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RESEARCH

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Folk taxonomy of wild mushrooms in communities of the indigenous groups Chatino, Chontal, and Chinantec in Oaxaca, Mexico

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Abstract

Background Traditional names of wild mushrooms have long served as crucial links between these organisms and humans. In Mexico, cultural groups traditionally use indigenous and Spanish names and have developed effective methods for classifying and naming mushrooms. This has allowed the suitable use of fungal resources and the transmission of ancestral knowledge regarding each species. The present study explores the folk taxonomy of wild mushrooms in communities belonging to the Chatino, Chontal, and Chinantec indigenous groups of Oaxaca, Mexico. The goal was to assess the origins and meanings of the mushroom names, their connections to local culture, and the similarities in folk taxonomy among indigenous groups to understand the dynamics of classification and assignment of names.

Methods Between April and October 2022, 10% of the inhabitants in each community, including children, youth, adults, and elderly individuals, were interviewed to gather information related to their knowledge of wild mushrooms. Local translators assisted in analyzing the origins and meanings of mushroom names. Field trips to collect sporomes were conducted with community members. Regression analysis and analysis of covariance were performed to assess the use of traditional names among community members.

Results A total of 43 indigenous names were recorded for 32 mushroom species. The Chatino people use 22 indigenous names for 23 species and refer to mushrooms as "Kía"; the Chontal group uses 15 names for 16 species, and the term for mushrooms is "Jlapilí"; the Chinantec group has six names for six mushroom species and uses the generic term "Naẗ." Indigenous names consist of a generic term for mushroom and a specific suffix. Since the mushroom names are assigned based on ecological, morphological, and cultural factors, similarities in their meanings can be observed among the communities. People's age is positively related to the number of indigenous mushroom names they use. Women use more Spanish names than men.

Conclusions The variety of names used in each studied community underlines the relevance of wild mushrooms for these indigenous groups. They have developed a comprehensive folk taxonomy that enables them to effectively utilize fungal resources and ensure the transmission of traditional knowledge.

Keywords Ethnomycology, Indigenous names, Traditional knowledge, Nomenclature, Edible mushrooms, Medicinal mushrooms

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Background

Macromycetes are a group of fungi characterized by the production of sporomes, or fruit bodies, commonly referred to as mushrooms. Historically, wild mushrooms have been of great significance in various cultures; they have been revered as essential sources of food, medicine, sacred entities, and as means to achieve spiritual experiences. Ethnomycological studies have contributed to our understanding of how ancestral practices about mushrooms reflect profound and enriching wisdom in several rural regions of the world. From this perspective, we can recognize the distinct knowledge of wild mushrooms that every ethnic group has developed and incorporated deeply into their daily practices and worldviews [1, 2]. This knowledge is shown not only through the practical use of mushrooms but also in the ways human communities have created complex systems to comprehend and classify them, leading to a folk taxonomy. Since the pioneering works of Schultes [3] and the contributions of Berlin [4], folk taxonomy has been conceptualized as a system for classifying and naming biological species, particularly in indigenous cultures where taxonomy results from their traditional knowledge.

Folk taxonomy has recently become a topic of great interest as it represents an important tool for scientists to engage with indigenous groups, and it has proven to be one of the most relevant elements for understanding the usage of wild mushroom species [5, 6]. Although folk taxonomy is not as universally applied as scientific taxonomy, it is regarded as pre-scientific knowledge with a well-developed and systematic basis, and it has been utilized by scientists to classify species [4].

The names given to mushrooms in folk taxonomy, known as myconyms, have become a key tool for facilitating information exchange between ethnomycologists and indigenous groups [7, 8]. Within a cultural group, folk names provide a precise and unique reference to particular mushroom species and play an essential role in shaping identity and fostering a sense of belonging [4, 9]. Also, myconyms enable the evaluation of popular classification systems regarding their ability to address practical problems related to the use of mushrooms and their relevance in human communities [10]. These classification systems take into account ecological, biological, cultural, and religious elements, along with the morphological traits of each species [11].

In Mexico, the diverse array of languages spoken across the country, combined with its high mushroom richness, has led to the generation, preservation, and transmission of extensive knowledge regarding mushroom names [12]. Until over two decades ago, the connection between multiculturalism and mushroom diversity resulted in ca. 3400 traditional names (indigenous and Spanish names), with at least 1600 of them being indigenous names recorded among 32 of the 68 indigenous groups in Mexico. However, the current number of traditional names is unknown, due to the limited attention, this topic has received in ethnomycological studies [13, 14]. Several indigenous groups have documented names for wild mushrooms, including the Tarahumara, Otomí, Purépecha, Náhuatl, Matlatzinca, Maya, Tzotzil, Tzeltal, Mazahua, and Tlahuica, among others. In the state of Oaxaca, studies regarding the folk taxonomy of mushrooms have been conducted in the Zapotec, Chinantec, Mixtec, and Mazatec groups, and reported at least 500 traditional names, including both indigenous and Spanish terms [8, 15–17].

The highest number of speakers of the Otomanguean linguistic family (second largest linguistic family in Mesoamerica) is found in the state of Oaxaca, where a robust folk taxonomy and traditional nomenclature have been reported, reflecting a deep connection between ecological knowledge, worldview, and language among the Otomanguean people. Their hierarchical taxonomic systems are often unclear, but the descriptive richness and preservation of key species names highlight their cultural and biocultural significance. For example, in the Zapotec group, the names of mushrooms follow a binomial structure consisting of a root word meaning "mushroom" and a modifier describing either morphological or ecological characteristics, or similarities to elements of the environment [8]. The Chinantec nomenclature includes names that range from binomial to pentanomial, describing attributes such as color, shape, texture, and uses of mushrooms [15]. The Mazatec people categorize mushrooms based on their usefulness: edible, medicinal, and non-edible, recognizing them as a distinct group separate from plants and animals [17]. In Mixtec nomenclature, binomial names are used to describe morphological or ecological characteristics and, similar to the Chinantec and Mazatec people, they regard mushrooms as a group parallel to plants and animals [16]. The Otomí group refers to mushrooms using a specific term, and the names describe characteristics such as shape, color, growth location, and use, emphasizing their dietary and cultural significance, as most of these names refer to edible species [18].

