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Medicinal plants used in rural communities from the municipality of Dolores Hidalgo, Guanajuato, Mexico

[Plantas medicinales utilizadas en comunidades rurales del municipio de
Dolores Hidalgo, Guanajuato, México]

Alberto Medrano-Guerrero[1], Eleazar Carranza[2], María del Carmen Juárez-Vázquez[3], Eloy Solano[4], Alan Joel Ruiz-Padilla[1], Yeniley Ruiz-Noa[5], Martha Alicia Deveze-Alvarez[1], Lorena Michele Brennan-Bourdon[6] & Angel Josabad Alonso-Castro[1]

[1]Departamento de Farmacia, División de Ciencias Naturales y Exactas, Universidad de Guanajuato, Guanajuato, Guanajuato México
[2]Instituto de Investigación de Zonas Desérticas, Universidad Autónoma de San Luis Potosí, San Luis Potosí, Mexico, Mexico
[3]Departamento…. en Ciencias Biológicas y de la Salud, Universidad Autónoma Metropolitana, Mexico City, Mexico
[4]Facultad de Estudios Superiores Zaragoza, Universidad Nacional Autónoma de México, Mexico City, Mexico
[5]Departamento de Ciencias Médicas, División de Ciencias de la Salud, Universidad de Guanajuato, León, Guanajuato, México
[6]Comisión para la Protección Contra Riesgos Sanitarios del Estado de Jalisco. Guadalajara, Jalisco, México.

Abstract: This study recorded the use of medicinal plants in the rural communities from the municipality of Dolores Hidalgo, Guanajuato, Mexico. Data were obtained through open semi-structured interviews with local respondents (n=181), and medicinal plants were recorded and identified in herbariums. The Relative importance (RI) and Informant Consensus Factor (ICF) were calculated to analyze the survey data. In total, 68 plant species belonging to 33 families were reported. Asteraceae had the highest number of species, representing 14. The highest RI was accounted by *Chamaemelum nobile* (RI = 2.0), followed by *Thymus vulgaris* (RI = 1.83), and *Moringa oleifera* (RI = 1.60). The highest ICF was reported by diseases associated with the respiratory (ICF = 0.80), digestive (ICF = 0.75), and musculoskeletal systems including connective tissues (ICF = 0.71). Respondents have knowledge about medicinal plant use for primary health care and other chronic diseases. The information obtained here could be extrapolated to different rural areas in Mexico.

Keywords: Ethnobotany; Traditional knowledge; Mexican traditional medicine; Medicinal plants; Informant consensus factor.

Resumen: Este estudio registró el uso de plantas medicinales en las comunidades rurales del municipio de Dolores Hidalgo, Guanajuato, México. Los datos se obtuvieron a través de entrevistas abiertas semiestructuradas con encuestados locales (n=181), y las plantas medicinales se registraron e identificaron en los herbarios. La importancia relativa (RI) y el factor de consenso del informante (ICF) se calcularon para analizar los datos de la encuesta. En total, se reportaron 68 especies de plantas pertenecientes a 33 familias. Asteraceae tuvo el mayor número de especies, representando 14. El RI más alto fue contabilizado por *Chamaemelum nobile* (RI = 2.0), seguido por *Thymus vulgaris* (RI = 1.83) y *Moringa oleifera* (RI = 1.60). La ICF más alta se informó por enfermedades asociadas con los sistemas respiratorio (ICF = 0,80), digestivo (ICF = 0,75) y musculoesquelético, incluidos los tejidos conectivos (ICF = 0,71). Los encuestados tienen conocimientos sobre el uso de plantas medicinales para la atención primaria de salud y otras enfermedades crónicas. La información aquí obtenida podría extrapolarse a diferentes zonas rurales de México.

Palabras clave: Etnobotánica; Conocimiento tradicional; Medicina tradicional mexicana; Plantas medicinales; Factor de consenso del informante.

INTRODUCTION

The use of medicinal plants in Mexico occurs in rural and urban areas. Their efficacy and low-cost are among the most important factors for their selection and use (Juárez-Vázquez *et al*., 2013; Alonso-Castro *et al*., 2019). Current ethnobotanical studies document the use medicinal plants for the empirical treatment of emerging illnesses, such as mental diseases (i.e., anxiety, depression, epilepsy, Parkinson disease, etc.), metabolic disorders (obesity and anorexia), sexual dysfunction, and cardiovascular diseases (hypertension, stroke, etc.), among others. Therefore, the need to perform ethnobotanical studies in Mexico will update the ethnomedicinal flora information and provide new data to carry out chemical, pharmacological, and toxicological studies.

