Herbal Medicine used for the treatment of diarrhea and cough in Kampala city, Uganda

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Abstract

Background: Globally, diarrheal and respiratory diseases are among the top ten causes of mortality, and are the major ailments for which humans seek treatment. Kampala, the capital city of Uganda is facing a proliferation of herbalists that sell herbal medicine (HM) used to manage ailments such as diarrhea and cough. The ethnopharmacological and economic aspects of HM sold in Uganda's major cities such as Kampala are poorly understood, and this deters the HM sector from achieving its optimal capacity to adequately support health promotion and poverty reduction. The aim of this research was to: (i) profile the plant species used in the treatment of diarrhea and cough, and (ii) determine the basic economic aspects of HM trade in Kampala city. The purpose was to support the conservation of ethnopharmacological knowledge, and the design of strategic plans towards fostering optimal HM trade in urban settings.

Methods: A cross-sectional survey was conducted using a mixed methods approach. Sixty-five herbalists were selected in the five divisions of Kampala. The herbalists were interviewed using semi-structured questionnaires. Field observations were used to collect qualitative data. The data was analyzed using descriptive and inferential statistics with STATA version-**15.0.**

Results: Eighty-four plant species from 41 families were documented: Fabaceae and Myricaceae with the highest number of species (9, 10.7% each). *Citrus limon* was the most commonly cited for cough, with a relative frequency of citation (RFC) of 1.00, and its relative medical importance was not significantly different from the other top 5 species except for *Azadirachta indica* (RFC=0.87), (χ^2 =8.923, p=0.0028). *Entada abyssinica* (RFC=0.97) was most cited for diarrhea. Trees (34, 40.5%) were mostly used, and mainly harvested from wild habitats (55.2%), found in 20 districts across Uganda. These HM were mainly sold as powders and concoctions, in markets, shops, pharmacies, and roadside or mobile stalls. The highest prices were Uganda Shillings (UGX) 48,000 ($ 13.15)/Kg for *Allium sativum*, and UGX 16,000 ($ 4.38)/Kg for *C. limon*. All participants used HM trade as a sole source of basic needs; majority (60.0%) earned net monthly profit of UGX. 730,000 ($ 200) ≤ 1,460,000 ($ 400). The main hindrances to HM trade were the; disruptions caused by the COVID-19 pandemic (n=65, 100%), and the scarcity of medicinal plants (58, 89.2%).

Conclusion There is a rich diversity of medicinal plant species traded in Kampala to treat diarrhea and cough. The HM trade significantly contributes to the livelihoods of the traders in Kampala, as well as the different actors along the HM value chain throughout the country

1.0 Background

Diarrheal and respiratory infections are among the major causes of global mortality and morbidity, triggering approximately 1.8 and 2.4 million annual deaths respectively (1–4), especially in low and middle-income countries (LMIC) (3). For example, in Tanzania and Uganda, diarrheal and respiratory illnesses are ranked among the six major causes of both adult and childhood mortality (4,5). Consequently, diarrhea and cough are the commonest syndromes for which humans seek medical care in both the rich and resource-poor countries (4,6). The infections associated with diarrhea and cough are mostly caused by microbial pathogens such as bacteria, viruses, parasites, and fungi (7–11).

The rising burden of antimicrobial resistance (AMR) is increasingly counteracting the potential of conventional medicines to manage these complications (12). The AMR burden, coupled with other factors such as the high cost and limited availability of synthetic medicine, especially in resource-poor countries, lure most communities to resort to herbal medicine (HM) as an alternative treatment strategy (13–15). The use of HM for healthcare needs in Uganda is estimated at 90% in rural settings (16). In the recent decades, the trade of HM in Uganda's urban settings is on the rise. The herbalists also offer consultation services, and/or sell HM for managing common community ailments (17). Kampala district, being Uganda's capital and commercial city, has a high number of herbalists compared to other urban districts (17). This could partly be attributed to the high demand, and the lucrative market offered by the large population of residents, travelers, and the business community in the city (18). The resident population in Kampala city mostly comprises of low-income earners that live in the suburbs, and have high inclination to HM (17,19–21).

Besides healthcare provision, the HM industry in Kampala and Uganda, has become one of the significant sources of employment for communities (22). The sector provides an avenue for traditional experts to enter the urban cash economy (22,23). The need for strategic plans is paramount to nurture the HM trade industry to achieve its optimal capacity, and to effectively support Uganda's fight against escalation of poverty and unemployment (24,25). According to the World Bank, over 21.7% of this country's population currently live below the poverty line of US$ 1.90 per person per day (26,27). Also, the government of Uganda has estimated that an additional 2.6 million people could slide into extreme poverty due to the socio-economic impacts of the COVID-19 pandemic (28). Development of the HM sector might broaden income generation for not only the herbalists, but also the other various stakeholders (e.g., farmers, collectors, transporters, and pharmacies) along the HM value chain in Uganda.

Though Kampala city is now perceived to be potentially rich in medicinal plant biodiversity stock, the ethnopharmacological research related to these plant species is scarce. Further, the commercial aspects of HM commonly traded in Kampala city are poorly understood due to limited research on the sector. The development of urban HM trade requires comprehensive research on various aspects of the sector, such as the ethnopharmacology, and the economic aspects. The aim of this study was to document the plant species sold for the treatment of diarrhea and cough in Kampala, and information on their usage, trade, the sector-challenges. The findings could support conservation of ethnopharmacological knowledge and guide strategic planning and designing of regulatory frameworks; to enhance the potential use of HM in counteracting health burdens and poverty.

2.0 Methods

2.1 Study area

The study was conducted in five administrative divisions of Kampala, located in the central region of Uganda, stretching over an area between DMS Lat: 0° 12' 46.755"N, Long: 32° 30' 32.567"E and DMS Lat 0° 12' 20.692"N, Long: 32° 40' 14.054"E. It is bordered by Mukono district to the East; Lake Victoria to the

South East; and Wakiso district to the West, South, and North (Fig. 1). Its five administrative divisions are; Kampala central, Kawempe, Nakawa, Makindye and Rubaga divisions. According to the recent Uganda national population census, the city is populated by about 1,680,601 – 2,915,200 residential occupants (29), plus large numbers of individuals that enter and leave the city on a daily basis (18).

2.2 Study design and sampling technique

A cross sectional survey was conducted on sixty-five traditional herbalists, between May and July 2021. Pre-tested, semi-structured questionnaires were administered to the respondents by research assistants, to collect information such as the socio-demographic profile of respondents, local names of plant species used in treatment of diarrhea and/or cough, and how they were prepared and packaged, prices, challenges related to HM trade. In addition, qualitative data, such as, HM packaging patterns, categories of traditional HM outlets, and the pharmaceutical forms of HM sold, were examined through field observations which were supplemented using photography.

2.3 Study Population

The study focused on herbalists in Kampala city. The sampling frame exclusively involved herbalists that were engaged in trade, harvesting, and/or preparation of the HM.

2.4 Sampling

Sample size determination

The sample size for this study was calculated by using the formula for unknown population, by Kothari, (2004): $n=Z^2SD^2/e^2$. Where: Z = Standard error from the mean, ≈ 1.96 at 95% confidence interval; Standard deviation (SD) ≈ 0.205 or 20.5% (30); and e = Tolerable sampling error / precision, ≈ 0.05 at 95% confidence interval. Then, the sample size was calculated as:

$$n = \frac{[(1.96)^2\ x\ (0.205)^2]}{(0.05)^2} \approx 65$$

Therefore, sixty-five herbalists were recruited into this study.

