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Original Article

Children's versus adult's knowledge of medicinal plants: an ethnobotanical study in Tremezzina (Como, Lombardy, Italy)

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A B S T R A C T

The study was developed in order to collect information about knowledge on medicinal plant uses by students from some primary school classes located in a small community on the western shore of Lake Como (northern Italy). This information was compared with the one collected from the students' relatives and from other people they were in contact with, in order to evaluate differences and similarities between the children's and the adults' knowledge. Two workshops were led in each of the classes taking part in the project. The first one was performed to introduce our research and the topic of healing plants to the students. During the second workshop we asked the students to fill a survey focusing on which plant remedies they would use as medicines. In another phase of the project each child was given a new survey to be filled in at home while conducting the interviews with their relatives or other adults. Tremezzina children reported the use of 24 medicinal species; 78% of students listed at least one species but only 9% showed to know more than three species and uses. In total, adults reported 85 species in eighteen categories of use. Children listed eight species and eleven uses that were not reported by the adults, suggesting that some of the Tremezzina children's knowledge of the medicinal plants are specific to them. Both children and adults learned about the use of the medicinal plants mainly from their family; however, other sources of knowledge were also reported. Differences related to age and gender in both the informants' groups were also discussed. Our results provide valuable qualitative and quantitative data on the plants used for the medicinal purpose within the studied community.

Introduction

Herbal medicine has been reported worldwide as an essential component of the cultural heritage of a group or society. In the rural areas of developing countries, where medicinal plants are often the only available and affordable treatment, the use of herbal preparations plays a crucial role in the livelihoods of people (WHO, 2002). In the Western countries with highly developed health care systems, phytotherapy is considered as a part of Complementary and Alternative Medicine (CAM) and its importance has steadily increased in recent years within the "green wave" and the healthy lifestyle framework (Koleva et al., 2016; Wegener, 2017). For example, a national survey showed that the herbal medicine is one of the most used alternative medicine in Italy (Menniti-Ippolito et al., 2002). More recently, Biagi et al. (2016) reported that Italy is the European country showing the fastest increase in the herbal products market, with 50,000 products available in many different marketing categories, ranging from medicine to nutrition and cosmetics. Similar trends exist in other European countries, USA, Canada and Australia (Fisher and Ward, 1994; Eisenberg et al., 1998; Wegener, 2017). There is now substantial information concerning the knowledge and use of medicinal plants by adult people; this is due to the high number of papers published on this topic, including those on CAM use as well as those dealing with the ethnomedicinal knowledge (see, for example, Wegener, 2017 and Reyes-García, 2010). Nonetheless, little is still known about herbs' knowledge by younger generations, with particular reference to the field of the ethnobiological research (Zarger, 2010; Gallois and

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Reyes-García, 2018). Especially in industrialized countries, school-age children have been showed to hold little direct experience in nature and often lack of basic information on the recognition of living organisms, their biology and their role in the ecosystem or their contribution to human life (Tunnicliffe, 2001). While one might expect this circumstance to be more common in the urban context (Tuan, 2012), some studies reported the evidence of environmental knowledge loss in children from the rural settings too (Ianni et al., 2015; Díez et al., 2018). It has been shown that children may ignore plants and often exhibit a general disinterest towards them (Bebbington, 2005; Strgar, 2007; Patrick and Tunnicliffe, 2011). This phenomenon is acknowledged as "plant blindness" (Wandersee and Schussler, 2001). However, some researches (Hammann, 2011; Pany, 2014; Pany and Heidinger, 2015) report that medicinal plants and stimulant herbal drugs can be very attractive to students of all grades and should be used as key species for teaching botany in school. Interest in herbal medicine by younger generations has been reported in Bulgaria (Koleva et al., 2016), Slovenia (Strgar et al., 2013) and Spain (Ramet et al., 2018). In their study, Strgar et al. (2013) showed that most of the interviewed students used medicinal plants occasionally. However, knowledge on these plants was not adequate: informants were only able to identify correctly a few species and most of them were not able to recognize the poisonous plants. According to data obtained from high school students in Izmir (Turkey), Ugulu and Aydin (2011) concluded that the transmission of ethnobotanical skills is not sufficient for allowing traditional phytomedicinal practices to persist within the local community. To the best of our knowledge, only one paper (Menghini et al., 2015) has specifically investigated perception and use of herbal products among younger generations in Italy. This study was carried out by interviewing a sample of undergraduate students attending the school of pharmacy at the University of Chieti and hailing from different areas of central and southern Italy. We focused instead our research on primary school students living in a small community of northern Italy. Several studies pointed out how the emic point of view of children may be a key target in conservation education programmes, taking into consideration the role children will play in the future development of society (Hunn, 2002; Buhler-Niederberger and van Krieken, 2008; Dounias and Aumeeruddy-Thomas, 2017). For this purpose, we were interested in investigating whether the traditional herbal knowledge, which forms part of the local cultural heritage, has been lost or is still being passed on to new generations.

The following specific questions were to answer in this study:

1 What do students know about medicinal plants and their uses?
2 Are there differences between children's and adult's knowledge?
3 Does local knowledge on medicinal plants differ with regard to age and gender both in children and adults?
4 What are the dominant modes of knowledge transmission?

The term 'local knowledge' is often used interchangeably to refer to 'indigenous knowledge'. However, as observed by some authors (Frazão-Moreira et al., 2009; Alves et al., 2014), local knowledge does not necessarily correspond to indigenous knowledge: it is a dynamic construct entailing an incessant dialog between native (endogenous) and non-native (exogenous) sources of information. In this research, we recorded any information about herbal products used in the area for health care, whether or not they are part of the local traditional knowledge or indirectly derived from independent sources (books, television, internet, newspapers, and exchange of information with herbalists or practioners of alternative medicines), to respond to this further question:

5 What's the contribution of endogenous and exogenous sources in shaping ethnobotanical knowledge both in children and adults?

We collected qualitative and quantitative data on the medicinal plants used within the investigated community by applying a multiphase methodological approach.

Materials and methods

Study area

Geographical and enviromental characteristics

The area where the study was carried out, the Val Tremezzina in the province of Como (northern Italy) (Fig. 1), is a valley located at the foot of Lombardy Prealps at an altitude ranging from 170 m to 1700 m. The valley is 29.41 km^2 and includes four villages (Lenno, Mezzegra, Ossuccio and Tremezzo) united in the municipality of Tremezzina since 2014 (Table 1). These four villages lay along the western shore of Como lake. Due to the mitigating effect of the lake's water mass on the temperatures, the climate is humid temperate with mild and wet winters and relatively cool summers. The average temperature in the area varies between 2 °C (January) and 21.5 °C (July) with low seasonal thermal excursions; the annual rainfall ranges from 900 to 1100 mm, with a dry period in summer. The landscape is characterized by deciduous forests dominated by different oak species (*Quercus* sp. pl.) and European hop-hornbeam (*Ostrya carpinifolia* Scop.) up to 600–70 m, with the presence of sweet chesnut (*Castanea sativa* Mill.) from 400 up to 1000 m (Selva, 2009). At montane and subalpine level, forests are characterized by common beech (*Fagus sylvatica* L.) and different conifers, such as Norway spruce (*Picea abies* (L.) H. Karst.) and mugo pine (*Pinus mugo* Turra) (Selva, 2009). Alpine pastures represent the main land use at higher altitudes. Due to the mild climate conditions, vegetation growing along the lake banks is Mediterranean (*e.g.*, *Cupressus sempervirens* L., and *Laurus nobilis* L.). Some toponyms recall the tradition of olive growing in the area (*Olea europaea* L.): for example, the area between the villages of Lenno and Sala Comacina is known as the Zoca de l'oli (Oil Basin).