The percentage pf population living in rural areas in Mexico has changed from 41% in 1970 to 22% in 2010 (INEGI, 2010). The loss of traditional medicine based on herbs, might occur during migration to urban areas. Most of the ethnobotanical studies in Mexico have been carried out in the central and southern regions of the country. However, there are few ethnobotanical studies that include quantitative tools in the central-north region of Mexico. In the state of Guanajuato, there are approximately 3206 plant species (Villaseñor, 2016). However, information obtained by using quantitative tools to determine the number of medicinal plants used in the state of Guanajuato is scarce. The aim of this study was to document local traditional knowledge of medicinal plants used in rural communities from the municipality of Dolores Hidalgo, Guanajuato, Mexico, a town where the independence of Mexico began in 1810. This study also aimed to preserve the cultural heritage of the ethnobotanical knowledge since rural areas in Mexico are experiencing an immigration phenomenon where most of the current population are elderly residents.

MATERIAL AND METHODS
Study area
The rural communities of San Vicente (21°1'40.74" North latitude, 101°0'34.739" West longitude, and an altitude of 2030 meters above sea level) and San Marcos de Abajo (21 1'20.661" North latitude, 101°1'2.969" West longitude) are located in the municipality of Dolores Hidalgo (northwest of the state of Guanajuato, Mexico) (Figure No. 1). The type of vegetation in this region is grassland, and the weather is temperate, sub-humid with summer rains and low humidity (INEGI, 2009). These communities have a low population density of less than 500 inhabitants per community, low socioeconomic level, low educational level, and are mostly composed of elderly residents, women, and children (SEDESOL, 2013). Most men find themselves in need of migration to the United States of America to improve their living conditions. The main livelihood strategy of inhabitants is based on agriculture and livestock. In general, these rural populations have basic services, such as drinking water, drainage, and electricity. Moreover, a large part of the general population does not have internet access. There is also a small clinic in these communities, however, informants indicated that during the last 6 months, there were no attending physicians.

Figure No. 1
Map of the Dolores Hidalgo Municipality, Guanajuato, Mexico

Data collection
Both communities had a total population of 944 inhabitants. The calculation for the population sample was analyzed using the Raosoft software, considering a 5.5% margin of error at 90% confidence level and 50% distribution. A total of 66 men and 115 women (n= 181) from both communities in an age group between 18 and 90 years were interviewed individually during January-October 2019. Before starting the interviews, consent to participate was obtained to collect the medicinal plant use information, such as common name, preparation, and the part of the plant used. Information about the concomitant use of plant-herb and adverse reactions induced by the consumption of medicinal plants was recorded. The scientific names of the plant species and the family were searched in specialized bibliographies. For further reference, samples of plant species were preserved and identified in the herbarium of the Facultad de Estudios Superiores Zaragoza Universidad Nacional Autónoma de México (FEZA) [School of Higher Studies Zaragoza, National Autonomous University of Mexico] and the herbarium Isidro Palacios (SLPM), Universidad Autonoma de San Luis Potosi, Mexico [Autonomous University of San Luis Potosi, Mexico]. The proper botanical names were corroborated with the 2020 Missouri Botanical Garden-Tropicos and International Plant Names Index.

Data analysis
The illnesses empirically treated with the medicinal flora from the San Vicente and San Marcos de Abajo communities were grouped into 11 categories, considering the classification used by the International Classification of Diseases of the World Health Organization (ICD - International Statistical Classification of Diseases and related health problems, 2017).

Relative importance (RI)
The relative importance (RI) of the cited species was calculated (Oliveira *et al.*, 2010) according to the following formula:

$$RI = PP+AC$$

PP is the number of pharmacological properties accredited to a medicinal plant divided by the highest number or properties accredited to the most resourceful medicinal plant. AC is the number of ailment categories treated by the most resourceful medicinal plant.

Informant consensus factor (ICF)
ICF is used to analyze the agreement in the use of a medicinal plant for diseases categorized according to the ICD and reported in the study area (Trotter & Logan, 1986).

$$ICF= (Nur-Nt)/(Nur-1)$$

Where Nur refers to the number of use-reports for a specific disease category, Nt: refers to the number of plant species used for a specific disease category.