Selection of respondents

Prior informed consent was obtained from all the participants of the study and the ethical approval for the study was also obtained from the School of Health Sciences Research and Ethics Committee of Makerere University. Based on the required sample size of 65 participants, 13 respondents from in each of the five divisions of Kampala were recruited using a systematic random sampling approach (31). In brief, at each of the sampling sites, the traditional healthcare units such as herbal shops, and herbal-market stalls were visited, and the available population of eligible herbalists was determined through direct counting. The resultant population size was divided by the required number of respondents to deduce the sampling interval (K). Then, every K^{th} member of the population at the respective sampling site was recruited until the required sample size was attained.

2.5 Data collection

Pre-tested, researcher administered questionnaires were used to collect data regarding the HM used for treating diarrhea and cough in the study community. The observational survey was conducted using an observation guide, and a high-resolution digital camera inbuilt in a Phantom-9 Mobile Phone, model AB7/2019, Techno Mobile Limited (32). All data was collected following the guidelines for research on HM products, established by the Uganda National Drug Authority (NDA) and the World Health organization (33,34).

2.5.1 Collection and identification of plant specimens

Voucher specimens of the medicinal plant species of interest were procured from HM markets and surrounding environs, in randomly selected market stalls, herbal shops, roadside stalls, and mobile stalls. The voucher specimens were pressed and transported to Makerere University Herbarium for identification. The identified plant species were authenticated according to the database at https://www.theplantlist.org, accessed on 21st July 2021. The plant families were checked against the Angiosperm Phylogeny Group IV.

2.6 Data analysis

Descriptive, and inferential statistics like frequencies, percentages, and Chi-square were used to analyze the data. The Relative Frequency of Citation (RFC) was used to evaluate the ethnopharmacological data.

2.7 Relative frequency of Citation (RFC)

The relative frequency of citation (RFC) for each HM was computed to determine the number of herbalists that considered particular plant species as being worth mentioning in the management of diarrhea and cough. **The values range between 0 and 1 (where** 1 indicates the highest level of respondents' consensus on the use of that species to manage a particular disease**).** The value was calculated using a formular described by Tardio and Santayana (35);

$$RFC = \frac{FCs}{N} = \sum_{i=i1}^{iN} uRi/N$$

Where, *FC* is the number of herbalists who cited a particular species, and *N* is the total number of herbalists (table 2).

3.0 Results

3.1 Socio-demographic profile of participants

Majority (n=36, 55.4%) of the respondents recruited were men, while females constituted 44.6% (n=29). Three quarters (n=44, 67.7%) of the participants were aged 18 ≥ 47 years, while two (3.1%) were ≥ 64 years. The majority of participants (n=26, 40.0%) had attended secondary education, while three (4.6%) had attained tertiary education. The participants who had practiced traditional medicine for a duration of between 5 years and 15 years constituted 72.3% (n=47). Sixty-five (100%) participants unanimously perceived the importance of medicinal plants and the need to trade these remedies, viz; all participants indicated that they generate significant profits to meet their basic livelihood needs, and that they were optimistic about the future of herbal medicine trade in Uganda. A net monthly profit of UGX 730,000 ($ 200) ≤ 1,460,000 ($ 400) was earned by 39 (60.0%), while 5 (7.7%) earned above UGX. 1,825,000 ($ 500) from HM sales (Table. 1).

Table 1: Socio-demographic characteristics of commercial herbalists in Kampala city (N-65)

Variable		Frequency, n (%)
Gender	Male	36 (55.4)
	Female	29 (44.6)
Age (years)	18-47(Youths)	44 (67.7)
	48-63 (Middle aged)	19 (29.2)
	≥ 64 (Elderly)	2 (3.1)
Nationality	Ugandan	65 (100)
	Non-Ugandan	0 (0.0)
Marital status	Married	39 (60.0)
	Single	26 (40.0)
Education	None	8 (12.3)
	Primary	26 (40.0)
	Secondary	28 (43.1)
	Tertiary	3 (4.6)
Years of experience in HM	5≤15	47 (72.3)
	16≤20	15 (23.1)
	>20	3 (4.6)
Type of HM establishment	Roadside stalls	18 (27.7)
	Market stalls	18 (27.7)
	Herbal shops	17 (26.2)
	Mobile stalls	12 (18.4)
Estimated monthly net profit from HM, UGX (USD)	< 730,000 (200)	9 (13.8)
	730,000 ≤ 1,460,000 (400)	39 (60.0)
	1,460,000 < 1,825,000 (500)	12 (18.5)
	≥1,825,000 (500)	5 (7.7)

Key; UGX: Uganda Shillings, $: United States Dollar, HM: Herbal Medicine

3.2 Diversity of medicinal plants traded for treatment of diarrhea and cough in Kampala

A total of 84 medicinal plant species belonging to 41 families and 73 genera used in the management of diarrhea and cough were documented in the commercial HM establishments surveyed (Table. 2). (Table. 2). Families, Fabaceae and Myricaceae contributed 9 (10.7%) species each, and Asteraceae (7, 8.3%). Diarrhea was treated by 44 species (52.4%) as compared to cough (31, 36.9%); while 9 (10.7%) were used to treat both diarrhea and cough. Tree species (34, 40.5%) were the most dominantly cited (Table. 2).

3.3 Methods of preparation and modes of administration

All (84, 100%), of the plant species recorded were administered orally, in four main forms, that is, decoctions (n=70, 83.3%), infusions (n=13, 15.5%), powders licked (n=2, 2.4%), and fresh plant materials chewed (n=2, 2.4%) (Table 2). Leaves were the major plant part used (n=61, 93.8%) followed by the stem bark (n= 21, 32.3%) (Fig.2).

Table 2: Medicinal plants used for treatment of diarrhea and cough in Kampala city, Uganda

SPECIES USED AGAINST COUGH

Family, Voucher no,	Serial no, Local name	Scientific name	Life form	Parts used	Mode of administration	RFC
Alliaceae						
KHM03	1. Katungulchumu* Tungulucumu[⍰]	*Allium sativum* L.	Herb	Bulb	Decoction+minced ginger, drunk	0.64
Asparagaceae						
KHM05	1. Kajjolyenjovu*	*Dracaena steudneri* Engl.	Tree	Leaves	Decoction drunk/Powder licked	0.07
Astareceae						
KHM06	1. Artemesia [Ω]	*Artemisia annua* L.	Herb	Leaves	Infusion+salt drunk	0.03
KHM07	1. Mululuuza*	*Vernonia amygdalina* Delile	Shrub	Leaves, Roots	Decoction drunk	0.61
Bignoniaceae						
KHM36	1. Mussa*[ß]	*Kigelia africana* (Lam.) Benth.	Tree	Leaves	Decoction+honey drunk	0.09
KHM37	1. Kifabakazi*	*Spathodea campanulata* P.Beauv.	Tree	RB	Decoction drunk	0.04
Caricaceae						
KHM08	1. Mupapaali[ß]	*Carica papaya* L.	Tree	Leave, Roots	Decoction drunk	0.10
Celastraceae						
KHM09	1. Mayirunji*	*Catha edulis* Forssk.	Shrub	Leaves	Chewed, extract swallowed	0.02
KHM10	1. Muwaiswa[µ]	*Gymnosporia senegalensis* (Lam.) Loes.	Shrub	Roots, Leaves	Decoction drunk	0.02
KHM14	1. Musaali*	*Symphonia globulifera* L.f.	Tree	Roots	Decoction drunk	0.03
Crassulaceae						
KHM15	1. Kiyondo Ekyeru*	*Kalanchoe densiflora* Rolfe	Herb	Leaves	Decoction drunk	0.06
Cucurbitaceae						
KHM11	1. Suunsa*	*Cucurbita maxima* Duch.	Creeper	Leaves	Decoction drunk	0.11
Ebenaceae						
KHM16	1. Mangholu [χ]	*Euclea schimperi* (A.DC.) Dandy	Shrub	Leaves	Decoction drunk twice a day before meals	0.02