Cultural history and socioeconomic characteristcs

The rich and stratified political and cultural history of Tremezzina had an important role in shaping the complexity of local landscape (Brumana et al., 2015). The area was located on an important road junction connecting Aquileia to North Europe and to the Rhine region during the Roman period. Its geographical position has been strategic for the connection of communities living in the two Alps sides, allowing the birth of defensive systems and religious sites in the Early Middle Ages. From the end of 16th to 18th century Tremezzina became important for the production and trade of lemons, an activity deeply transforming local landscape with the construction of cultivated lemon terraces. Between 19th and 20th centuries, the area has been discovered as an exclusive touristic destination due to the beauty of landscape and the mild climate. Most of the gardens and the luxurious villas on the lakeside date back to this period. Nowadays, Tremezzina has become a mass tourism destination and it is economy is mainly based on the service sector. The hunting and fisheries sectors and the silvicultural activities played an important economic role up to some decades ago; they are now marginal occupations employing a small and declining fraction of the population. Due to the high pressure of aggressive tourism, the cultural identity and the authenticity of the cultural heritage are threaten in the area. For this reason, the Como province and the Tremezzina municipality are promoting activities aimed to capture the corpus of historical and cultural traditions

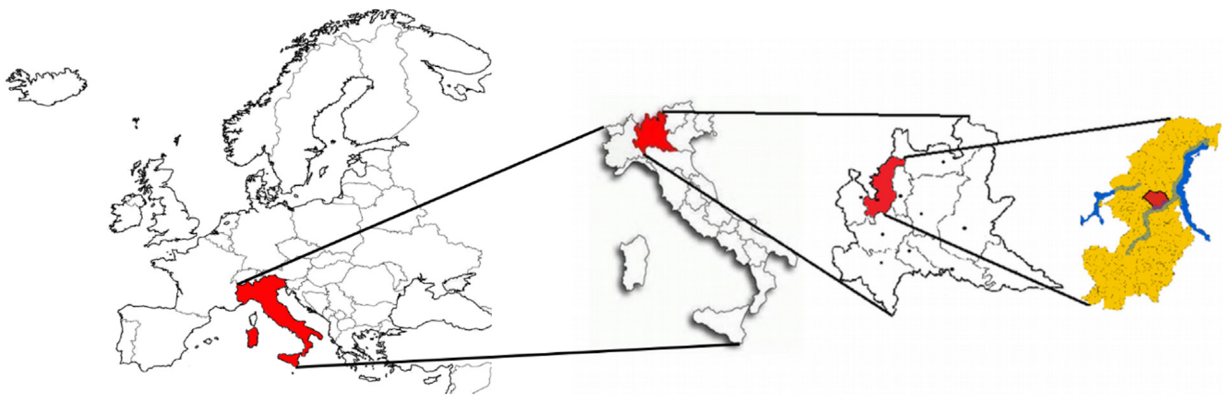

Fig. 1. Map of the study area showing Europe, Italy, Lombardy region, Como province and Tremezzina. Geographical coordinates of the study area: Lat. 45°59′3″84 N; Long. 09°13′10″56 E.

Table 1
Geographic and demographic data of the study area compared to the whole Como province. As explained in the methods section Tremezzina municipality includes four villages: Lenno, Mezzegra, Ossuccio and Tremezzo. Villages involved in the study are signed with a star.

	SA (Km^2)	# INH	AVA	# < 15	# > 65	E/C (%)	#FA	#FAM	CC %
Lenno*	9.94	1873	45.5	234	454	194	816	2.30	59
Mezzegra	3.31	1037	44.9	133	244	183	451	2.30	61
Ossuccio*	8.34	1,005	45.1	125	230	184	476	2.11	58
Tremezzo*	7.82	1238	47.7	130	345	266	575	2.15	51
Tremezzina municipality	29.41	5153	46.8	622	1273	204	2,318	2.22	57
Como province	1279	599,300	44.7	81,865	135,724	166	258,215	2.31	58

SA = size of the area; # INH = number of inhabitants; AVA = average age; # <15 = number of inhabitants <15 years old; # >65 = number of inhabitants >65 years old; E/C (%) = elder/child ratio (or ageing index). This index shows the rate of ageing in the population and it is calculated as the percentage ratio between inhabitants over 65 years and inhabitants under 15 years; #FA = number of families; #FAM = number of members per family; CC = percentage of couples with children. These data were extrapolated from ISTAT (2018) statistical databases. Available: http://demo.istat.it/.

and to transfer this knowledge to the local community, promoting a more sustainable tourism approach at the same time.

According to the ISTAT statistical data (ISTAT, 2018), 5153 inhabitants live in Tremezzina, with the highest number of residents in Lenno (1873 inhabitants) and Tremezzo (1238 inhabitants) (Table 1). Despite the large foreign immigration (+21% immigration rate for the period 2010–2017), the population growth rate is negative (−1% growth rate for the period 2010–2017) (ISTAT, 2018). The number of children (622 children aged 0–14 years old) is about the half of elderly people (1273 people older than 65 years old) and the ageing index is 204% (Table 1).

Everyday children's life

Most of the everyday life of Tremezzina children, between 6 and 11 years old, takes place in institutionalized places such as private homes, schools and recreational institutions. Children stay at school until 1 p.m., when they are taken home by their parents or other relatives. In the afternoon, children stay inside or play outside and many of them participate to various leisure-time activities (for example, music or different sports) at some locations. The relatively quiet streets and the wide countryside areas provide attractive possibilities for spending time out in the air. However, although parents feel safe to let their kids walk and play outside alone, Tremezzina children play outside less frequently than in the past. The amount of time children spend at home has grown and activities that they used to do outdoors are now part of the indoor children's culture. For this reason, the culture to get contact with nature risks to disappear in the next future.

Study design and interviews

This study included the students attending different grades of primary school in three different villages: 1st, 2nd, 3rd, 4th and 5th at Tremezzo, 3rd A and 3rd B at Lenno and 5th at Ossuccio. Schools were selected depending on the willingness of the teachers, students and parents to actively participate in this study. Preliminary meetings were held with the teachers and parents to explain the project's purpose and to obtain a list of the health problems most frequently affecting the children of the community. In total, 120 students (65 boys and 55 girls) between 6 and 10 years old (mean = 8 ± 1) participated in the study. Students and their parents gave written assent to the use personal data, pictures and statements collected during the interviews. Data were collected during normal teaching hours by a multi-step approach. In the first step we used a Power Point presentation to introduce the research group and explain the topic of our study to the students of each class, carefully simplifying the scientific language. The aim of these meetings was also to arouse the children's attention and interest for the topic, to make children familiar with both the term and the concept of "pianta medicinale" (medicinal plant) and to understand their perception of different diseases. Since this first step we involved the teachers in monitoring our study to validate the congruence of the proposed issues and of the research tools with the cognitive abilities of the students. In the second step we used a free-listing approach, asking the students to list all the medicinal plants they knew in order to draw up a first working list of plants used in their families for health care. Then, we collected research data by conducting structured interviews with children in 3rd, 4th and 5th grade. The questionnaire was developed in a child-oriented way by using sketches to elicit interest and to help the child identify ailments and their relation to the different parts of the body. The questionnaire consisted of closed and open-ended questions organized in three sections. The first section included personal information about the student and the family members: name, surname, age, sex and school grade of the child; name, age and profession of the parents; name and age of the grandparents. It was followed by a section concerning the children's perception of diseases and different ways of treating them:

for example, "when I've stomach ache my parents/grandparents give me: a. pill; b. syrup; c. suppository; d. shot; e. drops". Based on the information collected during the preliminary meetings, we considered the following eleven illnesses/discomforts: ear ache, eye ache, stomach ache, vomit, wounds and burns, cold and cough, tooth ache, leg/foot/arm ache, insect bites, head ache, sleeplessness. In the third section the students were asked to write which plant remedies, if any, they currently use, for which purpose they were used and how they were applied. Questionnaires were administrated by the teachers in order to provide numerous participation of the students and to ensure that their compilation occurred under the ordinary conditions to which children were accustomed during the school hours. Since first and 2nd grade students were not yet able to completely understand and correctly fill all the questionnaire sections, in these cases we adopted a group discussion approach to promote the students' contribution and engagement. A teacher was also present during the interviews. Each classroom group proceeded through a series of questions intended to encourage open discussion on the use of medicinal herbs. The answers were recorded and then transcribed for further analysis. To examine adults' knowledge, all the students involved in the survey were given four copies of the questionnaire for the family members, with the request to interview almost both parents. Children were prepared for the interview by discussing with them the various sections composing the questionnaire. For this purpose, during the meeting carried out in each 3rd, 4th and 5th class we simulated an interview situation in which the students pretended to be the adults and one of the researchers took the role of the interviewer. In particular, we took care to explain some simple rules to be followed during the interview with the adults, *e.g.*, asking everyone only the plants they currently use as remedies, asking everyone the same questions in the same order, filling the questionnaire in the correct form etc. We also organized a meeting with the students' families in order to illustrate the project and to show each section of the questionnaire.

