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Original Research Article

The Use of Medicinal Plants during the COVID-19 Pandemic in Meknes, Morocco: A Cross-Sectional Survey

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ABSTRACT

Since ancient times, using plants for therapeutic purposes has been part of Moroccan culture to treat human health problems. However, during the COVID-19 pandemic, this practice has been increasingly adopted to reduce or treat symptoms related to this new virus. This study was conducted, for the first time in north-central Morocco and aimed to identify the medicinal plants used by the population during the pandemic and related factors. A cross-sectional survey was carried out among on the general population of the city of Meknes from March 31 to June 30, 2023. The survey included 875 respondents with a median age of 33.5 [22-46] years. A total of 74.86% reported that they used medicinal plants to prevent or treat respiratory symptoms at least once. The origin of the information came in 33.59% of cases from family, followed by 23.97% from social media and 17.71% from popular culture. The most common plants reported were *Allium sativum* (90.08%), *Eucalyptus globulus Labill* (62.29%) and *Syzygium aromaticum* (47.63%). The primary mode of administration was oral and the preferred method of preparation was infusion. According to several studies, most medicinal plants are used to treat many respiratory diseases. These plants offer many advantages, but some of them may contain toxic substances, that can cause various overdose-induced toxicities and other health disorders.

Keywords: Medicinal plants, Meknes, COVID 19, Morocco, Ethnobotanical study

Introduction

Throughout history, humans have utilized substances and natural resources, such as plants, to generate different drugs, whose objective was to alleviate pain or address illnesses. Fossil analyses suggest that herbal medicine has been used by humans for at least 60,000 years.[1] The use of traditional medicine has evolved over time due to the advancements in medicine and pharmacology, as well as the emergence of new diseases. Such as the novel virus that emerged in December 2019, known as severe acute respiratory syndrome Coronavirus-2 (SARS-CoV-2).[2] Progressive and severe pneumonia is a characteristic of this disease, and its primary symptoms are fever, dry cough, dyspnea, headache, fatigue, anosmia, and ageusia.[3] To prevent transmission, physical isolation was the main preventive measure implemented globally, which led to multiple lifestyle changes among people.[4] Also, the loss of family and friends has led to anxiety and mental distress for many individuals.[5] Increased self-medication, medicinal plant use, and other alternative treatments have resulted from the widespread disinformation, fake news, and anti-vaccine comments.[6]

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For all these reasons, the population believes that the only resource accessible to them is self-support, personal care and self-medication.[7] Therefore, they rely on medicines or medicinal plants that have not been verified to be efficient against Coronavirus Disease 2019 (COVID-19).[8] Medicinal plants have been recommended by Chinese, Indian, and Iranian medicine to prevent, treat, and fight viral diseases, such as COVID-19.[9] Viral replication and proliferation blockage may be associated with the Chinese herbal formula, according to some studies.[9]

Morocco's herbal medicine tradition is one of the longest and richest, and its residents have a wealth of knowledge about medicinal plants. More than 600 plants were identified by the researchers as being commonly employed in phytotherapy within this North African country.[10] In addition, respiratory diseases can be treated and prevented with the use of over 60 plants.[10,11] In this context, the Moroccan population has resorted to herbal medicine for several reasons. Such as the wealth of the country in medicinal plants, the economic situation, illiteracy, and the inaccessibility of modern medicine.[12] There is no evidence to support the biological effects of medicinal plants on the coronavirus.[10] The diversity of secondary metabolites contained in these plants provides numerous benefits. Essential oils are among the compounds that are widely known for their positive biological effects on respiratory and circulatory functions.[10]

The current research is focused on the study of medicinal plants used to prevent the COVID-19 outbreak in Morocco. A cross-sectional survey was considered appropriate to capture the community's real-time practices and perceptions during the pandemic. To the best of our knowledge, this is the first study

conducted in north-central Morocco to explore the use of medicinal plants during the COVID-19 pandemic.

