Ethnobotanical Study Aimed at Investigating the Use of Medicinal Plants to Treat Nervous System Diseases in the Rif of Morocco

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ABSTRACT

Objective: The aim of this study was to assess the knowledge and use of medicinal plants in the treatment of neurological diseases in the Rif region of northern Morocco.

Methods: An ethnobotanical survey was carried out in the Rif (northern Morocco) from 2016 to 2018. In order to gather information about indigenous medicinal plants and local ethnomedical knowledge, 625 local traditional herbalists and users of these plants were interviewed. The data were collected through semistructured interviews and group discussions, analyzed, and compared by quantitative ethnobotanical indices such as family importance value, relative frequency of citation, plant part value (PPV), fidelity level, and informant consensus factor (ICF) .

Results: Data were collected from 31 medicinal plant species belonging to 14 botanical families. Asteraceae and Lamiaceae were the most commonly reported medicinal plants, with 5 species each. Concerning the diseases treated, epilepsy problems have the highest ICF (0.99). The survey revealed that leaves were the most used part of the plants (PPV= 34.7%), and the most commonly used preparation was an infusion (41.6%).

Conclusion: There exists indigenous ethnomedical knowledge of medicinal plants in the Moroccan Rif to treat neurologic diseases. Based on our findings, we recommend that phytochemical and pharmacologic research be considered to discover potential treatments from these documented plants. (J Chiropr Med 2020;19;70-81)

Key Indexing Terms: *Plants; Medicinal; Nervous System Diseases*

INTRODUCTION

Humans have always used medicinal plants (MPs) to treat themselves and fight diseases. In all ancient civilizations and on all continents, one finds traces of this use.[1] Thus, even today, despite the progress of pharmacology, the therapeutic use of plants is very present in some countries, especially developing ones.[2]

Neurologic diseases are strongly associated with the activation of inflammatory pathways, and long-term use of anti-inflammatory drugs reduces the risk of developing these diseases. In São Tomé and Príncipe, several medicinal plants are used both for their positive effects in the nervous system (treatment of mental disorders, analgesics) and for their anti-inflammatory properties.[3]

Morocco, by its biogeographical position, offers a very rich ecological and floristic diversity constituting a true plant genetic reserve, with about 4500 species belonging to 940 genera and 135 families; the mountainous regions of the Rif and Atlas being the most important areas for endemism.[4] This biodiversity is characterized by a very marked endemism[5] that allows Morocco to occupy a privileged place among the Mediterranean countries, with a long medical tradition and traditional know-how based on medicinal plants.[6] Indeed, phytotherapy has always occupied an important place in the traditions of medication in Morocco, and the Rif region is a concrete example. Analysis of the Moroccan medicinal bibliography shows that the data on regional medicinal plants are very fragmentary and dispersed. The medicinal species counted do not exceed 600 or 14.28% of the total Moroccan flora.[4] We believe that this heritage of medicinal flora requires regular monitoring and evaluation in terms of quality and quantity.

Accordingly, we chose to conduct this ethnobotanical study in the Moroccan Rif, which has considerable lithological, structural, biological, and floristic diversity because

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of its relief, topography, and geographic location. The economy of the local people is mainly based on subsistence agriculture, livestock, and to a lesser extent, forest resources. Traditional medicine is the first choice for health problems for this population, and traditional healers in this area are reputed to have good knowledge on MPs and disease treatment. The aim of this study was to assess the knowledge and use of medicinal plants in the treatment of neurologic diseases in the region of northern Morocco.

Materials and Methods

Description of the Study Area

Tangier-Tetouan-Al Hoceima, which is one of the twelve regions of Morocco established by the territorial division of 2015, is part of the Rif region.[7] This region is limited to the north by the Strait of Gibraltar and the Mediterranean Sea, to the west by the Atlantic Ocean, to the southwest by the Rabat-Salé-Kénitra region, to the southeast by the Fès-Meknès region, and to the east by the Oriental region, as shown in Figure 1.

According to the 2014 national census report,[8] the total area of study is about 11,570 km^2, with a human population of 3 549 512 and an average population density of 222.2 people/km^2. The study area has a Mediterranean climate, with a maximum temperature above 45°C during summer (July and August) and below 0°C during winter (December and January); annual rainfall is about 1000 mm.

Ethics Approval and Consent to Participate

Before conducting interviews, informed consent was obtained from all participants. This study was approved by the Department of Biology, Faculty of Sciences, Ibn Tofail University.

Methodology

Data Collection. In order to gather information on MPs used for treating neurologic disorders, an ethnobotanical survey was conducted from June 30, 2016, to June 1, 2018. Interviews were administered as semistructured, and open-ended interviews were conducted through face-to-face interviews and focus groups. The inclusion criterion was that individuals be qualified health care professionals, such as pharmacists, herbalists, practitioners, and therapists; the exclusion criterion was not living in the study area. In total, 625 informants aged 17 to 80 years were randomly selected for interviews in the study area (at hospitals, pharmacies, houses, mosques, and weekly markets). The health care professionals were informed about the objective of this study, and after signing a consent form, they were asked to regularly collect and document indigenous knowledge of plant usage in neurologic diseases. The questionnaire used consists of 2 parts: the first part deals with the demographic characteristics of the informants, and the second focuses on the plants used in the treatment of the nervous system diseases (Appendix A). The sample was made up of 321 women and 304 men from different socioeconomic strata, chosen at random from the Rif's population. It was

