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ETHNOBOTANICAL STUDY OF MEDICINAL PLANTS USED BY K'HO-CIL PEOPLE FOR TREATMENT OF DIARRHEA IN LAM DONG PROVINCE, VIETNAM

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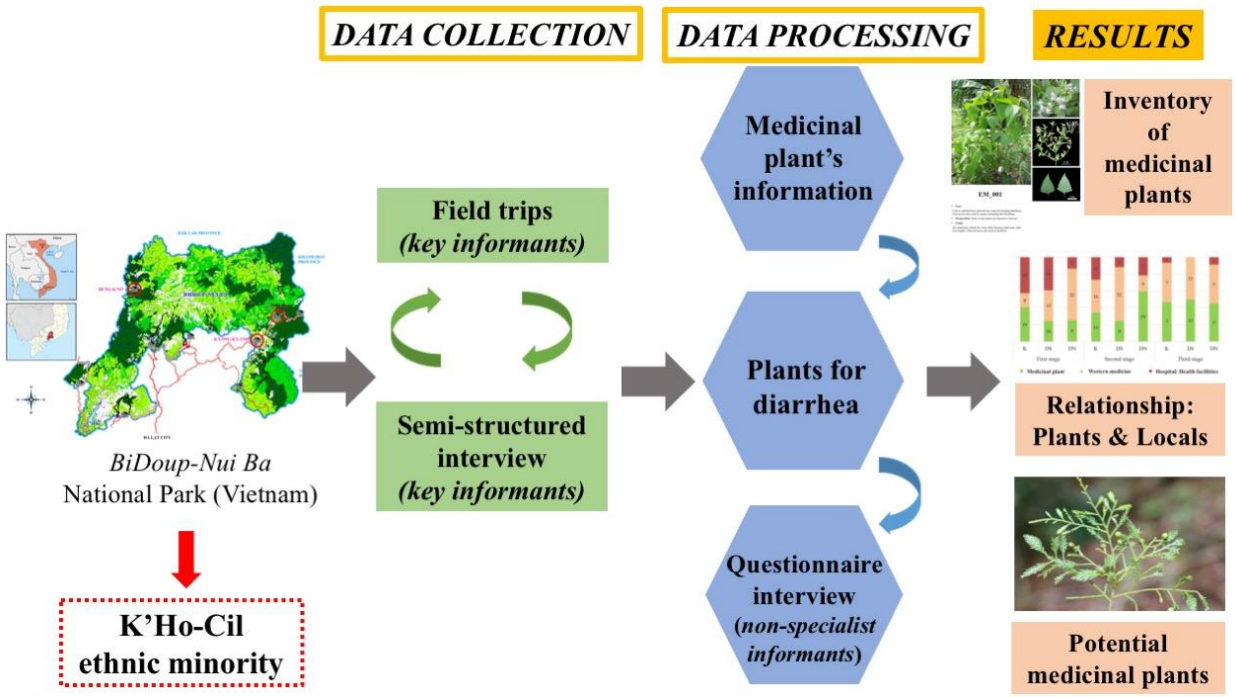
Graphical abstract



Abstract

Background: Many medicinal plants have been used in Vietnam but most of them have not been studied and documented. In this study, the traditional plants used by K'Ho-Cil people living in BiDoup-Nui Ba National Park, Vietnam for treatment of diarrhea and identified potential medicinal plants were documented.

Methods: Information of the medicinal plants used was collected through field surveys and semi-structured interviews with key informants. Plants used for anti-diarrhea were selected for further analysis in structured questionnaires. The potential medicinal plants were identified through quantitative tools: fidelity level (FL) and choice value (CV). The relationship between traditional knowledge and gender, age and geological site was also evaluated using statistical analysis.

Results: Of the 133 taxa reported by 12 key informants, 34 anti-diarrheal plants were confirmed by 127 non-specialist informants. Interestingly, these plants were also used for 35 other health problems. Among the medicinal plants, Asteraceae was the most predominant family. *Elephantopus mollis* and *Chromolaena odorata* belonging to this family with the highest CV were the most preferred ones in diarrheal treatment (1.23 and 1.04, respectively). Moreover, in regard to FL and literature review, several potential plants for further studies were identified, for example *Hedyotis capitellata* var *pubescens* and *Syzygium ripicola* (FL = 100%), or *Clitoria mariana* and *Dacrycarpus imbricatus* (FL = 80%).

Conclusion: In Vietnam, folk medicine has been widely used by many people without documentation for preservation and scientific study. This study contributes a database of anti-diarrhea plants used by K'Ho-Cil people living in BiDoup-Nui Ba National Park, Vietnam.

Keywords: Ethnobotany; medicinal plants; diarrhea; fidelity level; knowledge transmission; K'Ho people.

1. Introduction

The widespread use of common folk medicine is an important widely used in most countries around the world. In some Asian and African countries, about 80% of the population relies predominantly on plants and plant preparation for primary health care (WHO, 2013). In Vietnam and China traditional plant-based medicines are being integrated into the national mainstream healthcare system (Kew Royal Botanic Gardens, 2017; Ngo and Tran, 2011). Recently, the trend of using herbal medicines alongside pharmaceutical drugs has become popular in some Western countries (Kew Royal Botanic Gardens, 2017). In addition, medicinal plants also offer significant economic benefits. Sales of plant-based drugs in the United States amounted to 15.5 billion dollars. The precise value of global markets for products derived from plants is difficult to estimate, but it is clear that the industry is growing rapidly by over 4% per annum (Kew Royal Botanic Gardens, 2017; Saroya, 2011).

Vietnam is the easternmost country on the Indochina Peninsula in Southeast Asia with its own long traditional medicine history. For several thousand years, Vietnamese Traditional Medicine (VTM) has evolved under the shadows of Chinese Traditional Medicine, culture, and rule but medical texts and instruments found in Northern Vietnam suggested that Vietnamese people already had a developed system of medicine. In addition, among Chinese medical texts from the 4th century B.C., references were given to the "Yue Prescriptions", indicating that "Thuoc Nam" (Southern Medicine or Vietnamese Traditional Medicine) was an established discipline, discriminated from "Thuoc Bac" (Northern Medicine or Traditional Chinese Medicine). However, traditional Vietnamese and Chinese Medicine continued to evolve closely for the next millennium as a consequence of Chinese's conquest (Thai, 2011). It can be said that VTM has developed from its early beginnings and gradually developed into an essential part of

the present-day Vietnamese medical system like Oriental traditional medicine, VTM was built based on the philosophy of ancient dialectical materialism presented in works such as I Ching, Confucius and Lao-tzu and discriminated from the logical foundation of modern medicine (Woerdenbag et al., 2012). In recent years, traditional medicine particularly from medicinal plants, has drawn much attention from Vietnamese government, institutes and researchers, demonstrated through the increased number of publications over time. However, it is regretted that most of them are written in Vietnamese or just presented within national conferences. Moreover, previous and present studies mainly focus on chemical properties and pharmacological activities while medicinal plants and indigenous knowledge still have other interesting issues that are not thoroughly studied (Nguyen et al., 2001). According to the non-exhaustive survey of the Institute of Medicine (Ministry of Health), at the end of 2005, there were 3,948 species of plants and mushrooms used as medicinal drugs in Vietnam. In regard to their origin and distribution, over 85% of these species are found in forest habitats and mostly used as folk medicine (Project Support specialized non-timber forest products in Vietnam - stage II, 2007) (Luu, 2009). Only about 20-30% of total species have been assessed for their therapeutic activity and mechanism of action, which implies that many species may have not yet been discovered.

It is estimated that nearly 25% of modern medicines are derived from nature, many of which were derived from traditional uses (De Luca et al., 2012) and the recent document of Kew Royal Botanic Garden reported at least 28.187 plant species are currently recorded as being of medicinal use (Kew Royal Botanic Gardens, 2017). However, traditional medicinal plants and indigenous knowledge now fade because most of home remedies are mainly verbally transmitted from generation to generation. In addition to the changes in the economy, culture and society such as the neglect of the younger generation to inherit this precious knowledge from their family, the overexploitation of the environment seriously threatens medicinal plant resources (Kim, 2007; Simbo, 2010). These reasons above motivated us to carry out a comprehensive ethnobotanical study of medicinal plants used by K'Ho-Cil people, one of ethnic minorities in Vietnam. The local people reside in the area of BiDoup-Nui Ba National Park, Lam Dong Province for a long time and have a close relationship with the forests but their traditional medicinal plants have been poorly studied. Only some studies have been conducted on biodiversity or non-timber products. In ethnobotanical studies, apart from documents which extensively report knowledge of plants held by native groups, there are also some works designed to quantify the local knowledge using popular indices of relative or cultural importance. It has become increasingly common among ethnobotanists to apply rigorous scientific methodologies in analyzing diversified ethnobotanical data over the last fifty years. According to Phillips (1993), the quantitative approaches for analyzing informant knowledge can be grouped into three categories: informant consensus, subjective allocation and total uses (Phillips and

Gentry, 1993). In the two latter approaches, the relative importance of each plant used is subjectively assigned by the researcher whereas it is obtained directly from the informant's responses in the informant consensus method. One of its applications is the classification of potential medicinal plants according to their rank-order priority or fidelity level before performing experimental evaluations (Friedman et al., 1986). Therefore, the aim of the present study is to document systematically plants used by local people for treatment of diarrhea. In addition, potential healing plants are also identified based on fidelity level, a quantitative tool in order to provide further information for phytochemical and pharmacological studies in future.