Table 2 continued

Family, Voucher no	Serial no, Local name	Scientific name	Habit	Parts used	Mode of administration	RFC
Fabaceae						
KHM17	1. Akasaana *	*Acacia hockii* De Wild.	Shrub	SB	Decoction drunk	0.05
KHM20	1. Nkooge*	*Tamarindus indica* L.	Tree	Fruit, SB, Leaves	Decoction drunk	0.18
Dracaenaceae						
KHM19	1. Akasandasanda*	*Euphorbia hirta* Lnn.	Herb	Leaves	Decoction drunk	0.06
Rubiaceae						
KHM18	1. Odwong#	*Gardenia ternifolia* Schumach. & Thonn. subsp. jovis-tonantis (Welw.) Verdc. var. jovis-tonantis	Tree	Root bark	Infusion of dry powder drunk	0.02
Lamiaceae						
KHM01	1. Kyewamala*	*Tetradenia riparia* (Hochst.) Codd	Shrub	Leaves	Infusion drunk	0.22
KHM02	1. Kibwankulata*	*Plectranthus cyaneus* Gürke	Herb	Leaves	Decoction drunk	0.39
KHM21	1. Kachumita	*Basilicum polystachyon* (L.) Moench	Herb	Leaves	Decoction drunk	0.02
Lauraceae						
KHM22	1. Ovakedo*	*Persea americana* Mill.	Tree	Leaves, SD, SB	Decoction drunk	0.66
Malvaceae						
KHM23	1. Lusaala*	*Hibiscus fuscus* Garcke	Herb	Leaves	Ash licked	0.08
Moraceae						
KHM24	1. Muvule*	*Milicia excelsa* (Welw.) C.C.Berg	Tree	Leaves, SB	Decoction drunk	0.21
Moringaceae						
KHM25	1. Molinga*	*Moringa oleifera* Lam.	Tree	Leaves, Roots, SD	Decoction drunk	0.32
Myricaceae						
KHM26	1. Nkikimbo*	*Morella kandtiana* (Engl.) Verdc. & Polhill	Shrub	Roots	Decoction drunk	0.02
KHM13	1. Kalitunsi*	*Eucalyptus grandis* W. Hill	Tree	Leaves, SB	Infusion drunk	0.74
KHM62	1. Kalatuc[ø]	*Eucalyptus viminalis* Labill.	Tree	Leaves, RB	Decoction drunk	0.06
KHM27	1. Mwambalabutonya*	*Callistemon citrinus* (Curtis) Skeels	Shrub	Leaves	Decoction drunk	0.95
KHM28	1. Kalitunsi*	*Corymbia citriodora* (Hook.) K.D.Hill & L.A.S.Johnson	Tree	Leaves, SB	Concoction drunk	0.05
KHM29	1. Jjambula*[µ]	*Syzygium cumini* (L.) Skeels	Tree	Leaves	Decoction drunk	0.66
KHM30	1. Mupeera*	*Psidium guajava* L.	Tree	Leaves	Decoction drunk	0.75
Rutaceae						
KHM04		*Citrus limon* (L.) Osbeck	Shrub	Fruits	Decoction of whole fruit/Infusion of freshy	1.00

	1. Niimu* Ndima∞				mesocarp drunk, or juice squeezed out and swallowed.	

Table 2 continued

SPECIES USED AGAINST DIARRHEA						
Family, Voucher no.	Serial no, Local name	Scientific name	Habit	Parts used	Mode of administration	RFC
Acanthaceae						
KHM41	1. Wankuura[illegible]	*Thunbergia alata* Bojer ex Sims	Climber	Leaves	Decoction drunk	0.02
Anacardiaceae						
KHM43	1. Muziru*	*Pseudospondias microcarpa* (A. Rich) Engl.	Tree	Roots	Decoction drunk	0.22
Annonaceae						
KHM44	1. Mugaali*	*Annona senegalensis* Pers.	Tree	SB, leaves	Decoction drunk	0.02
Apocynaceae						
KHM45	1. Mulondo*ß	*Mondia whytei* (Hook.f.) Skeels	Climber	Roots	Infusion/Chew	0.49
Aristolochiaceae						
KHM39	1. Nakasero* Musujja awalaba[illegible]	*Aristolochia littoralis* Parodi	Herb	Leaves	Decoction drunk	0.70
Astareceae						
KHM46	1. Akalulusa ahasindeχ	*Microglossa angolensis* Oliv. & Hiern.	Shrub	Leaves	Decoction drunk	0.03
KHM47	1. Kafugankande*	*Conyza pyrrhopappa* Sch.Bip. ex A. Rich	Herb	Leaves	Decoction drunk	0.95
KHM12	1. Etutum#	*Microglossa pyrifolia* (Lam.) O.Kuntze	Herb	Roots, Leaves	Decoction drunk	0.09
KHM48	1. Mugango*	*Solanecio mannii* (Hook.f.) C.Jeffrey	Herb	Leaves	Decoction drunk	0.04
KHM42	1. Ssere*	*Bidens pilosa* L.	Herb	Leaves	Decoction drunk	0.33
Balanitaceae						
KHM49	1. Liggwa limu*	*Balanites aegyptiaca* (L) Delile	Tree	Roots	Decoction drunk	0.11
Burseraceae						
KHM50	1. Muwafu*	*Canarium schweinfurtii* Engl.	Tree	SB	Decoction drunk	0.26
Capparaceae						
KHM51	1. Mukolokombi*	*Capparis tomentosa* Lam.	Shrub	Roots	Decoction drunk	0.04
Convolvulaceae						
KHM53	1. Lumonde*	*Ipomoea batatas* (L.) Lam.	Vine	Leaves	Decoction drunk	0.31

Table 2 continued

Family, Voucher no	Serial no, Local name	Scientific name	Habit	Parts used	Mode of administration	RFC
Crassulaceae						
KHM52	1. Kiyondo*	*Bryophyllum pinnatum* (Lam.) Oken	Herb	Leaves	Decoction drunk	0.41
Euphorbiaceae						
KHM69	1. Ahadunga[χ]	*Euphorbia heterochroma* Pax	Tree	SB	Decoction drunk	0.04
KHM55	1. Murangara[]	*Croton macrostachyus* Hochst. ex Delile	Tree	Leaves	Decoction drunk	0.02
Fabaceae						
KHM56	1. Lusiiti*[ß]	*Abrus precatorius* L.	Tree	Leaves	Decoction drunk	0.13
KHM57	1. Muwologoma*	*Acacia amythethophylla* A. Rich.	Shrub	Roots	Decoction drunk	0.17
KHM58	1. Katasubwa[ß]	Acacia senegal (L.) Willd.	Shrub	Roots	Decoction	0.06
KHM59	1. Mugavu* Kiluku[K]	*Albizia coriaria* Oliv	Tree	Stem bark	Decoction drunk	0.35
KHM60	1. Nkolimbo*[ß]	*Cajanus cajan* (L.) Millsp.	Herb	Leaves	Decoction/Infusion drunk	0.24
KHM61	1. Jjirikiti*	*Erythrina abyssinica* DC.	Tree	SB, Roots	Decoction drunk	0.05
KHM67	1. Kiyugeyuge[ß]	*Tylosema fassoglensis* (Schweinf.) Torre & Hillc.	Climber	Roots	Concoction drunk	0.02
Lauraceae						
KHM66	1. Mukomamawananga*	*Punica granatum* L.	Shrub	SB	Decoction drunk	0.02
Meliaceae						
KHM65	1. Musonko*	*Lovoa trichilioides* Harms	Tree	SB, SD, Leaves	Infusion drunk	0.05
Moraceae						
KHM64	1. Mutuba*	*Ficus natalensis* Hochst.	Tree	SB	Decoction drunk	0.16
Myricaceae						
KHM63	1. Kalitunsi*	*Eucalyptus globulus* Labill.	Tree	SB, Leaves	Decoction drunk	0.03
KHM68	1. Kalitunsi*	*Eucalyptus saligna* Sm.	Tree	Leaves	Decoction drunk	0.06

