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ETHNOMEDICAL AND ETHNOBOTANICAL INVESTIGATIONS ON THE RESPONSE CAPACITIES OF GUINEAN TRADITIONAL HEALTH PRACTITIONERS IN THE MANAGEMENT OF OUTBREAKS OF INFECTIOUS DISEASES: THE CASE OF THE EBOLA VIRUS EPIDEMIC

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Abstract

Ethnopharmacological Relevance: The recent outbreak of Ebola virus infections has mostly remained confined to the West African countries Guinea-Conakry, Sierra-Leone and Liberia. Due to intense national and international mobilizations, a significant reduction in Ebola virus transmission has been recorded. While international efforts focus on new vaccines, medicines and diagnostics, no coherent national or international approach exists to integrate the potential of the traditional health practitioners (THPs) in the management of infectious diseases epidemics. Nevertheless, the first contact of most of the Ebola infected patients is with the THPs since the symptoms are similar to those of common traditionally treated diseases or symptoms such as malaria, hemorrhagic syndrome, typhoid or other gastrointestinal diseases, fever and vomiting.

Materials and methods: In an ethnomedical survey conducted in the 4 main Guinean regions contacts were established with a total of 113 THPs. The socio-demographic characteristics, the professional status and the traditional perception of Ebola Virus Disease (EVD) were recorded.

Results: The traditional treatment of the main symptoms was based on 47 vegetal recipes which were focused on the treatment of diarrhea (22 recipes), fever (22 recipes), vomiting (2 recipes), external antiseptic (2 recipes), hemorrhagic syndrome (2 recipes), convulsion and dysentery (one recipe each). An ethnobotanical survey led to the collection of 54 plant species from which 44 identified belonging to 26 families. The most represented families were Euphorbiaceae, Caesalpiniaceae and Rubiaceae. Literature data on the twelve most cited plant species tends to corroborate their traditional use and to highlight their pharmacological potential.

Conclusions: It is worth to document all available knowledge on the traditional management of EVD-like symptoms in order to evaluate systematically the anti-Ebola potential of Guinean plant species.

Keywords: Ebola virus disease; traditional health practitioners; Guinea-Conakry

List of abbreviations

CRVPM	Centre de Recherche et de Valorisation des Plantes Médicinales
ETC	Ebola Treatment Center
EVD	Ebola Virus Disease
THP	Traditional Health Practitioner
WHO	World Health Organization

1. Introduction

New pathogens and resistant forms of older pathogens continue to emerge or to re-emerge, sometimes with the potential for rapid and global spread, leading to high morbidity and mortality [Tapper; 2006]. From these, infectious viral diseases remain an important worldwide problem. Viruses have resisted prophylaxis or therapy longer than any other form of life [Vanden Berghe *et al.*, 1986]. Since 1980, the world has seen an increasing number of infectious disease outbreaks from an increasing number of sources. Between 1980 and 2013, a total of 12,102 outbreaks of 215 diseases, with 44 million individual cases in 219 countries around the world have been recorded [Smith *et al.*, 2014]. Within the poorest developing countries in Africa, acute febrile illnesses such as malaria, acute respiratory infections, typhoid fever, tuberculosis and viral hemorrhagic fevers comprise the majority of human disease burden and figure with cholera among the major infectious killers [Traore *et al.*, 2013; WHO, 2003]. Of the 58 public health events in Africa reported to the Regional Office between January and December 2014, 95% (55 / 58) were due to infectious diseases such as cholera (31%), Ebola (13%), Dengue (13%), meningitis (11%), polio (7%), Lassa (5%) or measles (5%) [WHO, 2015]. Three West African countries, more in particular Guinea, Sierra Leone and Liberia are well-known to have cholera outbreaks every 3–5 years, with epidemics often spreading regionally [Azman *et al.*, 2015]. In Guinea, from 1970 to 2011, most cholera cases were reported in Low-Guinea, Upper-Guinea and Forest-Guinea. In 2012, the Guinean Cholera Outbreak accounted for 7350 cases with 133 deaths and was linked to the outbreak in Sierra Leone [WHO, 2013]. Lassa fever is prevalent in the West-African sub-region where about 3-5 million individuals are infected yearly. Lassa fever is known to be endemic in Guinea, Liberia, Sierra Leone and Nigeria, where about 500,000 individuals are infected yearly, about 5,000 for which resulting in death [Ibekwe, 2012; Ogbu *et al.*, 2007]. In Guinea, Lassa virus (*Arenavirus*) infection was found to be widespread, with an occurrence in the Guinean northern regions, and with a high occurrence in coastal, savannah and forest areas [Bausch *et al.*, 2001; Demby *et al.*, 2001; Fichet-Calvet *et al.*, 2005].

Regarding other viral infections, arboviruses such as yellow fever, Dengue, and West-Nile (flavivirus), Chikungunya and O'nyong Nyong (alphavirus), Rift Valley Fever (phlebovirus), and Tahyna (bunyavirus) are common causes of diseases and circulate frequently in Guinea [Jentes *et al.*, 2010]. Noteworthy, the occurrence of both Lassa (*Arenavirus*) and Ebola (*Filovirus*) viruses was presumed earlier during an outbreak of a hemorrhagic fever in Madina Oula, a sub-prefecture of Kindia in 1982-1983 [Boiro *et al.*, 1987]. However, the 2014 Ebola

