



RESEARCH ARTICLE

# Ethnopharmacological survey of medicinal plants used in traditional treatment of respiratory system disorders in the Southeast region of Morocco

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## Abstract

The use of medicinal plants in primary healthcare in Africa, especially among populations in developing countries, is a common practice. To identify the most commonly used medicinal plants in traditional medicine for treating common respiratory disorders, an ethnobotanical survey was conducted in the Draa Tafilalet region, South-Eastern Morocco, involving 235 herbalists and sellers of medicinal plants from three provinces (Errachidia, Tinghir, and Zagora). Ethnobotanical data were evaluated using use value (UV), frequency of citation (FC), relative frequency of citation (RFC), and family importance value (FIV). The survey identified a total of 76 species belonging to 39 families, with the most represented being Lamiaceae, Apiaceae, and Asteraceae, followed by Fabaceae. As for the most commonly used species against respiratory disorders, they include *Origanum vulgare* L. (UV = 0.413), *Artemisia herba-alba* (UV = 0.370), *Foeniculum vulgare* (UV = 0.357), *Thymus vulgaris* (UV = 0.332), *Lavandula dentata* (UV = 0.319), *Matricaria chamomilla* (UV = 0.311), *Nigella sativa* (UV = 0.302), *Allium sativum* L. (UV = 0.298), *Eucalyptus globulus* (UV = 0.289), and *Plantago major* L. (UV= 0.281). Decoction (48.68%) and infusion (47.37%) are the most recommended preparation methods by herbalists for remedies. Leaves are the most prescribed part, while the majority of plants are exclusively administered orally (92.11%). This ethnobotanical survey holds the potential to aid scientists and researchers in identifying plants that treat common respiratory disorders, potentially invaluable for the development of novel drugs.

## Keywords

Draa Tafilalet; ethnobotanical survey; Morocco; respiratory disorders; traditional medicine

## Introduction

The crucial importance of medicinal plants lies in their easy accessibility, their natural origin, and the fact that they are less expensive to treat and less likely to cause side effects than synthetic drugs. Traditional plant-based medicine plays a vital role in preserving human health by combating potentially fatal diseases (1). Several studies show that medicinal plants are used to treat a variety of disorders, such as respiratory problems, scorpion and snake stings, gastrointestinal ailments, malaria, diabetes, oral and dental problems, muscle and bone disorders, and kidney problems (2-5).

According to the World Health Organization (WHO), phytotherapy is the most widely used medical treatment worldwide (6). In developing countries, the utilization of plants as medicines constitutes a significant component of the healthcare system (7-10). Ishtiaq and Khan (11) reported that over 80% of prescribed medicines originate from substances extracted from medicinal plants or are developed using semi-synthetic methods.

Respiratory tract disorders encompass ailments that primarily impact the nasal passages, bronchi, and lungs, constituting the air conduits. These disorders are dichotomized into acute respiratory infections and chronic respiratory diseases, including asthma, chronic obstructive pulmonary disease, and lung cancer (12). Respiratory diseases pose a significant global health challenge. According to the WHO estimates, asthma affected 262 million individuals and resulted in 461,000 deaths in 2019 (13). Chronic obstructive pulmonary disease ranked as the third leading cause of mortality worldwide in 2019, accounting for approximately 3.23 million deaths (14). In 2022, tuberculosis emerged as the second leading cause of death globally from a single infectious agent, following the coronavirus, causing nearly twice as many deaths as HIV/AIDS (15). Lung cancer affects 1.6 million individuals annually (16), while millions live with pulmonary hypertension (17), with over 1 billion people affected by chronic respiratory diseases (18).

Morocco is one of the Mediterranean countries with a long-standing medical tradition and significant traditional expertise in medicinal plants (19). Furthermore, all regions of Morocco are known for their strong ethnomedicinal tradition and a wealth of ethnomedicinal knowledge accumulated over centuries, although the risk of it no longer being transmitted remains. To date, knowledge of medicinal flora in Morocco remains primarily

empirical (20-24). To the best of our knowledge, this study represents the first ethnobotanical research on medicinal plants used in the traditional treatment of respiratory system disorders conducted in the Draa Tafilalet region, located in the Southeast of Morocco. This region is renowned for its substantial floral diversity and rich traditional knowledge of medicinal plants, owing to the demographic diversity of its inhabitants, including Berbers, Arab-Muslims, and Jews. Our objective is to carry out a series of ethnobotanical surveys to inventory medicinal plants and collect as much information as possible regarding the therapeutic uses practiced by the population of the Draa Tafilalet region for treating respiratory system disorders and infections.

## Materials and Methods

### Study Area

The study was conducted in the Draa Tafilalet region of South-Eastern Morocco (Fig. 1), covering an area of 88,836 km<sup>2</sup>, which represents 12.5% of the national territory and 46% of the surface area of Moroccan oasis zones. The region has a population of over 1,632,418 people. Its location in the pre-Saharan zone bestows upon the region an arid sub-desert climate, characterized by significant temperature variations spanning from 2°C in winter to +45°C in summer. The average annual temperature stands at 20°C, while the rainfall fluctuates, ranging from 60 mm in the south to 250 mm in the extreme north of the area (25). This region is bordered by the regions of Fes-Meknes and Beni Mellal-Khenifra to the north, by the Oriental region and Algeria to the east, and by the regions of Marrakech-Safi and Souss-Massa to the south. Table 1 presents the characteristics of the 3 towns studied in the region provinces (Errachidia, Tinghir, and Zagora) (25).