2. Material and Methods

2.1 Study area

BiDoup-Nui Ba National Park (BNNP) (12°00' to 12°52'N, 108°17' to 108°42'E), one of four centers of biodiversity in Vietnam, which is entirely located within Lac Duong District and a small portion of Dam Rong District, Lam Dong Province, Central Highland of Vietnam (Figure 1), covers an area of about 70,038 hectares.

Although BNNP is situated in the tropical monsoon region, the high elevation contributes to its cool climate, leading to its rich diversity of vegetation. The annual average temperature is about 18^0C with high humidity (over 80%) and the average rainfall is about 1,800 mm. However, in areas with elevation above 1,900 m such as Bidoup, Hòn Giao,and Gia Rích, the rainfall can reach 2,800-3,000 mm per year (Nguyen and Kuznetsov, 2011).

K'Ho is one of fifty-four ethnic minorities in Vietnam, using the Môn-Khmer language. They embrace five minor groups: Sre, Lạch, Mạ, Cil and M'Nông who reside in different parts of Southern Central Highland area and Lam Đong Province, Vietnam. According to national demographics in 2004, the K'Ho's population was approximately 14,585,000 and they mainly settled in Lam Dong Province (Niê K'Dam, 2011) .

K'Ho-Cil community follows matriarchy system in which descent and relationship pass through the female line. They have a nomadic farming lifestyle but at present the local people develop settled agriculture. Their major income is derived from the sales of coffee (one crop per year). Moreover, farming, hunting and gathering non-timber forest products like firewood, mushrooms, bamboo shoots and orchid flowers and handicrafts also supplement the household income, especially in the period after harvest time.

Nowadays, owing to the government's investment in infrastructure (roads, hospitals, schools, …), the living condition of K'Ho-Cil people has been much improved. However, they still retain their close connection with natural resources, especially medicinal plants for daily health care.

2.2 Collecting ethnobotanical information

Three villages of K'Ho-Cil people, namely K'Long K'Lanh (K), Đưng K'Si (DS) and Đưng K'Nớ (DN), were the subjects of an ethnobotanical study from 2013-2015. In order to have an overview of traditional medicine from local people, K and DN villages were chosen because they were located not only near the forests (core zone) but also on two different sides of BNNP with different vegetation covers. In addition, DS village, adjacent to K village, was also chosen for an ethnobotanical hypothesis test (Figure 1).

Prior to the survey, preliminary meetings with local authorities, leaders and representatives of villages were organized with the assistance of BNNP's officials in order to explain the aims of the study and to obtain their verbal agreements in documenting the traditional knowledge of medicinal plants.

The collection of information was carried out in two progressive stages:

- First stage (May 2013 - March 2014): A total of 12 key informants knowledgeable in using medicinal plants were contacted according to advice from local authorities and habitants as well as BNNP's officials. Researchers accompanied key informants on field trips to collect all medicinal plants that they encountered along the routes. The information of 133 traditional plants obtained through semi-structured interviews was recorded following Martin's method (1995) (Martin, 1995). From which, 37 plants mainly used for the treatment of diarrhea, one of the most prevalent health problems in the study area, were compiled into an illustrated book with the photos of each plant in its natural habitat in order to facilitate an extensive interview later.
- Second stage (July-August 2015): About 10% of total households in each village were randomly chosen for the extensive ethnobotanical study. A total of 127 non-specialist informants participating in structured interviews were independently asked about the 37 plants present in the illustrated book which was prepared during the first stage. They were interviewed using the same set of questions (questionnaire), such as do you know this plant? If so, have you ever used it for any medicinal purposes and which plant parts do you use in the treatment of health problems? and others… (Appendix A). For each household, the interviews were conducted in the presence of the head of the family, usually the husband and/or wife and their children over the age of 12. Most of the informants were familiar with the Vietnamese official language (Kinh) so that they were able to understand and reply in Kinh. But whenever necessary, translation was done by the head of the village or key informants accompanying the researchers.

2.3 Botanical identification

All plants mentioned by key informants were collected two-fold, coded, and dry-pressed in the field. One set of voucher specimens was deposited at the Herbarium of University of Science, Vietnam National

University, Ho Chi Minh City (HCMUS) and the second one was preserved at BNNP.

The taxonomic identification was carried out by PhD. student, a botanist, Nguyen Xuan Minh Ai with the help of standard literatures (Lecomte, 1907; Pham, 2001). The nomenclature of identified plants followed The Plant List (The Plant List, 2013) while the taxonomy system referred to Tropicos® (Tropicos, 2017).

2.4 Data analysis

2.4.1 Fidelity level (FL)

The FL was firstly introduced by Friedman (1986) to quantify the importance of a species for a given purpose (Friedman et al., 1986).

The fidelity level of each plant was determined as follows:

$$FL = \frac{I_p}{I_u} \times 100$$

in which: I_p is the number of informants who suggested the use of the species for the same major purpose, here being anti-diarrhea/dysentery.

I_u is the total number of informants who mentioned the plant for any medicinal use.

It is assumed that medicinal plants which are more frequently cited by respondents for the same category are more likely to be biologically active plants (Giday et al., 2009; Tariq et al., 2015).

2.4.2 Choice value (CV)

Kremen (1998) suggested the choice value (CV) to determine the most preferred species in each use category (Kremen et al., 1998). In the present study CV was used to measure relative preference for treatment of diarrhea.

$$CV = \frac{P_{cs}}{S_c}$$

in which: P_{cs} is percent of informants who cited certain species for diarrheal treatment

S_c is total number of species mentioned for treatment of diarrhea by all informants

CV ranges from 0 to 100, in which a species with higher value reflected greater preference and/or few alternatives.

2.4.3 Status of plants

The status of each medicinal plant according to the Vietnam Red Data Book (flora section) (2007) (Vietnam Academy of Science and Technology, 2007) and IUCN Red List of Threatened Species (2016) (International Union for Conservation of Nature and Natural Resources, 2016) was verified.

2.5 Statistical analysis

Data were analyzed using the SPSS software, version 23. Pearson's Chi-Square test, paired *t*-test, independent *t*-test and ANOVA one-way tests were performed to test significant differences among studied variables with α=0.05.

3. Results and discussion

3.1 Demographic characteristics of local informants

The social demography of 127 non-specialist informants participating in the ethnobotanical interviews is detailed in Table 1. There were 47 people from K; 41 from DS and 39 from DN with an age range of 12 to 70 years (mean = 34.9 ± 2.2); 12 to 63 (mean = 33.6 ± 1.7) and 12 to 84 (mean = 45.9 ± 2.8), respectively (Figure 2). The average age of males and females was 39.3 ± 2.1 and 36.6 ± 1.8, respectively. There was no significant difference (independent-samples *t*-test, p = 0.35) in informants' ages between genders (Figure 2).

Most local people mainly depended on agricultural practices as a means of income (94.5%) but with old fashioned cultivation techniques. Some families also raised cattle with funding from local authorities. It was also noted that no one was a traditional practitioner or an herbalist, even the 12 key informants.

3.2 Overview of K'Ho pharmacopoeia

From the field surveys with the 12 key informants, 133 taxa used for all medicinal purposes were recorded. Of which, 37 species were mainly used for diarrhea, one of the most prelevant ailments in the study area and were, therefore, selected for an extensive ethnobotanical survey with 127 non-specialist informants. The criterion for consensus was that medicinal plants cited by less than three individual reports would be excluded from any further discussion (Johns et al., 1990). As a result, there were 34 plants mentioned by at least three local people not only for the treatment of diarrhea but also for a variety of health problems (35 disorders) (Table 2). This result showed the effectiveness of using extensive interviews with non-specialist informants for cross-checking and adding further information which had previously been gathered from key informants (Grosvenor et al., 1995a).

The majority of the 34 K'Ho medicinal plants were used individually (73.5% of total plants), known as single-ingredient remedies. Only 9 species (33 citations, 3.6% of total reported) were prescribed in combination with others for treatments, but the combination was quite simple using 2-3 plants only or the medicinal plants were used with other elements (salt, honey, eggs). For example, *Mimosa pudica* was combined with *Zingiber officinale* and *Cymbopogon* spp. to treat malaria, while *Paederia microcephala* was mixed with fresh eggs and the mixture was either used directly or cooked for the treatment of

diarrhea. The popularity of simple herbal recipes of K'Ho people was obviously different from the practice which was found with Bunong people (Cambodia) who utilized up to 68% of the total of plants collected in multi-ingredient remedies (Chassagne et al., 2016). Teklehaymanot and Giday (2007) reported that healers tend to use multiple prescriptions more than non-healers (Teklehaymanot and Giday, 2007). This was also found to be true in the present study where the use of the combination of medicinal plants was usually reported by key informants who were knowledgeable about the plants.

3.2.1 Diversity of medicinal plants

Regarding the distribution of medicinal plants in the taxonomy system, 34 taxa belonged to 20 genera, 21 families, 16 orders, 2 subclasses. Of these, Asteraceae was the most predominant family with 7 species cited (20.5% of the total plants), followed by Fabaceae (4 species, 11.8%). The remaining 19 families contained one to two species (Figure 3A). The fact that Asteraceae was one of the most common medicinal families was also reported in previous studies (Aati et al., 2019; Bahmani et al., 2014; Luziatelli et al., 2010). This is probably due to its widespread growth and large number of species.

3.2.2 Growth forms and habitats

Of the 34 medicinal plants, herbs and trees were dominant with 11 species for each group (32.4%), followed by vines/ lianas/ climbers with 6 species (17.6%) while shrubs, geophytes and hydrophytes contributed only 2 taxa of the medicinal flora (5.9% each) (Figure 3B). The common growth form of the first two groups was also found in a study by Luziatelli et al (Luziatelli et al., 2010; Umair et al., 2019).