During the interviews, adult informants were asked to describe plant remedies, used plant parts, their preparation and administration. Moreover, they were asked to indicate the source of knowledge for each remedy ("How have you learned your current knowledge about medicinal plants?") in order to discriminate between endogenous source (*i.e.*, knowledge developed and traditionally transmitted within the family or the community) and exogenous source (*i.e.*, knowledge got through books or other publications, television and practitioners of different medicines). We used three general categories to describe the source of knowledge in order to facilitate the children's task of interviewing adults. The category "family in general" combined parents, grandparents, uncles and older familial relatives. "General community" combined elders in the community, neighbours or friends, primary school teachers, traditional healers and spouses. In "other" we included exogenous sources such as: books and newspapers, internet, television, herbal practitioners and academic people.

Altogether, 173 adults between 16 and 93 years old (mean: 50 ± 15) participated in the questionnaire. Women formed the larger portion of the informants (above 76%); men were often reluctant to be interviewed and some of them did not possess any information. Data from other studies carried out in neighbouring alpine areas show that men are usually less interested than women in participating to this kind of research (see for examples the unequal balance of women and men participating to the studies carried out by Vitalini et al., 2009, 2013; Dei Cas et al., 2015). For this reason, only 26 were the families for which data on plants' knowledge from both parents were available. Forty-four were the families with data available only from one parent: 37 from the mother and seven from the father. Thirty families had data from one or both grandparents. The remaining families had data from other relatives.

After the questionnaires had been completed and examined we selected three adult informants reporting the highest number of species and known by the community as the most knowledgeable and skilled in the use of medicinal remedies. These key informants were interviewed further in order to reflect about the topics of the semistructured interviews, to validate the information obtained and to avoid recall bias (*i.e.*, errors occurring when informants do not remember previous events or experiences accurately or omit details) (Calvet-Mir et al., 2016). Each of these interviews was carried out by a student supported by one or more members of the research group.

Sample collection and botanical identification

Most of the wild and cultivated plants listed during the interviews were collected from field and gardens following the informants' indications. For botanical identification of collected plant samples, Flora d'Italia (Pignatti, 1982) and local flora texts (Selva, 2009; Banti et al., 2015) were used. We did not collect samples of common plants (*e.g.*, chamomile, lemon, orange) or herbal drugs bought in supermarkets or herbalist shops (*e.g.,* devil's claw, ginger, stevia, turmeric). Botanical families and species names were reported according to The Plant List (http://www.theplantlist.org/).

Data analysis

Data from the students' and the adults' interviews were filed in a Microsoft Excel spreadsheet where each row represents a citation, defined as a single use reported for a single species by a single informant (Signorini et al., 2008). A single use is the use category (UC), a category coinciding with general therapeutic indications, such as colds and respiratory tract diseases, digestive system disorders etc. We considered as distinct citations those differing from one another in at least one of the following data: species, informant, use category. In the columns the following attributes are reported for each citation: botanical species, botanical family, vernacular plant name/s, informant code, use category, detailed therapeutic use of the species (*e.g.*, stomach ache, nausea etc.), used plant part, preparation, way of administration. Derived tables were obtained from this data sheet using the program 'EBtools', a collection of scripts in Visual Basic for Applications (VBA) in Microsoft Excel, performing advanced sorting, filtering and counting of data according to specific user requirements. The Informant Consensus Factor (ICF) was calculated according to Heinrich et al. (1998) as follows:

$$ICF = n_{ur} - n_t / n_{ur} - 1$$

Where n_{ur} is number of use citations in each use category; n_t is the number of species used. ICF was used to identify the main disease categories facing the studied community and to determine if there is agreement among the informants on the use of plants for treating a specific ailment.

Mann-Whitnet U test was used to identify significant differences concerning the knowledge of plants and uses between children and adults. Generalized linear model (GLM) factor analyses, with a Poisson error distribution and a log-link function, were used to assess whether the independent variables sex and age explain the dependent variables number of known species and number of known uses. Four adult informants were not included in this statistical analysis due to lack of information on their age. A comparison between data collected in our research and ethnomedicinal studies carried out in the same Alpine region (Vitalini et al., 2009, 2013, 2015; Dei Cas et al., 2015) was performed by considering Jaccard Similarity Index (JI):

$$JI = c/(a + b + c)$$

Table 2
List of species cited by children in Tremezzina valley.

Botanical species	Local name	Botanical family	Status	#i	#c	Part	#uc	Use categories
Allium sativum L.	Aglio	Liliaceae	C	2	2	Ho	1	EAR
Aloe vera (L.) Burm.f.	Aloe	Xanthorrhoeaceae	E	1	1	L	1	SKI
Arnica montana L.	Arnica	Asteraceae	WL	2	2	Fl	1	SKI
Calendula officinalis L.	Calendula	Asteraceae	WR	4	7	Fl	1	SKI
Camellia sinensis (L.) Kuntze	Tè	Theaceae	E	39	50	L	6	DSD, CRD, EAR, EYE, HEA, NEU
Citrus limon (L.) Osbeck	Limone	Rutaceae	C	17	21	Fr	5	DSD, CRD, EAR, EYE, NEU
Citrus sinensis (L.) Osbeck	Arancio	Rutaceae	C	19	20	Fr	5	DSD, CRD, HEA, MOU, NEU
Cucurbita maxima Duchesne	Zucca	Cucurbitaceae	C	2	2	S	1	DSD
Curcuma longa L.	Curcuma	Zingiberaceae	E	1	1	Ho	1	CRD
Foeniculum vulgare Miller. subsp. *vulgare* var. *azoricum* (Miller) Thell.	Finocchio	Apiaceae	C	5	5	Ep, Fl, L	2	DSD, NEU
Foeniculum vulgare Miller subsp. *piperitum* (Ucria) Bég.	Finocchio	Apiaceae	WR, C	1	1	Fl	1	DSD, NEU
Lavandula angustifolia Mill.	Lavanda	Lamiaceae	WR	3	3	Fl, L	3	CRD, HEA, MOU
Malus domestica Borkh.	Melo	Rosaceae	C	6	6	Fr	4	CRD,DSD, MOU, SKI
Malva sylvestris L	Malva	Malvaceae	WL	6	7	Fl	3	DSD, MOU, MSD
Matricaria chamomilla L.	Camomilla	Asteraceae	WL	51	74	Fl	7	CRD, DSD, EAR, EYE, HEA, NEU, SKI
Melissa officinalis L.	Melissa	Lamiaceae	WL	2	2	Fl, L	2	DSD, NEU
Mentha x *piperita* L.	Menta	Lamiaceae	WR, C	4	5	L	4	CRD, DSD, HEA, MOU
Oryza sativa L.	Riso	Poaceae	C	16	17	S	2	DSD, EAR
Petroselinum crispum (Miller) Fuss.	Prezzemolo	Apiaceae	C	1	1	L	1	SKI
Salvia officinalis L.	Salvia	Lamiaceae	C	2	2	L	1	MOU
Solanum tuberosum L.	Patata	Solanaceae	C	9	9	Ho	4	DSD, EYE, MOU, SKI
Thymus serpyllum L. (s. l.)	Timo	Lamiaceae	WR, C	5	5	Fl, L	1	CRD
Urtica dioica L.	Ortica	Urticaceae	WL	1	1	L	1	MSD
Zingiber officinale Rosc.	Zenzero	Zingiberaceae	E	1	1	Ho	1	CRD

Status: C (cultivated), E (exotic), WL (locally native), WR (regionally native); #i: number of informants; #c: number of citations; Part (used plant part): Ep (epigeal part), Fl (Flowers), Fr (fruits), Ho (hypogeal organs), L (leaves), S (seeds), #uc: number of use categories; Use categories: CRD (colds and respiratory tract diseases), DSD (digestive system disorders), EYE (eye diseases), HEA (Headache), MOU (mouth problems), MSD (muscular/skeletal diseases), NEU (neurological problems), SKI (skin diseases and wounds).