epidemic affecting mainly Guinea, Sierra Leone and Liberia was considered as the largest, most complex and severe outbreak of Ebola in terms of the number of human cases and fatalities so far recorded in history. Of all the epidemics that Guinea has known during its history, this recent hemorrhagic fever with Ebola virus remains unique, not only because of its width and its very high lethality, but also because of its serious negative impact on social, economic, political and even diplomatic life. A total of 3797 positive, probable and suspected patients have been recorded from December 30th, 2013 till August 27th, 2015 and 2528 deaths (67%) were registered [OMS/Guinée, 2015]. The true number of infections and deaths is undoubtedly greater since evidence suggests that many Ebola infections might be under-reported. This is due to the lack of public health infrastructure together with delays in virus detection and implementation of control interventions in a region inexperienced with this disease [Baize *et al.* 2014] where people continue to hide the sick, conduct funerals in secret, and elude contact tracing [Ranu S and Daniel Kelly, 2015]. Moreover, although many Ebola infections are asymptomatic [Heffernan *et al.*, 2005] and are supposed to be unlikely infectious [Leroy *et al.*, 2000], it is convenient to note that an individual who was asymptomatic while traveling from Liberia to Dallas, Texas developed clinical findings consistent with Ebola virus disease approximately five days after arriving in the United States, and subsequently died [Centers for Disease Control and Prevention, 2014].

In the infected areas, the threat of Ebola continues to limit the ability of local health-care systems to provide standard care, leaving people with non-Ebola Virus Disease-related health disorders without necessary care. Moreover, fear of the disease prevents a number of patients to consult the conventional health care centers. Due to this dysfunctional healthcare system along with the lack of efficient therapy, the local custom and traditions and the mistrust towards the official authorities, millions of Guinean people remain consequently at risk of contamination. For these, traditional medicine will continue to be the first and most important source of medicinal solace when illness strikes health.

While international efforts focus on new vaccines, medicines and diagnostics, no coherent national or international approach exists to integrate the potential of the traditional health practitioners (THPs) in the management of infectious diseases epidemics. In spite of its social importance, traditional medicine continues to be largely disregarded in health development planning. It currently plays only a marginal role in biodiversity management and its contribution to the society in general is neglected. However, for centuries, both herbal and spiritual traditional practitioners have alleviated the ills of millions of Africans caused by

what western medicine classifies as acute or chronic diseases, infections, traumas and psychological illnesses [UNAIDS, 2006]. Like many other emerging diseases, the Ebola outbreak illustrated the crucial role of the ecological, social, political and economic context within which diseases emerge. Pandemics are no longer simply the domain of public health and clinical medicine, but are a social, a developmental and a global security issue [Castillo-Chavez *et al.*, 2015]. Due to their high credibility and deep respect among the population they serve, traditional health practitioners (THPs) have a crucial role to play in building the health system and supporting the national response to infectious diseases epidemics [UNAIDS, 2002]. Guinea has rich plant biodiversity and a long tradition of medicinal use of plants. Its flora counts about 3,000 vegetal species of which 2,960 are identified [Lisowski, 2009]. However, only a few of these have been documented in scientific literature. The strong local demand for medicinal plants has been met by indiscriminate harvesting of spontaneous flora including those in forests. As a result, many species have become extinct or are endangered, indicating the urgency of actions to preserve, protect and promote their rational uses. Upon the above considerations and taking into account traditional health practitioners have always played a central role in the medical management of their community and tend to be the entry point for care in many African communities, particularly in remote rural areas, the present study was realized in order to evaluate the level of implication of the Guinean traditional health practitioners during the recent EVD outbreak and to inventory their proposed remedies.

2. Material and Methods

2.1. Ethnomedical and ethnobotanical investigations

2.1.1. Study area:

With 245,857 km², Guinea is located on the Atlantic coast of West Africa. Limited to the West by the Atlantic Ocean, to the North-West by Guinea-Bissau, to the North by Senegal, to the North-East by Mali, to the East by the Ivory Coast, and to the South by Liberia and the Sierra Leone, it has Conakry as its capital. It sets out in four distinct geographic regions: the lowlands Low-Guinea, area of littoral plains; Middle-Guinea (Fouta Djallon), with mountainous solid masses and lateritic high plateaus; Upper-Guinea (northeast savannah), a vast plateau; and Forest-Guinea (southeastern rainforest), a true chain of mountains. The population was estimated at 12,043,898 in 2014 [WBG, 2015]. It is characterized by a diversity of ethnic groups, languages and religions. The main ethnic groups are Soussous

(Low-Guinea), Peuhls (Middle-Guinea), Malinkees (Upper- Guinea), Kissis, Tomas and Guerzees (Forest-Guinea). The principal occupation of the population is agriculture.

2.1.2. Ethnomedical survey

The survey targeted the traditional healers and herbalists of the following localities: the rural areas of the districts of Sékou Soriya, Safèrin, Kòlakhouré and Souleymania in the sub-prefecture of Madina Oula, prefecture of Kindia (Low-Guinea); the urban area of the prefecture of Kankan and Siguiri, the rural area of Diamonna, sub-prefecture of Sabadoubaranama in Kankan (Upper- Guinea); the rural and urban areas of Lola (Forest-Guinea); the districts of Thuo, Nyon, Serengbara, Gba, Foromogpa, Theassou, Gbenemou, Soronianta 1 and 2, Gbalemou, Tokpanata, Zaapa, Zikota (sub-prefecture of Bossou), the districts of Doromou and Gbakorè (sub-prefecture of Nzoo), the district of Zizou (sub-prefecture of Gueassou), Lola Centre; and the semi-rural areas of Taran, Fadi and Dara-Labé of the prefecture of Labé (Middle-Guinea).

