Indigenous traditional knowledge of medicinal plants used for the management of HIV / AIDS opportunistic infections in Katsina State, Nigeria

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Research

Abstract

Background: Medicinal plants are widely used for the management of many diseases including HIV / AIDS opportunistic infections in Katsina State, North-western part of Nigeria. The usage of those plants is, however, poorly documented.

Method: An ethnobotanical study was conducted to document medicinal plants used for the management of HIV / AIDS opportunistic infections in three Local Government Areas (one from each Senatorial Zone) of Katsina State, Nigeria. Information was obtained through a semi-structured questionnaire administered to 150 respondents comprising traditional healers, herbalists, farmers and HIV / AIDS patients.

Results: The survey revealed 48 plant species distributed among 44 genera and 28 families. The highest Relative Frequency of Citation was observed in *Anogeissus leiocarpa* (DC.) Guill. and Perr (0.75). Fabaceae represented by 11 species appeared to be the most utilised family. Highest Informant Consensus factor was observed in abnormal vaginal discharge and genital ulcer. Most of the cited species are trees that are sourced from the wild and majority of medications are prepared in the form of decoction which is taken orally. The most used plant parts were leaves (40%).

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Conclusion: The study revealed substantial numbers and knowledge of medicinal plants used for the treatment of HIV / AIDS related infections in Katsina State, Nigeria. Further investigations to establish the pharmacological potentials of the cited species with regard to the treatment of HIV / AIDS are highly recommended.

Keywords: Ethnobotanical survey; HIV / AIDS; Opportunistic infections; Medicinal plants; Katsina state

Background

Acquired Immuno-deficiency Syndrome (AIDS), caused by the Human Immuno-deficiency Virus (HIV), is one of the major global health care problems (Krishnaveni 2012). Reports from the World Health Organisation revealed that globally, more than 70 million people have been infected with HIV and about 36.3 million people have died from the endemic by the end of 2020 (WHO 2021). Sub-Saharan Africa is still the most severely affected region, accounting for about 70% of the worldwide people living with HIV / AIDS, with approximately one in every 25 adults (4.4%). Nigeria, the African most populous country, has the second-highest HIV burden in the world (UNICEF 2014). It is reported that about 3,229,757 people are living with HIV and about 210,031 people died from AIDS-related cases in Nigeria (Awofala and Ogundele 2016). National data suggest that 1.3% of young women and 0.7% of young men between the ages of 15 and 24 are living with HIV (UNAIDS 2014). Only 20% of people living with HIV are on treatment, with 27% of pregnant women among them are believed to have been receiving treatment for prevention of mother to child transmission (UNAIDS 2014)**.** The high HIV incidence in Nigeria is attributed to the inability of stakeholders to implement new intervention strategies, lack of strong and reliable health system, as well as inadequate finances from the national coffers (Bashorun *et al*. 2014).

HIV patients suffer from so many opportunistic infections. These infections occur more frequently and are more severe in people with weakened immune system. The Infections occur where either the patients are not receiving proper Antiretroviral Therapy (ART), or the treatment is not enough to trigger the immune system to fight off infections. Currently, there is no satisfactory curative treatment for HIV / AIDS. Antiretroviral (ART) drugs are still the best option in tackling the disease. Although governmental and nongovernmental organisations are trying to provide and / or subsidized pharmaceutical drugs used against HIV / AIDS, the majority of Africans lack access to the ART drugs (Langlois-Klassen *et al*. 2007). Prolong usage of ART drugs is also associated with drug toxicity and HIV strains that are resistant to ART drugs are always emerging (Singh *et al*. 2011). Various reports indicate that there is substantial reliance on Traditional Herbal Medicine (THM) by the majority of Sub-Saharan Africa population and various reports indicate that THM is used for the treatment of HIV-related symptoms (Langlois-Klassen *et al*. 2007).

Katsina, the fifth most populous state in Nigeria is also among the poor states of the country. Health facilities are scarcely distributed in the state, and where available, they are not equipped with necessary personnel and state of the art facilities. This coupled with stigma and discrimination against HIV / AIDS patients make medicinal plants to be the first and last resort of many people living with HIV / AIDS in the area. Due to its closeness to Sahara area, Katsina State is facing desertification at an alarming rate. This and other factors such as destruction of habitats due to artificial disasters such as military actions against insurgents, repurposing of land for residential purposes as a result of rapid population increase and wood collection for fuel and construction, pose serious threat to the medicinal plants' diversity in the area. This calls for urgent intervention in conserving the flora and the knowledge from being extinct. Katsina is relatively unexplored in the context of ethnomedicine, hence, this has necessitated this study. Documentation of these plant species will help to preserve the vital traditional knowledge that is at risk of being lost due to civilization and will in turn pave way for the isolation of active chemical constituents that can be transformed into potential antiretroviral drugs.

Materials and Method

Study Area

Katsina State is in the North-West geopolitical zone of Nigeria. It covers an area of 23, 938 sq km and it is located between the latitude 12.540°N and longitude 7.570°E. With over 5,800,000 residents as at 2006 (NPC 2006), Katsina State is the fifth largest state in Nigeria by population, despite the fact that it only ranks 17th out of 36 states in terms of area (NPC 2006). Demographically, the Hausa-Fulani people are the largest ethnic group in the state, and Islam is the most practiced religion (Bello *et al*, 2019). Katsina is known in history as **'**Cradle of Learning'**.** It is a centre of both formal and informal education. There have been in existence Islamic schools and other centers of scholarship as far back 14th century. The famous Gobarau Islamic Centre and Mosque, which at that time was the center of learning in the whole of Western Sudan was constructed during the reign of Emir of Katsina Muhammadu Korau (1348 – 1398 AD). At present the State has three Universities and other colleges and polytechniques. The

State has many health institutions scattered across including general hospitals, comprehensive health centres, dispensaries, Federal Medical Centre and a recently established teaching hospital. Katsina has a mean annual rainfall of about 800 mm – 1000 mm (Olofin 1985; Bello *et al.* 2019). It falls within the Sudan Savanna vegetation zone (White 1983) and is characterised by a variety of scattered trees in an expanse of grassland (Olofin 1985). Katsina is known to enjoy four distinct seasons: a dry and cool season, which starts from around November and ends in late March and is characterised by Harmattan winds; a dry and hot season, which is a short transitional period from March to about mid-May characterised by the warmest temperature of the year; a wet and warm season, which starts around May and ends in October during which 90% of the annual rainfall is received; and lastly, a dry and warm season, which starts from the end of October to mid-November (Olofin 1985).

The state is bordered from the east by Kano and Jigawa states, from the south by Kaduna state, from the west by Zamfara state, and the Republic of Niger from the northern axis (Figure 1).