Up to 85.5% of medicinal plants were wild and were found around the residential area, in the forest or along the riverbank. Only 3 species (8.3%) were cultivated in home gardens/ farm plots and 2 species (5.9%) were found in both wild and private areas (Figure 3C). There is no special protection or care given to wild plants. The fact that medicinal plants derived from the natural environment occupied a high proportion of K'Ho pharmacopoeia suggested that they still played an important role in health care among indigenous people.

3.2.3 Plant parts used

Regarding the plant parts used in the treatment of diarrhea and of other health problems, leaves were the main part used in both groups, making up 45.5% and 51.5% of the total citations, respectively. The second choice were roots/ tuberous roots making up 28.2% (diarrhea) and 21.3% (other medicinal uses). The remaining plant parts, such as sprouts, bark, stems/ rhizomes or the whole plant, were also utilized but they occupied a relatively small proportion of plant choice. While sprouts and bark were preferred for the treatment of diarrhea, they seemed to be used less for other ailments. In addition, flowers and latex

were only seen in several remedies for certain diseases, but not diarrhea (Figure 4B).

In previous studies, leaves were also prefered in traditional recipes (Kidane et al., 2018; Umair et al., 2019). Bhattarai (2006) suggested that leaves and roots were selected more than other parts because they were physically more vulnerable than fruits, seeds or stem bark, so they would potentially produce more chemically defensive compounds (Bhattarai et al., 2006).

3.2.4 Mode of preparation and administration

The K'Ho people preferred fresh material for preparing home remedies rather than dried (96.2% versus 3.8% of total reported) (Figure 4A). It could be due to the urgency of certain health issues. The thirty-four plants mentioned here were mainly used for diarrhea/ dysentery, followed by external injuries such as wounds or boils. These acute ailments need to be treated immediately with a minimum of preparation. Often in emergencies, the material was first used fresh (starting dose) and thereafter more carefully prepared (e.g. infusion, decoction) with fresh or dried material to continue the treatment more efficiently (maintenance dose). This result was higher than that of Bussmann'study (2010), in which the authors reported more than 60% of medicinal plants were prepared from fresh material for reproductive problems and female health in Northern Peru (Bussmann and Glenn, 2010).

The mode of preparation of herbal drugs was illustrated in Figure 4D. Although leaves were the most preferred plant parts used for both groups, diarrhea only and other ailments, each group also had their own preferred method of preparation, in which decoction was the first choice for diarrhea (57,7% of total citations), followed by "without preparation" where the plants were eaten directly or chewed in one's mouth (27.6%). For the "other ailments" group, simple methods of preparation were firstly chosen, including rub (29.9%) and crush (18.1%) in which the plant parts were impacted by hands or pestles. The decoction was in second place in that group (23.9%).

Regarding the route of administration, oral route was more largely predominant than topical one (98.0% versus 2.0% of total citations) for diarrheal treatments. In the "other ailments" group, herbal drugs were prescribed in more diverse ways. Among them, topical application was the most preferred method (56.7%), followed by oral (34.1%), bath/ steam bath (8.1%) and inhalation (1.0%). The popularity of a certain administration partially depends on the type of ailment, i.e. internal administration was normally used to treat internal conditions and vice versa, which is also true in the present study. However, there were some special instances which did not follow the general trend. For example, to treat diarrhea, besides the decoction taken orally, leaves of *Melicope pteleifolia* were also rubbed and applied on the abdomen or the whole plant of *Polygala paniculata* was used in steam baths for people who had high temperature. It was interesting that both medicinal species contained essential oils which can partially be attributed to pain relief and cooling effects (Pizzolatti et al., 2009; Thang et al., 2015). In such cases, external application should be effective for internal diseases (Chassagne et al., 2016; Grosvenor et al.,

1995a).

In the study area, the recommended dosage varied among informants for treating the same health problems. Hence, the measurements used to determine the dosages were not standardized and depended on the age and physical appearance of each individual. Usually they estimated through various ways, including fist size, bowls with a diameter of about 12-15 cm or small glasses with a volume of around 80 mL (similar to a shot glass). In general, children are usually given less than adults. For example, they are given one fourth of a coffee cup (2-5 ml) whereas adults take one glass (approximately 250 ml). As a result, traditional medicinal knowledge is often considered as having a lack of precision and standardization.

3.3 Traditional knowledge and geographical, social factors

Verma (2010) suggested that health status of different communities, particularly the tribal groups was influenced by their way of life including their social and economic conditions, age, socio-religious beliefs and superstitions, etc. (Verma et al., 2010). Therefore, a hypothesis is set whether there is a relationship between the knowledge of medicinal plants which is represented by the number of medicinal plants reported by informants and social factors, including gender, age and geographical features.

In terms of informant's gender, no difference in the number of medicinal plants reported was found between men and women (independent-samples *t*-test, $p > 0.05$). Although K'Ho society follows a matriarchy system in which descent and relationship are reckoned through the female line, even so the role of men in families is now becoming more recognized. They can now also learn and share knowledge of traditional medicine with other members, which had previously occurred only among females. This is contrary to Hoang's results (2008), who studied traditional medicinal plants in Bến En National Park (Vietnam), where women were reported to be mainly responsible for health care and collecting herbal medicines and also had a better knowledge of traditions than men at almost every age level (Hoang et al., 2008).

There seems to be a positive correlation between knowledge of medicinal plants and age of informants ($r = 0.254$, $p < 0.05$). However, the ANOVA (Analysis of Variance) test showed no significant difference in the number of cited plants among age groups. This might be because plant knowledge was also influenced by other factors.

It was expected that people living in areas further away from town center (DN village) more frequently resorted to medicinal plants for daily health care needs than those living close to town center (K and DS villages). However, the number of plants reported by people living in K village was equal to

those of DN village (7 plants) whereas the number of plants used in DS was the least (4 plants) (one-way ANOVA test, $p = 0.005$). This again showed that plant knowledge was simultaneously influenced by many variables.

In regard to ethnic group, most informants were K'Ho (96.8%). Included among the "other groups" (3.2%) were Kinh (2 people), ChuRu (1) and Mường (1) (Table 1), who came from other areas and settled there after marrying K'Ho women. It became clear that the number of medicinal plants they used was significantly less than those who were born in the village.

3.4 Fidelity level (FL) – Proposed potential healing plants

The World Health Organization (2013) reported that diarrhea is the second leading cause of death in children under five years old and is responsible for killing around 760,000 children every year. Globally, there are nearly 1.7 billion cases of diarrheal disease every year (WHO, 2013). Although the disease is usually not severe and patients can recover eventually by themselves, some acute cases are considered as a leading cause of death, especially in developing countries. In fact, diarrhea is not itself a disease, but can be a symptom of several ones and it's the most common clinical sign of gastrointestinal problems (Sarin et al., 2012). The causes can be bacterial, viral or parasite organisms which infect the intestine and easily spread through contaminated food, drinking water or from person-to-person as a result of poor hygiene.

According to our records, the studied people mostly use water from rivers and springs for daily activities like cooking or washing. Nevertheless, natural water sources are not always safe to use, especially when local people spray herbicides for their rice or corn crops, which are normally established near water resources for convenience. Only a few well-to-do families were able to contribute money to dig a well. Therefore, a quantitative ethnobotanical tool, fidelity level was used to quantify the relative importance of a species for anti-diarrhea activity.

Out of 34 species, there were 11 plants (32.3%) which scored FL values over 50% (Table 2, Additional file 2). It could be suggested that these plants had potential for further investigation, such as phytochemistry or bioactivity tests. In addition, the present study also followed another method suggested by Frieman (1986) to identify popular plants which were cited more frequently than others. Based on the number of informants reporting on a certain plant for any medicinal purpose and the number of different uses of that plant, Friedman established a co-ordinate system to classify plant popularity as popular and unpopular groups (Friedman et al., 1986). As can be seen in Figure 5, there seems to be a positive correlation between the number of informants reporting the plant and the number of plant's uses. It was true for the plants belonging to the unpopular group. However, for popular plants, for example the plants numbered 9, 30 and 34, even if the number of informants citing any sort of plant use notably increased, the number of uses per plant remained consistent, indicated by the horizontal line. This implied that all

the information concerning the plant was already fully reported. The intersection created by the linear line with the horizontal line marks the zone between popular and unpopular plants (Figure 5). It could be assumed that six plants belonging to the "popular" group were also potential for a certain activity due to their popularity in K'Ho traditional medicine.

In attempting to corroborate the anti-diarrheal effectivity in plants scoring high FL value (over 50%) (Table 2), the authors extended i/ cross-cultural comparison and ii/ literature review on bioassay tests. The bibliography review was carried out based on the valid nomenclature of species and its synonyms. The results were represented in Table 3.

