Medicinal plants used to treat infectious diseases in central part and a northern district of Bangladesh - an ethnopharmacological perception

Holly Siddique,[a,b] Barbara Pendry,[a] Mohammad A. Rashid[c] and M. Mukhlesur Rahman [a,*]

[a]School of Health, Sports and Bioscience, University of East London, Stratford Campus, Water Lane, London E 15 4LZ, UK;

[b]Royal Botanic Garden, Kew, Surrey, UK;

[c] Department of Pharmaceutical Chemistry, University of Dhaka, Dhaka 1000, Bangladesh

*Corresponding author.

Email: m.rahman@uel.ac.uk (M M Rahman); Tel: +44-2082234299

Abstract.

Introduction: Antimicrobial resistance (AMR) has become more challenging for the treatment of infectious diseases. Easy access to antibiotics, self-medication and irrational uses of antibiotics have made this problem even worse in the developing countries like Bangladesh. However, the indigenous people of Bangladesh have been using traditional Ayurvedic medicine for centuries for the treatment of infections. The aim of study was to document the medicinal plants that are being traditionally used for the treatment of various types of infections in the central part and a northern district of Bangladesh through an ethnopharmacological survey.

Materials and Methods: This survey involved interviewing 127 respondents including Ayurvedic and Unani practitioners (55.9%), patients (16.5%) and local inhabitants (27.6%) to generate data that were analysed in the context of quantitave indices including Use Value, Informant Consensus Factor, Fidelity Level and Rank Order Priority.

Results: The respondents recommended 71 medicinal plants belonging to 44 families that were used in this region for the treatment of various infections. The most cited plant families were Lamiaceae (26 citations), Meliaceae (23 citations) and Leguminasae (22 citations) whilst the most cited plant species were *Azadirachta indica* A. Juss. (23 citations) and *Ocimum tenuflorum* L. (18 citations). Leaf was most frequently used plant part in preparation. Plant species were documented based on rarity score, where 8.3% species were found to be very rare. Most common method of preparation was power form (39 reports) followed by decoction. Bacterial pneumonia was recorded as highest FIC value with 0.94 with 19 use plants reported for 2 plant species.

Conclusion: The present findings are encouraging to look into traditionally used plants to explore compounds which are responsible for anti-intective properties.

Keywords: Ethnopharmacology, Survey, Anti-infective, Medicinal plants, Bangladesh.

List of of Abbreviations

AMR: Antimicrobial resistance

C: Cultivated

CDC: Centers for Disease Control and Prevention

ECDC: European Centre for Disease Prevention and Control,

FIC: Informant Consensus Factor

FL: Fidelity Level

MRSA: Methicillin-resistant *Staphylococcus aureus*

ROP: Rank order priority

RP: Relative popularity

UREC: University research ethics committee

UV: Use value

W: Wild

WHO: World Health Organization

1. **Introduction**

The emergence of the number of bacterial pathogens with antimicrobial and multidrug resistance to antibiotics has significantly increased over the past few decades. The mishandling, misuse and abuse of antimicrobial agents are the main reasons behind the emergence of the resistant gene in microorganisms. Antimicrobial resistance (AMR) may occur due to the mutation in bacterial DNA or the acquisition of bacterial resistance gene by gene transfer in the presence of antimicrobial agent (WHO, 2018). Antimicrobial resistance is now a serious and complex problem for global health requiring a multi-disciplinary approach involving partners from all health sectors including public health authorities and the scientific community.

According to a report published by the World Health Organization (WHO, 2019a), resistant infection has become the third leading cause of mortality worldwide. AMR infections currently acounts for more than 67,000 infections in Europe with approximately 33,000 death (ECDC, 2019) costing around €1.1 billion whilst there are more than 2.8 millions infections and more than 35,000 AMR related death certificates currently issued in the United State (CDC, 2019). Methicillin-resistant *Staphylococcus aureus* (MRSA) is a big concern as this is a major cause of both healthcare- and community-associated infections around the world. It has been estimated there are more than 150,000 patients due to MRSA infections in Europe which costs approximately €380 million for EU healthcare systems (Köck et al., 2010). Pan-European surveillance data on bloodstream infections showed that more than 10% *Staphylococcus aureus* infections in 15 European countries are due to MRSA with some of these countries seeing such resistance closer to 50% (ECDC, 2014). AMR has made the battle against diseases such as HIV and malaria more challenging. Unless appropriate action is taken to tackle the threat, drug resistant infections will be the cause of death for an extra 10 million people annually worldwide by 2050 costing the world an extra $100 trillion (O'Neill, 2014). The WHO (2017) published a list of bacteria related to diseases in humans which urgently demanded new antibiotics for hard-to-treat infections. *Acinetobacter baumannii, Pseudomonas aeruginosa and Enterobacteriaceae* (Carbapenem- resistant) and *Staphylococcus aureus* (Methicillin resistant, vancomycin resistant) which pose particular threats in nursing homes and hospitals have been categorised as critical in terms of AMR. It is imperative to discover alternative therapeutics for treating infectious disease.

Plant derived medicines have contributed largely to human health since antiquity; hence plants may be a source for the development of new novel antimicrobial compounds followed by subsequent clinical, pharmacological and chemical studies (Dias et al., 2012). For example, the most prominent anti-inflammatory agent acetylsalicyclic acid commercially known as the drug aspirin isolated from the bark of the willow tree *Salix alba* L. (Der Marderosian and Beutler, 2003). Quinine isolated from bark of *Cinchona pubescens* Vahl has been used traditionally to treat malaria, indigestion, fever, mouth and throat disease for centuries (Der Marderosian and Beutler, 2003). The roots of modern medicine lie in herbalism. It is estimated that 25% of modern drugs were derived from herbal medicine (Sahoo et al., 2010). Every ancient civilisation has used plants for healing and in many cultures the use of natural products has magical-religious significance with different points of view regarding the concepts of health and disease existing within each culture. According to the World Health Organization, today's herbal medicine is still the primary form of healing used by over 80% of the world's population in developing countries (WHO, 2019b). In Bangladesh, approximately 75% of the total population are using plant originated medicine for fundamental health care (Ghani, 2003) because they are more accessible to local people and comparatively safer and more affordable compared to orthodox or conventional medicine. Bangladesh is enriched with a vast plant diversity having about 450-500 plants with medicinal properties in traditional healthcare system such as Ayurvedic, Unani, Hekimi and other forms of folk treatments because of its favourable micellenous ecologic conditions such as temperate and humid weather and fertile alluvial soil. Moreover, Bangladesh has a national botanical garden, hilly tracks and the largest mangrove forest (Sundorban, Khulna) where thousands of medicinal plants flourish (Yousuf et al., 2009; Ghani, 2003).

Ayurvedic medicine, a traditional system of medicine that originated in India over 5000 years ago, is widely practiced in Bangladesh. The concept of Ayurvedic medicine with regard to health and disease is to promote the use of herbal remedies, special diet and other unique health practices. The local population of Bangladesh have a long history of using traditional medicine for primary healthcare. Ayurvedic and Unani practitioners (qualified practitioners) and local healers (using knowledge handed down through the generations) of Bangladesh prescribe such medicinal plants for the treatment of various diseases including different types of infections

(Rahmatullah et al*.,* 2012; Seiikh et al*.,* 2011). Bangladeshi medicinal plants that have been traditionally used for centuries by Ayurvedic and Unani practitioners to treat infectious diseases may contain phytochemicals with the potential for the development of new modern drugs. Both Ayurvedic and Unani practitioners are very popular among local inhabitants in the cities and are sought based on their skills in treating disease. On the other hand, local healers who are not qualified practitioners but recommend medicinal plants to village people in the rural areas of Bangladesh based on their experience and knowledge are well known in the Bengali community. The knowledge and use of plants for medicinal purposes is an integral part of many ethnic cultures. This valuable indigenous knowledge associated with plants is now being recognised as a source of knowledge and the wisdom of using medicinal plants by traditional healers and communities which otherwise could be lost over time, needs to be conserved and documented to enable more research into the identification of the key chemical compounds and mechanism of action by which traditional medicine works.

An ethnopharmacological survey, a strategy to select medicinal plants for scientific exploration of the biologically active compounds, documents the information of traditional and the local knowledge on application of medicinal plants for treating a range of ailments. Ayurvedic practitioners, local healers and inhabitants in Bangladesh narrate the use of local medical plants for the treatment of infectious diseases which may contribute significantly to antibacterial drug development. Ethnopharmacological knowledge has mostly been the starting point for developing drug for centuries but researchers are often unaware of this knowledge and after finding the initial lead for drug development. Ethnopharmacological context focuses on documenting the benefites and risks of using traditional medicinal plants and provides a safer use of resources. Moreover, it also advocates in the prevention of rare plant species from extinction. Several ethnopharmacological surveys have been conducted in different parts of Bangladesh focussing on different aspects of health problems such as diabetes mellitus, diarrhoea or dysentery or which have just simply catalogued the medicinal plants used by tribes of the hill tract areas (Kadir et al., 2012; Rahman 2013; Rahman and Roy 2014; Uddin et al., 2015a; Uddin et al., 2015b; Nur et al., 2016,). These studies only featured the qualitative analysis of forest or hill tract areas of Bangladesh and lacked any data analysis using the various quantitative parameters associated with this type of study. Kadir and his colleagues published several studies on Bangladesh medicinal plants with data analysis, however these focussed on the plants used to treat gastrointestinal disorders solely in the hill tracts of Bangladesh (Kadir et al., 2012, 2013 and 2014). According to the authors' knowledge, to date no studies have been carried out to investigate the use of Bangladeshi medicinal plants to treat infections. However, ethnopharmacological surveys were carried out previously in the Bunda district of Tanzania, Buhunga parish, (Uganda Tugume and Nyakoojo, 2019) and Guinea (Magassouba et al., 2007) to document medicinal plants that were being used by local traditional healers and experienced inhabitants for treating infectious diseases.