Table 2 continued

Family, Voucher no	Serial no, Local name	Scientific name	Habit	Parts used	Mode of administration	RFC
Onagraceae						
KHM70	1. Kajampuni[µ] Kanyebwa*	*Oxalis latifolia* Kunth	Herb	Shoot	Decoction drunk	0.24
Peraceae						
KHM72	1. Mubarama[]	*Clutia abyssinica* Jaub. & Spach	Shrub	Leaves	Infusion/ Decoction drunk	0.02
Phyllanthaceae						
KHM31	1. Katazamiti*	*Bridelia micrantha* (Hochst.) Baill	Tree	Leaves, SB	Decoction drunk	0.06
KHM32	1. Mutulika*	*Phyllanthus ovalifolus* Forssk.	Shrub	Leaves	Decoction drunk	0.05
Poaceae						
KHM71	1. Ekyisubi*	*Cymbopogon flexuosus* (Nees ex Steud.) W. Watson	Grass	Leaves	Infusion drunk	0.96
KHM73	1. Lumbugu*	*Digitaria abyssinica* (A. Rich.) Stapf	Grass	Leaves	Decoction drunk	0.48
Polygalaceae						
KHM33	1. Mukondwe*	*Securida longipedunculata* Fresen.	Tree	Roots, Leaves	Concoction drunk	0.11
Portulacaceae						
KHM74	1. Muhanga[]	*Maesa lanceolata* Forssk.	Tree	SB	Decoction drunk	0.02
Rosaceae						
KHM34	1. Ntaseesa[ß], Ngwabuzito*	*Prunus africana* (Hook.f.) Kalkman	Tree	SB, Leaves	Decoction drunk	0.13
KHM38	1. Ensaali*	*Eriobotrya japonica* (Thumb) Lindl.	Shrub	Leaves	Decoction drunk	0.08
Lamiaceae						
KHM75	1. Mujaaja*	*Ocimum gratissimum* L	Herb	Leaves	Decoction drunk	0.04
KHM40	1. Mubolo*	*Citropsis articulata* (Willd. ex Spreng.) Swingle & M.Kellerm	Shrub	SB	Decoction drunk	0.07

Table 2 continued

Family, Voucher no	Serial no, Local name	Scientific name	Habit	Parts used	Mode of administration	RFC
Verbenaceae						
KHM76	1. Enkami*	*Priva flabelliformis* (Moldenke) R. Fern.	Herb	Leaves	Decoction drunk	0.47
Zingiberaceae						
KHM35	1. Ntangawuzi*	*Zingiber officinale* Roscoe	Herb	Rhizome	Tincture drunk	0.14
SPECIES USED AGAINST BOTH DIARRHEA AND COUGH						
Anacardiaceae						
KHM54	1. Muyembe* Mengu∞	*Mangifera indica* L	Tree	Leaves	Decoction drunk	0.75[C], 0.21[D]
KHM77	1. Kakwansokwanso*	*Searsia pyroides* (Burch.) Moffett	Shrub	Leaves, Roots	Decoction drunk	0.19 [C], 0.07[D]
Canellaceae						
KHM79	1. Omuya*	*Warburgia ugandensis* Sprague	Tree	Leaves, SB, Roots	Decoction/Infusion drunk	0.03[D], 0.08 [C]
Cucurbitaceae						
KHM83	1. Bombo* Bomoℓ	*Momordica foetida* Schumach	Climber	Leaves	Infusion drunk	0.98[C], 0.40[D]
Meliaceae						
KHM81	1. Neem Ω	*Azadirachta indica* A.Juss.	Tree	Roots, Leaves, SB	Decoction drunk	0.87 [C], 0.03[D]
Passifloraceae						
KHM82	1. Katunda*▯	*Passiflora edulis* Sims	Climber	Leaves	Decoction drunk	0.04[D], 0.26 [C]
Poaceae						
KHM80	1. Teete*	*Cymbopogon citratus* Stapf	Grass	Leaves	Decoction or Infusion drunk	0.32 [C], 0.06[D]
Rutaceae						
KHM78	1. Muchungwa*ß Chungwaℓ	*Citrus sinensis* (L.) Osbeck	Shrub	Leaves, Roots, SB, Fruit	Decoction drunk	0.03[D], 0.71 [C]
Fabaceae						
KHM84	1. Mwolola*	*Entada abyssinica* A. Rich	Tree	SB, Leaves	Infusion/Decoction drunk	0.97[D], 0.20 [C]

Key: D = Diarrhea, C = Cough, SB=Stem bark, SD=Seeds, RB= Root bark. Languages spoken: *= Luganda, ß = Lusoga, μ = Lugishu,

▯ = Runyankore, χ = Lunyole, ∞ = Lugbara, ℓ = Langi, # = Ateso, ø = Luo, *K* = Ik/Karamojong, Ω = Local name not available

3.4 Highly traded species for management of diarrhea and cough in Kampala.

C. limon attained the highest RFC of 1.00 for cough treatment, followed by *M. foetida* (RFC = 0.98). *E. abyssinica* was the most highly cited HM in the management of diarrhea (RFC = 0.97). *C. edulis* and *G. senegalensis* were least mentioned (each with RFC = 0.02) for cough treatment, while *T. fassoglensis*, and *P. granatum* were least mentioned for diarrhea treatment. The most frequently cited plant species (RFC ≥ 0.70) are summarized in Table. 3 and some illustrated in Plate 1a – e.

Table 3: Frequently mentioned and used species for diarrhea and cough treatment in Kampala

Plant species	Disease treated	RFC	χ^2	*p*-value	Previous reports on diarrhea and/or cough treatment
Citrus limon	Cough	1.00 REF			(36)
Momordica foetida	Cough	0.98	1.303	0.2537	(37)
Entada abyssinica	Diarrhea	0.97	1.964	0.1611	(38)
Cymbopogon flexuosus	Diarrhea	0.96	2.631	0.1048	(39)
Callistemon citrinus	Cough	0.95	3.305	0.0691	(38,40)
Conyza pyrrhopappa	Diarrhea	0.95	3.305	0.0691	(41)
Azadirachta indica	Cough	0.87	8.923	0.0028	(42)
Psidium guajava	Cough	0.75	18.047	0.0001	(43)
Mangifera indica	Cough	0.75	18.047	0.0001	(44)
Eucalyptus grandis	Cough	0.74	18.830	0.0001	(45)
Citrus sinensis	Cough	0.71	21.232	0.0001	(45)
Aristolochia littoralis	Diarrhea	0.70	22.068	0.0001	(46)

χ^2 = Chi-square, RFC = Relative Frequency of Citation, REF; Reference value

3.5 Herbal medicine trade in Kampala city

3.5.1 Sources of herbal medicines traded in Kampala

Among the 65 herbalists interviewed, 59 (90.8%) had information about of their habitats and from where the medicinal plants were harvested. Although the rest were knowledgeable about the HM they sold, they were unable to provide information about the habitats of some plants. These participants attributed the knowledge-deficit to the fact that they often purchased most of the HM from fellow herbalists who were also whole sellers, hence minimal knowledge on the natural settings from where some of the HM were sourced. Most participants claimed to obtain the HM from wild habitats such as bushes (56.9%) and forests (44.6%) (Fig.3a). Only 16.9% (n=11) of the participants identified the source of their raw materials as Mabira central Forest Reserve, which covers the districts of Mukono, Jinja and Buikwe districts in the Central and Eastern Uganda (Fig.3b). Most HM were sourced from Mukono (64.6%) and Wakiso (58.5%) districts, which boarder Kampala City (Fig. 3b).