The anti-diarrheal activity of medicinal plants probably relates to their antibacterial, antiviral and/ or astringent effects. These properties are normally considered to be involved with the presence of high tannin content in plant parts (Djipa et al., 2000; Jaradat et al., 2016; Mukherjee et al., 1998; Murugan et al., 2011). Indeed, from the literature survey on the eleven highest-fidelity-level plants, similarities in traditional uses which had been reported by other ethnic minorities as well as scientific evidence validated the bioactivity of four plants, particularly for anti-diarrheal activity. For example, Shah et al. (2010) studied the anti-diarrheal and spasmolytic activities *in vitro* and *in vivo* of *Alstonia scholaris* whose methanol extract of the aerial part significantly inhibited the frequency of defecation in castor oil-induced diarrheal mice. The extract also showed an intestinal smooth muscle relaxant (spasmolytic) activity in isolated rabbit jejunum (Shah et al., 2010). Furthermore, the later study of Qin et al. (2015) confirmed the antibacterial activity of two new indole alkaloids Alstoniascholarine F and J against *Pseudomonas aeruginosa* which was considered as a cause of infectious diarrhea (Qin et al., 2015). Another high-fidelity-level plant, *Careya arborea* was also verified for its traditional use as an anti-diarrheal plant through *in vivo* test (Rahman et al., 2003). Consequently, the remaining plants deserve to be studied further in order to validate their traditional uses which have previously existed in local communities.

Johns et al. (1990) admitted that the first impression that they obtained from their ethnobotanical data was its inconsistency and high degree of randomness, in which nearly 50% of the remedies were reported only once (Johns et al., 1990). Similar results were seen in Friedman's study (1986) (Friedman et al., 1986). Although there were only three plants in the present study excluded from further discussion according to the criteria of consensus, most of the remaining ones had certain uses which were known by one or two local people (out of total of 127 informants). It pointed out that there is an urgent need to conduct more ethnobotanical studies before traditional knowledge completely disappears. At the same time, randomness in the ethnobotany data should not be equated with unreliability, which was demonstrated through the authors recent study on the species *Medinilla septentrionalis* reported for its medicinal uses for the first time (Nhut et al., 2017). In fact, its relatively low FL and CV value (22.2 and 0.05, respectively) indicated that the plant was not widely known and used in the community. However,

the results showed that the ethanol extract obtained from the aerial part of *M. septentrionalis* expressed strong antibacterial activity, particularly against diarrhea-related bacteria such as *Salmonella* spp., *Shigella* spp. *Vibrio* spp. and *E. coli*. In addition, the extract also effectively prevented enteropooling and reduced either time of charcoal transit in small intestine or defecation in castor oil-induced mice (Nhut et al., 2017).

The reasons why one species is known by few people is probably because its remedy is either a family secret remedy or gradually lost over time due to verbal transmittance handed down from generation to generation. Another probability suggested by Johns (1990) is that if the plant was considered ineffective by certain people than it could be replaced by other ones that were available in their environment (Johns et al., 1990).

Together with FL, CV was also calculated for each species (Table 3.4). *Elephantopus mollis* and *Chromolaena odorata* with the highest CV values (1.23 and 1.04, respectively) were the most preferred plants in treatment of diarrhea in this area. Both plants also displayed among the highest FL group (56.4 and 60.6, respectively). However, it was not always true that a species with high CV also exhibited high FL value. For example, although *Streptocaulon juventas* ranked as the third highest CV plant (0.42), its FL scored less than 50%. Indeed, this plant was also used for 8 other health problems along with diarrhea. As a result, the informant's consensus represented by FL value considerably decreased. Therefore, CV is also additional index for selecting potential plants for further phytochemical and pharmacological studies.

3.5 Pattern resort for health problems

Local people try employing different means when encountering health problems, especially for minor ailments such as colds, fever, coughing, diarrhea or wounds. Normally, they choose simple methods like using medicinal plants (home remedies) or western drugs which they can buy from general stores without prescriptions during the first stage of a treatment. If health condition does not improve, a more modern treatment can be adapted as an alternative and at that time, they would have to go to hospitals/ health facilities which are usually quite far away from where they live (about 60 km). Thus health-seeking behaviors were studied to learn about how medicinal plants are important in their lives.

Among the 124 respondents, 98 people took the choice of medicinal plants at least once during their treatment (79.0% of total reported) for the following reasons: availability, accessibility and more effectiveness. This implied that traditional herbs still play an important role in the daily health care in rural areas which usually lack modern medical services.

There was a difference in health-seeking behavior of the respondents living in the three different villages (Figure 6). Specifically, in the first stage of treatment, the selection of health care method was

significantly different between K and the others (DS and DN) (Pearson Chi-square test, $p < 0.05$). Generally, when encountering health problems, the people from K village tended to use medicinal plants primarily, which was greater than those living in DS and DN who preferred western medicine first (40.4% *versus* 24.4% and 25.0%, respectively). If they did not feel better, alternatives would be sought out in the second stage.

In the second stage, although there was a slight decrease in the consumption of medicinal plants in K village (40.4% decreased to 34.1%), the choice of home remedies was still higher than that of DS (24.2%). It should be noted that there was a tendency of often switching from modern health facilities to home remedies among DN (increased from 25.0% to 59.4%). At the third stage, the choice of health treatment was equally shared between both medicinal plants and western medicine.

While the choice between medicinal plants and western medicine fluctuated during the stages of health care (increased in a certain stage and decreased in following stages), the choice of hospitals/ health facilities always decreased over time for all three villages. This might be because it was the most time-consuming and expensive method for local people.

3.6 Transmission of traditional knowledge in the study area

Unlike other minorities in Vietnam, especially in the northern regions and elsewhere, K'Ho people in the three villages studied did not have their own traditional healers, herbalists or apothecaries who could earn a living by prescribing or collecting herbs (Jaradat et al., 2016; Shale et al., 1999) Instead they sought the advice of knowledgeable people who were experienced in medicinal plants who often used these plants for solving their own health problems or for their families and neighbors. Knowledge of medicinal plants in this area is transmitted verbally from ancestors to descendants.

According to Eyssartier (2008), cultural transmission is a process of social dissemination in which behavioral patterns, cosmological beliefs and a culture's technological knowledge were communicated and acquired (Eyssartier et al., 2008). There are two main types of transmission, one occurring between individuals of different generations but within the genealogy, called 'Vertical transmission', as is the case from parents to children. The other consists in the transmission between individuals from the same generation, irrespective of their relationship, called 'Horizontal or contagious transmission'.

In this study, vertical transmission is more common than the horizontal. About 70.6% of the informants said that they learned traditional knowledge through family experiences. The remaining (29.4%) achieved knowledge from their neighbors, spouses, siblings, or from books, communication or the media (Table 4). Similar results were also found in the previous study (Jaradat et al., 2016).

In the vertical transmission group, parents (25.0%) were mentioned as the most important transmitters who passed on the traditional knowledge to their family members, followed by grandparents (19.4%). The role of the father and mother in such cases seemed to be equal because most informants confirmed that

both their father and mother had taught them how to use the plants. This correlated with the results mentioned above which showed that men and women had equal knowledge of medicinal plants. Although K'Ho society is matriarchal, nowadays the role of husbands/fathers in the family has increased. They have become the breadwinners as well as decision-makers in their family.

The transmission of traditional knowledge related to the uses of medicinal plants begins in the early life stages. Locals start studying when they were about 12 years old. People probably think that such an age is too young for a child to acquire medicinal plant knowledge, but it is the case that exists in the study area where the children have to help their parents to do chores and work in the fields after school. Therefore, the transmission of medicinal skills might take place on these occasions. For example, parents show their children certain medicinal plants that they accidentally encounter on the road on their way to the fields or the children can study how to use herbs when they themselves are being treated by their parents.

Currently, there are fewer opportunities, especially for children and teenagers, to spend time learning traditional knowledge from their parents and others who are proficient with medicinal plants due to the socio-cultural changes, such as the introduction of schooling in the family life and the neglect of younger generations or the availability of Western medicine. Another great concern is that the transfer of valuable knowledge from generation to generation mainly practiced by word of mouth, might be lost forever due to the lack of a proper written system. Indeed, while some medicinal plants were frequently cited, a lot of herbal species were used for medicinal purposes by only a quite limited number of people within the communities, such as *Calamus palustris* (4 reported), *Engelhardtia serrata* (5 reported). Although local people are aware of this vertical transmission, it is still declining quickly and they have no idea about how to resolve this inextricable problem. Therefore, it is crucial that the results of this project will provide them with feedback in various ways (documents and talks for example), as a thankful return for their participation in the study, and to allow the spread and sustainability of those skills and traditions in the community as well as in the whole population and eventually at an international level (publications, databases).

3.7 Conservation of medicinal plants: an important issue

All medicinal plants are checked for their presence in the Vietnam Red Data Book (Plant section) (2007) (Vietnam Academy of Science and Technology, 2007) and the Red List of IUCN (2016) (International Union for Conservation of Nature and Natural Resources, 2016). Despite there not being any plants cited in the endangered or vulnerable group does not mean that there is no cause for concern. For example, although not mentioned as an endangered species, *Dacrycarpus imbricatus* has been

decreasing in population according to IUCN and is even listed as a protected species in the Vietnam Red Data Book. Local people confirmed that it was hard to find big trees in the surrounding areas.

Additionally, most of the medicinal plants (85.5% of total) were collected from natural vegetation. However, there is no special protection or care given to these plants. Therefore, medicinal plants might be too damaged to satisfy the demands of local people who do not much pay attention to conservation issues.

In fact, the interrelationship between society and nature is close and has only recently become widely acknowledged. Human health cannot be considered in isolation but depends highly on the quality of the environment in which people live (De Albuquerque, 2009). Damage which can be included as biodiversity loss equals a reduction of the supplies of raw materials for industries, drug discovery as well as the decline of food production, water quality and the spread of human diseases. It is also quite clear that the practice of traditional medicine is not immune to the current environmental crisis facing our planet (Alves and Rosa, 2007). Degradation of forests affects the erosion of the sole health care option for the poor living in remote rural areas.

