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Giving Birth in the Mountains: Plants and Practices in Reproductive Health of Zapotec Women in Northern Oaxaca, Mexico

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ABSTRACT

Midwives/healers assist women in rural communities in Mexico and use medicinal plants to relieve different conditions related to reproductive health. This knowledge has been passed down and preserved through generations. The aims of the study were: 1) to document the floristic richness of medicinal plants used in the reproductive health of Zapotec women from the Sierra Norte of Oaxaca; 2) to document moments, stages, and conditions during reproductive health; and 3) to provide evidence on the continuity of midwifery practices in the region. We interviewed 100 Zapotec women, 11 midwives/healers, the municipal authorities of four municipalities: Tabaá, Yojovi, Solaga, and Analco, and personnel from each health center. We recorded 66 plant species, with cinnamon, avocado, and rue the most mentioned. Asteraceae, Lamiaceae, Poaceae and Fabaceae were the most abundant. We identified five moments with different stages/conditions during the reproductive health of women. The number of species mentioned by Analco collaborators differed by age category, indicating a breakdown in traditional knowledge. Multivariate analysis comparing the knowledge of native and introduced species between the collaborators of four municipalities revealed that they were clustered because of the mention of some introduced species (Analco) or because some species were mentioned once (Laxopa). However, the same analysis using native species shows no grouping, suggesting that women share similar knowledge. Traditional midwifery practices and medicinal plants used during the reproductive stage of Zapotec women are still based on native Mexican plants, and their persistent use will depend on the socioeconomic and cultural context of each locality and the influence of the traditional over the occidental medicinal system.

Keywords: Biocultural knowledge, Herbal medicine, Medicinal plants,Traditional midwifery.

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SIGNIFICANCE STATEMENT

This manuscript is a summary of the traditional knowledge regarding reproductive health in zapotec communities of Oaxaca, Mexico. Even though the Mexican government's health care system has expanded throughout the country, local communities are still responsible for addressing their health problems and needs. In the case of reproductive health, we discovered that ancestral practices are still current and that more recent or even contemporary practices have been added to treat various illnesses and pains. The use of native and introduced plants, as well as an ancestral cosmovision, is central to these practices. If Indigenous communities continue their efforts to preserve their traditions and if personnel from the dominant health system foster bridges for the connectivity of practices, it is possible to avoid the complete disappearance of these practices.

INTRODUCTION

More than eight million indigenous Mexicans are considered the custodians of traditional knowledge, which consists of ancestral skills, techniques, and traditions acquired through generations of interacting with nature. This traditional knowledge represents an understanding of local reality, is part of a community's cosmovision, and is crucial to the formulation and implementation of survival strategies based on the multiple lines of the utilization of natural resources (CONABIO-GIZ 2017; Toledo and Barrera-Bassols 2008).

Traditional knowledge and use of plants for medicinal purposes, along with different customs, rituals, and ceremonies associated with their use, constitute a complex health system that continues to exist in many Mexican communities. Several studies have documented the use of medicinal plants in at least one of the thirteen diseases and health problem categories defined by the World Health Organization (WHO) (2022) (Alonso-Castro et al. 2012; Pérez-Nicolás et al. 2017; Cruz-Pérez et al. 2021). The most common disease categories are gastrointestinal, urogenital, dermatological, respiratory, and cultural bound syndromes (related to psychosomatic diseases like *susto*, *mal de ojo*) (García-Alvarado et al. 2001; Heinrich et al. 1998a).

Many ethnobotanical works talk about the reproductive health of women, which includes aspects like pregnancy, childbirth, and puerperium (WHO, 2022), and others like menstruation and menopause, in which different plants and traditional practices are described (for example, to encourage breastfeeding) (e. g. Browner 1985; Gheno-Heredia et al. 2011; Smith-Oka 2008).

Documenting the Mesoamerican civilizations' use of medicinal plants for reproductive health has been a significant endeavor since the Spanish conquest. In the section titled "Remedies for the parturient, menstruation, lavage of the parturient's belly, breast tumor, medicine to produce milk," the Aztec codex *Libellus de medicinalibus indorum herbis*, written by Martín de la Cruz [1552] and translated into Latin by Juan Badiano, describes various preparations containing plants, animals, and minerals used as medicine. This would be the first report on women's health-related therapeutic flora in Mexico. Other contributors include Fray Bernardino de Sahagún and Francisco Hernández, who documented the numerous treatments midwives used during childbirth and acknowledged their significant role in Mesoamérica (Ravelo-Rodríguez 2020).

More recently, in Mexico, a few ethnobotanical studies have recorded different aspects of reproductive health. For the state of Oaxaca, Browner (1985) and Galante (1992), conducted studies in a Chinantec community and four Zapotec communities in the Isthmus of Tehuantepec, respectively. Katz (1993) described the indigenous perception of conception, pregnancy, and birth and compared these traditional procedures with modern Western practices. For the state of Veracruz, Gheno-Heredia et al. (2011) and Smith-Oka (2008), conducted studies with Nahua women in the municipality of Ixhuatlán de Madero and with the *Nahuatlxihuitl Organization* of traditional Indigenous midwives and physicians, respectively. The latest review of medicinal plants used for reproductive health in Mexico listed 185 species (Cabada-Aguirre et al. 2023). Nonetheless, a more exhaustive review of Mexican literature reveals at least 394 plant species utilized in women's reproductive health (Mahecha-Ruiz 2021).

Floristic information from these studies indicates a preference for medicinal plants belonging to the Asteraceae, Lamiaceae, and Fabaceae families, supporting the hypothesis that there is a pattern in the use of medicinal species belonging to certain botanical families, based on their phytochemical properties (Heinrich et al. 1998b; Moerman et al. 1999; Weckerle et al. 2012). This floristic composition is conformed of native and introduced or exotic species. The importance of introduced plants has had little attention, even though they are vital resources for the communities and have been used medicinally (Bennett and Prance 2000). The incorporation of introduced plants into the traditional Mexican medical system occured since early moments of Hispanic contact. Some explanations rest on their morphological similarity with plants already known and utilized in the territory (e.g., *hierba maestra/lagafee* (*Artemisia absinthium* L. which is like *Artemisia ludoviciana* Nutt.)), but also on their therapeutic properties or therapeutic value of

many ornamentals and food plants. Another explanation is the diversification hypothesis, which suggests that introduced plants fill vacancies that native plants cannot satisfy (Bennett and Prance 2000; Alencar et al. 2010).

Since pre-Hispanic times, women have been in charge of important activities within the communities: They have participated in the selection, cultivation and use of plants either as food or medicine. Women's knowledge about plants has been inherited from generation to generation and has served to improve the quality of life of the communities, in addition to contributing to the conservation of natural resources (Alberti-Manzanares 2006).

Women have predominated in the area of health care, traditional medicine and pharmacopeia (Marcos 1989; Flores-Cisneros and Rodríguez-Salauz 2010). Adult women and midwives are those who have the greatest knowledge about medicinal plants, and they are mostly those who participate in female reproductive health (Smith-Oka 2008; Albuquerque et al. 2011).

Traditional midwives/healers accompany and assist women during pregnancy, childbirth, and postpartum, or attend to illnesses and ailments related to the reproductive system. These practices have been strengthened among women due to trust, credibility, comfort, console, and protection between them (Parra 1991). However, in smaller percentages, there are men related to this knowledge, who are healers and/or midwives who know about medicinal plants used for this purpose (Alberti-Manzanares 2006).

Because of the dominant health system, the medicalization of childbirth, and the training needed to become a biomedical professional, midwives and their traditional practices have become less important since Spain took over. Although historically "midwives" have been in charge of childbirth assistance and herbal therapy, there are no sources written by them that support their practices and knowledge; There are several very old written sources, whose authors are male doctors, that contain valuable information: "Obstetrics has been written in feminine and written in masculine" (Oliver 2000).

Additionally, practices that are unrelated to their cosmovision have taken their place (Argüello-Avendaño and Mateo-González 2014; Carvajal-Barona et al. 2018; Cosminsky, 2018; Flores-Cisneros and Rodríguez-Salauz 2010; Jiménez et al. 2008; Ravelo-Rodríguez 2020). In 1999, 30% of births in Mexico were attended by midwives; by 2014, that percentage had declined to 2.7% (Pelcastre et al. 2005; INEGI 2015).

It has been frequently supposed that new generations of women have abandoned the traditional reproductive healthcare system, due to a more presence of the occidental medical system. Some studies suggest that older women retain more traditional knowledge, use more plants to treat some illness, ailments (Quinlan y Quinlan 2007; Smith-Oka 2008; Giovannini et al. 2011). However, no one made a comparative quantitative analysis to probe this data.

Despite this scenario, in many localities of Mexico, many women are engaged in these practices. In the Sierra Norte of Oaxaca, traditional reproductive health practices for women are still prevalent (Flores-Cisneros and Rodríguez-Salauz 2010). However, the occidental medical system was introduced during the decade of 90, and its influence on reproductive health system, including use of medicinal plants, was not documented.Due to the loss of midwives and knowledge of reproductive health practices, including the knowledge of medicinal plants used for this purpose, the aims of this study were: 1) to document the floristic richness and biogeographic origin of medicinal plants used in reproductive health in four zapotec communities with different socioeconomic and cultural conditions from the Sierra Norte of Oaxaca; 2) to compare the traditional knowledge and use of plants, as well as moments, stages, and conditions in reproductive health between women from different communities, and with different ages; 3) to provide evidence on the continuity of midwifery practices in the region.