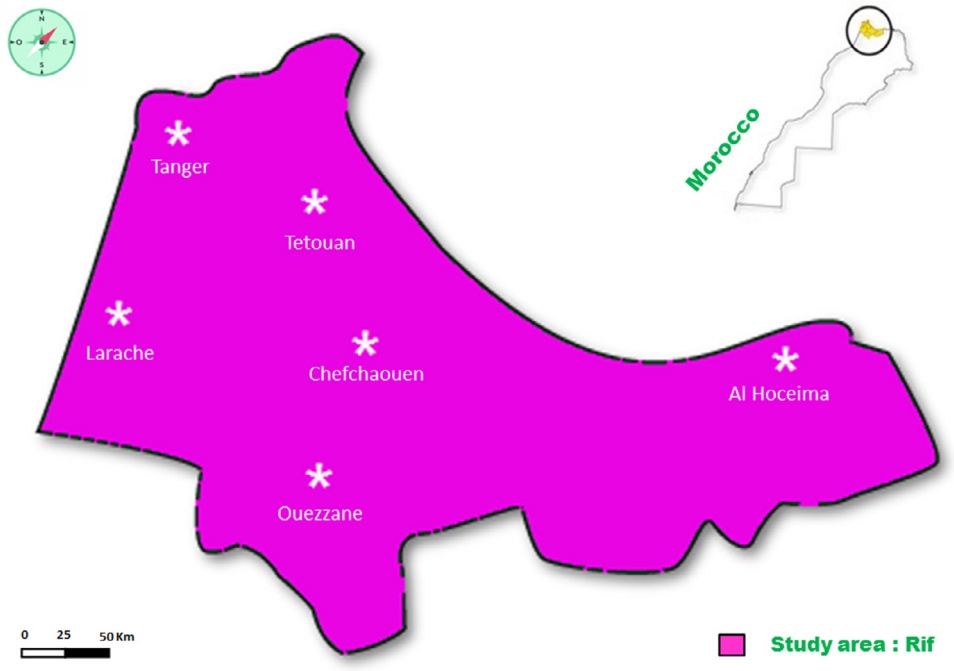

Fig 1. *Map of the study area.*

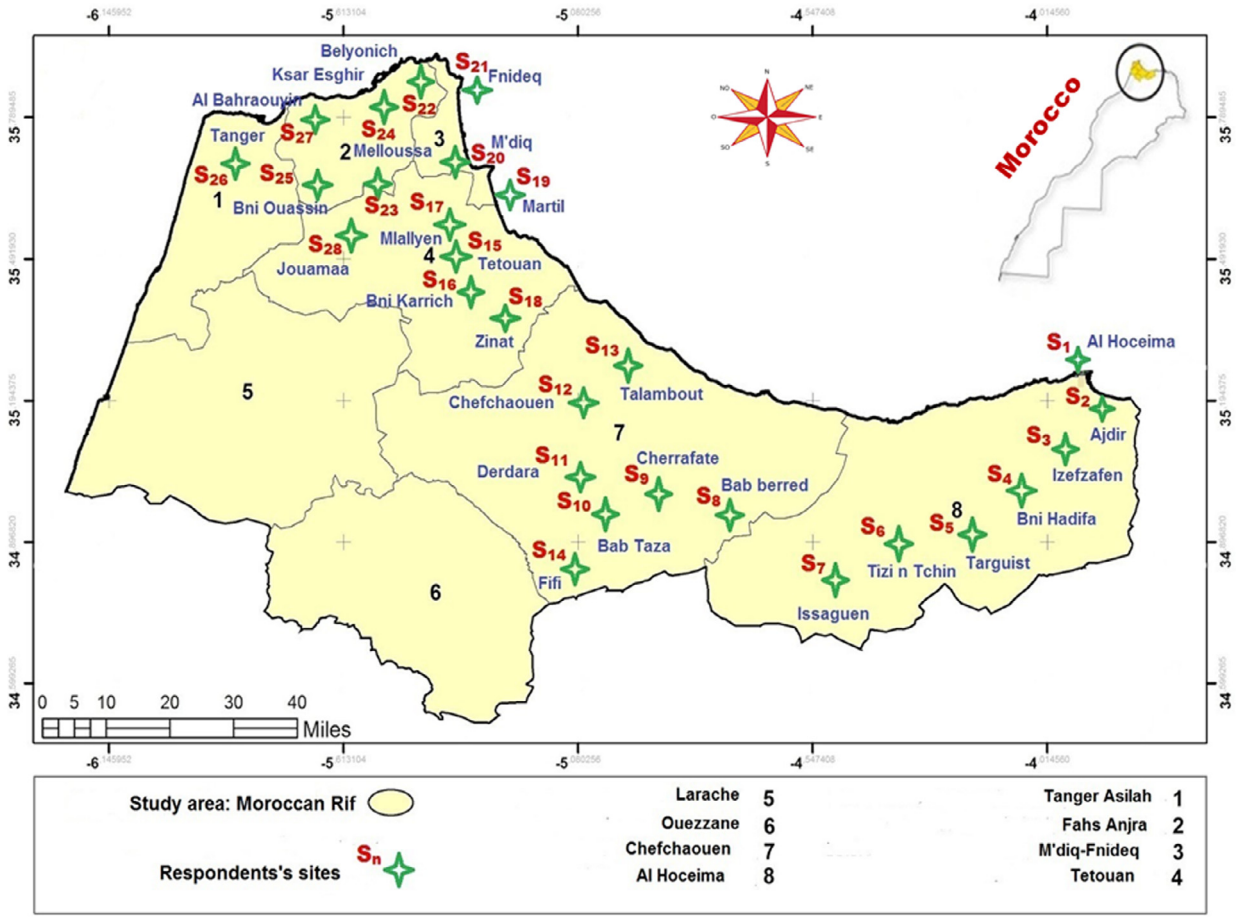

Fig 2. *Distribution of survey points at the study area level.*

developed using a stratified random sampling method to conduct various surveys from site to site in the study area.[9] According to this sampling method, we divided our study area into 28 sites that correspond to the number of divisions in the study area (Fig 2).