Where c is the number of species common to the two sites, a is the number of species used only in the site A, and b is the number of species used only in the site B.

We carried out this analysis separately for children and adults. Moreover, in order to make a fair comparison, we focused the analysis only on wild or locally cultivated species, excluding introduced ones (bought in the supermarkets or in herbalist's shops).

One sample t-student test was used to statistically evaluate the different modes of plant knowledge transmission. For this purpose, we analysed data concerning the source of knowledge for each remedy as reported by adult informants. We performed a parametric test because the data collected were normally distributed. Finally, information from children was check-crossed against that of their own family in order to evaluate the possible correspondence between uses cited by kids and uses cited family members. This allowed to verify if knowledge of medicinal plants is acquired by children within the family.

Results

This study provided information about 93 species belonging to 87 genera and 42 families. Asteraceae was the dominant botanical family with 16 species and 235 citations, followed by Lamiaceae (nine species, 209 citations) and Apiaceae (six species, 23 citations). Forty-three species (46% of the total species; 392 citations) were local native, eigth (9%; 52) regional native, twenty (22%; 297) cultivated, seventeen (18%; 108) exotic and five (5%; 79) both regional native and cultivated.

Students' knowledge

The interviewed students cited 24 species in nine use categories for a total of 245 citations (Table 2). Cultivated species (10 species; 42% of the total species cited by children) were reported more than local native (5; 21%), exotic (4; 17%) and regional native (2; 8%). Three species (12%) were both regional native and cultivated. On average the students reported 1.66 ± 1.37 species and 2.04 ± 1.86 uses each. Twenty-seven of them (22% of the total) did not report any species; 34 (28%) reported one species and one use; 48 (40%) 2–3 species with a number of uses ranging from 2 to 9; 11 (9%) cited more than three species with a number of uses ranging from 4 to 8. Girls proved to know a significantly higher number of both plants (mean ± standard deviation = 2.00 ± 1.37) and uses (2.52 ± 1.86) than boys (1.38 ± 1.38; 1.63 ± 1.72) (Tables 4 and 5). Both the number of known medicinal plants ($p < 0.01$) and of medicinal uses ($p < 0.001$) increased with the age (Tables 4 and 5): the students of first and 2nd grades (6–7 years old) reported 1.20 ± 1.23 species and 1.34 ± uses; these numbers increased to 1.50 ± 1.27 and 1.71 ± 1.58 (3rd grade; 8 years old), 1.93 ± 1.22 and 2.86 ± 1.80 (4th grade; 9 years old), 2.50 ± 1.50 and 3.16 ± 2.27 (5th grade; 10 years old). Interaction between the gender and the age had no significant effect: the older girls did not know more species and uses than the boys of the same age class (Table 4). The

Table 3
List of species cited by adults in Tremezzina valley.

Botanical species	Local name	Botanical family	Status	# i	# c	Part	# uc	UC
Achillea erba-rotta All. subsp. *moschata* (Wulfen) I.Richardson	Achillea moscata	Asteraceae	WR	2	2	Fl	1	DSD
Achillea millefolium L. (s. l.)	Achillea	Asteraceae	WL	7	8	Fl, L	4	CRD, DSD, GEN, SKI
Allium cepa L.	Cipolla	Amaryllidaceae	C	3	3	Ho	3	DSD, SKI, URI
Allium sativum L.	Aglio	Amaryllidaceae	C	13	14	Ho	8	CRD, CSD, FEV, GEN, MSD, OTH, PAR, SKI
Allium ursinum L.	Aglio orsino	Amaryllidaceae	WL	1	1	Ho	1	CSD
Aloe vera (L.) Burm.f.	Aloe	Xanthorrhoeaceae	E	16	18	L	4	MOU, GEN, PRE, SKI
Arctium lappa L.	Bardana	Asteraceae	WL	2	2	Ho, Ep	2	DSD, MSD
Arctostaphylos uva-ursi (L.) Spreng.	Uva Ursina	Ericaceae	WR	2	2	L	1	URI
Arnica montana L.	Arnica	Asteraceae	WL	11	11	Fl	1	MSD
Artemisia vulgaris L.	Artemisia	Asteraceae	WL	1	2	L	2	DSD, GEN
Atropa belladonna L.	Belladonna	Solanaceae	WR, C	1	1	L	1	CRD
Betula pendula Roth	Betulla	Betulaceae	WL	2	3	L, S	2	URI, MET
Borago officinalis L.	Borragine	Boraginaceae	WL	2	2	L, Wp	2	CRD, URI
Brassica oleracea L. var. *sabauda* L.	Verza	Brassicaceae	C	3	3	L	3	DSD, GEN, MSD
Calendula officinalis L.	Calendula	Asteraceae	WR, C	17	19	Fl	6	DSD, EYE, MOU, MSD, OTH, SKI
Capsicum annuum L.	Peperoncino	Solanaceae	C	2	2	Fr	1	CSD
Castanea sativa Miller	Castagno	Leguminosae	WL	1	1	L	1	FEV
Chelidonium majus L.	Celidonia	Papaveraceae	WR	1	2	L, Sh	2	DSD, GEN, SKI
Cichorium intybus L.	Cicoria	Asteraceae	WL	2	3	L	2	GEN
Cinnamomum camphora (L.) J.Presl	Canfora	Lauraceae	E	1	1	B	1	CRD
Citrus limon (L.) Osbeck	Limone	Rutaceae	C	11	12	Fr, L	3	CRD, DSD, PAR
Coriandrum sativum L.	Coriandolo	Apiaceae	E	1	1	Fl	1	SLI
Crataegus monogyna Jacq. (s.l.)	Biancospino	Rosaceae	WL	5	5	Fl	1	NEU
Crocus sativus L.	Zafferano	Iridaceae	C	1	1	Fl	1	GYN
Cupressus sempervirens L.	Cipresso	Cupressaceae	WL	1	1	Fr	1	DSD
Curcuma longa L.	Curcuma	Zingiberaceae	E	3	4	Ho	3	CRD, GEN, MSD
Cynara cardunculus L.	Carciofo	Asteraceae	C	4	4	Fl, Fr, L	3	DSD, GEN, MET
Daucus carota L. subsp. *carota*	Carote	Apiaceae	WL	1	1	Ho	1	DSD
Echinacea purpurea (L.) Moench	Echinacea	Asteraceae	E	1	1	Ho	1	CRD
Equisetum arvense L.	Equiseto	Equisetaceae	WL	4	4	L, Wp	3	GYN, SKI, URI
Eucalyptus globulus Labill.	Eucalipto	Myrtaceae	E	2	2	Fr, L	1	CRD
Foeniculum vulgare Miller var. *azoricum* (Miller)Thell.	Finocchio	Apiaceae	C	12	12	Fr, L, S	2	DSD, GEN
Fraxinus sp. pl.	Frassino	Oleaceae	WL	1	1	L	1	URI
Gentiana lutea L.	Genziana	Gentianaceae	WR	1	2	Wp	2	DSD, FEV
Glycyrrhiza glabra L.	Liquirizia	Leguminosae	E	5	6	Ho	3	CSD, DSD, GEN
Harpagophytum procumbens (Burch.) DC. ex Meisn.	Artiglio del Diavolo	Pedaliaceae	E	2	2	Ho	2	GEN, MSD
Hedera helix L.	Edera	Araliaceae	WL	2	2	L	2	CRD, SKI
Humulus lupulus L	Luppolo	Cannabaceae	WL	1	1	Fl, L	1	GEN
Hypericum perforatum L.	Iperico	Hypericaceae	WL	7	7	Fl	2	NEU, SKI
Juglans regia L.	Noce	Juglandaceae	WL	2	3	L, Sh	3	CSD, DSD, SKI
Juniperus communis L.	Ginepro	Cupressaceae	WL	4	4	Fr, L	3	DSD, MSD, SKI
Lactuca sativa L.	Lattuga	Asteraceae	C	1	1	L	1	CSD
Laurus nobilis L.	Alloro	Lauraceae	WL	21	22	Fr, L	6	CRD, DSD, MOU, MSD, NEU, OTH
Lavandula angustifolia Mill.	Lavanda	Lamiaceae	WR, C	14	15	Fl	3	CRD, NEU, SKI
Linum usitatissimum L.	Lino	Linaceae	C	6	6	S	3	CRD, DSD, GEN
Lycium barbarum L.	Goji	Solanaceae	E	1	1	Fr	1	GEN
Malva sylvestris L.	Malva	Malvaceae	WL	74	79	Fl, L	8	CRD, DSD, EYE, GEN, HEA, MOU, MSD, SKI
Matricaria chamomilla L.	Camomilla	Asteraceae	WL	62	73	Fl	8	CRD, DSD, EYE, FEV, GEN, HEA, NEU, SKI
Melaleuca alternifolia (Maiden & Betche) Cheel	Albero del Tè	Myrtaceae	E	3	3	L	1	SKI
Melissa officinalis L.	Melissa	Lamiaceae	C	15	15	Fl, L	4	CSD, DSD, GEN, NEU
Mentha sp.	Menta	Lamiaceae	WR	32	35	L	5	CRD, DSD, GEN, MOU, NEU
Ocimum basilicum L.	Basilico	Lamiaceae	C	5	10	L	5	CRD, DSD, GEN, MOU, NEU