Over the past four decades, a concerning trend has been observed in Mexico, indigenous mushroom names are increasingly being replaced by Spanish terms. This trend is closely related to the decline of traditional knowledge among various indigenous groups in the country, as well as to processes of transculturation

and acculturation [19–21]. Biodiversity loss, habitat fragmentation, and fast modernization significantly contribute to this phenomenon [22], which underlines the loss of valuable cultural heritage and the ongoing threats to biodiversity and sustainable practices in Mexican indigenous communities [6].

Understanding folk taxonomy is crucial for ensuring food security and well-being among rural communities, as it helps identify beneficial and harmful wild mushroom species. Moreover, recognizing how rural communities classify and name mushrooms is essential for preserving their traditions and values, as well as strengthening their cultural identity. Folk taxonomy of wild mushrooms reflects the knowledge that includes both biological and cultural aspects of the environment, and its intergenerational transmission helps preserve the mycocultural heritage of these communities.

The present study includes two languages from the Otomanguean family, Chinantec (with 11 variants) and Chatino (with 6 variants) [23]. These cultural groups were selected because of their linguistic diversity, cultural relevance, and representativeness in the context of ethnomycology. The languages in both groups have developed independently due to factors such as geographic isolation, migration, and interaction with external influences, leading to unique cultural adaptations in the classification, naming, and use of mushrooms. The Chontal community was included in this study because locals have shown a particular worldview that influences their relationship with natural resources, including mushrooms [24]. Furthermore, the Chontal language, which belongs to the Tequisistec linguistic family, is critically endangered and has received little attention in ethnomycological studies [6].

Therefore, the aims of the present study were to document and evaluate how wild mushroom species are named and classified in each indigenous community, analyze classification patterns across the three communities, compare folk taxonomy with scientific taxonomy to identify similarities in the classification of mushroom species, and assess the use of indigenous and Spanish names among the inhabitants of the communities. We hypothesize that (1) the ecological and morphological traits of mushroom species growing in the surrounding areas of the studied communities mainly influence the development of folk taxonomy for wild mushrooms, along with cultural factors, (2) similarities in the composition of mushroom species used within the studied communities may reflect similarities in the meanings of the names assigned to mushrooms among the three localities, (3) the folk taxonomy in the studied communities corresponds with scientific taxonomy by using binomial or trinomial names that consist of generic names followed by specific suffixes, and (4) the number of traditional names (indigenous and Spanish names) used by individuals differs both within and among the communities.

Methods

Study area

The research was conducted within three rural communities in the state of Oaxaca, Mexico (Table 1).

Santa Lucía Teotepec is an agency of the municipality Santos Reyes Nopala, located in the Costa region and belonging to the Chatino indigenous group (Fig. 1). The climate is humid subtropical dry, and its vegetation is the result of a transition zone between subtropical forest and temperate forest [25], located at an altitude of 1172 m. It has a population of 1844 inhabitants, with over 80% speaking the local indigenous language [26]. Authorization to carry out the study in Santa Lucia Teotepec was given by the municipal agent and the interviewed people.

Santo Domingo Chontecomatlán is in the Sierra Sur region of Oaxaca, within the municipality of Santa María Ecatepec, and it is part of the Chontal indigenous group (Fig. 1). Its climate is subhumid and semi-warm temperate, and the vegetation is pine-oak [27], located at an altitude of 2010 m. It has a population of 388 inhabitants and is one of the few communities in the world with native speakers of the Chontal language [26]. Authorization to carry out the study in Santo Domingo Chontecomatlán was given by the municipal agent and the interviewed people.

San Antonio Otate is part of the Chinantec municipality of San Juan Bautista Valle Nacional, located in the Cuenca del Papaloapan region (Fig. 1). Its climate is warm-humid, and the main vegetation is montane rainforest, located at an altitude of 336 m. It has a population of 238 inhabitants, with over 90% speaking the local indigenous language [26]. Authorization to carry out the study in San Antonio Otate was given by the Supervisory Board and the interviewed people.

Ethnomycological work

Interviews were conducted from March to September 2022 in the three communities described above. In accordance with the guidelines established in the Code of Ethics of the Latin American Society of Ethnobiology [28], verbal authorizations were obtained from local authorities, and the individuals interviewed to conduct the study in the Chontal, Chatino, and Chinantec communities. In the case of minors, consent was provided by their parents.

The number of interviewees from each community was determined using the method proposed by Burrola-Aguilar et al. [19] and Domínguez-Romero et al. [29], which

Table 1 Sociodemographic characteristics of the studied communities and information of the interviewed people

	Santa Lucia Totepec	Santo Domingo Chontecomatlán	San Antonio Oate
Ethnicity	Chatino	Chontal	Chinantec
Linguistic family	Otomanguean	Tequisistec	Otomanguean
Language	Chatino	Chontal	Chinantec
Cultural name	Cha´tnio	Xanuc	Dzä mii
Religion	Christian	Christian	Christian
Number of inhabitants	1844	388	238
Percentage of local language speakers	80%	80%	90%
Number of interviewees	62	14	8
Interviewees' age			
7–20	24	3	1
21–40	8	4	3
41–60	20	6	2
61–91	10	1	2
Interviewees' gender			
Male	31	7	4
Female	31	7	4
Interviewees' occupation			
Housewife	18	6	3
Peasant	16	5	5
Bricklayer	1	-	–
Student	17	2	–
Security guard	1	-	–
Trader	8	1	–
Baker	1	–	–

applies probabilistic cluster sampling to randomly select households, considering that any member of the family unit may possess traditional knowledge. A total of 84 individuals were interviewed (42 men and 42 women). There were 62 interviewees in the Chatino group, 14 in the Chontal group, and 8 in the Chinantec group, representing 10% of the population in each community. The selection of interviewees was carried out by randomly choosing households from locality maps and interviewing one family member per household. The interviewees were grouped by age and included children, youth, adults, and elderly individuals (Table 1). A minimum age of 6 was established for participants since children begin to engage in field activities at that age in the studied communities.

Interviews were conducted through open questions about the identification of wild mushrooms, their names, and meanings and likely origins of those names (Additional file 1). Since many individuals speak only the local indigenous language, interviews were conducted with the assistance of a bilingual guide to facilitate communication. Local teachers and translators from each community were consulted for the translation and writing of the mushroom names. In the present study, the term "traditional names" encompasses both indigenous and Spanish names, with clear distinctions made when mentioning indigenous or Spanish names specifically.

