Application of ethnobotanical indices for ethnopharmacology and ethnobotany of the family *Lamiaceae* used by population in National Talassemtane Park (North of Morocco)

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Research

Abstract

Background: The Talassemtane National Park (PNTLs) is characterized by a rich floristic diversity. We carried out an ethnobotanical survey in the PNTLs, we have identified a total of 152 medicinal plant species belonging to 44 botanical families. The Lamiaceae is one of the 20 largest plant families, and one with the significantly higher proportion of medicinal plants. The study aimed to specify the medicinal uses of the Lamiaceae in PNTLs and evaluate the context of the application of ethnobotanical indices.

Methods: Open-ended interviews, semi-structured interviews, and questionnaires were conducted between 2014 and 2017 in PNTLs on a sample of 200 people between the ages of 20 and 60. The ethnobotanical data were quantitatively analyzed using indices, Use Value (UV), the Medicinal Plant Knowledge index (MPKi), the Medicinal Plant Use index (MPUi), and the Confidence level (Cl), Informant agreement ratio (IAR).

Results: The study identified a total of 27 taxa belonging to the Lamiaceae families. With a total of 3113 use reports, we have identified 183 medicinal uses to treat 58 conditions or symptoms according to the international classification of primary care (ICPC-2). Most remedies are prepared as an infusion (46%), the most used parts of the plant are leaves (34%), and the most common mode of administration is oral (67%). The analysis revealed that the

highest value of UV was obtained for *Lavandula angustifolia* Mill. (UV=1,8). In addition, the highest degree of agreement from informants (IAR) was recorded for Ear disorders (H) and Pregnancy, Childbearing, and Family Planning (W) (1).

Conclusions: This study shows a promising perspective for future ethnomedicinal studies, and for the conservation of traditional knowledge of medicinal plants in the Park.

Keywords: ethnobotanical indices; medicinal plants; Lamiaceae; Parc National Talassemntane.

Background

Ethnobotanical scientific studies are widely usedto identify and evaluate plant uses, which are of great importance in people's cultures. (Martin 2001, Albuquerque *et al*. 2006, Dudney *et al*. 2015). Medicinal plants are valuable sources for herbal products, and herbal medicine is of major importance to humanity (Fabricant & Farnsworth 2001, Kalaichelvi & Swaminathan 2009, Chen *et al*. 2016, Dossou-Yovo *et al*. 2017, Monika *et al*. 2020, Surendran *et al*. 2023). Medicinal plants are also used as raw materials for pharmaceutical factories (Hamilton 2004).

Ethnopharmacological research includes the study of the identification and classification of natural materials (plants, animals, minerals) from which remedies are made, their preparation, and their effects on humans and animals (Etkin 2001, Silja *et al*. 2008, Gertsch 2009, Heinrich & Jäger 2015, Bruhn & Rivier 2019). In this field, several recent research projects have been carried out in the Mediterranean region (Aleo *et al*. 2013, Benítez *et al*. 2010, Cornara *et al*. 2009, Cakilcioglu & Turkoglu 2010, Cakilcioglua *et al*. 2011, Durmuşkahya & Öztürk 2013, Leporatti & Impieri 2007, Licata *et al*. 2016, Guarrera & Leporatti 2007, González-Tejero *et al*. 2008, Idolo *et al*. 2010, Mükemre *et al*. 2015, Özdemir & Alpınar 2015, Pieroni & Giusti 2009, Leto *et al*. 2014, Valentina *et al*. 2011, Tuttolomondo *et al*. 2014a, 2014b, 2014c, El Haouari *et al*. 2018, Eddouks *et al*. 2017, Teixidor-Toneu *et al*. 2016).

Traditional medicinal plants are widely used in Morocco, as well as in different parts of the Mediterranean (Leonti et al. 2010, 2011, Heinrich et al. 2006, Heinrich 2000, Heinrich 2010, Rivera *et al*. 2006). Studies in Morocco on popular medical beliefs have been progressing since the end of the last century, starting with the work of Bellakhdar during the 1970s, 1980s, and 1990s (Bellakhdar 1978, 1984, 1997, Bellakhdar *et al*. 1982, 1991). A detailed study of the numerous ethnobotanical and ethnopharmacological data published sheds light on their knowledge among the various local populations of Morocco (Teixidor-Toneu et al. 2016, Eddouks et al. 2017, Eddouks *et al*. 2002, Merzouki et al. 2000, 2003, Boulos 1983, Kahouadji 1995, Hmammouchi 1999, Jouad *et al*. 2001, El Hilaly *et al*. 2003, Tahraoui *et al*. 2007, El Gharbaoui et al. 2017, Redouan et al. 2020, Ziyyat *et al*. 1997, Fakchich & Elachouri, 2014, El-Ghazouani *et al*. 2021).

Quantitative techniques have been used in ethnobotany to compare the uses and the cultural importance of different plants. These techniques have been developed to answer questions regarding the interrelationship between man and plants, both qualitatively and quantitatively (Verpoorte 2012, Gertsch 2009, McLeod 2018, Leonti *et al*. 2020, Leonti 2022). There are several papers published by ethnobotanists on quantitative criteria of medicinal plants (for example, Friedman et *al*. 1986, Troter & Logan 1986, Phillips & Gentry 1993a, 1993b, Bennett & Prance 2000, Byg & Balslev 2001, Gomez-Beloz 2002, Castañeda & Stepp 2007, Phillips 1996, Leonti & Weckerle 2015, Weckerle *et al*. 2018, Leonti 2022). These analyses are of great scientific interest for conservationand traditional cultural uses of plant taxa and for biodiversity (Byg & Balslev 2001, Garibaldi & Turner 2004).

This study aims to document traditional herbal remedies that are used by the local population of PNTLS with a focus on the species of the Lamiaceae family. Additionally, we evaluated the context of the application of quantitative techniques.

The Lamiaceae botanical family

The Lamiaceae (*Labiatae*, mint family), is a family of flowering plants including many well-known plants, herbs, shrubs, and trees of horticultural, economic, and medicinal importance. It is made up of about 7200 species, organized into 236 genera. (Ramasubramania 2012, Drew & Sytsma 2012).The largest genera are *Salvia* (900), *Scutellaria* (360), *Stachys* (300), *Plectranthus* (300), *Hyptis* (280), *Teucrium* (250), *Vitex* (250), *Thymus* (220), and Nepeta (200). *Clerodendrum* was once a genus of over 400 species but from 2010, it had been narrowed to about 150 (McKay & Blumberg 2006). The original family name is Labiatae-because the flowers typically have petals fused into an upper lip and a lower lip. The oldest complete taxonomic classification of Lamiaceae was proposed by Bentham (1832-1836) which was modified in 1876. Briquet (1895-1897) made improvements to Bentham's system.

Another modification of this system was proposed by Melchior in 1964. An alternative classification of the *Lamiaceae* based on the palynological characters was proposed by Erdtman (1945). Wunderlich (1967) put forth a new system of classification which was built on Briquet's system with many important modifications (Batool Zahra & Shinwari 2016). This family is rich in essential oils contained in glands in epidermal cells, with a high variety of phenolic compounds in addition to polyphenols, tannins, iridoids, quinones, coumarins, diterpenoids, triterpenoids, saponins, in some cases, pyridine and pyrrolidine alkaloids (Evans 1996, Cimanga *et al.* 2002, Lamiri *et al.* 2001). Many species of Lamiaceae are noted for their aromatic oils, and many have commercial or cultural importance, such as *Salvia officinalis* L., *Rosmarinus officinalis* L., *Mentha* L. spp., *Thymus vulgaris* L., *Origanum* L. spp., *Satureja hortensis* L., *Monarda* L. spp., *Melissa officinalis* L., *Lavandula* L. spp., *Ocimum* spp., (Kuhnt *et al.* 1995, Guillén & Manzanos 1999). Northern Morocco has a total of 127 species in 24 genera (Valdés *et al.* 2002), while numbers for the whole country rise to 204 species in 28 genera (Fennane *et al.* 2007).

Materials and Methods

Study area

The investigated area is in the Talassemtane National Park (PNTLS) (Chefchaouen province), located in the North of Morocco (35° 14′ N, 5° 08′ O). It covers a surface of about 60 000 ha, and is limited to the north by Wadi Tissikiste, douars Amahousse, Arhiniame, and Souk El Had, to the east by Oued Kanar and douars Assimrane and Assifane, to the south by the road joining Assifane to the main road to Bab Taza, and to the west by douar Benizid, Ain Tissimlane, Tarhzoute, Jble Sidi Salah, and Tamalout (Figure 1).

The climate is bioclimatic; humid temperate, humid fresh, and per-humid cold, according to Rivas-Martínez and Rivas-Sáenz (2018) classification of the world bioclimates. The recent publication of a biogeographic map of Morocco (Molero Mesa *et al.* 2018) shows that PNTLs are located in the "Rif sector, Rif-Tell Atlas province, Maghreb Mediterranean sub-region of Mediterranean region". Regarding the socio-economic activities practiced in the park, agriculture is visibly the most representative, especially tree growing fruit and beekeeping. Rif Mountain has recently undergone significant changes in the landscape, economic activities, and lifestyle. The cultivation of cannabis for consumption as a socio-economic activity practiced by the PNTLS population has increased the abandonment of traditional farming systems, which are now being replaced by cannabis crops (Chouvy & Macfarlane 2016, 2018, Meklach *et al.* 2017, Afhasi 2015).