3.5.2 Types of traditional healthcare establishments where HM are traded

The herbal medicine-selling establishments (HMSE) were classified into two major categories for this study: (i) formal and (ii) informal. The formal was in places gazetted for trade by the government of Uganda. In this category, three main HMSE were observed namely; herbal shops, market stalls, and pharmacies. The informal HMSE included roadside stalls, and mobile stalls (Plate 2 A - J).

3.5.3. Pharmaceutical forms and packaging of herbal medicines traded in Kampala city

The HM were presented in two broad categories namely: (a) herbal medicine products (defined as finished, labelled medicinal herbal product containing active ingredients in form of plant parts which may be in crude state, or as preparations, or in combination with other excipients which are not of plant origin), and (b) herbal substances (defined as either whole or fragments of fresh or dry plants that have not been subjected to isolation and purification of active ingredients) (33) (Plate 3). The packaging of HM fell into three categories namely; (i) original packaging materials (bought from manufacturer/supplier and had never been used for other purposes), (ii) Recycled/re-used packages (previously used for other purposes), and (iii) non-packaged (plainly displayed for sale) (Plate 3).

3.5.4 Demand and supply of commonly traded herbal medicine used for treating diarrhea and cough in Kampala

Among the 84 plant species identified in this survey, 15 were categorized as commonly used by virtue of having high relative frequency of citation (RFC ≥ 0.70). The rate at which these HM were purchased was also examined, and categorized as: high (H), moderate (M), and low (L). The majority (8/15, 53.3%) were highly demanded, while 5/15 species were on low demand (Table. 4). Declining availability in the natural habitats was reported for 9/15 (60%) of the frequently used species (Table. 4). Except for *E. grandis*, all the 15 most frequently mentioned species were reported to be out pf stock in ≥ 3 traditional healthcare establishments during the survey. The most expensive plant species were: *A. sativum* sold at UGX 48,000 ($ 13.15), *C. limon* at UGX 16,000 ($ 4.38) and *E. grandis* at UGX 13,500 ($ 3.70) per kilogram respectively. The least priced were *P. americana*, and *S. cumini* each sold at UGX 4,000 ($ 1.10) per kilogram (Table. 4).

Table 4: Availability, demand and prices of frequently traded diarrhea and cough herbals in Kampala (N = 65)

Species name	Disease treated	Availability in HM selling premises during survey	Demand	Availability in natural habitats	Average price, UGX (USD)/Kg*
Citrus limon	Cough	Available (n= 28, 43.1%) Out of stock (n=37, 56.9%)	H (n=65, 100%)	Declining (n= 16, 24.6%) Rare (n=49, 75.4%)	16,000 (4.38)
Momordica foetida	Cough, Diarrhea	Available (n=50, 76.9%) Out of stock (n= 9, 14.1%)	H (n= 59, 91%)	Rare (n= 59, 91.0%)	11,000 (3.01)
Callistemon citrinus	Cough	Available (n= 47, 72.3%) Out of stock (n=10, 15.7%)	H (n=57, 88%)	Declining (n= 52, 80%) Rare (n=5, 0.08%)	10,000 (2.74)
Entada abyssinica	Cough, Diarrhea	Available (n= 30, 46.2%) Out of stock (n=10, 15.7%)	M (n=58, 89.2%) R (n=5, 0.77)	Declining (n=3, 4.6%) Rare (n=60, 92.3%)	7,000 (1.92)
Cymbopogon flexuosus	Diarrhea	Available (n= 18, 27.7%) Out of stock (n=37, 56.3%)	M (n=11, 16.9%) L (n=44, 67.7%)	Declining (n=55, 84%)	9,500 (2.60)
Conyza pyrrhopappa	Diarrhea	Available (n= 7, 20.5%) Out of stock (n=46, 61.5.3%)	M (n=5, 0.37%) L (n=48, 78.3%)	Rare (n=53, 82%)	6,000 (1.64)
Azadirachta indica	Cough	Available (n= 16, 24.7%) Out of stock (n=34, 52.3%)	H (n=50, 77%)	Declining (n=50, 77%)	10,000 (2.74)
Psidium guajava	Cough	Available (n= 31, 47.7%) Out of stock (n=18, 27.7%)	H (n=10, 15.4%) M (n=39, 59.6%)	Abundant (n=42, 64.6%) Declining (n=7, 10.4%)	7,000 (1.92)
Mangifera indica	Cough	Available (n= 44, 67.7%) Out of stock (n=4, 7.3%)	M (n=48, 75.0%)	Abundant (n=48, 75.0%)	5,000 (1.37)
Eucalyptus grandis	Cough	Available (n= 48, 74.0%)	H (n= 48, 74.0%)	Declining (n= 48, 74.0%)	13,500 (3.70)

Table 4 continued

Key: UGX: Uganda Shillings; USD: United States Dollars; Kg: Kilogram; HM: Herbal Medicine; H: High; M: Moderate; L: Low; *Average exchange rate of USD 1.0 = UGX 3,650 (47)

3.5.5 Challenges associated with herbal medicine trade in Kampala city

The herbalists interviewed in this study reported 25 challenges (Fig. 4). HM trade-challenges were grouped into six themes using thematic analysis (Fig. 4 i). These included: (i) HM trade regulations and policies (n=9); (ii) financing (n=5); (iii) attributes of traditional herbalists (n=4); (iv) HM quality and safety (n=3); (v) HM availability and efficacy (n=2); and (vi) geographical stature of the study area (n=2). The national COVID-19 preventive measures (n=65, 100%) was the frequently mentioned challenge under theme (i) (Fig. 4vii). This was followed by the scarcity of some herbal medicine stocks (n=58, 89.2%) which aligned with theme (v) (Fig. 4ii). The least cited challenge was the report of adverse reactions in some HM consumers (n=3, 4.6%), which aligned with theme (iv) (Fig. 4 v).

4.0 Discussion

4.1 Socio-demographic profiles of participants

The majority of the herbalists interviewed in this study were men. The predominance of men in HM trade was previously reported in Tanzania (48), Malawi (49), and some parts South Africa (50). However, in the KwaZulu-Natal, Gauteng, and Mpumalanga provinces of South Africa, the majority of commercial herbalists were women (51). In the current study, close to three quarters of the participants were aged between 18 to 47 years. The age bracket of 15 to 48 years is classified as the youthful group (52). Therefore, trade in HM in Kampala city has the potential for future expansion since majority of the respondents belonged to the very active age group. The relatively high profits obtained from HM sales, as reported in this study, highlight the potential contribution of the herbal medicine industry to Uganda's national economy, and the role these plant species play towards the attainment of the participants' livelihood needs, primary health care services, and cultural heritage. Cunningham (53) also reported that medicinal plants constitute an important feature of the cultural, economic, medicinal, and ecological components of all cities in the world.