To identify mushroom species and their traditional classification, photographs of wild mushrooms reported in studies from the state of Oaxaca were utilized, following the recommendations by Tibuhwa [5] and Reyes-López et al. [30]. Fresh sporocarps were also utilized to assist in identifying the species mentioned during the interviews.

Data analysis

Linear regression analyses were performed to determine the relationship between the people's age and the number of indigenous and Spanish mushroom names they use. Analyses of covariance (ANCOVAs) controlling for age were carried out to assess differences between the number of men and women using indigenous and Spanish mushroom names. Data analyses were performed for the three studied indigenous groups together and separately for each group, considering all interviewees together as well as men and women individually. Analyses were performed in R Studio [31].

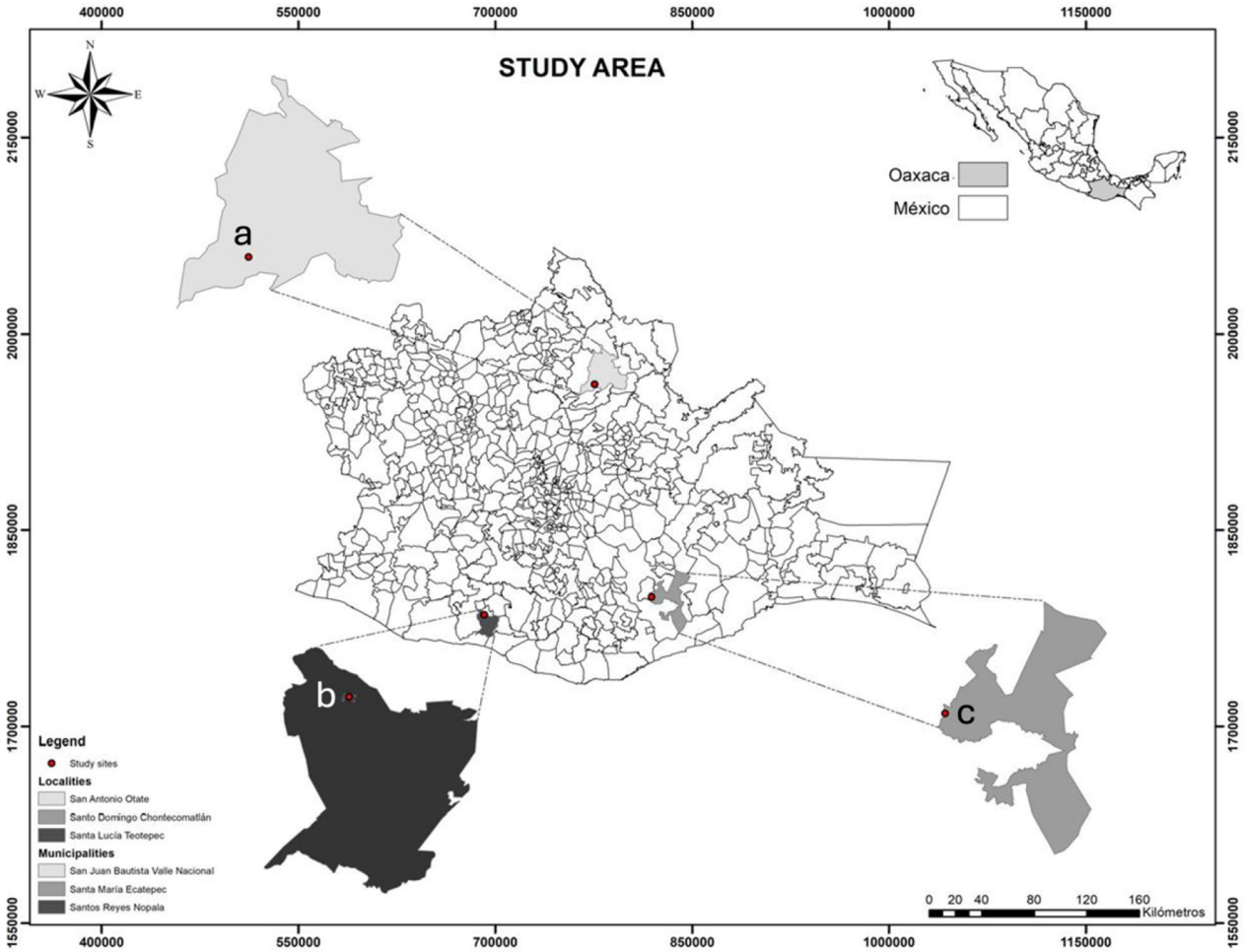

Fig. 1 Location of the studied communities in different municipalities of Oaxaca, Mexico. **a** San Antonio Otate (Chinantecs), **b** Santa Lucía Teotepec (Chatinos), and **c** Santo Domingo Chontecomatlan (Chontales). Image by López-García A

Results

Number of wild mushroom species and traditional names

A total of 43 indigenous and 43 Spanish names were recorded for 32 wild mushroom species of biocultural importance in the three studied communities (Additional file 2). Only 20 mushroom species had to be collected for identification (Additional file 3).

In the Chatino community, 22 indigenous names and 22 Spanish names associated with 23 species were recorded, the Chatino term for “mushroom” is "Kía." The Chontal group uses 15 indigenous names and 15 Spanish names for 16 species they consume, and the common indigenous name for mushrooms is "Jlapilí." The differences in the number of traditional mushroom names and species recorded in both the Chatino and Chontal communities arise from their categorization of species of the genera *Amanita* and *Ramaria* under a single name, Kía jikaloó and Jlapilí jleúla-keitk, respectively. The Chinantec group consumes six species of wild mushrooms, using six indigenous names and six Spanish names, and the term used by the Chinantec people for "mushroom" is "Naï." The main use of wild mushrooms recorded in the communities was as a food source, comprising 30 species. Additionally, *Psilocybe* sp. and *Pycnoporus sanguineus* are utilized in traditional medicine within the Chatino and Chinantec communities, respectively.

The concept of fungi: mycophilia and mycophobia

Interviewees emphasized their ability to easily distinguish between fungi, plants, and animals, having specific myconyms for each group of organisms. In all cases, the initial response of people to the word "mushrooms" was to associate them with a valuable food source during the rainy season, considering them one of the healthiest foods available.