Materials and Methods

Study area

The study was carried out in the city of Meknes (33°53° N, 5°33° W), which is located in northwestern Morocco at an altitude of 564 m (Figure 1). It is located in the northern part of Morocco, 140 km east of the capital Rabat and 60 km southwest of Fez.[13] With a population of roughly 835,695, Meknes is the second most populous city in the Fez-Meknes region.[14,15,16] According to the Moroccan High Commission for Planning, Meknes covers a total area of 1,786 square kilometers. The city is located between two mountain ranges (the Pre Rif and the Middle Atlas) and is one of the main communication routes between the various cities in the Kingdom of Morocco.[15]

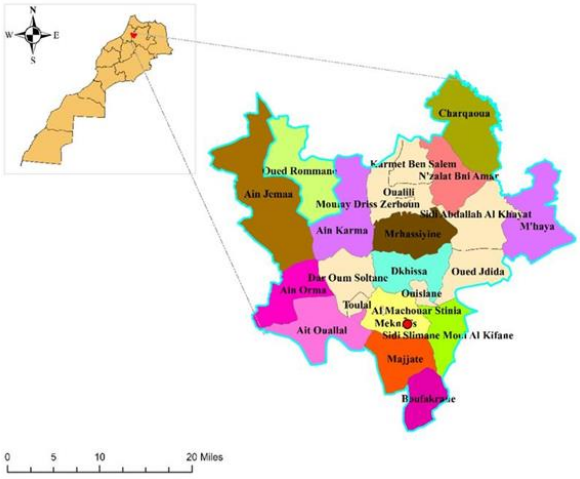

Figure 1: Location of the study area, Meknes, Morocco.[15]

Study Design and Sampling

From March 31 to June 30, 2023, a self-administered questionnaire was used to conduct a cross-sectional survey to collect information on medicinal plants used during the COVID-19 pandemic. The Cochran formula[17] was used to calculate the minimum population sample of 384, for a general population estimated at 835,695, with a 95% confidence level and a 5% margin of error. After the deletion of incomplete responses, 875 respondents participated in the study. To verify the questionnaire's reliability and validity, a pilot test was conducted with 35 participants. A few modifications were made after the pilot test. It is important to note that the 35 participants involved in the pilot test were not included in the main study.

Questionnaire Design

Three sections were covered by the survey, which included closed and open questions in three languages, including French, Arabic, and Amazigh, which are spoken in Morocco. All sections of the questionnaire were designed using data obtained from the existing literature. The questions were read and explained for participants who were not educated. In general, it took each participant 10 to 15 minutes to respond to all questions.

Inclusion and Exclusion Criteria

The inclusion criteria included being an adult (aged 18 years or older), consenting to participate in the study, and residing in the city of Meknes. In addition, the study did not include pregnant women or minors.

Ethical Considerations

This study received approval from the High Institute of Nursing and Health Techniques, Fez Annex in Meknes (N°6372/2023). All procedures followed the principles of informed consent and ensured participant anonymity. Before taking part in the research, participants were asked to give their informed consent by signing a consent form. No personally identifiable information was collected, and participants' privacy was fully protected. The participants did not take part in any stages of the study.

Data Analysis

Data collected were entered into Microsoft Excel for Windows 10 (Microsoft Corp., Redmond, WA, USA; 2018), cleaned, coded, and analyzed using the IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, NY, USA; 2019). Frequencies, percentages, means, extreme values, and standard deviations were used to present the data.