Ethnomedical and ethnobotanical investigations were conducted from October 24th to November 8th 2014 and December 28th 2014 to February 26th in Upper-Guinea; from October 26th to November 8th 2014 and February 15th to 28th, 2015 in Low-Guinea; from 15th to 30th January 2015 and May 25th to June 25th 2015 in Middle-Guinea; and from March 12th to April 24th 2015 in Forest-Guinea. Traditional Health Practitioners (THPs) were identified through the help of religious leaders, patriarchs or administrative chiefs. The selection of the interviewees was done on the basis of their assent, their presence in the community at the time of the investigation, their fixed domiciliation in the area of the investigation and their professional recognition by the local community. The objectives of the study were clearly explained and a verbal consent was obtained from each informant before any interview to disclose the information. The THPs were interviewed at home using a questionnaire. The questionnaire and oral interviews were based on the standardized model designed by the “Centre de Recherche et de Valorisation des Plantes Médicinales (CRVPM) – Dubréka”. The main questions focused on demographic data (age, sex, educational level, professional experience), traditional considerations (experience on outbreaks) and management of the Ebola virus disease (knowledge, behaviors, treatments).

2.1.3. Ethnobotanical survey

The plant species mentioned were inventoried and collected in close collaboration with the THPs. Collected voucher specimens were pressed, dried, identified and deposited at the herbarium of the CRVPM – Dubréka. The plant species were botanically identified by the botanists from the “CRVPM – Dubreka”.

3. Results and Discussion

3.1. *Ethnomedical survey*

As shown in Fig. 1, the number of patients in the prefectures of Kankan, Siguiri (Upper-Guinea), Kindia (Lower-Guinea), and Lola (Guinea-Forest) were 32, 34, 114, and 111, respectively, from December 30th, 2014 until August, 27th, 2015. Labé (Middle-Guinea) was accounted as one of the seven Guinean prefectures without Ebola. A total of 113 THPs were contacted, more in particular 4 in Siguiri, 29 in Kankan, 10 in Labé, 25 in Madina Oula (Kindia) and 45 in Lola.

3.1.1. *Socio-Demographic Characteristics*

Only 27% (31/113) of THPs were females, all from Upper-Guinea (14) and Forest-Guinea (17). The age of the traditional healers ranged from 28 to 90 years old. 96% (109/113) of the recorded THPs were 60 years old or less. The oral transmission of traditional medicine knowledge was done through parental inheritance for 63% (71/113) THPs, by relation for 27% (30/113; mainly the females (25/31, 81%)), by training for 5% (6/113), by dream for 4% (4/113) or by revelation for 1% (1/113). A total of 15% (17/113) of the THPs had less than 10 years of experience in traditional medicine (2 in Upper-Guinea, 5 in Low-Guinea and 10 in Forest-Guinea), 48% (54/113) had 10 to 30 years of experience (16 from Upper-Guinea, 5 from Middle-Guinea, 11 from Low-Guinea and 22 from Guinea-Forest) and 37% (42/113) more than 30 years (15 from Upper-Guinea, 5 from Middle-Guinea, 8 from Low-Guinea and 14 from Guinea-Forest). The educational levels of the interviewees were low: only 15/113 (13%) of the THPs had attended a higher education institution or traditional koranic schools

3.1.2. *Professional status of the practitioners*

All the contacted practitioners were well-known as THPs within their communities. Among the interviewed THPs, only 27% (31/113) had been listed by the Department of Traditional Medicine of the Ministry of Health and Hygiene and had their membership card. Of these, 6 (6/27; 22%) were from Kankan (Upper-Guinea) and 25 (25/45, 56%) from Lola (Forest-Guinea). The majority (82/113) practiced in a more secluded way, justifying their attitude by the obligation to protect a family heritage (30/82, 37%), mistrust towards administrative services (23/82, 28%), the long distance from the national authorities (18/70, 26%), or the lack of information about registrations (11/82, 13%). In fact, it is well known that old THPs usually live and practice in their villages and do not attach any importance to

this registration. This situation contrasts with the official recognition of the practice of traditional medicine and could be due partly to an inadequate budgeting to facilitate the functioning of the Traditional Medicine Board. In most developing countries, THPs far outnumber modern health practitioners, and the majority of the population use traditional medicine. In Sub-Saharan Africa, the ratio of traditional healers to the population is approximately 1:500, in contrast to 1:40,000 for medical doctors [Smith, 2014]. Moreover, distribution of these medical doctors may be uneven, with most being found in cities or other urban areas, and therefore difficult for rural populations to access.

3.1.3. Traditional perception of Ebola Virus Disease

Based on the symptoms, most THPs were very confused about the origin of EVD. For 17% THPs (19/113: 2 in Guinea-Forest; 3 in Low-Guinea, 6 Middle-Guinea, 8 in Upper-Guinea), the disease is due to the sorcerers. For 27% (30/113) others (8 in Kindia, 1 in Labé, 8 in Kankan, 2 in Siguiri and 11 in Lola), EVD could be an aggravation of a previously untreated digestive disease, or a failed treatment. For 12% THPs (14/113; 2 in Kankan, 4 in Lola, 5 in Kindia and 3 in Labé), EVD could be an expression of a food poisoning. In Kankan, 8 THPs cited Ebola similar diseases like “Köba” or “cholera”, “dysentery”, “typhoid fever”, “Séi dangba” or “dirty jaundice”, “Kunfilatou”, “Donkafèlè”, “Gnoni” (probably chickenpox), “Fögnöba diankoro” or “disease of the high wind”, “wounds of the digestive tract” causing the occurrence of blood in stools. According to one THP from this region, the disease resulted from the eating of the venomous snake “Fonfoni”, the drinking of stagnant water where some animals had died. None of them was convinced about the contamination through the consumption of wild meat (bushmeat), traditional corpse management, or promiscuity with sick people, since they have a long habit of these without any problem.