4. Conclusion

The present study recorded 34 traditional medicinal plants used by K'Ho-Cil people. These results help to preserve the plant lore and contribute basic data for phytochemical and pharmacological studies on potential medicinal plants as well as provide precious information for the Vietnamese pharmacopeia. For example, the information on the number of medicinal plant species distributed in the families in the present study along with data on phytochemical active compounds obtainined from literature surveys could serve as a signpost for future drug development with the Asteraceae and Fabaceae families containing the most medicinal plants.

Among the medicinal plants cited, several species are widely used for the treatment of various health problems by not only local people but also other minorities elsewhere. For example, *Ageratum conyzoides* for wound healing, diarrhea or flu, common cold*; Chromolaena odorata* for wound healing and diarrhea and *Eurycoma longifolia* for diarrhea or malaria (Agyare et al., 2009; Ahmed et al., 2014; Chassagne et al., 2016; Inta et al., 2013; Nguyen-Pouplin et al., 2007; Ong and Nordiana, 1999; Sharma et al., 2014; Silalahi et al., 2015; Waruruai et al., 2011). In addition, it is worth noting that there are still some potential anti-diarrheal plants whose high FL values have been recorded for the first time, including *Clitoria mariana*, *Paederia microcephala* and *Syzygium ripicola*. For this reason, further studies on their phytochemistry and *in vitro*, *in vivo* tests are essential for the validation of ethnomedicinal plants.

Although medicinal plants still have an important role in the daily health care of local people, it seems that the dissemination of valuable traditional knowledge is not fully appreciated. Wild herbs are facing overexploitation, misuse or environmental degradation, which may lead to the extinction of more than

15.000 plant species (Aati et al., 2019). It is necessary therefore to establish projects with the aim of improving awareness of social, cultural and political dimensions on the ecosystem and valuable knowledge before traditional plants and their associated knowledge completely disappear. Moreover, agro-techniques should be applied for potential domesticated medicinal plants to enhance their yield and quality. A seed bank would also be helpful for the preservation of genetic diversity of medicinal plants. Once the local people's income is improved, negative impacts caused by them on biodiversity may be reduced.

Ethics approval and consent to participate

Before conducting interviews, prior informed consent was obtained from all participants. No further ethics approval was required.

Consent for publication

This manuscript does not contain any individual person's data and further consent for publication is not required.

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Conflicts of interests

The authors declare that they have no competing interest.

Appendices

Appendix A: Questionnaire used in extensive ethnobotanical interviews.

Appendix B: Photographs of 11 plants with high fidelity level value.

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List of figures

Fig 1. Map of BiDoup-Nui Ba National Park.

The map shows the location of the three K'Ho villages participating in the ethnobotanical survey (red circles).

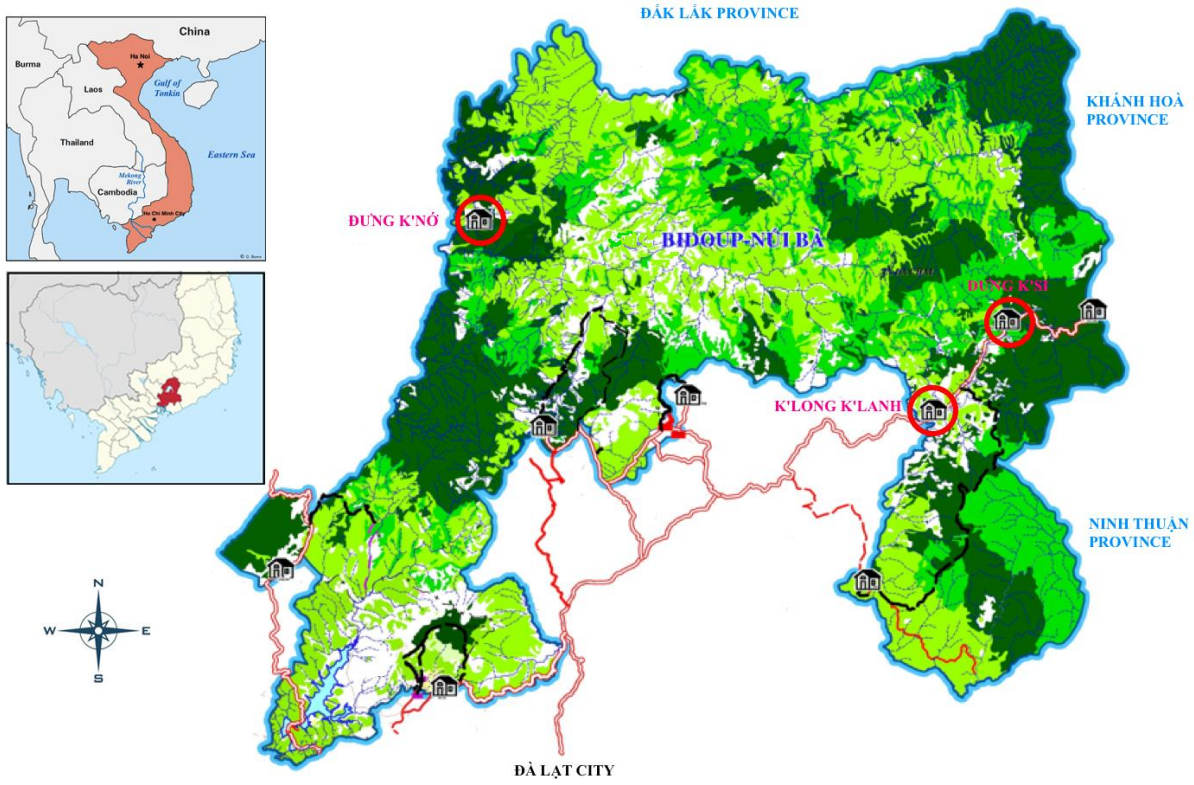

Fig 2. Age of informants by village and gender.

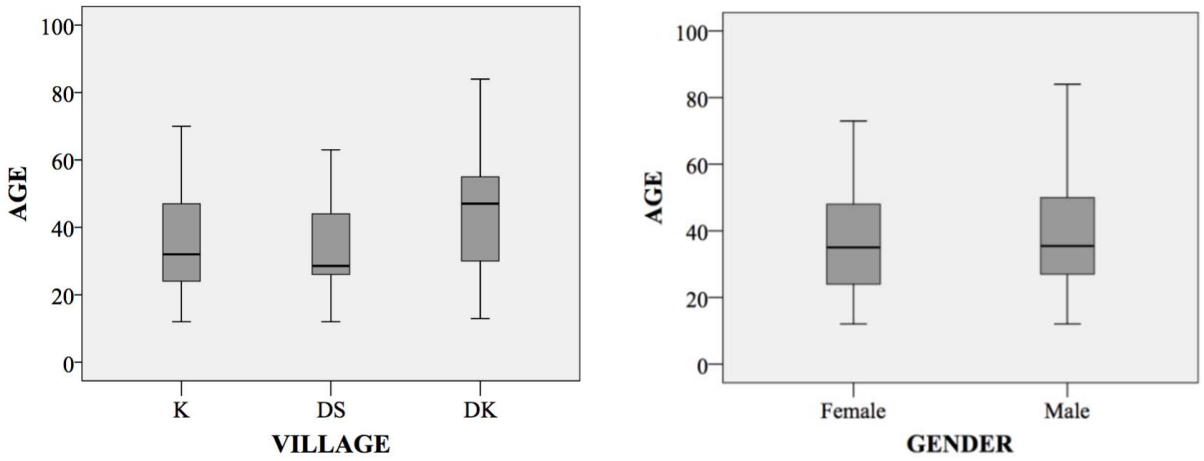

Fig 3. Distribution of medicinal plants in (A) Family, (B) Growth form and (C) Habitat.

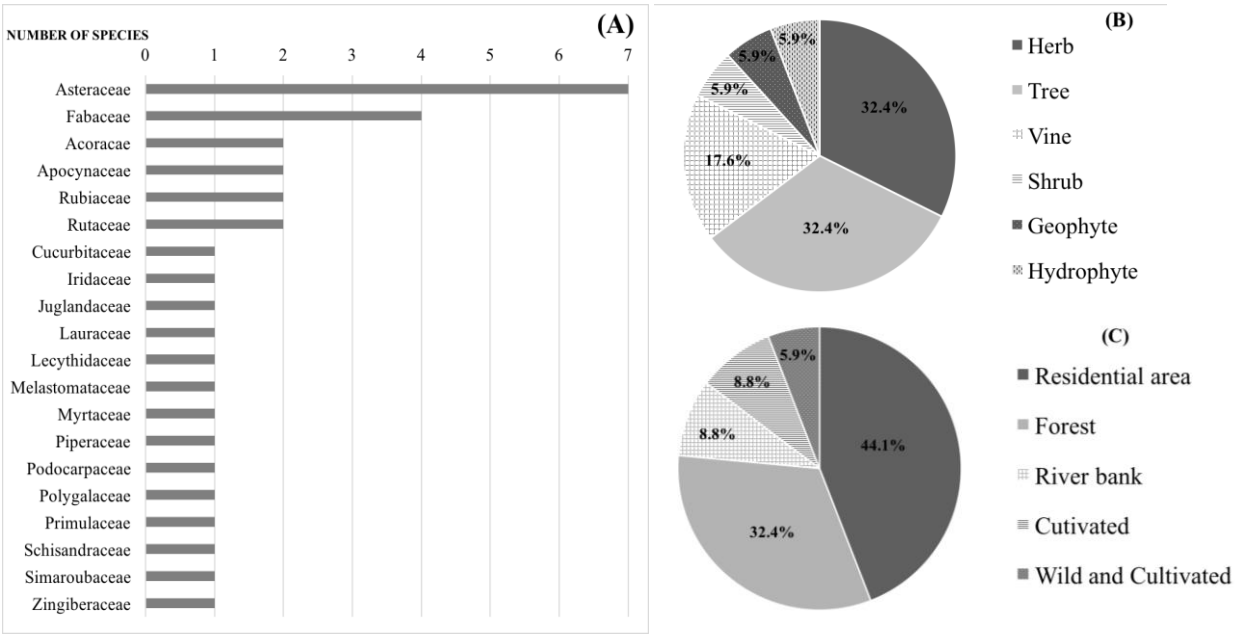

Fig 4. Percentage of the local's choice in preparing herbal medicines.