Ethnobotanical data collection

Ethnobotanical data were collected using semi-structured interview (Alexaides 1996, Martin 1995) sheets conducted with the local inhabitants of the National Park, held between 2014 and 2017. All the homes in the community were visited, totaling 200 interviews. The interview focused on basic questions concerning the informant's knowledge of the uses of local plants. The ethnobotanical survey is based on the previous works of our research group (Merzouki *et al.* 1997, 2000, 2001, El Gharbaoui *et al.* 2017). These interviews were performed individually for each informant, in Arabic local dialects (Darija). These interviews were previously based on questionnaires containing direct questions including demographic information about the interviewee (including gender, age, education level, and family situation), the local vernacular name of the used plants (Arabic and Roman alphabets), therapeutic and traditional uses of the plants, including the preparation method, mode of administration, parts used, and diseases treated.

During discussions, the focus was put on understanding local healing strategies, including the causes of sickness and their symptoms. With the gathered information, we developed a database on Microsoft Access and Microsoft Excel. This database also includes the later association of the emic categories for diseases (as they were recorded in the interviews) with an etic category and its classification in pathological groups following the International Classifications of diseases (ICPC-2) of the WHO (following Staub et al. 2015). At all times, the association of ethnobotanical use with the scientific name of plants was established after the identification of plant material, which was provided by our informants, or met from the field and showed them during the interview.

Plant specimen collection and identification

The specimens were collected and scientifically identified, and a voucher specimen was deposited at the Faculty of Sciences of Tetouan (Abdelmalek Essâadi University) based on the local botanical checklist and catalogue of Benabid, 2008, and the available Floras which include the study area (Fennane *et al.* 1999, 2007, 2014, Maire 1952-1987). Voucher numbers for the included plants are provided in the results. Once our database with the plant use and the above-mentioned data was compiled, we performed a bibliographical review of previous ethnobotanical works in the surrounding territories to know the previously reported ethnobotanical uses and the local novelties.

In this sense, the works of El-Hilalye *et al.* (2003), Fakchich *et al.* (2014), Merzouki *et al.* (2000), and Bellakhdar (1997) were highly valuable. All scientific names were reviewed using the plant list (www.theplantlist.org) as Rivera *et al.* (2014) suggested and the database of the world flora (www.worldfloraonline.org).

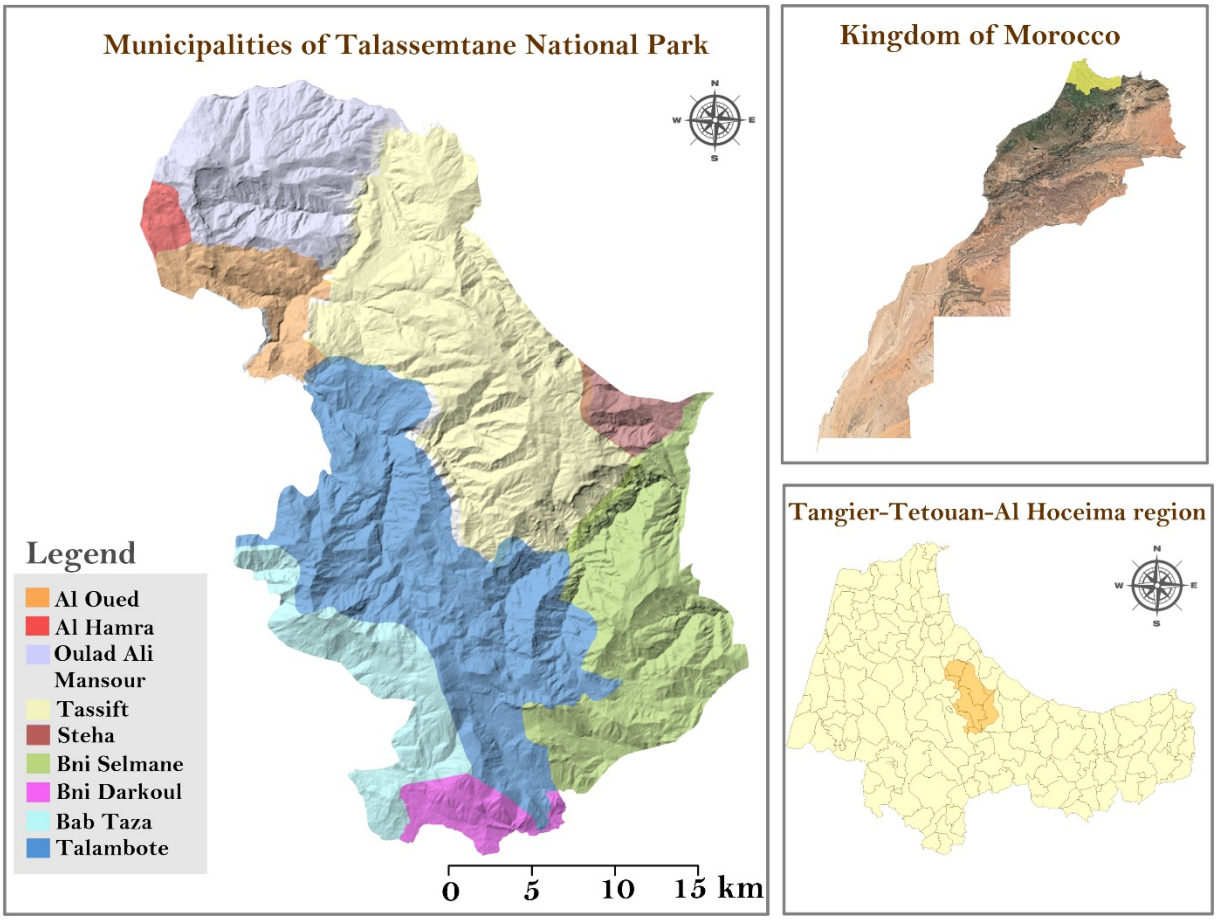

Figure 1. Map of Northern Morocco showing the location of the study area, Talassemtane National Park

Data analysis

Once obtained, the data were compiled using Microsoft Excel and presented in the form of graphs and tables. The data also includes the treated diseases that were classified according to the international classifications of diseases (ICPC-2, International Classification of Primary Care, 2015) of the WHO (as suggested by Staub *et al.*, 2015).

Quantitative ethnobotanical data analysis

To better interpret the results of our study, the ethnobotanical data were collected using various quantitative indices including use value (UV), Medicinal Plant Knowledge index (MPKi), the Medicinal Plant Use index (MPUi), the Confidence level, and Informant agreement ratio (IAR).

Use value

Use-Value (UV) is an index widely used to quantify the relative importance of each plant species known locally to be used as an herbal remedy, and it was calculated using the following formula (Trotter & Logan 1986, Phillips and Gentry 1993, Šavikin, *et al.* 2013, Albuquerque *et al.* 2006, Bussmann *et al.* 2016a, 2016b, 2017a, 2017b, 2018, Rossato *et al.* 1999).

$$UV = u / n$$

u is the number of participants that state different uses of plants and n are the number of informants

Medicinal Plant Knowledge index (MPKi), Medicinal Plant Use index (MPUi), and Confidence level (Cl, measured as MPUi/MPKi) were calculated for each plant species (Merzouki *et al.* 2000) using the following formulae:

$$\mathbf{MPKi\ (\%) = (Ik / N) \times 100}$$
$$\mathbf{MPUi\ (\%) = (IU / N) \times 100}$$
$$\mathbf{Cl = MPUi / MPKi}$$

Where Ik is the number of informants who cited the plant; IU is the number of interviewers who reported the use of a specific medicinal plant in each pathological category, and N is the total number of interviewers.

Informant agreement ratio

The Informant agreement ratio (IAR) for each use category was calculated using the following formula by Trotter & Logan (1986) and Heinrich *et al.* 1998.

$$\mathbf{IAR = Nur - Nt\ /\ Nur - 1}$$

Where IAR is the Informant Agreement Ratio, N_{ur} is the number of mentions in each category, and N_t is the number of taxa used in each category. The values for the factor range from 0 to 1.

Results and Discussion

Demography of informants

Ethnobotanical and ethnomedicinal information was obtained and recorded from 200 informants, 113 (56.5%) male and 87 (43.5%) female. They were interviewed through a questionnaire and face-to-face interviews during our fieldwork. The data are reported in Table 1.

Table 1. Demographic and socio-educational features of the interviewees (Redouan *et al.* 2020b)

	Categories	Statistics (200)	Percentages (%)
Age	<20	11	5.5
	[20-40[	99	**49.5**
	[40-60[	67	33.5
	>60	23	11.5
Gender	F	87	43.5
	M	113	**56.5**
Status	Divorced	2	1
	Married	150	**75**
	Single	42	21
	Widow	6	3
Education	**Illiterate**	94	**47**
	Koranic School	32	16
	Literacy Center	4	2
	Primary School	28	14
	Secondary School	21	10.5
	High School	3	1.5
	University	18	9

The descriptive analysis of our sample revealed that men are slightly more represented than women (56.5%). Some women refused to be interviewed or, occasionally, the house was unoccupied during the research period. Considering the age groups, most of the informants were of upper age from 20-40 and 40-60. Most of the interviewed informants were illiterate (47%) and their knowledge of medicinal plant use, therefore, originated from an oral transmission (Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006, Abouri *et al.* 2012, Eddouks *et al.* 2002, 2017, Saadi *et al.* 2013, Teixidor-Toneu *et al.* 2016).

The data obtained were analyzed using principal component analysis (PCA) to identify the influence of socio-demographic factors (gender, education, and age group). The results of the PCA analysis indicated that socio-demographics did not exhibit any significant differences regarding the use of medicinal plants (Redouan *et al.* 2020b).