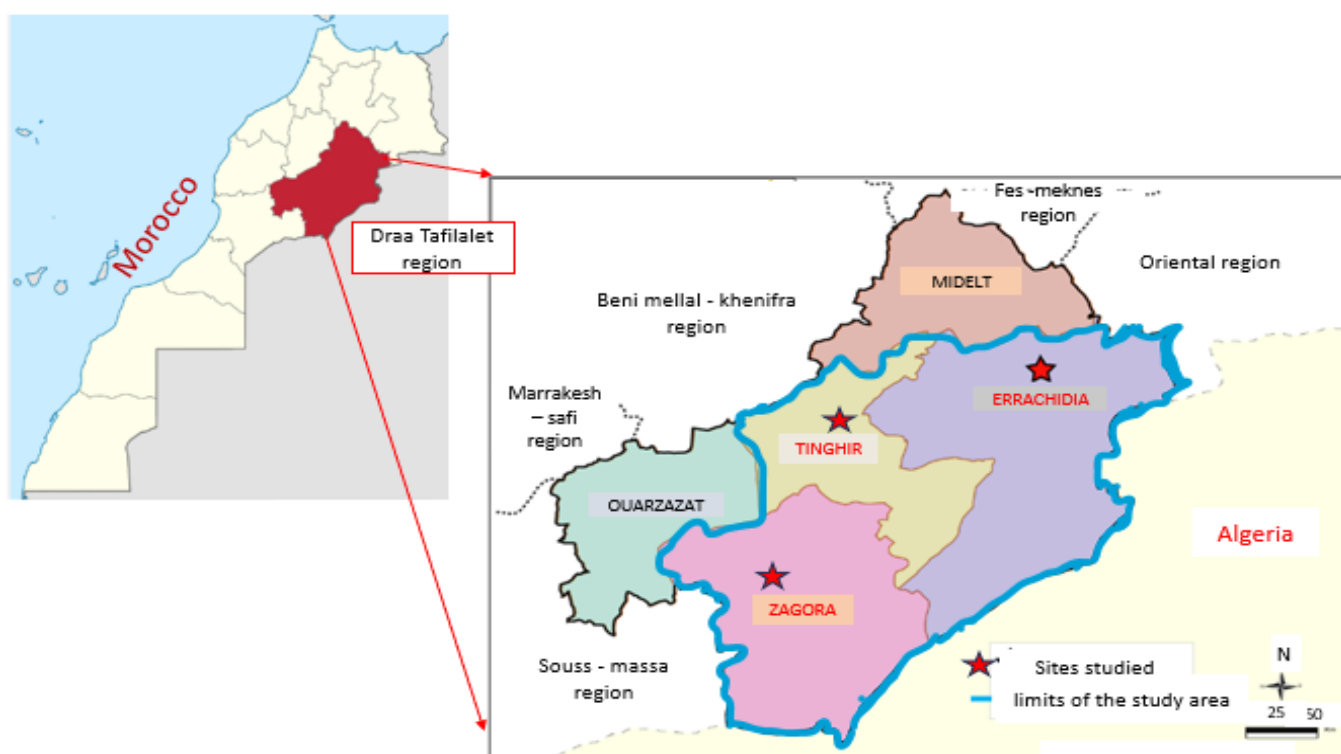


Fig 1. Study area

**Table 1.** Characteristics of the three towns studied in the Draa Tafilalet region.

Study sites	Geographical coordinates	Population number
Errachidia	31° 55' 55" N, 4° 25' 28" W	418026
Zagora	30° 19' 54" N, 5° 50' 15" W	306905
Tinghir	31° 30' 53" N, 5° 31' 58" W	321742

## Methods

To collect data on medicinal and aromatic plants employed in the treatment of respiratory disorders, we conducted an ethnobotanical survey from April to October 2022. During this period, 235 survey forms were filled in by herbalists and sellers of aromatic and medicinal plants in the three provinces under investigation (Table 2). Participants were apprised of the study's purpose following the establishment of trust, and they were consistently interviewed in either Amazigh or Arabic dialects, depending on the linguistic preference of each individual. This approach aimed to systematically gather and document indigenous knowledge regarding the usage of plants for respiratory diseases. To fulfill the study's objective, our survey utilized a questionnaire comprising two sections. The first section focuses on the socio-demographic profile of respondents (age, gender, education level, sources of knowledge). The second section is designed to gather details about each mentioned medicinal plant. This information enables us to assess herbalists' knowledge of medicinal plants, i.e., their uses, recommended preparation methods, diseases treated, and plant conditions.

**Table 2.** Distribution of ethnobotanical surveys according to the sites studied.

Province	Number of surveys
Errachidia	135
Tinghir	50
Zagora	50
Total	235

## Data analysis

We employed a descriptive statistical approach, utilizing frequencies and percentages, to analyze the socio-demographic and ethnobotanical data gathered from interviewed herbalists. The indices outlined by Sreekeesoon and Mahomoodally (26), namely use value, frequency of citation, the relative frequency of citation, and family importance value were employed for this analysis.

Use Value (UV) serves as a micro-statistical measure to indicate the comparative significance of each plant within the study area for treating respiratory disorders. UV is determined through the application of the following formula:  $UV = \sum UR / Ni$

(UR represents the sum of citations of a plant, while Ni indicates the total number of herbalists)

Frequency of Citation (FC) was determined as follows:  $FC = UR / Nc \times 100$

(UR represents the sum of citations of a plant, while Ni indicates the total number of the species listed)

Relative Frequency of Citation (RFC) indicates the local significance of each species, obtained by dividing the number of informants who mention the use of the species (FC) by the total number of informants participating in the survey (Ni). RFC is calculated using the following formula:  $RFC = FC / Ni$

Family importance value (FIV) identifies the significance of medicinal plant families. It is determined by dividing the number of informants mentioning the family (FC family) by the total number of species in each family (Ns). FIV is calculated using the following formula:  $FIV = FC_{family} / N_s$

## Results

### Socio-demographic data

The predominance of males among the surveyed herbalists is evident, accounting for 93.2% (219 individuals), while only 6.8% are females (16 individuals) (Fig. 2A). Regarding age groups, the 40 to 50 age group is the most represented, accounting for 35% of the surveyed herbalists, followed by the age groups of 30 to 40 and 50 to 60, with respective percentages of 25.95% and 17.87% (Fig. 2B). Concerning education level, herbalists with primary education are the most numerous, representing 48.94%, followed by those with secondary education and illiterate individuals, with percentages of 38.30% and 10.64% respectively. Herbalists with a university education represent only 2.13% (Fig. 2C). Regarding professional experience, herbalists with a duration of 15 to 20 years in the profession are the most common, representing 25.96%, followed by those with durations of 10 to 15 years, 20 to 25 years, and 25 to 30 years, with respective percentages of 19.57%, 17.02%, and 13.62% (Fig. 2D). The family members of the surveyed herbalists constitute the most significant source of knowledge about medicinal plants and their uses, at 49.36%, followed by individuals outside the family (herbalists) representing 35.74% as a source of information. However, only 14.9% of the surveyed herbalists acquired their knowledge through self-training or from documentary sources such as the Internet or books (Fig. 2E).

### Floristic analysis

According to the established survey forms (235 forms), 76 species have been reported and are utilized by the population of the three provinces in the Draa-Tafilalet region for treating respiratory system disorders and illnesses. These plants are distributed across 39 families (Fig. 3). According to Table 3, the most represented families used in phytotherapy for respiratory disorders in the study area are the Lamiaceae, representing 18.42% with 14 species (FIV = 0.008), followed by the Apiaceae and Asteraceae with 5 species each, accounting for 6.58% (FIV = 0.009) and 8.00% (FIV = 0.008) respectively. The Fabaceae represent 5.26%, totaling 4 species (FIV = 0.004). The remaining families (34 families) are represented by 3, 2, or only one species.