MATERIAL AND METHODS

Study Area

The municipality is the geopolitical unit inside each one of the 32 states of Mexico. Oaxaca is divided into 570 municipalities. Most of the municipalities are subdivided into different municipal agencies. This study was conducted in four municipalities of the Sierra Norte de Oaxaca in southern Mexico (Figure 1): San Juan Tabaá, Santiago Laxopa, San Juan Evangelista Analco, and San Andrés Solaga. In the case of the first three municipalities, the fieldwork was developed in the municipality head; in the case of Solaga, it was followed in Santo Domingo Yojovi (Figure 2a), which is one of its two municipal agencies.

The four municipalities are characterized by precipitous slopes and mountains dominated by pine, pine-oak, and cloud forests (Figure 2b) (Rendón-Aguilar et al. 2022; SAI 2016) (Table 1).

The population advocated to agriculture and livestock vary between municipalities; however, in comparative terms, more people from Analco (6.64) are dedicated to other activities. More than 70% of the people are of Zapotec ethnic composition, except in Analco, where more than 50% are mestizos and do not speak Zapotec. It also highlights that a high percentage of people from Analco have reached educational

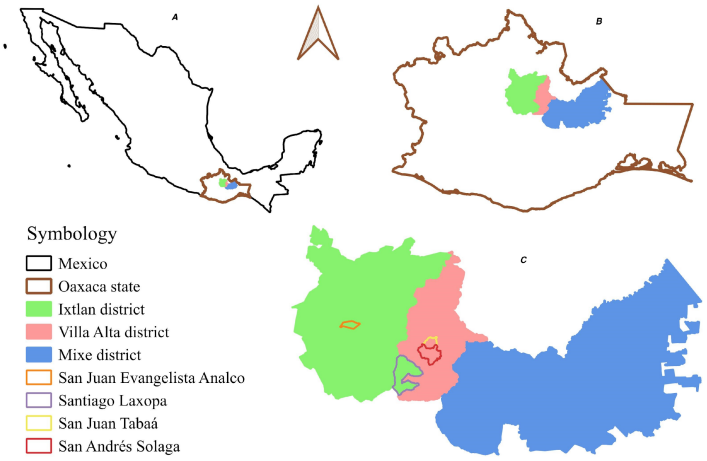

Figure 1. Study area: a) Oaxaca state; b) Location of Districts and Municipalities in the State of Oaxaca; c) Location of the three municipalities: San Juan Tabaá, and Santo Domingo Yojovi (Villa Alta district); Santiago Laxopa, and San Juan Evangelista Analco (Ixtlán District) (Design: Luis Alberto Bernal Ramírez).

levels above graduate, opposite to Tabaá, Yojovi, and Laxopa (DataMexico 2023a, b, c, d; DIGEPO 2015a, b, c, d) (Table 1).

Agriculture is sustained in milpa (maize, *Zea mays* L.) in polyculture (Figure 2c), where beans (*Phaseolus* spp.), squashes (*Cucurbita* spp.), and other crops like chili (*Capsicum* spp.) accompanied by maize. People also gather wild or tolerated edible plants from the plots, named *quelites*, which contribute to their nutritional diversity (Bye, 1981).

Additionally, they cultivate coffee (*Coffea arabica* (Spreng.) Link & Otto ex Benth.) using a traditional shade system of wild trees mixed with native and exotic cultivated fruit trees. Strong familial and community ties are centered on performing activities for multiple benefits, such as the *gozona*, which consists of family organization for special activities like cultivation, house repair, or construction, or for community benefits, such as the *tequio*, where residents coordinate activities such as the construction and maintenance of municipal buildings, schools, and roads (SAI 2016; LCMR *pers. obs.)*. They also participate in the assembly, which is the highest level of community authority and is primarily used to resolve community issues, elect council members and other service providers, program *tequios*, or organize parties (Figure 2d, e) (SAI 2016) (Table 1). Zapotec women (*nholh xhon* in Zapotec) from the Sierra Norte de Oaxaca are members of the communal authority if they are single mothers, widows, or their husbands have emigrated to work elsewhere. Aside from that, they assist their husbands in communal activities. Many of them have also served on health and education panels. They prepare meals, including the entire process of preparing *tortillas* (Figure 2f), collecting firewood, and taking care of their backyard and domestic animals (SAI 2016; LCMR *pers. obs.)*.

Each community has a health center with one doctor and one nurse on staff, which tries to offer general medical services like treatment for pain, intoxication, the flu, stomach issues, or headaches. In terms of reproductive health, Tabaá, and Yojovi share the same health center, where medical personnel monitors pregnant and postpartum women, but they do not provide childbirth services; consequently, the women must travel to Villa Alta (the nearest district heading around two hours away by car). When babies are delivered at home, the midwife must submit a form to the health center with the most pertinent information about the birth so that it can be registered, and the mothers can receive their birth certificates. Each of Laxopa and Analco has its own health center. They provide care for pregnant women, childbirth, and postpartum if the pregnancy is secure; otherwise, they must travel from these communities to Ixtlán de Juárez, which is in another district (around two hours away by car).

Table 1. Sociodemographic information of San Juan Tabaá, San Andrés Solaga, Santiago Laxopa, and San Juan Evangelista Analco (DataMexico 2023a,b,c,d; DIGEPO 2015a,b,c,d).

		MUNICIPALITY			
Socioeconomic indicators		**San Juan Tabaá**	**San Andrés Solaga**	**Santiago Laxopa**	**San Juan Evangelista Analco**
Marginalization		High	High	Medium	Low
Number of Inhabitants		1241	1771	1291	407
Number of women		646	914	696	215
Number of men		595	857	595	192
Educational level (%)	Elementary	39.3	71	52.7	48.9
	Secondary	37.2	18	40.2	29.6
	Highschool	15.9	8.13	4.39	10.7
	Graduate	3.06	1.08	1.5	5.86
Productive Activity (%)	Primary	34.17	33.37	24.72	20.38
	Secondary	0.61	3.04	7.05	2.13
	Tertiary	1.57	4.11	2.03	6.64
Migration (%)		2.61	1.1	2.21	16.5
Language (%)	Zapotec	84.1	84.5	76	41.5
Environmental conditions					
Geographic coordinates		17°18'17" N and 96°12' 23" W	17°18'05" N and 96°12'32" W	17°13'09" N and 96°18'42" W	17°13'09" N and 96°18'42" W
Altitude (m asl)		1 348 m	1 380 m	1 950 m	1 950 m
Precipitation (mm)		1500-2000	1200-2000	800-1200	700-1000
Range of Temperature		16-24°C	16-24°C	10-20°C	12-22°C
Climate		Semi-warm humid with abundant rains in summer	Semi-warm humid with abundant rains in summer, temperate humid with abundant rainfall in summer	Humid temperate with abundant rainfall in summer	Subhumid temperate with rainfall in summer
Vegetation Species more representative		Temperate forest and tropical dry deciduous forest: Pinus oocarpa, P. patula, P. chiapensis; Quercus acatenangensis, Q. candicans; Litsea glaucescens, Mimosa albida, Guazuma ulmifolia, Swietenia humilis, Diphysa carthagenensis, Colubrina elliptica, Enterolobium cyclocarpum, Leucaena leucocephala	Temperate forest and tropical dry deciduous forest: Pinus oocarpa, Pinus devoniana, Quercus crassifolia, Bursera fagaroides, Ceiba spp., Amphipterygium adstringens.	Temperate forest: Pinus oocarpa, Quercus laurina, Quercus crassifolia, Arbutus xalapensis, Persea americana, Clinopodium macrostemum.	Temperate forest and tropical dry deciduous forest: Pinus pseudostrobus, Quercus candicans, Quercus conzatii, Quercus crassifolia, Quercus dysophylla, Quercus glabrescens, Alnus acuminate, Litsea glaucescens, Arbutus xalapensis.

Fieldwork

Eight ten-day visits were conducted between December 2018 and November 2019. To comply with the code of ethics for ethnobiological research in Latin America (Cano-Contreras et al. 2016), we immersed ourselves in the cultural context of the communities, and through a written request, a solicited project approval from all four municipal administrations was made. We frequently reported to them the advances in the research and highlighted the significance of ethnobiological research to continue the fieldwork. Following the code of ethics, we denoted collaborators as those who contributed with their knowledge and experience about reproductive health. Our collaborators were patients, midwives and/or healers, doctors and nurses, and local authorities. Before interviews, we asked for their consent to take photos and gather voucher specimens; during the fieldwork, we understood that they could keep information about their experience, history, cosmovision, and other aspects of their way of life.

Patients: Following the stratified method based on age criteria, we randomly sampled 25 women per municipality (Albuquerque et al. 2019). Five women were chosen from the following age categories: <29 years old, 30-39, 40-49, 50-59 and >60. These women included those with one or more children and those who were expecting during the study. One hundred women between the ages of 18 and 89 were surveyed.

Midwives and/or healers: Using the snowball technique (Albuquerque et al. 2019; Bernard 2006), we requested collaborator referrals from authorities and patients. We contacted all the midwives/healers in each community.