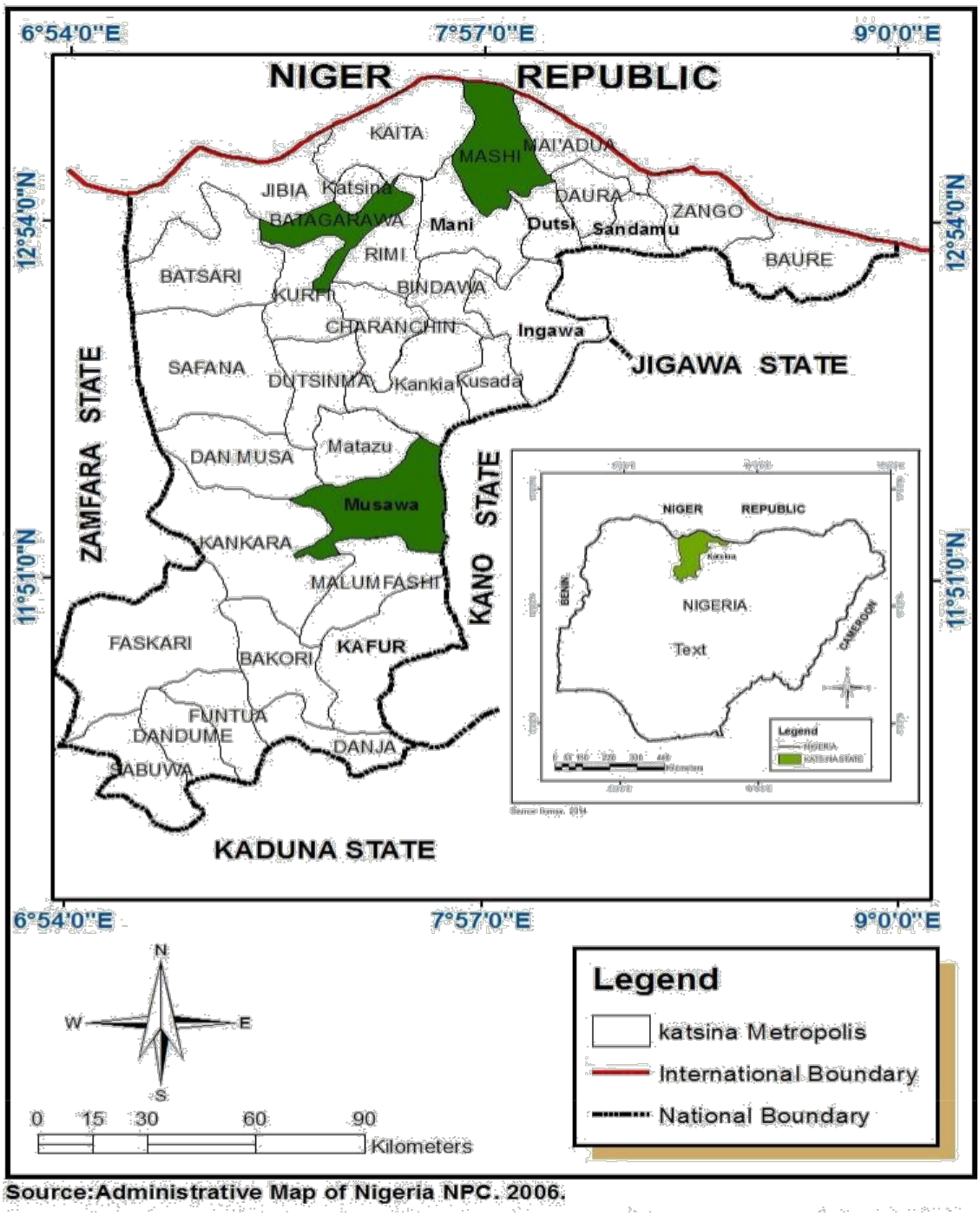

Figure 1. Map of Katsina State, Nigeria showing the study area.

Sampling method

Method of non-random probability, otherwise known as purposive sampling technique, as described by Zakariya *et al.* (2021) was used to obtain information from the four target groups, viz: herbalists, farmers, housewives and civil servants.

Ethnobotanical survey

The survey was conducted from July 2020 to August 2021. Information was gathered from respondents through interviews which were conducted in *Hausa*, the local language of the respondents, and facilitated by an experienced local field assistant. Prior to the survey, ethical approval was sought from the local authorities. Prospective respondents were fully informed about the importance of the study and only respondents who voluntarily gave their consent were involved in the study. All interviews were conducted in accordance with the International Society for Ethnobiology (ISE) Code of Ethics.

Semi-structured questionnaires were administered to 150 respondents and exhaustive field notes about the medicinal plants were taken on spot. The questionnaire was divided into two sections; in section A, the socio-demographic information of the respondents was recorded, and section B contains the survey information. In order to avoid confusion with respect to the identity of the medicinal plants**,** the informants assisted in the collection of the medicinal plants from the wild**.**

Identification of the medicinal plants

Identification of the surveyed plants was done at the herbarium of Umaru Musa Yaradua University Katsina. Verification of names was done using the Plants of the World Online database (http: / / www.plantsoftheworldonline.org /), African Plant Database (http: / / www.ville-ge.ch / musinfo / bd / cjb / africa) and the catalogue of life database (www.catalogueoflife.org). Names were arranged by local name, common name, scientific name, and family. Voucher specimens were deposited at the Herbarium of Umaru Musa Yar'adua University, Katsina, Nigeria.

Data Analysis

Demographic information of the respondents was presented as percentages and analysed using Principal Component Analysis (PCA). The analysis was performed using software PAST4.03 (https: / / www.nhm.uio.no / english / research / infrastructure / past /). The result of the surveyed plants was analyzed using the Relative Frequency of Citation (RFC), using the relation: RFC = F_C / N (Tardıo and Pardo-deSantayana, 2008), where F_C is the number of respondents who cited a particular species and N is the total number of the respondents. Informant Consensus Factor (ICF) was used to analyze the respondents' agreement on the use of various plant species to manage particular opportunistic infection, using the following relation: ICF = Nur-Nt / (Nur-1) (Tardıo and Pardo-deSantayana, 2008). Where Nur = 'total number of use' citation in each ailment category and Nt =total number of species cited for each ailment. To check the informant consensus factor in this study, all the diseases were grouped into different ailment categories. The ICF value varies from 0 to 1. A high value (1.0 or close to 1) indicates that a large proportion of the informants use a relatively small number of plant species. The low value, on the other hand, indicates that the informants disagree about the usage of plant species within a specific ailment group. Eight ailments were considered for this study as follows: skin infection, abnormal vaginal discharge, respiratory tract infection, bowel infection, oral infection, gonorrhoea, genital ulcer, and malaria.

