Review

Traditional uses of medicinal plants in gastrointestinal disorders in Nepal

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Abstract

Ethnopharmacological relevance: Gastrointestinal disorders cause morbidity and can lead to mortality, especially in the developing world where sanitation is deficient. A large part of the human population relies on medicinal plants for treating various diseases, including gastrointestinal disorders. The present review summarizes the traditional uses of medicinal plants of Nepal used to treat gastrointestinal disorders, and evaluates their bio-ef ficacy based on a review of the available phytochemical and pharmacological literature.

Material and methods: We searched different electronic databases and libraries for the literature on medicinal plants used in Nepal to treat gastrointestinal disorders. For each species, we also searched the literature for information on conservation status, as well as for phytochemical and pharmacological studies in support of the ethnobotanical information. We used principal component analysis to explore the relation among disorders and plant families, plant life forms, plant parts, and preparation modes. We also performed permutation tests to determine if botanical families were used more often than expected considering their availability in the Nepali flora.

Results: We documented a total of 947 species belonging to 158 families and 586 genera used to treat gastrointestinal disorders in Nepal. Diarrhea was the disorder treated by the highest number of species (348), followed by stomachache (340) and dysentery (307). Among the reported species, five were endemic to Nepal, whereas 16 orchid species were protected under CITES Appendices II and III. The randomization test showed that species belonging to 14 families were used less often than expected, whereas plants belonging to 25 families were used more often than expected. The PCA scatter plot showed distinct groups of gastrointestinal disorders treated with similar plant life forms, plant parts, and preparation modes. We found 763 phytochemical studies on 324 species and 654 pharmacological studies on 269 species.

Conclusion: We showed the diversity and importance of medicinal plants used to treat gastrointestinal disorders in the traditional health care system of Nepal. As such disorders are still causing several deaths each year, it is of utmost importance to conduct phytochemical and pharmacological studies on the most promising species. It is also crucial to increase access to traditional medicine, especially in rural areas. Threatened species need special attention for traditional herbal medicine to be exploited sustainably.

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1. Introduction

It is estimated that 70–80% of the human population, mostly in the developing world, relies on medicinal plants for primary health care (WHO, 2008). Herbal medicines are also gaining popularity among the western population because they have minor or no side effects if administered properly (Jordan et al., 2010). Besides medicinal use, plants are increasingly used in cosmetics (Aburaj and Natshel, 2003) and nutraceuticals (Espín et al., 2007; Bernal et al., 2011). Herbal medicines have been proved to be highly effective to treat a wide range of diseases (Blumenthal, 2002; Mukherjee and Wahle, 2006), including gastrointestinal disorders (Heinrich et al., 1992; Manandhar, 2002; Madikizela et al., 2012; Street and Prinsloo, 2013).

Gastrointestinal disorders are ailments affecting the functions of the digestive tract, i.e., food and liquid absorption, digestion, or excretion (Neamsuvan et al., 2012). Such disorders are caused by infections by various kinds of bacteria, viruses, and parasitic organisms (Mathabe et al., 2006; Karki and Tiwari, 2007). Common gastrointestinal disorders are stomach/abdominal pain, diarrhea, dysentery, gastritis, constipation, vomiting, etc. (WHO, 2008). These disorders cause morbidity and can lead to mortality, especially in the developing world where sanitation is deficient (Heinrich et al., 1992; Pawlowski et al., 2009; Tuite et al., 2011). Outbreaks of diarrhea, dysentery, or cholera caused by contaminated drinking water have claimed millions of lives worldwide, mainly infants and children (Sarkar et al., 2007; Ryan, 2011). For example, serious diarrhea/dysentery/cholera outbreaks were reported in Ethiopia (Bartels et al., 2010), Haiti (Tuite et al., 2011), Vietnam (Anh et al., 2011), Zimbabwe (Fisher, 2009), and Nepal (Bhandari et al., 2009), all with a high death toll.

In Nepal, 80–85% of the population depends on traditional medicine for primary health care (Manandhar, 2002). The use of medicinal plants is widespread, not only because they are easily accessible and affordable, but also due to persistent cultural beliefs and practices, as well as the lack of access to modern health care systems in rural areas (Coburn, 1984; Pohle, 1990; Baral and Kurmi, 2006). Medicinal plants are used to treat various gastrointestinal disorders ranging from simple types such as vomiting to more complex problems like peptic ulcer (Lama et al., 2001; Rajbandari, 2001).