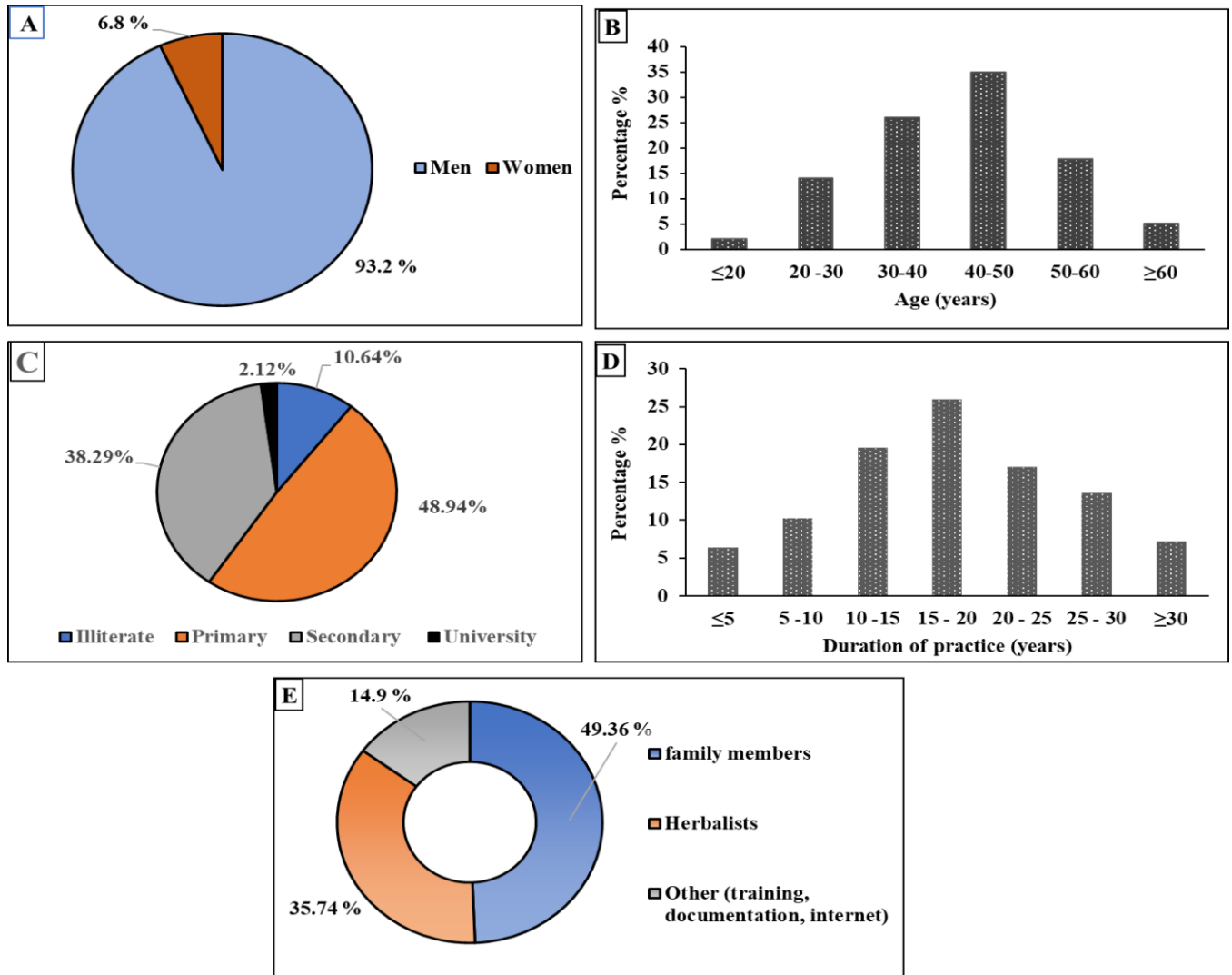


Fig. 2. Demographic characteristics of the herbalists: (A) gender, (B) age groups, (C) education level, (D) duration of practice (years), and (E) source of knowledge.

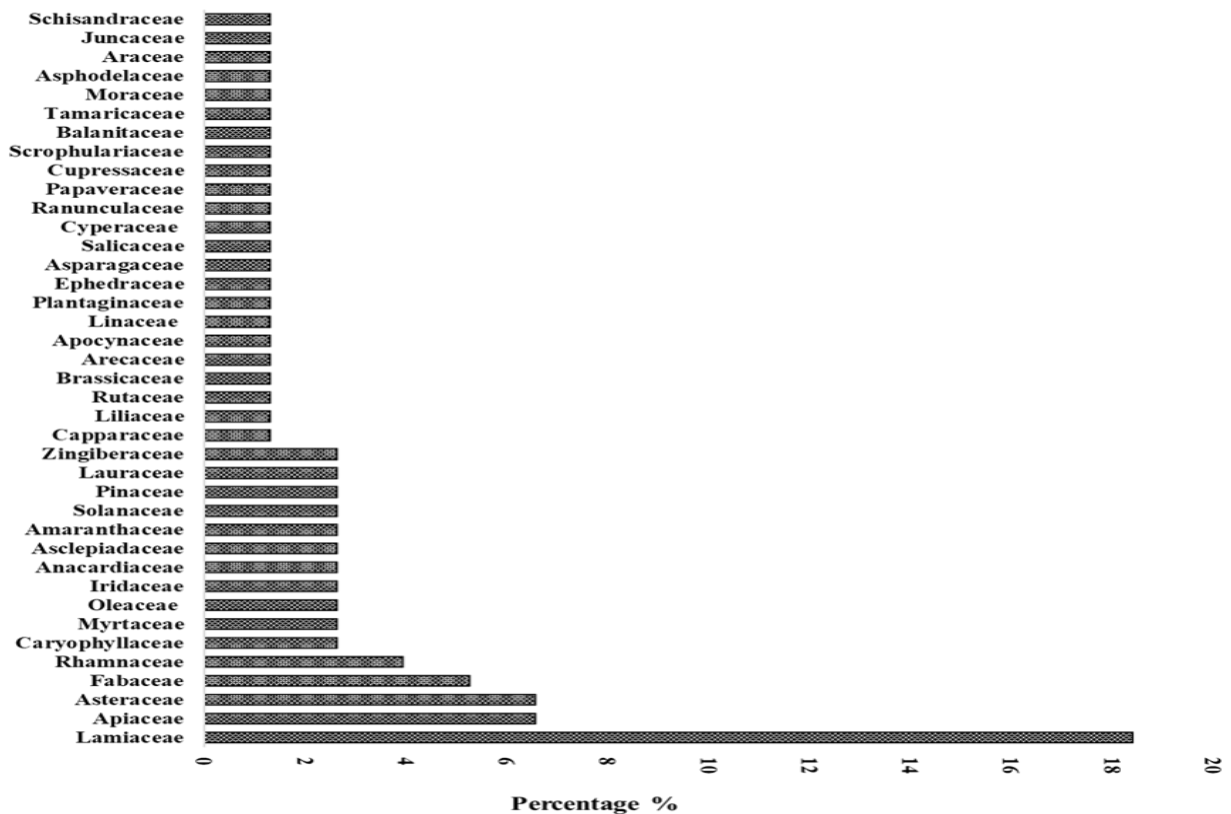


Fig. 3. The richness of plant families used for the treatment of respiratory diseases in the study area.