Results and Discussion

Demographic profile of the respondents

Table 1 shows the demographic profile of the respondents, further analised and summarised by PCA (Figure 2). It can be seen that males 94(63%) constitute the greater percentage of the total respondents, while females were represented by 56 (37%) respondents. The PCA in this regard also revealed that male respondents contribute more to the first Principal Component. The gender difference might be explained by the fact that male knowledge holders in communities are more comfortable to talk about Sexually Transmitted Infections than female knowledge holders who faced cultural restrictions when it comes to discussion about matters related to sex. Similar finding was also reported from Rundu, Kavango East Region, Namibia (Chinsembu *et al.* 2015). The survey also revealed that most of the respondents are members of the higher age group; the age range of 50 and above as shown in Table 1. This is further supported by the PCA results (Figure 2b) which reveals that respondents in the above 50 age category contributed more to the first PC. This is an indication that there is a wide gap of ethnomedicinal knowledge between the elderly and the younger generation. Similar observation was reported from Livingstone, Southern Province of Zambia (Chinsembu, 2016). It also agrees with the findings of Kisangau *et al.* (2007) who reported that 73% of the respondents in an ethnomedicinal study on the use of traditional medicines for the management of HIV / AIDS

opportunistic infections in a rural district of Tanzania were people aged above 50 years. This however poses a serious threat to the indigenous knowledge because it may eventually be lost following the demise of the older generation (Kankara *et al.* 2015). Cultural changes as a result of modernization have contributed to making younger generation undermine traditional values (Giday *et al.* 2003). Most of the respondents had no formal education (Table 1 and Figure 2c). It was previously reported that formal education was a major factor contributing to the degradation of traditional knowledge. Bruyere *et al.* (2016) for example reported negative correlation between formal education and medicinal plants' knowledge, attributing it to the constraints formal education places on students' time and dismissiveness of traditional knowledge. The PCA results on the occupation of the respondents (Figure 2d) further revealed that farmers and housewives contributed more in the study. This may not be unconnected with the fact that herbalists hardly revealed information on specific species while civil servants are in most, cases people with formal education and therefore less concern with herbal practice as seen earlier. Although there is strong correlation between divorced and widow respondents (Figure 2e), married respondents were significant in this study. This could be explained that majority of the respondents were male of higher age and therefore married. It is worth noting the PCA results validate the descriptive results. Although important inferences can be made using descriptive statistics, analysing ethnobotanical data using dimension reduction tools such as PCA are considered to be more effective (Bussmann *et al.* 2021; Leonti, 2022).

Table 1. Socio-demographic profile of the respondents

Biodata	Category	Frequency	Percentage (%)
Sex	Male	94	63
	Female	56	37
Health status	HIV / AIDS Patients	11	7
	Non-HIV / AIDS Patients	139	93
Age	20-30years	9	6
	31-40years	47	31
	41-50years	33	22
	51-above	61	41
Education	Non-formal	111	74
	Primary certificate	19	13
	Secondary certificate	14	9
	Others	6	4
Occupation	Herbalists	28	19
	Farmers	75	50
	Housewives	43	29
	Civil servants	4	2
Marital status	Married	60	40
	Single	11	7
	Divorced	37	25
	Widow	42	28

Diversity of ethnomedicinal plants

The study revealed a total of 48 plants species distributed among 28 families and 44 genera (Table 2). The most represented family used for managing HIV / AIDS opportunistic infections in the study area is Fabaceae represented with 11 species. It is followed by Combretaceae and Olacaceae which were represented by two species each. Anacardiaceae, Asteraceae, Moraceae, Myrtaceae, Rhamnaceae and Rubiaceae on the other hand were represented by two species each, while the remaining 11 families were represented by only one species (Figure 3). This result agrees with the report that Fabaceae constituted most of the plant species used in the management of HIV / AIDS related disease in Livingstone, Zambia (Chinsembu, 2016). The dominance of Fabaceae could be attributed to its higher number of species in the tropics compared to other families (Bello *et al.* 2021). It was however reported that Combretaceae family represented the most frequently used plant species for the treatment of HIV / AIDS opportunistic infections in Katima Mulilo community of Namibia (Hedimbi & Chinsembu, 2010). The contradiction might be due to the difference in the flora diversity of respective study areas. The high occurrence of the Fabaceae could be explained by the fact that most species belonging to the Fabaceae family are mostly found throughout the seasons because they are adapted to withstand the adverse effects of dry regions (Kankara *et al.* 2015). Frequent use of Fabaceae family might also be due to the presence of carbohydrates and / or glycosides, tannins, flavonoids, saponins and sterols and / or triterpenes in the members of this family (Mohamed *et al.* 2013).