Plant Species Collection and Identification. Each plant used by our informants was placed in the herbarium or in a plastic bag with a label indicating its vernacular name. We photographed them and took samples for identification later at the Resources and Biodiversity Laboratory, Department of Biology, Faculty of Sciences, Ibn Tofail University, Kenitra, Morocco, using the following botanical works: *The Medicinal Plants of Morocco*,[10] *Practical Flora of Morocco*,[11] and *Checklist of Vascular Plants of Northern Morocco With Identification Keys, Volume 1*.[12]

Data Analysis

The results of the ethnobotanical survey were analyzed using the family importance value (FIV), relative frequency of citation (RFC), plant part value (PPV), fidelity level (FL), and informant consensus factor (ICF). All statistical analyses were carried out with Statistical Package for Social Science (SPSS), version 21, and Microsoft Excel 2010.

Family Importance Value. The FIV identifies the significance of plant families. It is an index of cultural importance which can be applied in ethnobotany to calculate the value of a biological plant taxon. To calculate FIV, we use the formula

$$\mathrm{FIV} = \frac{\mathrm{FC}_{\mathrm{family}}}{N_S},$$

where $\mathrm{FC}_{\mathrm{family}} = \mathrm{RFC}$ is the number of informants mentioning the family and N_S is the total number of species within each family.[13]

Frequency of Citation and Relative Frequency of Citation. RFC[14] is obtained by dividing frequency of citation (FC) by the total number of informants in the survey (N):

$$\mathrm{RFC} = \frac{\mathrm{FC}}{\mathrm{N}} \quad (0 < \mathrm{RFC} < 1).$$

The RFC value for species of medicinal plants is based on the citing percentage of informants for every species.

Plant Part Value. PPV was calculated using the formula

$$\mathrm{PPV} = \frac{\mathrm{RU}_{\mathrm{plant\_part}}}{\mathrm{RU}} \times 100,$$

where RU is the number of uses reported of all parts of the plant and $\mathrm{RU}_{\mathrm{plant\_part}}$ is the sum of uses reported per part of the plant. The part with the highest PPV is the most used by the respondents.

Fidelity Level. FL[15] is the percentage of informants who mentioned the uses of certain plant species to treat a particular ailment in the study area, calculated using the formula

$$\mathrm{FL} = \frac{N_p}{N} \times 100,$$

where N_p is the number of informants that claimed a use of a plant species to treat a particular disease, and N is the number of informants that use the plants as a medicine to treat any disease.

Informant Consensus Factor. ICF[16] was derived in order to seek an agreement between the informants on the reported cures for each group of diseases:

$$\mathrm{ICF} = \frac{N_{\mathrm{ur}} - N_{\mathrm{t}}}{N_{\mathrm{ur}} - 1},$$

where N_{ur} is the number of use reports in each disease category and N_{t} is the number of species used.

Statistical Analysis. Statistical analysis of knowledge scores was performed using Statistical Package for Social Sciences (SPSS) to test for the influence of sex, level of education, and age on ethnomedical knowledge. The Mann-Whitney U test was used to determine gender-related differences in knowledge of medicinal plants. The Kruskal-Wallis test was used to test the relationship between socio-demographic data of the informants and ethnomedical knowledge.

Table 1. *Demographics of Participants in the Study Area*

Variable	Category	Number of informants (N = 625)	%	Test	*P*
Sex	Female	321	51.3	U = 334.5	.340
	Male	304	49.7		
Age group (y)	<20	6	1	$x^2 = 85.697$	<.001
	20-40	141	22.5		
	40-60	258	41.3		
	>60	220	35.2		
Family situation	Married	504	80.6	$x^2 = 82.820$	<.001
	Divorced	67	10.7		
	Widowed	35	5.7		
	Single	19	3		
Educational level	Illiterate	409	65.4	$x^2 = 102.721$	<.001
	Primary	169	27		
	Secondary	42	6.8		
	University	5	0.8		
Income/month (Moroccan dirham)	Unemployed	314	31.4	$x^2 = 88.560$	<.001
	250-1500	189	45.1		
	1500-5000	99	21.5		
	>5000	18	2		

Results

Demographics of Participants

In total, 625 local informants were interviewed (Table 1): 321 women and 304 men (with a female to male ratio of 1.06). In the Moroccan Rif, herbs work for the treatment of conditions for both women and men; in our study, women made up 51.3% of participants and men 48.7%.

The majority of respondents were aged 40 to 60 years (41.3%), followed by those older than 60 years (35.2%) and those 20 to 40 years (22.5%). Informants younger than 20 years came in last position (1%).

The analysis of the collected data shows that MPs are used more often by health care professionals who are married (80.6%) compared with those who are divorced (10.7%); widowers made up 5.7% of the participants, and single people only 3%.