RESULTS
Demographic features of the respondents
As shown in Table 1, a total of 181 respondents participated in this study, of which 36.5% were men and 63.5% women, with a mean age of 55 years. The largest age group of respondents was 51 to 65 years old (44.8%). The predominant education level and occupation were middle school (33.7%) and merchants (33%), respectively.

Medicinal plants recorded in rural communities from the municipality of Dolores Hidalgo
In total, 68 plant species belonging to 33 families were reported. Asteraceae had the highest number of species (14), followed by Lamiaceae (7), Euphorbiaceae, Lauraceae, Malvaceae, and Rutaceae (each had 3) (Table No. 2). Approximately, 38% of plants recorded in this study are endemic to Mexico (Table No. 2).

The most cited plant parts were leaves (42 mentions), followed by the stem (17), whole plant (10), and flowers (7) (Table No. 2). The most common preparation mode was infusion, and the main route of administration was oral (93% of plant species) (Table No. 2). The highest RI was accounted by Chamaemelum nobile (RI = 2.0), followed by Thymus vulgaris (RI = 1.83), Moringa oleifera (RI = 1.60), and Mentha citrata (RI = 1.27) (Table No. 2). Most of the medicinal plants (95%) had more than a single therapeutic use. Approximately, 60% of medicinal plants were harvested. The highest ICF was reported by diseases of the respiratory (ICF = 0.80), digestive (ICF = 0.75), and musculoskeletal systems and connective tissues (ICF = 0.71) (Table No. 3).

Table No.1
Sociodemographic characteristics of survey respondents

Characteristics	TOTAL N=181 n (%)
Gender	
Female	115 (63.5)
Male	66 (36.5)
Age (years old)	
50 or younger	30 (16.6)
51 to 65	81 (44.8)
Older than 65	70 (38.7)
Age years (mean ± SD)	54.69 ± 14.69
Education	
Literate	33 (18.2)
Primary school	34 (18.8)
Middle school	61 (33.7)
High school	39 (21.5)
University	14 (7.7)
Occupation	
Housewife	55 (33)
Merchant	60 (33)
Retiree	28 (15.5)
Teacher	13 (7.2)
Industry Worker	8 (4.4)
Farmer	7 (3.9)
Unemployed	10 (5.5)

Table No. 2
List of medicinal plants collected during the ethnobotanical survey in Dolores Hidalgo (Central Mexico)

Family	Scientific name (Voucher number)	Common name in Spanish	Part used	Preparation/ Application	Disease/ symptoms	Number of mentions	Relative importance
Alliaceae	*Allium cepa L.* (SLPM 43614)	Cebolla	Roots	Infusion/Oral	Diarrhea	1	0.37
Amaranthaceae	*Chenopodium ambrosioides* L. (FEZA 18181) #	Epazote	Leaves and stem	Infusion/Oral	Abortifacient and vermifuge	1	0.73
	Chenopodium graveolens Willd. (SLPM41711) #	Epazote de zorrillo	Leaves and stem	Infusion/Oral	Cough/Diarrhea	2	0.73
Anacardiaceae	*Schinus molle* L. (FEZA 18193)	Pirul	Resin	Infusion/oral	Digestive and stomachache	1	0.53
Apiaceae	*Eryngium carlinae* F. Delaroche (FEZA 18185)	Hierba del sapo	Leaves and stem	Infusion/oral	Backache, wound	9	1.10