Table 3 (*Continued*)

Botanical species	Local name	Botanical family	Status	# i	# c	Part	# uc	UC
Olea europaea L. var. *europaea*	Ulivo	Oleaceae	WL	4	6	L	3	CSD, URI, SKI
Origanum vulgare L. (s.l.)	Origano	Lamiaceae	WL	3	4	L	3	CRD, DSD, GEN
Oxalis corniculata L.	Acetosella	Oxalidaceae	WL	2	2	Fl, L	2	GEN, MET
Panax ginseng C.A.Mey.	Ginseng	Araliaceae	E	1	1	Ho	1	GEN
Papaver rhoeas L.	Papavero	Papaveraceae	WL	3	5	Fl, S	3	CRD, FEV, NEU
Passiflora caerulea L.	Passiflora	Passifloraceae	E	1	1	L	1	NEU
Pilosella officinarum Vaill.	Pilosella	Asteraceae	WL	1	1	Fl, L	1	URI
Pimpinella anisum L.	Anice	Apiaceae	WR, C	2	2	Fl, Fr	2	GEN
Pinus mugo Turra	Pino mugo	Pinaceae	WL	1	1	Fr	1	CRD
Plantago sp. pl.	Piantaggine	Plantaginaceae	WL	2	2	L	2	CRD, GEN, SKI
Primula sp. pl.	Primula	Primulaceae	WL	1	1	Fl, L	1	CRD
Prunus avium (L.) L.	Ciliegio	Rosaceae	WL	1	1	L	1	CSD
Rheum officinale Baill	Rabarbaro	Polygonaceae	E	3	3	L, Tw	1	DSD
Rosa canina L. (s.l.)	Rosa canina	Rosaceae	WL	1	1	Fl, L	1	GEN
Rosmarinus officinalis L.	Rosmarino	Lamiaceae	C	22	26	Fl, L	8	CRD, DSD, EYE, GEN, GYN, MOU, MSD, NEU
Ruta graveolens L.	Ruta	Rutaceae	WL	1	1	L	1	DSD
Salvia officinalis L.	Salvia	Lamiaceae	C	50	60	Fl, L	7	CRD, DSD, GEN, GYN, MOU, NEU, URI
Sambucus nigra L.	Sambuco	Adoxaceae	WL	18	20	Fl, Fr	7	CRD, DSD, GEN, MSD, NEU, OTH, URI
Silene vulgaris (Moench) Garcke	Silene	Caryophyllaceae	WL	1	1	Sh	1	GEN
Silybum marianum (L.) Gaertn.	Cardo Mariano	Asteraceae	WL	2	2	Fr	2	DSD
Solanum tuberosum L.	Patata	Solanaceae	C	12	13	Ho	4	EYE, MOU, SKI, URI
Stevia rebaudiana (Bertoni) Bertoni	Stevia	Asteraceae	E	1	2	L	2	GEN, OTH
Syzygium aromaticum (L.) Merr. & L.M.Perry	Chiodi di garofano	Myrtaceae	E	1	1	Fl	1	MOU
Tanacetum parthenium (L.) Sch.Bip.	Partenio	Asteraceae	WL	1	1	Fl	1	HEA
Taraxacum officinale Weber (s. l.)	Tarassaco	Asteraceae	WL	19	20	Fl, Ho, L	3	GEN, PRE, URI
Thymus serpyllum L. (s. l.)	Timo	Lamiaceae	WL	23	26	Fl, L, S	5	CRD, DSD, GEN, HEA, SKI
Tilia sp. pl.	Tiglio	Malvaceae	WL	7	8	Fl	3	CRD, DSD, NEU
Urtica dioica L.	Ortica	Urticaceae	WL	11	13	L, Wp	5	CSD, CRD, GEN, MSD, URI
Vaccinium myrtillus L.	Mirtillo	Ericaceae	WL	2	2	Fr	2	CSD, DSD
Vaccinium vitis-idaea L.	Mirtillo Rosso	Ericaceae	WR	1	1	Fr	1	URI
Valeriana officinalis L.	Valeriana	Caprifoliaceae	WR	7	7	Ho, L	1	NEU
Viola sp.	Violetta	Violaceae	WL	1	1	Fl	1	CRD
Zingiber officinale Rosc.	Zenzero	Zingiberaceae	E	10	11	Ho	4	CRD, DSD, GEN, OTH

Status: C (cultivated), E (exotic), WL (locally native), WR (regionally native); #i: number of informants; #c: number of citations; Part (used plant part): B (bark), Ep (epigeal part), Fl (Flowers), Fr (fruits), Ho (hypogeal organs), L (leaves), S (seeds), Sh (shoot), TW (twigs), Wp (whole plant). #uc: number of use categories; Use categories: CRD (colds and respiratory tract diseases), CSD (circulatory system diseases), DSD (digestive system disorders), EYE (eye diseases), GEN (general status), FEV (fever), GYN (gynecological problems), HEA (Headache), MET (metabolic diseases), MOU (mouth problems), MSD (muscular/skeletal diseases), NEU (neurological problems), OTH (other), PAR (external parasites), PRE (preventive), SKI (skin diseases and wounds), URI (urinary tract diseases).

most reported species was *Matricaria chamomilla* L. (51 informants; 74 citations; 7 used categories), followed by *Camellia sinensis* (L.) Kuntze (39; 50; 6), *Citrus sinensis* (L.) Osbeck (19; 20; 0.166; 5) and *Citrus limon* (L.) Osbeck (17; 21; 5). Only one (*M. chamomilla*) of the five most frequently reported species was native, while three of them were cultivated (*Citrus sinensis*, *C. limon* and *Oryza sativa* L.) and one exotic (*Camellia sinensis*). Plants were mainly reported to treat digestive system disorders (13 species; 98 citations), followed by respiratory tract diseases (10; 55), toothache (8; 14) and skin diseases and wounds (7; 18). The Informant Consensus Factor (ICF) calculated for each disease category (Table 6) ranged from 0 to 0.88. The highest values were recorded for the digestive system disorders (ICF = 0.88), the neurological problems (ICF = 0.83) and the respiratory tract diseases (ICF = 0.83). Remedies are mostly prepared as infusion (11 species; 141 citations), followed by the use of raw (*i.e.*, not prepared) plant parts (9; 23). The most frequent way of administration was by oral route (11 species; 179 citations), followed by plant parts consumed as food (5; 27). Flowers were cited as the main used parts in the preparation of medicines, with 97 citations pertaining to 9 species, followed by leaves (75 citations; 13 species).