Thus an ethnopharmacological survey was conducted in Bangladesh during late summer and autumn in 2016 in order to document indigenous knowledge in regard to the treatment of infections with the ultimate aim of identifying plants that could be selected for extensive phytochemical investigation to identify key secondary metabolites responsible for their anti-infective properties. Herein the authors report the ethnopharmacological survey carried out in Bangladesh using two sets of semi-structured and structured questionnaires to identify anti-infective medicinal plants that have been recommended by Ayurvedic and Unani practitioners as well as by local healers and the patients who received such traditional treatments.

2. Materials and methods

2.1 Study area

Bangladesh (Figure 1) is a south Asian country located at the apex of the Bay of Bengal and boarded by India and Myanmar (latitudes 20° and 27°N and longitudes 88° and 93°E) with a population of over 162 million- 8th most densely populated country in the world. It is well known for its rigorous greenery and numerous waterways. Bangladesh has been classified as monsoon climate which means heavy rainfall during raining season, with high temperature and high humidity. There are four ethnic groups including Bengali, Mongolian, proto- Australian and Dravidian. Bengalis are 98% of total population, Mongolians are the local tribes of hilly tracks of Bangladesh, proto- Australian group such as Khasia and Santals are mainly labourers of tea gardens of Bangladesh (Banglapedia, 2016). 70% of overall population lives in rural area. 28% of people are treated by alternative medicine (Ayurveda, Unani and Homeopathy) in government hospitals (WHO, 2021). Natore, a northern district of Bangladesh, is well known for practicing folk medicine among local inhabitants. It has been reported that the soils of this area are rich alluvium with the pH of 7.22 which is a favorable condition for agriculture and gardening (Rahmatullah et al., 2013).

An ethnopharmacological survey was conducted to explore potential medicinal plants used for treating various infectious diseases by using a sets of structured and semi structured interviews. The interviews included Ayurvedic and Unani practitioners at their practice places, patients at Ayurvedic hospitals, local healers and inhabitants in common areas (National Botanical Fair and herb markets). As recommended by the practitioners and academics of two recognised Ayurvedic and Unani colleges (Government Unani and Ayurvedic Degree College and Hospital at Mirpur and Tibbia Habibia Ayurvedic College and Hospital at Bokshi Bazar) in Bangladesh, the survey was carried out in greater Dhaka (Mirpur, New Market, Chalk Bazar, Sutrapur, Moulobhibazar, Shahbag), Tangail (near Modhupur forest), Gazipur (Telipara), Mymensingh, Jamalpur and a northern district named Natore. The later district was included in the survey as this is well known for medicinal plants being cultivated as well as being recommended by local healers and some practitioners.

2.2 Ethnopharmacological survey

The ethnopharmacological survey was conducted with prior ethical approval from the University research ethics committee (UREC) of University of East London (Reference number: UREC- 1516 154). Relevant approval to carry out the survey in Bangladesh was also sought from the University of Dhaka. During the interview processes, all the participants were provided with a participant information sheet to explain the process and purpose of the study. Additionally, a participant consent form both in English and Bengali were also provided for participants to agree and sign prior to interview.

The ethnopharmacological survey was carried out in Bangladesh during late summer and autumn in 2016. Two different sets of questionnaires were compiled whereby 71 practitioners, 21 Ayurvedic hospital patients and 35 local inhabitants participated in the survey. The questionnaire for practitioners was structured to gather maximum information about medicinal plants. Some questions such as scientific name, dose and route of administration of suggested plant materials or how many years they have been practicing as a practitioner were solely asked to Ayurvedic and Unani practitioners. On the other hand, hospital patients and village inhabitants were asked about obvious signs and symptoms they experienced in relation to bacterial diseases, (for example, burning sensation while urinating; sufferring from high temperature for long time, itchy, red, dry, sore skin, unable to swallow food, whitish area inside the mouth, frequent defecate due to upset stomach etc) and plant materials ingested to treat such illness. The patients were also asked how long they had been taking the suggested plant(s) material to treat the disease. Information about medicinal plants to treat bacterial disease was collected from participants *via* face to face interviews by using questionnaires (available in supplementary data) written in both English and Bengali.

The inclusion criteria for the selection of participants were as follows

a. Adults above the age of 25
b. The participants should be literate enough to read and sign the consent form written in either Bengali or English
c. The Ayurvedic and/or Unani practitioners interviewed should have a minimum of 5 years' experience in clinical practice.
d. The local inhibitants interviewed had to be familiar with the use of plants to treat themselves with herbal medicine

Information collected from experienced Ayurvedic and/or Unani practitioners and ayurvedic hospital patients or local inhabitants aged above 25 years were given higher priority as they tended to have more accurate knowledge on traditional medicinal plants. Two hospitals named 'Tibbia Habibia Unani College and Hospital' and 'Government Unani and Ayurvedic Medical College and Hospital' were visited. Ayurvedic and/or Unani practitioners working in these two hospitals were interviewed. A directory of Ayurvedic and Unani practitioners of Bangladesh published by Hamdard Laboratories Limited, an Ayurvedic manufacturing company in Indian subcontinent, also helped to communicate with some practitioners. Accordingly, most of the Ayurvedic and Unani practitioners who worked privately and were located in different areas of Dhaka city were contacted and interviewed at their practice place *via* prior appointments. With prior permission from the above mentioned hospitals, outpatients in the waiting area were also interviewed. Local inhabitants were interviewed at the 'National tree Fair' which was held in Agargaon, Dhaka in August- September 2016 and also at an herb market located in Moulobhibazar, Dhaka. More interviews of inhabitants were carried out in Dhaka (Mirpur, New Market, Chalk Bazar, Sutrapur, Shahbag), Gazipur, Mymensingh Jamalpur, Tangail and Natore in social gathering places where people meet and greet in the evening.

Both sets of questionnaires were comprised of two sections. The first section consisted of participants' personal information such as name, age, gender, profession, education level, how long they had been working as a practitioner (for Ayurvedic and Unani practitioners only), how long they had been admitted to the hospital (ayurvedic hospital patients only) and how they acquired their knowledge about traditional medicine (local inhabitants only).

The second section of questionnaires was comprised of open questions in order to gather information regarding medicinal plants used to treat infectious diseases. Respondents were asked to share their experiences of plants they used to treat bacterial disease. During the interview, a full description of the medicinal plants used for a bacterial disease (or symptoms indicative of bacterial infection) was requested in regard to its local name, scientific name (if known), use, therapeutic indication, parts of the plant used and growth form, route of administration, method of preparation, site of collection, form of usage (fresh or dried), dosage, possible side effects, signs and symptoms of the disease (patients and inhabitants only) and other therapeutic actions besides antibacterial activity (if any). The above questionnaires complied with the guidelines for an ethnophamacological survey as provided by Professor Michael Heinrich of UCL School of Pharmacy which have been subsequently published (Heinrich et al., 2018). Scientific names of the medicinal plants have been checked and updated with the with reference to book (Yusuf et al., 1994) and online resources of the Royal Botanic Gardens, Kew (www.theplantlist.org).

2.3 Data analysis

The plant species with their family, scientific name, local name, common name, plant parts used, habitat, plant parts used, plant materials' source (wild or cultivated) and method of preparation are listed in alphabetical order in Table 2. The information gathered through this ethnopharmacological survey was analysed quantatively using various parameters including use value (UV), informant consensus factor (FIC), Fidelity Level (FL) and Rank order priority (ROP).

The use value (UV) demonstrates the relative importance of the suggested plant species. Use value (UV) is calculated using the following formula (Savikin et al., 2013)

$$\mathbf{UV}\boldsymbol{i} = \sum \frac{\mathbf{U}\boldsymbol{i}}{\mathbf{N}\boldsymbol{i}}$$

where U_i is the number of use reports cited for a given plant species *i* and N_i is the total number of informants interviewed for a given plant species *i*. (Phillips et al., 1994).

The relative healing potential of a plant can be established by using the Fidelity Level index (FL; Friedman et al., 1986) determined by the following formula

$$FL = \frac{\mathrm{Ip}}{\mathrm{Iu}} \times 100$$

where Ip is the number of participants who independently cited the use of a plant species for the same disease and Iu is the total number of participants who mentioned the plant for any major disease. A high FL value means that the plant species was used frequently to treat a specific ailment category by the participants (Friedman et al., 1986).

Rank order priority (ROP) was determined by using the following formula (Eddouks et al., 2017).

$$\mathbf{ROP = FL \times RP}$$

where ROP is Rank order priority, FL is Fidelity level, RP is Relative popularity. ROP is the combination of fidelity level and relative popularity.

Relative popularity was calculated as a ratio of the number of informants who suggested a particular plant species to the number of informants who cited the most frequently cited plant species (Table 3).

The informant consensus factor (FIC) was calculated to check the homogeneity of the information using the following formula (Heinrich et al., 1998).

$$\mathrm{FIC} = \frac{Nur - Nt}{Nur - 1}$$

where 'Nur' is the number of use-reports for each disease category and 'Nt' is the number of plant species used.