3.1.4. Involvement of traditional healers in the management of EVD

The involvement of THPs can be resumed in 3 phases: before the current EVD outbreak, during the first year of the outbreak and the second year of the outbreak. Before the present EVD outbreak, it is important to bear in mind that THPs are typically the first, and often the only responders to health crises in sub-Saharan Africa, particularly in the remote rural areas where usually infectious diseases are common. Because arbovirus, Lassa and Ebola viruses are common causes of undiagnosed febrile illnesses that have been described to circulate in Guinea before the present outbreak [Boiro *et al.*, 1987; Jentes *et al.*, 2010], most likely THPs have been in the frontline for the treatment of a number of known and unknown

illnesses before the present outbreak. Undoubtedly, they were placed at high risk of exposure more likely than all other health actor categories. During the first year of the EVD outbreak (2014), all the THPs have continued to treat patients complaining of fever, malaria, typhoid, influenza, blood vomiting and dysentery. None of them was aware of the existence of a new disease called “Ebola”. Some THPs considered the new disease as a political invention to hide the current social and economic difficulties (58/113; 51%), a lie to discredit the government efforts (18/113; 16%), a measure to prevent demonstrations (21/113; 19%), and an opportunity to eliminate undesirable people (16/113; 14%). Hence, a widespread reluctance to preventive measures was observed within the THPs as well as the population in 2014.

During the second year of the outbreak (2015), after one year of an intensive sensitizing campaign, 27% of the THPs (30/113: 12 from Upper-Guinea, 8 from Middle-Guinea, 10 from Low-Guinea) admitted to be ultimately convinced of the existence of the disease. The others were either dubious (61/113; 54%) or without any opinion (22/113; 19%). A total of 67% (20/30) of the convinced THPs were able to cite at least four of the following symptoms: fever, headache, vomiting, nausea, diarrhea, muscle pain, difficulty swallowing, conjunctivitis, weakness, hiccups, pharyngitis, hemorrhagic syndrome, stomach ache, rash, blood in the stools. Fever, diarrhea, vomiting (with or without blood), stomach ache were the most cited symptoms.

3.1.5. Involvement of THPs in the prevention measures

During the first year of the outbreak (December 2013 to December 2014), the social leaders such as THPs were not adequately involved in the national prevention program. Such negligence could explain a series of violence outbreaks in some regions of Forest-Guinea (Macenta, Nzérékoré, Lola), Low-Guinea (Conakry, Coyah, Forécariah, Dubréka, Boffa, Boké, Kindia, Téliélé), and Upper-Guinea (Faranah, Kissidougou, Kouroussa). Significant community reserves were widely recorded in the affected areas. The deadly nature of the disease was combined with fear that was often stoked by a flood of irresponsible public commentary. Most of the preventive measures recommended in the fight against Ebola fever upset the usual beliefs, practices and customs of local communities. All the THPs have shown solidarity to the populations in the rejection of most of unfamiliar preventive measures including pulverizations, burials and quarantines. In fact, 80/113 (71%) of the THPs were suspicious of official attempts to combat the disease. However, after nearly one year of sensitization, 4/10 (40% in Labé), 20/25 (80% in Kindia), 20/45 (44% in Lola), 4/4 in Siguiri and 22/29 (76%) in Kankan were in agreement with the preventive measures such as a regular

hand washing with soap and water or use of an alcohol-based sanitizer, good hygiene, and clean environment. However, due to cultural and religious reasons, 98/113 (87%) of the THPs remained hostile with the measures about burials and quarantines.

The THPs from Forest-Guinea were not really convinced about the transmission of Ebola disease via cooked “bush meat” since this was a secular practice among the populations. Moreover, nowadays, they estimate that wild animals are more and more rare. If hand-washing is the only measure accepted by all the THPs, its application within their office was effective only for 41% (46/113). THPs from Kindia and Kankan recommended the use of a maceration of the fruits of *Citrus lemon* in case of lack of hand sanitizers such as soap, sodium hypochlorite or methyl alcohol. To prevent any contamination, a THP from Kankan suggested wiping the skin with a decoction of a mixture of *Lawsonia inermis* and *Citrus lemon* leaves.

The lack of cooperation by the population seemed to be related to the way how the messages were given, due to a wrong interpretation. Ultimately, in order to communicate preventive measures during an outbreak of disease, it is essential to give a good message as well as to have a good messenger. Having this in mind, THPs in rural areas are the main health referees, the good messengers who in periods of outbreaks must be included, just as well as the administrative, religious and traditional health leaders. Culturally close to clients, TPHs represent an undeniable health social basis. Because of their proximity to the communities, they must be fully involved in the implementation of any health program and/or promotion.

3.1.6. Mortality within traditional health workers

From December 2013 to August 27th, 2015, the global lethality of the confirmed, probable and suspected Ebola cases in Guinea was 67% (2,528 / 3,797). While the lethality of the confirmed cases was 49% (281/569) in Conakry, in the investigated areas, it was 71% (66/93), 64% (50/78), 62% (16/26), and 65% (20/31) for Lola, Kindia, Siguiri and Kankan, respectively. Regarding the health-care workers, the available data are mainly focused on the conventional ones. The health-care professionals responding to the crisis have paid dearly for Ebola with 196 confirmed cases, from which 76 in Conakry, 1 in Kindia, 3 in Lola, 3 in Siguiri and 1 in Kankan. Among the confirmed global infected health workers, 51% (99/196) died from the disease. Among these died health workers, 31 were from Conakry, 1 from Siguiri and 1 from Kankan [OMS/Guinée, 2014]. Regarding the death of THPs, the available data are still insufficient. The death in December 2014 of a famous fetisher from Banankoro

(prefecture of Kérouané) was not formally related to Ebola [OMS/Guinée, 2014]. On the other hand, 13 Ebola infected health workers in Forecariah (6), Conakry (5), Kindia (1) and Boffa (1) were hospitalized in the Secured Treatment Center of health-care workers since its opening in March 15, 2015; among these 13 health practioners, 2 were THPs [Migliani, 2015]. Except these 2 infected THPs, no clear and specific data are still available about these health actors. Nevertheless, according to the interviewees in the studied areas, no deaths have been recorded among THPs in their communities since the beginning of the outbreak. It could be of interest to study in detail the survival among the THPs living in the Ebola affected areas.