Species name	Disease treated	Availability in HM selling premises during survey	Demand	Availability in natural habitats	Average price, UGX (USD)/Kg*
Allium sativum	Cough	Available (n= 29, 44.6%) Out of stock (n=12, 19.4%)	H (n=41, 64%)	Abundant (n=7, 10.8%) Declining (n=8, 12.3%) Rare (n=26, 40.9%)	48,000 (13.15)
Vernonia amygdalina	Cough	Available (n= 36, 55.4%) Out of stock (n=4, 5.6%)	M (n=40, 61%)	Abundant (n=31, 47.7%) Declining (n=9, 13.3%)	5,000 (1.37)
Persea americana	Cough	Available (n= 27, 41.5%) Out of stock (n=16, 24.5%)	M (n=6, 9.2%) L (n=37, 56.8%)	Abundant (n=43, 66.0%)	4,000 (1.10)
Syzygium cumini	Cough	Available (n= 30, 46.2%) Out of stock (n=13, 19.8%)	M (n=8, 12.3%) L (n=35, 53.7%)	Abundant (n=43, 66.0%)	4,000 (1.10)
Citrus sinensis	Cough	Available (n= 43, 66.2%) Out of stock (n=3, 4.8%)	H (n= 46, 71.0%)	Declining (n= 46, 71.0%)	8,000 (2.19)
Aristolochia littoralis	Diarrhea	Available (n= 20, 30.8%) Out of stock (n=25, 39.2%)	M (n=12, 18.5%) L (n=33, 51.5%)	Abundant (n=20, 30.8%) Rare (n=25, 39.2%)	5,500 (1.51)

4.2 Herbal medicine diversity, methods of preparation, and administration

The majority of medicinal plant species identified in this study were in the family Fabaceae, Myricaceae and Asteraceae. Previous studies showed similar trends where Asteraceae and Fabaceae, Euphorbiaceae and Cucurbitaceae were the most traded botanical remedies in Botswana (54), while Fabaceae , Asteraceae, and Hyacinthaceae were majorly traded taxa in South Africa (55). Plant families such as Fabaceae, Asteraceae, and Euphorbiaceae have the greatest number of species traded as herbal medicine possibly because these families are large and characterized by numerous species (http://www.theplantlist.org/). Some of the plants documented in the current study, such as *C. flexuosus*, *C. limon*, and *A. sativum* have been reported as having nutritional and commercial values plus treating other health complications (40,45,56,57).

The number of medicinal plant species reported in the current study is generally small compared previous ethnobotanical and/or ethnopharmacological surveys conducted in Uganda (40,46,56–60). The earlier studies were mostly based in rural settings, and focused on documenting HM used for treating all the health complications prevalent in the study communities and therefore resulted in higher numbers of species than reported in this study. In this study the low number of species could be attributed to the fact that commercial herbalists who use HM as a cardinal source of income did not divulge out all the secrets for fear that the researchers could use their information to start a similar business. Nevertheless, to the best of our knowledge, some of the plant species cited in the current study, such as that under family Rubiaceae, are mentioned for the first time in managing cough and/or diarrheal diseases in this part of Uganda. However, *Gardenia ternifolia* was reported as used to manage opportunistic diseases in people living with HIV/AIDs of which diarrhea and/or cough are frequent (38). Studies that aim at profiling the plant species used for treating selected ailments, such as diarrhea and/or cough, can be more suitable for informing the discovery of specialized medicine for the ailments of interest, compared to those that document all the medicinal plants in a study community.

4.3 Highly traded plant species and their parts for diarrhea and cough management

C. limon was cited by all the participants for the treatment of cough. This highlights its great potential in the management of respiratory infections. However, its relative medical importance was not significantly different from the rest of the plant species except those with RFC less than 0.95 such as *A. indica*. The frequent use of *C. limon*, *M. foetida*, and *C. citrinus* for the management of cough as reported in the current study corroborates with previous studies in other parts of Uganda (45,57). Additionally, *C. flexuosus* used as a diarrhea remedy, is also an aromatic herb in hot drinks and beverages in Nepal (61). In the current study, leaves were majorly used as medicine, followed by the stem bark. The use of leaves is commendable since this promotes sustainable utilization of the plant species and preservation of their genetic stocks, as opposed to the usage of roots, stems and/or whole plants which would rather cause obliteration of the plants (62). However, indiscriminate plucking of leaves of highly used plant species may eventually become unsustainable (63), while use of bark may result in death of some medicinal species.

4.4 Sources of herbal medicines traded

Forests were the main source of HM followed bushes and homestead farms with minimal reports of obtaining HM stocks from wetlands and herbal shops. In Uganda, earlier studies also reported getting HM from forests (58,64). In the current study, the report of high dependence on Mabira Central Forest Reserve as a source of HM might be attributed to several factors: (i) it is the largest natural forest in central Uganda; (ii) it is endowed with enormous medicinal plant species diversity; (iii) relatively close proximity (54 kilometers) to Kampala; (iv) easily accessible, and (v) legal allowance to harvest non-timber vegetation resources from this forest (58,64,65). The minimal dependence of herbal shops within Kampala, as a source of HM stock, could partly be explained by the

scarcity of whole sale herbal shops, which points to the need for most herbalists to source medicinal plant species direct from the natural habitats. In addition, the knowledge of HM is generally personalized and confidential (55), which potentially lures each herbalist into searching and harvesting the plants from the natural habitats. The HM stocks were sourced from 20 (14.8%) of the 135 districts of Uganda (29), and these were evenly distributed all over the country. Hence, the findings reported in this study represent HM information from many different cultures across the country.

4.5 Demand and supply of traded medicinal plants used for diarrhea and cough treatment in Kampala

More than half of the respondents indicated that some species were on high demand but either rare or their populations declining in the habits where they were harvested. Though the top five wild species frequently cited are not Red-listed as nationally threatened species (66), several other plants identified in this study are on the Red List (66). These included; *C. articulata* (African Cherry Orange), *P. africana* (African Almond), and *L. trichilioides* (African Walnut), all cited in the treatment of diarrhea; as well as *M. excelsa* (African Teak), *T. indica*, and *W. ugandensis*, for cough (66). Mounting demand of many wild medicinal species leads to a potential increase in the harvesting pressure, making the affected species susceptible to local extinction. The local extinction of medicinal plant species may have global implications for human health (53). Additionally, the recent increase in market demand for cultivated species such as *C. limon*, and *C. sinensis* is global and has been attributed to their perceived roles in the management of patients of Coronavirus disease-2019 (COVID-19) (67,68). Citrus fruits are some of world's most important vegetal reservoirs of zinc, selenium, and vitamins C & D (69–72). These minerals have been reported as effective boosters of natural immunity, which have been proven effective against respiratory viral pathogens such as SARS-Cov-2, the causative agent of COVID-19 (67,73,74). Consequently, medicinal plants are historically known to have been used in counteracting the previous pandemics (75). As such, some countries like China (76), and Uganda (77,78) have already approved the use of herbal products as part of the medical interventions against the COVID-19 pandemic. Similarly in Madagascar, combination of A*rtemisia annua* L, *C. sinensis*, *A. sativum* and *Z. officinale* has been adopted as an important anti-COVID agent (79).

Despite *A. sativum* perceived abundancy, it was the most expensive HM, sold at a price of UGX 48,000 ($13.15) per kilogram. This could be attributed to its role as a spice, but also as medicine for a wide spectrum of common ailments. including respiratory diseases, gastrointestinal upsets, and cardiac complications (80,81). Many farmers in Uganda do not locally grow *A. sativum* but it is mostly imported from China and India (82). The least priced medicinal plant species were sold at UGX 4000 ($ 1.10) per kilogram. The findings of this survey show a price discrepancy with the amounts previously reported in HM markets in Eastern Cape province of South Africa, where the most expensive herbal drugs were sold at $ 10.30 and the cheapest at $ 1.90 (83). Therefore, HM trade in Kampala may offer better financial gains than in some cities elsewhere (51,55).