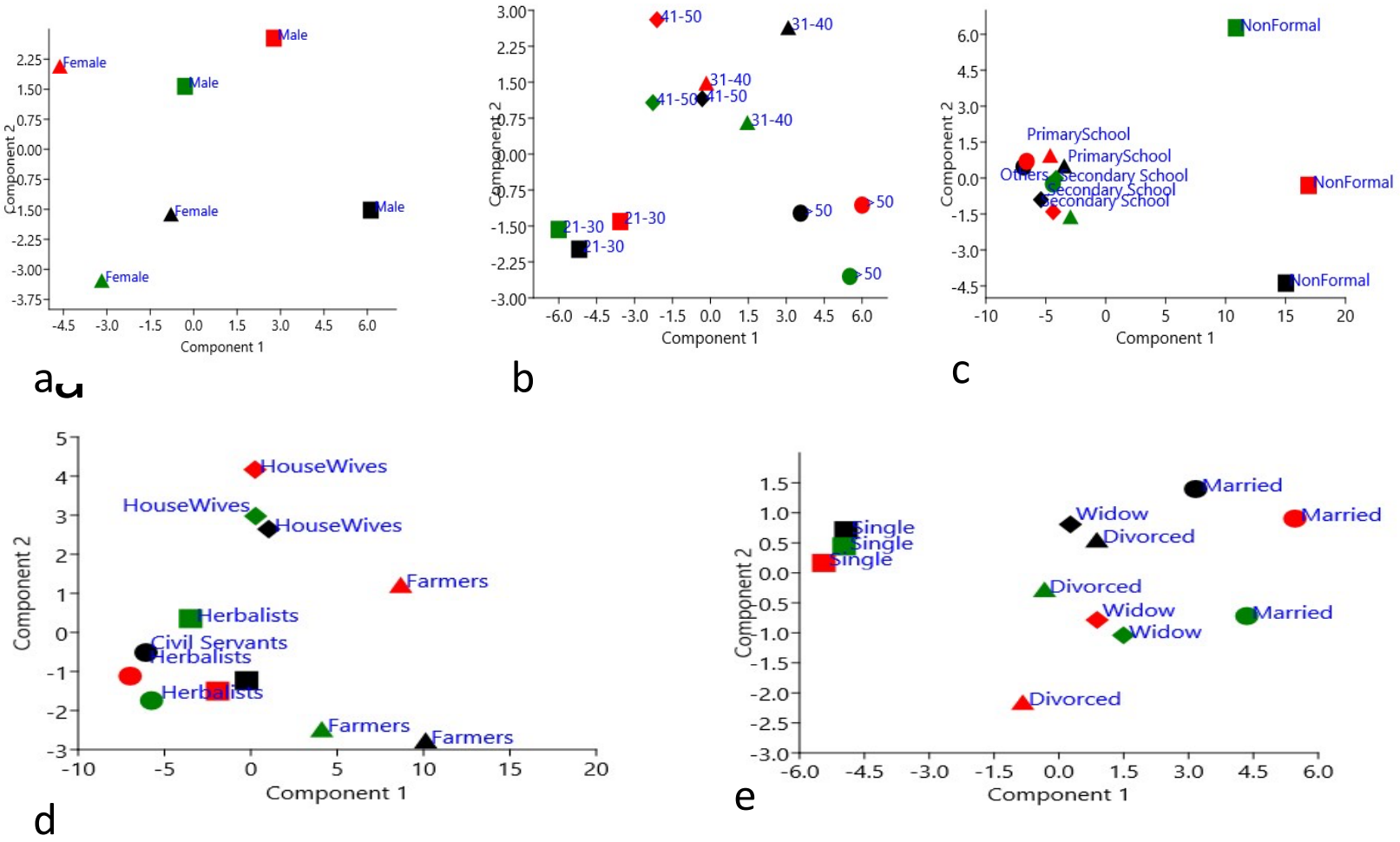

Figure 2. Principal Component Analysis comparing gender (a) age (b), educational qualification (c) occupation (d) and marital status (e) of the respondents. Different shapes represent different categories while black, red and green colours represent Batagarawa, Mashi and Musawa Local Government Areas, respectively.

Table 2. Medicinal plants used for the management of HIV / AIDS opportunistic infections in Katsina State, Nigeria

Family	Scientific name	Local name	Common name	Condition managed	RFC	Part(s) used	Voucher No.	Habit / Habitat	MOP / MOA
Anacardiaceae	*Sclerocarya birrea* (A. Rich.) Hochtst.	Danya	Marula	Bowel Infection	0.23	L	SSK022	T / W	Maceration / oral
Anacardiaceae	*Mangifera indica* L.	Mangwaro	Mango	Malaria	0.35	L	SSK10	T / W	Decoction / steaming
Araceae	*Pistia stratiotes* L.	Zakankau	Water Cabbage	Oral Infection	0.25	Rt	SSK117	T / W	Powder / oral
Arecaceae	*Hyphaene thebaica* (L.)Mart.	Kaba	Down palm	Gonorrhea	0.08	B	SSK120	T / W	Decoction / oral
Aristolochiaceae	*Aristolochia albida* Dutch.	Duman dutsi	Medicine of the earth	Gonorrhea	0.01	Rt	SSK118	H / W	Decoction / oral
Asteraceae	*Centaurea acarnanica* Matthas (Greuter)	Dayi	Thistle	Gonorrhea	0.23	B	SSK024	H / W	Decoction / oral
Asteraceae	*Pulicaria crispa* (Forssk), Oliv	Kurar shanu	Cow's dust	Skin Infection	0.19	L	SSK113	S / W	Powder / dermal
Burseraceae	*Boswellia dalzielii* Hutchinson	Hano	Frankincense tree	Bowel Infection	0.30	L	SSK017	T / W	Powder / Oral
Cochlospermaceae	*Cochlospermum tinctorium* Perr. ex A. Rich	Rawaya		Malaria	0.15	Rt	SSK070	S / W	Decoction / oral / steaming
Combretaceae	*Anogeissus leiocarpa* (DC.) (Guill. And Perr)	Marke	African birch	Respiratory Tract Infection	0.75	B	SSK071	T / W	Direct / oral
Combretaceae	*Guiera senegalensis* J.F. Gmel	Sabara	Moshi medicine	Bowel Infection	0.25	L	SSK009	S / W	Maceration / oral
Combretaceae	*Terminalia macroptera* Guill and Perr.	Kandare	Woloba	Malaria	0.20	B	SSK121	T / W	Decoction / oral / steaming
Cucurbitaceae	*Momordica balsamina* L.	Garahuni	African pumpkin	Skin Infection	0.05	L	SSK029	S / W	Powder / dermal / oral
Ebenaceae	*Diospyros mespiliformis* Hoschst ex. A.DC	Kanya	African ebony	Skin Infection	0.09	B,Rt,L	SSK016	T / W	Powder / dermal
Euphorbiacea	*Jatropha curcas*	Cin da zugu	Barbados nut	Oral Infection, Gonorrhea	0.07	L, Rt	SSK042	S / W	Powder / oral
Fabaceae	*Vachellia polyacantha* Willd	Karaki	Catechu tree	Respiratory Tract Infection	0.10	B	SSK100	T / W	Decoction / oral

Fabaceae	*Piliostigma thoningii*	Kalgo	Mountain ebony	Bowel Infection	0.05	B	SSK067	T / W	Powder / oral
Fabaceae	*Albizia chevalieri* Harms.	Katsari	Flat Crown	Bowel Infection	0.10	L	SSK098	S / W	Powder / Oral
Fabaceae	*Prosopis africana* (Guill. And Perr.)Taub	Kirya	African mesquite	Bowel Infection	0.15	B	SSK050	T / W	Powder / Oral
Fabaceae	*Detarium microcarpum* Guill. And Perr.	Taura	Sweet Dattock	Bowel Infection	0.05	B	SSK034	T / W	Powder / Oral
Fabaceae	*Cassia arereh* Delile.	Malga		Gonorrhea	0.02	Rt	SSK093	S / W	Decoction / oral
Fabaceae	*Swartzia madagascariensis* Desv.	Bayama	Snake bean tree	Malaria	0.05	Rt	SSK123	T / W	Decoction / oral / steaming
Fabaceae	*Erythrina senegalensis* DC.	Minjirya	Coral tree	Malaria	0.10	B	SSK092	H / W	Decoction / oral / steaming
Fabaceae	*Senna occidentalis* L.	Tafasar Masar	Coffee senna	Malaria	0.67	L	SSK084	S / W	Decoction / oral / steaming
Fabaceae	*Acacia senegal* (L.) Willd	Dakwara	Gum Arabic tree	Oral Infection	0.36	L	SSK061	T / W	Direct / oral
Fabaceae	*Parkia biglobossa* (Jacq) G. Don	Dorowa	African locust bean	Skin Infection	0.20	L	SSK023	T / W	Maceration / oral / dermal
Fabaceae	*Senna singueana* (Delile) Lock	Runhu	Wild cassia	Skin Infection	0.20	B,Rt,L	SSK054	S / W	Powder / dermal
Fabaceae	*Vachellia nilotica* (L.) Delile	Bagaruwa	Black piquant	Skin Infection, Oral Infection, Genital Ulcer	0.57	L	SSK011	T / W	Merceration / dermal
Malvaceae	*Waltheria indica* L.	Hankufa	Sleepy morning	Skin Infection	0.25	L	SSK122	H / W	Powder / oral / dermal
Meliaceae	*Azadirachta indica* A. Juss	Bedi	Neem tree	Malaria	0.25	L	SSK003	T / Wor C	Decoction / steaming
Menispermaceae	*Cissampelos owariensis* P.Beauv. ex DC	Jibda kasa	Velvet leaf	Skin Infection	0.05	Rt	SSK114	H / W	Powder / oral / dermal
Moraceae	*Ficus congensis* Engl.	Baure	Fig	Bowel Infection	0.18	B	SSK106	S / W	Powder / Oral
Moraceae	*Ficus thonningii* Bl.	Cediya	Strangler fig	Malaria	0.10	L	SSK111	T / W	Decoction / steaming