Results and Discussion

At the onset of the COVID-19 pandemic, our understanding of the virus and its potential management was quite limited. The new viral infection has created an urgent need to mitigate it through experimental therapies and even reusing drugs already in use. The researchers' intensive efforts have resulted in significant progress in understanding COVID-19 and its control. Innovative therapeutic remedies and new vaccines have experienced extraordinary improvements due to this.[18] Some investigators have shifted towards plant-based therapeutic approaches because of the lack of precise effective therapeutics against SARS-CoV-2. The reason for this is that many drugs are either made from plants or contain bioactive herbal constituents. Therefore, there is a significant interest in detecting potential anti-COVID-19 herbal medicines, as plant-based therapeutics have shown encouraging efficiency against various viruses by reinforcing immunity.[19]

Among the 875 respondents, 510 (58.3%) identified as female and 365 (41.7%) as male, yielding a female-to-male sex ratio of 1.40. This gender disparity aligns with global ethnobotanical trends, where women frequently act as custodians of intergenerational plant knowledge—a pattern observed in African and Asian contexts, where maternal roles often encompass the management of herbal therapies.[20] The median age of participants was 33.5 years (range: 22–46), with the majority (66.3%) falling within the 20-40 age bracket. Educational attainment was notably high: 62.9% held a higher education degree, followed by 27.4% with secondary-level education, and 6.5% reporting no formal literacy. All participants resided in urban areas, with income levels distributed as follows: 89.4% (n=782) reported medium income, 7.5% (n=66) low income, and 3.1% (n=27) high income (Table 1). Notably, 71.9% (n=629) of participants had access to medical insurance, while 28.1% (n=246) were uninsured. Healthcare facilities were easily accessible to 91.4% (n=800) of respondents, though 1.7% (n=15) reported challenges in accessing care. Despite the prevalence of economic stability and insurance coverage-factors often associated with reduced reliance on traditional medicine-cultural preferences and perceptions of herbal safety appear to sustain plant-based practices, even among populations with access to conventional healthcare.[21] Urban contexts may further shape these trends, as urbanization frequently disrupts the transmission of traditional plant knowledge, favoring instead the adoption of commodified species such as *Zingiber officinale* and *Curcuma longa*, which are aggressively marketed through digital platforms.[22] Younger, educated demographics may disproportionately prioritize herbs with perceived scientific legitimacy, such as *Artemisia sp*, or those popularized through social media-driven health trends.[21]

The diagnosis of COVID-19 was confirmed by both biological and clinical methods in only 69 (10.53%) participants. The use of medicinal plants increased during the period of COVID-19 among 569 (86.87%) participants, 74 (11.30%) kept the same trend of use and 12 (1.83%) had decreased the consumption of medicinal plants. The use of these substances was either to prevent the appearance of symptoms similar to those of COVID-19 (74.96%) or to treat them (25.04%) (Table 2).

Table 1: Socio-demographic characteristics of respondents (N=875)

Parameters	Group	Respondents (n)	Percentage (%)
Gender	Male	365	41.71
	Female	510	58.29
Age range	< 20	176	20.11
	20-40	580	66.29
	40-60	81	09.26
	> 60	38	04.34
Education level	No education	57	06.51
	Primary	28	03.20
	Secondary	240	27.43
	University	550	62.86
Locality	Urban	875	100
	Rural	0	0
Income level	Low	66	07.54
	Medium	782	89.37
	High	27	03.09
Access to health care facilities	Easy access	800	91.43
	Medium access	60	06.86
	Difficult access	15	01.71
Medical insurance	Yes	629	71.89
	No	246	28.11

Our results are similar to those obtained in Peru with a rate of 71%.[3] In a province in the same region of Meknes, a Moroccan study revealed a utilization rate of 66%. The high rate could be a result of several factors. Firstly, these plants are accessible and are present in all Moroccan homes, and some of them are part of the country's culinary customs. Secondly, the massive flow of information from different sources was responsible for the increased use of these natural products. Thirdly, for economic reasons since 89.37% of participants had medium income. The use of these plants seems to be very beneficial, as they all possess antioxidant, antiviral, anti-inflammatory, and antimicrobial activities (Table 3).