**Table 3.** List of medicinal plants used in traditional treatment of respiratory system disorders in the southeast region of Morocco

Families	Scientific name	Common name	Used part	Diseases treated	State of the plant (fresh/dry)	Method of administration	Mode of utilization	UR	FC	UV	RFC	FIV
Capparaceae	<i>Capparis spinosa</i> L.	Kebbar	Leaves / Seeds	Cough / Asthma	Dry	Oral	Infusion	23	0.932	0.098	0.004	0.004
Brassicaceae	<i>Lepidium sativum</i> L.	Heb rchad	Seeds	Cough/ Asthma/ Duspnoea.	Dry	Oral	Decoction / Infusion	55	2.229	0.234	0.009	0.009
Caryophyllaceae	<i>Corrigiola telephifolia</i> Pourr.	Sarghina	Root	Allergy / Other respiratory disorders	Dry	Oral	Powder	27	1.094	0.115	0.005	0.005
	<i>Saponaria officinalis</i> L.	Tighcht	Root	Bronchitis/ Cough	Dry	Local application	Cataplasme	30	1.216	0.128	0.005	
Lamiaceae	<i>Origanum vulgare</i> L.	Zaater	Leaves / Flowers	Sinusitis/ Common cold/ Cough/	Dry	Oral / Nasal	Decoction/ Infusion/ Maceration /	97	3.932	0.413	0.017	0.008
	<i>Ocimum basilicum</i>	Lahbaq	Leaves	Asthma/ Bronchitis/ Cough/	Fresh or Dry	Oral	Maceration / Infusion	15	0.608	0.064	0.003	
	<i>Origanum majorana</i>	Marddouch	Leaves	Allergy/ Bronchitis/ Sinusitis	Dry	Oral	Infusion	41	1.662	0.174	0.007	
	<i>Thymus vulgaris</i>	Ziitra	Leaves / Flowers	Cough/ Bronchitis/	Dry	Oral - Nasal	Infusion/ Decoction	78	3.162	0.332	0.013	
	<i>Mentha suaveolens</i>	Timijja	Leaves	Cough/ Asthma	Fresh or Dry	Oral	Infusion	52	2.108	0.221	0.009	
Lamiaceae	<i>Lavandula multifida</i>	Wizerhyoul	Leaves	Bronchitis/ Cough	Dry	Oral	Decoction	49	1.986	0.209	0.008	0.008
	<i>Ajuga iva</i>	Temarna or Chendgura	Leaves	Asthma	Dry	Oral	Infusion / Decoction	17	0.689	0.072	0.003	
	<i>Mentha pulegium</i> L.	Fliyou	Leaves / Flowers	Common cold/ Asthma	Dry	Oral / Local application	Infusion / Cataplasme	38	1.540	0.162	0.007	
	<i>Teucrium polium</i>	Guertoufa	Aerial part	Bronchitis	Fresh or Dry	Oral	Infusion	19	0.770	0.081	0.003	
	<i>Salvia officinalis</i> L.	Salmiya	Leaves/ Flowers	Bronchitis/ Asthma	Dry	Oral /Nasal	Infusion/ Decoction/ Cataplasme /Maceration	49	1.986	0.209	0.008	
	<i>Marrubium vulgare</i> L.	Merriwa	Leaves / Tige	Cough/ Bronchitis / Asthma	Dry	Oral	Maceration/ Decoction/ Cataplasme	38	1.540	0.162	0.007	
	<i>Rosmarinus officinalis</i> L.	Iklil ljabel	Aerial part	Asthma	Fresh or Dry	Oral /Local application	Decoction / Infusion	44	1.784	0.187	0.008	
	<i>Mentha viridis</i> L.	Naenae	Aerial part	Expectoran t / Bronchitis / Sinusitis / Cough	Fresh	Oral	Infusion / Maceration	37	1.500	0.157	0.006	
	<i>Lavandula dentata</i>	Lakhzama	Aerial part	Bronchitis/ Influenza/	Fresh or Dry	Oral/ Nasal / Local application	Infusion/ Decoction/ Maceration/ Cataplasme	75	3.040	0.319	0.013	

Plantaginaceae	<i>Plantago major</i> L.	L-messâssa	Aerial part	Inflammation of the respiratory tract / Tracheitis/ Laryngitis/ Asthma	Fresh or Dry	Oral	Infusion	66	2.675	0.281	0.011	0.011
Myrtaceae	<i>Eucalyptus globulus</i>	Kalitous	Leaves/ Branch	Bronchitis/ Influenza/ Common cold/ Cough / Asthma	Fresh or Dry	Nasal / Local application	Infusion / Distillation	68	2.756	0.289	0.012	0.007
	<i>Syzygium aromaticum</i>	L'kronfel	Seeds	Influenza / Pharyngitis / Common cold	Dry	Oral	Cataplasme / Decoction	37	1.500	0.157	0.006	
Asteraceae	<i>Anvillea radiata</i> (Coss et Dur)	Jirou	Leaves	Bronchitis	Dry	Oral	Decoction	21	0.851	0.089	0.004	
	<i>Calendula officinalis</i> L.	Jemra	Flowers	Pharyngitis	Dry	Oral	Decoction	18	0.730	0.077	0.003	
	<i>Matricaria pubiscens</i> (Desf.) Schultz	Ouazouaza	Leaves	Asthma/ Common cold	Dry	Oral	Decoction / Infusion	39	1.581	0.166	0.007	0.008
	<i>Matricaria chamomilla</i>	Babounj	Leaves/ Flowers	Cough / Bronchitis	Dry	Oral	Infusion / Decoction	73	2.959	0.311	0.013	
	<i>Artemisia herba-alba</i>	Echehh	Leaves/ Flowers	Common cold / Bronchitis / Cough	Dry	Oral	Decoction	87	3.527	0.370	0.015	
Fabaceae	<i>Ceratonia siliqua</i> L.	L'kharroub	Fruit	Bronchitis	Dry	Oral	Decoction	59	2.392	0.251	0.010	
	<i>Acacia gummifera</i>	Taleh	Leaves	Asthma/ Cough	Dry	Oral	Infusion / Decoction	10	0.405	0.043	0.002	
	<i>Acacia raddiana</i>	Amerad	Leaves	Pulmonary problems	Dry	Oral	Decoction	14	0.567	0.060	0.002	0.004
	<i>Glycyrrhiza glabra</i>	Arek souss	Root	Bronchitis / Pharyngitis/ Asthma	Dry	Oral	Decoction / Direct consumption	15	0.608	0.064	0.003	
Rhamnaceae	<i>Rhamnus lycioides</i> subsp. <i>Oleoides</i> (L.)	Nbek	Fruit	Inflammation of the respiratory tract	Dry	Oral	Maceration/ Direct consumption/ Powder	13	0.527	0.055	0.002	
	<i>Rhamnus alaternus</i>	Mliless	Leaves / Fruit	Pharyngitis / Other respiratory diseases	Dry	Local application	Decoction/ Infusion	21	0.851	0.089	0.004	0.0027
	<i>Frangula alnus</i>	Sderr	Leaves	Laryngitis/ Tracheitis	Dry	Oral	Powder	13	0.527	0.055	0.002	
Oleaceae	<i>Olea laperrini</i> (Boit et Trab)	Zebbouj	Aerial part	Bronchitis/ Cough	Dry	Local application / Oral	Tisane/ Infusion	21	0.851	0.089	0.004	0.004
	<i>Olea europaea</i>	Wrak Zitoune	Leaves	Common cold / Influenza	Fresh or Dry	Oral	Decoction / Direct consumption	22	0.892	0.094	0.004	
Linaceae	<i>Linum usitatissimum</i>	Zeriet lkettane	Seeds	Asthma / Other respiratory disorders	Dry	Oral	Powder	33	1.338	0.140	0.006	0.006