Medicinal plants and traditional uses

By ethnobotanical analysis of medicinal plants, we have identified 27 taxa belonging to the Lamiaceae family most used by the populations in the PNTLS region. The list of species is provided in Table 2. In the list, we also have included local vernacular names (Arabic and Roman alphabets), information regarding diseases and/or symptoms treated (with ICPC-2 codes), the part of the plant used, the mode of preparation of the plant, the mode of administration of medicine, and reported uses. Previously reported uses have been cited, as well as a short review of the chemical composition of the plant if such information was known. Pharmacological evidence for the use of some plants has also been provided for cases in which that information was available, and the number of citations for the diseases of each plant, the frequency of use, and the calculated use value (UV).

The most use of this family is due to the richness of Moroccan flora, and it was the most reported family in several ethnopharmacological studies in other Moroccan regions (Redouan *et al.* 2020b, Bouyahya *et al.* 2017, Eddouks *et al.* 2017, Tahraoui *et al.* 2007, Merzouki *et al.* 2000, Jouad *et al.* 2001, Fakchich and Elachouri 2014, El-Hilaly *et al.* 2003, Eddouks *et al.* 2002).

Plant part used and modes of preparation and administration

The most utilized plant parts were leaves (34%), followed by flowery summit (22%), aerial part (20%), stems, and whole plant (12% each) (see Fig. 2). Leaves are commonly used for the preparation of herbal medicines, because of the likely presence of active compounds and ease of phytochemical and pharmacological studies compared to other plant parts (Choudhury *et al.* 2015, Maduka *et al.* 2014, Fakchich & Elachouri 2014, Shil *et al.* 2014, Telefo *et al.* 2011, González *et al.* 2010, Abo *et al.* 2008, Vall 2008, Mahishi *et al.* 2005).

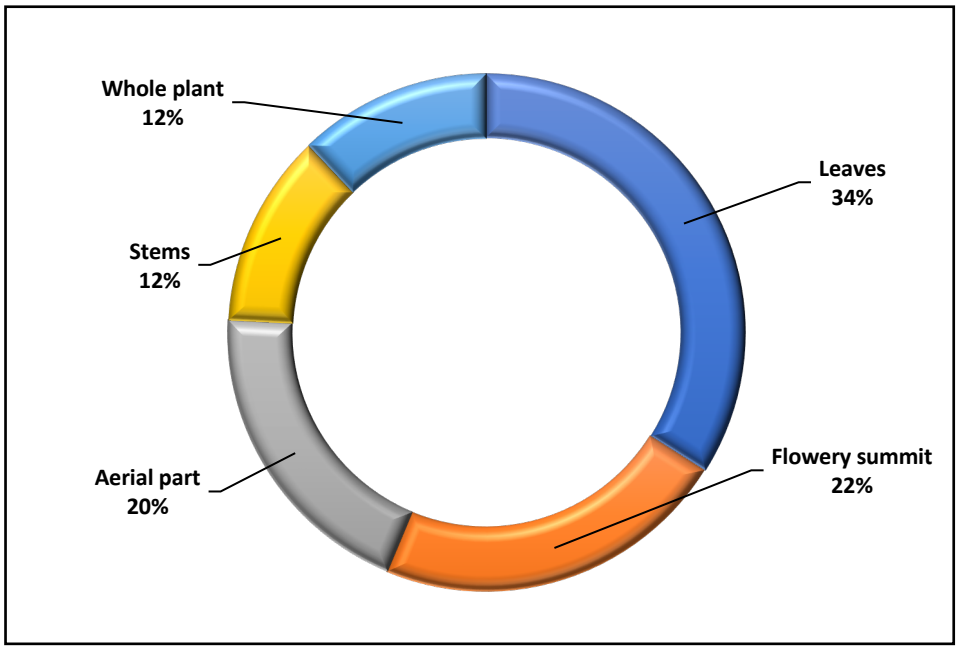

Figure 2. Frequencies of part used of the medicinal plants in PNTLs

The most frequently used mode of preparation is an infusion (46%), followed by decoction (44%), powder (4%), fresh (3%), mashed (2%), and fumigation (1%). The largest proportion of remedies is prepared as infusions. The present study is not in concordance with some research in other regions of the world where different modes of preparation, such as decoction, are reported (e.g. Miara *et al.* 2013, 2019, Togola *et al.* 2005, Eddouks *et al.* 2016, Alzweiri *et al.* 2011, Nadembega *et al.* 2011, Rehecho *et al.* 2011).

Table 2. List of medicinal Lamiaceae used in the PNTLs including local names, treated diseases, parts used, modes of preparation, administration, Knowledge index (MPKi), the use index (MPUi), and the confidence level index, use value and citations.

Species (Vouchers)	**local names in Arabic (Roman alphabets)**	**Treated diseases & symptoms codes**	**Used parts**	**Modes of preparation**	**Mode of administration**	**Use reports**	**MPUi %**	**MPKi %**	**Cl**	**UV**	**Previous references**
***Ajuga chamaepitys* L. Schreb. (TMP-B111)**	شندكورة Chendgûra	Abdominal pain epigastric D02	Leaves	Decoction	Oral	22	19,1	86	0,22	0,42	Chermat, & Gharzouli 2015
		Laceration S18	Leaves	Infusion	Cataplasm	9					Chermat, & Gharzouli, 2015
		Hemorrhoids K96	Leaves	Decoction	Oral	5					
		Indigestion D07	Whole plant	Decoction	Oral	22					
		Intestinal pains D01	Whole plant	Decoction	Oral	22					
		Diabetes non-insulin dependent T90	Whole plant	Decoction	Oral	4					
***Ajuga iva* (L.) Schreb. (TMP-B112)**	شندكورة Chendgûra	Intoxication A86	Whole plant	Infusion	Oral	3	18, 5	86	0,21	0,56	Bellakhdar 1997
		Diabetes non-insulin dependent T90	Whole plant	Decoction	Oral	7					Merzouki *et al.* 2003, El-Hilaly *et al.* 2003, Jouad, *et al.* 2001, Bellakhdar 1997, Eissa *et al.* 2014
		Stomach function disorder D87	Whole plant	Decoction	Oral	22					Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997,

											Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006
		Fever A03	Whole plant	Infusion	Cataplasm	12					Bellakhdar 1997
		Chills A02	Whole plant	Infusion	Cataplasm	12					Bellakhdar 1997
		Contusion S16	Whole plant	Decoction	Cataplasm	5					Benítez *et al.* 2010
		Laceration S18	Whole plant	Decoction	Cataplasm	6					Bellakhdar 1997
		Hair care S24	Whole plant	Decoction	Lotion	16					
		Indigestion D07	Whole plant	Decoction	Oral	22					Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006
		Wart S03	Whole plant	Decoction	Oral	7					Bellakhdar 1997, Eissa *et al.* 2014
***Ballota hirsuta* Benth. (TMP-B113)**	Termas ترماس	Diabetes non-insulin dependent T90	Leaves and stems	Decoction	Oral	11	3,4	13	0,26	0,05	Kechar *et al.* 2016
***Clinopodium nepeta* (L.) Kuntze (TMP-B114)**	Manta مانتا	Cough R05	Aerial part	Infusion	Oral	36	36,5	93	0,39	0,66	
		Heart pain K01	Aerial part	Decoction	Oral	19					

		Fever A03	Leaves and stems	Infusion	Oral	26					
		Influenza R80	Leaves	Decoction	Oral	26					
		Chills A02	Aerial part	Decoction	Oral	26					Merzouki *et al.* 2000
***Lavandula angustifolia* Mill. (TMP-B115)**	khzâma الخزامى	Asthma R96	Flowery summit	Infusion	Cataplasm	29	52,5	86	0,61	1,8	Vitalini *et al.* 2015
		Urinary calculus U95	Flowery summit	Infusion	Oral	16					Teixidor-Toneu *et al.* 2016
		Hair care S24	Flowery summit	Decoction	lotion	19					Teixidor-Toneu *et al.* 2016
		Diabetes non-insulin dependent T90	Leaves and stems	Decoction	Oral	15					
		Joint symptom L20	Leaves	Powder	Cataplasm	22					
		Abdominal pain epigastric D02	Flowery summit	Infusion	Oral	29					Teixidor-Toneu *et al.* 2016
		Teeth ache D19	Leaves	Infusion	Gargle	6					Teixidor-Toneu *et al.* 2016
		Eczema S87	Leaves	Powder	Cataplasm	46					Teixidor-Toneu *et al.* 2016
		Weakness N18	Leaves and stems	Decoction	Oral	21					
		Headache N01	Leaves and stems	Decoction	Cataplasm	12					Cornara *et al.* 2009

		Chills A02	Leaves	Infusion	Cataplasm	12					Teixidor-Toneu *et al.* 2016
		Cough R05	Leaves	Infusion	Oral	23					Teixidor-Toneu *et al.* 2016
		Pneumonia R81	Leaves and rods	Decoction	Oral	23					Teixidor-Toneu *et al.* 2016
		Vaginal infections X14	Flowery summit	Infusion	Lotion	32					
		Pediculosis S73	Leaves	Decoction	Lotion	31					
		Sweating problem A09	Leaves	Decoction	Oral	25					Leto *et al.* 2013
***Lavandula dentata* L. (TMP-B116)**	الخزامى البلدية Khzama lbeldiya	Joint symptom L20	Flowery summit	Powder with oil olive	Massage	18	46,5	86	0,54	0,83	Teixidor-Toneu *et al.* 2016
		Liver disease D97	Flowery summit	Decoction	Oral	12					Fakchich & Elachouri 2014, Ziyyat *et al.* 1997, Jouad *et al.* 2001
		Gastro-intestinal infection D70	Flowery summit	Decoction	Oral	8					Teixidor-Toneu *et al.* 2016, Fakchich & Elachouri 2014, Ziyyat *et al.* 1997, Jouad *et al.* 2001
		Urinary calculus U95	Flowery summit	Decoction	Oral	13					Teixidor-Toneu et al. 2016
		Menstruation Excessive X06	Leaves and rods	Infusion	Oral	19					Teixidor-Toneu *et al.* 2016,