It is important to note that all mushrooms not consumed in these communities are classified as toxic or potentially deadly. To refer to these species, they assign

a unique name in each community, Chatinos name them "Kía láa" (bad mushroom), Chinantec people call them "Naï guii" (spicy mushroom), and Chontales name them "Jlapilí tii" (poisonous mushroom).

According to the interviewees, at least one death due to wild mushroom poisoning has been reported in each community. This situation created a deep fear among younger generations, leading many to avoid harvesting and consuming wild mushrooms. Additionally, nearly 30% of interviewees over the age of 40 have reduced the consumption of wild mushrooms to protect their families from potential risks.

From the Chatino perspective, there are toxic mushrooms in pine-oak forests that closely resemble edible ones. These species are referred to as "Kía súaro," which translates to "similar mushrooms" or "twin mushrooms." The species that often cause confusion include *Amanita* spp. (Fig. 2a), *Cantharellus cibarius* (Fig. 2b), and *Russula mexicana* (Fig. 2c). The cases of deaths and intoxications in the Chatino community are linked to species in the *Amanita muscaria* complex, as reported during the interviews. Interviewees highlighted the crucial role of education and accurate species identification in mushroom harvesting. This is essential not only for preserving traditions but also for ensuring food security and community health.

The nomenclatural complex

In the three studied communities, a one-to-one correspondence was evidenced, meaning that mushroom species have a unique name in the indigenous language, but the inhabitants translate these names into Spanish when interacting with visitors from outside the community.

Children, youth, adults, and elderly individuals in the three communities use both the indigenous names and their Spanish equivalents. They emphasized the importance of maintaining uniqueness and consistency in assigning traditional names to facilitate the use of fungal resources. Moreover, people have observed that this practice improves communication and fosters understanding of the resource, both within the community and in interactions with outsiders, thereby aiding in the preservation and valorization of local mycological diversity.

Indigenous nomenclature

The first level of classification of mushrooms, including those of biocultural significance and those not utilized in the studied communities, is based on their trophic strategies. Mushrooms are categorized into two groups: those that grow on the ground and those that grow on tree trunks or branches. After considering this element, mushrooms are classified into edible, medicinal, and toxic species. All species deemed without any use in the studied communities are classified as toxic.

Fig. 2 Edible wild mushrooms: **a** *A. jacksonii*, **b** *C. cibarius*, **c** *R. mexicana*, **d** *Pleurotus djamor*, **e** *Inonotus* sp., **f** Dish prepared with *Inonotus* sp., **g** *Ramaria* sp., and **h** *L. indigo*. Images by López-García A

For edible and medicinal species, indigenous names can be assigned in three different ways: (1) using ecological elements, (2) based on morphological traits, or (3) using religious/cultural aspects.

Six species names based on their ecological characteristics were recorded (Additional file 2). *Neolentinus ponderosus* is known by the Chontal people as Jlapilí góli (pine mushroom) because it exclusively grows on trees of the genus *Pinus*. *Pleurotus djamor* (Fig. 2d) is called Naï majee (jonote mushroom) by the Chinantec people because it grows on trunks of the jonote tree (*Heliocarpus appendiculatus*). *Pseudofistulina radicata* is known as Jlapilí ganmamú (cuachepil mushroom) by both the Chatino and Chontal people due to its exclusive growth on the cuachepil tree (*Senna* sp.). Also, for the Chatino people, *Inonotus* sp. (Fig. 2e, 2f) is known as Kía shia (Castilla mushroom), due to its association with the tree species *Castilla elastica*, known as Castilla tree.

Regarding morphology, 33 indigenous names and 33 Spanish names were assigned to 22 mushroom species (Additional file 2). For example, *Favolus tenuiculus* is named by Chatinos as Kía jitóo (hammock mushroom) due to the porous and intertwined arrangement of its hymenium. *Hypomyces lactiflourum* is known by the Chontal people as Jlapilí kashi (rooster crest mushroom) due to the color and shape of its sporocarp. For the Chinantec people, the shape, color, and pubescence of the sporome of *Lentinus crinitus* are reasons to name it Nat logua quiic (badger's ear mushroom). *Lactarius volemus* is known as Jlapilí fuska-gaja and Kía squí (milk mushroom) by the Chontal and Chatino people, respectively, due to the secretion of white latex when its sporocarp is cut. *Russula crustosa* is referred to as Kía edjee (salt mushroom) in the Chatino community because its striated pileus resembles being covered in salt.

Beliefs and religions are often reflected in the names of some mushroom species given by indigenous cultures. This is mainly because people associate mushrooms with their fruiting dates, which generally correspond to a saint, or because the effects of consuming certain mushroom species are thought to be divine. A total of four religious-related names assigned to mushroom species were recorded (Additional file 2). *Amanita* species are known by the Chatino people as Kía kuí (San Juan mushroom) because San Juan's day (June 24th) marks the beginning of the rainy season, and it is when the sporomes of *Amanita* grow. In the case of *Psilocybe* sp., known as Kía indiose (God's mushroom) in the Chatino community, older people commented that it serves as a means of communication between humans and gods. *Lactarius indigo* (Fig. 2h) is known as San Antonio mushroom in the Chatino community because the indigo color of its sporocarp resembles the blue cloak worn by San Antonio de Padua.

Polytypic ethnotaxa (names grouping multiple species) were recorded for species of the genera *Amanita* and *Ramaria*. *Amanita jacksonii* and *Amanita laurae* were recorded in the Chatino community, and their name refers to their fruiting dates. The macromorphological similarities between these *Amanita* species categorize them as Kía kuí (San Juan mushroom), with the only distinction being the pileus color. The Chatino and Chontal people categorize the species of the genus *Ramaria* under a single name, despite recognizing that there are various similarities and differences in the color of their sporomes. In the Chatino community, *Ramaria* species (Fig. 2g) are known as Kía jikaloó (little corral mushroom), while the Chontal people call them Jlapilí jleúla-keitk (deer antler mushroom).