4.6 Types of herbal-selling establishments and packaging of HM in Kampala

The HM were sold in herbal shops, market stalls, pharmacies, roadside stalls, and mobile establishments. Similarly, these types of HM ventures were reported in other urban settings in countries like south Africa (55), Kenya (84), Tanzania (85), Malaysia (86), and China (55,87). In Uganda, the sale of indigenous herbal products in pharmacies is symbolic of the recent widespread innovations related to improved packaging and branding of HM, comparable to the standards that are acceptable in pharmacies. Ultimately, this might raise the confidence levels among pharmacists and physicians on the use of HM in Uganda, boosting the country's HM industry. The presence of mobile and semi-mobile HM sellers in Kampala could pose herbal safety concerns since the effective monitoring and regulation of such arrangements can be difficult (88). Further, the reuse of packaging materials that had been discarded as wastes in Kampala, has been associated with the introduction of pathogenic microbial contaminants in HM, threatening public health elsewhere (17,84,89–92).

4.7 Challenges hindering herbal medicine trade in Kampala city

The current study revealed that herbalists in Kampala operated under numerous challenges most of which were linked to HM regulation and policies, as well as financial constraints. Particularly, the disruption caused by the COVID-19 pandemic was cited as a cardinal challenge. The disruption of economic activities by COVID-19 has been reported globally (67,93,94). Some herbalists were able to follow up their clients, hence the reports of side effects of some HM. This action is commendable since it promotes herbalist-patient/client trust and pharmacovigilance, the later which is rare among herbalists worldwide (95).

5.0 Conclusions

Herbal remedies are a vital resource for treatment of cough and diarrhea in Kampala. These medicines are collected from numerous habitats especially in the wild across the country. Most of the frequently used species for management of these diseases were reported to be rare or their availability declining in their natural habitats. Therefore, in addition to the validation of the therapeutic claims, the conservation and preservation of these species is warranted. Although the trade of herbal remedies in Kampala is limited by various hindrances, most of which are linked to the policies and regulation of the herbal medicine industry, it offers a unique opportunity for rural traditional herbalists to enter the urban cash economy. Further research focusing on streamlining of herbal medicine trade, more so in urban settings, should be conducted, to support the formulation of regulatory frameworks, and to bridge the knowledge gaps in herbal medicine safety, quality, and dosages.

Declarations

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Authors' contributions

Abdul Walusansa (AW), and Savina Asiimwe (SA) conceived the research idea, and were involved in field data collection and manuscript writing. Jamilu. E. Ssenku (JES) and Godwin Anywar (GA) were involved in data analysis and manuscript writing. Milbert Namara (MN) was involved in data collection and manuscript writing. Jesca. L. Nakavuma (JLN) and Esezah. K. Kakudidi (EKK), were the overall supervisors and were involved in manuscript writing. All the authors proofread and approved the final draft of the manuscript.

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Availability of data and materials

All data generated and analyzed during this study are included in the article.

Declarations

Ethical approval and consent to participate

The study sought ethical approval from the Makerere University School of Health Sciences Research Ethics Committee (Ref: MAKSHSREC-2020-72), Uganda National Council for Science and Technology (Ref: HS1278ES), and Kampala Capital City Authority (Ref: DPHE/KCCA/1301). The research was conducted in conformity to the national guidelines for the conduct of research in the COVID-19 era established by the Uganda National Council for Science and Technology (UNCST) (96). Informed consent to participate in this study was obtained in writing from the study participants. Respondents' identifiers were recorded in form of assigned codes instead of names to ensure anonymity.

Consent for publication

Consent to publish the findings of this study was obtained in writing from the study participants.

Competing interests

The authors declare that they have no competing interests

Abbreviations

HM; Herbal medicine, TMP; Traditional Medical Practitioners, WHO; World Health Organization, Coronavirus Disease-2019 (COVID-19), KCCA; Kampala capital City Authority,