											Bellakhdar 1997
		Urine retention U08	Leaves and rods	Infusion	Oral	14					Teixidor-Toneu *et al.* 2016
		Laceration S18	Leaves	Mashed	Cataplasm	3					Teixidor-Toneu *et al.* 2016
		Neurological symptom N29	Flowery summit	Infusion	Oral	7					Teixidor-Toneu *et al.* 2016
		Chills A02	Flowery summit	Decoction	Cataplasm	27					Teixidor-Toneu *et al.* 2016, Fakchich & Elachouri 2014, Ziyyat *et al.* 1997, Jouad *et al.* 2001
		Headache N01	Flowery summit	Decoction	Cataplasm	12					Alami *et al.* 2014
		Hair care S24	Flowery summit	Decoction	Lotion	34					Alami *et al.* 2014
***Lavandula stoechas* L. (TMP-B117)**	الحلحال Al'halhal	Hair loss S23	Leaves	Decoction	Lotion	34	25,5	69	0,37	1	
		Chills A02	Flowery summit	Fumigation	Inhalation	12					Benítez *et al.* 2010, Bellakhdar 1997
		Asthma R96	Flowery summit	Decoction	Oral	21					Bellakhdar 1997
		Cough R05	Flowery summit	Decoction	Oral	26					Benítez *et al.* 2010
		Bronchiolitis R78	Flowery summit	Decoction	Oral	26					Bellakhdar 1997
		Joint symptom L20	Leaves	Decoction	Oral	17					Benítez *et al.* 2010, El-Hilaly *et al.* 2003

		Urinary calculus U95	Flowery summit	Decoction	Cataplasm	9					Benítez *et al.* 2010
		Neurological symptom N29	Leaves	Infusion	Oral	15					
		Loss of appetite T03	Leaves	Infusion	Oral	12					
		Indigestion D07	Aerial part	Decoction	Oral	23					Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006
		Diabetes non-insulin dependent T90	Leaves	Decoction	Oral	6					Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2007
***Marrubium vulgare* L. (TMP-B118)**	Merrîw مرو	Diabetes non-insulin dependent T90	Leaves	Decoction	Oral	28	36	43	0,84	0,77	Eddouks *et al.* 2017
		Urine retention U08	Whole plant	Decoction	Oral	10					Rafouri *et al.* 2015
		Fever A03	Whole plant	Mashed	Cataplasm	10					Teixidor-Toneu *et al.* 2016
		Menstruation absent X05	Whole plant	Infusion	Oral	8					
		Bronchitis R78	Leaves	Infusion	Oral	9					Teixidor-Toneu *et al.* 2016, Fakchich & Elachouri

					2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006
Cough R05	Leaves	Infusion	Oral	9	Teixidor-Toneu *et al.* 2016, Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003 Tahraoui *et al.* 2007
Stomach function disorder D87	Leaves and stems	Decoction	Oral	12	Teixidor-Toneu *et al.* 2016
Intestinal pains D01	Leaves and stems	Decoction	Oral	12	Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991 Ziyyat et al., 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2007, Rafouri

											et al. 2015, Teixidor-Toneu *et al.* 2016
		Anorexia P86	Leaves and stems	Decoction	Oral	15					
		Loss of appetite T03	Leaves	Infusion	Oral	11					
		Toothache D19	Whole plant	Fresh	Mastication	6					Bellakhdar 1997
		Ear pains H01	Leaves	Fresh	Drop	24					El-Hilaly *et al.* 2003
***Melissa officinalis* L. (TMP-B039)**	نعناع الترونجي Naânaâ trunji	Intestinal pains D01	Whole plant	Infusion	Oral	12	41	55	0,75	0,28	
		Stomach function disorder D87	Whole plant	Infusion	Oral	10					
		Abdominal pain epigastric D02	Whole plant	Infusion	Oral	8					
		Indigestion D07	Whole plant	Infusion	Oral	15					
		Feeling anxious/nervous/ tense P01	Whole plant	Infusion	Oral	11					
***Mentha piperita* L. (TMP-B119)**	النعناع البلدي Naânaâ beldi	Hemorrhoids K96	Leaves	Decoction	Oral	9	35,2	60	0,59	0,21	Leonti *et al.* 2010
		Stomach function disorder D87	Whole plant	Infusion	Oral	13					Sargın *et al.* 2013, Leonti *et al.* 2010, Valentina *et al.* 2011, Bellakhdar 1997
		Fever A03	Whole plant	Fresh	Cataplasm	21					Leonti *et al.* 2010,

											Bellakhdar 1997
***Mentha pulegium* L. (TMP-B120)**	Flaio فلايو	Cough R05	Leaves	Infusion	Cataplasm	32	62	100	0,62	1,29	Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006, Rafouri *et al.* 2015, Teixidor-Toneu *et al.* 2016, Eddouks *et al.* 2017
		Fever A03	Leaves	Infusion	Cataplasm	26					Teixidor-Toneu *et al.* 2016
		Respiratory infection R74	Leaves and Stems	Infusion	Cataplasm	70					Teixidor-Toneu *et al.* 2016, Eddouks *et al.* 2017, Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006 Fakchich

					& Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006
Indigestion D07	Leaves and Stems	Infusion	Oral	22	Bellakhdar, 1997, Teixidor-Toneu *et al.* 2016 Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006
Bronchitis R78	Leaves and Stems	Infusion	Cataplasm	35	Bellakhdar, 1997, Eddouks *et al.* 2017, Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003,

										Tahraoui *et al.* 2006
		Abdominal pain epigastric D02	Leaves and Stems	Infusion	Oral	22				Bellakhdar 1997, Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006
		Throat pain R21	Leaves	Infusion	Cataplasm	26				Bellakhdar, 1997, Teixidor-Toneu *et al.* 2016
		Chills A02	Leaves	Infusion	Cataplasm	26				Teixidor-Toneu *et al.* 2016
		Skin inflammation S11	Leaves	Infusion	Rinsing	12				El-Hilaly *et al.* 2003
***Mentha rotundifolia* (L.) Huds. (TMP-B121)**	مششترو Mchichtro	Chills A02	Leaves and Stems	Infusion	Oral	5	31,5	93	0,34	0,28	El-Hilaly *et al.* 2003, Bellakhdar 1997
		Hemorrhoids K96	Leaves and Stems	Decoction	Oral	7				Bellakhdar 1997
		Abdominal pain epigastric D02	Leaves and Stems	Decoction	Oral	13				Eddouks *et al.* 2017, Bellakhdar 1997, Teixidor-

											Toneu *et al.* 2016
		Flatulence D08	Leaves and Stems	Infusion	Oral	13					Merzouki *et al.* 2000
		Laceration S18	Leaves	Mashed	Cataplasm	5					Bellakhdar 1997
		Indigestion D07	Aerial part	Infusion	Oral	13					Eddouks *et al.* 2017, Merzouki *et al.* 2000, Idolo *et al.* 2010, Leto et *al.* 2013, El-Hilaly *et al.* 2003, Teixidor-Toneu *et al.* 2016
***Mentha suaveolens* Ehrh. (TMP-B122)**	مششترو Mchichtro	Joint symptom L20	Aerial part	Infusion	Cataplasm	22	23,5	74	0,32	0,43	Teixidor-Toneu *et al.* 2016
		Cough R05	Aerial part	Infusion	Oral	36					Rafouri *et al.* 2015, Bellakhdar, 2006, Teixidor-Toneu *et al.* 2016
		Abdominal pain epigastric D02	Aerial part	Infusion	Oral	23					Teixidor-Toneu *et al.* 2016, Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991
		Sexual desire reduced P07	Aerial part	Infusion	Oral	5					

Mentha viridis **(L.) L. (TMP-B123)**	Naânaâ النعناع	Helminthiasis D96	Aerial part	Infusion	Oral	21	75,3	100	0,75	0,18	Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006
		Hypertension K86	Leaves	Infusion	Oral	15					Jouad *et al.* 2001
Ocimum basilicum **L. (TMP-B124)**	Al'Hbak الحباق	Mouth ulcers D20	Leaves	Fresh	Mastication	9	87	100	0,87	0,34	
		Hair care S24	Leaves and Stems	Decoction	Lotion	8					Idolo *et al.* 2010
		Anxiety disorder P74	Leaves	Infusion	Oral	13					
		Laceration S18	Leaves	Mashed	Cataplasm	6					
		Indigestion D07	Leaves	Infusion	Oral	21					Rafouri *et al.* 2015, Bellakhdar 2006, Menale *et al.* 2014, El-Hilaly *et al.* 2003, Valentina *et al.* 2011
		Fever A03	Leaves	Infusion	Cataplasm	11					Bellakhdar 1997
Origanum compactum **Benth. (TMP-B125)**	Azzaatar الزعتر	Laceration S18	Leaves	Powder	Cataplasm	10	43,5	100	0,44	1,01	
		Cough R05	Aerial part	Infusion	Oral	21					Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat

					et al. 1997, Jouad *et al.* 2001
Abdominal pain epigastric D02	Aerial part	Infusion	Oral	42	Rafouri *et al.* 2015, Bellakhdar 2006, Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001
Heart pain K01	Aerial part	Powder with oil olive	Massage	9	
Diarrhoea D11	Aerial part	Decoction	Oral	35	Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001
Gum symptom D19	Aerial part	Infusion	Gargle	22	Bellakhdar 1997
Sexual desire reduced P07	Aerial part	Decoction	Oral	10	Bellakhdar 1997
Loss of appetite T03	Aerial part	Decoction	Oral	31	Bellakhdar 1997
Influenza R80	Aerial part	Decoction	Oral	23	Rafouri *et al.* 2015, Bellakhdar 2006, Fakchich & Elachouri 2014,

											Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001
***Origanum majorana* L. (TMP-B126)**	مرددوش Merdeddush	Abdominal pain epigastric D02	Aerial part	Infusion	Oral	35	23	72	0,32	0,82	Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006
		Headache N01	Aerial part	Infusion	Oral	8					Bellakhdar 1997
		Menstrual irregular X07	Aerial part	Infusion	Oral	21					
		Cough R05	Aerial part	Infusion	Oral	27					El-Hilaly *et al.* 2003
		Influenza R80	Aerial part	Infusion	Oral	27					Sargın *et al.* 2013
		Sweating problem A09	Leaves	Infusion	Lotion	23					El Haouari *et al.* 2018
		Chills A02	Whole plant	Infusion	Oral	23					Bellakhdar 1997
***Origanum elongatum* (Bonnet) Emb. & Maire (TMP-B127)**	Zâatar الزعتر	Indigestion D07	Aerial part	Infusin	Oral	24	21	43	0,49	0,33	Bellakhdar 1997
		Influenza R80	Aerial part	Infusion	Oral	32					Bellakhdar 1997
		Chills A02	Aerial part	Infusion	Oral	10					Bellakhdar 1997
***Origanum vulgare* L. (TMP-B128)**	Assahtar السحتر	Loss of appetite T03	Aerial part	Infusion	Oral	19	32	73	0,44	0,95	Vitalini *et al.* 2015
		Flatulence D08	Aerial part	Infusion	Oral	25					Leonti *et al.* 2010

		Menstruation absent X05	Aerial part	Infusion	Oral	13					
		Sweating problem A09	Aerial part	Infusion	Oral	5					
		Intoxication A86	Aerial part	Infusion	Oral	8					
		Urine retention U08	Aerial part	Decoction	Oral	12					
		Abdominal pain epigastric D02	Aerial part	Decoction	Oral	25					Eddouks *et al.* 2017
		Influenza R80	Aerial part	Infusion	Oral	14					Cakilcioglua*et al.* 2011, Polat & Satıl 2012, Benítez *et al.* 2010, Leto *et al.* 2013
		Bronchitis R78	Aerial part	Infusion	Oral	19					Leonti *et al.* 2010.
		Menstrual pain X02	Aerial part	Infusion	Oral	13					
		Indigestion D07	Aerial part	Decoction	Oral	25					Eddouks *et al.* 2017, Licata *et al.* 2016
		Diabetes non-insulin dependent T90	Aerial part	Infusion	Oral	12					Özdemir& Alpınar 2015
***Rosmarinus officinalis* L. (TMP-B129)**	Azir أزير	Skin infection S11	Leaves	Decoction	Cataplasm	11	56	78	0,72	0,64	Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003,

					Tahraoui *et al.* 2006
Loss of appetite T03	Leaves	Infusion	Oral	27	Bellakhdar 1997
Laceration S18	Leaves	Powder	Cataplasm	9	Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006
Urine retention U08	Leaves and Stems	Decoction	Oral	15	Merzouki *et al.* 2000, El-Hilaly *et al.* 2003
Menstruation absent X05	Leaves and Stems	Infusion	Oral	23	
Mouth symptom D20	Leaves	Infusion	Gargle	14	Benítez *et al.* 2010
Abdominal pain epigastric D02	Leaves and Stems	Decoction	Oral	29	Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006.

***Salvia officinalis* L. (TMP-B130)**	السالمية Assalmiya	Flatulence D08	Leaves	Decoction	Oral	13	49	72	0,68	0,65	Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006
		Intoxication A86	Leaves	Decoction	Oral	3					
		Gum symptom D19	Leaves	Infusion	Gargle	8					Bellakhdar 1997
		Toothache D19	Leaves	Fresh	Mastication	8					Leto *et al.* 2013
		Sweating problem A09	Leaves	Infusion	Oral	10					
		Upper respiratory infection acute R74	Leaves	Infusion	Oral	17					Cakilcioglu, *et al.* 2011, Pieroni *et al.* 2002, Leonti *et al.* 2010.
		Laceration S18	Leaves	Powder	Cataplasm	4					Leonti *et al.* 2010
		Diabetes non-insulin dependent T90	Leaves	Infusion	Oral	12					Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991, Ziyyat *et al.* 1997, Jouad *et al.* 2001, El-Hilaly *et al.* 2003, Tahraoui *et al.* 2006

		Menstruation irregular X07	Leaves and Stems	Decoction	Oral	15					Vitalini, *et al.* 2015
		Urine retention U08	Leaves and Stems	Decoction	Oral	26					Bellakhdar 1997
		Abortion induced W83	Leaves and Stems	Decoction	Oral	5					
		Hair care S24	Leaves	Infusion	Lotion	9					Alami *et al.* 2014, Leonti *et al.* 2010, Vitalini *et al.* 2015
***Salvia argentea* L. (TMP-B131)**	El القويسة kouissa	Genital pain female X01	Leaves	Infusion	Lotion	5	32	68	0,47	0,09	
		Urinary infection U71	Leaves	Infusion	Oral	13					
***Teucrium polium* L. (TMP-B132)**	Jaada الجعدة	Liver disease D97	Aerial part	Decoction	Oral	17	13	86	0,15	0,22	Fakchich & Elachouri 2014, Bellakhdar *et al.* 1991
		Laceration S18	Aerial part	Decoction	Cataplasm	3					Bellakhdar 1997
		Fever A03	Aerial part	Infusion	Cataplasm	7					Bellakhdar 1997
		Shortness of breath R02	Aerial part	Decoction	Oral	9					Mükemre *et al.* 2015
		Diabetes non-insulin dependent T90	Whole plant	Decoction	Oral	8					Durmuşkahya & Öztürk 2013, Cakilcioglua*et al.* 2011, Özdemir & Alpınar 2015, Cakilcioglu &

											Turkoglu 2010, Polat & Satıl 2012
***Thymbra capitata* L. (TMP-B133)**	Zîtra الزعيترة	Stomach function disorder D87	Leaves, flowery summit	Decoction	Oral	16	47	86	0,55	0,37	Lardos & Heinrich 2013
		Headache N01	Leaves, flowery summit	Infusion	Oral	12					Lardos & Heinrich 2013
		Pneumonie R81	Leaves, flowery summit	Decoction	Cataplasm	18					Lardos & Heinrich 2013
		Sweating problem A09	Leaves, flowery summit	Decoction	Oral	11					Tuttolomondo *et a*l. 2014
		Grippe R80	Leaves, flowery summit	Infusion	Oral	17					Benítez *et al.* 2010
***Thymus capitellatus* Hoffmanns. & Link. (TMP-B134)**	Zîtra الزعتيرة	Sexual desire reduced P07	Leaves, flowery summit	Decoction	Oral	6	23	49	0,47	0,33	
		Joint symptom L20	Leaves, flowery summit	Decoction	Cataplasm	16					
		Stomach function disorder D87	Leaves, flowery summit	Decoction	Oral	28					El-Hilaly *et al.* 2003 Bellakhdar 1997, Eissa *et al.* 2014
		Pneumonia R81	Leaves, flowery summit	Decoction	Cataplasm	17					Bellakhdar 1997
***Thymus willdenow*ii Boiss. (TMP-B135)**	Zîtra الزعيترة	Stomach function disorder D87	Leaves	Decoction	Oral	26	13	49	0,27	0,75	Parada *et al.* 2009, Leto *et al.* 2013, Cornara *et al.*

										2009, Bellakhdar 1997
		Respiratory infection R83	Leaves	Decoction	Cataplasm	30				Bellakhdar 1997
		Chills A02	Leaves	Decoction	Oral	15				Leto *et al.* 2013, Bellakhdar 1997
		Liver disease D97	Leaves	Decoction	Oral	9				
		Diarrhoea D11	Leaves	Decoction	Oral	19				
		Intestinal pains D01	Leaves	Decoction	Oral	19				Parada *et al.* 2009 Leto *et al.* 2013, Cornara *et al.* 2009, Bellakhdar 1997
		Teeth/gum symptom D19	Leaves	Decoction	Gargle	8				Parada *et al.* 2009
		Throat symptom R21	Leaves	Decoction	Oral	15				Parada *et al.* 2009
		Skin symptom S29	Leaves	Decoction	Rinsing	6				
		Intoxication A86	Leaves	Decoction	Oral	4				Parada *et a*l. 2009, Idolo *et al.* 2010, Cornara *et al.* 2009
***Thymus algeriensis* Boiss. & Reut (TMP-B136)**	Zîtra الزعيترة	Stomach function disorder D87	Leaves	Fresh with cold water	Oral	26	17	48	0,35	0,19	El-Hilaly *et al.* 2003, Bellakhdar 1997
		Teeth/gum symptom D19	Leaves, flowery summit	Infusion	Gargle	13					Chermat & Gharzouli, 2015