(A) Material, (B) Plant part used, (C) Route of administration and (D) Method of preparation

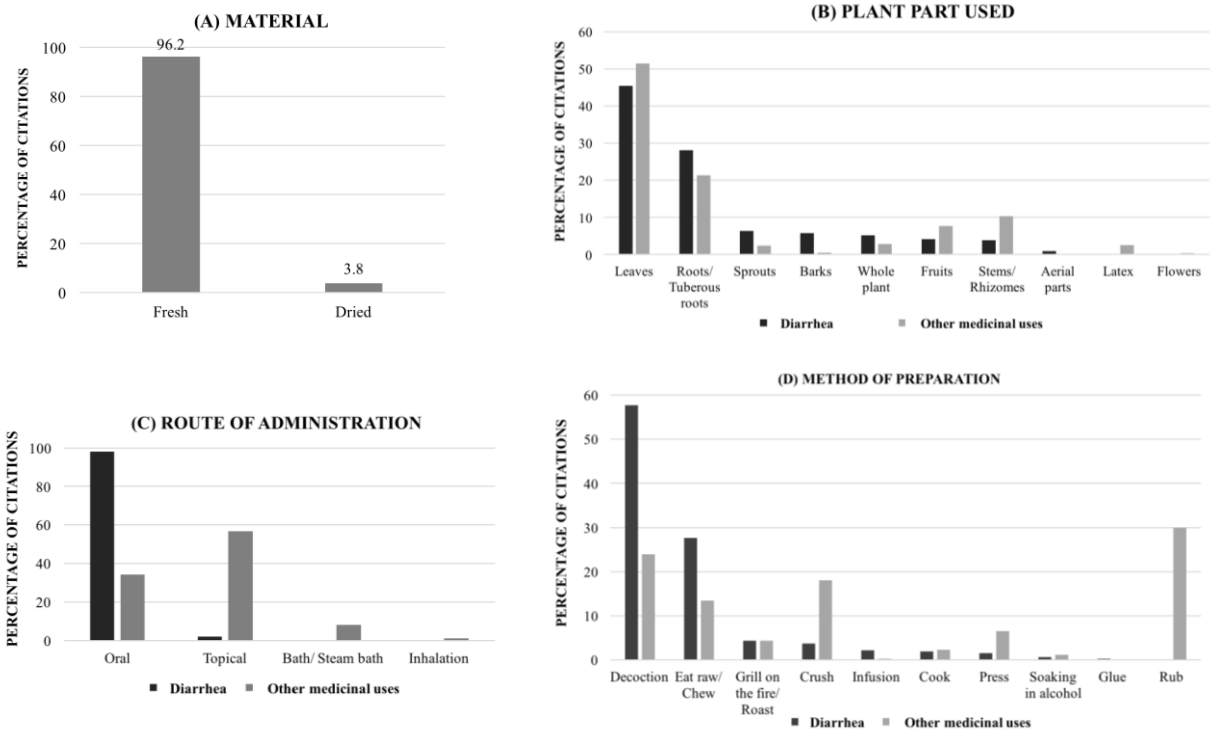

Fig 5. The popularity of medicinal plants.

The number in rectangle refers to the plant code in Table 2.

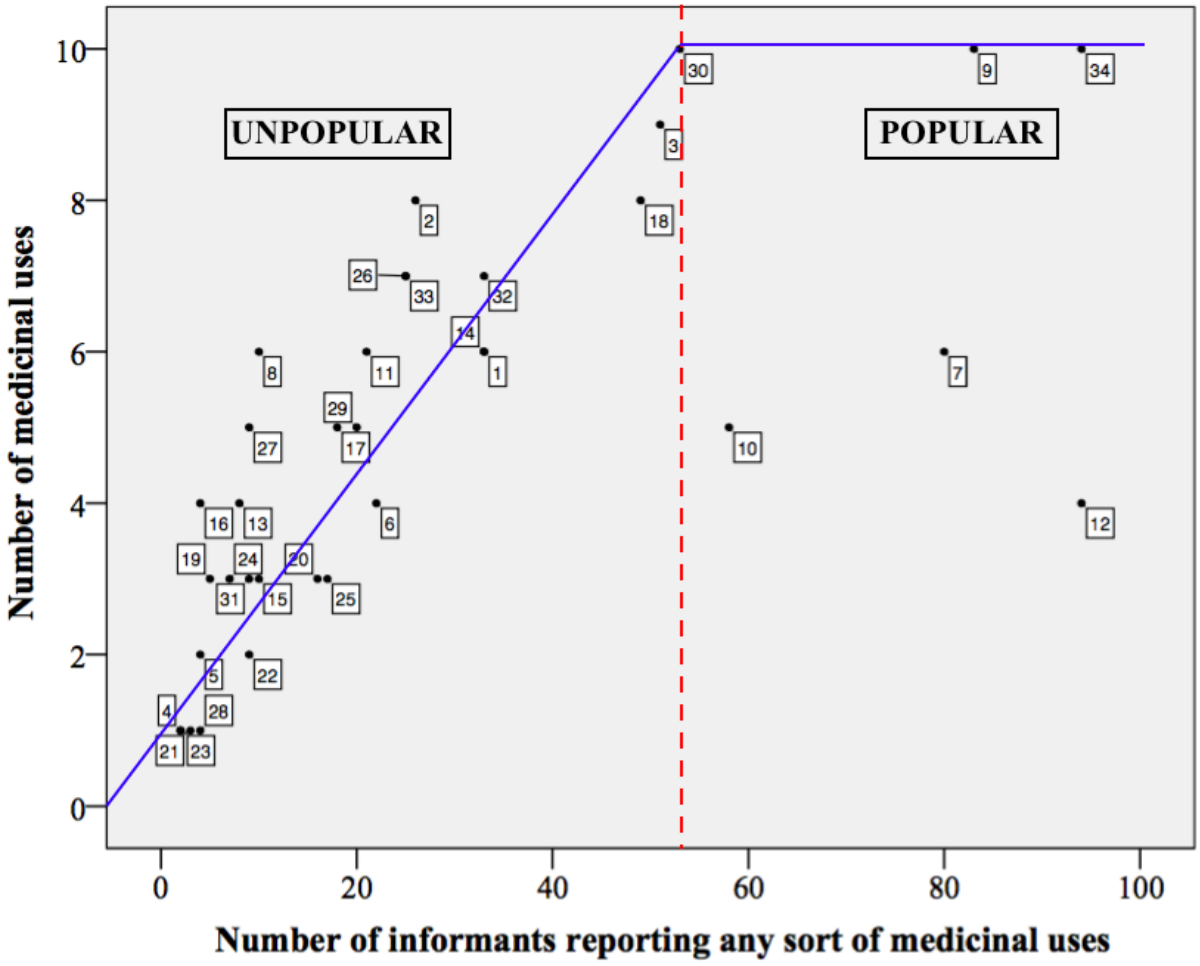

Fig 6. Health-seeking behavior of local people.

The numbers in columns represent the number of people who gave the choice for that case.

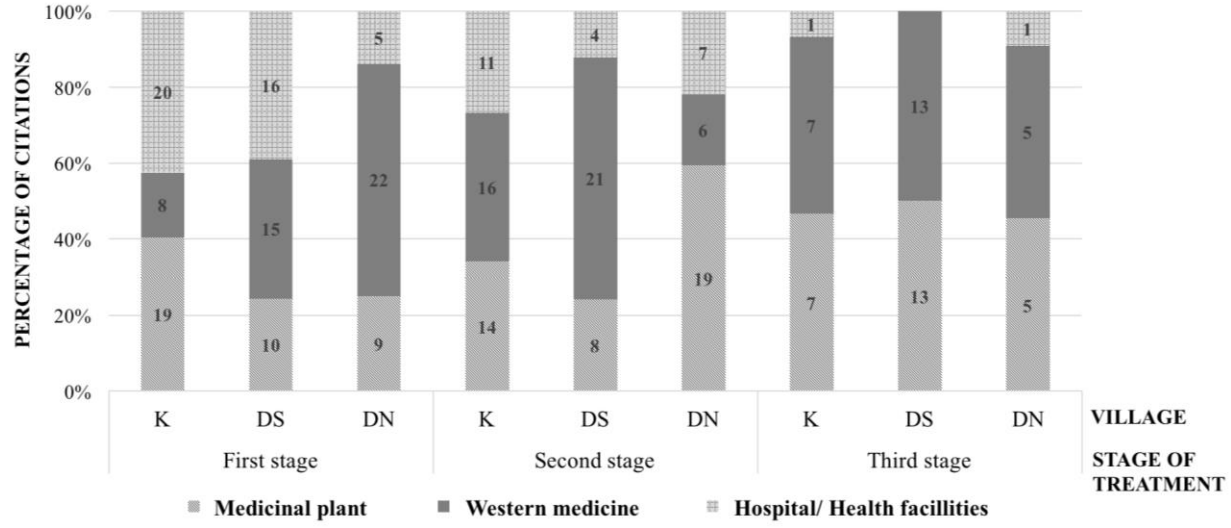

Table 1
Demographic characteristics of informants

Variable	Number of people (n=127)	Percent (%)
GENDER		
Male	60	47.2
Female	67	52.8
AGE GROUP *(male:female)*		
[12-23] years old	25 *(13:12)*	19.7
[24-33] years old	35 *(18:17)*	27.6
[34-49] years old	39 *(15:24)*	30.7
>49 years old	28 *(13:15)*	22.0
OCCUPATION		
Farmer	120	94.5
Teacher	3	2.3
Nurse/ Midwife	2	1.6
Local authorities	2	1.6
ETHNIC GROUPS		
K'Ho-Cil	123	96.8
Kinh	2	1.6
Churu	1	0.8
Mường	1	0.8
VILLAGE *(male:female)*		
K'Long K'Lanh (K)	47 *(23:24)*	37.0
Đưng K'Si (DS)	41 *(19:22)*	32.3
Đưng K'Nớ (DN)	39 *(17:22)*	30.7

Table 2
List of the medicinal plants used for the treatment of diarrhea (arranged alphabetically according to family) and their FL, CV values.