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Figures

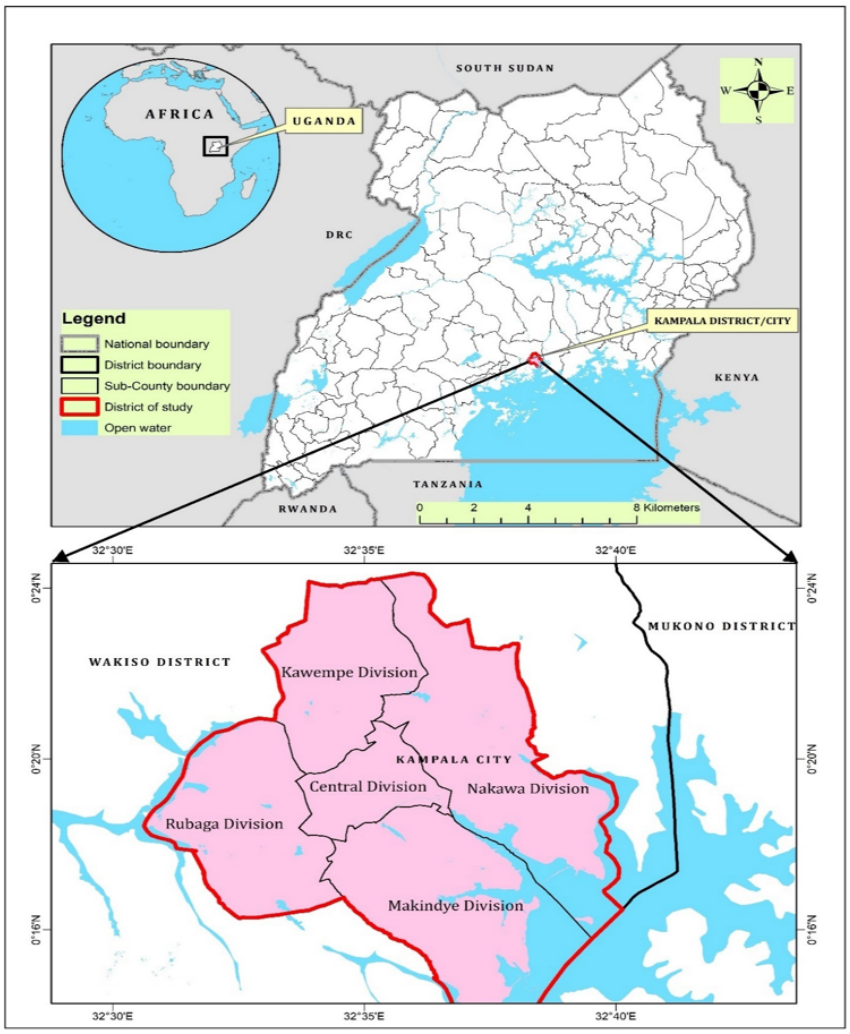


Figure 1

Study Locale: Kampala city showing the five administrative divisions

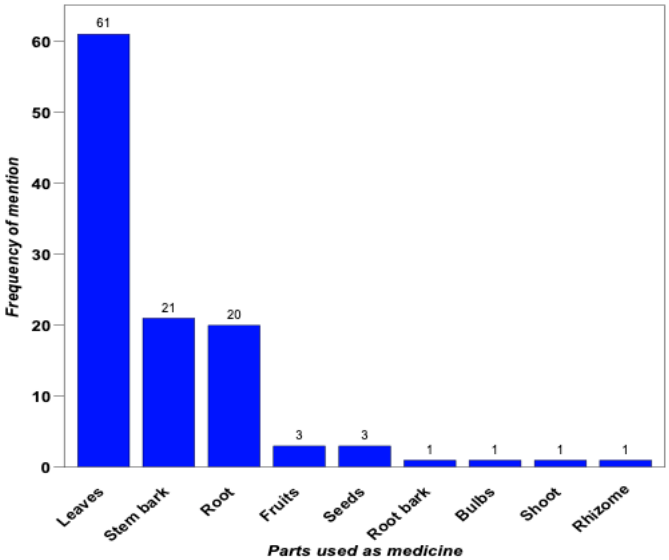
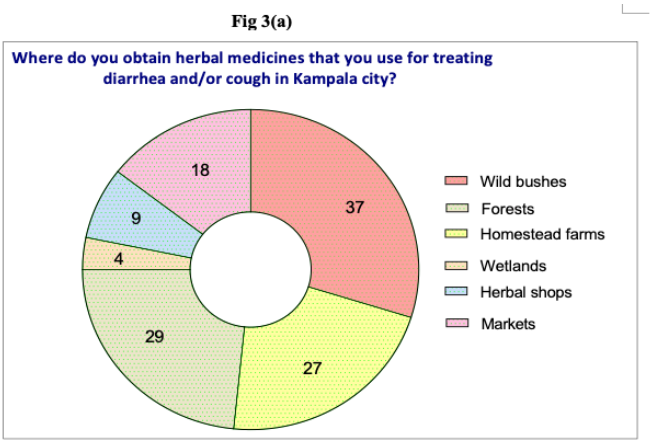


Figure 2

Medicinal plant parts used to treat diarrhea and cough in Kampala city



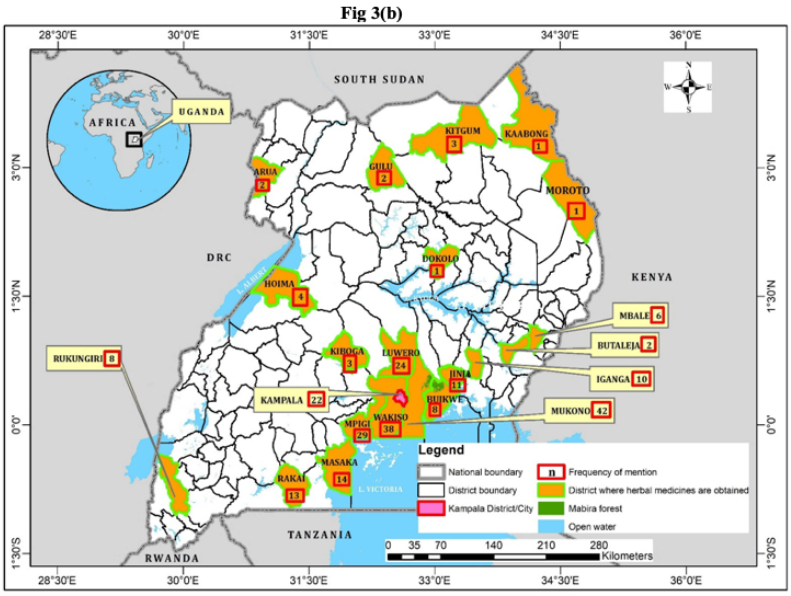


Figure 3

(a) & (b): Sources of HM traded by herbalists in Kampala

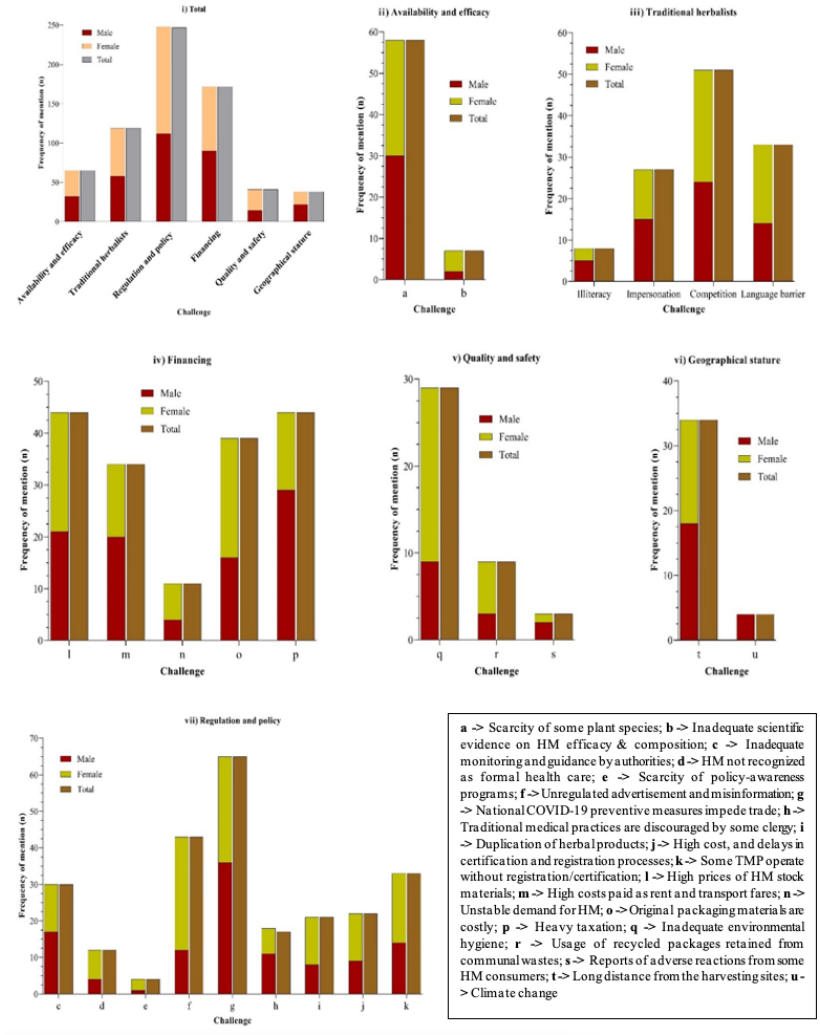


Figure 4

Herbal medicine trade challenges in Kampala city (n=65)

Figure 5

Plate 1: Some frequently used plant species in the management of diarrhea and/or cough in Kampala city. A: C. citrinus; B: C. pyrrhopappa; C: C. limon fruits; D: C. flexuosus; E: M. foetida

Figure 6

Plate 2: Some traditional health care establishments in Kampala city, where herbal medicines are traded: Formal HMSE (Herbal shops: A, B, C; Market stalls: D, E; Pharmacy: F). Informa HMSE (Roadside stalls: G, H; Mobile stalls: J).

Figure 7

Plate 3: (a) Pharmaceutical forms of commercial HM in Kampala: (i) Herbal Medicine Products [Liquid preparations (X1, X2, X2), Powders (P1, P2, P4, P5), Gels (P3), Herbal extracts concocted in clay (C1)]. (ii) Herbal substances [Leaves (L1), Stems (S1, S2, S3), Roots (R1), Whole plant (W1, L2), Fruits (F1), Seeds (Y1, Y2), Stem barks (SB)]. (b) Categories of HM packaging material: (i) Original packages [Plastic bottles (X1, X2), Polyethene bags (P2, P4), Tins (P3)], (ii) Recycled packages [Sacks (S1, S2, R1), Bottles (X3), Buckets (P5), Baskets (B1, B2)].