The diseases were classified into broad ailment categories in order to calculate the FIC (Informant consensus factor). The medicinal plants that are presumed to be effective in treating a certain disease have higher FIC values. FIC is the suggestive value of how the participants uniformly agree about the use of a particular plant species for treating a particular ailment category. The value of FIC ranges from 0 to 1. A value close to 1 indicates that few plant species were used by a large group pf participant. Alternatively, a low value indicates disagreement within the participants with regard to the use of a plant species for the treatment of a specific disease in an ailment category (Table 4).

3. Results

3.1 Demographic data analysis

The data gathered through this ethnopharmacological survey was analysed based on the demographic variables such as gender, age, educational background, occupation, and number of years of experience of the practitioners (Table 1). Among 127 participants, 55.91% (n=71) were male whilst 44.09% (n=56) were female. A significant association ($p < 0.05$) was observed in some of the demographic variables such as age, sex, educational background and profession. A particularly significant association ($p < 0.01$) was recorded for the age group of male and female users compared to experience of the practitioners ($p > 0.05$). However, no clear-cut trend was observed in terms of age group and plant users. Most of the participants were young and fell within the age group of 25-35 (33.86%, n=43) followed by the age range of 36-45 (23.62%, n=30) and then 66-75 (21.26% n=27). Surprisingly participants in the age range of 56-65 (10.24%; n=13) were the least plant users. Most of the participants were young because the majority of the interviewees were qualified Ayurvedic practitioners (71) between the ages of 25-35 compared to local people and Ayurvedic patients. Apart from qualified practitioners, local inhibitants and patients from two Ayurvedic hospitals claimed to have acquired ethnobotanical knowledge from their ancestors stating that botanical remedies were part of their culture. The literacy level of the participants was higher (40.94%) with 3 practitioners having higher degree qualifications (2 practitioners with PhD degree and 1 with MPhil degree). It is interesting to note that no interactions of herbal remedies with orthodox medicine were reported by any of the participants. In terms of empirical knowledge, 29.6% (39 out of a total of 71 participants as practitioners) of practitioners had at least 6-10 years' experiences followed by 18.3% with 21-30 years of experience of treating patients with herbal medicine.

3.2 Analysis of data with growth forms and plant parts used

Analysis of growth forms of the plants recommended by the practioners, patients and local inhibitants implied that plant species were either tree, shrub, under-shrub, herb and climber. Investigation into the plant parts used for the various types of infections indicated that leaves (28%) were most commonly used in preparation of traditional medicines followed by bark (19%), fruits and whole plant (15% each), flowers (8%), seeds and roots (6% each), pulp, latex and thorn (1% each) (Figure 2).

3.3 Methods of preparation, routes of administrations and phytotherapeutical applications

The ways the formulations from the medicinal plants recommended were prepared fall into 8 well defined categories- raw, powder, mash, paste, decoction, infusion, oil and tea. Among these, the most commonly used preparation was powder (39 reports) followed by decoction and paste (26 reports each), mash (9 reports) and infusion (8 reports) whereas there were only one report tea, oil and raw (Figure 3). These preparations were given either orally or through topical application into the skin. The overall dose of the formulation given for ailments of specific types of infections depend on age and physical fitness of the patients (Kayani et al., 2014). In some cases, plant parts like leves were taken as raw while in other instances plant parts like seeds were pressed to produce oils. In order to prepare powders, plant materials were sun-dried for several days followed by grinding into powders. Herbalists sometimes ground fresh plant parts with a mortar and pestle followed by making thick and soft substance by adding small amount of liquid to produce pastes. Sometimes the formulations include some additives like water, milk, honey, sugar, oil as vehicles or medium for the preparations. (Abbasi et al., 2013).

3.4 Quantitative data analysis

3.4.1. Use value (UV)

The data gathered through this ethnopharmacological survey was analyzed by calculating the use value (UV) which validates relative importance of plant species or family for a population and traditional medicinal uses by local inhabitants. The high value of this index for a species can be attributed to its frequent use in the treatment of various ailments with high number of informants and use reports. During this investigation, the highest use value were observed by the *Azadirachta indica* A. Juss. (UV 0.18; 23 citations) followed by *Ocimum tenuflorum* L. (UV 0.14; 18 citations), *Justicia adhatoda* L. (UV 0.13; 16 citations), *Curcuma longa* L. (UV 0.10; 13 citations), *Cynodon dactylon* (L.) Pers. (UV 0.09; 12 citations) and *Kalanchoe pinnata* (Lam.) Pers. (UV 0.09; 12 citations). The least use value were recorded for several plant species with only 1 citation (UV 0.01; Table 3).

i. Fidelity level, rank order priority and rariry score:

Fidelity level (Table 3) was calculated to determine the relative healing potential of a plant. Most of the plants in a particular disease category scored 100% but *Aloe vera* (L.) Burm.f. scored the least (18%) followed by *Justicia adhatoda* L. (25%) compared to other plant species. High FL of species indicates the prevalence of specific diseases in the study area. The species having high value of FL validates its exclusivity for the treatment of a particular disease. Fidelity level for the plant species during this investigation is listed in Table 3. Plant species exhibited 100% FL in this study include *Acmella oleracea* (L.) R.K. Jansen, *Alstonia scholaris* (L.) R. Br., *Amaranthus spinosus* L., *Artemisia absinthium* L., *Boerhavia diffusa* L., *Bombax ceiba* L., *Cassia angustifolia* Vahl, *Cassia fistula* L., *Cassia tora* L., *Ceiba speciose* (A. St.-Hil) Ravenna, *Chrozophora prostrata* Dalzell & A.Gibson, *Cissampelos pareira* L., *Cuminum cyminum* L., *Diospyros malabarica* (Desr.) Kostel., *Eupatorium odoratum* L., *Ficus heterophylla* L.f., *Fumaria officinalis* L., *Glycyrrhiza glabra* L., *Hibiscus rosasinensis* L., *Holarrhena antidysenterica* (Roth) Wall. ex A.DC., *Lavandula stoechas* L., *Musa acuminate* Colla, *Neolamarckia cadamba* (Roxb.) Bosser, *Nigella sativa* L., *Nyctanthes arbor-tristis* L., *Nymphaea nouchali* Burm.f., *Paederia foetida* L., *Peperomia pellucida* (L.) Kunth, *Phyllanthus niruri* L., *Piper betle* L., *Pistacia integerrima* J. L. Stewart ex Brandis, *Portulaca grandiflora* Hook., *Psidium guajava* L., *Santalum album* L., *Saraca indica* L., *Solanum xanthocarpum* Schrad. & H. Wendl., *Solanum nigrum* L., *Sphaeranthus indicus* L, *Tagetes erecta* L., *Terminalia chebula* Retz., *Vateria indica* L., *Viola odorata* L., *Zingiber montanum* (J.Koenig) Link ex A.Dietr., *Zingiber zerumbet* (L.) Roscoe ex Sm., *Ziziphus jujube* Mill. In cases of rank order priority (ROP), *Kalanchoe pinnata* (Lam.) (43.3), *Azadirachta indica* A. Juss. (34.8), *Ocimum tenuiflorum* L. (34.63), *Lagenaria siceraria* (Molina) Standl. (30.3), *Cuminum cyminum* L. (26), *Cynodon dactylon* (L.) Pers. (26) and *Musa acuminata* Colla (26) highest scores (>25).

The plant species recommened through this study were also ranked based on their rarity (Giday et al., 2016); very rare species (RS 1), moderately rare/ available species (RS 2) and widely available species (RS 3). Among a total of 71 plants recoded through this study, 8.3% species (a total of 6) were found very rare (RS 1).

3.4.3. Informant consensus factor (FIC) for each category of ailments:

The agreement for the use of plants to treat particular ailment categories among the participants was determined by calculating the FIC value (Table 4). The FIC value varied from 0-0.94. Bacterial pneumonia recorded the highest FIC value 0.94 with 19 use reports for 2 plant species. *Ocimum tenuiflorum* L. was the species responsible for the highest consensus factor with 18 out of 19 reported events, followed by wound healing (FIC 0.85; 49 use reports, 8 species), gastrointestinal disorder (FIC 0.83; 59 use reports, 11 species), rheumatic fever (FIC 0.83; 47 use reports, 9 species). A high FIC value indicates the efficiency of treating a particular ailment with medicinal plants. Bacterial pneumonia had the highest FIC value which confirmed that this ailment was common in the study area probably due to a weakened immune system caused by malnutrition. Moreover, there was good communication present among the informants for treating this ailment category.

3.5 Literature review of the plants recorded through this study: Plants recommended through the ethnopharmacological survey have been searched for the reports on phytochemical and antimicrobial investigations. The overall literature review together with associated references are incorporated in the 'Supplementary material' (Table S1). A diverse range of chemical compounds including terpenes, flavonoids, phenolics, glucosides, alkaloids, sterods and saponins have been reported from common medicinal plants like *Nigella sativa*, *Ocimum tenuiflorum*, *Piper betle*, *Psidium guajave* and *Terminalia arjuna*. Almost all the plants recommended through this survey were previously investigated for antibacterial activity against various group of Gram positive or Gram negative bacteria such as *B. subtilis*, *S. aureus*, *P. aeruginosa*, *E. coli*. However, there were no reported antibacterial activity of *Chrozophora prostrata* and *Ficus heterophylla*.