Iridaceae	<i>Crocus sativus</i> L.	Zaafraane lhor	Stigmat	Common cold / Other respiratory disorders	Dry	Oral	Decoction	23	0.932	0.098	0.004	0.003
	<i>Iris germanica</i> L.	Tafzoute	Root	Bronchitis/ Asthma	Dry	Oral	Decoction	10	0.405	0.043	0.002	
Papaveraceae	<i>Papaver rhoeas</i> L.	Bel-amane	Petals	Asthma/ Cough	Fresh or Dry	Oral/ Local application	Infusion/ Syrup. Cataplasme	19	0.770	0.081	0.003	0.003
Cupressaceae	<i>Juniperus communis</i> L.	El-aaraar	Leaves / Fruit	Cough / Other respiratory disorders	Dry	Oral - Local application	Infusion / Decoction / Distillation	51	2.067	0.217	0.009	0.009
Liliaceae	<i>Allium sativum</i> L.	Tawm	Bulb	Common cold / Influenza	Fresh	Oral	Maceration	70	2.837	0.298	0.012	0.012
Rutaceae	<i>Citrus aurantium</i> L.	Ranje ou t'runje	Fruit	Pharyngitis	Fresh	Oral	Juice	50	2.027	0.213	0.009	0.009
Anacardiaceae	<i>Pistacia atlantica</i> L.	Idderh	Fruit	Bronchitis/ Cough	Dry	Local application	Crude	14	0.567	0.060	0.002	0.002
	<i>Rhus tripartitus</i>	Tizrha	Leaves	Inflammation of the respiratory tract	Dry	Oral	Decoction	12	0.486	0.051	0.002	
Apiaceae	<i>Foeniculum vulgare</i>	Nafae	Seeds	Cough / Bronchitis / Inflammation of the respiratory	Dry	Oral	Infusion	84	3.405	0.357	0.014	0.009
	<i>Pimpinella Anisum</i>	Hebba hlawwa	Seeds	Cough / Cough / Bronchitis	Dry	Oral	Maceration / Distillation	30	1.216	0.128	0.005	
Apiaceae	<i>Papaver somniferum</i> L.	Kerwiya	Seeds	Bronchitis/ Common cold	Dry	Oral	Decoction / Infusion	56	2.270	0.238	0.010	
	<i>Eryngium ilicifolium</i>	Chekkar	Aerial part/ Root	Common cold/ Laryngitis/ Pharyngitis	Dry	Oral	Decoction	32	1.297	0.136	0.006	0.009
	<i>Ammi visnaga</i>	Bechnikha	Aerial part	Asthma / Bronchitis / Dyspnoea / Cough	Dry	Oral / Local application	Infusion / Cataplasme	58	2.351	0.247	0.010	
Arécaceae	<i>Phoenix dactylifera</i> L.	Nekhla / tazdayett	Fruit / Leaves	Common cold/ Pharyngitis/	Dry	Oral	Decoction	14	0.567	0.060	0.002	0.002
Apocynaceae	<i>Nerium oleander</i>	Defla	Leaves	Common cold/ Cough	Dry	Oral	Decoction	20	0.811	0.085	0.003	0.003
Asclepiadaceae	<i>Calotropis procera</i> (Ait)	Taoureja	Leaves	Asthma/ Cough	Dry	Oral	Tisane	15	0.608	0.064	0.003	0.003
	<i>Pergularia tomentosa</i> L.	Sellakha	Aerial part	Bronchitis	Dry	Oral	Decoction	17	0.689	0.072	0.003	
Amaranthaceae	<i>Atriplex halimus</i> L.	Lekteff / Lhetba	Aerial part	Common cold	Dry	Oral	Decoction	24	0.973	0.102	0.004	0.005
	<i>Hammada scoporia a</i> (Pomel)	Remt	Aerial part	Common cold	Dry	Oral	Maceration	33	1.338	0.140	0.006	
Ephedraceae	<i>Ephedra alata</i> (Decne)	El-alanda	Leaves	Asthma	Dry	Oral	Tisane	13	0.527	0.055	0.002	0.002
Asparagaceae	<i>Dipcadi serotinum</i> (Medik) L.	Bessal dibe	Bulb	Bronchitis/ Influenza/ Common cold	Fresh or Dry	Oral / Local application	Infusion / Cooked	16	0.649	0.068	0.003	0.003



Salicaceae	<i>Populus euphratica</i>	Essefssaf	Leaves	Bronchitis	Fresh or Dry	Nasal	Infusion	37	1.500	0.157	0.006	0.006
Solanaceae	<i>Hyoscyamus muticus</i> Ssp falezlez (Coss) Maire	Rhanjete	Leaves / Flowers	Asthma	Dry	Oral/ Local application	Decoction/ Crushed	12	0.486	0.051	0.002	0.002
	<i>Datura stramonium</i> L.	Chdek jmel	Leaves / Flowers	Asthma/ Cough	Dry	Local application /fumigation	Tisane/ Cataplasme	20	0.811	0.085	0.003	
Ranunculaceae	<i>Nigella sativa</i>	Lhebba sawdae	Seeds	Allergy/Asthma/ Bronchitis	Dry	Oral	Direct consumption	71	2.878	0.302	0.012	0.012
Zingiberaceae	<i>Zingiber officinalis</i>	Skinjber	Rhizome	Common cold / Influenza/ Pharyngitis / Laryngitis	Dry	Oral	Decoction/ Powder	56	2.270	0.238	0.010	0.006
	<i>Elettaria cardamomum</i>	El-hell	Seeds	Bronchitis	Dry	Oral	Infusion	17	0.689	0.072	0.003	
Pinaceae	<i>Cedrus atlantica</i>	Aroz khechb	Fruit	Bronchitis / Asthma	Fresh	Oral/ Local application/ Nasal	Distillation	14	0.567	0.060	0.002	0.002
Pinaceae	<i>Pinus halepensis</i>	Tayda	Leaves	Common cold / Sinusitis/ Bronchiques / Influenza	Dry	Oral	Decoction	18	0.730	0.077	0.003	0.003
Lauraceae	<i>Cinnamomum verum</i>	L'karfa	Root	Bronchitis	Dry	Oral	Infusion	10	0.405	0.043	0.002	0.003
Lauraceae	<i>Laurus nobilis</i>	Wrak sidna moussa	Leaves	Inflammation of the respiratory tract	Dry	Oral	Infusion / Decoction	19	0.770	0.081	0.003	0.003
Scrophulariaceae	<i>Verbascum thapsus</i> L.	Mslah nder	Flowers	Cough/ Laryngitis / Bronchitis	Dry	Oral / Local application	Infusion	19	0.770	0.081	0.003	0.003
Balanitaceae	<i>Balanite aegyptiaca</i> L.	Tourha	Bark	Cough/ Bronchitis	Dry	Oral	Maceration	15	0.608	0.064	0.003	0.003
Tamaricaceae	<i>Tamarix articulata</i> (Vahl)	Tekbout / laadba	Root	Asthma	Dry	Oral	Decoction	20	0.811	0.085	0.003	0.003
Moraceae	<i>Ficus carica</i>	Chriha	Fruit	Cough	Dry	Oral /Local application	Infusion / Cataplasme	25	1.013	0.106	0.004	0.004
Asphodelaceae	<i>Asphodelus microcarpus</i>	Lerhri	Root	Bronchitis	Dry	Oral	Infusion	10	0.405	0.043	0.002	0.002
Araceae	<i>Arisarum vulgare</i> L.	Yerni	Leaves	Bronchitis/ Asthma	Dry	Oral	Maceration	22	0.892	0.094	0.004	0.004
Juncaceae	<i>Juncus maritimus</i>	Semmar	Leaves/ Rhizome	Asthma	Dry	Oral	Infusion	11	0.446	0.047	0.002	0.002
Schisandraceae	<i>Illicium verum</i>	Nejma lhindia / badyana	Seeds	Cough/ Asthma / Other respiratory disorders	Dry	Oral	Infusion	37	1.500	0.157	0.006	0.006
Cypéaceae	<i>Cyperus rotundus</i> L.	Nbat essaed	Leaves	Inflammation of the respiratory tract / Pulmonary problems	Dry	Oral	Decoction	14	0.567	0.060	0.002	0.002



