observed in the present study. Similarly, other studies have also shown that the frequency of therapeutic targets influences the accumulation of medical information for their treatment (Albuquerque et al. 2019b; Nascimento et al. 2016; Santoro et al. 2015; Silva et al. 2019).

Therefore, our results suggest that we must relativize the importance of the perception of disease frequency when assessing its effects on the way people share and prioritize their medicinal knowledge. However, our experimental design only allowed us to prove this speculation in terms of the effects of plant popularity on cultural salience. Future studies should investigate this in greater detail using "real" *in situ* information on the frequency of diseases in a community through therapeutic calendars, visits to health posts, or regular monitoring of people's health to resolve this debate.

LIMITATIONS AND RECOMMENDATIONS

Unlike the concept of a structural core formulated by Ferreira Júnior and Albuquerque (2015), our study is based exclusively on cognitive/perceptual variables of qualitative factors related to medicinal plant resources, including the perceived efficiency and availability of plants as well as the perceived frequency of diseases treated by these plants. In the present study, we did not collect data on non-cognitive variables associated with popular plants, such as biological efficiency or phytosociological structuring parameters, which may have enriched the discussion in this study.

Another important issue is the need to investigate the general evolutionary patterns of local practices over time through periodic data collection on the knowledge of local populations about their resources. Individual perception, for example, is a subjective variable, although our results support the key role of one such variable in the formation of the structural core. Spatiotemporal variation can modify the factors that people use to prioritize the recall of information from memory. In this context, future studies should aim at periodic (e.g., annual, monthly) surveys of knowledge of medicinal plants using free lists to capture variations in the salience of medicinal plants in the studied communities.

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DATA AVAILABILITY

The data and materials that support the findings of this study are available upon reasonable request.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTION STATEMENT

Conception of the idea presented: UPA and WSFJ.
Conduct of fieldwork: DCPS.
Conducting data analysis: DCPS, UPA
Drafting of the manuscript: DCPS.
Review and final drafting of the manuscript: DCPS, JMBM, YACS, UPA and WSFJ.
Supervision: UPA and WSFJ.

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