We conducted semi-structured interviews. Patients were asked about their experiences with midwives addressing reproductive health, as well as the use of medicinal plants for a variety of conditions and health moments. Similarly, midwives/healers were questioned regarding their experiences providing for women's reproductive health in their respective communities, as well as the medicinal plants they employed. The health workers of the health centers and the municipal authorities of each municipality were interviewed to determine their perspectives on midwifery practices and the use of medicinal herbs, as well as their attitudes regarding this activity. Several patients and midwives/healers participated in field visits to collect specimens for research. From the interviews, we obtained a list of medicinal plants that were collected during the study. They were collected with reproductive structures, and they were processed according to Lot and Chang (1986).

Voucher specimens (No. 1 to 88) were deposited in different herbaria: Interdisciplinary Research Center for Integral Regional Development, Oaxaca (CIIDIR), María Agustina Batalla in National Autonomous University of Mexico (FCME-PF).

Data Analysis

The results of interviews were systematized to characterize the different moments that patients and midwives/healers recognized during reproductive health, as well as the plant names and application methods. We categorized a group of principal moments, based on the physiological processes involved, and the physiological independence of each one. We categorized the stages of each moment based on whether a sequential physiological response occurred. Otherwise, we categorized conditions as those in which distinct ailments, aches, and symptoms are associated with a specific moment, but are independent.

The voucher specimens were determined by distinct taxonomists. Nomenclature was accorded to Tropicos.org and POWO (2022). A database was created to organize information about plants mentioned in interviews. It comprised botanical family, species, common name in Spanish, Zapotec, biogeographic origin at country level (native or introduced), frequency of mention, stage, condition, municipality, and collaborator.

IBM SPSS Statistics, version 21 (2012) was used to conduct Kruskal-Wallis tests to identify statistically significant differences in the number of stages and conditions described by patients by municipality and by age category within each municipality (<29 years old, 30-39, 40-49, 50-59 and >60), as well as in the number of mentioned species. In the case of midwives/healers, a Kruskal-Wallis test was applied to evaluate possible differences in the number of medicinal plants mentioned at the municipality level. Due to the low number of midwives/healers inside each municipality, this analysis could not be done.

To evaluate the variation of medicinal plants used among the patients and midwives/healers of the four municipalities, and to identify possible species that are used in a particular way in any of them, two Principal Coordinates analysis (PCoA) based on two absence-presence matrices were performed using the Numerical Taxonomy System (NTSYSpc) 2.2 program (Rohlf 2009): the first one including all the native and introduced species mentioned; the second, only the native species.

An indicator of the prevalence of midwifery practices was qualitatively obtained from the interviews. We compared the number of children born to patients delivered by a midwife/healer versus those born to patients delivered by conventional methods. We also considered the age at which the following events occurred: a) women whose all childbirths occurred without a

Figure 2. a. Landscape of Santo Domingo Yojovi (San Andrés Solaga) b. Montane cloud forest in San Juan Tabaá. c. Woman storing harvested cobs. d. Tequio in Tabaá: Building the municipal office e. Party dedicated to San Juan Bautista (San Juan Tabaá) f. Women making tortillas for the municipal party.

midwife's assistance; b) women who had at least one childbirth assisted by a midwife/healer; c) women who had all their children at home with the assistance of a midwife/healer; and d) women whose mothers were assisted during childbirth by a midwife/healer.

RESULTS

Medicinal Plants Used in Reproductive Health

The medicinal plants used for reproductive health included 66 species from 31 botanical families (Additional File 1), with Asteraceae, Lamiaceae, Poaceae, and Fabaceae being the most common. The number of botanical families in Tabaá was highest (29), then Analco (22), Laxopa (18), and Yojovi (12). Analco showed the highest number of species mentioned (41), followed by Tabaá (37), Laxopa (33), and Yojovi (21). 48% of species were native to Mexico (Additional File 1). Tabaá showed the highest number of native species (20), and Yojovi the lowest (11). Analco recorded the biggest number of introduced species (20), and Yojovi showed the lowest (10).

We found that the most mentioned species were cinnamon (*Cinnamomum verum* J.Presl) (64) (Figure 3a), *aguacate* and *aguacatillo* (*Persea* spp.) (52) (Figure 3b), and rue (*Ruta graveolens* L.) (51). In contrast, 26 species were only mentioned for one or two people: amaranth (*Amaranthus hybridus* L.), *perlas de la india* (*Phytolacca icosandra* L.), *flor de mayo* (*Plumeria rubra* L.) and *hierbamora* (*Solanum americanum* Mill.).

Vara de San José (*Adiantum tricholepis* Fée.), muskmelon (*Cucumis melo* L.), *corona de cristo* (*Euphorbia milii* Des Moul.), *kuan-chebe'e* (*Pellaea ovata* (Desv.) Weath.), oak (*Quercus muehlenbergii* Engelm.), cocoa (*Theobroma cacao* L.), wheat (*Triticum aestivum* L.), *chichicastle o chichicasle* (*Urera verrucosa* (Liebm.) V.W.Steinm., and *algarrobo* (*Vachellia macracantha* (Humb. & Bonpl. Ex Willd.) Seigler & Ebinger are reported for the first time as being used for reproductive health in the state of Oaxaca.

Some plants were employed exclusively in one moment, stage, or condition, whereas others were utilized in most (Table 2). In Tabaá and Yojovi, two neighboring municipalities, only six collaborators (1%) mentioned the *Lagafixhe/Kuanbixe* plant (Leaf for infertility, herb for infertility, respectively in Zapotec), which is used to "dry" the womb and prevent pregnancy. According to the collaborators, it was not collected or determined because "it no longer appears" or "very infrequently, only during the rainy seasons."

Other species were commonly used in all municipalities. *Persea* spp., which is native to Mexico and is used during childbirth and postpartum, as well as an emmenagogue, topped the list of the most frequently mentioned plants (75% of the collaborators). Moreover, it is used as a fresh plant or common ingredient in postpartum recovery therapies. *C. verum*, mentioned by 77% of the collaborators, is employed for placenta delivery and womb cleaning; *R. graveolens* was another commonly mentioned plant by 63% of the collaborators; it is used during pregnancy, but externally: midwives place hot leaves on the belly to benefit the pregnancy; it is also used in infusion for baths for postpartum recovery, and its infusion is consumed during childbirth to accelerate the delivery, it cleans the womb, induces menstruation, and relieve menstrual pain. Only in Analco, rue is also added to chocolate preparations (*T. cacao*) to accelerate delivery and induce menstruation. 28% of the collaborators mentioned these treatments.

Several plants are frequently used to induce lactation, processed like hot beverages known as *atoles*, made from different cereals like *maize*, sesame (*Sesamum indicum* L.), oat (*Avena sativa* L.), amaranth, rice (*Oriza sativa* L.) or wheat. Most of the collaborators (76%) of all municipalities mentioned them.

The *quelites* were mentioned by 61% of the collaborators in Tabaá and Yojovi, which included *frijol rojo* (*Erythrina coralloides* DC)., and *perlas de la india*. Only in Analco did 68% of the collaborators mention the use of *anona* (*Anona cherimola* Mill.) leaves, which are warmed over a fire and placed in the breasts.

Several collaborators from Tabaá and Yojovi (28%) drew parallels between morphological and physiological components and specific functions. For instance, thorny plants, such as orange (*Citrus* x *sinensis* (L.) Osbeck.) and *dormilona* or *vergonzosa* (*Mimosa pudica* L.) are used in postpartum baths because the thorns symbolize virtue and provide women with the strength they require for recovery. *Mimosa albida* Humb. & Bonpl. ex Willd., also known as shameful or sleepyhead, is known as a "closing herb" because its leaves close when they are touched. They are utilized to reinforce the back and close the womb.

It was found that *susto,* which has been classified as a syndrome of cultural connection (Remorini et al. 2012), can affect the reproductive health of women, and this local knowledge is widespread in all municipalities. There are different kinds of *susto*, such as when a dog tries to bite a person, a snake crosses their path, or someone gets worried, and each one has a particular traditional treatment. In the case of reproductive health, *susto* has different consequences: menstruation could be delayed, and problems during pregnancy or childbirth (which could be difficult or delayed) can happen. To prevent this, midwives/healers *limpian* pregnant women. *Limpiar* is a procedure consisting of tapping softly and repeatedly on the body of the affected person with *chichicastle* or *chichicaste* (*U. verrucosa*) leaves. This species is commonly used because its leaves are very spiny and have urticant properties. If the person does not feel the tapping or blisters in the skin appear, then they need more than one *limpia*.

There were some differences in the number of

Figure 3. a. Cinnamon (*Cinnamomum verum*), the species most used during childbirth. b. *Aguacate* (*Persea* sp.) is the genus most used in almost all moments of reproductive health. c. Estela, a midwife from San Juan Evangelista Analco. d. Paula, the San Juan Evangelista Analco healer, picks up medicinal plants. e. *Temazcal* is common inside Laxopa's houses. Exterior view. f. Interior view of *temazcal* with blanket and medicinal plants inside.

species mentioned by patients between municipalities and age-based categories, according to the Kruskall Wallis test. Analco exhibited statistically significant differences from the other municipalities (Table 3), as patients aged 50 to 59 mentioned a significantly greater number of species than those younger than 50 (Figure 4). Regarding the number of reproductive health moments and their respective stages and conditions, the Kruskall-Wallis test did not reveal any significant age-based differences within each municipality (Table 3).