There are many studies related to traditional uses of plant species in Nepal (Manandhar, 2002; Shrestha et al., 2004; Joshi and Joshi, 2005; Kumwar and Bussmann, 2008). Besides ethnobotanical studies, in-vitro and in-vivo trials were realized to identify the mechanisms explaining the effectiveness of some of the medicinal plants used in traditional medicine (Griggs et al., 2001; Parthi and Chaudhary, 2006; Rajbandari et al., 2009). This practice of establishing phytochemical or pharmacological explanations for traditional uses is not only helpful to institutionalize traditional medicine, but can also lead to the development of new drugs (Newman and Cragg, 2007) or indicate future directions for bio-prospecting (Soejarto et al., 2005; Douwes et al., 2008). However, only a few studies have so far linked traditional medicinal uses to pharmacological or phytochemical properties in Nepal (Kumwar et al., 2009; Uprety et al., 2010; Gaire and Subedi, 2011; Luitel et al., 2014).

The present study aimed at documenting the traditional uses of medicinal plants to treat gastrointestinal disorders in Nepal, and to evaluate the efficacy of plant species based on a review of the literature. Specifically, we sought to answer the following questions: (i) What plant species are used in gastrointestinal disorders in Nepal? (ii) Have pharmacological or phytochemical studies been conducted to determine which metabolites are active against gastrointestinal disorders? (iii) What gastrointestinal disorders are treated with the highest number of medicinal plant species? (iv) Are some botanical families more or less used than expected in gastrointestinal disorders? and (v) Which diseases are commonly treated by which plant parts, plant types, modes of admission, and botanical families?

2. Material and methods

2.1. Data collection

We reviewed studies published in journals, reports and books dealing with traditional uses of medicinal plants in Nepal to treat various gastrointestinal disorders. Different online databases were used (ISI Web of Science, MEDLINE, Science Direct, Scopus, and Google Scholar), with specific search terms such as ‘medicinal plants’, ‘plants’, ‘gastrointestinal’, ‘gastro’, ‘diarrhea’, ‘dysentery’, ‘stomach’ and ‘Nepal’ (for all terms see Table 1). The term ‘Nepal’ was used to limit the geographical scope of the search. We also carried out library search for hard copies. We reviewed a total of 94 publications. A master list was produced, providing vernacular name(s), mode(s) of use, and references for each species (Electronic Appendix 1).
The precision of species names provided in this paper depends on that from the original sources. However, we verified currently accepted name(s) in Press et al. (2000) and online nomenclature sources (http://www.theplantlist.org and http://www.tropicos.org). The currently accepted name is sometimes followed by synonyms, when provided in the source references. Available vernacular names are also provided. The most frequently used plants were identified based on the highest number of use reports from the literature. Life forms and origin (wild/cultivated) of the different plant species were noted if mentioned in the original documents, otherwise we used other sources of information (Pulunin and Stainton, 1984; Stainton, 1988; Storrs and Storrs, 1998; Lama et al., 2001; Manandhar, 2002; Baral and Kurmi, 2006).

We searched the above-mentioned databases for pharmacological or phytochemical studies providing supporting evidence of medicinal uses for each species. Pharmacological studies show direct explanation for traditional uses, whereas phytochemical studies provide indirect information. Plants contain several types of secondary metabolites that have different therapeutic properties. We did not restrict the search to Nepal, as species might have been tested elsewhere. Due to the huge number of studies having been consulted, we only provide the reference(s), and complete information on pharmacological and phytochemical properties can be retrieved from the original studies. We provide a complete set of references in Electronic Appendix 1.

2.2. Data analysis

We categorized gastrointestinal disorders into 20 categories following the classification of Cook (1995) (Table 1). Categories consisting of similar disorders or physiological effects of medicinal plants were grouped, such as carminative/flatulence/tpympanites, constipation/laxative/purgative, emetic/nausea/vomiting, hepatoprotective/jaundice, and indigestion/digestion/digestive. An ‘other diseases’ category was created, consisting of diseases not included into other categories: somatosis, enteritis, swollen stomach, food poisoning, pharyngitis, colon carcinoma proliferation and inflammation of the intestinal membrane.


We applied data reduction methods to summarize the data. Principal component analysis (PCA) was used to determine which gastrointestinal disorders (dependent variable) were treated with particular combinations of plant life forms, plant parts, or preparation modes (independent variables) (Leš and Šmilauer, 2003). PCA was also used to verify which types of gastrointestinal

Table 1
Number of plant taxa used to treat various gastrointestinal disorders.