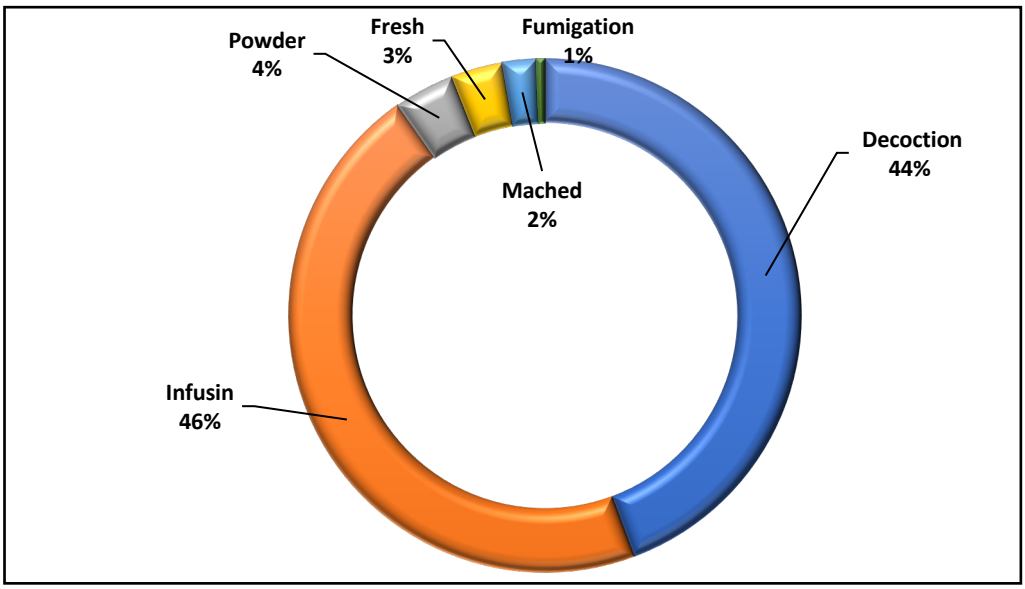

Figure 3. Modes of preparation of the medicinal plants used in PNTLs

The results showed that most of the informants took herbal medicines orally in an internal mode (89%), orally (67%), inhalation, and drop (1%). As main external administration forms (32%), they used cataplasm (19%), lotion (5%), gargle (3%), mastication (2%), massage, and rinsing (1%). The data, also, showed that the oral mode allows better absorption of active compounds contained in an herbal remedy (Yebouk *et al.* 2020, Redouan *et al.* 2020a, Redouan *et al.* 2022).

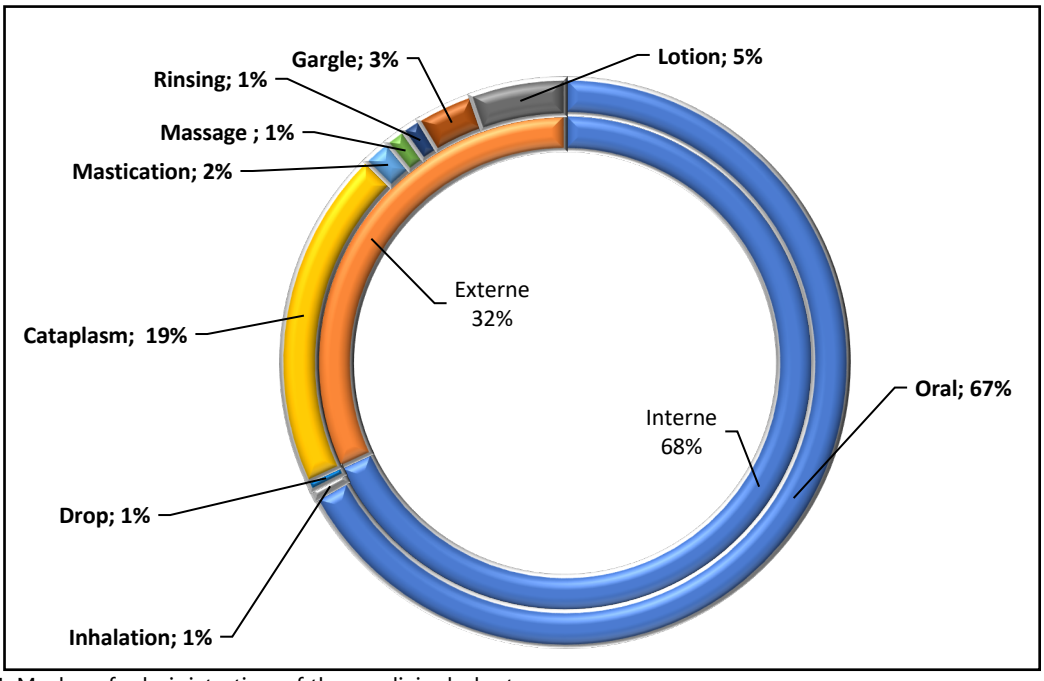

Figure 4. Modes of administration of the medicinal plants

Conditions and symptoms of digestive group

As reported by the interviewers, the identified medicinal plants are used for curing and/or preventing 13 pathological groups of diseases (Table 3). The major illnesses treated by plant products include digestive disorders (D) (28%), followed by Respiratory (R) (16%), General and Unspecified disorders (A) (14%), and Skin (S) (11%). Endocrine/Metabolic and Nutritional (T) (8%), Female Genital (X) (5%), Urological (R) and Neurological disorders (N) (4% each), the diseases such as Cardiovascular (K), Psychological (P) and Musculoskeletal (L) (3% each). Pregnancy, Childbearing, and Family Planning represent (1%).

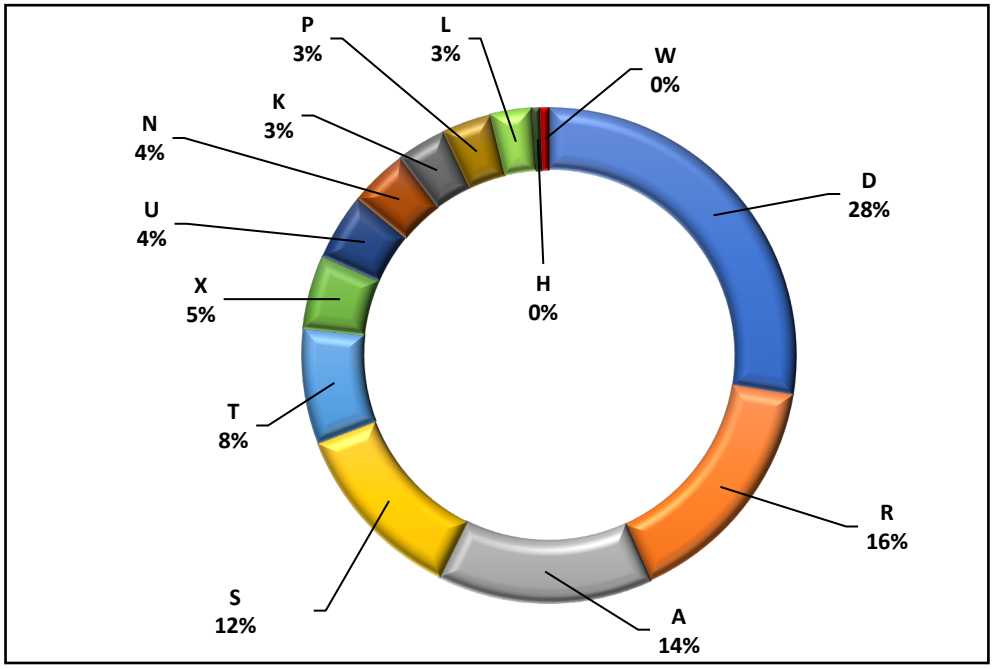

Figure 5. Frequencies of the pathological group treated in PNTLS. Codes for pathological are according to ICPC-2

Table 3 shows the number of treatments made with taxa of the Lamiaceae family, sorted by pathological groups. The species used for treating the greatest number of diseases in the PNTLS is *Lavandula angustifolia*, which has been reportedly used to treat sixteen different ailments, followed by *Lavandula stoechas*, *Origanum vulgare*, and *Salvia officinalis*, twelve for each taxon.

Quantitative ethnobotany

Use reports (UR)

In this study, we identified 183 medicinal uses for the 27 taxa included are used locally to treat 58 conditions and symptoms, categorized into 13 pathological digestive groups. According to the ICPC-2 international classification of diseases, with a total of 3113 UR, overall, we got very high use ratios for most uses. The most cited condition was abdominal pain epigastric (D02) and up to 10 plant-based remedies can be used in the study area (248 UR).

Also, a high number of remedies and use reports were achieved for Cough R05 (8 species and 210 UR) and Indigestion D07 (9 species and 187 UR). Nevertheless, hypertension is worth mentioning, with 146 UR for only five species. For 18 diseases, only one species has been reported (Figure 7).