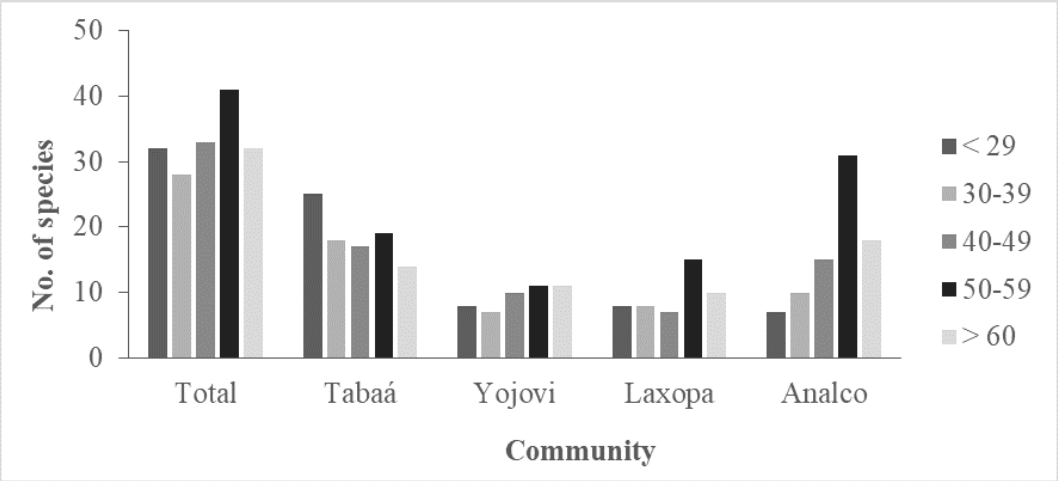

Figure 4. Number of species mentioned by Zapotec women of different age categories from San Juan Tabaá, Santo Domingo Yojovi, Santiago Laxopa, and San Juan Evangelista Analco.

In the case of midwives/healers, there were not significant differences between municipalities. Regarding the biogeographic origin, the PCoA of the absence/presence of total species (native and introduced) indicates a slight tendency for the distribution of women based on their municipality (Figure 5). However, the percentage of variation explained by the first two dimensions is low (Coordinate1= 11.04 and Coordinate2= 10.18). The first coordinate differentiates between the women of Tabaá and Yojovi and those of Analco. The species with the highest values were: rosemary (*Rosmarinus officinalis* L., Santa María (*Tanacetum parthenium* (L.) Sch.Bip.), *T. cacao*, *árnica* (*Heliopsis* sp.). The second coordinate separated women of Laxopa from all others; the species with the highest values were: *verbena* (*Verbena* cf. *carolina* L.), *C. melo*, and *cola de caballo* (*Equisetum myriochaetum* L.). In contrast, the PCoA based on the absence/presence of native species did not exhibited defined groups, even when the variation explained was higher than the previous one (Coordinate1= 23.98 and Coordinate2= 13.95), thus indicating an homogeneous knowledge of medicinal plants.

Continuity of midwifery practices in the communities

In Tabaá, Yojovi, and Laxopa, midwives continue to accompany patients during pregnancy (Figure 3c, d), care for or accommodate the baby, and provide care during postpartum and childbirth. For example, in Tabaá, child births assisted by a midwife occurred even in 2019. And currently, they visit patients at their houses.

In the case of Laxopa, the use of *temazcal* during different moments of reproductive health is common. Midwives mentioned that a few years ago, they used them during childbirth. At present, they only use them to accompany patients before and after this event. *Temazcal* is a small, closed, rectangular room 2m2 with a small door where patients enter (Figure 3e,f). Inside, there is a hole in the corner with many boiled rocks. When the patient adds water to the rocks, the room fills with water steam, and the patient must clean with different medicinal plants, while sweating. Most of the houses share one, which is used for different purposes: to clean the body, to treat some diseases (flu, headache).

In Analco, old midwives died, and they never transmitted their knowledge to new generations. At the present, two midwives are still alive. One of them (Esperanza Hernández) learned techniques about midwifery from a nurse that was living in the community. The other one (Eugenia Reyes), is an old and sick midwife that abandoned these practices few years ago. Thus, young midwives do not exist.

Regarding midwifery practices, the perspectives of Zapotec women are varied. In Tabaá and Yojovi, very few patients prefer the doctor, question the efficacy of herbs, or view home birth as a risk, especially those who have been assisted by a midwife (including women under 35 years old). In Laxopa, the fear of bad events, like maternal death, which occurred in recent years, has demotivated the role of midwives in the community. In recent years, an increasing number of women from the three municipalities have chosen to visit health centers (Table 4). However, this group is minimal compared with Analco´s women, and it is not directly related to age.

Table 2. Moments with their respective stages or conditions recognized in reproductive health among Zapotec women of Sierra Norte of Oaxaca. The number of medicinal plants, the form of use, and most frequently mentioned species are indicated.

MOMENT	STAGE (S) OR CONDITION (C)	NUMBER OF MEDICINAL PLANTS	FORM OF USE OF MEDICINAL PLANTS	SPECIES WITH MORE MENTIONS
Pregnancy	Support well development (C)	17	Infusions, baths, *temazcal*, warm branches and leaves on the body or blows on the body	*Urera verrucosa*(14),*Persea* spp. (5) *Wigandia urens*(4)
	Swelling (C)	6	*Temazcal*, warm branches and leaves on the body	*Piper auritum*(3)
Childbirth	Labor (S)	16	Infusions or concentrated cold beverages	*Cinnamomum* sp. (38) *Ruta graveolens*(11) *Saccharum officinarum* (10)
	Delivery of placenta (S)	6	Decoction, steam baths, and seed food.	*Origanum* sp. (3) *Cinnamomum* sp. (2)
Postpartum	Recovering from childbirth (S)	30	Infusions, baths, *temazcal*	*Persea* spp. (33) *Litsea glaucescens*(19) *Citrus sinensis*(15) *Ruta graveolens*(14)
	Cleaning the womb (S)	14	Infusions	*Persea* spp. (7) *Ruta graveolens*(2) *Saccharum officinarum*(2)
	Cleaning cesarean wound (S)	2	Baths	*Quercus muehlenbergii* (1) *Heliopsis* sp. (1)
	Lactation (S)	16	Hot preparation with seeds (Atoles), warm leaves on the breast and back, temazcal, quelites food	*Sesamum indicum*(25) *Zea mays*(25) *Annona cherimola* (17) *Saccharum officinarum*(17)
Menstruation	Dysmenorrhea (C)	22	Infusions	*Cinnamomum* sp. (20) *Ruta graveolens*(12) *Matricaria chamomilla*(9)
	Stopping menstruation (C)	5	Infusions	*Mimosa pudica*(2)
	Inducing menstruation (C)	13	Infusions, baths, blows with plant leaves on the body	*Urera verrucosa*(11) *Ruta graveolens*(10)
	Hemorrhage (C)	2	Infusions	*Zea mays*(2)
Others	Abortion (C)	7	Infusions	*Persea* spp. (10) *Ruta graveolens*(10)
	Inducing pregnancy (C)	7	Baths and temazcal	*Ruta graveolens*(2)
	Avoiding pregnancy (C)	4	Infusions	*Persea* spp. (2)

Table 3. Kruskall-Wallis test to compare differences in the number species of medicinal plants, and the number of conditions and stages of reproductive health mentioned between the patients of the five age categories inside the four municipalities and between midwives and healers of the four municipalities.

		SAN JUAN TABAÁ	**SANTO DOMINGO YOJOVI**	**SANTIAGO LAXOPA**	**SAN JUAN EVANGELISTA ANALCO**
Number of plants mentioned	*F*	1.067	4.447	8.168	14.198
	fd	4	4	4	4
	p	0.900^{ns}	0.349^{ns}	0.086^{ns}	0.007*
Number of stages/conditions	*F*	1.882	5.070	2.867	8.565
	fd	4	4	4	4
	p	0.758^{ns}	0.280ns	0.580^{ns}	0.073^{ns}
Number of plants mentioned between midwives/healers of different municipalities					F= 1.177 fd= 3 $p = 0.6484^{ns}$
Number of stages/conditions mentioned between midwives/healers of different municipalities					F= 3.739 fd= 3 $p = 0.076^{ns}$

(ns = no significant differences. * = significant differences, p< 0.05).