4. Discussion:

An ethnopharmacological survey was carried out in 10 different locations of the capital city Dhaka and its surrounding areas and also in a northern district, Natore. Dhaka is one of the world's largest cities and the 4^{th} most densely populated city in the world with the population of 18.89 million (Population and housing census, 2011). Despite the improved economic system in Bangladesh, the country is still experiencing remarkable public health issues. There is a strong interest in improving the complementary medicine system in Dhaka city and nearly districts due to limited medical sources. At Natore district of Bangladesh, around 200 farmers shifted their livelihood from conventional crops and vegetables to medicinal plants among which *Aloe vera* was the main medicinal plant to be cultivated since 2000 (Shahidullah and Haque, 2015). An ethnopharmacological survey was conducted in Bangladesh to accurately document information with regard to the herbal remedies used traditionally for the management of infective diseases such as syphilis, gonorrhoea, chronic dysentery and bacterial pneumonia in order to identify the anti-infective lead compounds from selected plant materials and to preserve valuable ethno-medical information.

55.91% males and 44.09% females participated in the survey. The majority of the participants were Ayurvedic or Unani doctors (71 practitioners out of 127 participants). Yoshida and co-workers (2017) were interviewed 86 male medical doctors and 73 female doctors to determine the attitude and perception of the doctors to Ayuvedic medicine. A significant gender difference was observed in terms of education because it is a common practice not to educate daughters in rural households of Bangladesh as it is believed that females are only born to manage the households (Amin and Nuzhat, 2016).

The market in Bangladesh for herbal medicine is huge both locally and internationally. The market size for importing herbal medicine is more than 100 million dollars annually. Some inhabitants were interviewed at the national tree fair in 2016. The national tree fair, held in Dhaka comprises around 100 stalls displaying thousands of varieties of plants including flowers, fruit trees and medicinal plants. Local inhabitants get the opportunity to buy these plants for their garden. The plants selected for phytochemical study were based on statistical analysis and a literature review of the plants suggested by participants. Most of the selected plants were collected from the National Botanical Garden of Bangladesh with prior permission from the authority. The National Botanical Garden of Bangladesh is a well-known recreation place and the largest plant preservation centre (210 acres) as it is the accumulation of 56,125 trees, shrubs, herbs and aquatic plants (Botanic Gardens Conservation International, 2018). It is known as a knowledge centre for botanists and nature lovers because exotic and rare medicinal plant species can be found there. The samples of all selected plants were deposited in Bangladesh National Herbarium. Bangladesh National Herbarium is a scientific centre where the collected dried plant specimens were recorded and preserved for reference purposes (Banglapedia, 2015b).

The patients of two Ayurvedic and Unani hospitals "Tibbia Habibia Unani College and Hospital" and "Government Unani and Ayurvedic Medical College" were interviewed. Two hospitals were non-profit medical colleges and hospitals where people get the opportunity to study for a Bachelor’s degree in Unani or Ayurvedic Medicine and also patients get treatment based on herbal medicine. The suggested use of plants from practitioners was different from local inhabitants and patients. Inhabitants and patients suggested commonly used medicinal plants mostly for cough and cold such as aloe vera, turmeric or tulsi basil however, the practitioners suggested plants used for herbal formulations which were either manufactured by an herbal company or the practitioners prepared the formula themselves and then handed this over to the patients the next day.

The outcome of the survey revealed that a large number of medicinal plants were used by informants to treat bacterial diseases. Out of 71 reported plants being distributed over 44 families, Legumes (7 species) and Asteraceae (5 species) were the highest represented families with the highest number of species closely followed by Lamiaceae (4 species), and Apocynaceae (3 species) and Zingiberaceae (3 species). The remaining plant families were represented by 1-2 species each. The possible reason for the use of plants from specific families is that the flora of these families have a tendency to dominate the pharmacopoeia due to the monsoon climate of Bangladesh (Sharma et al., 2012). Gurib-karim, (2006) reported that Asteraceae, Rutaceae and Laminaceae were shown to be important families to contribute to drug discovery and development. Legumes were reported to be the highest family used. One factor that may explain the extensive use of this taxonomic family is that legumes are the third largest family with 20,000 species. Moreover, Legumes are an economically important family due to its agricultural relevance. Most of the plants of the legume family provide edible oils, food for both human and animals, fibres and edible seeds that contain high protein and essential amino acids. (Gepts et al., 2005)

Results from the survey indicated that various plant parts (stem, bark, leaf, root, flower, and rhizome) were used for the herbal formulations. Among these plant parts, leaves (28%) were reported to be used most frequently for making herbal formulations. A similar result was found from the previous ethnopharmacological surveys conducted in different tropical regions (Khulna, Rangamati and Chittagong hill tracts) of Bangladesh for identifying the important species used in traditional medicine (Kadir et al., 2012, 2014; Dulla and Jahan, 2017). The predominance of using the leaves is their easy availability to collect and use compared to other plant parts. In addition, there is generally a higher concentration of active compounds present in the leaves due to the presence of photosynthates (Ghorbani, 2005). This can be explained by the fact that the leaves act as reservoirs for photosynthesis or exudates that are thought to contain toxins for plant protection and survival which consequently find medical values in treating diseases (Namsaa et al., 2009; Vitalini et al., 2009; Wambugu et al., 2011). The second most frequently used plant parts reported were barks (19%) followed by fruits (15%), whole plant (15%), and flowers (8%) whereas the root (6%) and seed (6%) were not commonly used because this would lead to cessation of the plants. Alzweiri and co-workers (2011) suggested that the selection of the correct plant parts was important to achieve a therapeutic response to an herbal formulation as different plant parts contain different chemical constituents. The current study showed that village people of Bangladesh used plant parts based on cultural heritage not on scientific grounds. Most of the plant parts mentioned in the present study were collected by the informants from the wild and the method of preparation was mostly powder form followed by mash and decoction. The possible reason behind this was most of the participants were Ayurvedic practitioners (71 out of 127) who prescribed their formulations as a powder form. Moreover, local people also tend to pick medicinal plants and dry them to store in a powder form for future use. Therefore, fresh plant parts were collected, and sun dried during the spring season prior to making into powder (Alzweiri et al., 2011).

The current study found that informants commonly mixed the herbal powder remedy with water followed by honey and sugar to improve compliance when taken orally. Previously Chintamunnea and Mahomodally (2012) reported that there was a direct association between the taste of a preparation and the need to use additives to improve compliance.

In this study, three main ethnopharmacological quantitative indexes were calculated to figure out the main medicinal plants used by the participants. The first parameter used was UV (use value) which was applied to identify relative importance of each plant species mentioned by the participants; the FIC (Informants consensus factor) was calculated to determine the main categories of anti-bacterial diseases for which plants were used. Finally, FL (fidelity level) was applied to determine the most important plant species from the selected disease category.

According to the high UV value (Table 3), *Azadirachta indica* A. Juss. (23 citations) and *Ocimum tenuflorum* L. (18 citations) followed by *Justicia adhatoda* L. (16 citations) and *Curcuma longa* L. (13 citations) were the most cited plants by the informants. The current study showed that the fresh leaf of *Azadirachta indica* A. Juss. is used for wound healing. This property has been endorsed by several studies (Babu et al., 2016; Shrivastav et al., 2018). For example, Narendhirakannan and his colleagues (2012) also conducted an in vitro study on *A. indica* A. Juss. and other traditional medicinal plants originating from the neighbouring country India and claimed that the presence of flavonoids (polyphenols), terpenes, alkaloids, saponins in *A. indica* A. Juss. were responsible for exhibiting strong antibacterial and antioxidant activity which contributing to significantly quicker wound healing (83%) compared to a commercial ointment (76%). Notably, *A. indica* A. Juss. has been widely mentioned in the literature in regard to its medicinal value. In Swahili, this plant is referred to as "Muarubaini" (meaning treat 40 different diseases and frequently used as an insecticide, antimicrobial, antimalarial and antiviral (Baritkar et al., 2014; Haque et al., 2007; Thakurta et al., 2007).

Ocimum tenuiflorum L. is widely known as tulsi or holy basil. In Ayurveda, tulsi is recognised as "Mother Medicine of Nature" and "the Queen of Herbs". The fresh leaves of *O. tenuiflorum* were used for treating common cough and cold and bacterial pneumonia by the participants. Previous studies reported antibacterial, antioxidant, wound healing, antifertility, antidiabetic, anticancer, immunomodulatory, anti-inflammatory, radiation protective and anti-stress activity of *Ocimum tenuiflorum* L.. (Godhwani et al., 1988; Prashar et al., 1998, Prakash and Gupta, 2000, Kelm et al., 2000, Ahmed et al., 2002, Vats et al., 2004, Subramanian et al., 2005, Yanpallewar et al., 2004, Mukherjee et al., 2005, Karthikeyan et al., 1999).