Plant code	Scientific name/ Vietnamese name/ Voucher specimen	Family	Anti-diarrheal treatment		FL (%)	CV	Other medicinal uses	Non-medicinal purposes
			Plant parts used	Mode of preparation and administration				
1	*Acorus calamus* L./ Thuỷ xương bồ/ PHH0004869	Acoraceae	Rhizomes	Eaten raw.	3.0	0.02	*__Stop bleeding__ (wound or menstruation problems), cough, fever, parturition stimulant	Condiment
2	*Acorus calamus* var. *angustatus* Besser/ Bồ bồ núi/ PHH0004870	Acoraceae	Rhizomes	Boil with water. The decoction is used orally.	11.5	0.05	**Cough,** stop bleeding, wound healing, fever, typhoid, stomachache, kidney stone	Handicraft
3	*Streptocaulon juventas* (Lour.) Merr./ Hà thủ ô/ PHH0004871	Asclepiadaceae	- Leaves or sprouts or whole plant - Roots	- Boil with water. The decoction is used orally. - Eaten raw or boil with water.	35.3	0.42	Stop bleeding, wound healing, cough, aches and pains, insect bites, toothache, insomnia, parturition stimulant	Tea Shampoo (helps hairs black and silk)
4	*Alstonia scholaris* (L.) R. Br./ Hoa sữa/ PHH0004872	Apocynaceae	Leaves	Boil with water. The decoction is used orally.	100.0	0.05		Construction material
5	*Calamus palustris* Griff/ Mây tàu/ PHH0004873	Arecaceae	Pith of young stem	Roasted piths are eaten raw.	50.0	0.05	Malaria	Food Handicraft Construction material
6	*Erigeron canadensis* L./ Thượng lão/ PHH0004874	Asteraceae	- Leaves - Leaves/ Aerial parts	- Eaten raw or cook with meat or fish as daily meal. - Cut into small pieces, air-dry and boil with water. The	54.5	0.28	Stop bleeding, wound healing, headache	Edible vegetable Tobacco

				decoction is used orally when required.				
7	*Chromolaena odorata* (L.) R.M. King & H. Rob./ Cỏ hôi/ PHH0004875	Asteraceae	Leaves	- Eaten raw. - Crush fresh leaves. The juice is added with a little salt and used orally. - Boil fresh or air-dried leaves with water. The decoction is used orally.	60.6	1.04	Stop bleeding, typhoid, sinusitis, itching, arthralgia	Edible vegetable Fertilizer
8	*Emilia scabra* DC./ Chua lè nhám/ PHH0004876	Asteraceae	Stems	Boil with water. The decoction is used orally.	10.0	0.02	Stomachache, burn, itching, sinusitis, inflammation	Vegetable Feedstuffs
9	*Ageratum conyzoides* (L.) L./ Cứt heo/ PHH0004877	Asteraceae	Leaves	Eaten raw or boil with water. The decoction is used orally.	7.2	0.14	**Stop bleeding**, wound healing, sinusitis, flu, cough, runny nose, stomachache, burn, leg swelling	Feedstuffs
10	*Gynura divaricata* (L.) DC./ Rau tàu bay/ PHH0004878	Asteraceae	Leaves	Eaten raw or boil with water. The decoction is used orally.	3.4	0.02	**Stop bleeding**, typhoid, body cooling, burn	Edible vegetable Feedstuffs
11	*Blumea balsamifera* (L.) DC./ Từ bi xanh/ PHH0004879	Asteraceae	- Leaves - Barks	- Eaten raw or boil with water. The decoction is used orally. - Air-dried, grind into powder and boil with water. The decoction is used orally.	23.8	0.12	Sprain, aches and pains, malaria, cold, itching	Construction material
12	*Elephantopus mollis* Kunth/ Chân voi mềm/ PHH0004880	Asteraceae	Leaves	- Eaten raw - Boil fresh or roasted with water. The decoction is used orally.	56.4	1.23	Stop bleeding, healing wound, cough	Tea

				- The mixture of leaves and rice is roasted. After that, add water and boil.				
13	*Solena heterophylla* Lour./ Cầu quả dị diệp/ PHH0004881	Curcubitaceae	Tuberous roots	Boil with water. The decoction is used orally.	50.0	0.09	Cough, fever, headaches	Tea Vegetable Fish-poisoning substance
14	*Senna floribunda* (Cav.) H.S. Irwin & Barneby/ Muồng nhiều hoa/ PHH0004882	Fabaceae	- Fruits - Leaves and/or Roots	- Eaten raw. - Boil with water. The decoction is used orally when required	48.5	0.37	Cough, good for liver troubles, fatigue, malaria, headaches	Tea Fruit
15	*Clitoria mariana* L./ Biếc tím/ PHH0004883	Fabaceae	- Fruits - Roots	- Eaten raw - Eaten raw or boil with water. The decoction is used orally.	80.0	0.19	Stomachache, constipation	Vegetable Snack
16	*Entada rheedii* Spreng./ Bàm bàm/ PHH0004884	Fabaceae	Roots	Boil with water. The decoction is used orally.	25.0	0.02	Stomachache, aches and pains, dandruff	
17	*Mimosa pudica* L./ Mắc cở/ PHH0004885	Fabaceae	Whole plant	Make the decoction which is used orally when required.	22.2	0.09	**Enuresis**, malaria, parturition stimulant	
18	*Eleutherine bulbosa* (Mill.) Urb./ Sâm đại hành/ PHH0004886	Iridaceae	Barks	Boil with water. The decoction is used orally.	6.1	0.07	Stop bleeding (wound or for women afterbirth), wound healing, cough, burns, boil, toothache	Vegetable Feedstuffs
19	*Engelhardtia serrata* Blume/ Chẹo có răng/ PHH0004887	Juglandaceae	Leaves	Eaten raw or boil with water. The decoction is used orally.	40.0	0.05	Itching, toothache	Fish-poisoning substance Furniture
20	*Cinnamomum burmanni* (Nees & T. Nees) Blume/ Quế trèn/	Lauraceae	Leaves	Boil with water. The decoction is used orally.	50.0	0.14	Cough, typhoid	Tea

	PHH0004888							
21	*Careya arborea* Roxb./ Vừng xoan/ PHH0004889	Lecythidaceae	- Young leaves - Barks	- Eaten raw. - Boil with water. The decoction is used orally.	100.0	0.07		Edible fruits
22	*Medinilla septentrionalis* (W.W. Sm.) H.L. Li/ PHH0004868	Melastomataceae	- Piths of young stems - (Young) leaves	- Eaten raw. - Boil with water. The decoction is used orally.	22.2	0.05	**Cough**	Water supply for fieldtrip Tea Edible vegetable and fruits
23	*Syzygium ripicola* (Craib) Merr. & L.M. Perry/ Trâm suối/ PHH0004890	Myrtaceae	Barks and/or Stems	Boil with water. The decoction is used orally.	100.0	0.05		Edible fruits Tea
24	*Piper sarmentosum* Roxb./ Lốt/ PHH0004891	Piperaceae	- Leaves - Whole plant	- Eaten raw or make the decoction. - Air-dried and boiled with water. The decoction is used orally.	71.4	0.12	Toothache, hypertension	Edible vegetable Dye
25	*Dacrycarpus imbricatus* (Blume) de Laub/ Bạch tùng/ PHH0004867	Podocarpaceae	- Sprouts - Barks or Wood or Roots	- Eaten raw in urgent cases. If the diarrhea does not stop, continue with the plant's infusion or decoction. - Scrap barks to obtain powder which is dissolved in warm water. The infusion is used orally. - Boil with water. The decoction is used orally.	80.0	0.35	Cough, itching	Construction material
26	*Polygala paniculata* L./ Kích nhũ thơm/ PHH0004892	Polygalaceae	- Leaves - Root or Whole plant	- Eaten raw. - Boil with water. The decoction is orally used.	20.0	0.12	Tiredness, versicolor pityriasis, itching, fever, urinary disorder,	Tea Shampoo (fragrant)