	#				healing, and arthritis		
	Foeniculum vulgare (L.) Mill FEZA 3919	Hinojo	Leaves and stem	Infusion/Oral	Stomachache, pain, nervousness	6	1.10
Apocynaceae	*Asclepias curassavica* L. (SLPM 22069)	Algodoncillo	Leaves and stem	Infusion/Oral	Arthritis, toothache, and vermifuge	7	1.10
Arecaceae	*Cocos nucifera* L. (FEZA7304)	Coco	Fruit	Infusion/Oral	Tooth ache	3	0.57
Asteraceae	*Achillea millefolium* L. (FEZA 18202)	Real de oro	Whole plant	Infusion/Oral	Chest pain, wound healing, and varicose veins	7	1.10
	Arnica montana L. (FEZA 18204)	Árnica	Whole plant	Infusion/Oral	Wound healing, rheumatism, and body pain	5	0.90
	Artemisia absinthium L. (FEZA 18200)	Ajenjo	Leaves	Infusion/Oral	Stomachache, vermifuge, and depression	8	0.93
	Artemisia ludoviciana Nutt. (SLPM 27583)	Estafiate	Leaves and branches	Infusion/Oral	Stomachache and gastritis	4	0.53
	Brickellia cavanillesii (Cass.) A. Gray (SLPM618) #	Prodigiosa	Leaves	Infusion/Oral	Stomachache, vermifuge, and diabetes	6	1.10
	Bidens pilosa L. (FEZA 18182)	Aceitilla	Leaves	Infusion/oral	Weight loss	2	0.37
	Calendula officinalis L. (FEZA 18190)	Calendula	Flower	Infusion/Oral	Wound healing, menstrual colic, gastritis	7	1.10
	Chamaemelum nobile (L.) All. (FEZA 18187)	Manzanilla	Whole plant	Infusion/Oral	Stomachache, chest pain, flu, eye infection, headache, nervousness	22	2.00
	Galinsoga parviflora Cav (SLPM 43947)	Estrellita	Flower	Infusion/Oral	Wound healing and toothache	4	0.73
	Gnaphalium oxyphyllum DC. (SLPM 51564) #	Gordolobo	Flower	Infusion/Oral	Cough, bronchitis, and asthma	5	0.70
	Lapsana communis L (SLPM 31756)	Hierba de los pechos	Whole plant	Maceration/Rubbed	Wound healing and anti-inflammatory	4	0.73
	Tagetes lucida Cav (FEZA 18196) #	Pericón	Leaves	Infusion/Oral	Stomachache, dysentery, and nervousness	8	0.90

	Tanacetum parthenium (L.) Sch. Bip. (FEZA 18192)	Santa Maria	Whole plant	Infusion/Oral	Menstrual colic and headache	2	0.73
	Taraxacum officinale FH Wigg. (SLPM 24700)	Diente de León	Leaves	Infusion/Oral	Stomachache, diabetes, and diarrhea	6	0.90
Bignoniaceae	*Mansoa hymenaea* (DC.) A.H. Gentry (SLPM 59802) #	Bejuco de ajo	Leaves	Maceration/rubbed	Muscle relaxant	2	0.37
Boraginaceae	*Borago officinalis* L. (SLPM 41302)	Borraja	Whole plant	Infusion/Oral	Fever and diuretic	4	0.73
Crassulaceae	*Kalanchoe daigremontiana* Raym. Hamet & H. Perrier (SLPM 26139)	kalanchoe	Leaves and stem	Infusion/Oral /Rubbed	Cancer, hemorrhoids	3	0.53
	Sedum praealtum A. DC. (SLPM 49732) #	Siempreviva	Leaves	Infusion/oral	Gastritis and stomachache	3	0.53
Equisetaceae	*Equisetum myriochaetum* Cham. (FEZA7253) #	Cola de caballo	Whole plant	Infusion/Oral	Stomachache, diarrhea, and urinary burning	7	0.90
Euphorbiaceae	*Cnidoscolus aconitifolius* (Mill.) I.M. Johnst. (SLPM 38126) #	Chaya	Leaves	Infusion/Oral	Hypertension, hemorrhoid, and weight loss	8	0.90
	Euphorbia pulcherrima Willd. ex Klotzsch (SLPM 16284) #	Flor de noche buena	Leaves	Infusion/Oral	Abortifacient, emmenagogue	2	0.73
	Ricinus communis L. (FEZA 18191)	Higuerilla	Leaves	Infusion/oral	Backache	3	0.37
Ericaceae	*Arctostaphylos pungens* Kunth (SLPM 26499) #	Pingüica	Fruit	Infusion/oral	Diuretic, asthma, and diarrhea	9	1.10
Fabaceae	*Mimosa tenuiflora* (Willd.) Poir. (SLPM 28599) #	Tepezcohuite	Whole plant	Maceration/Rubbed	Burns and wound healing	3	0.53
	Senna septemtrionalis (Viv.) H.S. Irwin & Barneby (SLPM 43980) #	Retama	Leaves and stem	Infusion/oral	Stomach infection and induce menstruation	4	0.73
Lamiaceae	*Marrubium vulgare* L. (SLPM 51380)	Marrubio	Leaves	Infusion/Oral	Stomachache, diarrhea, and menstrual colic	5	0.90
	Mentha citrata Ehrh (FEZA 18188).	Hierbabuena	Leaves and branches	Infusion/Oral	Stomachache, vomiting, cough, pain chest	13	1.27
	Ocimum sanctum L. (FEZA 18195)	Albahaca	Leaves	Infusion/Oral	Stomachache, menstrual colic, childbirth pain	10	1.10