Moringaceae	*Moringa oleifera* Lam.	Zogala	Drumstick tree	Gonorrhea	0.07	Rt	SSK58	S / W	Decoction / oral
Myrtaceae	*Syzygium guineense* (Willd.) DC	Malmo	Woodland water berry	Respiratory Tract Infection	0.15	B	SSK115	T / W	Decoction / oral
Myrtaceae	*Eucalyptus camaldulensis* Dehnh	Turare	River red gum	Malaria	0.32	L	SSK012	T / W	Decoction / steaming
Olacaceae	*Ximenia Americana* L.	Tsada	Jallow wood	Bowel Infection	0.15	B	SSK083	T / W	Powder / Oral
Olacaceae	*Psidium guajava* L.	Gwaba	Guava	Malaria	0.32	L	SSK122	S / W or C	Decoction / steaming
Olacaeae	*Ximenia americana* L.	Tsada	Jallow wood	Skin Infection	0.15	B	SSK083	T / W	Maceration / oral / dermal
Onagraceae	*Ludwigia octovalvis* (Jacq.) P.H. Raven	Shashatau	Willow primrose	Respiratory Tract Infection	0.07	WP	SSK039	S / W	Maceration / oral
Poaceae	*Cynodon dactylon* (L.) Pers.	Kiri kiri	Bamuda grass	Gonorrhea	0.10	Rt	SSK082	H / W	Decoction / oral
Rhamnaceae	*Ziziphus mauritiana* Lam.	Magarya	Indian jujube	Abnormal Vaginal discharge	0.25	L	SSK094	S / W	Maceration / oral
Rhamnaceae	*Ziziphus mucronata* Willd.	Magaryar kura	Buffalo thorn	Gonorrhea	0.02	Rt	SSK119	T / W	Decoction / oral
Rubiaceae	*Mitrogyna inermis* (Willd.)Kuntze	Giyayya	False abura	Gonorrhea	0.07	L, B	SSK030	S / W	Decoction / oral
Rubiaceae	*Mitrocarpus hirtus* (L) DC.	Goga masu	Tropical girglepod	Skin Infection	0.57	L	SSK112	H / W	Direct / dermal
Rutaceae	*Citrus aurantifolia* (Christm.)	Lemun tsami	Lime	Respiratory Tract Infection	0.15	F	SSK069	S / C	Juice / oral
Solanaceae	*Solanum lycopersicum* L.	Tumatur	Tomato	Oral Infection	0.09	F	SSK080	H / C	Juice / oral
Zingiberaceae	*Zingiber officinale* Roscoe	Citta	Ginger	Respiratory Tract Infection	0.20	Rh	SSK110	S / C	Decoction / oral

MOA: Mode of Administration, MOP: Mode of Preparation, RFC: Relative Frequency of Citation, B: Bark, F: Fruits, L: Leaves, WP: Whole plant

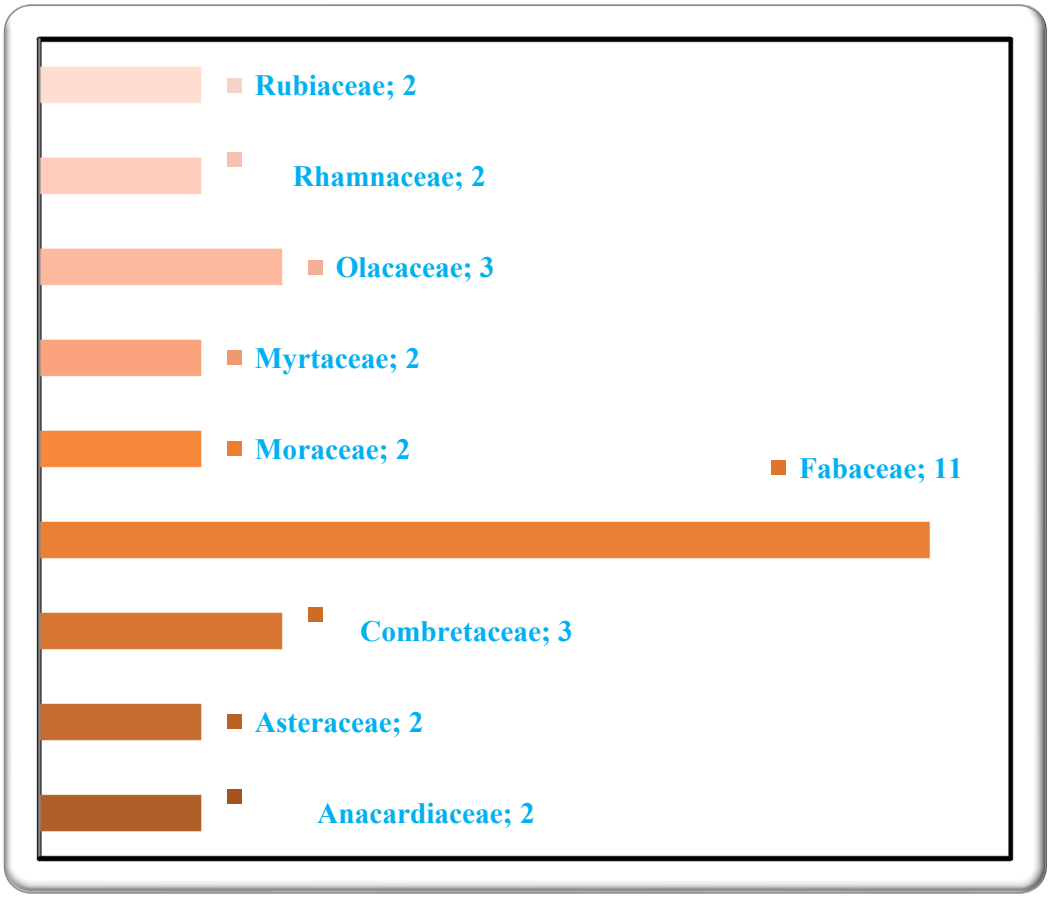

Figure 3. Family distribution of plant species used for the management of HIV / AIDS opportunistic infections in Katsina State, Nigeria.