							constipation	
27	*Ardisia cadieri* Guill./ Cơm nguội Cadier/ PHH0004893	Primulaceae	- Fruits - Roots	- Eaten raw. - Boil with water. The decoction is orally used.	11.1	0.02	**Itching**, scars, cough, nosebleed	Edible fruits
28	*Hedyotis capitellata* var. *pubescens* Kurz/ An điền mềm/ PHH0004894	Rubiaceae	Roots	Roast and boil with water. The decoction is used orally.	100.0	0.09		
29	*Paederia microcephala* Pierre ex Pit./ Mơ đầu nhỏ/ PHH0004895	Rubiaceae	Leaves	- Boil with water. The decoction is used orally. - Crush, mix with fresh eggs. The mixture is used orally.	80.0	0.37	Stop bleeding, flu, eye sore, nosebleed	Edible vegetable Condiment
30	*Melicope pteleifolia* (Champ. ex Benth.) T.G. Hartley/ Dấu dầu ba lá/ PHH0004896	Rutaceae	Leaves	- Boil with water. The decoction is used orally. - Rub and apply on abdomen.	11.3	0.12	**Itching**, headache, malaria, cough, aches and pains, typhoid, stop bleeding	
31	*Zanthoxylum myriacanthum* Wall. ex Hook. f./ Hoàng mộc nhiều gai/ PHH0004897	Rutaceae	Tuberous roots	Remove the bark, cut the core into small pieces and the infusion is made with hot water.	22.2	0.05	Toothache, itching	Water supply for fieldtrip Edible vegetable and fruits Ornament Roof material
32	*Illicium griffithii* Hook. f. Thomson/ Đại hồi núi/ PHH0004898	Schisandraceae	Leaves or fruits	Boil with water. The decoction is used orally.	12.1	0.07	**Cough**, wound healing, stop bleeding, liver cooling, typhoid, swelling caused by a fall (contusion).	Condiment
33	*Eurycoma longifolia* Jack/ Bá bệnh/ PHH0004899	Simaroubaceae	Roots	- Air-dried and macerated in alcohol. The extract is used	44.0	0.25	Foster health, itching, aches and pains, malaria,	Edible fruits

				orally when required. - Boil with water. The decoction is used orally.			fever, toothache, wound healing	
34	*Curcuma* sp4./ Nghệ/ PHH0004900	Zingiberaceae	Tuberous roots	- Eaten raw. - The decoction is used orally. - Crushed. The juice is cooked with rice and honey.	l8.1	0.39	**Acne**, sunburn, stomachache, wound healing, scars, cough, itching, headache, constipation	Condiment Bath (fragrant)

* **Bold letters** found in "medicinal uses" column indicate that this is the most important medicinal use for the plant mentioned. If not, it means that the plant is mainly used for the treatment of diarrhea.

Table 3
Literature review on anti-diarrheal plants with FL over 50%.

Plant	FL (%)	Medicinal uses in the present study	Cross-cultural comparison	Bioassay tests
Alstonia scholaris	100.0	**Diarrhea/ Dysentery***	**- Diarrhea** (Pardo de Tavera, 2008; WHO, 2009; Wiart, 2006). - Malaria (Pardo de Tavera, 2008; WHO, 2009; Wiart, 2006) - Other health problems: fever, diabetes, beriberi, … (WHO, 2009; Wiart, 2006)	- Antibacterial activity (broad spectrum) (Khan et al., 2003; Liu et al., 2015; Qin et al., 2015) - **Anti-diarrheal activity** (Shah et al., 2010)
Careya arborea	100.0	**Diarrhea/ Dysentery**	- Astringent and tonic (Mandal et al., 2006) - **Diarrhea/ dysentery** (Bhandary et al., 1995; Chassagne et al., 2016; Rajakumar and Shivanna, 2009; Swain and Padhy, 2015) - Sore in intestine (Bhat et al., 2014; Swain and Padhy, 2015) - Ulcer (Chandrashekara and Somashekarappa, 2016).	**- Anti-diarrheal activity** (Rahman et al., 2003) - Antileishmanial activity (against *Leishmania donovani*) (Mandal et al., 2006) - Antibacterial activity (10 strains isolated from clinical samples) (Swain and Padhy, 2015)
Hedyotis capitellata var. *pubescens*	100.0	**Diarrhea/ Dysentery**	No reference was found for *H. capitellata* var. *pubescens* but for *H. capitellata* Wall. ex G.Don, it was used for the treatment of - **dysentery** (Grosvenor et al., 1995b) - postpartum and kidney problem (Lajis and Ahmad, 2006; Ong and Nordiana, 1999) - wound (Wiart et al., 2004)	*Hedyotis capitellata* Wall. ex G.Don was found to have antibacterial activity against: *Staphylococcus aureus* and *Proteus vulgaris* (Grosvenor et al., 1995b; Nakanishi et al., 1965), *Bacillus cereus* (Wiart et al., 2004).
Syzygium ripicola	100.0	Diarrhea/ Dysentery	No reference	No reference was found for *S. ripicola* but several species from the same genus *Syzygium* were reported to have activity against diarrhea. For example, *S. cumini* (synonym *Eugenia jambolana* Lam.) (Mukherjee et al., 1998), *S. samarangense* (Ghayur et al., 2006).

				Moreover, antimicrobial activity was also found with *S. jambos* (Djipa et al., 2000; Murugan et al., 2011)
Clitoria mariana	80.0	**Diarrhea**, stomachache, **constipation**	No reference was found for *C. mariana* but a lot of information for the common herb *C. ternatea*: various therapeutic effects, including **constipation** (Mukherjee et al., 2008), snake bite, indigestion, tumour (Rahmatullah et al., 2010), **diarrhea** (Upwar et al., 2010).	No reference was found for *C. mariana* but anti-diarrheal activity of *C. ternatea* Linn. was investigated (Sini et al., 2011; Upwar et al., 2010)
Dacrycarpus imbricatus (syn. *Podocarpus imbricatus*)	80.0	**Diarrhea**, cough, itching	**Diarrhea** (Sujarwo et al., 2015)	Anti-proliferative activity (against A549-human lung adenocarcinoma epithelial and NCI-H292-human lung mucoepidermoid carcinoma cell lines) (Han et al., 2014)
Paederia microcephala	80.0	Diarrhea, stop bleeding, nosebleed, flu, eye sore	No reference	No reference was found for *P. microcephala* but the species in same genus *P. foetida* possessed anti-diarrheal (Afroz et al., 2006) and antibacterial activities (Uddin et al., 2007)
Piper sarmentosum (syn. *P. lolot*)	71.4	Diarrhea, **toothache**, hypertension	- (Malarial) fever (Ong and Nordiana, 1999; Zakaria et al., 2010) - Postpartum dizziness, headaches (De Boer et al., 2012; Zakaria et al., 2010) - Stone kidney (De Boer et al., 2012) - **Toothache** (De Boer et al., 2012) - Other health problems: beriberi, …. (De Boer et al., 2012; Zakaria et al., 2010)	- Anti-microbial activity against: *Bacillus subtilis* and *Escherichia coli*) (Masuda et al., 1991), *E. coli* and *Fusobacterium nucleatum* (Teanpaisan et al., 2016) - **Anti-nociceptive** and anti-inflammatory activities (Zakaria et al., 2010) - Hypoglycemic effect (Peungvicha et al., 1998)
Chromolaena odorata (syn. *Eupatorium odoratum*)	60.6	**Diarrhea/ dysentery**, typhoid, fever, **stop bleeding**, **itching**, sinusitis	This is a very common plant used by other ethnic groups elsewhere. - **Diarrhea** (Chassagne et al., 2016) - **Rashes** (Inta et al., 2013) - **Stop bleeding** (Ong and Nordiana, 1999), **wound**	Antibacterial (against *Pseudomonas aeruginosa* and *Streptococcus faecalis*) (Irobi, 1992) and **anti-diarrheal** bacteria strains (*Klebsiella oxytoca*, *Salmonella enterica*, *Shigella sonnei* and *Vibrio cholera*) (Atindehou et al.,

			healing (Agyare et al., 2009; Inta et al., 2013)	2013).
Elephantopus mollis	56.4	**Diarrhea**, stop bleeding, **wound healing**, **cough**	- Asthenic fever (Breitbach et al., 2013) **- Cough**, anemia, **dysentery**, hepatitis, diabetic, **wound healing** and diseases related to free radical-mediated (Ooi et al., 2011) - Fracture healing, abdominal pain, cancer, snake bites (Ngueguim et al., 2012)	Cytotoxic, apoptotic and anti-α-glucosidase (Ooi et al., 2011)
Erigeron canadensis (syn. *Conyza canadensis*)	54.5	**Diarrhea/ dysentery, stop bleeding, wound healing,** headaches	Various health problems, including **diarrhea**, **dysentry**, **styptic**, **injuries**, etc. (Gairola et al., 2014; Shinwari and Khan, 2000; Thakur et al., 2016; Zheng and Xing, 2009)	Antibacterial and antifungal activities (Shakirullah and Ahmad, 2011)

* Medicinal uses reported in both present study and other bibliographic data were written in **bold letters**.

Table 4
Main transmitters in medicinal knowledge in K'Ho communities.

	Main transmitters	**Number of reports** *(% of total reported)*
Vertical transmission	Parents	40 *(25.0)*
	Grandparents	31 *(19.4)*
	Father	22 *(13.7)*
	Mother	17 *(10.6)*
	Mother/ Father-in-law	3 *(1.9)*
Horizontal transmission	Neighbors/ Community	35 *(21.9)*
	Husband/ Wife	6 *(3.7)*
	Newspaper/ Book/ Television	3 *(1.9)*
	Siblings	3 *(1.9)*
	Total	**151** ***(100.0)***