Analysis of the collected data shows that MPs are used most often by health care professionals who are herbalists (5.3%), followed by nobles (3.8%), priests (1.5%), pharmacists (0.9%), and nurses (0.4%); 88.1% of the respondents had no occupation.

Regarding the level of education, 65.4% of the participants were illiterate, followed by the categories of primary and secondary education, with percentages, respectively, of 27% and 6.8%. People with a university-level education use MPs the least, with a percentage of 0.8%.

In our study, 45.1% of the health care professionals had a low socioeconomic level, 31.4% were unemployed, 21.5% had an average level, and only 2% had a higher level.

Medicinal Plant Diversity. A total of 31 medicinal plant species belonging to 14 botanical families were used to treat neurologic diseases in the study area. These plants are presented in Table 2 in alphabetical order by family. For each plant listed, we give the family, the scientific name, the local name, the part used, the method of preparation adopted by the local population, and the condition it was used to treat, as well as the FL (%), FC, RFC, and FIV.

The most representative families, in terms of number of species, were Asteraceae and Lamiaceae (5 species each), and Cucurbitaceae and Solanaceae (4 species each); other families were represented by 1 or 2 species only (Fig 3). Based on the FIV, the 5 most cited families were Verbenaceae (FIV = 0.168), Myristicaceae (0.154), Cupressaceae (0.130), Liliaceae (0.127), and Rubiaceae (0.104).

Quantitative Data Analyses

Relative Frequency of Citation. To evaluate the relative importance of reported MPs, RFC was calculated based on the informants' citations for the specific plant under study. Values ranged from 0.002 to 0.214. *Marrubium echinatum* L. exhibited the highest RFC (0.214), followed by *Allium cepa* L. (0.197), *Aloysia citrodora* L. (0.168), *Myristica fragrans* L. (0.154), and *Artemisia herba-alba* L. (0.152). The lowest RFC (0.002) was exhibited by eight MPs, as shown in Table 2.

Fidelity Level. FL for each species was also evaluated from the available information. It indicates the informants' choices for particular ailments and the potential of the species related to the ailments. The FL of a plant species for a specific disease in the present study area varied between 51.22% and 100%. We found 27 plant species having a maximum 100% FL.

Informant Consensus Factor. ICF values are important guides to identify more efficacious plants, and they also tell the level of prevalence of diseases in the Rif. Results of the current study revealed that epilepsy was most prevalent in the study area, exhibiting an ICF value of 0.99, and migraine was ranked second, with an ICF of 0.93. Sciatica (0.88) and meningitis (0.65) were also observed through ICF calculations (Table 3).

Parts of the Plant Used to Treat Neurologic Problems. In current investigations, people of the Moroccan Rif harvest different plant parts for the preparation of traditional remedies (eg, seed, root, stem, fruit, bulb, flower, leaf). Based on the PPV, leaves were reported as the dominant plant part for neurologic remedy preparation in the study area (PPV 34.7%), followed by seeds (PPV 16.5%), bulbs (PPV 14%), other combination (PPV 11.8%), whole plants (PPV 8%), flowers (PPV 7.6%), roots (PPV 3.7%), stems (PPV 2.9%), and fruit (PPV 0.6%) (Fig 4).

Methods of Preparation. In order to facilitate the administration of the active principles of the plant, several modes of preparation are used (Fig 5):

- Decoction is a method of extraction by boiling herbal or plant material to dissolve the chemicals of the material, which may include stems, roots, bark, and rhizomes.
- Infusion is the process of extracting chemical compounds or flavors from plant material in a solvent such as water, oil, or alcohol, by allowing the material to remain suspended in the solvent over time (a process often called steeping).
- A cataplasm is a poultice or plaster—a soft moist mass, often warm and medicated, that is spread over the skin to treat an inflamed, aching, or painful area, to improve the circulation, and so on.
- Maceration is an extractive technique that is conducted at room temperature. It consists of immersing a plant in a liquid (eg, water, oil, alcohol) inside an airtight container for a variable time based on the plant material and liquid used.
- Fumigation is a method of killing pests, termites or any other harmful living organisms to prevent transfer of exotic organisms. Normally, fumigation is done for wood material used for packing of goods to be exported. In some cases, empty containers are fumigated before being filled with cargo.

Table 2. *List of Medicinal Plants Used to Treat Neurological Diseases in the Rif region of Morocco*