Ethnopharmacological relevance of the cited species

Information on medicinal plants used for the management of HIV / AIDS opportunistic infections is presented in Table 2. The table reveals the local name, scientific name, family, plants' parts used as well as modes of preparation and routes of administration of the surveyed plants. From the table, it can be seen that *Anogeissus leiocarpa* (DC.) Guill and Perr was the most cited medicinal plant, with the highest RFC of 0.75. The plant is used to manage respiratory tract infections. The plant is also reported as a remedy for the treatment of common cold in Jos, Plateau state, Nigeria (Ohemu *et al.* 2014). *Anogeissus leiocarpa* belongs to the family Combretaceae, and some species of this family like *Combretum collinum* and *Terminalia mollis* were also reported as herbal remedies for the management of tuberculosis in Tanzania (Kisangau *et al.* 2007). Phytochemical screening revealed that members of Combretaceae family were very rich in tannins, which could be responsible for their antibacterial activity (Elegami *et al.* 2002). Although immunomodulatory potential of *A. leiocarpa* is not reported, its free radical scavenging and antioxidant properties which were attributed to the species' high phenolic, and flavonoids were earlier reported (Olugbami *et al.* 2014).

Sclerocarya birrea (A. Rich.) was cited in this study as remedy for bowel infections. This agrees with a previous study where it was cited as a medicinal plant used for the treatment of diarrhoea (Semenya and Maroyi, 2012). Other antidiarrhoeal usage of this plant was also reported (El-gorashi *et al.* 2003; Runyoro *et al.* 2006). *Ximenia americana* L. was cited in this study as a herbal remedy for diarrhoea and skin rashes. This species was also reported to have been used for same condition in other places (Burkill, 1997; Kone *et al.* 2004, Kisangau *et al.* 2007). The plant was also reported to be used against other infectious diseases such as skin infection (Chinsembu *et al.* 2015); Candidiasis (Runyoro *et al.* 2006; Chinsembu and Hedimbi, 2010) and throat infections (GrØnhaug *et al.* 2008). The widespread use of *X. americana* L. suggests that this plant may contain several active compounds which are responsible for its reported activities (Chinsembu *et al.* 2015).

Most of the species reported in this study had been reported to be used for the management of HIV / AIDS opportunistic infections in other parts of the world. *Mangifera indica, Sclerocarya birrea, Adansonia digitata,*

Mormodica balsamina, *Diospyros mespiliformis, Vachellia ataxacantha, V. nilotica, Ficus thonningii, Senna occidentalis, Psidium guajava, Ximenia american, Ziziphus mauritania* and *Z. mucronata* for example, had been reported to be used for treating different HIV / AIDS opportunistic infections in Lusaka, Zambia (Chinsembu *et al*. 2019). *Senna occidentalis* L., *M. indica* L., *A. indica* and *Psidium guajava* reported to be used for the treatment of malaria in this study were reported for same in Aleiro local government area of Kebbi State, Nigeria (Sanjay & Rupashee, 2014). *Waltheria indica*, a medication for skin rashes in this study, had also been reported to manage syphilis in Ohangwena region of Namibia (Hedimbi & Chinsembu, 2010). *Mangifera indica* and *Azadirachta indica* reported in this study were also among the widely used species used to manage opportunistic infections among people living with HIV / AIDS in Uganda (Anywar *et al*. 2020). *Azadirachta indica, M. indica, P. guajava* and *Aloe vera* were also among the medicinal plants reported to have use for the management of various HIV / AIDS opportunistic infections in Njeru Sub-County, Buikwe District, Uganda (Shehu *et al*. 2018).

It is interesting to note that *Vachellia nilotica* (formerly *Acacia nilotica*) is the only species reported to be used in the management of three different opportunistic infections (skin infection, oral infection, and genital ulcer). Previous reports revealed that *V. nilotica* is one of the most important medicinal plants of the study area (Kankara *et al*., 2015, 2018, 2020). It is equally important to know that many studies have substantiated the folkloric use of *V. nilotica*. Kankara *et al* (2017), for example reported the effect of *V. nilotica* in wound healing by suppressing oxidative stress and pro-inflammatory cytokines. *Vachellia nilotica's* immunomodulatory effects showed by its ability to proliferate immune cells and inhibit immunosuppressive cytokines was also earlier reported (Ahovègbé, *et al*. 2021). In another study, it was reported that *Adansonia digitata* leaf, root bark and fruit pulp methanol extracts displayed promising immunomodulatory property based on their ability to stimulate T-cells via increase in delayed-type hypersensitivity (Sharma & Rangali, 2016). It was also reported that solvent fractions of *Diospyros mespiliformis* significantly increased the production IgG, IgM and TNF-α in *Plasmodium berghei*-infected mice, thereby substantiating the immunomodulatory property of the former (David *et al*. 2021). Methanol extract of *Moringa oleifera* also showed immunomodulatory effect in mice as it significantly increased adhesion of neutrophils, attenuation of cyclophosphamide-induced neutropenia as well as phagocytic index (Sudha *et al*. 2010). In another study, purified ginger polysaccharide isolated from *Zingiber officinale*, significantly stimulates the phagocytic activity of RAW264.7 cells and exhibited strong protection against H_2O_2-induced damage (Mingda *et al*. 2021).

Plant parts used

Figure 4 shows the proportions of the plant parts used for the management of the reported opportunistic infections. The result shows that leaves are the most utilized plant part (40%) cited by the informants in the management of the infections. This result agrees with what was previously reported from the Amathole district of the Eastern Cape Province, South Africa (Otang *et al*. 2012). This is however contrary to the findings of Ohemu *et al*. (2014) who reported bark as the most used part in the traditional treatment of viral infection in Jos, Nigeria. High use of leaves by the local people was explained by the fact leaves are easier to access and majority of the plants cited were trees whose leaves were also being utilised as food. The frequent use of leaves could also be explained by the fact that leaves are the site of photosynthesis and therefore the repository of most secondary metabolites (Kankara *et al*. 2015).

Habit and habitat status of the cited species

From Table 2, it can also be seen that most of the cited species are trees. This is because most of the species cited are trees that are in most cases, available throughout the year. There is also the belief that wild species (which are mostly trees) are more effective in herbal medicine. This result is however contrary to the findings of Otang *et al*. (2012), who reported that majority of medicinal plants used to treat opportunistic fungal infections were herbs. It has also been reported that 50% of all the plant species that were used by Bapedi traditional healers in the management of HIV / AIDS in Limpopo Province of South Africa were herbs (Semanya & Maroyi, 2012). It can also be seen that most of the cited species in this study are sourced from the wild. This may not be unconnected with the belief that plants source from the wild are "mightier" medicinally than their cultivated counterparts. Similar finding was earlier reported from the study area (Kankara *et al*. 2015).