The case of *C. cibarius* is unique, the indigenous names assigned to this species in the Chatino and Chontal communities highlight the importance of certain foods in these regions of the country. Both names given to this mushroom reference edible plant species of the genus *Cucurbita*. The Chatino people refer to the mushroom as Kía kie (flower mushroom), because the yellow color of its sporome resembles that of a pumpkin flower. Similarly, the Chontal people call it Jlapilí kahúa (pumpkin mushroom), due to its shape and color, which are reminiscent of the pumpkin flower. In both the Chatino and Chontal communities, people use pumpkin flowers as food.

Two mushroom species were reported to share names in the Chontal and Chatino communities. *P. radicata* is referred to as the cuachepil mushroom in both communities because it grows on a tree species belonging to the genus *Senna*, known as cuachepil tree. The indigenous name for *P. radicata* in Chontal is Jlapilí ganmamú, and Kía jikafkhía is the name in Chatino. Since the use of *P. radicata* was introduced to the Chontal community by an individual from the Mixtec region who settled in the area, only one interviewee mentioned this species. The Mixtec individual began collecting and consuming *P. radicata* over 20 years ago and demonstrated its use to some members of the Chontal community. In contrast, the Chatino community has consumed *P. radicata* for several generations, and it was mentioned by over 40% of the interviewees. *L. volemus* is known as "milk mushroom" in both the Chatino and Chontal communities due to the secretion of latex when the sporocarp is cut. The indigenous name for *L. volemus* in the Chontal community is Jlapilí fuska-gaja, while the Chatino people refer to it as Kía squí.

Regarding the use of Spanish terms in indigenous mushroom names, it was found that *Boletus* sp. is known in the Chontal community as Jlapilí chiapaneca (chiapaneca mushroom), being the only recorded species with an indigenous name that includes a Spanish suffix. Mushroom species and their indigenous names recorded in the three communities are listed in Additional file 2.

Statistical analyses

The linear regression analyses indicated that the number of indigenous mushroom names used by locals in the three studied groups together was positively related to their age ($r^2 = 0.23$, $F = 23.91$, $p < 0.0001$; Fig. 3a). Likewise, the number of indigenous names used by both men and women in the three studied groups was positively related to their age ($r^2 = 0.21$, $F = 10.48$, $p < 0.01$; $r2 = 0.26$, $F = 13.78$, $p < 0.001$, respectively Fig. 3b, 3c). However, the number of Spanish names used in the three studied groups was not significantly related to people's age ($p > 0.05$).

In the Chatino group, the number of indigenous mushroom names reported by all the interviewees was positively related to their age ($r^2 = 0.36$, $F = 33.57$, $p < 0.0001$; Fig. 3d), as well as the number of names reported by men and women individually ($r^2 = 0.45$, $F = 23.98$, $p < 0.0001$; $r^2 = 0.28$, $F = 11.13$, $p < 0.01$, respectively Fig. 3e, 3f). The number of Spanish names used in the Chatino community was not significantly related to locals' age ($p > 0.05$). Similarly, the number of both indigenous and Spanish mushroom names used by the Chontal and Chinantec groups was not significantly related to people's age ($p > 0.5$).

The ANCOVAs controlling for age in the three studied groups together and the Chatino group showed significant differences between the number of men and women using Spanish names for mushrooms ($F = 6.189$, $p < 0.05$; $F = 13.07$, $p < 0.001$, respectively), being women the predominant users of Spanish names. Nevertheless, no significant differences were found in the Chinantec and Chontal groups ($p > 0.05$). Additionally, there were no significant differences in the use of indigenous names by men and women when controlling for age,

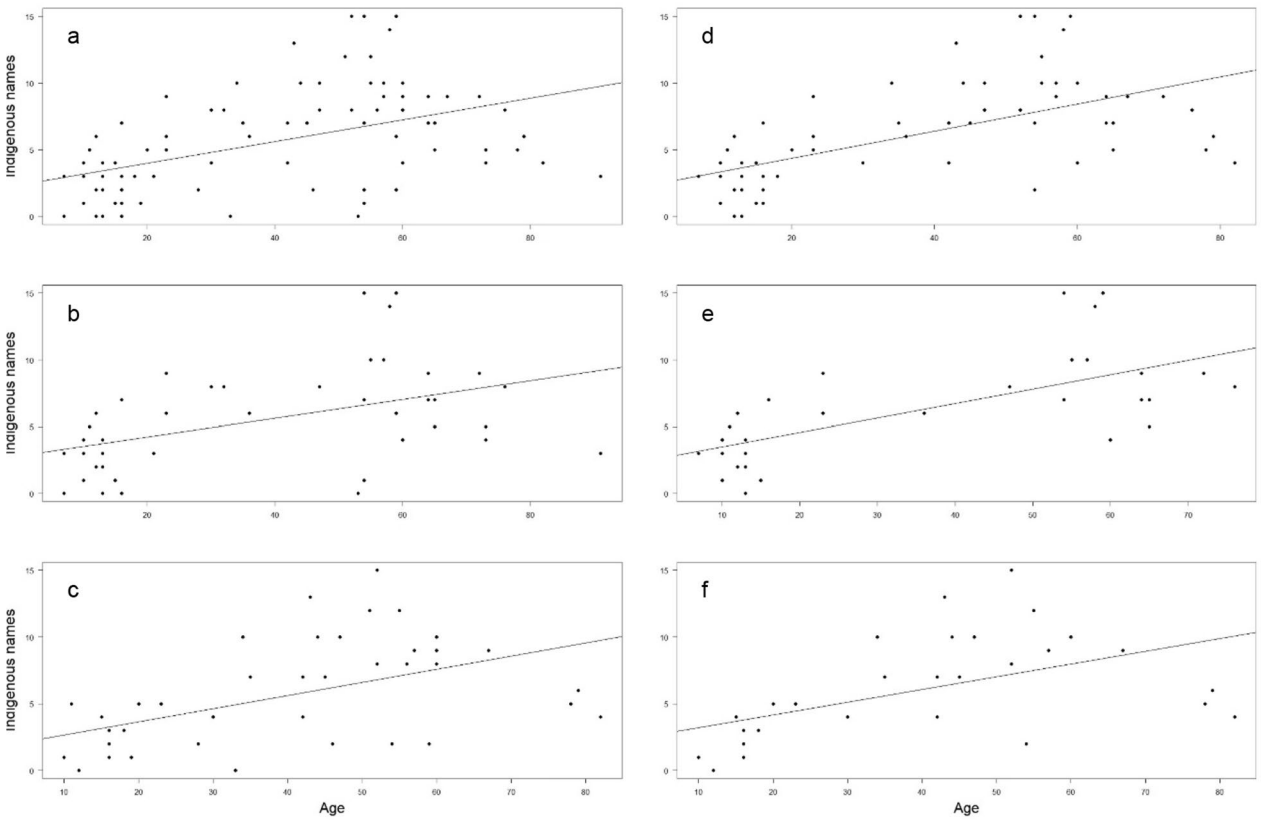

Fig. 3 Linear regression analysis. There is a positive relationship between people's age and the number of indigenous mushroom names used by **a** all the people from the three studied communities together, **b** men from the three communities together, **c** women from the three communities together, **d** all the Chatino inhabitants, **e** Chatino men, and **f** Chatino women

both in the analysis of the three groups together and individually within each group ($p > 0.05$).