The leaf of *Justicia adhatoda* L. was used fresh or as a powder for treating respiratory tract infections by the participants. A double-blind randomized placebo-controlled study confirmed that the leaf of *Justicia adatoda* L. relieved common cough and cold in combination with the root of *Echinacea purpurea* (L.) Moench and *Eleutherococcus senticosus* Rupr. & Maxim. Maxim. (Barth et al., 2015). Several investigators reported antibacterial activity of the isolated compounds from *Justicia adhatoda* L.. For instance, Duraipandiyan and co-authors (2015) reported that *Justicia adhatoda* L. contained vasicine acetate which possessed antibacterial activity against *M. luteus* (125 µg/mL), *E. aerogenes* (125 µg/mL), *S. epidermidis* (125 µg/mL), and *P. aeruginosa* (125 µg/mL). 2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl isolated from *Justicia adhatoda* L. showed promising antioxidant activity (Dhankhar et al., 2014). Plants with a low UV value (Table 3) are not necessarily less important but this may be an indication that the traditional knowledge on these plants has been lost or may be attributed to scarcity of the plant species (Sharma et al., 2012).

For the calculation of FIC value (Table 4), the reported diseases were grouped into 12 different ailment categories. Diseases mentioned such as tuberculosis, cholera, scalp infection, dengue fever, syphilis and gall bladder infection, cystitis and jaundice were not included in this category because only one plant was suggested for this ailment category. Bacterial pneumonia was recorded to have the highest FIC value 0.94 which was generally treated with the second highest cited plant *Ocimum tenuiflorum* L. followed by wound healing (0.85), Gastrointestinal infection (0.83) and rheumatic fever (0.83). The high FIC values of these ailments indicated that the information in regard to the plants are homogenous and used by a large number of people. Several authors have reported that medicinal plants that scored a high FIC value were assumed to be efficient in treating a certain ailment category and that information was passed between informants (Boulogne et al., 2011; Uddin and Hassan, 2014). Therefore, it can be concluded that most of the plants mentioned in the current study may be effective in treating infective diseases.

The fidelity level value (Table 3) was calculated to identify the most important plant in each disease category. Most of the plant species showed 100% FL value which indicated that most of the plant species might have potential for good healing to treat a particular disease (Ayyanar and Ignacimuthu, 2011).

In respiratory tract infection, *Justicia adhatoda* L. scored the lowest FL value (i.e. 25%) which indicated that culturally it was probably a less important plant for treating that particular disease.

Rank order priority (ROP; Table 3) index were calculated to determine the knowledge of the species with regard to the abundance of the resources mentioned in the studied use catagory (Eddouks et al., 2017). *Kalanchoe pinnata* (Lam.) (43.32%), *Azadirachta indica* A. Juss. (34.80%), *Ocimum tenuiflorum* L. (34.63%) had the highest ROP value, which indicated that these species were the most familiar to informants. while few plants such as *Alstonia scholaris* (L.) R. Br. (0.04), *Paederia foetida* L. (0.04) showed a lower priority among the reported medicinal plants by the informants.

However, the mode of action of the 71 suggested plants was beyond the aim of this study. Some of the listed plants in our investigation were used to treat other diseases besides infectious disease. For example, Alzweiri et al., 2011 and Chintamunnea and Mahomodally, (2012) reported that the bulb of *Allium sativum* L. was used for snake bites, muscle relaxation, blood circulation problem, asthma, gastrointestinal disorder or hypertension but in the current study participants suggested *A. sativum* L. solely for treating metabolic disorders such as gout. Similarly Chintamunnea and Mahomodally (2012) mentioned *A. indica* A. Juss. was used in the tropical region of Mauritius as an antidiabetic agent while in Bangladesh most of the people used it for treating common cold and cough.

5. Conclusion

The traditional knowledge on medicinal plants still provides the foundation to pharmacological research in many aspects. There was a lack of scientific data on using medicinal plants for the management of infective diseases in Bangladesh. This is the first reported study to exhibit the existence of real knowledge from qualified and experienced Ayurvedic practitioners as well as local village people on medicinal plants in the treatment of infectious diseases. The reported plants from ethopharmacological survey could be a source of detailed research and analysis for searching novel active antibacterial compounds for tackling catastrophic threat antimicrobial resistance. Bangladesh is abundant with natural flora with potential anti- infective lead compounds that could be a good source for further anti- microbial resistance studies, multi- drug resistance and AMR drug discovery in accordance with ecological imperatives to aid novel treatments. The overall outcome of this research with a list of anti-infective medicinal plants could be shared with Ayurvedic practioners and health regulatory bodies in Bangladesh for proper record keeping of such plants as well as the recognisation of traditional healers' knowledge in the treatment of infectious diseases. Based on the outcome of this survey, the authors have identified a list of plants to be explored for extensive bioassay directed isolation and identification of antibacterial compounds. The have already investigated some of these plants to characterize antibacterial compounds. Other plants are currently undergoing antibacterial screening and phytochemical studies in the laboratory.

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Authors' contributions

The overall survery including two sets of questionnairies was designed by BP and MMR. The face to face interview was carried out by HS, with the direct supervison of MAR and remote guidance of MMR and BP. Literature search and data analysis were done by HS who also prepared the first draft of the manuscript which further improved by MR and BP. All authors agreed on the final draft of the manuscript.

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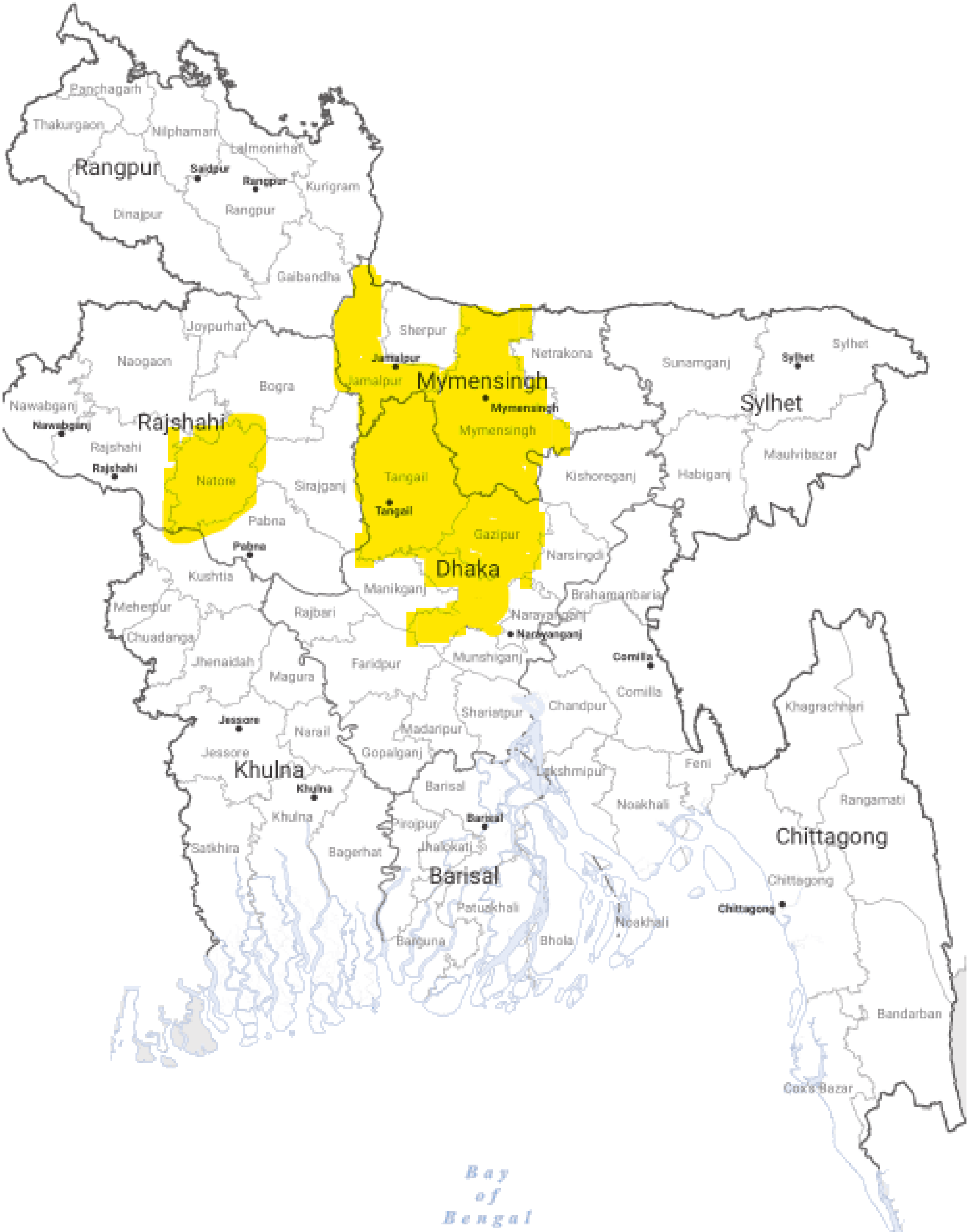

Figure 1: Map of Bangldesh showing the study region (Source: Government of Bangladesh WFP,201