Based on the results of the present study and considering the use value (UV) of the recorded species, the ten most commonly used species by the population of the studied sites are as follows: firstly, *Origanum vulgare* L. (UV= 0.413), followed by *Artemisia herba-alba* (UV= 0.370), *Foeniculum vulgare* (UV= 0.357), *Thymus vulgaris* (UV= 0.332), *Lavandula dentata* (UV= 0.319), *Matricaria chamomilla* (UV= 0.311), *Nigella sativa* (UV= 0.302), *Allium sativum* L. (UV= 0.298), *Eucalyptus globulus* (UV= 0.289), and *Plantago major* L. (UV= 0.281) ( Fig. 4).

## Ethnobotanical analysis

### Respiratory disorders treated

The plants cataloged during this ethnobotanical study are used as remedies for various respiratory disorders and illnesses, including bronchitis, cough, influenza, asthma, and the common cold. The results from Fig. 5 show that 44.74% of the species recorded are used in the treatment of bronchitis (equivalent to 34 plants), followed by cough, asthma, the common cold, and influenza, which are treated by 38.16%, 36.84%, 23.68%, and 10.53%, respectively (equivalent to 29, 28, 18, and 10 plants).

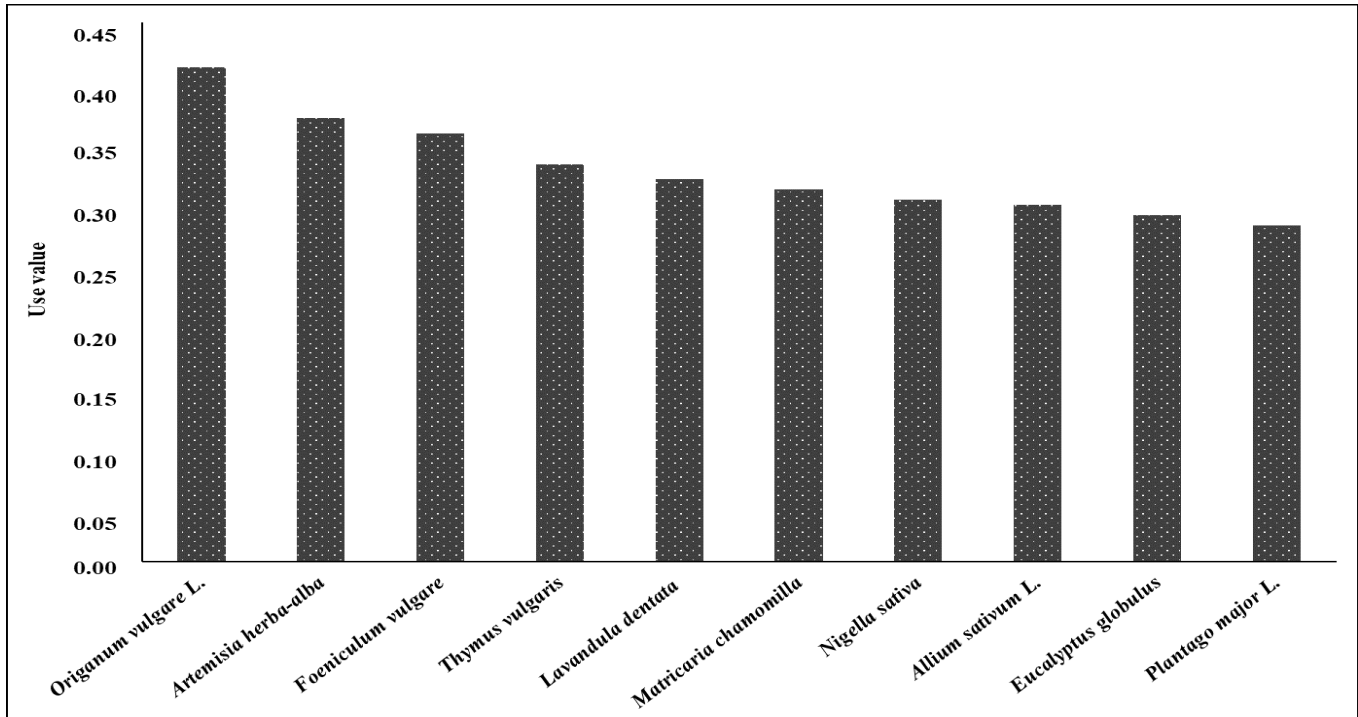


Fig. 4. The most commonly used species to treat respiratory illnesses in the study area.