Adults' knowledge

In total, the adults reported 85 species in 18 categories of use for a total of 683 citations (Table 3). Thirty-four species (52%) were local native, 8 (9%) regional native, 14 (16%) cultivated, 3 (4%) both regional native and cultivated and 16 (19%) exotic. On average each adult knew 3.54 ± 1.98 species and 3.95 ± 2.43 uses. Seventeen informants (10% of adults) did not report any species or use; 14 (8%) reported only one species and one use; 50 (29%) 2–3 species and uses; 52 (30%) 4–5 species with a number of uses ranging from 4 to 10; 40 (23%) cited more than five species with a number of uses ranging from 6 to 12. Gender had no significant effect on the number of medicinal species reported (Tables 4 and 5); however, there was a significant difference ($p < 0.05$) between the number of different uses cited by women (4.18 ±2.47) and men (3.22 ± 2.17).

Table 4
Mean number and standard deviation (±) of species and uses for children and adults in Tremezzina valley. Data were reported according to sex and age.

Sex	#	Age	Species		Uses	
			Mean	St. Dev.	Mean	St. Dev.
Children						
M	20	6–7	0.95	1.46	1.05	1.70
M	27	8	1.25	1.19	1.44	1.36
M	8	9	1.75	1.28	2.62	2.19
M	10	10	2.3	1.49	2.50	1.77
All	65		1.38	1.38	1.63	1.72
F	15	6–7	1.53	0.74	1.73	0.96
F	19	8	1.84	1.34	2.10	1.82
F	7	9	2.14	1.21	3.14	1.34
F	14	10	2.64	1.54	3.64	2.53
All	55		2.00	1.37	2.52	1.86
Adults						
M	12	<40	3.83	1.85	3.83	1.85
M	18	41–60	2,89	2.21	3.00	2.32
M	11	>61	2.50	2.01	2.90	2.33
All	41		3.07	2.08	3.22	2.17
F	40	<40	3.43	2.03	3.90	2.73
F	46	40–60	3.89	2.02	4.36	2.36
F	46	>61	3.73	1.77	4.25	2.36
All	132		3,69	1.94	4.18	2.47

Table 5
Generalized Linear Model (GLM) factor analyses, with a Poisson error distribution and a log-link function.

	Species			Uses	
	gl	Wald	*p*	Wald	*p*
Children					
Sex	1	3,97426	a	7,1105	b
Age	3	14,00258	b	24,8378	c
Sex*Age	3	0,87918	ns	0,5881	ns
Adults					
Sex	1	3,4195	ns	6,5746	a
Age	2	1,5767	ns	0,6147	ns
Sex*Age	2	4,5496	ns	3,0381	ns

ns = not significant.
[a] $p < 0.05$.
[b] $p < 0.01$.
[c] $p < 0.001$.

There was no significant effect of the age classes on the number of plants species or the number of different uses. *Malva sylvestris* L. was the most important species (74 informants; 79 citations; 8 used categories), followed by *Matricaria chamomilla* (62; 73; 8) and *Salvia officinalis* L. (50; 60; 7). Two of the five mostly cited taxa were local native (*Malva sylvestris* and *Matricaria chamomilla*), one regional native (*Mentha* sp.) and two cultivated (*Salvia officinalis* and *Rosmarinus officinalis* L.). The most frequently reported medicinal uses were for the digestive system (36 species; 122 citations), the general status problems (*i.e.*, a plant remedy used as a generic therapy aimed to play a "depurative", "tonic", "refreshing" or a general anti-inflammatory action) (34; 128), the respiratory tract diseases (29; 105) and the skin diseases (19; 59). The ICF values (Table 6) were higher for the neurological problems (ICF = 0.85) and the mouth problems (ICF = 0.82). The remedies were mostly prepared as infusion (52 species; 317 citations) and decoction (43; 188) and administered mainly by oral route (75 species; 500 citations). The most used parts were leaves, cited for 21 species (389 citations), followed by flowers, cited for 18 species (193 citations).

Children's and adults' knowledge compared

The adults performed significantly better than the children both on the number of known species (U = 4740; Z = –7.762; $p < 0.0001$) and the number of uses (U = 5307; Z = 6.956; $p < 0.0001$). Overall,

Table 6
ICF (Informant Consensus Factor) calculated for each cited use in both children and adults. # species: number of species; #: number of citations.

	# species	# citations	ICF
Children			
Digestive system diseases	13	98	0,88
Neurological diseases	6	35	0,85
Colds and respiratory tract diseases	10	55	0,83
Skin diseases and wounds	7	18	0,65
Headache	5	10	0,56
Eye problems	3	5	0,50
mouth problems	8	14	0,46
Earache and ear pain	5	8	0,43
Muscular and skeletal system diseases	2	2	0,00
Adults			
Neurological diseases	15	95	0.85
Mouth problems	10	51	0.82
General status	34	128	0.74
Colds and respiratory tract diseases	29	105	0.73
Eye problems	5	16	0.73
Digestive system diseases	36	122	0.71
Skin diseases and wounds	19	59	0.69
Headache	4	8	0.57
Other	6	11	0.50
Muscular and skeletal system diseases	13	25	0.50
Urinary tract diseases	14	26	0.48
Circulatory system diseases	11	18	0.41
Gynaecological problems	4	5	0.25
Fever	5	5	0.00
Metabolic problems	3	3	0.00
Preventive	3	3	0.00
External parasites	2	2	0.00

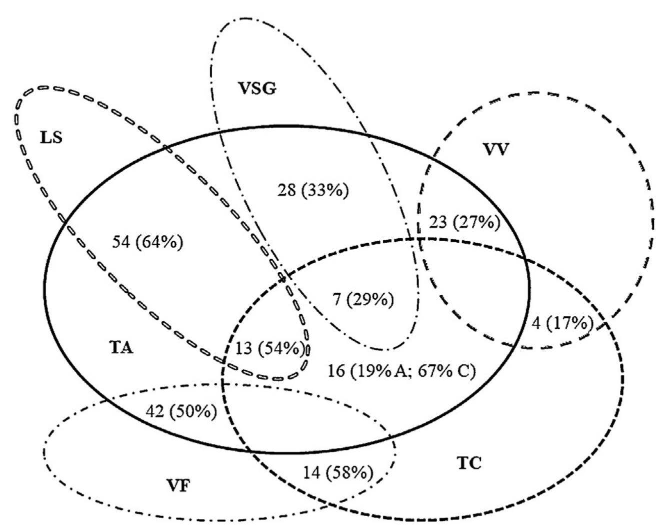

Fig. 2. Overlap of medicinal plants (native, cultivated and exotic) used in Tremezzina Valley (TA = adults; TC = children) and in neihburing areas. LS: Lombard Stelvio National Park (Vitalini et al., 2015); VSG: Val San Giacomo (Vitalini et al., 2013); VF: Valfurva (Dei Cas et al., 2015); VV: Valvestino (Vitalini et al., 2009). We reported the number and the percentage (calculated over the Tremezzina adults' and children's list) of common species.

the children listed about one third the number of species and uses adults reported. Sixteen species (67% and 19% of the species cited by children and adults, respectively) were common (Fig. 2); however, eight species (*Camellia sinensis*, *Citrus sinensis*, *Cucurbita maxima* Duchesne, *Foeniculum vulgare* Miller subsp. *piperitum* (Ucria) Bég., *Malus domestica* Borkh, *Mentha* × *piperita* L., *Oryza sativa* and *Petroselinum crispum* (Miller) Fuss.) were listed only by children. For example, *Cucurbita maxima* seeds are ingested to treat stomachache and vomit; *Malus domestica* fruits are mashed and ingested to treat flue and cough, eaten as raw against stomachache and toothache or directly applied on the skin to treat wounds; *Petroselinum crispum*

Table 7
Jaccard Similarity Index of medicinal plants (exotic excluded) in Tremezzina (TA = adults; TC = children) and in neighbouring areas. LS: Lombard Stelvio National Park (Vitalini et al., 2015); VSG: Val San Giacomo (Vitalini et al., 2013); VF: Valfurva (Dei Cas et al., 2015); VV: Valvestino (Vitalini et al., 2009).