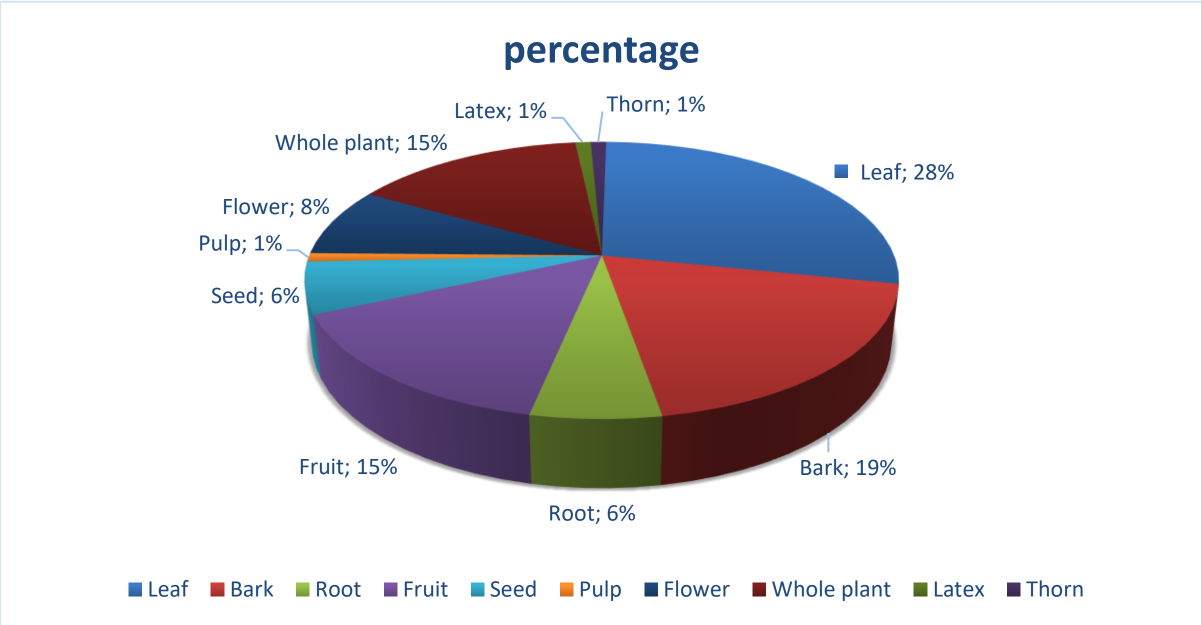

Figure 2: Frequency of the use of plant parts in management of bacterial infection in the central part and a northern district of Bangladesh

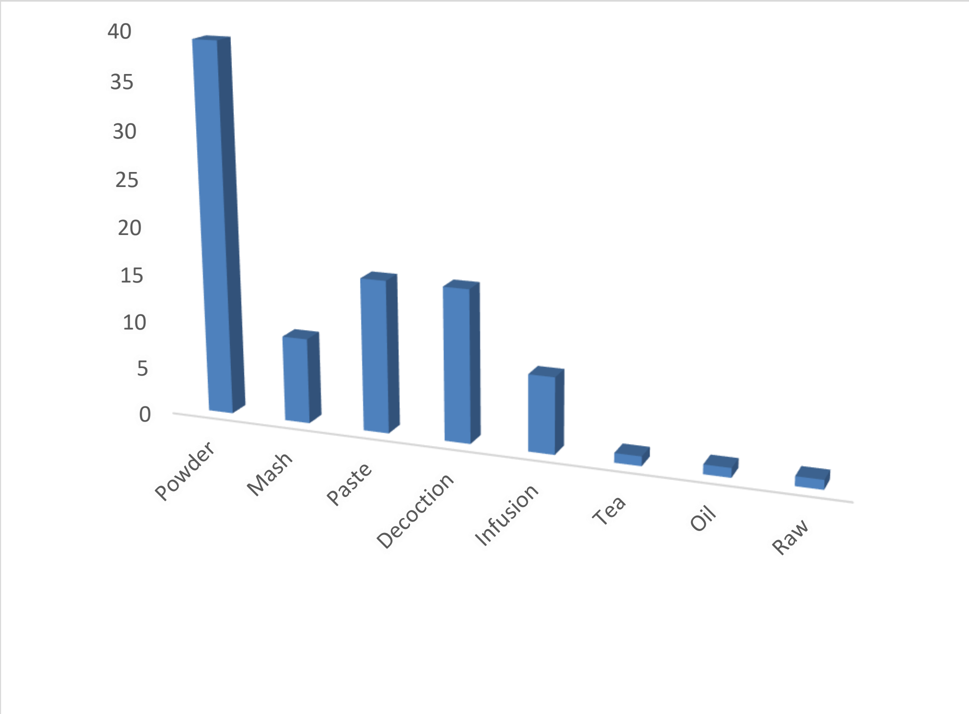

Figure 3: Frequency of the methods of preparations of traditional formulations in management of bacterial infection in the central part and a northern district of Bangladesh

Table 1: Classification of the informants with demographic data

Variable	Qualified practitioners		Ayurvedic patients		Inhabitant		Total	
	Frequency	% Frequency	Frequency	% Frequency	Frequency	% Frequency	Frequency	% Frequency
Total Informant	71	55.9	21	16.5	35	27.6	127	100
Gender								
Female	25	19.6	14	11.0	17	13.4	56	44.1
Male	46	36.2	7	5.5	18	14.2	71	55.9
Age-group (in years)								
25-35	30	23.6	5	3.9	9	7.1	44	34.6
36-45	22	17.3	4	3.1	7	5.5	33	25.9
46-55	9	7.1	3	2.4	4	3.1	16	12.5
56-65	7	5.5	1	0.8	5	3.9	13	10.2
66-75	3	2.4	8	6.3	10	7.9	21	16.5
Educational background								
No education	0	0	12	9.4	8	6.3	20	15.7
Completed 8 years of education	0	0	3	2.4	8	6.3	11	8.7
Completed 10 years of education	0	0	2	1.6	5	3.9	7	5.5
Completed 12 years of education	0	0	0	0	10	7.9	10	7.9
Diploma	12	9.4	4	3.1	0	0	16	12.5
Bachelor degree	50	39.4	0	0	4	3.1	54	42.5
Master’s degree	4	3.1	0	0	0	0	4	3.1

MPhil	3	2.4	0	0	0	0	3	2.4
PhD degree	2	1.6	0	0	0	0	2	1.6
Years of experience as practitioner								
5 years	11	15.5	-	-	-	-	11	15.5
6-10 years	21	29.6	-	-	-	-	21	29.6
11-15 years	10	14.1	-	-	-	-	10	14.1
16-20 years	10	14.1	-	-	-	-	10	14.1
21-30 years	13	18.3	-	-	-	-	13	18.3
Profession (practitioner only)								
Hakim	6	4.7	-	-	-	-	6	4.7
Unani	18	14.2	-	-	-	-	18	14.2
Ayurvedic	30	23.6	-	-	-	-	30	23.6
Medical officer of Ayurvedic hospital	17	13.4	-	-	-	-	17	13.4
Other for inhabitants and patients								
Housewife	-	-	18	14.2	19	14.9	37	29.1
Farmer	-	-	0	0	5	3.9	5	3.9
Teacher	-	-	0	0	7	5.5	7	5.5
Other workers	-	-	3	2.4	4	3.1	7	5.5

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Table 2: Family, scientific name, common (local) name, nature, plant parts used, fresh or dried, source and method of preparation of the reported plants

Family	Scientific name	Common name (Bengali name)	Nature/ Habitat	Plant parts used	Fresh or dried	Cultivated or Wild	Method of preparation
Acanthaceae	*Andrographis periculata*	Green chireta (Kalomegh)	Annual herb	Leaf, Bark	Both	C	Powder; Infusion
Acanthaceae	*Justicia adhatoda* L.	Malabar nut (Bashokpata)	Perennial shrub	Leaf	Both	W	Powder; Mash
Amaranthaceae	*Amaranthus spinosus* L.	Spiny amaranth (katanote)	Herb	Root	Both	W	Infusion; Mash
Amaryllidaceae	*Allium sativum*	Garlic (Rosun)	Aromatic bulb	Fruit	Both	C	Paste; Powder
Anacardiaceae	*Pistacia integerrima* J. L. Stewart ex Brandis	Crabs claw (Kakrashingi)	Tree	Fruit	Both	W	Powder; Decoction
Apiaceae	*Cuminum cyminum* L.	Cumin (Jeera)	Herb	Seed	Dry	C	Powder
Apocynaceae	*Alstonia scholaris* (L.) R. Br.	Blackboard tree (Chatim)	Tree	Bark	Dry	W	Powder
Apocynaceae	*Holarrhena antidysenterica* (Roth) Wall. ex A.DC.	Kurchi (Kutoj)	Flowering plant	Bark	Both	W	Powder; Decoction
Apocynaceae	*Tylophora indica*	Emetic swallow-wort (Onontomul)	Climber	Root	Both	W	Paste
Asphodelaceae	*Aloe vera*	Aloe vera	Short-stemmed shrub	Fruit/ pulp	Fresh	C	Mash; Powder
Asteraceae	*Acmella oleracea* (L.) R.K. Jansen	Paracress Plant (Shurjo konna)	Flowering herb	Flower, root	Dry	W	Powder
Asteraceae	*Artemisia absinthium* L.	Wormwood (Nagdona)	Shrub	Whole plant	Dry	W	Powder