Discussion

The variation in the names given to mushrooms and other organisms by ethnic groups worldwide can be traced back to several cultural, linguistic, environmental, and social factors, which create specific terms that reflect the identity and cultural perspectives of the different groups [30, 32–34]. Our findings showed that each studied community uses a unique generic name for mushrooms that are specifically associated with this biological group and does not relate to other elements, unlike in other cultures. In the Nahuatl language, the term "nanacatl," which refers to mushrooms, translates to "meat" [30]; the Mixtec people refer to mushrooms as xi'i, which translates to dead or dying [35]; the Mazatec group refers to mushrooms using the term "tjiin," which translates to "thick" [17]; for the Zapotec group, the generic name for mushrooms has been reported to be associated with insects [8]. In some indigenous languages, the generic names for mushrooms may not literally translate to another element; instead, they may represent cases of semantic homonymy, where the phonetic similarity with other terms does not imply a direct relationship with the meaning [15].

Different geographic areas can exhibit unique ecological conditions that are conducive to the growth of specific mushroom species throughout the rainy season, as observed in the Chatino community, where mushrooms are identified not only by their morphology but also by the month they fruit. Mushrooms of the genus *Amanita* are seen by Chatinos as indicators of climate conditions and are closely linked to the start of the harvesting season. The local environment can lead human communities to adapt their knowledge and language to more effectively describe the mushroom species growing in their surroundings. As a result, variations in the mushroom names can occur even among communities from the same cultural group but located in different areas [8, 34]. Understanding the phenology of each species is essential for classifying and utilizing fungal resources, thus, rural communities possess profound knowledge of the seasons when wild mushrooms fruit [36]. Among the Chontal and Chatino groups, as well as the Otomí group in the State of Mexico and the Chinantec people in La Chinantla Alta of Oaxaca, accurate identification of mushroom species that fruit at the beginning, middle, and end of the rainy season has been documented [19, 37]. In the Chatino community, the mushrooms of San Juan (*A. jacksonii and A. laurae*) are the first to grow, whereas *N. ponderosus* marks the beginning of the mushroom season in the Chontal community, corresponding with the observed in the Chinantec locality at Santiago Comaltepec [37]. Nevertheless, our results showed that Chinantec people in the assessed community do not distinguish between the variations in the phenology of mushroom species; they believe that as long as it rains, mushrooms will be available, and any of the species they consume can grow at any time. This topic has been addressed in studies on sporome availability in different ecological zones, reporting a greater spatial and temporal abundance of mushrooms in tropical areas, such as this Chinantec community [38].

Our findings showed that *L. volemus* and *P. radicata* share common names among the Chatino and Chontal people, being known as "milk mushroom" and "cuachepil mushroom," respectively. However, *L. volemus* is widely recognized by various indigenous groups in Oaxaca under the same name, including the Chinantec community of the Chinantla Alta, the Zapotec people of the Sierra Norte and Valles Centrales, as well as the Mixtec community of the Mixteca Alta [1, 35, 37, 39]. This popularity comes from the mushroom releasing white latex when its sporocarp is broken, a characteristic that inspired both its traditional name and that of its genus in scientific taxonomy. Moreover, cultural exchange resulting from migration and other interactions has enhanced the sharing of traditional knowledge about mushroom names.

While using indigenous names for mushrooms is essential for preserving cultural identity and the richness of biocultural knowledge, replacing them with Spanish names may dilute this richness [15, 17]. Traditional Spanish names can provide a basic understanding of mushroom species, but names derived from indigenous languages hold a meaningful significance. These names encompass the identity of the species, their cultural relevance, practical uses, and historical connections with humans [4, 14, 16]. Nevertheless, the combined use of both languages can be a sign of cultural richness rather than a loss, as long as indigenous names continue to hold their significance. This linguistic combination can strengthen traditional knowledge and promote dialog between indigenous groups and modern scientists, fostering mutual understanding of the fungal resources [14]. However, it is crucial to ensure that this balance does not reduce indigenous names to mere translations or secondary alternatives compared to Spanish.

In Mexico, ethnomycological studies addressing the replacement of indigenous names with Spanish names have been conducted in the central region of the country. For the Otomí group in the State of Mexico, Burrola Aguilar et al. [19] reported that people assign Spanish names to the 56 species of wild mushrooms they

recognize, whereas Montoya et al. [18] found that only 13 indigenous names are assigned to 35 species used by the Otomí people of Tlaxcala. Alonso-Aguilar et al. [40] reported that the mestizos and Nahuas of Tlaxcala use 69 traditional names for 46 species of edible mushrooms, with fewer than 10 of these names being in indigenous language.

In various indigenous communities of Mexico, mushrooms represent not only a valuable food source and income during the rainy season but also an intricate network of knowledge and perceptions [41]. The accurate identification of mushrooms signifies one of the most crucial factors for their use and directly relates to the understanding of each species [6]. The knowledge about toxic species, highlighted by the terms Kía láa (bad mushroom), Naï guii (spicy mushroom), and Jlapilí tii (poisonous mushroom) recorded in the studied communities, underscores the importance of recognizing the risks associated with non-edible fungi. This classification approach based on "good" and "bad" underlines the importance of clear distinction and in-depth knowledge about fungi, emphasizing the intrinsic relationship of people with food security and the perception of potential risk [4].