	Origanum majorana L. (FEZA 18198)	Mejorana	Leaves	Infusion/Oral	Pain chest, urinary infection, and headache	7	0.90
	Origanum vulgare L. (FEZA 18184)	Oregáno	Leaves and stem	Infusion/Oral	Cough, sore throat, and menstrual colic	6	0.90
	Rosmarinus officinalis L. (FEZA 18205)	Romero	Leaves and stem	Infusion/Oral and soap/cutaneous	Stomachache, weight loss, and wound healing	8	1.10
	Thymus vulgaris L. (FEZA 18197)	Tomillo	Whole plant	Infusion/Oral	Stomachache, menstrual colic, pneumonia, chest pain, and urinary infections	17	1.83
Lauraceae	*Cinnamomum verum* J. Presl (SLPM 50579)	Canela	Stem	Infusion/Oral	Stomachache	2	0.37
	Laurus nobilis L. (FEZA 18186)	Laurel	Leaves	Infusion/oral	Digestive, stomachache, and diuretic	7	0.90
	Persea americana Mill (SLPM 56084) #	Aguacate	Leaves	Infusion/Oral	Bronchitis/Sore throat and body pain	6	0.90
Lythraceae	*Cuphea aequipetala* Cav (FEZA 18178) #	Hierba de Guadalupe	Leaves and stem	Infusion/oral	Diarrhea, cancer and diuretic	8	1.10
Malvaceae	*Chiranthodendron pentadactylon* Larreat. (SLPM 32841) #	Flor de manita	Leaves	Infusion/Oral	Headache, nervousness and hypertension	9	1.10
	Tilia mexicana Schltdl. (SLPM 11892) #	Tila	Leaves and stem	Infusion/Oral	Nervousness and menstrual colic	6	0.73
	Waltheria indica L. (SLPM 45577)	Tapa cola	Leaves and stem	Infusion/Oral	Infection in stomach, diarrhea, and stomachache	6	0.90
Meliaceae	*Cedrela odorata* L (SLPM 28964)	Cedro	Leaves	Infusion/Oral	Flu, asthma, and epilepsy	7	0.90
Moringaceae	*Moringa oleifera* Lam (SLPM 38819)	Moringa	Leaves and seeds	Infusion/Oral	Diabetes, Hepatitis, Bronchitis, Hypertension, weight loss, decrease cholesterol levels in blood	18	1.60
Myrtaceae	*Eucalyptus globulus*	Eucalipto	Leaves	Rubbed/Oint	Nasal	6	0.70

Family	Species	Common name	Part used	Preparation/Route	Uses		
	Labill (FEZA 18180)			ment	congestion, cough, and asthma		
	Psidium guajava L. (FEZA 18189) #	Guayaba	Leaves	Infusion/Oral	Diarrhea, stomachache, and dysentery	4	0.70
Nyctaginaceae	*Bougainvillea glabra* Choisy (SLPM 48659)	Flor de bugambilia	Flower	Infusion/Oral	Cough, tuberculosis, and bronchitis	4	0.70
Papaveraceae	*Argemone mexicana* L. (SLPM 8195) #	Chicalote	Flower and seeds	Infusion/Oral	Wound healing, diarrhea, and hemorrhoid	7	1.10
Poaceae	*Phalaris canariensis* L. (SLPM 11310)	Alpiste	Seeds	Infusion/Oral	Decrease cholesterol levels in blood, diuretic, and hypertension	5	0.90
	Zea mays L. (FEZA7257) #	Elote	Dried stigmata	Infusion/Oral	Urinary infections	3	0.37
Polemoniaceae	*Loeselia mexicana* Lam. (FEZA7312) #	Espinosillo	Stem	Infusion/Oral	Fever, bronchitis, and nervousness	8	1.10
Rosaceae	*Eriobotrya japonica* (Thunb.) Lindl. (SLPM 48851)	Níspero	Leaves	Infusion/Oral	Asthma, flu, and bronchitis	4	0.70
	Rosa gallica L. (SLPM 48931)	Rosa de castilla	Flower	Infusion/Eye	Eye infection	2	0.37
Rutaceae	*Citrus aurantium* L (FEZA 18179)	Naranja	Stem and Flowers	Infusion/Oral	Nervousness and insomnia	5	0.53
	Citrus limon L. (FEZA7294)	Limón	Leaves	Infusion/Oral, Ointment/Rubbed	Stomachache, cough, and flu	6	0.90
	Ruta chalepensis L. (FEZA 18203)	Ruda	Leaves and branches	Infusion/Oral	Earache, vomiting, chest pain	7	0.90
Solanaceae	*Cestrum fasciculatum* (Schltdl.) Miers (SLPM 48880) #	Hierba del perro	Whole plant	Infusion/Oral	Stomachache, diarrhea	10	0.53
Typhaceae	*Typha dominguensis* Pers. (SLPM 59464)	Espadaña	Leaves	Infusion/oral	Diuretic	1	0.37
Verbenaceae	*Aloysia triphylla* Royle (SLPM 37141)	Cedrón	Leaves and stem	Infusion/Oral	Nervousness and muscle relaxant, and menstrual colic	6	0.90