Various sources of information were used to obtain information on the use of medicinal plants for therapeutic or preventive purposes against COVID-19 by participants in this survey. The information was either gathered from individuals who have already had a similar experience like family and friends (33.59%) or from various social media (23.97%). Moroccan popular culture (17.71%) or herbalists (14.04%) were sources of knowledge for some participants. Finally, 10.69% opted for alternative sources of information such as books, magazines, and scientific articles (Table 2). In addition to plants, food supplements, vitamins, and various drugs were also used simultaneously by 408 (62.29%) of the respondents. This drug consumption was either self-medication or taken under medical prescription (Table 2).

The reliance on family and friends (33.59%) as a primary source of information aligns with findings from multiple recent studies conducted during the COVID-19 pandemic. For instance, a study in Algeria reported that traditional beliefs and familial influence were key drivers in the use of medicinal plants for COVID-19 prevention and treatment.[23] Additionally, the significant role played by social media (23.97%) as observed in our study echoes global trends, where online platforms facilitated both the dissemination of useful knowledge and the spread of misinformation.[24] This dual role of media has been associated with increased self-medication and a surge in herbal remedy usage, especially in low-resource settings.[25] The fact that over 60% of participants used supplements and pharmaceuticals concurrently with medicinal plants raises concerns about potential drug-herb interactions, a risk highlighted in recent literature emphasizing the need for public education on safe practices.[26] These findings underline the critical importance of integrating ethnobotanical knowledge with public health strategies, particularly in contexts where access to healthcare is limited. At least one of the symptoms described in Figure 1 was reported by participants in this study. The highest percentage reported is fatigue (91.91%), followed by headache (87.02%). At the end of the list, we discover congestion and sore throat with respective rates of 9.16 and 8.55% (Figure 2). The symptoms reported by participants in this study align with commonly documented manifestations of COVID-19, including fatigue (91.91%) and headache (87.02%), which are two of the most frequently reported symptoms in numerous studies.[27,28] These findings are consistent with those reported globally, where fatigue remains one of the most debilitating long-term effects of the virus, affecting a large percentage of COVID-19 patients.[29,30] Fatigue is often linked to post-viral fatigue syndrome and has been noted as one of the key indicators of long COVID.[31]

Headache also ranks high among the symptoms of COVID-19, and studies have shown that it can be persistent, even after recovery from the acute phase of the disease.[32] The prevalence of headache among COVID-19 patients has been reported to range between 30% to 70% in various studies,[33] with this study's finding of 87.02% being significantly higher, potentially reflecting regional variations or differences in the participant population.

On the other hand, symptoms such as congestion (9.16%) and sore throat (8.55%) are less frequently reported but still align with the broader spectrum of COVID-19 symptoms as described by the CDC and other health agencies.[34] These findings suggest that while the virus often presents with respiratory symptoms, fatigue and headache are the most prevalent complaints, indicating a need for further research into their long-term management. The study involved the use of 14 species from 7 botanical families by the respondents to treat and prevent the symptoms of COVID-19 in Meknes city. The most important family was the Lamiaceae, represented by five species (*Mentha pulegium, Origanum compactum Benth, Rosmarinus officinalis, Lamiaceae Lavandula, Origanum majorana*), followed by the family of Asteraceae with two species (*Matricaria chamomilla*, and *Artemisia herba-alba*), the family of Myrtaceae (*Eucalyptus globulus Labill* and *Syzygium aromaticum*), the family of Zingiberaceae (*Zingiber officinale* and *Curcuma longa*). In addition, only one species for the families Verbenaceae (*Aloysia citriodora Palau*), Rutaceae (*Citrus limon*) and Amaryllidaceae (*Allium sativum*). The most used species were *Allium sativum* (90.08%), *Eucalyptus globulus Labill* (62.29%), *Syzygium aromaticum* (47.63%), and *Zingiber officinale* (46.87%) (Table 3).