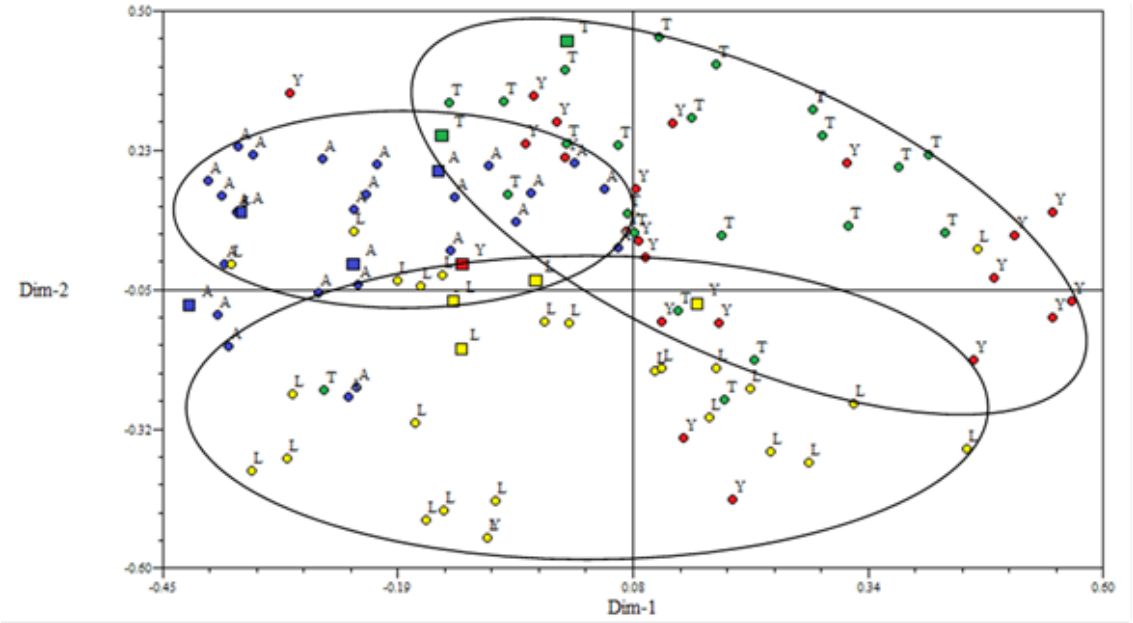

Figure 5. Principal Coordinate Analysis of 105 collaborators regarding all the species mentioned (66). Colors indicate municipalities: San Juan Tabaá (green), Santo Domingo Yojovi (red), Santiago Laxopa (yellow), and San Juan Evangelista Analco (blue). Circles indicate patients, and squares indicate midwives/healers.

Table 4. Midwifery activity in four Zapotec communities of the Sierra Norte of Oaxaca. Four groups of midwives were established based on the number of childbirths they assisted.

COMMUNITY	NUMBER OF CHILDREN/PATIENT (INTERVAL) (AGE INTERVAL)	NUMBER OF WOMEN WITH ALL CHILDBIRTHS WITHOUT MIDWIFE'S ATTENTION (%) (AGE INTERVAL)	NUMBER OF WOMEN WITH AT LEAST ONE CHILDBIRTH WITH MIDWIFE'S ATTENTION (%) (AGE INTERVAL)	NUMBER OF WOMEN WITH ALL CHILDBIRTHS ASSISTED BY MIDWIVES (%) (AGE INTERVAL)	NUMBER OF WOMEN THAT WERE BORN WITH MIDWIFE´S ATTENTION (%) (AGE INTERVAL)
SAN JUAN TABAÁ	1-13	2 (0.3)	8 (1.2)	15 (2.3)	25 (3.8)
	(22-69)	(32 - 33)	(27 - 71)	(22 - 69)	(22-69)
SANTO DOMINGO YOJOVI	1-12	6 (0.65)	6 (0.65)	13 (1.42)	25 (2.73)
	(18-68)	(18 - 35)	(30 - 64)	(26 - 68)	(18-68)
SANTIAGO LAXOPA	1-10	4 (0.57)	7 (1.0)	14 (2.0)	25 (3.5)
	(22-89)	(22 - 45)	(26 - 46)	(33 - 89)	(22-89)
SAN JUAN EVANGELISTA ANALCO	1-6	13 (6.0)	3 (1.4)	9 (4.1)	21 (9.8)
	(21-83)	(21 - 75)	(46 - 75)	(57 - 83)	(23 - 83)

DISCUSSION

Medicinal Plants Used in Reproductive Health

Concerning medicinal plants, our study recorded between 11%- 24% of the records reported previously (24%, Browner 1985; 24%, Geck et al. 2016; 14%, Gheno-Heredia et al. 2011; 11%, Smith-Oka 2008). The first two studies were also conducted in municipalities of Oaxaca, which can explain the higher percentage of similarity. However, the study of Geck with zoques, did not focus only on reproductive health, but in medicinal plants uses for different purposes. In the Browner´s study, she worked in a montane rain forest, which can influence the floristic composition. The other two studies were conducted in Veracruz, which is also related with different floristic elements. This explanation needs a deeper analysis, which is not the objective of the present study.

When comparing the most mentioned species in the present study, we found that only *Persea americana* Mill. has been mentioned in nearly all previous studies (Browner 1985; Smith-Oka 2008; Geck et al. 2016), whereas *C. verum* was mentioned only in Browner's study (1985), and *R. graveolens* was only mentioned by Geck et al. (2016). We also recorded nine medicinal plants used for reproductive health in Oaxaca that have not been mentioned before: *A. tricholepis*, *C. melo*, *E. milii*, *P. ovata*, *Q. muehlenbergii*, *T. cacao*, *T. aestivum*, *U. verrucosa* and *V. macracantha*. Another contribution is the record of chocolate (*T. cacao*), which Browner (1985) had mentioned as a beverage crucial for accelerating childbirth but did not include on her list of reported plants.

Concerning floristic composition at the family level, we found that Asteraceae, Lamiaceae, and Fabaceae were the most representative families used for different medicinal purposes. Our results are concordant with those findings reported in the literature (Aguilar et al. 1994; Browner 1985; Bussmann and Glenn 2010; Cruz 1991; Geck et al. 2016; Gheno-Heredia et al. 2011; Jiménez-Merino 2011; Martínez 1996; Smith-Oka 2008; Rendón-Aguilar et al. 2022).

Why are these families so valuable? The Asteraceae family provides the most medicinal plants (Moerman et al. 1999; Weckerle et al. 2012). Leonti et al. (2003) found that between popoloca culture, it is the second family most frequently used in gynecology. A possible explanation rests on its chemical composition, including sesquiterpene lactones, polyacetylenes, alkaloids, monoterpenes, and various phenolics such as flavonoids and properties like anti-inflammatory, cytotoxic, bactericidal, and fungicidal (Heinrich et al. 1998b; Leonti et al. 2003). In the case of Lamiaceae and Fabaceae, Leonti et al. (2003) suggest that both families have some compounds (choleretic compounds in their essential oils, tannins, and bitter diterpenoids (Lamiaceae), as well as polyphenols and triterpene saponins (Fabaceae) that play an important role in antimicrobial, antimycotic, antiviral, anti-inflammatory ailments or illness related to gynecology.

In these studies, the Poaceae family has not been recognized for its medicinal purposes, as it has been traditionally recognized as food, forage, and building materials (Leonti et al. 2003; Moerman et al. 1999; Weckerle et al. 2012). However, in the present study, people from all the communities have recognized and appreciated the medicinal benefits and biochemical properties of these plants. Poaceae does not have secondary compounds, which are characteristic of the most used families of medicinal plants (Stepp and Moerman 2001). In this context, our contribution consisted of recognizing Poaceae as a family with significant medicinal value.

Moments, Stages, and Conditions in Reproductive Health

Zapotec women of the Sierra Norte de Oaxaca maintain a traditional knowledge of the medicinal plants used for reproductive health based on moments, stages, and conditions. Most of the plants used during pregnancy are used as food, in baths, *temazcal*, or on their skin to encourage fetal development and the mother's health. Another group is consumed in infusions to facilitate childbirth, consequently, the use of plants depends on the stage of pregnancy (Malan and Neuba 2011). In the case of plants used during childbirth, Browner (1985), Flores-Cisneros and Rodríguez-Salauz (2010), Smith-Oka (2008) mentioned that these plants are preferred for their ability to warm the womb, as they are irritant plants that stimulate womb contractions and warm the blood. To avoid pregnancy, plants that "dry" the womb are also mentioned, corroborating what Browner reported (1985). San Francisco, a Chinanteco community in Oaxaca (Browner 1985) encloses mentions of the doctrine of signatures (Dafni and Lev 2002) in plants such as *M. albida*, in which certain morphological characteristics are associated with its postpartum functionality.

Regarding the most mentioned plants in this study that have also been reported in the literature with uses related to women's reproductive health, we found that *Persea* spp. native to Mexico, has been reported to be used during childbirth and postpartum and as an emmenagogue, among other uses, including also as a fresh plant or common ingredient for postpartum recovery remedies (Aguilar et al. 1994; Browner 1985; Galante 1992; Geck et al. 2016; Jiménez-Merino 2011; Smith-Oka 2008).

C. verum (Cinnamon) (Cabada-Aguirre et al.

2023), has been reported for abortion purposes, to accelerate labor, and to treat dysmenorrhea (Browner 1985; Díez-Urdanivia and Ysunza-Ogazón 2012; Jiménez-Merino 2011). *R. graveolens* has been extensively researched for its emmenagogue, abortifacient, and embryotoxic characteristics. It is contraindicated in pregnant women because its components stimulate the motility of the womb (Asgarpanah and Khoshkam 2012; Gheno-Heredia et al. 2011; González et al. 2007; Gutiérrez-Pajares et al. 2003; Zeichen et al. 2000). *T. cacao,* which is utilized in conjunction with *R. graveolens*, has not been reported for these purposes. Browner (1985) and Galante (1992) noted that its use is crucial after using plants to stimulate labor contractions.