3.1.7. Traditional treatment of Ebola-like symptoms

The traditional treatments were mainly symptomatic. The clinical features of malaria, typhoid and gastroenteritis can all mimic Ebola virus disease. Also diarrhea and vomiting, typical symptoms of cholera, are frequently encountered in Ebola patients. These treatments were based only on vegetal recipes (47/113; 42%) or vegetal remedies along with religious incantations (66/113; 58%). Usually, a number of young THPs see a lucrative opportunity of ‘curing’ people living with a complex disease, in the absence of a cure by modern medicine. This was not the case this time, the main reason being probably the fear of the disease among young people. All but one of the 113 THPs were inexperienced with Ebola virus disease and recognized their total unawareness of the term “Ebola” before the present outbreak. Unfortunately, none of them was specifically educated on the management of Ebola during the outbreak. However, based on the main Ebola described symptoms, 100% of the THPs claimed to be able to treat at least two or three combinations of fever, diarrhea (with or without blood), dysentery, vomiting (with or without blood) for up to 5 years. Only one THP (1/113), from Thuo (Lola), a border district with Liberia and Ivory Coast, ensured to be familiar with all the signs of Ebola. . He told to have acquired this specific experience through a dream and viewed EVD as a development of an old known disease he used to treat. During the Ebola outbreak he had treated about 10 Guinean and 5 Liberian patients. He claimed to have cured 14/15 patients which suffered from both fever, bloody diarrhea, abdominal cramps and vomiting. Due to persisting symptoms, two female patients were referred to the Ebola Treatment Center (ETC) at Macenta: one probably died in this center, while the other was cured, but came back with eye troubles. Common ocular problems to the “cured” patients coming back from the ETC have been observed in Lola. All the THPs assumed to treat

usually and successfully patients suffering either from fever, diarrhea, vomiting, hemorrhagic syndrome, stomach ache, hiccups, conjunctivitis, weakness, pharyngitis, rash, or blood in the stools. However, diarrhea, vomiting and fever remain the main symptoms treated by these THPs. Few THPs, i.e. 35/113 (31%) (6/29 from Kankan, 2/4 from Siguiri, 8/10 from Labé, 15/25 from Kindia and 4/45 from Lola) claimed they would be willing to refer to the ETC any patient with hemorrhagic syndrome. 69% (78/113) THPs would refer only in case of the failure of their own treatments.

As shown in Table 1, a total of 22, 14, 13 and 4 recipes were collected from Kindia, Labé, Kankan and Lola, respectively. According to their resemblance, these were gathered in 47 main recipes. All the remedies were focused on the treatment of diarrhea (22 recipes), fever (22 recipes), vomiting (2 recipes), external antiseptics (2 recipes), hemorrhagic syndrome (2 recipes), convulsion and dysentery (one recipe for each). A total of 27 recipes were composed of one plant species while 14 and 6 were a combination of 2 or 3 plant species, respectively. Two recipes from Kindia were sweetened with honey. One recipe from Kankan was a mixture of *Combretum micranthum*, *Citrus lemon* and a chemical product “Colphedrine” and was indicated for the treatment of a type of fever/diarrhea called “dunkafèlè”. From Lola, the single THP who assumed to “treat” Ebola did not wish to inform about his recipes.

3.2. Ethnobotanical survey

As indicated in Table 1, 54 plant species were recorded among which 44 were identified belonging to 26 families. The most represented families were Euphorbiaceae, Caesalpiniaceae, Rubiaceae with 8, 4 and 3 species, respectively, followed by Combretaceae, Rutaceae and Lamiaceae, with 2 species each. The remaining families were each represented by 1 species.

Before the outbreak of EBV, most of the collected and identified plant species were well-known and widely used as antimalarial (or antipyretic), antimicrobial or antidiarrheal in Guinean traditional medicine. These include *Adansonia digitata*, *Alchornea cordifolia*, *Allophyllus africanus*, *Annona senegalensis*, *Bridelia ferruginea*, *Carica papaya*, *Citrus lemon*, *Cola nitida*, *Combretum micranthum*, *Craterispermum laurinum*, *Crossopteryx febrifuga*, *Dialium guineense*, *Eleais guineensis*, *Euphorbia hirta*, *Ficus* sp., *Gardenia ternifolia*, *Harungana madagascariensis*, *Hymenocardia acida*, *Jatropha curcas*, *Khaya senegalensis*, *Lawsonia inermis*, *Mangifera indica*, *Mimosa pigra*, *Ocimum viridae*, *Parkia biglobosa*, *Piliostigma thonningii*, *Psidium guajava*, *Tamarindus indica*, *Terminalia albida*,

Uapaca somon, *Vernonia colorata*, *Zanthoxylum zanthoxyloides*, [Traoré *et al.*, 2013, 2014; Magassouba *et al.*, 2007; Basilevskaia, 1969].

The most frequently cited plants over the studied areas were *Alchornea cordifolia* for the treatment of fever and diarrhea and *Psidium guajava* for the treatment of diarrhea. The other plant species cited by more half of the THPs (either in one or in all investigated sites) for the treatment of fever and/or diarrhea were *Citrus lemon*, *Annona senegalensis*, *Gardenia ternifolia*, *Dialium guineense*, *Euphorbia hirta*, *Harungana madagascariensis*, *Piliostigma thonningii*, *Jatropha curcas*, *J. gossypifolia*, *Vernonia amygdalina*. According to some THPs from Labé, Kindia and Kankan, *A. cordifolia*, *P. guajava*, *D. guineense* were efficient against cholera or typhoid fever.