	Verbena officinalis L. (FEZA 18183)	Verbena	Leaves	Infusion/Oral	Headache, toothache, and sore throat	4	0.70
Zingiberaceae	*Curcuma longa L.* (SLPM 50048)	Curcuma	Roots	Infusion/Oral	Diarrhea and stomachache	3	0.53
	Zingiber officinale Roscoe (SLPM 50049)	Jengibre	Roots	Infusion/Oral	Decrease the levels of cholesterol and triglycerides in blood, and rheumatoid arthritis	6	0.90
Zygophyllaceae	*Larrea tridentata* (DC.) Coville (SLPM 39385) #	Gobernadora	Leaves and stem	Infusion/Oral	Gallstone, tuberculosis, and menstrual colic	8	1.10

 # Indicates species endemic to Mexico. References: Missouri Botanical Garden-Tropicos (2020) and International Plant Names Index (2020)

Table No. 3
Informant consensus factor

Category	Uses	Taxons	ICF
Certain infectious and parasitic diseases	13	9	0.33
Diseases of the circulatory system	13	6	0.58
Diseases of the digestive system	118	30	0.75
Diseases of the genitourinary system	32	19	0.42
Diseases of the musculoskeletal system and connective tissue	71	21	0.71
Diseases of the nervous system	27	10	0.65
Diseases of the respiratory system	80	17	0.80
Diseases of the skin and subcutaneous tissues	28	11	0.63
Endocrine, nutritional and metabolic diseases	19	9	0.56
Injuries, poisoning and other consequences of external causes	3	2	0.5
Neoplasms	3	2	0.5

Two informants described the concomitant use of Santa Maria (*Tanacetum parthenium)* and acetylsalicylic acid to treat menstrual cramps. In addition, two informants report the combination of real de oro (*Achillea millefolium)* and acetylsalicylic acid to treat chest pain. One informant reported the combined use of estafiate (*Artemisia ludoviciana)* and oxytetracycline for the treatment of gastritis, and another informant reported to use bismuth subsalicylate and hierba del perro (*Cestrum fasciculatum*) for the treatment of stomach pain.

Finally, one respondent reported the use of amoxicillin and *Chamaemelum nobile* for the treatment of influenza.

Some medicinal plants were used in combination for the treatment of several diseases. For instance, *Thymus vulgaris and Cinnamomum verum* (number of mentions=4), and *Cestrum fasciculatum* and *Cinnamomum verum* (number of mentions=3), *Ocimum sanctum,* and *Thymus vulgaris* (number of mentions=2) were used for stomach pain, whereas *Thymus vulgaris* and *Chamaemelum nobile* for chest

pain (number of mentions=2).

Some adverse reactions from the use medicinal plants were reported, including abortion (induced by *Tanacetum parthenium*), hallucinations (*Artemisia absinthium*), gastritis (*Curcuma longa* and *Zingiber officinale*), and sleepiness *(Borago officinalis, Origanum vulgare,* and *Tilia mexicana*).

DISCUSSION

Most of the respondents were elderly women. This can be explained since young adults from rural communities aged between 19 to 36 years emigrated to the United States of America (USA) to work and improve their living conditions. Approximately, 1.1 million inhabitants from Guanajuato live in the USA, of which 123 000 emigrated from 2005 to 2010, and 85% of them were men. It is estimated that 1.1% of these immigrants were from the municipality of Dolores Hidalgo (Government of the state of Guanajuato, 2017).

The use of medicinal plants is a common practice among Mexican population. In rural areas, the population can rely exclusively on medicinal plants for primary health care. Since there is no physician in the rural community of Dolores Hidalgo (state of Guanajuato, central Mexico), inhabitants treat their diseases with medicinal plants. This is a common trend in rural communities in Mexico (Velázquez-Vázquez *et al*., 2019). Most of the medicinal plants are harvested from nature, which is also a common practice in Mexico (Barrera-Catalán *et al*., 2015; Lara-Reimers *et al*., 2018). This trend can reduce health care expenditures of the population to treat non-severe acute diseases.