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Abbreviation(s)</th>
<th>No. of plant taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhea</td>
<td>Dia</td>
<td>348</td>
</tr>
<tr>
<td>Stomachache</td>
<td>Sto</td>
<td>340</td>
</tr>
<tr>
<td>Dysentery</td>
<td>Dys</td>
<td>307</td>
</tr>
<tr>
<td>Indigestion/Digestive/Digestive</td>
<td>Ind</td>
<td>303</td>
</tr>
<tr>
<td>Constipation/Laxative/Purgative</td>
<td>Con lax</td>
<td>221</td>
</tr>
<tr>
<td>Anethelmintic</td>
<td>Ant</td>
<td>175</td>
</tr>
<tr>
<td>Gastritis</td>
<td>Gas</td>
<td>173</td>
</tr>
<tr>
<td>Hepatoprotective/Jaundice</td>
<td>Hepja</td>
<td>127</td>
</tr>
<tr>
<td>Appetizer</td>
<td>App</td>
<td>102</td>
</tr>
<tr>
<td>Colic</td>
<td>Col</td>
<td>85</td>
</tr>
<tr>
<td>Bile disorder</td>
<td>Bil dis</td>
<td>72</td>
</tr>
<tr>
<td>Emetic/Vomiting/Nausea</td>
<td>EmeVom</td>
<td>70</td>
</tr>
<tr>
<td>Carminative/Flatulence/Tympanite</td>
<td>Car</td>
<td>67</td>
</tr>
<tr>
<td>Piles</td>
<td>Pil</td>
<td>52</td>
</tr>
<tr>
<td>Ulcer</td>
<td>Ulc</td>
<td>46</td>
</tr>
<tr>
<td>Splenopathy</td>
<td>Spl</td>
<td>37</td>
</tr>
<tr>
<td>Choleta</td>
<td>Cho</td>
<td>34</td>
</tr>
<tr>
<td>Intestinal disorder</td>
<td>Ind dis</td>
<td>21</td>
</tr>
<tr>
<td>Other diseases</td>
<td>Oth dis</td>
<td>16</td>
</tr>
<tr>
<td>Astringent</td>
<td>Ast</td>
<td>9</td>
</tr>
</tbody>
</table>

* A taxon may be used to treat more than one disorder.
disorders were treated with the same plant families. PCA was carried out using Canoco 5.01 (ter Braak and Smilauer, 2012).

We first counted the number of species in each family among the species used to treat gastrointestinal diseases. A high number of species in a given family may, however, have two explanations: the given plant family might have properties making it a valuable source of medicine, or it might only be common in the area. To explore these two possibilities, we tested if some botanical families had more species used in gastrointestinal diseases than expected from the total number of species in each family in the flora of Nepal (Press et al., 2000). Specifically, we tested whether the plants used in gastrointestinal diseases were random subsets of all vascular plants and all medicinal plant species regarding identity to botanical family, following the method described in Rokaya et al. (2012b).

For this, we performed permutation tests by drawing random samples of plants from the whole flora of Nepal and assigning them to plant families. We asked whether the number of species used in gastrointestinal diseases in a given family could result from a random sampling from the whole flora or from the medicinal flora of Nepal. For each family, we derived an empirical P-value, which indicated the probability that the number of species of a given family used to treat gastrointestinal diseases could be due to random sampling from the total flora or medicinal flora of Nepal. We performed 10,000 permutations using MATLAB 5.3 (1999).

3. Results

3.1. Diversity, uses, preparation modes

A total of 947 species belonging to 158 families and 586 genera were reported in the literature as being traditionally used in Nepal to treat different gastrointestinal ailments. Most of the reported medicinal plant species were Angiosperms (892 species: 777 Dicotyledons and 115 Monocotyledons), Pteridophytes ranked second (37 species), followed by Gymnosperms (16 species), Well represented Angiosperm families were Fabaceae (72 species), followed by Asteraceae (55), Lamiaceae (39), Rosaceae (32) and Ranunculaceae (31). Aconitum, Desmodium, Phyllanthus and Swertia were the most common genera representing 8 species, followed by Allium, Amaranthus, Arisaeana, Delphinium, and Potentilla with 7 species. The highest prevailing life form was herb (486 species), and most remedies were prepared from wild plant species (755 species) (Fig. 1). The nomenclature used in the consulted publications was different from the current accepted nomenclature for 53 plant species. We included these names as synonyms in our database.