Table 2: Description of plant use by study participants during COVID-19 in the city of Meknes, Morocco

Variables	Group	Respondents (n=655)	Percentage (%)
Diagnosed with COVID-19	Yes	69	10.53
	No	586	89.47
Preventing or treatment the development of symptoms	For prevention	491	74.96
	For treatment	164	25.04
Trend of medicinal plant use	Same	74	11.30
	Decreasing	12	01.83
	Increasing	569	86.87
Knowledge acquisition	Experience of others (family and friends)	220	33.59
	Social media	157	23.97
	Popular culture	116	17.71
	Herbalist	92	14.04
	Other sources*	70	10.69
Simultaneous use with medicines and food supplements	Yes	408	62.29
	No	247	37.71

Table 3: Medicinal plants used in traditional medicine in Meknes city, Morocco

Family name	Botanical name	Common name	Vernacular name	Parts used	Preparation mode	Administration mode	Citations (%)	Biological activities	References
Amaryllidaceae	*Allium sativum*	Garlic	Touma	Bulb	Raw	Oral	590 (90.08)	Rich in nutrients with antioxidant, antibacterial, antiinflammatory and antigenotoxic properties. Antiviral effects of allicin by boosting the immune response.	[10, 47, 48]
Myrtaceae	*Eucalyptus globulus Labill*	Eucalyptus	Calyptus	Leaves	Fumigation	Inhalation	408 (62.29)	Antimicrobial, antiviral, anti-inflammatory and antioxidant activities.	[10, 49]
Myrtaceae	*Syzygium aromaticum*	Cloves	Qrenfel	Flower	Infusion	Oral	312 (47.63)	Antimicrobial, antioxidant, anti-inflammatory, analgesic and anesthetic effects.	[50]
Zingiberaceae	*Zingiber officinale*	Ginger	Skine Jbire	Root	Infusion	Oral	307 (46.87)	A recent study showed that 8-gingerol and 10-gingerol isolated from *Z. officinale* were significantly more active against COVID-19 than hydroxychloroquine. In addition to other activities already defined by other studies, such as antioxidant, antibacterial and anti-inflammatory activities	[2, 51, 52]

Rutaceae	*Citrus limon*	Limon	Hamede	Fruit	Juice extraction	Oral	256 (39.08)	An in vitro study revealed that limonin had a positive effect on reducing the replication of New-castle disease virus (NDV) in all cell lines.	[2]
Lamiaceae	*Mentha pulegium*	Pennyroyal	Flio	Leaves	Infusion	Oral	129 (19.69)	Antioxidant, antimutagenic and antimicrobial effects.	[53,54]
Asteraceae	*Artemisia herba-alba*	Desert or white wormwood	Chihe	Leaves	Infusion, fumigation	Oral, inhalation	93 (14.20)	Antimicrobial, anticancer, anti-inflammatory and antioxidant activities.	[9, 52, 55]
Asteraceae	*Matricaria chamomilla*	German chamomile	Babounje	Flowers	Infusion, decoction	Oral	74 (11.30)	Antioxidant activity.	[52]
Verbenaceae	*Aloysia citrodora Palau*	Lemon verbena	Lwiza	Leaves	Infusion, decoction	Oral	51 (7.79)	Antioxidant and antimicrobial properties.	[56]
Lamiaceae	*Origanum compactum Benth*	Oregano	Zaatar	Leaves	Decoction Infusion Powder	Oral	48 (7.33)	*Origanum compactum Benth* was found to have several biological activities, including antibacterial, antioxidant, anticancer, antiphrastic, and antifungal effects, as reported in in vitro studies.	[57]
Lamiaceae	*Rosmarinus officinalis*	Rosemary	Azir	Leaves	Infusion, decoction	Oral	40 (6.11)	Antioxidant, antiviral, anti-proliferative, antibacterial, anti-inflammatory and antitumor activities.	[9]
Lamiaceae	*Lamiaceae Lavandula*	Lavender	Lkhzama	Flowers	Infusion	Oral	32 (4.88)	Antioxidant, anti-inflammatory, and antimicrobial activities.	[55]
Lamiaceae	*Origanum majorana*	Sweet marjorum	Mardedoch	Leaves	Infusion, decoction	Oral	24 (3.66)	Antioxidant, antimicrobial and cytotoxicity effects.	[58]
Zingiberaceae	*Curcuma longa*	Turmeric	Kharkoum	Roots	Powder	Oral	7 (1.07)	Antibacterial, cytotoxic, antioxidant, and anti-inflammatory activities.	[22]