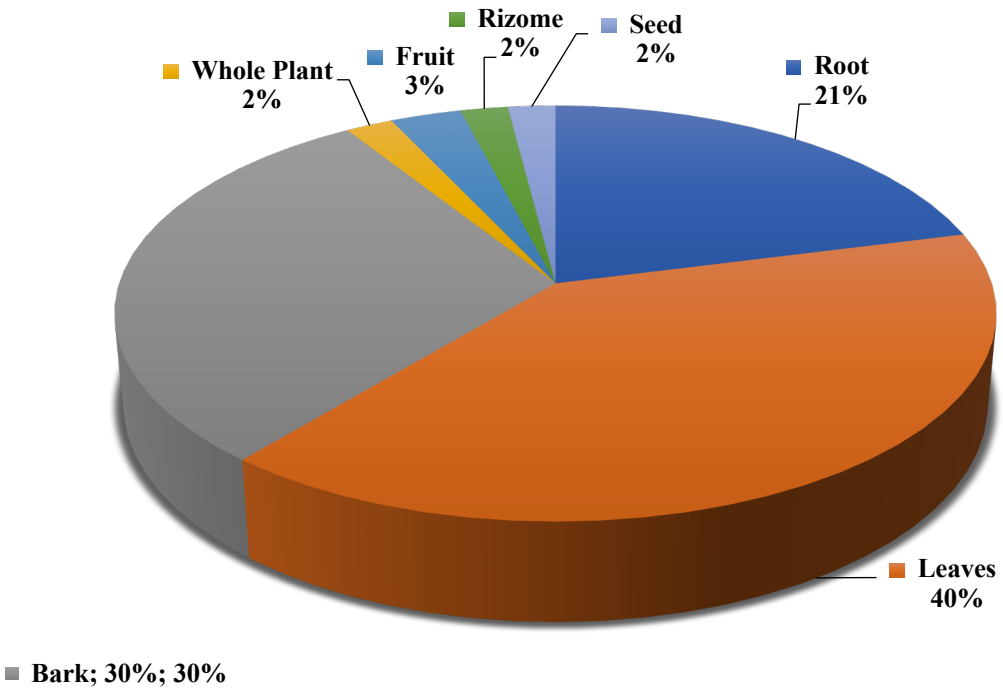

Figure 4. Proportion of plant parts used in the management of HIV / AIDS opportunistic infections in Katsina state, Nigeria

Mode of Preparation and route of administration

Decoction (46%) was the most frequent method of preparation of the herbal remedies in this study (Figure 5). This result agrees with other findings where decoction represent the most frequently employed method in the preparation of herbal medicines for the management of HIV / AIDS and other associated viral infections (Otang *et al.* 2012; Kisangau *et al.* 2007; Ohemu *et al.* 2014; Omoruyi *et al.* 2012). In order to neutralize the bitter taste of most of the decoction preparations, a white potassium called *jar kanwa* and *balma* are added. Same practice was reported from the study area for plants used for maternal health (Kankara *et al.* 2015). Powdered preparations are mostly dissolved in liquid food such as *fura, kunu, koko* or cow milk (*nono*). The powdered preparations of *Pulicaria crispa*, *Senna singueana,* and *Diospyros mespiliformis* are usually diluted with water and applied dermally, as this method has proven to be more effective for skin infections than ointment preparations. Most of the preparations are taken orally. This agrees with previous findings which revealed that oral ingestion is the most frequently used route of administration in traditional medicine (Otang *et al.* 2012; Ohemu *et al.* 2014; Hunde *et al.* 2004; Musa *et al.* 2011)

Frequency of medicinal plants used to manage specific opportunistic infection is presented in Figure 6. From the figure, it can be seen that most of the taxa (12 species) are used to manage bowel infection, while one species each was used to manage vaginal discharge and genital ulcer.

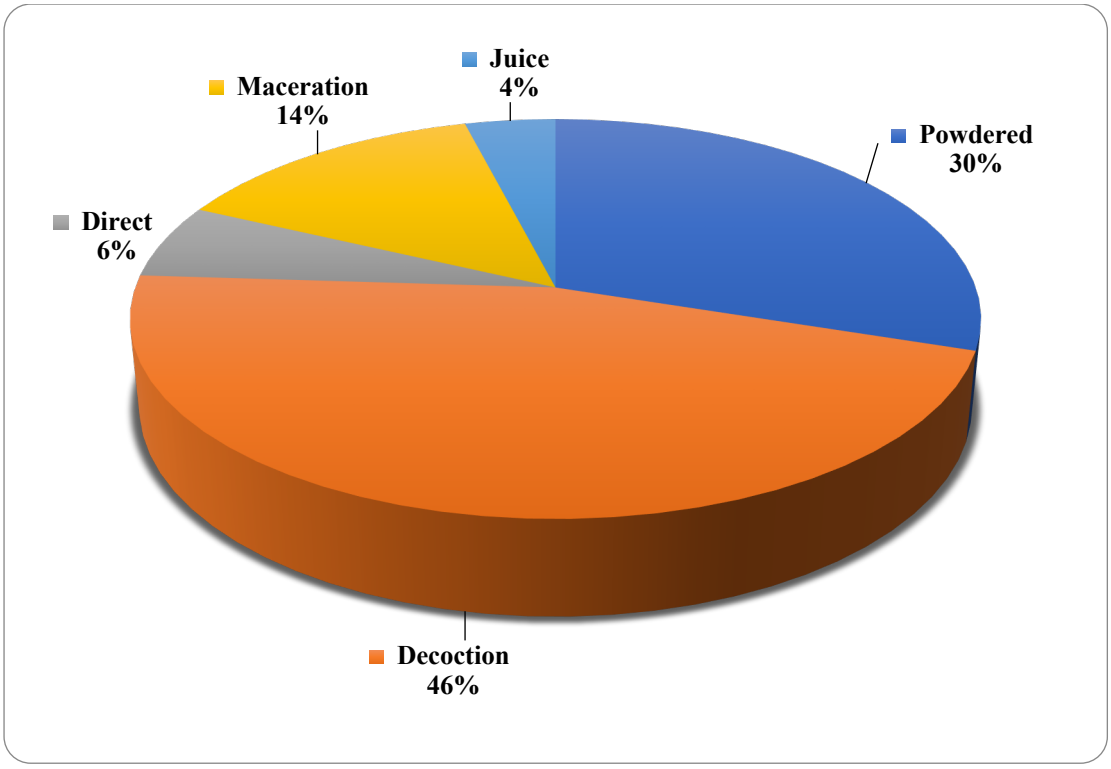

Figure 5. Proportion of mode of preparation of medicinal plants used in the management of HIV / AIDS opportunistic infections in Katsina state, Nigeria.