Comparisons	species used in both groups	species used in one group only (group 1/group 2)	Jaccard index
TC vs. VV	4	16/54	0.05
TC vs. VF	14	6/77	0.14
TC vs. VSG	7	13/53	0.10
TC vs. LS	13	7/164	0.07
TA vs. VV	23	48/26	0.24
TA vs. VF	42	29/50	0.35
TA vs. VSG	28	43/33	0.27
TA vs. LS	54	17/123	0.28
TC vs. TA	13	6/57	0.17

leaves are directly applied on the skin against insect bites. *Oryza sativa* seeds are eaten as raw against stomachache and ear pain. *Foeniculum vulgare* subsp. *peperitum* seeds are infused and drunk for alleviating the vomit sensation. Differences were also recorded in the use of species common to both informant's groups. In particular, eleven uses were specific to the children. For example, the use of *Allium sativum* L. bulbs as a compress to treat ear pain or the use of *Arnica montana* L. and *Calendula officinalis* L. to make topical ointments for the healing of wounds and the treatment of burns. *Urtica dioica* L. leaves were reported to be used as treatment of joint sprains while *Solanum tuberosum* L. tubers were eaten against stomachache. An infusion of *Foeniculum vulgare* Miller subsp. *vulgare* var. *azoricum* (Miller) Thell. seeds is reported to treat insomnia and irritability. When comparing the ten most cited species in the children's and adults' lists, only three items were common (*Calendula officinalis*, *Malva sylvestris* and *Matricaria chamomilla*).

While 64% of the species listed by the adults were local or regional native, most of the plants (59%) cited by the children were cultivated or exotic; these were mainly species playing an important role in the global market and widely known and used for their medicinal (*Aloe vera*) and nutraceutical activity (*e.g.*, *Allium sativum*, *Camellia sinensis*, *Curcuma longa*, *Citrus limon*, *C. sinensis*, *Oryza sativa*, *Salvia officinalis, Zingiber officinale*). The similarity Jaccard index, carried out comparing our data with data collected in the neighbouring areas by other researchers, ranged from 24% (Tremezzina vs. Valvestino) to 35% (Tremezzina vs. Valfurva) for adults and from 5% (Tremezzina vs. Valvestino) to 14% (Tremezzina vs. Valfurva) for children (Table 7). Seventy-five (88%) species reported in the adults' list were common to these other studies while nine (13%) species were new (*Achillea erba-rotta* All. subsp. *moschata* (Wulfen) I. Richardson, *Atropa belladonna* L., *Capsicum annuum* L., *Crocus sativus* L., *Cupressus sempervirens* L., *Foeniculum vulgare* subsp. *vulgare* var. *azoricum*, *Oxalis corniculata* L., *Pilosella officinarum* Vaill. and *Sylibum marianum* (L.) Gaertn.). The students reported only basic ailments of childhood (stomach ache, nausea/vomit, cough, ear pain, insomnia etc.); the category of use "earache and ear pain" was reported only by students (five species and eight citations). The digestive system disorders was the most reported category of use by both the informant groups; nevertheless there were important differences concerning the detailed therapeutic uses. In the children's list seven species and 32% of the citations pertained to the treatment of vomit and nausea while twelve species (68% of the citations) concerned stomach ache. In the adults' list only two species (1.6% of the citations in this category of use) were used to heal vomit.

Acquisition of the medicinal plant knowledge

Adults reported that sources of their medicinal plant knowledge were first the family members (75% of the total citations). A secondary source was represented by the individuals belonging to the community (16%). Exogenous ways of transmission accounted for about 14% of the total citations and most of them (85%) concerned the use of the exotic species. The sum of percentages is higher than 100% because some respondents indicated more than one source of knowledge. For example, knowledge of *Arnica montana* and *Calendula officinalis* uses were reported by some informants both as endogenous (transmitted by family or community members) and exogenous (herbal shops or media). When we compared these categories, significant differences among responses were found ($t = 52.29$; $p < 0.0001$). By analysing data concerning the families where both the parents were interviewed, we found that 100% of the plants' uses reported by children were also shared by their parents. In particular, 95.8% (±7.9) of the medicinal uses reported by children were shared by their mothers while only 41.0% (±39) of them were shared by their fathers. A similar rate of correspondence was observed when the information was collected by interviewing only one parent: the mother (93.4% ± 4.7) or the father (52.5% ± 28.7). Spearman correlation test showed that the number of medicinal plants cited by children was not significantly related to that reported by the full sample of mothers (0.33; $p > 0.05$) and fathers (0.36; $p > 0.05$) suggesting that children's acquisition of medicinal knowledge does not depend on the amount of species reported by their parents.

Discussion

We want to highlight some limitations of the used methodology, before discussing the main results of our study. Firstly, information was collected by children through interviews to their own family members at home without any direct researcher's supervision. Despite children were trained for the interviews by our team (see materials and methods), we cannot exclude bias due to the "interviewer effect" (*i.e.*, different personal characteristics and dispositions of the interviewers reducing the precision of survey) (Bailar et al., 1977). This could be the reason why 10% of the adults did not report any medicinal plants or use. Secondly, given the small number of men participating in the study, it was not always possible to collect the ethnobotanical information from both the parents of each child, which limits the comparison between children's vs. adults' knowledge and makes it more difficult to track the intergenerational transmission of this knowledge. Finally, it was not possible to systematically collect data concerning the profession, education and income of the family members because they were often regarded as private information by most of the informants. Socioeconomic factors have been proved to affect ethnobotanical knowledge (Giovannini et al., 2011; Quinlan et al., 2016). Although our investigation is limited to a small geographical area, it yields valuable insights into the understanding of children's knowledge of medicinal plants, a subject not studied before in Italy.

Children's knowledge about the medicinal plants

Students interviewed in this study reported the use of 24 medicinal species (245 citations); 78% of them listed at least one species but only 9% showed to know more than three species and uses. Moreover, they mentioned a significantly lesser number of species and uses than adults. Overall, these numbers reveal a relatively low knowledge of plants when compared with those from the ethnobotanical studies conducted in subsistence-based communities of tropical countries (Stross, 1973; Hunn, 2002; Setalaphruk and Price, 2007; Quinlan et al., 2016; Cruz-Garcia et al., 2018). However, when we compared our results with the children's plant knowledge in other industrialized countries, Tremezzina children were found to know a similar or greater number of species. For example, Bebbington (2005) found that only a few primary school age children were able to name more than three very common wild flowers in the UK. In their study, Strgar et al. (2013) showed that the students of the secondary schools have little knowledge of the uses and effects of medicinal plants. Data extrapolated from a study on traditional ecological knowledge in an Alpine rural community showed that informants in age class 8–18 know a limited number of medicinal plants but have completely lost any knowledge of their uses (Ianni et al., 2015). Menghini et al. (2015) reported that only 40% of the students attending a pharmacy degree course declared to know and use herbal-based products. The loss of knowledge in the younger generations has been explained as a consequence of cultural erosion caused by different factors such as the influence of modern culture and education systems, the globalization of trade and the access to modern medicines (Vandebroek and Balick, 2012). For example, some authors hypothesize that students attending school have less time to learn and experience ethnobotanical knowledge (Reyes-García et al., 2010). Children living in subsistence-based rural communities are deeply integrated into daily life, work and interact in the management of local resources, and have the opportunity to learn about plants through direct observation and gradual participation (Hunn, 2002; Setalaphruk and Price, 2007; Gallois, 2015; Quinlan et al., 2016). This experience-based model of knowledge acquisition has been largely compromised in the western cultural contexts (Pergams and Zaradic, 2008), causing a phenomenon referred to as the "extinction of experience" in child development literature (Kahn and Kellert, 2002). According to Giovannini et al. (2011), the increased exposure to global culture and the extinction of experience may strongly impact on ethnomedicinal knowledge and could "ultimately lead to a reorganization of the way medical knowledge is distributed and healthcare is provided in a community".

Children interviewed in this study listed eight species and eleven uses that were not reported by adults. These results seem to suggest that some of the Tremezzina children's knowledge of medicinal plants is specific to them. However, we cannot claim that these results support the idea that there is a true children's ethnobiological culture (*i.e.*, "a set of practices and knowledge produced by children for themselves, separated from the adult's world", according to Gallois et al., 2017). When asked about this issue, most of the relatives asserted to be informed of the items reported by children. In the words of two adult informants: "We know these remedies and we usually pass on to our children information about them"; "I used these remedies when I was child but now I do not use them anymore. They are typical of the childhood years". Differently, other adults stated to be completely unware of the items children listed. Tremezzina children know plants and uses for treating very common ailments or injuries occurring in childhood (Table 6). This set of practices is not necessarily retained as children move into adulthood (Gallois et al., 2017). However, we cannot claim that this knowledge is produced by children and is limited to child-child relations; instead, almost in the studied area, children's use of herbal drugs is encouraged and controlled by parents and it is strongly influenced by the relations with the adults at home, school and with the sociocultural and environmental context in which the children live.