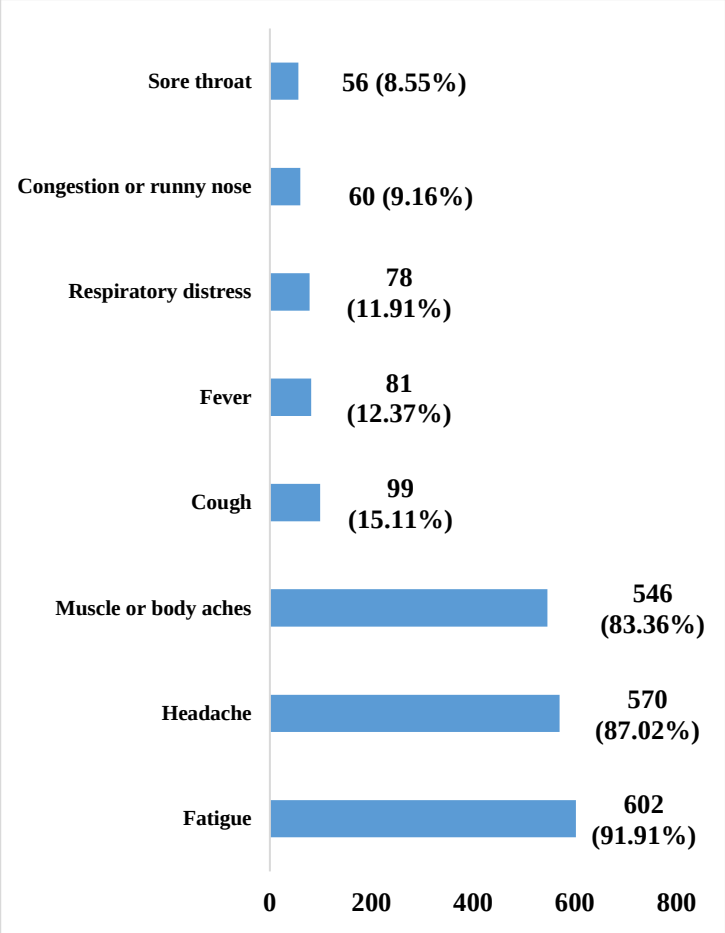

Figure 2: A summary of the symptoms reported by participants (n=655)

At the level of seven species, such as *Origanum majorana* and *Eucalyptus globulus Labill*, the leaves were the most utilized part. Followed by flowers from three species (*Syzygium aromaticum*, *Matricaria chamomilla*, and *Lamiaceae lavandula*). Other parts can be used, such as roots, bulbs, and fruits (Table 3). The most common methods for preparing natural preparations against COVID-19 are infusion and decoction, and oral administration was chosen by the participants. Table 3 contained information about the biological and pharmacological properties of all plants used for prevention or treatment during the Covid-19 pandemic.