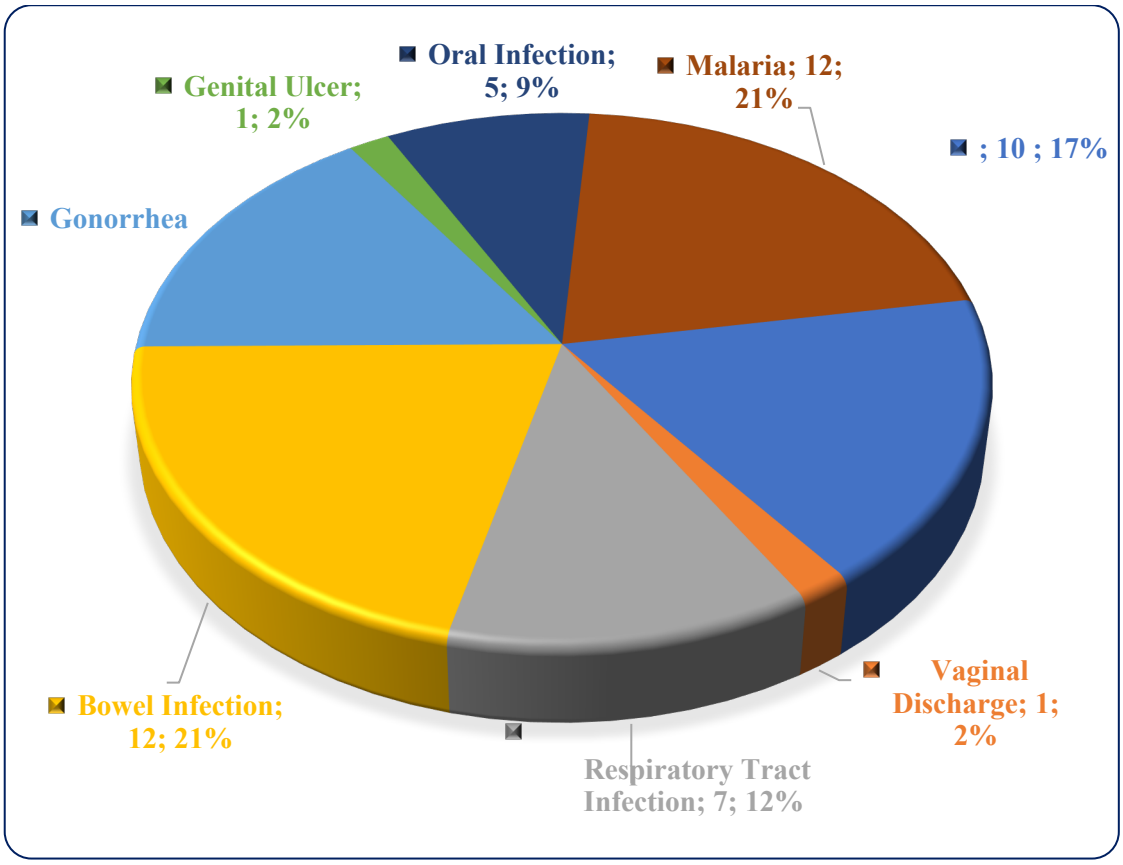

Figure 6. Proportion of medicinal plants used to manage HIV / AIDS opportunistic infections in Katsina State, Nigeria

Informant Consensus Factor (ICF)

The ICF of the surveyed plants is presented in Table 3. From the Table, it can be seen that abnormal vaginal discharge and genital ulcer had the highest ICF of 1 each. This means that there is agreement among all the respondents who cited the specific species used in the management of those ailments.

Table 3. Informant Consensus Factor (ICF) of medicinal plants used for the management of HIV / AIDS opportunistic infections in Katsina State, Nigeria.

Infection	No. of Species	Citation	Informant Consensus Factor
Skin infection	10	57	0.84
Abnormal vaginal discharge	1	25	1
Respiratory tract infection	7	40	0.85
Bowel infection	12	51	0.78
Oral infection	5	25	0.83
Gonorrhea	09	42	0.80
Genital ulcer	01	12	1
Malaria	10	67	0.86

Novelty of the study

To the best of our knowledge, it is the first independent study of its kind in the area and the region. Some species like *Aristolochia albida, Cissampelos owariensis, Pistia stratiotes, Pulicaria crispa, Swartzia madagascariensis* and *Syzygium guineense* were reported for the first time to possess ethnobotanical application from the study area. If properly harnessed, information from this study would be a source of baseline data based on which further studies aimed at discovering anti-HIV drugs could be carried out.

Conclusion and Recommendation

The current study shows that Katsina State is rich in abundance and diversity of medicinal plants. Indigenous people in the area use some of those species to manage HIV / AIDS Opportunistic Infections. The survey revealed 48 plant species distributed among 44 genera and 28 families. The highest RFC was observed in *Anogeissus leiocarpa*. Fabaceae represented by 11 species is the most utilised family. Highest ICF was observed in abnormal vaginal discharge and genital ulcer. Most of the cited species are trees sourced from the wild and majority of medications are prepared in the form of decoction which is taken orally. The most used plant parts were leaves (40%). It is therefore recommended to scientifically establish the therapeutic uses of the surveyed medicinal plants through phytochemical screening, bioassays and determine their safety through toxicological studies.

Declarations

List of abbreviations: AIDS: Acquired Immunodeficiency Syndrome, ART: Antiretroviral, HIV: Human Immunodeficiency Virus, ICF: Informant Consensus Factor, LGA: Local Government Area, MOA: Mode of Administration, MOP: Mode of Preparation, PCA: Principal Component Analysis, RFC: Relative Frequency of Citation.

Ethics approval and consent to participate: Ethical approval was granted, and all respondents were informed about the aim of the study. Their consent was voluntarily secured before the commencement of the interview and confidentiality was assured.

Consent for publication: Not applicable.

Availability of data and materials: Voucher specimens have been deposited at the Herbarium of Department of Biology, Umaru Musa Yar'adua University Katsina State, Nigeria.

Competing interests: The authors declared no conflict of interest.

Authors' contributions: All authors participated in the research. The author S.S.K. conceived the research idea, designed the study questionnaire, and participated in the field study. The author A.I.N. carried out the entire interview, participated in the field study and drafted the original manuscript. The author A.B. participated in the field study, provided the scientific names of the cited species, and reviewed the manuscript. Author A.I.B. review the manuscript and offer valuable suggestions. Authors M.R.H and K.A.B. participated in the field study and collection of plant samples. All authors read, review and approved the final draft manuscript.

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