The randomization test with all the vascular plants of Nepal showed that species belonging to 14 families were used less often than expected (e.g., Poaceae, Scrophulariaceae, Caryophyllaceae, etc.), whereas plants belonging to 25 families were used more often than expected in gastrointestinal diseases (Fig. 2). Considering only the medicinal flora, plant species belonging to six families were used less often than expected and plants from seven families were used more often than expected in gastrointestinal disorders (Fig. 3).

The reported plants were used in 20 different gastrointestinal ailment categories (Table 1). Diarrhea was the disorder treated by the highest number of species (348), followed by stomachache (340) and dysentery (307). Two-thirds of the species (65.96%) were used to treat more than one ailment, whereas 34.04% were used to treat a single ailment (Electronic Appendix 1).

Almost all plant parts were used to prepare different medicinal formulations: roots/rhizomes/bulbs/tubers/corm/cloves, fruits/seeds/pulp, leaves/petiole, stem/wood, bark, flowers/buds, gum/sap/latex/milk/resin and whole plant. The most frequently used plant parts were the underground parts followed by fruits/seeds (Fig. 4). Paste was the most frequently used preparation technique, followed by decoction and powder (Fig. 5). As gastrointestinal disorders are related to internal body parts, most medicinal formulations were consumed orally, often with water and sometimes with milk and honey. It was also reported that leaves of some species, such as Artemisia dubia, were put over a heated flat stone on which patients would sit or lie to treat common-dysentery or blood-dysentery.

The first axis of the PCA of disorders in relation to plant parts, plant types and modes of preparation explained 58.59% of the variance in treated disorders. It separated modes of preparation, with plants ingested raw, or as juice or soup on one side, and plants applied or ingested using more elaborate preparations on the other side (Fig. 6). The second axis explained 17.58% of the variance and separated trees and shrubs on one side, from herbs, climbers and fungi on the other side. Powder and decoction from underground

**Fig. 3.** Proportional deviation of medicinal plants used in gastrointestinal disorders compared to total abundance of medicinal plants. Only significant deviations are shown.

**Fig. 4.** Use frequency (number of species) of different plant parts.

**Fig. 5.** Use frequency of remedy preparation techniques.
parts and flowers of shrubs were used as anthelmintic, appetizer or in bile disorders. Juice, soup/vegetables from herbs were used for several disorders, including indigestion/digestion, diarrhea, intestinal disorder, hepatoprotective/jaundice, constipation/laxative/purgative, splenopathy, emetic/vomiting/nausea and ulcer. Paste from gum or fungi was used in colic (Fig. 6).

A PCA was also realized to examine the relation between diseases and botanical families. Species from the Valerianaceae family was used for emetic/vomiting/nausea. Species from the Nymphaeaceae, Sapotaceae, Brassicaceae, Myrtaceae and Clusiaceae families were used as astringent. Species from the Taxaceae and Apiaceae families were used as carminative/flatulence/tympanite. Species from the Fabaceae and Malvaceae families were used in bile disorders, constipation and splenopathy. Species from the Rosaceae and Poaceae families were used in dysentery and diarrhea. Species from the Euphorbiaceae and Asteraceae families were used in hepatitis/jaundice and as anthelmintic. Species from the Ranunculaceae family was used in stomachache, internal disorders, indigestion, gastritis, and ulcers (Fig. 7).

3.2. Ethnicities, districts and regions

The different studies reviewed were carried out from 15 different ethnic communities (Bankariya, Bantar, Chepang, Darai, Gurung, Limbu, Magar, Meche, Newar, Rai, Rahi, Satar, Sherpa, Tamang and Tharu) from nine areas (Bagmati zone, central Nepal, far west Nepal, Karnali zone, Khaptad National Park, Rapti zone, Panchase region, Rolwaling region and Kali Gandaki watershed area) and 35 districts in Nepal. There were more studies from central Nepal compared to other areas. The earliest studies we found were published in 1974 and the year with the most studies published was 2000.