Family and Scientific Name	Vernacular Name	Part Used	Mode of Preparation	Medicinal Uses	FL (%)	FC	RFC	FIV
Asparagaceae								0.002
Agave sisalana Linnaeus	Aloe vera	Leaf	Cataplasm	SC	100	1	0.002	
Agave karatto Linnaeus	Sabra	Leaf	Cataplasm	MG	100	1	0.002	
Asteraceae								0.051
Artemisia mesatlantica Linnaeus	Chih, Izri	Leaf	Decoction	MR	100	1	0.002	
Artemisia herba-alba Linnaeus	Chih, Izri	Leaf	Decoction	EL, MG	97.9	95	0.152	
Xanthium spinosum Linnaeus	Lzik chouki	Leaf	Decoction	SC	100	1	0.002	
Chrysanthemum coronarium Linnaeus	Lgahwân, Lgentus	Flower	Infusion	EL	100	63	0.097	
Anacyclus radiatus Linnaeus	Far dahabya	Whole plant	Infusion	MR	100	1	0.002	
Cucurbitaceae								0.011
Ecballium elaterium Linnaeus	Faggous el hemar	Fruit	Other	MR	100	2	0.003	
Cucumis melo Linnaeus	Btikh	Leaf	Infusion	MR	100	13	0.021	
Citrullus vulgaris Linnaeus	Dlah	Leaf	Decoction	MR	100	9	0.014	
Lagenaria siceraria Linnaeus	El garâa-slâwiya	Fruit	Cataplasm	SC	100	5	0.008	
Cupressaceae								0.130
Tetraclinis articulata Linnaeus	El A'râr	Leaf	Infusion	EL	100	81	0.130	
Fabaceae								0.058
Retama monosperma (L.) Boiss	Rtem	Stem	Decoction	EL	100	32	0.051	
Retama raetam Linnaeus	Rtem	Root	Decoction	EL, MR	75.61	41	0.065	
Lamiaceae								0.078
Marrubium echinatum Linnaeus	Mrywt, Ifzi	Other combination	Cataplasm	EL	100	134	0.214	
Mentha spicata Linnaeus	Na'a na'a	Whole plant	Infusion	MR	100	23	0.037	
Mentha × *piperita* Linnaeus	Na'na el-aabdi	Leaf	Infusion	SC	100	6	0.01	
Mentha pulegium Linnaeus	Fliyou	Whole plant	Infusion	EL	100	67	0.107	
Vitex agnus-castus Linnaeus	Kharwae	Seed	Infusion	MR	100	15	0.024	
Liliaceae								0.127
Asphodelus microcarpus Linnaeus	Lberwag, Inghri	Bulb	Decoction	SC	100	36	0.057	
Allium cepa Linnaeus	Bassla, Azalim	Bulb	Cataplasm	EL, MR	51.22	123	0.197	
Myristicaceae								0.154
Myristica fragrans Linnaeus	El goza	Seed	Infusion	EL	100	96	0.154	
Nyctaginaceae								0.002
Mirabilis jalapa Linnaeus	Chob ellayl	Root	Decoction	MG	100	1	0.002	
Poaceae								0.013
Dactyloctenium aegyptium Linnaeus	Njem rjel djaja	Seed	Decoction	MG	100	8	0.013	
Rubiaceae								0.104
Coffea arabica Linnaeus	Qahwa	Seed	Decoction	EL	100	65	0.104	
Solanaceae								0.042
Datura stramonium Linnaeus	Chedak jmal	Seed	Other	MG	100	2	0.003	
Lycium europaeum Linnaeus	Haded europa	Leaf	Cataplasm	SC	100	1	0.002	
Nicotiana glauca Linnaeus	Tembak berri	Flower	Decoction	MR	100	23	0.037	
Solanum tuberosum Linnaeus	Batâta	Leaf	Cataplasm	EL	100	78	0.125	
Typhaceae								0.002
Typha angustifolia Linnaeus	Bot, Kseb	Stem	Other	MG	100	1	0.002	
Verbenaceae								0.168
Aloysia citrodora Linnaeus	Lwiza	Leaf	Infusion	EL, MR, MG	95.24	105	0.168	

EL, epilepsy; *FC*, frequency of citation; *FIV*, family importance value; *FL*, fidelity level *MG*, meningitis; *MR*, migraine; *RFC*, relative frequency of citation; *SC*, sciatica.

Table 3. *Informant Consensus Factor (ICF) Values by Category for Treating Neurological Diseases*

Category	Plant Species Used and Number of Citations	Total number of		ICF
		Species	Use citations	
Epilepsy	*Artemisia herba-alba* Linnaeus (93), *Chrysanthemum coronarium* Linnaeus (63), *Tetraclinis articulata* Linnaeus (81), *Retama monosperma* (L.) Boiss (32), *Retama raetam* Linnaeus (31), *Marrubium echinatum* Linnaeus (134), *Mentha pulegium* Linnaeus (67), *Allium cepa* Linnaeus (60), *Myristica fragrans* Linnaeus (96), *Coffea arabica* Linnaeus (65), *Solanum tuberosum* Linnaeus (78), *Aloysia citrodora* Linnaeus (100)	12	900	0.99
Migraine	*Ecballium elaterium* Linnaeus (2), *Cucumis melo* Linnaeus (13), *Citrullus vulgaris* Linnaeus (9), *Mentha spicata* Linnaeus (23), *Vitex agnus-castus* Linnaeus (15), *Nicotiana glauca* Linnaeus (23), *Anacyclus radiatus* Linnaeus (1), *Artemisia mesatlantica* Linnaeus (1), *Aloysia citrodora* Linnaeus (3), *Allium cepa* Linnaeus (63), *Retama raetam* Linnaeus (10)	11	163	0.93
Sciatica	*Lagenaria siceraria* Linnaeus (5), *Mentha* × *piperita* Linnaeus (6), *Asphodelus microcarpus* Linnaeus (36), *Lycium europaeum* Linnaeus (1), *Agave sisalana* Linnaeus (1), *Xanthium spinosum* Linnaeus (1)	6	50	0.88
Meningitis	*Dactyloctenium aegyptium* Linnaeus (8), *Datura stramonium* Linnaeus (2), *Typha angustifolia* Linnaeus (1), *Agave karatto* Linnaeus (1), *Aloysia citrodora* Linnaeus (2), *Artemisia herba-alba* Linnaeus (2), *Mirabilis jalapa* Linnaeus (1)	7	17	0.65

In the Rif area, infusion remains the most dominant method of preparation (41.6%), followed by cataplasm (30.36%) and decoction (27.6%). The incidences of the other modes of preparation (fumigation and maceration) combined does not exceed 0.44%.