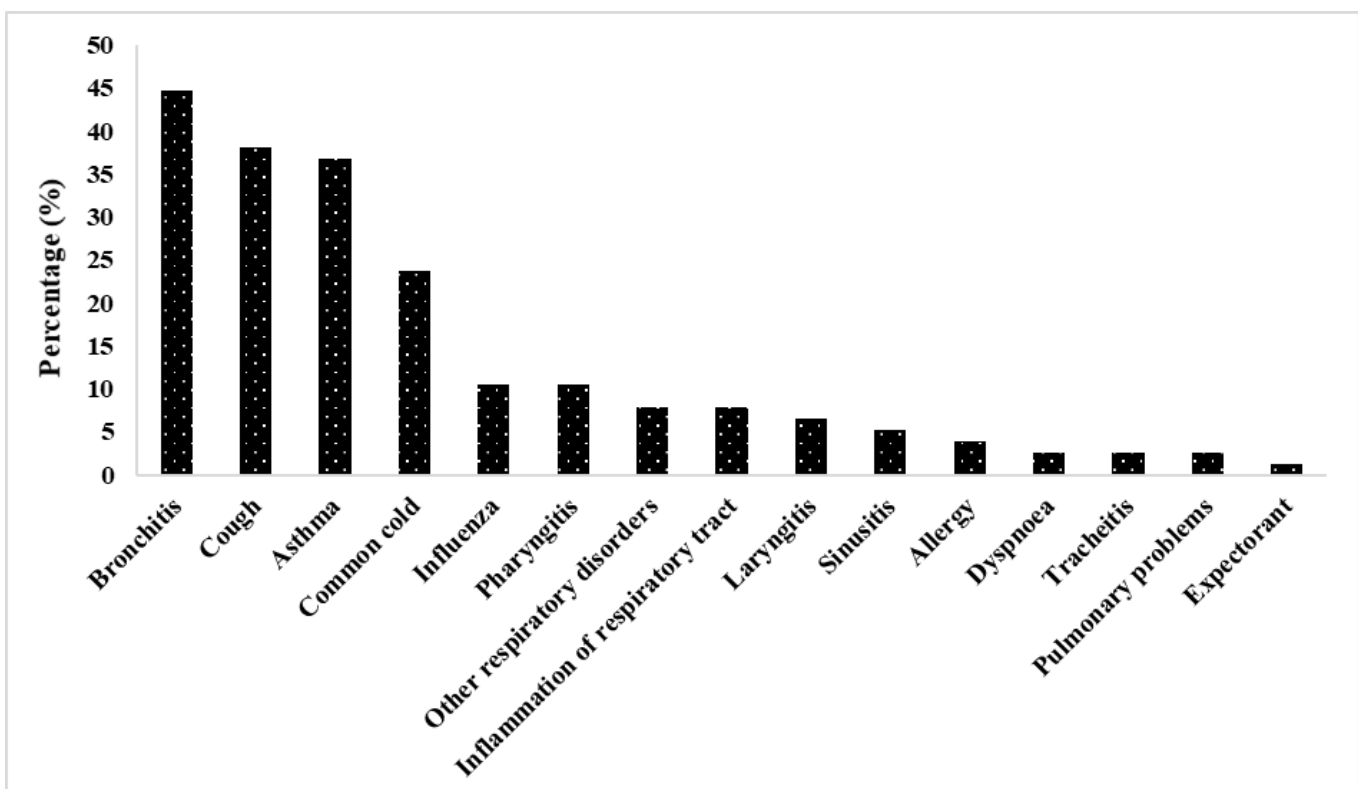


Fig. 5. Respiratory diseases treated traditionally in the Southeast region of Morocco.

### Used parts, plant state, mode of preparation, and administration used

The results reveal that leaves are the most utilized plant part, accounting for approximately 46.05% (35 citations), followed by aerial parts at 15.79% (12 citations). Additionally, seeds, flowers, fruits, and roots are used at rates of 14.47%, 14.47%, 11.84%, and 10.53%, respectively (11, 11, 9, and 8 citations, respectively) (Fig. 6A). According to the Fig. 6B, 80.26% (61 plants) of the recorded species in this study are used in a dried state. However, 11 species (14.47%) are utilized in both fresh and dried states, while only 4 species are used exclusively in a fresh state (5.26%). Analyzing the administration routes of the medicinal plants cited by the surveyed herbalists (Fig. 6C), it was found that 70 plants are administered orally (92.11%), while 18 species are used topically (23.68%), followed by nasal administration at 9.21% (7 species) and fumigation at 1.32% (one species). Various preparation methods were mentioned during the study to extract active principles from the plants, including decoction, fumigation, poultice, infusion, and maceration, among others (Fig. 6D). In the studied region, decoction and infusion remain the most commonly used preparation methods (48.68% and 47.37%, respectively), followed by maceration (15.79%) and poultice (13.16%). However, the proportion of other preparation forms (powder, herbal tea, direct consumption, others) does not exceed 7% each.

### Discussion

Ethnopharmacological research provides a cost-effective method for identifying potential natural remedies for various diseases (27-29). Among Saharan communities,

there exists a wealth of traditional knowledge and practices passed down through generations, utilized in the treatment of diverse ailments. This study aims to document the ethnopharmacological relevance of medicinal plants employed in the traditional management of respiratory system disorders in the south eastern region of Morocco. The analysis of data collected from 235 herbalists and vendors of medicinal plants used in the treatment of respiratory diseases reveals a predominance of men, accounting for 93.2% of the surveyed individuals. The majority of these practitioners have attained only a primary level of education, comprising 48.87% of the respondents, a trend consistent with findings reported by Dagni et al. (30). Our survey further highlights that the most prevalent age group falls between 30 and 50 years, encompassing 60.95% of the respondents, with 22.97% being over 50 years old. In contrast, individuals aged 20-30 represent 14.04%, while those under 20 years old constitute a mere 2.12% of the respondents. The significant presence of older individuals in this profession plays a crucial role in the transmission and preservation of traditional medicinal knowledge. Their experience and accumulated wisdom contribute to the efficacy and continuity of traditional healing practices within the community. These findings align with previous studies conducted by El Hilah et al. (31) and Ben Akka et al. (21). This correlation is further supported by our findings regarding the duration of professional experience, with 63.83% of herbalists having practiced their profession for over a decade. The survey conducted identified a total of 76 species of medicinal plants representing 39 families, with the most frequently mentioned being Lamiaceae, Apiaceae, and Asteraceae. These findings align with