3.3. Pharmacological and phytochemical evidences

We found slightly more phytochemical studies (763 studies for 324 species) than pharmacological studies (654 studies for 269 species) on plant species used in gastrointestinal disorders in Nepal (Electronic Appendix 1). We found both types of studies for 126 plant species. More pharmacological studies were in-vivo experiments (249) than in-vitro experiments (178). Almost all in-vivo experiments were conducted for diarrhea, induced in Wistar rats by castor oil and magnesium sulfate, _Escherichia coli_ enterotoxin, charcoal meal, castor oil-arachidonic acid, and prostaglandin (PGE). The in-vitro experiments included antimicrobial tests for diarrhea or dysentery or for other diseases caused by bacteria such as _Escherichia coli_, _Shigella_, _Salmonella typhi_, _Vibrio cholera_, _Pseudomonas aeruginosa_ and _Aeromonas hydrophila_. Species from the Fabaceae, Lamiaceae and Asteraceae families were highly investigated, both for pharmacological bioassays and phytochemical studies.

Plant species with various kinds of secondary metabolites such as alkaloids, amino acids, tannins, terpenoids, and flavonoids (e.g., _Abras procatorius_; fatty acids, sugars, asarone, sesquiterpine ketones (e.g., _Acorus calamus_); artemisia ketone, germacrene B, borneol and cis-chrysanthenyl acetate (e.g., _Artemisia indica_); flavonoid glycoside, flavinoids, pyrrolidine (e.g., _Drymaria diandra_, _Lobelia chihensis_), emodin (e.g., _Rheum australe_); phenolic acids (Terminalia species); sterols, lactones and glycosides (e.g., _Tinospora cordifolia_ and _Withania somnifera_) were used to treat gastrointestinal disorders, mainly diarrhea and dysentery.

3.4. Multiple-use species

A total of 35 species were reported to treat more than eight different gastrointestinal disorders (Table 2). A few species were reported to treat more than 10 disorders (_Bombax ceiba_, _Chenopodium album_, _Cinnamomum tamala_, _Oxalis corniculata_, _Phyllanthus emblica_ and _Psidium guajava_).

Out of the 35 plant species used to treat the most different disorders, pharmacological studies were available for 27 and phytochemical studies for 32 species (Table 2). Species for which no pharmacological studies were available were _Catunaregam spinosa_, _Curcuma orchioides_, _Euphorbia royleana_, _Juniperus indica_, _Nardostachys grandiflora_, _Rubia manjith_ and _Thymus linearis_, whereas species...
with no phytochemical studies were *Chenopodium album*, *Citrus medica*, and *Rubia manjith*. In-vivo experiments (n = 40) were more frequent than in-vitro (24). Stomachache was treated by the highest number of species (32), followed by diarrhea (30). In terms of preparation, decoction was the most common form (20 species), followed by paste or powder (16).

3.5. Conservation status

Of all the medicinal plant species used to treat gastrointestinal disorders, 102 species were included in various conservation categories. Forty eight plant species were highly traded (GoM/MoFSC, 1995, 2006; ANSAB, 2013), 42 species were in CAMP threat categories, and 37 in IUCN threat categories. *Nardostachys grandiflora*, *Neopicrorhiza scrophulariiflora*, *Rubia manjith*, and *Rubia pumila* were the most threatened species. *Berberis mucrifolia*, *Coryllalis megacephala*, *Delphinium himalayai*, *Euphorbia longifolia* and *Heracleum littl* were endemic to Nepal. Sixteen orchid species were protected under CITES Appendices II and III (Electronic Appendix 1).

4. Discussion

Medicinal plants are important in primary health care systems in Nepal and thus have been widely studied. However, studies on specific disease types are still lacking except for a few on anthelmintic (Bhattarai, 1992), diarrhea and dysentery (Bhattarai, 1993), gastrointestinal disorders (Thapa et al., 2013) and gynecological treatments (Bhattarai, 1994). Here, we reviewed the literature and documented plant species used in Nepal to treat 20 different disorders related to the digestive system. We focused on gastrointestinal disorders because many people die each year in Nepal due to gastrointestinal related diseases such as diarrhea, dysentery and cholera (Bhandari et al., 2009). The prevalence of these gastrointestinal ailments is likely due to malnutrition, poor hygiene, and lack of clean drinking water, as is the case in India (Dey and De, 2012). Notwithstanding the importance of addressing the public health issues at the root of gastrointestinal disorders, it is as crucial to improve our understanding of how these ailments can be treated. Medicinal plants are part of the solution.
4.1. Diversity, uses, preparation modes