What was more interesting in our study was that contents and nature of knowledge were different between the children and the adults. The low number of wild species in the children's list is in agreement with Campos et al. (2012); Bermudez et al. (2017) and Cruz-Garcia et al. (2018). This finding could be explained on the basis of student's direct observation of the plants grown in home yards or fields (*e.g.*, *Aloe vera*, *Allium sativum*, *Foeniculum vulgare* var. *piperitum*, *Mentha* × *piperita*, *Oryza sativa*, *Salvia officinalis*, *Thymus serpyllum*) and of the products (*Citrus limon* and *C. sinensis* fruits) commonly eaten as part of the daily diet. Exotic drugs such as *Curcuma longa* and *Zingiber officinale* are purchased by children's relatives in the supermarkets and are widely used mostly as spices and marginally for therapeutic applications. Most of the wild species reported by students are rather common in the surrounding environment and are well recognizable (*e.g.*, *Malva sylvestris*, *Melissa officinalis*, *Urtica dioica*), confirming that children learn more easily the use of easy-to-target species growing in the close environment (Quinlan et al., 2016; Gallois et al., 2017). The significance of these results is reinforced by comparing information collected in our study with ethnobotanical data obtained in neighbouring areas. Using Jaccard Index, we found that the adults' knowledge was more similar to that reported for other investigated valleys than the children's one. Taken as a whole, these data suggest that the adults' knowledge is more intimately connected to the wild resources growing in the area and then attributable to a corpus of endogenous cultural knowledge developed within the community.

Effect of age and gender on medicinal plants knowledge

A finding of our study was that girls performed better in listing plants and uses than boys. This supports the idea that girls are more interested in learning about medicinal plants (Dawson, 1983; Gatt et al, 2007; Kos and Jerman, 2015) and may reflect different gender-based interests and preconceptions (Campos et al., 2012). The results of our investigation also showed that children's knowledge significantly increased with the age. This is not surprising and it's in line with the findings reported in previous empirical studies. For example, Hynes et al. (1997) showed that 10–14 years old children living in a montane environment of northwestern Argentina could identify plants and name their uses better than 6–9 years old children. The same finding was reported by Gallois (2015) who showed tha Baka children's knowledge varied according to age. Similarly, Cruz-Garcia et al. (2018) showed that age was one of the main factor impacting on children's knowledge of the wild food plants in the Ucayali region of Peru, with the older kids showing a more rich knowledge of plants than the younger ones. As reported in several ethnobiological studies (see for example, Zarger and Stepp, 2004; Demps et al, 2012), childhood is the period when knowledge of the local environment and skills are most efficiently attained, and these knowledge and skills increase with the age and the direct experience of the individuals in the process of passing to the adulthood. In other words, children have fewer direct experiences in nature and cognitive skills than adults, but they could achieve adult rates of knowledge over time. Because we did not systematically interview middle and secondary school students, it was impossible to assess the existence of a process involving a gradual accumulation of knowledge during transition to the adulthood life stage (Quinlan and Quinlan, 2007). However, our study showed that some children had the same amount of knowledge than adults and some adults had lesser knowledge than children, confuting the hypothesis about a linear increase of knowledge acquisition. Similar conclusions were drawn by Wyndham (2010) and Vanderbroeck and Balick (2012).

When we analysed data concerning the adult informants' group, a significant difference was found in the number of uses mentioned by women and men but no difference in the number of mentioned species. The significantly higher number of uses reported by women might been influenced by the higher number of women interviewed (Table 3). Nevertheless, it is expected that women would know more medicinal uses than men since women in this area represented the primary healthcare providers for the family until the recent past, a situation that prevails in other Italian regions (Savo et al., 2011).

Elderly informants did not always show to be the most knowledgeable individuals within the studied community. As a matter of the fact, knowledge of plant species seems to drop after 60 years old (Table 2). This is an interesting finding because ethnobotanists usually work with the elders which are considered to have a greater knowledge on plants and the local environment. As suggested by Demps et al. (2012), decrease in mental functions and physical abilities may contribute to the decline in maximum knowledge score as people age. We can also interpret this pattern as a specific cultural interest in herbal products by younger generations within the “green wave” and healthy lifestyle framework. These results raise questions about the role of elders as holders of ethnobotanical knowledge within the community and about the intergenerational transmission of this knowledge within the family. Ramet et al. (2018), for example, did not find a significant relationship between the proximity to grandparents and the children’s knowledge of medicinal plants in two groups of Spanish scholar children. They hypothesized other factors explaining this knowledge acquisition such as direct observation of the surrounding environment, contact with peers, school programs or personal interest in medicinal plants.

Acquisition of the medicinal plant knowledge

Transmission of ethnobiological knowledge has mainly been studied in rural communities of tropical and sub-tropical areas (see, among the others, Zarger, 2002; Reyes-Garcia et al., 2009). The number of studies carried out in European countries is more limited (Dolan, 2007; Dopico et al., 2008; Calvet-Mir et al., 2016). Data collected in our study suggest that adult informants learned about the use of medicinal plants mainly from their family (for similar results, see Lozada et al., 2006; Dopico et al., 2008). The results of cross-checking the information reported by children against data from their own families indicate that family members (especially the mothers) are the most important sources of knowledge for the new generations too. Tremezzina children know species for improving health and alleviating symptoms, especially in families where at least one parent also uses these species. Nevertheless, we also observed other ways of acquiring knowledge in adult sample (*i.e.* from individuals belonging to the community and from exogenous sources). All these results may suggest that medicinal plant knowledge is first acquired within the family context during childhood but that it changes as a result of a lifelong exposure to other knowledge sources, including exogenous ones. Similar considerations were made by Mathez-Stiefel and Vandebroek (2012) studying the transmission of medicinal plant knowledge in rural Andean communities. In particular, the exogenous sources of information (books and newspapers, internet, television, herbal practitioners) seem to influence the local medicinal knowledge by introducing the use of several exotic species. Some authors have shown that market integration can strongly affect ethnobotanical knowledge (Benz et al., 2000; Reyes-García et al., 2005). According to Reyes-García (2010), increasing exposure to market economy and to new commercial herbal products, might influence ethnopharmacological knowledge in a way where the concept of “local tradition” may be constantly reinvented. On the other hand, this has to be viewed as an inevitable process in the era of globalization. In particular, children are cultural sponges (Mesoudi, 2011), they are able to rapidly get information from different sources and to use this information to produce a new knowledge.

Conclusions

Through the focus on children’s knowledge, our research offers the opportunity to get valuable qualitative and quantitative data on common healing herbs used within the Tremezzina community. This knowledge is constantly growing and changing, updated with new information coming from different sources. As many of the youngest generations living in other western cultures (see for example, Menéndez-Baceta et al., 2017), Tremezzina children could be experiencing the interactive and overlapping nature of different sources of knowledge. New generations should be aware of the value and crucial contribution of the traditional knowledge to the adaptation and resilience of human societies and be empowered to build their own sustainable future based upon both the endogenous and exogenous sources. For this reason, it is important to collect more information on introduced vs. traditional plant uses and how this medicinal knowledge is disseminated within the community; this should provide baseline and target data for educational activities in the conservation of the local biocultural diversity. It is in this perspective that we suggest to identify and plan school-family activities (*e.g.*, meetings between key informants and students) to preserve memory of traditional plant uses and to foster intergenerational dialogue over all area involved in this study.

Conflicts of interest

The authors declare no conflicts of interest.

Author contribution

PB: design of the study, data analysis and interpretation, writing of the paper; MS: performing of the experiment, data collection; AM: performing of the experiment, data collection; MAS: design of the study, writing of the paper; GF: design of the study, data collection, data analysis and interpretation, writing of the paper. All authors have given approval for the publication of the final version of the paper.

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