Asteraceae	*Eupatorium odoratum* L.	Siam weed (Ashamlota)	Perennial shrub	Whole plant	Fresh	W	Mash
Asteraceae	*Sphaeranthus indicus*	East Indian Globe Thistle (Mundari)	Herb	Flower	Both	W	Decoction; Powder
Asteraceae	*Tagetes erecta*	Mexican marigold (Gada)	Annual or perennial herb	Leaf	Fresh	C /W	Mash
Bombacaceae	*Bombax ceiba* L.	Silk cotton (Shimul)	Deciduous trees	Bark	Fresh	W	Infusion
Bombacaceae	*Ceiba speciose* (A. St.-Hil) Ravenna	Silk Floss (Tut/Reshom)	Deciduous tree	Fruit	Dry	C / W	Powder
Combretaceae	*Terminalia arjuna*	Arjun	Tree	Bark	Dry	W	Powder
Combretaceae	*Terminalia chebula*	Gall nut (Horitoki)	Tree	Fruit	Dry	C/W	Powder
Crassulaceae	*Kalanchoe pinnata* (Lam.) Pers.	Cathedral bells (Pathorkuchi)	erect succulent, glabrous herb	Leaf	Fresh	W	Mash
Cucurbitaceae	*Lagenaria siceraria*	Bottle gourd (Lao)	Annual climber	Leaf	Fresh	C	Tea
Dipterocarpaceae	*Vateria indica*	White Damar (Shatdhup)	Tree	Latex	Fresh	W	Oven dry followed by grinding into powder
Euphorbiaceae	*Chrozophora prostrata* Dalzell & A.Gibson	Nilkonthi	Herb	Flower, leaf	Fresh	W	Decoction; Powder
Fagaceae	*Quercus infectoria*	Oak gall (Majuphal)	Evergreen Shrub	Fruit	Fresh	C	Powder; Decoction
Fumariaceae	*Fumaria officinalis* L.	Common fumitory (Shahatara)	Annual flowering herb	Whole plant	Dry	W	Mash; Powder
Gentianaceae	*Swertia chirayita*	Chirayta (Chirota)	Herb	Stem bark	Dry	W	Powder; decoction
Lamiaceae	*Mentha piperica*	Peppermint (Pudina)	Perennial herb	Whole plant	Fresh	W	Mash; Powder
Lamiaceae	*Ocimum tenuiflorum* L.	Holy basil (Tulsi)	Aromatic perennial tree	Leaf	Fresh	C	Powder; Mash
Lamiaceae	*Vitex negunda*	Chinese chaste tree (Nishinda)	Aromatic shrub	Leaf	Fresh	W	Powder; Decoction
Lamiaceae	*Lavandula stoechas* L.	French lavender (Usthokhuddus)	Evergreen shrub	Flower	Dry	W	Decoction; Powder

Leguminosae	*Cassia angustifolia* Vahl	Senna (Shonapata)	Shrub	Leaf	Dry	W	Powder
Leguminosae	*Cassia fistula* L.	Indian laburnum (Banorlathi)	medium-sized tree	Fruit	Fresh	W	Powder
Leguminosae	*Cassia tora* L.	Sickle senna (Chakunde)	Annual herb	Seed	Dry	W	Paste
Leguminosae	*Cynometra ramiflora*	Yeminga (Shingra)	Evergreen tree	Whole plant	Dry	W	Powder
Leguminosae	*Glycyrrhiza glabra* L.	Liquorice (Jeshthomodhu)	Perennial, Not climbing, Herb	Bark	Dry	W	Powder
Leguminosae	*Saraca indica*	Asoka Tree (Ashok)	Rain-forest tree	Bark	Dry	W	Decoction
Leguminosae	*Uraria picta*	Prsniparni (Sankarjata)	Perennial undershrub	Leaf	Fresh	W	Paste
Lythraceae	*Lawsonia inermis*	Henna (Mehedi)	tall shrub or small tree	Leaf	Fresh	C	Paste
Malvaceae	*Abroma augusta*	Devil's cotton (Ulotkombol)	Evergreen shrub	Stem bark	Dry	W	Paste
Malvaceae	*Hibiscus rosasinensis* L.	China rose (Jaba)	deciduous or evergreen shrubs, trees	Leaf	Fresh	W	Paste
Meliaceae	*Azadirachta indica* A. Juss.	Neem	Tree	Leaf	Fresh	C/W	Paste
Menispermaceae	*Cissampelos pareira* L.	Velvet leaf (Fataklota)	slender tomentose climber	Whole plant	Dry	W	Powder
Menispermaceae	*Tinospora cordifolia*	Heart-leaved moonseed (Jigar)	deciduous climbing shrub	Bark	Both	W	Powder; Decoction
Moraceae	*Ficus heterophylla* L.f.	Assamese (Dumur)	Shrub	Leaf	Fresh	W	Paste
Musaceae	*Musa acuminate* Colla	Banana (Kach kola)	frost tender	Fruit	Fresh	C	Infusion
Myrtaceae	*Psidium guajava* L.	Guava (Peyara)	evergreen shrub or small tree	Leaf	Fresh	C	Decoction
Nyctaginaceae	*Boerhavia diffusa* L.	Red spiderling (Purno nova)	A spreading, prostrate herb	Leaf	Both	C/W	Decoction; Powder
Nymphaeaceae	*Nymphaea nouchali* Burm.f.	Water lily (Shapla)	Aquatic plant	Flower	Fresh	W	Decoction

Oleaceae	*Nyctanthes arbor-tristis* L.	Night-flowering jasmine (Shiuly gach)	Shrub or a small tree	Leaf	Fresh	W	Infusion
Phyllanthaceae	*Phyllanthus niruri* L.	Seed-under-the-leaf (Vui amla)	Herb	Whole	Dry	Dry/W	Powder
Piperaceae	*Piper betle* L.	Betel Pepper (Pan pata)	Climber	Leaf	Fresh	C/W	Paste
Piperaceae	*Peperomia pellucida* (L.) Kunth	Pepper elder Luchipata	annual, shallow-rooted herb	Whole plant	Dry	W	Paste
Poaceae	*Cynodon dactylon* (L.) Pers.	Bermuda grass (Durbaghash)	Grass	Whole plant	Fresh	W	Paste; Infusion
Portulacaceae	*Portulaca grandiflora*	Rose moss (Nuneshag)	Colourful annual plant	Whole plant	Fresh	/W	Decoction
Ranunculaceae	*Nigella sativa* L.	Black Seed (Kalo gira)	annual flowering plant	Seed	Fresh	Fresh /C	Oil
Rhamnaceae	*Ziziphus jujuba*	Common jujube (Onnab)	Small deciduous tree or shrub	Fruit	Fresh	Fresh /W	Fresh
Rubiaceae	*Neolamarckia cadamba* (Roxb.) Bosser	Common bur-flower tree (Kodom)	evergreen, tropical tree	Bark	Fresh	Fresh/W	Decoction
Rubiaceae	*Paederia foetida* L.	Chinese fever vine (Gondhobhadule)	Climber	Whole plant	Both	W	Paste; Powder
Rutaceae	*Aegle marmelos*	Golden apple (Beal)	deciduous shrub or small to medium-sized tree	Fruit	Dry	C/W	Powder
Rutaceae	*Feronia limonia*	Wood-apple (Kathbel)	deciduous tree	Whole plant	Dry	C	Powder
Santalaceae	*Santalum album*	Sandal wood oil (Shetchandan)	small tropical tree	Bark	Dry	W	Powder
Scaridae	*Diospyros malabarica* (Desr.) Kostel.	Indian Persimmon (Gaab)	long-lived, very slow-growing tree	Fruit	Fresh	W	Infusion
Solanaceae	*Solanum xanthocarpum*	Yellow-berried Nightshade (Kontikari)	a herb which is erect, sometimes woody	Stem bark, root	Dry	W	Powder

Solanaceae	*Solanum nigrum*	Black Nightshade (Kakmachi)	common herb or short-lived perennial shrub	Seed, bark	Both	W	Decoction; Powder
Umbelliferae	*Centella asiatica*	Asiatic pennywort (Thankuni)	Herb	Leaf, root	Both	Both /W	Decoction
Umbelliferae	*Foeniculum vulgare*	Funnel (Mouri Shauf)	a hardy, perennial herb	Seed	Both	Both /C	Powder; Decoction
Violaceae	*Viola odorata*	Wood Violet (Banafsha)	perennial climber	Flower, leaf	Both	Both/W	Decoction; Powder
Zingiberaceae	*Curcuma Longa*	Turmeric (Holud)	upright, perennial herb	Whole plant	Fresh	Fresh/C	Paste
Zingiberaceae	*Zingiber zerumbet*	Shampoo ginger (Ekanghi)	a perennial herb	Leaf	Both	Both /W	Powder; Paste
Zingiberaceae	*Zingiber montanum*	Cassumunar ginger (bunoada)	a perennial herb	Fruit	Fresh	Fresh/W	Paste
Zygophyllaceae	*Tribulus terrestris*	Puncture vine (Gokhur kata)	a small leafy plant	Thorne	Dry	W	Powder

Table 3: Number of citation, use value (UV), fidelity level (FL), relative popularity (RP), rank order priority (ROP) and rarity score of the reported plants through the ethnopharmacological survey

Scientific name	Ailment category	Principle use	No. of citation	UV value	I_P	I_U	FL Value (%)	RP	ROP	Rarity score
Abroma augusta	Disease of bladder	Urinary tract infection	8	0.063	5	8	62.5	0.35	21.88	3
Acmella oleracea (L.) R.K. Jansen	Disease of the digestive system	Dysentery, Malaria, Plague	2	0.016	2	2	100	0.09	9	1
Aegle marmelos	Disease of digestive system	Any stomach related disease	8	0.063	4	8	50	0.35	17.5	3
Allium sativum	Disease of the arthritis	Gout	7	0.055	2	7	28.6	0.3	8.58	3
Aloe vera	Injury, poisoning and certain other consequences of external causes	Wound	11	0.087	2	11	18.2	0.48	8.74	3
Alstonia scholaris (L.) R. Br.	Disease of viral/bacterial infection	Fever	1	0.008	1	1	100	0.04	4	3
Amaranthus spinosus L.	Disease of the urinary tract	Urine infection	2	0.016	2	2	100	0.09	9	2
Andrographis periculata	Injury, poisoning and certain other consequences of external causes	Wound	5	0.039	2	5	40	0.22	8.8	3
Artemisia absinthium L.	Disease of liver	Hepatitis	1	0.008	1	1	100	0.04	4	1