A clear duality in people's relationships with mushrooms has been observed worldwide: mycophiles and mycophobes. Mycophiles have a remarkable ability to identify a wide variety of mushroom species due to their experience and interest in them. In contrast, mycophobes often struggle to distinguish between different types of mushrooms because they lack familiarity with these organisms and may feel aversion or distrust toward consuming them [2, 41]. Several studies indicate that communities inhabiting highland areas, such as the Chontal and Chatino groups, utilize a wider variety and larger quantity of mushrooms compared to communities in lowland areas, such as the Chinantec community evaluated in this study [1, 18, 35, 37, 42]. Nevertheless, it has been suggested that differences in mushroom consumption between regions can be explained by the greater availability of other food resources in lowland areas [6].

The concepts of mycophilia and mycophobia can be focused on specific indicators that define a cultural group's attitude toward fungi, such as the cultural importance of mushrooms as a group, classification systems, and the work of local experts who facilitate successful knowledge transmission [41]. In the studied communities, older generations exhibited a higher level of mycophilia, evidenced by their extensive knowledge of edible, medicinal, and toxic mushroom species. Younger generations, particularly within the Chatino community, displayed a great indifference toward mushrooms or mycophobia, which can be linked to reduced participation in agricultural activities and diminished contact with the natural environment. In the Chontal and Chinantec communities, young people tend to be more involved in agricultural practices, which fosters a positive attitude concerning mushrooms and the preservation of ethnomycological knowledge. Variations in environmental conditions, fungal resource availability, and sociocultural dynamics have been observed to directly influence the use and understanding of mushrooms in rural areas [38, 41].

The distinctiveness of assigning indigenous names to mushrooms in the studied communities underscores their interest in a clear and consistent folk taxonomy. Having a unique indigenous name for each mushroom species, similar to scientific taxonomy, can facilitate internal communication, strengthen the relationship between inhabitants and their mycological environment, and make more efficient the use of fungal resources [14]. Despite the uniqueness of assigning local names and the variety of terms, there are similarities in the methods used by human groups to assign names across different regions of the planet, as seen in Argentina, Tanzania, and Ethiopia [5, 7, 43].

The extensive use of indigenous names in the studied communities was clearly evident; however, the choice between using indigenous names and their Spanish equivalents is influenced by factors such as age and the specific contexts in which the names are used. This trend appears to arise from young people's need to fit into a globalized environment that prioritizes communication in a major language like Spanish [44], even though there is a strong attachment to their own culture. Maintaining the uniqueness and consistency of indigenous names is an effective way to transmit knowledge and preserve mycological culture across generations [14], but the use of names in Spanish can foster cultural unity, even across countries, as seen in southeastern Mexico and parts of Guatemala [45].

Our findings indicated that age is associated with the number of indigenous mushroom names utilized by people, particularly within the Chatino community where older individuals tend to use more indigenous names than younger ones. The decreasing use of indigenous names among younger generations in the Chatino community clearly indicates that traditional knowledge of wild mushrooms is being lost locally. Correspondingly, a parallel study carried out in the same indigenous communities unveiled a decline in traditional knowledge of mushrooms among Chatino inhabitants, as older individuals had a significantly greater understanding of mushroom species and their uses compared to younger members [6]. Our results showed that in both

the Chontal and Chinantec communities, traditional knowledge of mushrooms is evenly distributed among people regardless of their age, suggesting that this knowledge is being preserved across generations. This phenomenon can be attributed to the fact that young people in the Chontal and Chinantec communities tend to be actively engaged in agricultural-related activities, whereas younger generations in the Chatino community are more involved in activities within urban areas than in rural environments. Greater traditional knowledge about wild mushrooms was observed to be mainly associated with age, and studies suggest that traditional learning in several rural areas is acquired from childhood through active participation in activities such as mushroom gathering, milpa farming, and community life [46–48].

In Chontal and Chinantec communities, men and women use both indigenous and Spanish names equally. In the Chatino community, women use Spanish names more frequently than men, which can be attributed to women's migration for educational purposes. Upon returning to the community, Chatino women often establish small businesses, where communicating in Spanish helps them interact with locals and visitors [6]. Meanwhile, men remain in the community and maintain a continuous relationship with the natural environment, reinforcing the use of indigenous mushroom names. In Chinantec and Chontal communities, the equal involvement of men and women in mushroom harvesting and sales, and agricultural activities generate a shared understanding of these organisms [6, 49, 50]; thus, their traditional knowledge about wild mushrooms is comparable.

Traditional knowledge (e.g., ethnoecological, ethnomycological, and ethnobotanical knowledge) can gradually be lost, primarily affecting younger generations. The intergenerational transmission of ethnoecological knowledge has been observed to follow three key mechanisms: (1) vertical (from parents to children), (2) horizontal (among members of the same generation), and (3) oblique (from scientists or external institutions) [51]. The first two mechanisms were observed in the Chatino, Chontal, and Chinantec communities, where both family and non-family relationships play a key role in preserving knowledge. This pattern has been observed in most indigenous communities in Mexico and worldwide. For example, within the Chinantec communities of Oaxaca, Mexico, parents are the primary source of knowledge, although younger generations also learn by interacting with other families; among the Wixarika people of Zacatecas and Jalisco, Mexico, grandparents play a central role in transmitting knowledge; in the Brazilian Amazon, women play a key role in preserving traditional knowledge within their communities [37, 51, 52]. However, within a Tlahuica community in the State of Mexico, where the highest number of useful wild mushrooms has been recorded worldwide for an ethnic group (more than 200 species), knowledge is transmitted through all three mechanisms mentioned. In this community, parents teach their children, mushroom gatherers share their knowledge, and scientists, government institutions, and non-governmental organizations contribute to the learning process. This underscores the crucial role of support from scientific, governmental, and non-governmental organizations in enhancing the preservation of traditional knowledge about wild mushrooms [51, 53].

The folk taxonomy in each studied community aligns with scientific taxonomy by utilizing binomial names. Indigenous names in most mushroom species consist of a generic name followed by a specific suffix. In certain cases, such as with species of the genus *Amanita*, trinomial names are utilized to describe particular characteristics, similar to the scientific classification of fungi by varieties. It has been suggested that categorizing the natural world by observable and practical traits can lead to identifying folk varieties and subcategories within a species [4]. Our findings indicate that the classification patterns and name assignments for mushrooms found in the studied communities correspond to those reported in other cultural groups, not only in Mexico but also in regions worldwide. In Tanzania, communities in the Serengeti and Ngorongoro classify fungi based on color, size of the sporome, habitat, and edibility. For example, in the genus *Termitomyces*, species names are based on the shape and size of the pseudorhiza, which shows a remarkable correspondence with scientific taxonomy [54]. Similarly, in the Menge district in Ethiopia, mushroom nomenclature can be either monomial or binomial, with names assigned based on the growth substrate, color, and sporome shape and size [43].