Previous investigations on the above plant species have highlighted the biological importance of their extracts and/or constituents.

Alchornea cordifolia

A. cordifolia leaves showed a strong dose-dependent anti-inflammatory activity after topical application, which was related to the presence of daucosterol, *N*-1,*N*-2-diisopentenyl guanidine and *N*-1,*N*-2,*N*-3-triisopentenyl guanidine. These compounds as well as acetyl aleuritolic acid isolated from the root were shown to be more active than indomethacin [Mavar-Manga *et al.*; 2004, Mavar-Manga *et al.*, 2008]. Polysaccharides isolated from the leaves of *A. cordifolia* have shown an immunomodulatory activity [Kouakou *et al.*, 2013]. Besides the antibacterial activity against *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Escherichia coli* and *Staphylococcus aureus* [Ebi, 2001; Adeshina *et al.*, 2012], the alcoholic and aqueous leaf extracts inhibited the growth of *Helicobacter pylori*, *Salmonella typhi*, *S. enteritidis*, *Shigella flexneri* and the enterohemorrhagic *E. coli*, indicating a great potential in treating gastric ulcer and diarrhea caused by the aforementioned bacteria [Adeyemi *et al.*, 2008].

Annona senegalensis

This species was reported to be an effective anthelmintic in livestock [Agaba *et al.*, 2015]. It was suggested that leaves possessed anticonvulsant, central depressant and anxiolytic-like properties attributable to flavonoids. Crude flavonoids isolated from the stem bark exhibited an *in vitro* antibacterial activity against *Shigella* species, *E.coli* and *S. typhi*. Phytochemical screening indicated the presence of saponins, steroids, terpenoids, alkaloids,

essential oils, flavonoids and glycosides [Okoli *et al.*, 2010; Jada *et al.*, 2015; Ameen *et al.*, 2011] .

Citrus spp.

Citrus spp. leaves possess significant antioxidant activity which can be attributed to its high phenolic, flavonoid and phenolic acid content [Adnan *et al.*, 2014]. The peel extracts were active against *Klebsiella pneumoniae*, *S. flexneri*, *Bacillus cereus* [Madhuri *et al.*, 2014]. The unripe peel extract and gentamycin were found to have similar antibacterial activity against *S. aureus*, *P. aeruginosa*, and *E. coli* [Nwankwo *et al.*, 2014]. The *Citrus* peel oils showed strong antimicrobial activity against *P. aeruginosa*, *S. typhimurium* and *Micrococcus aureus* [Maruti *et al.*, 2011]. The lemon juice was active against the Gram-positive *S. aureus*, *S. epidermidis*, *Enterococcus faecalis*, *Streptococcus pneumoniae*, *S. pyogenes*, *S. agalactiae* and the Gram-negative *E. coli*, *Enterobacter aerogenes*, *K. pneumoniae*, *Proteus spp.*, *S. typhi*, *Acinetobacter spp.*, *Moraxella catarrhalis* [Hindi and Chabuck, 2013]. Moreover, previous studies have shown the high biological potential of essential oil of *C. lemon*, particularly, against the multidrug resistant *Acinetobacter* spp. [Guerra *et al.*, 2013].

Dialium guineense

Biological investigations on *D. guineense* demonstrated a significant analgesic activity [Ezeja *et al.*, 2011] along with antimicrobial properties against *S. typhi*, *S. aureus*, *S. pneumonia*, and *Candida albicans* [Olajubu *et al.*, 2012]. The crude leaf extract exhibited significant anti-*Vibrio* activities against *Vibrio fluvialis*, *V. vulnificus*, *V. parahaemolyticus* which all can cause infections in humans [Akinpelu *et al.*, 2011]. Phytochemical screening showed the presence of anthraquinones, alkaloids, flavonoids, tannins, steroids and saponins [Olajubu *et al.*, 2012, Akinpelu *et al.*, 2011].

Euphorbia hirta

E. hirta is widely used against diarrhea, dysentery, especially amoebic dysentery, vomiting, bronchitis, hay fever, venereal diseases [Shih and Cherng, 2012]. In the Philippines, the water decoction of leaves is used as a folk medicine to treat Dengue fever: internal hemorrhagy will stop and Dengue fever will be cured after 24 h [Abd Kadir *et al.*, 2013]. *E. hirta* is well documented for its biological activities such as antidiarrheal, sedative, anthelmintic, antipyretic, anti-inflammatory, antioxidant, antibacterial, antifungal,

antimalarial, diuretic, increases electrolytes, and anticancer among others [Hussain *et al.*, 2014; Huang *et al.*, 2012]. Terpenoids, essential oils, phenols and flavonoids are the main constituents of the plant. The aerial parts and roots also contain diterpene esters of the phorbol and ingenol type, as well as the highly toxic tinyatoxin, a resiniferonol [Linfang *et al.*, 2012].

Gardenia ternifolia

Besides the significant antiplasmodial activity of the aerial parts of *G. ternifolia*, the root has shown a virucidal activity against the African Swine Fever Virus (ASFV), which infects its natural hosts, warthogs (*Phacochoerus africanus*) and bushpigs (*Potamochoerus porcus*) through soft ticks of the *Ornithodoros* genus, and causes a haemorrhagic fever with high mortality rates in pigs [Silva *et al.*, 1997, Michaud *et al.*, 2013]. Phytochemical investigations led to the identification of stigmaterol, sitosterol and flavonoids including naringenin methylether, naringenin dimethylether, quercetin dimethylether, kaempferol methylether and dihydroxy-dimethoxyflavanone [Ochieng *et al.*, 2010].