Administration of MPs. Route of administration also varies depending on the disease and materials used. In general, most of the prepared recipes are orally prescribed (83%), followed by massage (6%), other modes of administration (5.9%), swabbing (3%), and rinsing (2.1%).

Condition of Preparations. The majority of the remedies in the study area were prepared from fresh parts of MPs (71.3%), followed by dried forms (24%) and 4.7% prepared from either dry or fresh plant parts. A study conducted by Abdurhman[17] indicated that 86% of preparations were in fresh form, and Getahun[18] reported that most MPs (64%) were used in fresh form, with 36% in dried from.

Knowledge of Medicinal Plants

In our ethnobotanical survey, the majority of health care professionals (68%) acquired knowledge about medicinal use of plants as a remedy for neurologic diseases through others' experiences. This reflects the relative transmission of traditional practices from one generation to another. It was followed by herbalists (15.3%) and pharmacists (12.7%), and only 4% had built this knowledge by reading

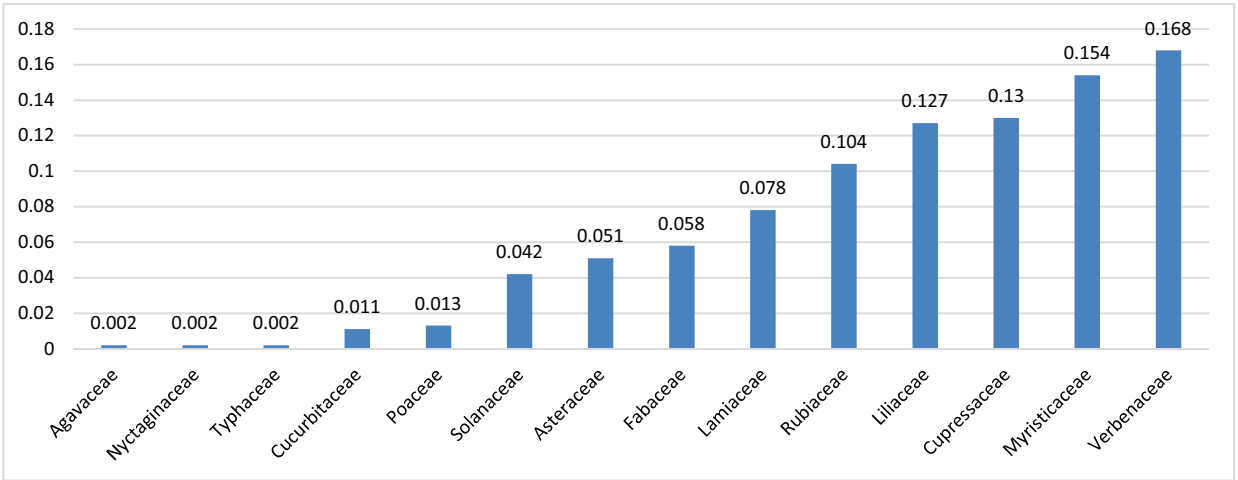

Fig 3. *Family importance values of medicinal plants.*

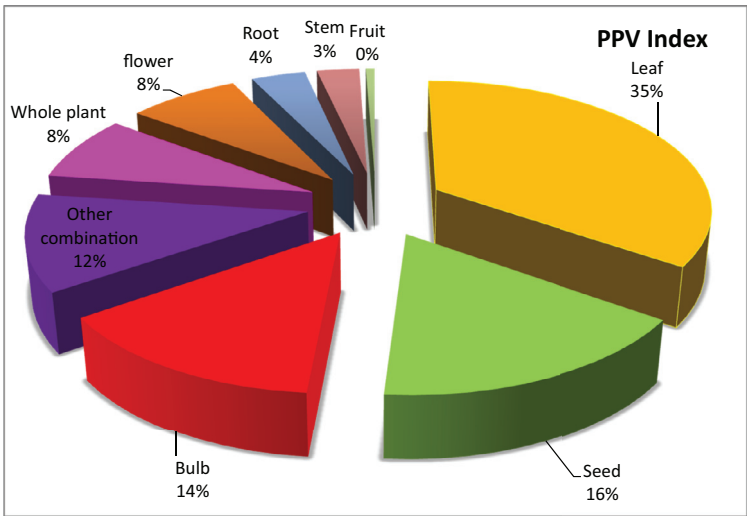

Fig 4. *Plant parts used in the treatment of neurologic diseases in the study area.*

books about traditional Arab medicine, by watching television programs, or by their own experience with a large number of medicinal plants in their surroundings. The environment and others' experiences therefore remain the most effective means of transmitting knowledge about medicinal uses of plants (Fig 6).