Lamiaceae is a significant family of medicinal plants and is highly regarded for its diverse biological and medicinal properties. The antiviral potential of plants in this family has been studied extensively, with a particular emphasis on their antiviral properties.[35] Most of the antiviral effects of Lamiaceae plants have been confirmed in vitro. Other experiments have confirmed certain effects, such as indirect effects in healthy volunteers.[36, 37] A wide variety of diseases are frequently treated by Moroccans using these plants. Featuring disorders related to the lungs, allergies, asthma, sleep apnea, bronchititis, rhinitis, pneumonia, flu, colds, sinusitis and pharyngitis.[10] Several studies have indicated that the majority of these plants are utilized to treat various respiratory diseases that manifest symptoms and signs similar to those caused by coronavirus.[38] Known for its use as a condiment, garlic (*Allium sativum*) is also integral to traditional Chinese and Indian medicinal practices. The active ingredients of this substance consist of organosulfides, saponins, and polysaccharides. The polysaccharides are the main reason for its immunomodulatory activity, which regulates the immune system's homeostasis and maintains the immune response.[39] The bioactive compounds present in garlic have potential effects on respiratory tract infections, intra-alveolaredema, pulmonary fibrosis, sepsis, and acute lung injury.[40] Antiviral, antifibrotic, antioxidant, anti-inflammatory, and immunomodulatory properties can be attributed to the activity of allicin, sallyl cysteine (SAC), alliin, and diallyl thiosulfonate (allicina).[40] Several studies have shown that *Eucalyptus globulus* is an effective antiviral agent against coronavirus, particularly SARS-COV-2. The respiratory tract's functioning is improved by the essential oil's bronchodilatory properties. The main inhibitor against SARS-CoV-2 is its eucalyptol content, which comprises ether (-O), ketone (-=O), and hydroxyl (-OH) groups according to Flochi and Fikri-Benbrahim.[41]

Traditional medicine has known for centuries that *Syzygium aromaticum* can be used therapeutically to treat respiratory ailments. The phytochemical constituents that make it active against various viruses have been proven to be effective, especially in combating COVID-19.[41]

A randomized controlled study was conducted to evaluate the effects of *Zingiber officinale* on respiratory manifestations in COVID-19 patients.[42] The experimental group was treated according to the therapeutic protocol, which included taking 1000 mg ginger tablets three times per day for seven days with standard treatment.[42] The clinical symptoms, including fever, dry cough, and other symptoms, improved within 7 days of treatment.[42] Ginger consumption has been shown to have properties that prevent pneumonia and pulmonary fibrosis.[40]

Leaves were identified as the most commonly utilized part of medicinal plants (7/14 species), followed by flowers (3/14 species). The frequent use of the leaves is due to the nature of the species used in our study used and the simplicity of the harvest. It could also be explained by the stored metabolites responsible for the biological activities of the species.[43] Bioactive constituents are abundant in underground parts, which include roots and rhizomes.[44] However, the indiscriminate use of underground parts may pose a threat to conservation, particularly for wild species.[44]

For plant preparation methods, they are used to facilitate the extraction of active ingredients from medicinal plants. In our study, infusion and decoction were the most used methods by respondents. These findings are in agreement with those of other ethnobotanists.[43] According to the research conducted in Morocco, the methods of plant preparation and use are almost identical for all plants in different Moroccan regions.[9, 10, 12, 41,45,46]

Research is still ongoing on the beneficial effects of these traditional medicines and their clinical trials. The current findings indicate that flora can be a crucial source for the identification of medicinal agents that are effective against COVID-19. The presence of toxic substances in these plants can cause various intoxications and overdose disorders. The majority of medicinal plants used for prevention during the Covid-19 pandemic may contain toxic substances. Overdose of these substances, such as phenols, carvone, colchicine, neoanisatin, anisatin, anethole, cyanogenic glycosides, coumarin, myristicin, safrole, and nigellin, can lead to a wide range of disorders and intoxications.[10]

Conclusion

Moroccan people have traditionally relied on medicinal plants for healing, especially in rural areas where herbal medicine remains widespread. During the COVID-19 pandemic, our study identified 14 medicinal plant species from seven botanical families commonly used. These plants contain diverse secondary metabolites, including bioactive compounds like essential oils, known for their beneficial effects on respiratory and circulatory health. Despite the lack of concrete evidence on their effects against coronavirus, these plants offer significant therapeutic potential. However, raising public awareness is critical to prevent overdose intoxications and adverse interactions. Understanding potential risks is essential for safe use. Future research should prioritize pharmacological validation through laboratory and clinical studies to establish efficacy, safety, and antiviral properties. This approach will help integrate traditional knowledge with modern medicine effectively.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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