Harungana madagascariensis

The plant showed a high antioxidant potential [Prosper-Cabral *et al.*, 2007], anti-protozoal effects against *Trichomonas gallinae* and *Plasmodium*, both *in vitro* (*P. falciparum*) and *in vivo* (*P. yoelii nigeriensis*) [Iwalewa *et al.*, 2008], and antibacterial activity against *S. aureus*, *S. intermedius*, *Pseudomonas cepacia*, *P. aeruginosa*, *B. subtilis*, *E. coli* [Moulari *et al.*, 2007, Kisangau *et al.*, 2007]. Phytochemical investigation revealed the presence of saponins, tannins, alkaloids, anthracenic derivatives and flavonoids [Moulari *et al.*, 2006]. Prenylated anthracene derivatives from the leaves were strongly active against the Gram-positive *Bacillus megaterium* [Kouam *et al.*, 2007], while astilbin, a flavanone also isolated from the leaves was active against bacterial strains representative of skin microflora [Moulari *et al.*, 2006].

Jatropha curcas

Used against malaria, rheumatic and muscular pains, the leaves of *J. curcas* contain tannins, steroids, carbohydrates, saponins, phenols, triterpenoids, minerals, flavonoids (apigenin, vitexin and isovitexin among others). The latex serves as a disinfectant in mouth infections in children and contains alkaloids including Jatrophine, Jatropham and curcain with anti-cancerous properties [Thomas *et al.*, 2008, Ahirrao *et al.*, 2011, Harry-Asobara *et al.*, 2014]. The leaf extract and the biflavone di-C-glucoside exhibited an immunomodulatory

effect through stimulation of both humoral and cell-mediated sero-response. Remarkable effective increases of the antibody titers, lymphocyte and macrophage cells, in blood were recorded. Specific pathogen-free chicks treated with the tested samples exhibited protection against Newcastle disease virus after being vaccinated [Howaida *et al.*, 2009]; the Newcastle disease virus is a contagious bird disease affecting many domestic and wild avian species; it is transmissible to humans and can cause conjunctivitis and influenza-like symptoms [Nelson *et al.*, 1952].

Jatropha gossypifolia

The leaf extract of *J. gossypifolia* was found to be active against *Staphylococcus* spp., *Bacillus* spp., *Escherichia* spp. and *Pseudomonas* spp. Phytochemical analysis indicated the presence of phenolic compounds, tannins, lignin and saponins [Dhale and Birari, 2010].

Piliostigma thonningii

The leaves of this species showed a significant antipyretic effect [Venkateshwarlu *et al.*, 2011], a high antibacterial activity against Methicillin Resistant *S. aureus* (MRSA), *S. aureus*, *E. coli*, *B. cereus*, *P. aeruginosa*, *Streptococcus agalactiae*, *Shigella sonnei* and *Mycobacterium tuberculosis*. [Daniyan *et al.*, 2010; Njeru *et al.*, 2015; Nguta *et al.*, 2013]. The stem bark extracts inhibited the replication of both Herpes simplex virus type 1 (HSV-1) and African swine fever virus (ASFV), strain Lisbon 60 [Silva *et al.*, 1997]. The presence of carbohydrates, glycosides, flavonoids, tannins, saponins, balsams, volatile oil, and terpenes has been described in the leaves [Egharevba and Kunle, 2010].

Psidium guajava

The leaf of *P. guajava* exhibited a pronounced antimicrobial activity against a series of bacteria such as *S. aureus*, *Micrococcus flavus*, *B. subtilis* [Nair and Chanda, 2007], *P. aeruginosa*, *E. coli*, *Aeromonas hydrophila*, *S. flexneri*, *S. dysenteriae* (can cause deadly epidemics), *S. sonnei*, *S. boydii*, *S. typhi*, *Vibrio parahaemolyticus* [Mahfuzul Hoque *et al.*, 2007], *V. harvey* [Ida *et al.*, 2009], *V. cholerae* [Choudhury *et al.*, 2012, Birdi *et al.*, 2010], *V. cholerae* O1(el tor) [Chanu *et al.*, 2011]. The flavonoids (morin-3-*O*-xyloside, morin-3-*O*-arabinoside, quercetin, and quercetin-3-*O*-arabinoside) isolated from the leaves were active against the pathogenic *Bacillus stearothermophilus*, *Brochothrix thermosphacta*, *E. coli* O157:H7, *Listeria monocytogenes*, *Pseudomonas fluorescens*, *Salmonella enterica*, *S. aureus* and *V. cholerae* [Rattanachaikunsopon and Phumkhachorn, 2010]. The significant

antibacterial effect of the crude aqueous extract of the leaves against multidrug-resistant *V. cholerae* O1 suggested a great potential of *P. gujava* for use in indigenous, herbal medicine for controlling epidemics of cholera [Rahim *et al.*, 2010]. On the other hand, the leaf extract inhibited *in vitro* the growth of Dengue virus: water boiled with guava leaves was used to avoid bleeding in Dengue Hemorrhagic Fever (DHF), and increased platelet counts to 100.000/mm³ within a period of approximately 16 h [Abd Kadir *et al.*, 2013].

Vernonia amygdalina

The antibacterial, antimalarial, antioxidant and cytotoxic effects of *V. amygdalina* along with the isolation of steroid glucosides, sesquiterpene lactones and flavonoids which contributed to its bioactivities have been described [Yeap *et al.*, 2010].