The comparison of classification systems and name assignments for mushrooms among different cultural groups indicates that folk taxonomy follows universal patterns that integrate ecological knowledge, sensory perception, and cultural worldview (Fig. 4). However, variations in the complexity of names reflect the particularities of each cultural context, making evident the diversity of traditional classification systems. The folk taxonomy used by the Chatino, Chontal, and Chinantec groups symbolizes their vast cultural richness and deep understanding of fungal resources. This practice aids in preserving general knowledge about mushrooms and species conservation, fostering greater interest and awareness of their significance in the communities. Nevertheless, folk taxonomy differs across geographical areas, limiting its usefulness to specific regions or communities [8, 30,

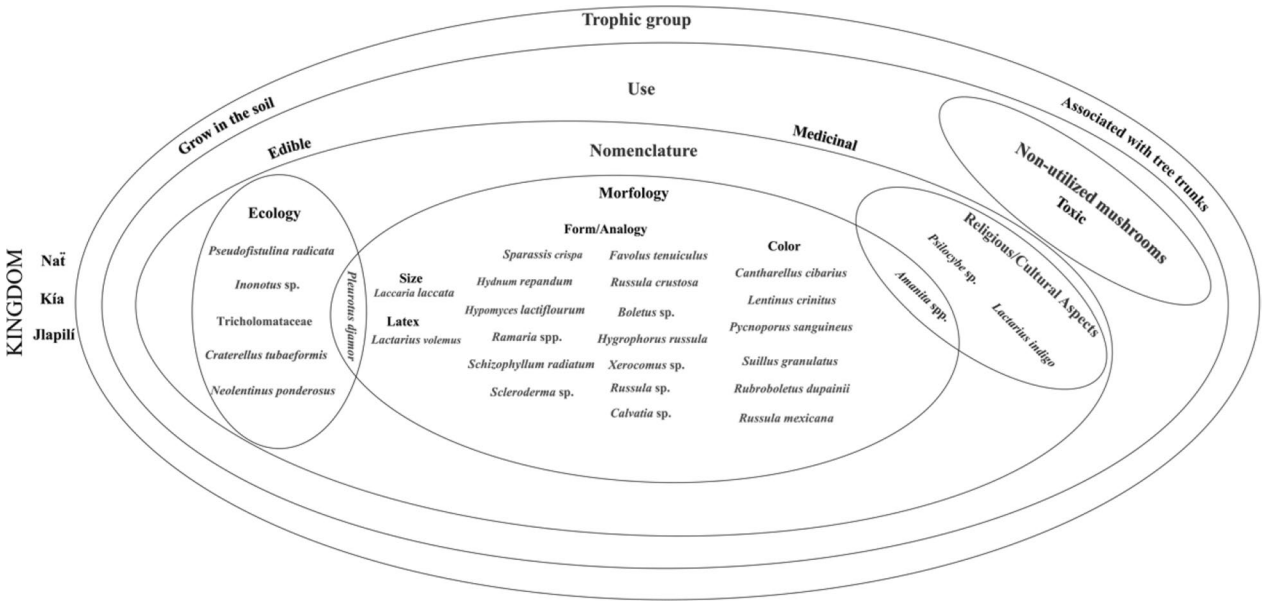

Fig. 4 Classification system and name assignment for wild mushrooms in the studied indigenous communities of Oaxaca. KINGDOM indicates the generic terms for mushrooms in each indigenous community: Naï (Chinantec), Kía (Chatino), and Jlapilí (Chontal)

34]. Given the significant loss of biodiversity worldwide, it is essential to generate valuable information aimed at addressing this issue in specific local areas, and ethnomycological studies can play a highly relevant role in this effort [6, 12, 55].

While the information from the inhabitants of the studied communities was obtained carefully, communication was a limiting factor since many individuals speak only the local indigenous language, making it difficult to conduct interviews, mainly in the Chatino and Chontal communities. Also, the present study faced challenges due to the linguistic complexity of the assessed languages, which complicated the systematization of the knowledge recorded in the indigenous communities. It is necessary to increase ethnomycological research in the Chatino, Chontal, and Chinantec groups of Oaxaca, including additional communities, to better understand the regional use and structure of mushroom folk taxonomy and classification systems.

Conclusions

The variety of names in both indigenous and Spanish languages utilized within each studied community emphasizes the importance of the fungal resources for these cultural groups. The structure of indigenous names shows that each community has a robust folk taxonomy, enabling the effective use of mushrooms and ensuring the successful transmission of traditional knowledge. Using unique indigenous names for each species demonstrates a strong preservation of ancestral knowledge, as each name encapsulates information related to the worldview and perceptions of the three indigenous groups. The comprehensive understanding and local classifications of mushroom species within each community play an essential role in conserving natural resources and can help reduce the negative effects of acculturation and transculturation. However, it is necessary to conduct similar studies in other communities belonging to these indigenous groups in order to gain a broader understanding of regional folk taxonomy.

Supplementary Information

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Additional file 1.

Additional file 2.

Additional file 3.

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Author contributions

A.L.G. designed the project, conducted the interviews, collected fungal samples, analyzed the data, interpreted the results, prepared the figures and tables, and wrote the first draft of the manuscript. M.G.H. designed the

project, analyzed the data, interpreted the results, prepared the figures and tables, reviewed and corrected the drafts of the work, and approved the final manuscript. E.G. designed the project, reviewed and corrected drafts of the work, and approved the final manuscript.

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Availability of data and materials
The datasets generated during this study are included in this published article and its supplementary information files.

Declarations

Human ethics approval and consent to participate
The approval and consent to conduct interviews and obtain information from the inhabitants of Santa Lucia Teotepec, Santo Domingo Chontecomatlan, and San Antonio Otate were given by the local authorities C. Francisco Sánchez, C. Jorge Mendoza Mejía, and the Supervisory Board, respectively, as well as the people interviewed.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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