Azadirachta indica	Injury, poisoning and certain other consequences of external causes	wound	23	0.181	8	23	34.8	1	34.8	3
Boerhavia diffusa L.	Disease of bladder	Urinary tract infection	1	0.008	1	1	100	0.04	4	3
Bombax ceiba L.	Disease of the digestive system	Chronic dysentery	1	0.008	1	1	100	0.04	4	3
Cassia angustifolia Vahl	Disease of genitourinary system	Urinary tract infection, syphilis, gonorrhoea	1	0.008	1	1	100	0.04	4	3
Cassia fistula L.	Disease of liver	Hepatitis	1	0.008	1	1	100	0.04	4	3
Cassia tora L.	Disease of skin	Eczema	2	0.016	2	2	100	0.09	9	3
Ceiba speciose (A. St.-Hil) Ravenna	Disease of the respiratory system	Tonsillitis,	1	0.008	1	1	100	0.04	4	3
Centella asiatica	Disease of digestive system	Diarrhoea	9	0.071	5	9	55.5	0.39	21.65	3
Chrozophora prostrata Dalzell & A.Gibson	Disease of bladder	Urinary tract infection,	1	0.008	1	1	100	0.04	4	3
Cissampelos pareira L.	Injury, poisoning and certain other consequences of external causes	Wound	1	0.008	1	1	100	0.04	4	3
Cuminum cyminum L.	Disease of the digestive system	Diarrhoea	6	0.047	6	6	100	0.26	26	3
Curcuma longa	Injury, poisoning and certain other consequences of external causes	Wound	13	0.102	5	13	38.5	0.57	21.95	3

Cynometra ramiflora	Disease of skin	Skin disease	7	0.055	3	7	42.9	0.3	12.9	2
Cynodon dactylon (L.) Pers.	Injury, poisoning and certain other consequences of external causes	Wound	12	0.094	6	12	50	0.52	26	3
Diospyros malabarica (Desr.) Kostel.	Disease of the digestive system	Chronic Dysentery	1	0.008	1	1	100	0.04	4	3
Eupatorium odoratum L.	Disease of blood	Haemostatic,	1	0.008	1	1	100	0.04	4	3
Ferolina limonia	Disease of the digestive system	Dysentery, diarrhoea	8	0.063	4	8	50	0.35	17.5	3
Ficus heterophylla L.f.	Disease of the skin	Boils	1	0.008	1	1	100	0.04	4	3
Foeniculum vulgare	Diseases of the genitourinary system	Gonorrhoea, Urinary tract infection,	2	0.016	1	2	50	0.09	4.5	3
Fumaria officinalis L.	Disease of bladder	Urinary tract Infection	2	0.016	2	2	100	0.09	9	1
Glycyrrhiza glabra L.	Disease of the digestive system	Gastric Ulcer	2	0.016	2	2	100	0.09	9	3
Hibiscus rosasinensis L.	Disease of digestive system	Dysentery	1	0.008	1	1	100	0.04	4	3
Holarrhena antidysenterica	Disease of the digestive system	Chronic dysentery	2	0.016	2	2	100	0.09	9	2

(Roth) Wall. ex A.DC.										
Justicia adhatoda L.	Disease of common cold	Respiratory tract infection	16	0.126	4	16	25	0.69	17.25	3
Kalanchoe pinnata (Lam.) Pers.	Disease of bladder	Urinary tract infection,	12	0.094	10	12	83.3	0.52	43.32	3
Lagenaria siceraria	Disease of digestive system	Cholera	9	0.071	7	9	77.7	0.39	30.3	3
Lavandula stoechas L.	Disease of infectious sinus	Sinusitis	1	0.008	1	1	100	0.04	4	1
Lawsonia inermis	Disease of bladder	Urinary tract infection,	3	0.024	1	3	33.3	0.13	4.33	3
Mentha piperita	Disease of the digestive system	Gastroenteritis	4	0.032	2	4	50	0.17	8.5	3
Musa acuminate Colla	Disease of the digestive system	Diarrhoea	6	0.047	6	6	100	0.26	26	3
Neolamarckia cadamba (Roxb.) Bosser	viral or bacterial infection	Dengue fever	1	0.008	1	1	100	0.04	4	3
Nigella sativa L.	Bacterial infection	Rheumatic fever	1	0.008	1	1	100	0.04	4	3
Nyctanthes arbor-tristis L.	viral or bacterial infection	Fever	1	0.008	1	1	100	0.04	4	3
Nymphaea nouchali Burm.f.	Disease of blood	Stops too much bleeding externally	1	0.008	1	1	100	0.04	4	3
Ocimum tenuiflorum L.	Inflammation in the lung	Bacterial Pneumonia,	18	0.142	8	18	44.4	0.78	34.63	3

Paederia foetida L.	Disease of digestive system	Chronic diarrhoea	1	0.008	1	1	100	0.04	4	3
Peperomia pellucida (L.) Kunth	Disease of the bladder	Urinary tract infection, Gall bladder infection, Cystitis	1	0.008	1	1	100	0.04	4	2
Phyllanthus niruri L.	Disease of the cirrhosis of the liver	Jaundice	1	0.008	1	1	100	0.04	4	2
Piper betle L.	Disease of the skin	Skin disease	2	0.016	2	2	100	0.09	9	3
Pistacia integerrima J. L. Stewart ex Brandis	Disease of the respiratory system	Respiratory infection	2	0.016	2	2	100	0.09	9	2
Portulaca grandiflora Hook.	Disease of metabolic disorder	Osteoporosis,	1	0.008	1	1	100	0.04	4	3
Psidium guajava L.	Disease of respiratory disease	Tonsillitis, ear, throat, nose Infection	3	0.024	3	3	100	0.13	13	3
Quercus infectoria	Disease of digestive system	Chronic dysentery	3	0.024	2	3	66.7	0.13	8.66	3
Santalum album	Disease of the bladder	Urinary tract infection	3	0.024	3	3	100	0.13	13	3
Saraca indica	Disease of liver	Jaundice	1	0.008	1	1	100	0.04	4	3
Solanum xanthocarpum	Disease of the respiratory	Respiratory tract infection	3	0.024	3	3	100	0.13	13	3
Solanum nigrum	Disease of bladder	Urinary tract infection,	1	0.008	1	1	100	0.04	4	1
Sphaeranthus indicus	Diseases of the genitourinary system	Skin disease. Gonorrhoea	1	0.008	1	1	100	0.04	4	2

Swertia chirayita	Injury, poisoning and certain other consequences of external causes	Wound	5	0.039	2	5	40	0.22	8.8	2
Tagetes erecta	Injury, poisoning and certain other consequences of external causes	Wound	2	0.016	2	2	100	0.09	9	3
Terminalia arjuna	Injury, poisoning and certain other consequences of external causes	wound	9	0.071	3	9	33.3	0.39	12.99	3
Terminalia chebula	Disease of the digestive system	Diarrhoea	3	0.024	3	3	100	0.13	13	3
Tribulus terrestris	Disease of the bladder	Urinary tract infection.	5	0.039	3	5	60	0.22	13.2	1
Tinospora cordifolia	Diseases of the genitourinary system	Gonorrhoea	6	0.047	3	6	50	0.26	13	3
Tylophora indica	Injury, poisoning and certain other consequences of external causes	Wound	7	0.055	3	7	42.9	0.3	12.87	3
Uraria picta	Disease of the respiratory system	Respiratory tract infection	8	0.063	5	8	62.5	0.35	21.88	2
Vateria indica	Disease of digestive system	Duodenal ulcer	1	0.008	1	1	100	0.04	4	3
Viola odorata	Disease of skin	Skin disease	1	0.008	1	1	100	0.09	9	3
Vitex negunda	Disease of the respiratory system	Respiratory tract infection	3	0.024	2	3	66.7	0.13	8.66	2
Zingiber montanum	Disease of digestive system	gastroenteritis	1	0.008	1	1	100	0.09	9	2
Zinziber zerumbet	Disease of the skin	Skin disease	1	0.008	1	1	100	0.09	9	2

Ziziphus jujuba	Disease of respiratory system	Respiratory tract infection	1	0.008	1	1	100	0.04	4	2

Ip is the number of participants who independently cited the use of a plant species for the same disease

Iu is the total number of participants who mentioned the plant for any major disease.

Table 4: Informant consensus factor (FIC) for each category of ailments

Ailment category	Number of taxa (Nt)	Number of use reports (Nur)	Consensus factor
Bacterial pneumonia infection	2	19	0.94
Wound healing	8	49	0.85
Gastrointestinal disorder	11	59	0.83
Rheumatic fever	9	47	0.83
Gonorrhoea	7	20	0.68
Sinusitis	3	7	0.67
Liver disease	3	7	0.67
Dermatitis and related skin disease	8	20	0.63
Urinary tract infection	13	31	0.60
Respiratory tract infection	4	7	0.50
Tonsillitis	3	5	0.50
Chronic dysentery	8	14	0.46

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