According to their conservation status (reviewed on the redlist.org), *Schinus molle, Achillea millefolium, Borago officinalis, Rosmarinus officinalis, Thymus vulgaris, Laurus nobilis, Eucalyptus globulus,* and *Bougainvillea glabra* are catalogued as least concern species, whereas *Marrubium vulgare* is catalogued as near threatened. Worldwide conservational programs should be implemented with these plants species to avoid a severe decrease in their populations and conserve their natural ecosystems. Only one plant species (*Kalanchoe daigremontiana*) is catalogued as endangered. No further pharmacological studies should be carried out with this plant species because its world population is dramatically decreasing. However, additional conservational studies with these plant species should be undertaken.

Chamaemelum nobile (RI=2.0) was the most versatile species in treating many diseases of the human body systems, followed by *Thymus vulgaris* (RI = 1.83), and *Moringa oleifera* (RI = 1.60). The pharmacological actions of these plant species have been evaluated in clinical trials (*i.e.,* Salmalian *et al*., 2014; Anthanont *et al*., 2016; Lopez-Jornet *et al*., 2016; Zemestani *et al*., 2016), which corroborate their extensive use in folk medicine. Lara-Reimers *et al*. (2018), found that the most versatile species in Zacatecas (Central Mexico) were *Matricaria chamomilla* (RI = 0.73), *Aloe vera* (RI = 0.71), and *Arnica montana* (RI=0.66). The results agree with the use of chamomile as the most versatile species.

Asteraceae family had the highest number of species found in this study, which is a common trend in other reports in Mexico (Fernández-Nava *et al*., 2001; Barrera-Catalán *et al*., 2015; Pérez-Nicolás *et al*., 2017; Campos-Saldaña *et al*., 2018; Lara-Reimers *et al*., 2018; Orantes-García *et al*., 2018; Reimers *et al*., 2019; Velázquez-Vázquez *et al*., 2019). In contrast, Estrada-Castillón *et al*., 2018 found that the Fabaceae family showed the highest number of plants in the Bustamante municipality, belonging to the state of Nuevo Leon (Northeastern Mexico). Asteraceae is the largest botanical family in Mexico, encompassing more than 3000 species (Villaseñor, 2016). Several metabolites, including terpenes, alkaloids, and flavonoids have been obtained from medicinal plants of the Asteraceae family used in Mexican traditional medicine (Heinrich *et al*., 1998). Therefore, Asteraceae family is a good source of compounds with pharmacological properties.

The leaves were the most cited plant part used in this study, which are easy to collect and do not affect plant survival. This is in accordance with other ethnobotanical studies in Mexico (Barrera-Catalán *et al*., 2015; Pérez-Nicolás *et al*., 2017; Estrada-Castillón *et al*., 2018; Lara-Reimers *et al*., 2018; Orantes-García *et al*., 2018; Reimers *et al*., 2019; Velázquez-Vázquez *et al*., 2019). Three members of the Asteraceae family were used for the treatment mental diseases. These results agree with the report by Hurrell *et al*. (2015), who indicated that the Asteraceae family contained the highest number of members used for mental diseases in Buenos Aires, Argentina. The main route of administration was oral and the most frequent way of preparation was infusion, which also agrees with other botanical studies in Mexico (Lara-Reimers *et al*., 2018; Orantes-García *et al*., 2018; Reimers *et al*., 2019). However, this result is in contrast with another study, which showed that maceration was the most frequent

way of preparation in Puebla (Central Mexico) (Velázquez-Vázquez *et al*., 2019). The preparation of medicinal plants as infusions corroborates their use in the treatment of respiratory and gastrointestinal diseases, which require an oral administration. This has been the main form of preparation in Mexico since pre-Hispanic times (Ríos-Castillo *et al*., 2012).

The highest ICF found in respiratory diseases showed a consensus for using medicinal plants to treat these diseases. This information agrees with the main causes of morbidity in the municipality of Dolores Hidalgo (Secretariat of Health, State of Guanajuato, 2015). It was interesting to note that mental diseases, such as anxiety and depression showed a high consensus (ICF = 0.65). This might be explained since the central-western region of Mexico, where the state of Guanajuato belongs, has the highest prevalence of mental disorders, which is 36.7%, whereas the national prevalence is 28.6% (Medina *et al*., 2003).