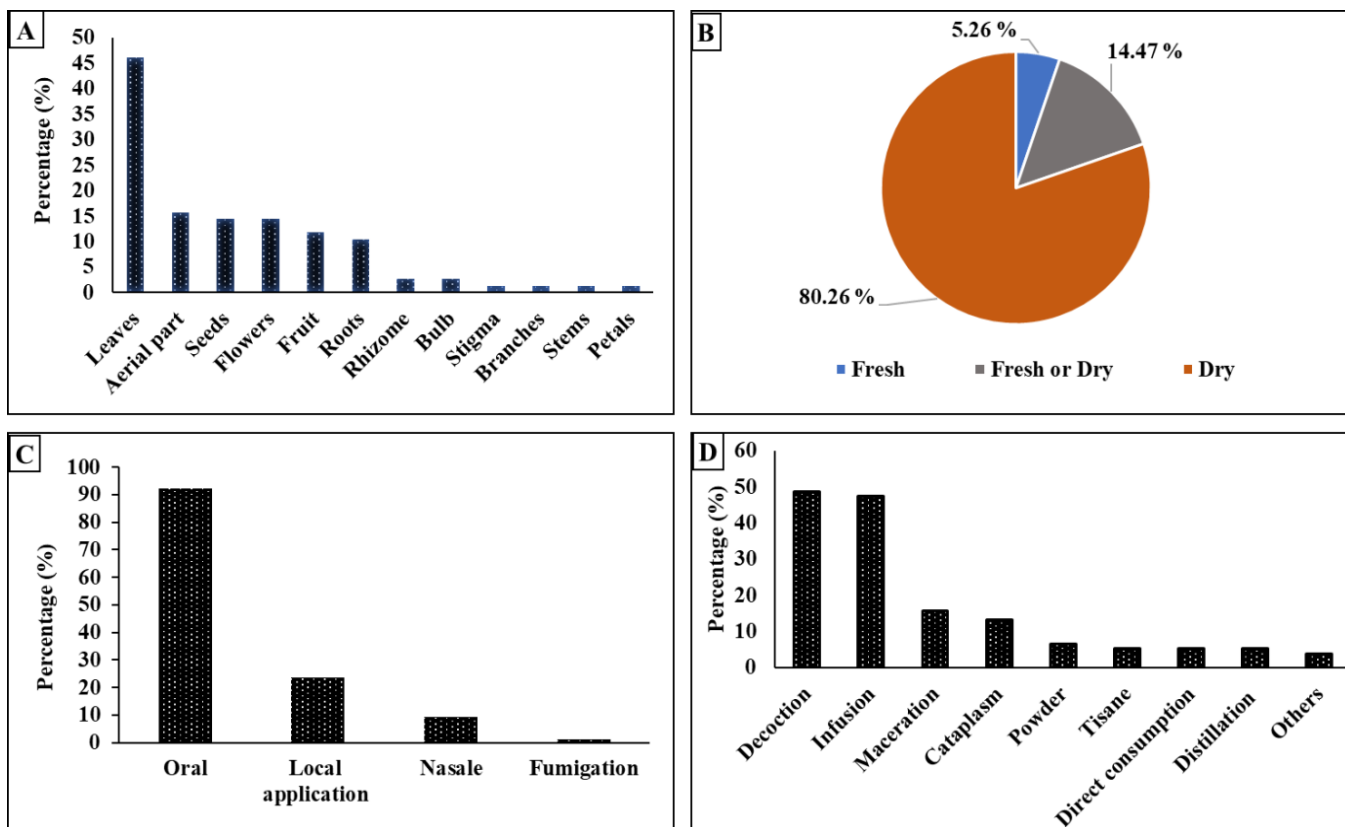


Fig. 6. Ethnobotanical analysis: used parts (A), state of the plant (B), method of administration (C), and mode of utilization (D).

previous ethnobotanical studies, which indicated that the most mentioned families in ethnomedicinal inventories were Asteraceae, Lamiaceae, Fabaceae, Poaceae, Apiaceae, and Solanaceae (32, 33, 20, 34, 22, 35). The predominance of the Lamiaceae, Apiaceae, and Asteraceae families in our ethnopharmacological survey can be explained by several factors. Firstly, these three families are known for their rich biodiversity and wide geographic distribution. They encompass numerous plant species found in various habitats of the region, making them easily accessible to local communities. Additionally, plants from the Lamiaceae, Apiaceae, and Asteraceae families can be easily found in the surrounding nature, making them accessible and economically viable for local communities as a source of traditional treatment for respiratory disorders. Lastly, Lamiaceae, Apiaceae, and Asteraceae are renowned for containing a variety of bioactive compounds (36), such as terpenoids, flavonoids, sesquiterpenes, and phenolic compounds, which are often associated with beneficial pharmacological properties for treating respiratory disorders. These compounds may have anti-inflammatory, antioxidant, expectorant, and antimicrobial effects, all of which are useful in addressing respiratory ailments (37-39). The chemical components of Lamiaceae, such as tannins, coumarins, mucilages, flavonoids, and phenolic acids like rosmarinic acid found in thyme or oregano, account for these distinct pharmacological characteristics. This explains the results of the present survey, which revealed that *Origanum vulgare* L. is the most commonly used species (UV = 0.413), a finding consistent with similar results reported by Pezzani et al. (40). Several species of the Lamiaceae family i.e. rosemary, oregano, sage, mint, and lavender, are widely exploited in the pharmaceutical field. In line with our results, *Origanum vulgare* L. has been found in several studies to be among the most commonly used species for treating respiratory disorders (41). According to Bouloumpasi et al. (42), *O. vulgare* could be used as a bactericide and antiseptic, as well as a stimulant and antispasmodic for the respiratory tract. Furthermore, this species is used to treat respiratory disorders, including cough, inflammation of bronchial mucous membranes, and as an expectorant (43). The most common respiratory diseases treated by medicinal plants in the study area are bronchitis, cough, asthma, common cold, and influenza. As for other respiratory conditions such as tracheitis, pulmonary issues, and dyspnea, they are less frequently treated with medicinal plants in this region. Similar findings were reported by Ben Akka et al. (21) in the Oum Rabia region, located in central Morocco, where influenza, colds, and coughs are the most commonly treated respiratory disorders with medicinal plants. We have also revealed that leaves (46.05%) and aerial parts (12.79%) are the most commonly utilized parts of plants. Similar findings were reported by (22, 44-46). This could be attributed to their easy accessibility and richness in secondary metabolites produced through photosynthesis, as well as their ease of use and preservation. Moreover, if harvesting is not excessive, it does not hinder the plant's growth and/or reproduction (47). Concerning the

preparation method for the treatment of respiratory ailments, this survey revealed a predominance of the decoction method among users of medicinal plants in the studied region. Decoction allows for the easy and efficient extraction of active constituents, as well as the mitigation and elimination of the toxic effects of certain compounds (48). However, traditional healers in Morocco value and often prefer decoction and infusion as modes of remedy preparation (49, 50). These results align with several previous studies (51, 38, 52). Generally, oral administration is the primary mode used for herbal therapies (92.11%). These findings are consistent with those reported by several scientists worldwide (20, 53, 54). The predominance of the oral route of administration can be explained by the fact that it is generally perceived as the most acceptable route for patients. In conclusion, our ethnopharmacological survey highlights the significance of medicinal plants in managing respiratory system disorders within the community of the Southeast region of Morocco.

## Conclusion

This study has allowed us to recognize the importance of traditional phytotherapy in the Draa Tafilalet region. The results of this survey show that the local population continues to prefer the use of natural species to address diseases affecting human health. In this regard, and according to the results obtained, the population of the study area uses a total of 76 species to treat respiratory disorders, with the most cited ones being *Origanum vulgare* L., *Artemisia herba-alba*, *Foeniculum vulgare*, *Thymus vulgaris*, *Lavandula dentata*, *Matricaria chamomilla*, *Nigella sativa*, *Allium sativum* L., *Eucalyptus globulus*, and *Plantago major* L. It was found that the dried state of the plant is the most recommended form (80.26%). All the recorded plants are distributed among 39 families, with the most represented being the Lamiaceae (18.42%), followed by the Apiaceae (6.58%), the Asteraceae (6.58%), and the Fabaceae (5.26%). The results indicate that leaves are the most commonly used component, with a rate of 46.05%. Most recipes are prepared using the decoction (48.68%) and infusion (47.37%) methods. Regarding the most recommended administration route for users, it is the oral route (92.11%), followed by the topical application mode (23.68%). On the other hand, the results obtained from this study can be considered a source of information for scientific research in the fields of phytochemistry and pharmacology, to focus on and initiate experimental studies on these medicinal plants to valorize their active substances.

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## Authors' contributions

AE and IJ: Methodology, investigation, writing. AE, IJ, and AA: Participation in surveys, development of the questionnaire, and data acquisition. AH and NL: Conceptualization, species identification, critical review, editing, and approval of the final version.

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interest to declare.

**Ethical issues:** None.

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