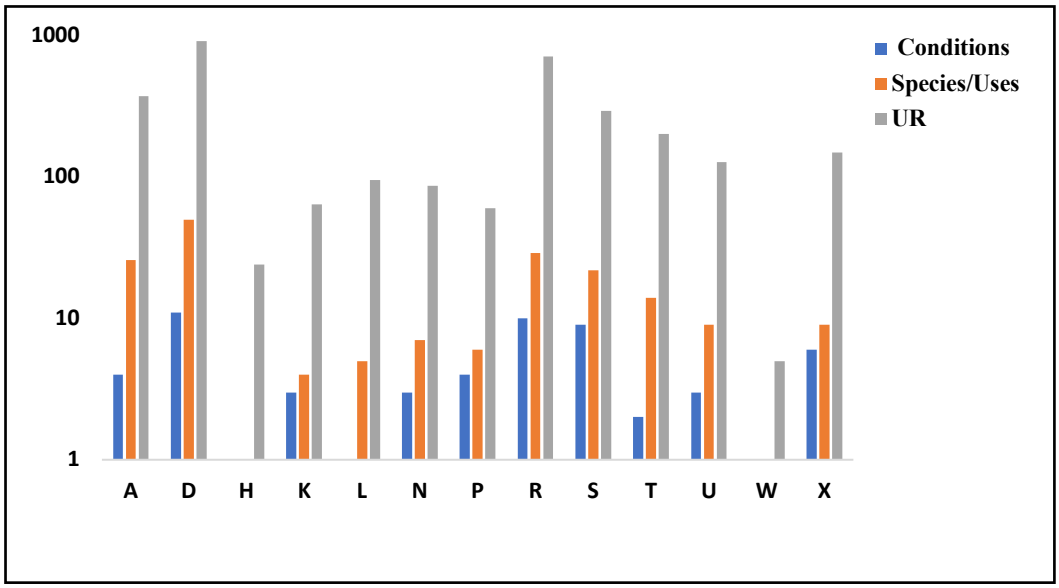

Figure 7. Number of conditions, uses and UR per pathological group. Note the logarithmic scale

Table 3. Number of treatments per pathological group made with Species cited by the PNTLs population

	Pathological Group (PG)																
Species (Vouchers)	**A**	**B**	**D**	**F**	**H**	**K**	**L**	**N**	**P**	**R**	**S**	**T**	**U**	**W**	**X**	**Y**	**Total citation per species**
Ajuga chamaepitys			3			1					1	1					6
Ajuga iva	3		2								4	1					10
Ballota hirsuta												1					1
Clinopodium nepeta	2					1				2							5
Lavandula angustifolia	2		2				1	2		3	3	1	1		1		**16**
Lavandula dentata	1		2				1	2			2		2		1		11
Lavandula stoechas	1		2				1	1		3	1	2	1				**12**
Marrubium vulgare	1		3		1				1	2		2			1		11
Melissa officinalis			4						1								5
Mentha piperita	1		1			1											3
Mentha pulegium	2		2							4	1						9
Mentha rotundifolia	1		3			1					1						6
Mentha suaveolens			1				1		1	1							4
Mentha viridis			1			1											2
Ocimum basilicum	1		2						1		2						6
Origanum compactum			3			1			1	2	1	1					9
Origanum majorana	2		1					1		2					1		7
Origanum elongatum	1		1							1							3
Origanum vulgare	2		3							2		2	1		2		**12**
Rosmarinus officinalis			2								2	1	1		1		7
Salvia officinalis	2		3							1	2	1	1	1	1		**12**
Salvia argentea													1		1		2
Teucrium polium	1		1							1	1	1					5
Thymbra capitata	1		1					1		2							5
Thymus capitellatus			1				1		1	1							4
Thymus willdenowii	2		5							2	1						10
Thymus algeriensis			2														2
Total citation per PG	26	0	51	0	1	6	5	7	6	29	22	14	8	1	9	0	**185**

According to the calculation made on the basis of the use-value UV (Trotter and Logan, 1986); *Lavandula angustifolia* Mill. (UV=1,8), *Mentha pulegium* L. (UV=1,29), *Origanum compactum* Benth. (UV=1,01), *Lavandula stoechas* L. (UV=1), and *Origanum vulgare* L. (UV=0,95), were reported to be of the highest use value (Table 2).

Lavandula angustifolia Mill. (UV=1,8): In Spain this herb is widely used in traditional medicine to treat dyspepsia, depression, rheumatism, pain, throat irritation, hypertension, hypercholesterolemia, diabetes, insomnia, sedative, cardiac tonic, asthma, alopecia, varicose veins, toothache, eczema, it is also used as carminative, depurative, aphrodisiac and aperitif (González-Tejero 1989, Guzmán 1998, Fernández Ocaña 2000, Benítez 2009, Casado-Ponce 2003). In Italy it is used as a sedative, eczema, acne, headache, and bad odour in the mouth (Tuttolomondo *et al.* 2014, Leto *et al.* 2013, Barbagallo *et al.* 2004).

Mentha pulegium L. (UV=1,29): this aromatic and medicinal plant is known in traditional phytotherapy of numerous countries particularly in Mediterranean area and Asia. In Italy, Mentha Pulegium is used against Hematomas, wounds, digestive, swelling, bruises, liver disease, refreshing, skin disease, cough, asthenia, and diarrhea (Tuttolomondo *et al.* 2014, Barbagallo *et al.* 2004, Licata *et al.* 2016). In Portugal, this plant is popularly used as an antihypercholesterolaemic agent, carminative, and it is also used as a headache and colds treatment and as an intestinal analgesic and hepatic protector (Novais *et al.* 2004). In Spain, this plant is widely used in traditional medicine to treat gastralgia, helminthiases, dyspepsia, cough, abortion, menstrual disorders, renal lithiasis, diabetes,, asthma, , constipation, vomiting, diarrhea, thinning, flatulence, hypercholesterolemia, rheumatism and it is also used as a blood purifying tonic, vaginal antiseptic, hepatic protector, aphrodisiac, diuretic, headache and toothache reliever, (González-Tejero 1989, Guzmán-Tirado 1998, Fernández Ocaña 2000, Benítez 2009). In Algeria, *M. pulegium* is well known as an antihypertensive and antispasmodic agent, it is also known as a remedy for respiratory tract diseases (Boudjelal *et al.* 2013; Benarba 2015).

Lavandula stoechas L. (UV=1): this medicinal plant is known in traditional phytotherapy. In Spain, it is used to treat digestive system diseases(stomachache, dyspepsia, gastric ulcers, liver disease, intestinal disorders), and it is also used against cough, renal lithiasis, rheumatism, hypercholesterolemia, affections of the throat, headaches, sciatica and as a diuretic. It is also useful to treat diabetes (González-Tejero 1989, Guzmán-Tirado 1998, Benítez 2009).

Origanum vulgare L. (UV=0,95); in folk medicine, this plant is used in Spain to treat digestive system diseases(stomachache), and various disorders of the respiratory system (bronchitis, asthma, coughs, and colds) (Gonzàles *et al.* 2010, Alarcón *et al.* 2015). In Andalusia, it is used to treat odontalgia, indigestion, cough, food poisoning, appetizer, pain, headache, burning, dysmenorrhea, flatulence, hypotension, throat irritation (González-Tejero 1989, Guzmán 1998, Galán-Soldevilla 1993, Fernández Ocaña 2000, Benítez 2009). In Italy, it is used for heartburn and asthma; it is also used as carminative, depurative, digestive, sedative, toothache, cough, flu, bronchial catarrh, aperitif, as well as a treatment for menstrual pain, swelling, torticollis and blocked noses (Vitalini *et al.* 2015, Licata *et al.* 2016, Barbagallo *et al.* 2004, Aleo *et al.* 2014, Leto *et al.* 2013, Tuttolomondo *et al.* 2014). In Turkey Origanum vulgare is used for treatment of Colds, flu, diabetes, and urinary inflammations (Özdemir & Alpınar 2015, Cakilcioglu *et al.* 2011).

The results show that there is a significant similarity between the uses of the species cited in our survey and those cited in other areas, in particular those belonging to the Mediterranean area. Among the quantitative techniques that have come in favor, the use value (UV) index proposed by Phillips and Gentry (1993) has been widely used to quantify the relative importance of species (Albuquerque et al. 2006, Rossato *et al.* 1999, Bussmann *et al.* 2016a, b, 2017a, b, 2018, Thomas & Van Damme 2010).

UV is considered to be effective in determining which plants are best suited for a particular group of people, in evaluating the potential uses of a plant and in determining the extent of knowledge about it within the group (Albuquerque *et al.* 2006, Morvin Yabesh *et al.* 2014, Phillips & Gentry 1993).

Knowledge index (MPKi) and the use index (MPUi)

We analyzed the level of knowledge using several indices to identify the species most used in the study area. We calculated for each plant the Knowledge Index (MPKi) and Utilization Index (MPUi) (Table 2). Knowledge of a specific medicinal plant is considered widespread when the number of people who know it (MPKi) and use it (MPUi) is high, and higher when the confidence level index (Cl = MPUi/ MPKi) is close to 1.

In this sense, the highest indices were obtained for Ment*ha pulegium, Mentha viridis, Ocimum basilicum,* and *Origanum compactum* with 100% of PMKi. Overall, the indices of average use and knowledge of all the species studied in this study provide an overview of the traditional pharmacopeia and ethnobotanical information of the studied population. The same can be said for the average confidence level.

Disease categories and their IAR values

In the present study, the IAR values ranged from (0,92) to 1 for uses categories (Table 3). The category with the highest degree of agreement from informants was Ear disorders (H) and Pregnancy, Childbearing, Family Planning (W) (1). The ranking was followed by Digestive (D) and Respiratory (R) (0.98). The disease categories are General and Unspecified (A), Musculoskeletal (L), and Endocrine / Metabolic and Nutritional (T) (0,96) (Table 4).