The most common families used to treat gastrointestinal disorders in Nepal were Fabaceae, Asteraceae, Lamiaceae, Rosaceae, and Ranunculaceae. This is in agreement with ethnobotanical studies from Africa, New Zealand and Ecuador (Bennett and Husby, 2008; Saslis-Lagoudakis et al., 2011). A review of medicinal plants used by indigenous people of the Canadian boreal forest also found Asteraceae, Rosaceae and Ranunculaceae to be highly used to treat gastrointestinal disorders, along with Lilaceae, Eriaceae, Betulaceae, Caprifoliaceae, and Salicaceae (Upnerty et al., 2012a). An ethnobotanical review of the Mapuche medicinal flora of South America (Argentina and Chile) showed that Asteraceae, Rosaceae, Solanaceae, Apiaceae and Fabaceae were frequently used in gastrointestinal problems (Molares and Ladio, 2009).

When using randomization tests to detect which plant families were more commonly used to treat gastrointestinal disorders than expected from their frequency in the total Nepali flora, the Fabaceae, Amaranthaceae, Euphorbiaceae, Anacardiaceae and Lamiaceae families stood out. The comparison between the families used most frequently and the families used more often than expected suggests that Fabaceae and Lamiaceae are not only very common, but host a disproportionately high number of species used against gastrointestinal disorders. In contrast, Asteraceae, Rosaceae and Ranunculaceae are commonly represented among medicinal plants simply because they are common in the Nepali flora. In addition, species from the Asteraceae family are less commonly used against gastrointestinal disorders than would be expected from their representation in the medicinal flora of Nepal. This indicates they are important medicinal plants, but most often used to treat other ailment types. The randomization test we performed highlighted the relative importance of some botanical families in the treatment of a particular type of ailment. Previous studies were conducted in Italy (Weckerle et al., 2012) and in North America (Moerman and Estabrook, 2003), showing that some families were used much more often than would have been expected considering their importance in the local flora. Unfortunately, the randomization test we used is a new addition to the ethnobotanical methodology, and it was thus impossible for us to compare our results with those from other studies. We suggest that the distinction between absolute and relative use frequency is important and that future studies should attempt to perform similar tests. Pharmacological and phytochemical studies should in fact primarily focus on the families hosting more medicinal species than would be expected, as these families show the highest potential.

Underground parts (bulbs, roots, rhizomes, tubers), and fruits and seeds were the most frequent parts used to prepare medicinal formulations, corresponding to previous findings from Nepal (Rokaya et al., 2010; Upnety et al., 2010, 2012b) and elsewhere (Srirhti et al., 2009; Kamatenesi et al., 2011; Semenya and Maroyi, 2012). This use pattern is possibly due to higher amounts of bioactive compounds being present in underground parts (Srirhti et al., 2009), as well as in seeds or fruits.

4.2. Efficacy of medicinal plants

We found pharmacological and phytochemical studies for 15.87% and 14.27% of the reported plant species, respectively, as was reported in previous studies (Upnety et al., 2010; Luitel et al., 2014). As there is a large number of species used against different gastrointestinal diseases, detailed phytochemical and pharmacological studies of untested species could be carried out to complement traditional knowledge, as was already done for Aegle marmelos (Baliga et al., 2011), Asparagus racemosus (Alok et al., 2013), Momordica charantia (Grover and Yadav, 2004) and Rheum australe (Rokaya et al., 2012c).

Chemicals like tannins help inhibit gastric secretions, whereas ellagic acid reduces stress and prevents gastric lesions, especially duodenal ulcers (Murakami et al., 1991), and also relieves diarrhea and dysentery (Heinrich et al. 1992; Pengelly, 2004). Many types of glycosides combined with vitamins (polyphenolic glycosides, flavonoids), alkaloid glycosides, glycosides in the group of antibiotics, glycopeptides, cardiac glycosides, steroids, terpenoid glycosides, etc. (Kren and Martinková, 2001) can be broken down by hydrolysis through the action of enzymes or acids. They are non-toxic, therapeutically beneficial, and exhibit expectorant, sedative, and digestive properties (Pengelly, 2004). Sugars help reduce the fecal volume and rehydrate the patient (Molla et al., 1985). Although it has been pointed out that many secondary metabolites are useful to treat different gastrointestinal diseases, the physiological mechanisms explaining their efficacy are not fully understood.