Discussion

The use of MPs in the Rif area is similar to that in other parts of Morocco. When participants were grouped according to sex, descriptive and inferential statistics revealed that the women (n = 321) showed higher medicinal plant knowledge than the men (n = 304), although the Mann-Whitney U test (U = 334.50, $P = .340$) did not show a significant difference between male and female informants on the number of medicinal plant species they listed and associated uses reported. These results confirm the results of other ethnobotanical work carried out at a national scale.[19-22] In the study area, the majority of the respondents were aged 40 to 60 years (41.3%), followed by informants aged more than 60 years (35.2%), with a very highly significant difference according to the Kruskal-Wallis test ($x^2 = 85.697$, $P < .001$). The relatively high score of the older informants, as expected, is due to experience. It might also be the case that the younger participants, especially from the youngest age group, are not interested in the tradition of medicinal plant gathering and peddling, as nobody from this age bracket mentioned their direct participation in plant collection and trade. At present, the traditional

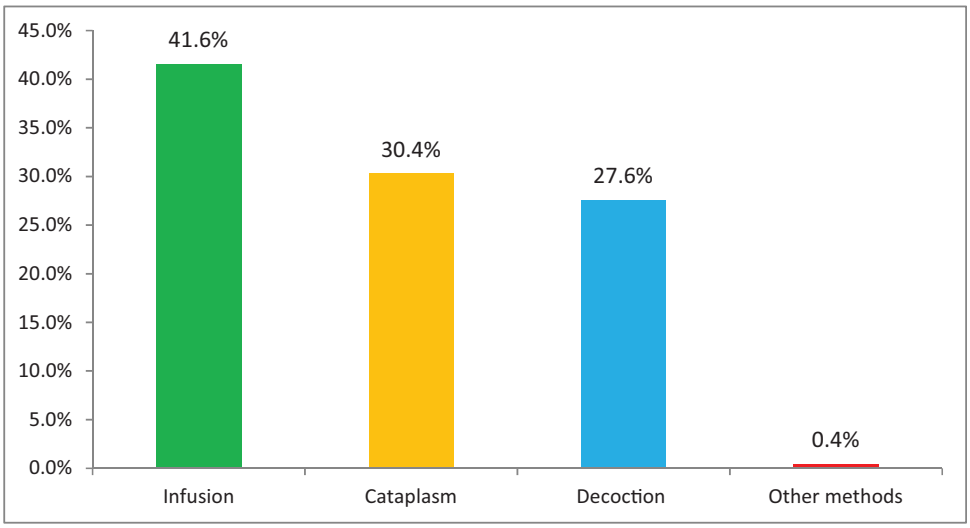

Fig 5. *Frequency of different methods of preparation.*

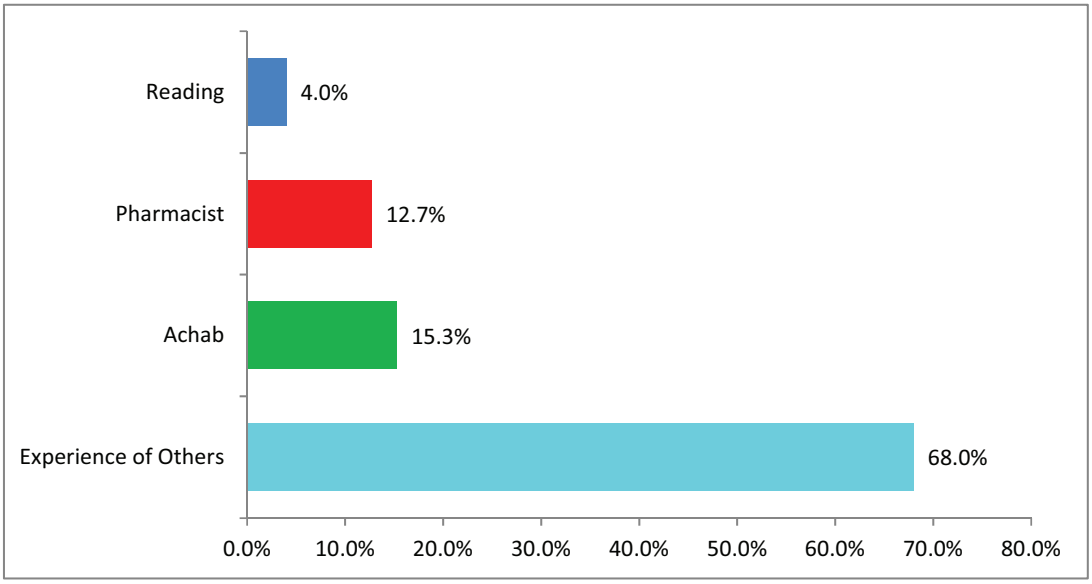

Fig 6. *Modes of acquisition of traditional knowledge.*

medical knowledge transmitted from generation to generation is in danger because transmission between older and younger generations is not always assured.[23] These values confirm the results obtained in other regions of Morocco.[24-26]

The analysis of the collected data shows that MPs are much more used by health care professionals who are married (80.6%) than divorced (10.7%), with widowers at 5.7% and single people at only 3% because married people can avoid or minimize the material charges required by doctors and pharmacists. The difference between family status and indigenous knowledge for the treatment of neurologic diseases was statistically significant (Kruskal-Wallis: $x^2 = 82.820$, $P < .001$). Those findings coincide with those of similar study conducted in the central plateau of Morocco.[27] Regarding the level of education, 65.4% of the health care professionals were illiterate; thus, the difference between educational level and indigenous knowledge was significant (Kruskal-Wallis: $x^2 = 102.721$, $P < .001$). We can therefore see that the use of MPs decreases as the level of education increases. This result is similar to previously reported findings.[27-29] In our study, 45.1% of the health care professionals had a low socioeconomic level. The difference between income per month and indigenous knowledge was significant (Kruskal-Wallis: $x^2 = 88.560$, $P < .001$). The high cost of modern medical treatments and their side effects are among the main reasons why respondents used herbal medicine. We can therefore see that the use of plants increases with the increase in monthly income of these informants. These results are similar to those obtained in the Moyenne Moulouya of Morocco.[30]