In our study, midwives and patients mentioned that bitter plants create an unpleasant womb environment that discourages the fetus from remaining there. This could be one of the selection criteria for plants like rue, chocolate, and *T. parthenium* (*Santa María*).

As mentioned in the results, some plants are commonly used in these communities during any reproductive health event but are associated with cultural bound syndromes (Díez-Urdanivia and Ysunza-Ogazón 2012; Remorini et al. 2012). One example is *U. verrucosa*, which is used when women have *susto*. It is interesting to note that other species of the Urticaceae family have been reported with the same common name and with similar or different medicinal uses, such as *Urtica dioica* L., which is used to calm nerves, and *Urtica chamaedryoides* Pursh., which is used to treat ailments of the musculoskeletal system, bruises, and sprains (Guzmán-Gutiérrez et al. 2014; Martínez-López et al. 2016; Pérez-Nicolás et al. 2017).

Medicine-Food dichotomy

People from these communities, commonly express that "food is medicine" (LCMR, pers. obs.). In the case of medicinal plants used for reproductive health, it is also a constant. Many plants that are common foods in these communities are also used for reproductive health, like *atoles*, as reported by Díez-Urdanivia and Ysunza-Ogazón (2012), and Katz (1993), particularly when there are difficulties initiating lactation during the first few days after childbirth or to maintain optimal lactation. Katz (1993) mentioned that *atoles* are metaphorically comparable with breastmilk, semen, and blood, that's why women drink them. The most important native species is maize. However, other introduced cereals are also valuable, like wheat, which is mentioned with the same uses (Cruz 1991). For the consumption of *atoles* to stimulate lactation, they must be extremely sweet. Because of this, they use *panela*, which people in these communities make from sugar cane (*Saccharum officinarum* L.). It has been reported that this product is administered to dairy cows as a galactagogue (Espinoza et al. 2006). This plant is a common ingredient in remedies for other conditions or stages of reproductive health, typically as a sweetener.

It is interesting to highlight that almost all the species used to prepare *atoles* belong to the Poaceae family. In previous reports, it was one of the least used or mentioned families for medicinal purposes (Moerman et al. 1999; Stepp and Moerman 2001; Leonti et al. 2003; Weckerle et al. 2012), whereas in this study, it is one of the most prevalent families. Despite not being rich in alkaloids, other nutritional properties, such as sugars, can make this family one of the most utilized in these communities (Moerman 1996).

Other important groups of plants are *quelites*, such as *E. coralloides* and *P. icosandra*, which have been reported as edible in other states of Mexico and have been appreciated for their nutritional and medicinal properties (Barros and Buenrostro 2007; Basurto-Peña et al. 1998; Díez-Urdanivia and Ysunza-Ogazón 2012; Gheno-Heredia et al. 2011; Linares et al. 2019), but not with the galactagogue uses recorded in the present study. The use of these plants has demonstrated that food has played an important role in the health of communities throughout history (Barros and Buenrostro 2007). According to Coria (2013), it is undeniable that foods are naturally endowed with various chemical substances that give them therapeutic properties, such as sugars, antioxidants, and omega 3 (Barros and Buenrostro 2007; Tan et al. 2022). How people utilize these plants is a result of biocultural knowledge (Toledo and Barrera-Bassols 2008). In the case of the food plants utilized in the reproductive health of women, they prove to be of significant nutritional, medicinal, and therapeutic value (Díez-Urdanivia and Ysunza-Ogazón 2012).

Balance Between Hot and Cold and the Use of Temazcal

Authors such as Browner (1985), Flores-Cisneros and Rodríguez-Salauz (2010), Galante (1992), Smith-Oka (2008) mention that when there is an imbalance between cold and heat in a woman's body, complications can arise during childbirth or conception. This concept of complementary opposites (Acuña 1984; Coria 2013) explains not only the use of steam baths but also the practice of giving birth in the kitchens of the houses and the utilization of the *temazcal*. This practice has been specifically preserved in the municipality of Laxopa, illustrating the prevalence of certain pre-Hispanic traditions in Mesoamérica (Aparicio-Mena 2006). According to Flores-Cisneros (2003), in the Sierra Norte of Oaxaca and Katz (1993) in the Mixtec highlands, the use of *temazcal* during pregnancy

is a preventive measure for its care; preparation for childbirth and recovery after childbirth are common practices. In the present study, some women have also given birth inside a *temazcal* that they have in their own home.

The use of the *temazcal,* practices within the kitchens, and steam baths are elements of great importance for the balance of cold and heat during reproductive health of women; for example, during childbirth, women can *agarrar aire* (grab air) and *enfriarse* (cool down), and in the postpartum period, the normal temperature of the body must be recovered, or else the parturient's health and life would be at risk (Díez-Urdanivia and Ysunza-Ogazón, 2012; Flores-Cisneros 2003). According to Coria (2013), cold and heat are part of an ancestral classification system in Mesoamerican medicine that up to the present, regulates many aspects of daily life and that were rescued and documented in various descriptions during the colonial period (Acuña 1984).

Variation in Reproductive Health Knowledge Regarding Medicinal Plants

The comparison of medicinal plants mentioned between the age categories indicates that, in the municipalities of Tabaá, Laxopa, and Yojovi, there is no loss of knowledge about medicinal plants, as well as about moments, stages, and conditions in reproductive health, suggesting that knowledge is transmitted between generations. The exception is Analco, where women between 50-60 years old mentioned numerous plants, suggesting that older female family members had midwifery experience that was passed on to this generation. We recorded a smaller number of plants among the oldest women (over 60) in this community because, in some instances, they did not remember the names of the plants. This does not mean that the traditional knowledge of this group of women is lost. However, younger generations are receiving dispersed knowledge just through oral transmission but not through personal experience, and it is therefore in the process of being lost. Kruskall Wallis test indicated that more variation was detected between women from Analco than the women from the rest of the municipalities, even when there were no significant differences. We support this based on some evidence: there are no active traditional midwives/healers; those who were interviewed do not practice for at least ten years; people do not practice traditional medicine, and they prefer occidental medicine.

The PCoA of women's knowledge based on native medicinal plants, where all women of different communities and ages are mixed, reinforces that the transmission of this knowledge is still happening and suggests that these species have efficacy for different purposes in reproductive health in all communities. It is possible that some chemicals, emmenagogues, and abortifacients in different areas of Central and South America, since prehispanic times (Browner and Ortiz de Montellano 1985; Gutiérrez and Villanueva 2007). It has been demonstrated that it contains serotonin and tyramine, which can stimulate uterine tissue (Farnsworth et al. 1975).

In addition, socioeconomic and cultural mechanisms are involved in the prevalence of this common knowledge or consensus, such as their shared ethnic history, geographical proximity, access routes, and close social interactions, as well as the potential role that midwives play when they travel to other municipalities to treat patients (Heinrich et al. 1998a). Furthermore, some versatile species are commonly used in different ways, such as in traditional Mexican cuisine.

Regionally, the use of native food plants as medicine for reproductive health has received little consideration; these plants deserve recognition and acknowledgement to increase the value of the natural and cultural heritage of the Zapotec region and the country.

Introduced plants deserve consideration because their presence has been a consequence of the incorporation of organisms, customs, and practices coming from foreign cultures that have been mixed with local ones (Beltrán-Rodríguez et al. 2014; Muniz de Madeiros et al. 2012), and they diversified Mesoamerican medicine and enriched the pharmacological heritage of the communities due to their chemical components, which may differ or be similar to those of native plants (Albuquerque 2006; Alencar et al. 2010; Bennett and Prance 2000). This is especially true for Analco, because in this municipality we recorded the highest number of introduced species, and the multivariate analysis of native and introduced species also distinguished Analco from the other municipalities.

Possible explanations for the presence of more introduced species rest on some socioeconomic and cultural aspects. Analco is the municipality with the highest rate of migration to other municipalities or even to the United States (16.5%) (DIGEPO 2015 a,b,c,d) (Table 1). It has the lowest percentage of residents who speak Zapotec (41.5%), and the highest percentage of access to graduate education (5.86%) (DataMexico, 2023a,b,c,d). These differences may have contributed to two processes of acculturation (Saynes-Vásquez et al. 2013): on the one hand, there are changes in plant knowledge due to the increase of introduced plants; therefore, only older women retain a portion of this knowledge, through their mothers or sisters who have practiced midwifery. On the other hand, we found an exponential decline between the different age categories in the number of plant species mentioned for reproductive health, as well as

the disappearance or death of old midwives/healers and the lack of interest of the new generations in becoming midwives/healers. But the most important thing is that the inhabitants themselves recognize these changes and consider that traditional knowledge, the use of plants, and the role of midwives are part of history. Many collaborators agreed with this perception.

Continuity of Midwifery practices in the communities

Despite the decline of traditional midwifery at the national level, in some Zapotec municipalities, such as Tabaá, Yojovi, and Laxopa, women are still cared for by midwives during pregnancy, and midwife-attended childbirths still occur infrequently. However, more young women are not treated by the midwives, and few young women are interested in learning and performing this role in the community. If no knowledge transmission includes these practices, these traditions will die (Smith-Oka 2008).