In this study, the highest ICF were recorded in respiratory (ICF = 0.8), gastrointestinal (ICF = 0.75), and musculoskeletal system and connective tissue diseases (ICF = 0.71). Other reports in the central region of Mexico agree with these results. Lara-Reimers *et al*. in 2018 found that the highest ICF in Zacatecas was obtained in diseases of the reproductive (ICF = 0.81), gastrointestinal (ICF = 0.80), and respiratory systems (ICF = 0.79). On the other hand, Reimers *et al*. in 2019 showed that poisonous bites (ICF = 0.92), oncologic (ICF = 0.91), and gastrointestinal diseases (ICF = 0.89) showed the highest ICF in the municipality of Papantla, Veracruz (Eastern Mexico). Lara *et al*. in 2019 reported diseases of the reproductive (ICF = 0.80), respiratory (ICF = 0.75), and gastrointestinal systems (ICF = 0.70) showed the highest ICF values in the region of Los Altos, Chiapas (Southern, Mexico).

The use of medicinal plants to treat symptoms related to gastrointestinal and respiratory diseases, such as cough, sore throat, flu, asthma, diarrhea, and stomachache is a common practice in these rural communities due the lack of medical facilities and the high level of margination (SEDESOL, 2013).

The combination of traditional and allopathic medications is a topic that requires special attention. Few information is known about the possible beneficial or toxic interactions between drug-herb. Lara-Reimers *et al*. (2018), found that 25.7% of the respondents in a botanical study in the state of Zacatecas (North Central Mexico) concomitantly use

medicinal plants and allopathic medicine. In this study, 4% of the respondents reported the concomitant use of medicinal plants and allopathic medicine.

Herb-herb combinations are also commonly practiced in different rural areas from Mexico (Juarez-Vazquez *et al*., 2013). It is believed that combining two or more medicinal plants will increase their individual pharmacological effects. However, pharmacodynamic studies should be carried out to analyze the type of interaction induced by combining herb-herb. This information could be useful to obtain a more effective pharmacological effect of medicinal plants or avoid the use of certain herb-herb combinations.

In this study, seven medicinal plants were reported to induce toxicity. The abortifacient effect of *Tanacetum parthenium* (Tana Pareek *et al*., 2011), the hallucinations induced by *Artemisia absinthium* (Lachenmeier, 2010), and gastric ulcers induced by *Curcuma longa* and *Zingiber officinale* (Vanaclocha and Cañigueral, 2019), were previously reported. In addition, Mombeini *et al*., 2015 showed that *Origanum vulgare* induces sedative effects, which corroborates sleepiness as a side effect reported in this study. Jäger *et al*., 2013 reported *Borago officinalis* as a sedative agent that exerts affinity to the serotonin transporter. In addition, Di Lorenzo *et al*., (2018) reported that *Borago officinalis* causes side effects in the central nervous system, such as agitation, confusion, and hallucinations. The sedative effects of *Tilia mexicana* were also previously reported (Aguirre-Hernández *et al*., 2007; Pérez-Ortega *et al*., 2008). Other toxicological studies with medicinal plants cited in this study should be contemplated.

According to a bibliographic research, phytochemical, pharmacological, and toxicological studies should be carried out with plant species native to Mexico, such as *Gnaphalium oxyphyllum*, *Lapsana communis*, *Sedum praealtum*, *Arctostaphylos pungens, Senna septemtrionalis, Cuphea aequipetala, Chiranthodendron pentadactylon, Loeselia mexicana, Ruta chalapensis,* and *Cestrum fasciculatum,* which have limited scientific studies. The rest of plant species present different scientific studies corroborating their medicinal properties. This work has provided an inventory of the medicinal plants currently used with limited scientific based evidence, so further studies are necessary. However, the transmission of ethnomedical knowledge from generation to generation, based on medicinal plants

might be extinct since most young adults left these rural communities to immigrate to the United States of America.

CONCLUSION

Respondents have knowledge about the use of medicinal plants for primary health care of respiratory and digestive diseases and other chronic diseases. *Chamaemelum nobile, Thymus vulgaris*, and *Moringa oleifera* were the most versatile species. The pharmacological actions of these plant species have been evaluated in clinical trials. Most plant species were used in a single prescription, whereas some combinations of herb-herb and drug-herb were reported. Toxicological studies need to be carried out with medicinal plants that cause adverse reactions. Pharmacodynamic studies are also essential to assess herb-herb and drug-herb interactions.

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