The diversity and number of MPs reported by informants show the rich traditional knowledge in the Rif, and the number of medicinal plants reported is greater than in other studies conducted in the western Rif of Morocco and neighboring regions.[25,27,31] In this study, we report the use of 31 medicinal species belonging to 14 families in treating nervous system diseases. Our results showed that the most predominant families were Asteraceae and Lamiaceae (5 species each), followed by Cucurbitaceae and Solanaceae (4 species each), whereas other families were represented by 1 or 2 species only. This high proportion could be explained by the high representation of these families in the Rif's flora due to ecological factors that favor the development and adaptation of the majority of their species. It was observed in the present study that the members of Asteraceae, Lamiaceae, and Cucurbitaceae are well-known potherbs and commonly used in herbal recipes. This partially coincides with other findings in Morocco and in the Mediterranean area with similar characteristics.[19,21,32-34]

Marrubium echinatum Linnaeus exhibited the highest RFC (0.214), followed by *Allium cepa* Linnaeus (0.197), *Aloysia citrodora* Linnaeus (0.168), *Myristica fragrans* Linnaeus (0.154), and *Artemisia herba-alba* Linnaeus (0.152). The high values of RFC can be explained by the fact that these plants are the best known and have long been used by the majority of informants, representing a source of reliability. In fact, many biological activity and phytochemical evaluations have been carried out for these plants, and these species are particularly interesting for research in bioactive compounds. The plant species with high RFC should be subjected to pharmacologic, phytochemical, and other biological studies to evaluate and prove their authenticity.[35]

The fidelity value is an important means to see for which ailment a particular species is more effective. It indicates the informants' choice for each ailment and the potential of

the species related to the ailments. The FL of plant species for specific diseases in the present study area varied between 51.22% and 100%. We found 27 plant species with the maximum 100% FL. The MPs that are widely used by the people of the Rif have higher FL values than those that are less popular. On the other hand, more MPs that are known as remedies of a single aliment have a 100% FL than those that are used as remedies for more than one type of aliment. The present study showed a high degree of agreement among interviewees, especially for epilepsy and migraine.

Recently, consensus analysis has been used as an important tool for analyzing of ethnobotanical data, and it also tells the level of prevalence of diseases in the Rif. Results of the current study revealed that epilepsy was most prevalent in the study area, with an ICF of 0.99. The ICF values indicated the maximal networking of indigenous people in the sharing of their knowledge on medicinal practices; this is usually the case with traditional healers who treat the most frequently encountered diseases in the study area. These high ICF values indicate reasonable reliability of informants on the use of MP species.[36] They also indicate that people share the knowledge of the most important MP species to treat the most frequently encountered neurologic diseases in the study area. Pharmaceutical and phytochemical studies should be undertaken to study whether the use of these herbs is valid.

Based on PPV, the leaf was reported as the dominant plant part for neurologic remedy preparation in the study area (34.7%). The preference of leaves was due to their easy availability, easy harvesting, and simplicity in remedy preparation. In addition, the leaves are the seat of photosynthesis and sometimes storage of the secondary metabolites responsible for the biological properties of the plant. Similar findings have indicated leaves as a major dominant plant part in Morocco[30,37,38] and in Africa more widely[39-42] for herbal medicine preparation.

In regard to the method of preparation, the plurality of remedies were prepared by infusion (41.6%). The frequent use of infusion can be explained by the fact that infusion makes it possible to collect the most active ingredients and attenuates or cancels out the toxic effect of certain recipes. Infusion was also the most-used herbal preparation in studies of other regions of Morocco.[21,22,27] This confirms that there is a perpetual exchange of information on the use of MPs between the people of Morocco. In general, most of the prepared recipes are orally prescribed (83%). The predominance of oral administration may be explained by a high incidence of internal ailments in the region.[43] On the other hand, it is thought that the oral route is the most acceptable for patients. The predominance of oral administration of the different MPs in the Moroccan Rif is in total agreement with most of the ethnobotanical studies carried out in Africa.[26,44,45]

Limitations

In this study, no information was provided about the efficacy of the herbs. These are herbs that are reportedly used for neurologic conditions, but we did not measure their effects.

Conclusion

The Moroccan Rif region has a great reservoir of ethnomedical knowledge, particularly regarding the use of medicinal plants in primary health care. Locals of the region have tremendous traditional knowledge to utilize plants for the treatment of neurologic diseases. On the basis of our results, we recommend that plants with high ICF and FL values receive further phytochemical and pharmacologic investigation. We also recommend that protection measures be adopted for the conservation of these potential medicinal plant species.

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Contributorship Information

Concept development (provided idea for the research): N.C.
Design (planned the methods to generate the results): L.Z.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): O.B.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): L.Z.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): N.C.
Literature search (performed the literature search): N.C.
Writing (responsible for writing a substantive part of the manuscript): N.C.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): L.Z.
Compiled the literature sources, data analysis, and interpretation and wrote the manuscript: N.C.
Helped in data: O.B.
Identified plant species: L.Z.

Practical Applications

- Based on the results of this study, higher use value, preference ranking scores, and fidelity levels of the recorded medicinal and aromatic plant species would empower future pharmaceutical and phytochemical studies and conservation practices.

- In this connection, attention should be drawn to the conservation of traditional medicinal plants and associated indigenous knowledge in the Moroccan Rif area to sustain them in the future.

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.jcm.2020.02.004.

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