4.3. Implications for primary health care, bio-prospecting and drug development

Even though many plant species are used in gastrointestinal disorders in Nepal, many people are still dying each year in suburban and rural areas due to diarrhea, dysentery, and cholera. There could be several reasons behind this. First, most plants that are effective in the treatment of gastrointestinal disorders are not necessarily available everywhere and all people do not have specialized knowledge on the required herbal formulations to be used against different disorders due to gaps in knowledge sharing within different communities (Manandhar, 2002; Rokaya et al., 2012b). It was in fact reported that medicinal plants and associated herbal knowledge is not uniformly distributed across the country (Rokaya et al., 2012b). The second, probably most convincing explanation could be related to poverty, low sanitation standards and lack of effective communication (low schooling, lack of health workers, no guidelines available) in many rural areas. Due to this, diseases tend to spread fast and herbal medicines do not allow prompt reaction. Thirdly, due to rapid advancement in modern medicine, more people are attracted to allopathic remedies that cure faster and thus traditional knowledge on plant use—mostly transmitted orally—is dwindling (Shrestha and Dhillon, 2003; Ghimire and Bastakoti, 2009; Bhattarai et al., 2010; Poudel et al., 2013). This is contrary to the western trend toward increased interest for medicinal plants (Jordan et al., 2010).

Our study shows potential for institutionalization of medicinal plants as an alternative and complementary medical system. There are some efforts in promoting the use of herbal medicine from government- and community-based organizations, but primary healthcare remains deficient in remote rural areas. The Ayurvedic Health Care Centers and the traditional Amchi (herbalists in mountain regions who follow the Tibetan philosophy) medical systems are the only institutionalized alternative and complementary health care systems in Nepal. The use of herbal medicines should be promoted at the local and national levels, especially in regions where access to allopathic medicines is limited, as medicinal plants are cheaper and associated with less health hazards. Herbal practitioners are mostly elders. Due to globalization and its influence on cultural settings in several areas including the Himalaya, knowledge transfer to new generations is not as efficient as it used to be (Bhattarai et al., 2006; Luitel et al., 2014), leading to depletion of traditional knowledge at an unprecedented scale. Therefore, to preserve traditional medicinal knowledge, the importance of herbal practitioners and their role in primary health care systems should be recognized at the national level. Capacity building of herbal practitioners and education of new generations will have substantial impact on the long-term sustainability of herbal knowledge.

Less than 16% of the plants reported in this study have been tested for biochemical efficacy, leaving room for bio-prospecting and testing.
The 35 plant species that are used to treat the highest number of gastrointestinal disorders could be of interest from a pharmacological perspective. Traditional uses of medicinal plants also need to be evaluated in terms of toxicity and for their potential side effects and interactions before integrating into modern health care systems. Commercial exploitation of medicinal plants should, however, make sure to safeguard the intellectual property rights of local people and traditional medicine (Sasilis-Lagoudakis et al., 2012) and respect the conservation status of plant species (Hamilton, 2004).

4.4. Conservation status of medicinal plants

Nepal has a high biodiversity due to climatic and topographic variation (Chaudhary, 1998). There are many plant species that are endemic (Shrestha and Joshi, 1996) and have medicinal value (Rokaya et al., 2012a). A large number of medicinal plant species are traded within the country (Tiwari et al., 2004) or exported outside (Edwards, 1996; Olsen and Helles, 1997; Olsen and Bhattarai, 2005). Collection and trade of wild medicinal plants have largely contributed to rural economy in Nepal. Apart from trade and medicinal purposes, several species are used as fodder, timber, firewood, etc. (e.g. Acacia catechu, Bombax ceiba, Juniperus spp., Mangifera indica, Pterocarpus marsupium, Taxus spp.). Multiple uses exert higher demand, leading to increased harvest, and such actions raise threats for some species. Most plant species are collected from the wild in unsustainable manners, also threatening species. Apart from harvesting, different factors such as deforestation, habitat encroachment, overgrazing, wildfires, shifting cultivation, and climate change contribute to species loss (Chaudhary, 1998; Upadhyay et al., 2011a; 2011b; Kunwar et al., 2013). It is thus important to identify valuable species, precisely map their distribution, document their status, study their life cycle, and formulate guidelines for their conservation and management.

5. Conclusion

In this review, we described the medicinal plants used in Nepal to treat gastrointestinal disorders. Parts used, administration process and doses can be of high value for drug formulation. Commercial exploitation of medicinal plants should make sure to safeguard the intellectual property rights of local people.

Acknowledgments

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.jep.2014.10.014.

References