Table 4. IAR values by categories for treating metabolic diseases

Categories	List of plant species used and number of uses	Nt	Nur	IAR
General and Unspecified (A)	*Ajuga iva* (L.) Schreb. (27), *Clinopodium nepeta* (L.) Kuntze (52), *Lavandula angustifolia* Mill. (37), *Lavandula dentata* L. (27), *Lavandula stoechas* L. (12), *Marrubium vulgare* L. (10), *Mentha piperita* L. (21), *Mentha pulegium* L. (52), *Mentha rotundifolia* (L.) Huds. (5), *Ocimum basilicum* L. (11), *Origanum majorana* L.(46), *Origanum elongatum* (Bonnet) Emb. & Maire (6), *Origanum vulgare* L. (13), *Salvia officinalis* L. (13), *Teucrium polium* L. (7), *Thymbra capitata* L. (11), *Thymus willdenowii* Boiss. (19)	17	369	0,96
Digestive (D)	*Ajuga chamaepitys* L. Schreb. (66), *Ajuga iva* (L.) Schreb. (44), *Lavandula angustifolia* Mill. (35), *Lavandula dentata* L. (20), *Lavandula stoechas* L. (23), *Marrubium vulgare* L. (30), *Melissa officinalis* L. (45), *Mentha piperita* L. (13), *Mentha pulegium* L. (44), *Mentha rotundifolia* (L.) Huds. (39), *Mentha suaveolens* Ehrh. (23), *Mentha viridis* (L.) L. (21), *Ocimum basilicum* L. (30), *Origanum compactum* Benth. (99), *Origanum majorana* L. (35), *Origanum elongatum* (Bonnet) Emb. & Maire (24), *Origanum elongatum* (Bonnet) Emb. & Maire (75), *Rosmarinus officinalis* L. (43), *Salvia officinalis* L. (29), *Teucrium polium* L. (17), *Thymbra capitata* L. (16), *Thymus capitellatus* Hoffmanns. & Link. (28), *Thymus willdenowii* Boiss. (81), *Thymus algeriensis* Boiss. & Reut (39)	24	1288	0,98
Ear (H)	*Marrubium vulgare* L. (24)	1	24	1
Cardiovascular (K)	*Ajuga chamaepitys* L. Schreb. (5), *Clinopodium nepeta* (L.) Kuntze (19), *Mentha piperita* L. (9), *Mentha rotundifolia* (L.) Huds. (7), *Mentha viridis* (L.) L. (15), *Origanum compactum* Benth. (9)	6	64	0,92
Musculoskeletal (L)	*Lavandula angustifolia* Mill. (22), *Lavandula dentata* L. (18), *Lavandula stoechas* L. (17), *Mentha suaveolens* Ehrh. (22), *Thymus capitellatus* Hoffmanns. & Link. (16)	5	95	0,96
Neurological (N)	*Lavandula angustifolia* Mill. (33), *Lavandula dentata* L. (19), *Lavandula stoechas* L. (15),*Origanum majorana* L. (8), *Thymbra capitata* L. (12)	5	87	0,95
Psychological (P)	*Ajuga chamaepitys* L. Schreb. (5), *Marrubium vulgare* L. (36), *Melissa officinalis* L. (11), Mentha piperita L. (9), *Mentha rotundifolia* (L.) Huds. (7), *Mentha suaveolens* Ehrh. (5), *Mentha viridis* (L.) L. (15), *Ocimum basilicum* L. (13), *Origanum compactum* Benth. (10), Thymus *capitellatus* Hoffmanns. & Link. (6)	10	117	0,92
Respiratory (R)	*Clinopodium nepeta* (L.) Kuntze (62), *Lavandula angustifolia* Mill. (75), *Lavandula stoechas* L. (73), *Marrubium vulgare* L. (18), *Mentha pulegium* L. (163), *Mentha suaveolens* Ehrh. (36), *Origanum compactum* Benth. (44), *Origanum majorana* L. (54), *Origanum elongatum* (Bonnet) Emb. & Maire (32), *Origanum*	14	840	0,98

	vulgare L. (33), *Salvia officinalis* L. (27), *Teucrium polium* L. (9), *Thymbra capitata* L. (35), *Thymus capitellatus* Hoffmanns. & Link. (17), *Thymus willdenowii* Boiss. (45)			
Skin (S)	*Ajuga chamaepitys* L. Schreb. (9), *Ajuga iva* (L.) Schreb. (34), *Lavandula angustifolia* Mill. (96), *Lavandula dentata* L. (37), *Lavandula stoechas* L. (34), *Mentha pulegium* L. (12), *Mentha rotundifolia* (L.) Huds. (5), *Ocimum basilicum* L. (14), *Origanum compactum* Benth. (10), *Rosmarinus officinalis* L. (20), *Salvia officinalis* L. (13), *Teucrium polium* L. (3), *Thymus willdenowii* Boiss. (6)	13	283	0,95
Endocrine/Metabolic and Nutritional (T)	*Ajuga chamaepitys* L. Schreb. (4), *Ajuga iva* (L.) Schreb. (7), *Ballota hirsuta* Benth.(11), *Lavandula angustifolia* Mill. (15), *Lavandula angustifolia* Mill. (18), *Marrubium vulgare* L. (39), *Origanum compactum* Benth. (31), *Origanum vulgare* L. (31), *Rosmarinus officinalis* L. (27), *Salvia officinalis* L. (12), *Teucrium polium* L. (8)	11	203	0,96
Urological (U)	*Lavandula angustifolia* Mill. (16), *Lavandula dentata* L. (27), *Lavandula stoechas* L. (9), *Marrubium vulgare* L. (10), *Origanum vulgare* L. (12), *Rosmarinus officinalis* L. (15), *Salvia officinalis* L. (26), *Salvia argentea* L. (13)	8	128	0,94
Pregnancy, Childbearing, Family Planning (W)	*Teucrium polium* L. (5)	1	5	1
Female Genital (X)	*Lavandula angustifolia* Mill. (32), *Lavandula dentata* L. (19), *Marrubium vulgare* L. (8), *Origanum majorana* L.(21), *Origanum vulgare* L. (26), *Rosmarinus officinalis* L. (23), *Salvia officinalis* L. (15), *Salvia argentea* L. (5)	8	149	0,95

The IAR results of the study proved that diseases that were frequent in the PNTLs area have a higher informant agreement ratio (values between 0.92 and 1) and indicate the agreement of selection of taxa between informants, whereas a low value indicates disagreement. These high IAR values indicated reasonable reliability of informants on the use of medicinal plant species. The informant agreement values also indicated that the people share the knowledge of the most important medicinal plant species to treat the most frequently encountered diseases in the study area. Therefore, species with high IAR are to be prioritized for further pharmacological and phytochemical studies (Lin *et al.* 2002, Uprety *et al.* 2010, Uniyal *et al.* 2011).

Conclusion

The ethnobotanical and ethnopharmacological studies enabled us to identify the medicinal plants most used in the Park studied. In our ethnobotanical study, conducted in the Adrar province in northern Mauritania, we achieved an interesting data set, including the medicinal traditional use of 27 species belonging to the Lamiaceae families. Local healers and inhabitants use these plants for a high variety of health conditions and symptoms, up to 58 conditions grouped into 13 pathological groups. A high consensus was achieved from the interviews performed with 200 informants, obtaining a total number of 3113 use reports. The most important group, as usual, was that of digestive disorders (D). Most of the herbal remedies are administered orally and mainly prepared as a decoction, the frequent use of decoction may be explained by the fact that decoction collects the active ingredients and attenuates or cancels the toxic effect of certain recipes. From the bibliographical comparison, we found that 19 of the 27 identified species, had been previously reported.

These plants still play a crucial role for people in PNTLs, but medicinal plants used to treat Ear disorders (H) and Pregnancy, Childbearing, Family Planning (W) in this region lacks ethnomedicinal evidence. Based on the results of the present studies, higher use value, informant agreement ratio scores and fidelity level values of the recorded medicinal plant species would empower future pharmaceutical and phytochemical studies and conservation practices. The analysis of the results revealed the highest value of UV was obtained for Lavandula angustifolia Mill. (UV=1,8). In addition, the highest degree of agreement from informants (IAR) was recorded for Ear disorders (H) and Pregnancy, Childbearing, Family Planning (W) (1).

The results of quantitative techniques demonstrated that both techniques place value on a given taxon based on the number of uses attributed to a species.

Based on our survey, traditional medicine in PNTLs is still being practiced, despite the development of modern medicine. This rich floral indicates the high potential of traditional knowledge to serve for the development of natural derivatives as affordable medicines. However, we noted that there is no transmission of this knowledge and experience from generation to generation, as young people do not know the plants or their uses.

In this connection, attention should be drawn to the conservation of herbal medicine and associated indigenous knowledge in the PNTLs to sustain them in the future.

Declarations

List of abbreviations: PNTLS: Park National Talassemtane, UR: Use report, MPKi: Knowledge index, MPUi: Use index, CI: confidence level index, UV: Use value, IAR: Informant agreement ratio.
Ethics statement: The study was approved by the University of Abdelmalek Essâadi (Faculty of Sciences, Tetouan-Morocco). Verbal consent was recorded from participants before interviews as most of the participants were illiterate.
Consent for publication: Not applicable.
Availability of data and materials: All the data are presented in figures, tables and appendix in the manuscript and are available with the corresponding author.
Competing interests: The authors declare that they have no competing interests.
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Authors' contributions: **Fatima Zahrae Redouan**: Conducting field surveys of the work, Drafting the work, Analysis and interpretation of data for the work, Corresponding author and submission. **Yebouk Cheikh**: Participated in the drafting of work, Analysis and interpretation of data for the work.**Alessandro Crisafulli**, **Rosa Maria Picone**: Revising botanical aspect of plants. **Aboubakr Boutahar**: Analysis and interpretation of data for the work.**Gaetano Maurizio Gargiulo**: Revision of English version of this manuscript. **Abderrahmane Merzouki**: Drafting and conception and design of the work, Revising and critically of the content, Final approval of the version to be published.

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