The case of Tabaá is highlighted, where one of the last midwives, recently deceased, was always recognized in the community, and she was allowed to arrive at the health center with the birth registration form, and then execute the necessary health system protocols. In this example, the relationship between the health workers and the midwife was closer.

Alongside these internal processes, the interaction with the formal health system plays an important role, as the introduction of formal practices can displace traditional ones (Cosminsky 2018; Flores-Cisneros and Rodríguez-Salauz 2010; Rubel and Browner 1999). For example, pregnant women are required to visit the municipality's health center monthly and are referred to the nearest clinic (district heading) for childbirth. If they do not attend, it is the responsibility of a health committee coordinated by municipal authorities to extend an invitation. In the case of Yojovi, women frequently feel compelled to attend to fulfill a mandatory requirement for the assignment of a newborn vaccination record, or, as Díez-Urdanivia and Ysunza-Ogazón (2012) note, many Zapotec women go to the clinic because it is one of the requirements to receive government assistance through the Opportunities Program. According to Sesia et al. (2007), if women in Oaxaca do not follow the health center's protocols they can be reprimanded, along with their husbands, instead of being provided with information they need to avoid risks during pregnancy, childbirth, and postpartum.

In these communities, women have benefited from the practices of healers/midwives. Not only do they have a health system in their community to treat a variety of reproductive health conditions, but they can also give birth at home without the need to move to a place outside the community, which is time-consuming and expensive, especially in an emergency. Furthermore, they feel safe, accompanied, and in solidarity due to the bonds of trust that are constructed with the midwives, their husbands, and other women in their family's community (Smith-Oka 2008).

Another benefit is the preservation of traditions and practices rooted in their cosmovision, such as the practice of burying the placenta in the backyard to ask for the child's protection. As described by Díez-Urdanivia and Ysunza-Ogazón (2012), the placenta must be wrapped in a clean cloth and avoid contact with the ground to prevent infections in the newborn's eyes.

The imposition of health entities on traditional medicine in Oaxacan communities has been mentioned (Rubel and Browner 1999) as also occurred in other communities or even countries, such as Guatemala (Cosminsky 2018). WHO also proposed that all births must be attended by a "qualified attendant" and generally in a hospital, replacing midwives, (Cosminsky 2018). These international norms have had negative effects on traditional midwifery. The Official Mexican Norm NOM-007-SSA2-2016 in Mexico, which governs the care of women during pregnancy, childbirth, and puerperium as well as the care of newborns, states that all institutions must train traditional midwives to identify complications, and traditional midwives can attend low-risk births. It has also been acknowledged that the formulation of health policies and the refusal of doctors to recognize the significance and worth of indigenous medical systems have obstructed the practice of midwifery (Mathez-Stiefel et al. 2012; Sesia et al. 2007).

Contrary to other studies where the inclusion of both traditional and government medicine has been promoted (Díez-Urdanivia and Ysunza-Ogazón 2012), in the communities where the present study was developed, it has not happened, except for Tabaá. Previous studies found that more spaces for dialogue between medical knowledge and traditional knowledge have been created, such as the articulation of use of the *temazcal* with the health brigades of the clinics (Flores-Cisneros and Rodríguez-Salauz 2010) or medicinal plants and certain medications (Díez-Urdanivia and Ysunza-Ogazón 2012; Giovannini et al. 2011; Mathez-Stiefel et al. 2012).

We consider that this dialogue must be necessary to allow midwives to attend to different moments, stages, and conditions in reproductive health, including childbirths, and to recognize the relevance and efficacy of traditional practices, and medicinal plants in the survival and sustenance of local communities.

Finally, as an act of gratitude and to recognize the great work that midwives have done in the Sierra Norte of Oaxaca and the traditional knowledge about prac-

tices and medicinal plants used in reproductive health, we elaborated a bilingual book (Zapotec and Spanish) with the results of this research. In this divulgatory text, we resumed the most important practices about reproductive health, including some photographs of plants, midwives, and some aspects of diary activities. their uses and other important information. This material can be used in other spaces, such as medical centers, schools, and even in the collaborator´s homes.

CONCLUSION

Traditional knowledge regarding medicinal plants used by Zapotec women of the Sierra Norte of Oaxaca in different moments and their respective stages and conditions of reproductive health is still valid, as evidenced by the fact that this knowledge has persisted for over 500 years. Some plants and practices come from the ancestral Mesoamerican cosmovision of reproductive health, such as the balance between cold and hot. This is also evident in the role of certain plants as both medicine and food, which also maintain balance, not only during the reproductive stage but throughout the life cycle. The similarity of medicinal plants mentioned by women from all four municipalities is an indicator of the identity and cultural/medical heritage of the region. This pattern is stronger when only native plants are mentioned, indicating that this knowledge is shared by women of all ages.

Regarding midwifery practices, younger women are increasingly utilizing the state-provided health care system to attend and perform their deliveries. If indigenous communities continue their efforts to preserve their traditions and if personnel from the dominant health system foster bridges for the connectivity of practices, it is possible to avoid complete disappearance of these practices.

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DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

CONTRIBUTION STATEMENT

Conceived of the presented idea. LCMR and BRA.
Suggested some adequations to the fieldwork. GIIMM and MAVD.
Carried out interviews and plant recollection. LCMR.
Carried out the data analysis. LCMR and BRA.
LCMR. Wrote the first draft of the manuscript in Spanish version.
BRA. Translated the first draft of the manuscript.
DVA, GIIMM and MAVD. Reviewed and modified the first English version.
LCMR and BRA. Review and final write of the manuscript.

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Additional Files

Add File 1. Medicinal plants used during the reproductive health among Zapotec women from Sierra Norte of Oaxaca. Event, Stage/Condition: Support well development (Sp), swelling (Sw), inducing labor (Il), expulsion of placenta (Ep), recovering from childbirth (Rc), cleaning the womb (Cw), claening wound (Cc), lactation (Lc), dysmenorrhea (Dys), stopping menstruation (Sm), inducing mestruation (Im), hemorrage (He), inducing pregnancy (Ip), avoiding pregnancy (Ap). Municipality: San Juan Tabaá (T), Santo Domingo Yojovi (Y), San Juan Evangelista Analco (A), y Santiago Laxopa (L). Collaborator: Midwives/Healers (M) and Patients (P).

FAMILY	SPECIES	SPANISH NAME	ZAPOTECO NAME	BIOGEOGRAPHIC ORIGIN	ABSOLUTE FREQUENCY OF MENTION	EVENTS, STAGE/ CONDITION	MUNICIPALITY	COLLABORATOR
Amaranthaceae	*Amaranthus hybridus* L.	Amaranto	*Maranth*	Native (Villaseñor, 2016)	2	Lc	T-L-A	P
Amaranthaceae	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	Epazote	*Bite-Bith*	Native (Villaseñor, 2016)	3	Sw-Dys-Ab	T-L-A	M-P
Annonaceae	*Annona cherimola* Mill.	Anona	*Laaga sheela bixho* *Lhe'e vichu'u*	Introduced (WFO, 2020)	19	Sp-Sw-Lc	L-A	M-P
Apocynaceae	*Plumeria rubra* L.	Flor de mayo	*Shiaj bxhigue*	Native (Villaseñor, 2016)	2	Cw	Y-A	M
Asteraceae	*Artemisia* sp.	Hierba maestra	*Laga tee*	-	5	Il-Dys	T-A	M-P
Asteraceae	*Calea urticifolia* (Mill.) DC.	Hierba amarga	*Xhia*	Native (Villaseñor, 2016)	6	Rc-Dys-Im	T-Y-A	M-P
Asteraceae	*Matricaria chamomilla* L.	Manzanilla	*Mansnhill*	Introduced (WFO, 2020)	17	Sp-Il-Rc-Dys	T-Y-L	M-P
Asteraceae	*Heliopsis* sp.	Arnica	*Shiaj fhechaj/Ilixhe duble*	Probably native(García *et al.*, 2004)	9	Rc-Cw-Dys-Sm	L-A	M-P
Asteraceae	*Oxylobus arbutifolius* (Kunth) A.Gray	Itamorreal	*Beko nixhe*	Native (Villaseñor, 2016)	1	Dys	A	P
Asteraceae	*Tagetes lucida* Cav.	Pericon	*Shiaj chen/Che'e desag*	Native (Villaseñor, 2016)	3	Sp-Dys-Ap	L-A	M-P
Asteraceae	*Tanacetum parthenium* (L.) Sch.Bip.	Santa María	*Yij sant Maria*	Introduced (Vibrans, 2009)	20	Il-Ep-Rc-Im-Dys-Ip-Ab	L-A	M-P
Cactaceae	*Opuntia* sp.	Nopal	*Bia*	Probably native (WFO, 2020)	1	Cw	Y	M
Cucurbitaceae	*Cucumis melo* L.	Melon		Introduced (WFO, 2020)	1	Sw	A	M-P
Cucurbitaceae	*Cucurbita* sp.	Calabaza	*Shito*	Probably native (Villaseñor, 2016)	1	Lc	A	P
Equisetaceae	*Equisetum myriochaetum* L.	Cola de caballo	*Llazhe'e*	Native (Villaseñor, 2016)	3	Rc-Cw-Ip	L	P
Euphorbiaceae	*Cnidoscolus* sp.	Mala mujer	*Sheche xhballia*	Probably native (Villaseñor, 2016)	3	Sp	T	P
Euphorbiaceae	*Euphorbia milii* Des Moul.	Corona de cristo	*Shiaj shéche*	Introduced (WFO, 2020)	2	Rc	T-A	P
Fabaceae	*Vachellia macracantha* (Humb. & Bonpl. Ex Willd.) Seigler & Ebinger	Algarrobo		Native (Villaseñor, 2016)	2	Rc	T	P
Fabaceae	*Erythrina coralloides* DC.	Frijol rojo	*Laga topha/Lagatocha*	Native (Villaseñor, 2016)	10	Lc	T-Y	P
Fabaceae	*Mimosa albida* Humb. & Bonpl. ex Willd.		*Sheshe shíia*	Native (Villaseñor, 2016)	2	Rc	T	P
Fabaceae	*Mimosa pudica* L.	Dormilona/vergonsoza	*Sheeche shalasto/Yag llexhe'e sthu'u*	Native (Villaseñor, 2016)	7	Rc-Cw-Sm	T-Y-L	M-P
Fabaceae	*Phaseolus vulgaris* L.	Frijol	*Laa/Sa'a*	Native (Villaseñor, 2016)	2	Il-Ep	L	M-P
Fagaceae	*Quercus conzattii* Trell.	Encino	*Shaaga shazirha/Yag sulutj*	Native (Villaseñor, 2016)	1	Ip	L-A	M-P

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Fagaceae	*Quercus muehlenbergii* Engelm.	Encino	*Shaaga shazirha/Yag sulutj*	Native (Villaseñor, 2016)	8	Rc-Cw-Cc-Ip	L-A	M-P
Hydrophyllaceae	*Wigandia urens* (Ruiz & Pav.) Kunth	Hojas de San Pablo	*Laga fea'j*	Native (Villaseñor, 2016)	4	Sp	T	M-P
Lamiaceae	*Clinopodium macrostemum* (Moc. & Sessé ex Benth.) Kuntze	Hierba de borracho/Poleo	*Llixh guia'a*	Native (Villaseñor, 2016)	4	Rc-Dys	L-A	P
Lamiaceae	*Mentha piperita* L.	Hierba buena	*Shixo fheaj/Llixguej*	Introduced (WFO, 2020)	19	Sp-Il-Rc-Cw-Dys-Ip	T-Y-L-A	M-P
Lamiaceae	*Ocimum carnosum* (Spreng.) Link & Otto ex Benth.	Albahaca		Native (Villaseñor, 2016)	1	Dys	Y-A	M-P
Lamiaceae	*Origanum* sp.	Oregano	*Guareg*	Introduced (WFO, 2020)	13	Il-Ep-Dys-Sm	T-L-A	M-P
Lamiaceae	*Rosmarinus officinalis* L.	Romero	*Llixhe rumer*	Introduced (WFO, 2020)	9	Sp-Rc-Dys	T-L-A	M-P
Lamiaceae	*Salvia microphylla* Kunth.	Mirto	*Llixhe duble*	Native (Villaseñor, 2016)	14	Sp-Rc-Dys-Im	L-A	M-P
Lauraceae	*Cinnamomum verum* J.Presl	Canela	*Karherha/Canhelh*	Introduced (WFO, 2020)	77	Sp-Il-Ep-Rc-Cw-Dys-Im-Ab	T-Y-L-A	M-P
Lauraceae	*Litsea glaucescens* Kunth.	Laurel	*Laaga shixo shine*	Native (Villaseñor, 2016)	19	Rc	T-Y	M-P
Lauraceae	*Persea* sp.	Aguacate/Aguacatillo	*Laaga shixo laaga/Llixhulau*	Native (Villaseñor, 2016)	83	Sp-Il-Ep-Lc-Rc-Cw-Dys-Im-Ap-Ip-Ab	T-Y-L-A	M-P
Malvaceae	*Theobroma cacao* L.	Cacao		Introduced (WFO, 2020)	8	Il-Im	L	M-P
Musaceae	*Musa* sp.	Plátano	*Sheela*	Introduced (WFO, 2020)	1	Lc	T	P
Myrtaceae	*Eucalyptus* sp.	Eucalipto		Introduced (WFO, 2020)	3	Rc	A	P
Myrtaceae	*Psidium guajava* L.	Guayaba	*Fheshiaj*	Native (Villaseñor, 2016)	1	Dys	T	P
Pedaliaceae	*Sesamum indicum* L.	Ajonjolí		Introduced (WFO, 2020)	24	Lc	T-Y-L-A	M-P
Phytolaccaceae	*Phytolacca icosandra* L.	Perlas de la india	*Laxhirha loshiaj/ Laxhirá*	Native (Villaseñor, 2016)	3	Lc	T-L-A	M-P
Pinaceae	*Pinus patula var. Longipedunculata* Loock ex Martínez	Ocote	*Shechhe/Llech*	Native (Villaseñor, 2016)	7	Rc-Cw-Dys-Im-Sm	T-L	P
Piperaceae	*Piper auritum* Kunth.	Hierba santa	*Laxhua*	Native (Villaseñor, 2016)	5	Sw-Lc	T-Y-A	M-P
Plantaginaceae	*Plantago major* L.	Yanten	*Laaga bin*	Introduced (WFO, 2020)	1	Sw	A	M
Poaceae	*Avena sativa* L.	Avena		Introduced (WFO, 2020)	4	Lc	T-L-A	P
Poaceae	*Oryza sativa* L.	Arroz	*Rroz*	Introduced (WFO, 2020)	2	Lc	T-L	P
Poaceae	*Arundo donax* L.	Carrizo	*Shia zhtirha/chhene*	Introduced (WFO, 2020)	12	Il-Rc-Im-Ap	T-Y-A	M-P
Poaceae	*Saccharum officinarum* L.	Caña de azucar	*Shetaj/Llethj*	Introduced (WFO, 2020)	49	Sp-Il-Ep-Lc-Cw-Im-Dys-Ab	T-Y-L-A	M-P
Poaceae	*Triticum aestivum* L.	Trigo		Introduced (WFO, 2020)	1	Lc	A	M
Poaceae	*Zea mays* L.	Mayz	*Xhua/Xhua'a*	Native (Villaseñor, 2016)	29	Il-Lc-He	T-Y-L-A	M-P
Pteridaceae	*Adiantum tricholepsis* Fée.	Vara de san Jose	*Shiaj pamporhe/Yij dhidhe*	Native (Villaseñor, 2016)	1	He	L	M-P
Pteridaceae	*Pellaea ovata* (Desv.) Weath.		*kuan-chebe'e*	Native (Villaseñor, 2016)	2	Sp	T	P
Rosaceae	*Prunus persica* (L.) Batsch	Durazno	*Torhaza/Truaz*	Introduced (WFO, 2020)	6	Rc	L-A	M-P

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Rosaceae	*Prunus* sp.	Cerezo	*Shagaa Nezía/Lhe'e shia*	Probably Introduced (WFO, 2020)	5	Rc	L-A	M-P
Rosaceae	*Rubus* sp.	Frambuesa	*Bisigaa*	Probably Native (WFO, 2020)	5	Sw-Lc-Rc	T	P
Rubiaceae	*Coffea arabica* (Spreng.) Link & Otto ex Benth.	Café	*Kafe*	Introduced (WFO, 2020)	6	Il-Lc	T-Y	M-P
Rutaceae	*Citrus limon* (L.) Osbeck.	Limón	*Fhii zichag*	Introduced (WFO, 2020)	5	Rcc-Im-Ab	T-Y	P
Rutaceae	*Citrus* x *sinensis* (L.) Osbeck.	Naranja	*Shaaga fhii*	Introduced (WFO, 2020)	19	Sp-Il-Rc-Dys	T-Y-A	M-P
Rutaceae	*Ruta graveolens* L.	Ruda	*Rhudh*	Introduced (WFO, 2020)	63	Sp-Il-Rc-Cw-Im-Dys-Ip-Es-Ab-Ap	T-Y-L	M-P
Solanaceae	*Brugmansia* sp.	Floripondio	*Shiag marhoo/Yag puré*	Introduced (WFO, 2020)	4	Sp-Rc	L-A	P
Solanaceae	*Solanum americanum* Mill.	Hierba mora		Native (Villaseñor, 2016)	3	Rc-Cw-Im	A	M
Urticaceae	*Parietaria* sp.	Peletaria		-	1	Rc	A	M
Urticaceae	*Urera verrucosa* (Liebm.) V.W.Steinm.	Chichicasle	*Lallia/Lhall*	Native (Villaseñor, 2016)	24	Sp-Im	T-Y-L-A	M-P
Verbenaceae	*Lippia graveolens* Kunth.	Oregano silvestre	*Guareg lhe'ellixhe*	Native (Villaseñor, 2016)	1	Sm	L	P
Verbenaceae	*Verbena* cf. *carolina.* L.	Verbena	*Xhkuan beese*	Native (Villaseñor, 2016)	5	Rc-Cw	T	M-P
Viburnaceae	*Sambucus nigra* L.	Sauco	*Laaga gorhapaj/Yag glapje*	Native (Villaseñor, 2016)	2	Sp-Il	L	M
Zingiberaceae	*Zingiber officinale* Roscoe.	Gengibre		Introduced (WFO, 2020)	1	Dys	A	P