Other plant species

The antimicrobial, antimalarial, antioxidant, or/and anti-inflammatory of *Adansonia digitata*, *Allophylus africanus*, *Cola nitida*, *Crescentia cujete*, *Crossopteryx febrifuga*, *Lawsonia inermis*, *Mangifera indica*, *Mimosa pigra*, *Ocimum sanctum* and *Tamarindus indica* have been also described [Kamatou *et al.*, 2011; Rahul *et al.*, 2015; Oladosu *et al.*, 2013; Kanoma *et al.* 2014; Jackie *et al.*, 2014; Olajide *et al.*, 2003; Toua *et al.*, 2015; Das *et al.*, 2014; Adeola *et al.*, 2011; Elufioye and Agbedahunsi, 2004; Halilu *et al.*, 2012; Abubakar *et al.*, 2008; Badoni *et al.*, 2014; Li *et al.*, 2013; Rajesh *et al.*, 2013; Kumar *et al.*, 2015; Bbosa *et al.*, 2007; Jasminder *et al.*, 2010; Mbatchou *et al.*, 2011, WAHO, 2013].

Antiviral activities

Regarding the antiviral potency of plant species, it has been suggested that selection of samples on the basis of ethnomedical considerations gives a higher hit-rate than screening programs of general synthetic products [Farnsworth and Kass, 1981]. Although there have been relatively few studies searching for antiviral agents from plants, those studies have revealed an unexpectedly frequent occurrence of activity in higher plants, and a number of compounds with antiviral effects have been extracted from various medicinal plants [Vanden Berghe *et al.*, 1986]. Potential *in vitro* antiviral activity against HIV, Vesicular Stomatitis Virus, Coxsackie B2 viruses has been found for some Guinean plant species such as *Pavetta owariensis*, *Harrisonia abyssinica* and *Borreria verticillata* [Baldé *et al.*, 1990a, 1990b; 1991; 1995; 2015]. Since the emergence of the Ebola in West Africa, a number of anti-Ebola

remedies have been proposed through internet or other media. Some were extremely doubtful like salted warm water and urine. Some others included honey; *Moringa oleifera*; a cocktail of *M. oleifera*, *Gingiber officinalis*, *Daucus carota*, mixed with honey; a complex herbal preparation made with *Aloe vera*, *Amaranthus caudatus*, *Azadirachta indica*, *Cymbopogon citratus*, *Dioscorea alata*, *Garcinia kola*, *Psidium guajava*, *Saccharum officinarum*, *Sesamum indicum*, *Vernonia amygdalina* or *Zea mays*, [Muanya, 2014]. *P. guajava* and *V. amygdalina* have also been cited by the Guinean THPs. The phytochemicals from red algae [Adams, 2014] and the extracts and biflavonoids from the seeds of *Garcinia kola* [Iwu, 1999; Gucciardi, 2014] were also cited as potential remedies against Ebola virus disease. But, the anti-Ebola effectiveness of the above plant recipes needs still a strong scientific support.

Undoubtedly, some valuable herbal formulae which may be lifesavers could exist. In this context, constituents from natural sources for which an interesting antiviral effect against the Ebola virus was described include flavonoids and alkaloids. Indeed, isoflavones and flavonoids exhibited antiviral properties *in vitro* and *in vivo* against a wide range of viruses. Genistein, the most studied soy isoflavone, has been shown to inhibit the infectivity of enveloped and non-enveloped viruses, as well as single-stranded or double-stranded RNA or DNA viruses [Andres *et al.*, 2009]; its use as a therapeutic or prophylactic against arenavirus and filovirus hemorrhagic fever has been suggested [Kolokoltsov *et al.*, 2012]. Regarding the alkaloids, among the approved drugs inhibiting Ebola virus entry into host cells with an $IC_{50} < 10 \mu M$ and a Selectivity Index (SI) > 10 , vinblastine, vincristine and colchicine have shown a strong effect ($IC_{50} = 0.048, 0.141$ and $0.238 \mu M$, respectively) and SI $> 10324, > 3554$ and > 2097 , respectively [Kouznetsova *et al.*, 2014]. These alkaloids occur in *Catharanthus roseus* (vinblastine, vincristine), *Colchicum autumnale* and *Gloriosa superba* (colchicine) [Bruneton, 1993]. Although the presence of the above constituents has not been described in the collected plant species, most of them contained alkaloids and/or flavonoids. The plant species containing both flavonoids and alkaloids include: *Adansonia digitata* [Kamatou *et al.* 2011; Jitin *et al.* 2015], *Alchornea cordifolia* [Osadebe *et al.* 2012; Osadebe *et al.* 2003], *Bridelia ferruginea* [Owoseni *et al.* 2010; Araromi *et al.* 2014], *Bridelia micrantha* [Benjamin *et al.* 2011], *Carica papaya* [Ayoola *et al.* 2010; Suhas *et al.* 2014; Pedro *et al.* 2011], *Crossopteryx febrifuga* [Kabena *et al.* 2014; Halilu *et al.* 2012], *Cola nitida* [Okeke *et al.* 2015; Dewole *et al.* 2013], *Craterispermum laurinum* [Samje *et al.* 2014], *Dialium guineense* [Gideon *et al.* 2012], *Eleais guineensis* [Shie *et al.* 2013], *Erythrina senegalensis* [Wandji *et al.* 1994; Doughari *et al.* 2010], *Euphorbia hirta* [Basma *et al.* 2011; Gopinath

*et al.*2012; N'Guessan *et al.* 2015], *Euphorbia prostrata* [Kengni *et al.* 2013], *Hymenocardia acida* [Ibrahim *et al.* 2007], *Jatropha curcas* [Tomar *et al.* 2015; Ehsan *et al.*2011], *Jatropha gossypifolia* [Vijayta *et al.* 2015 ; Abiodun *et al.* 2011], *Khaya senegalensis* [Sylvanus *et al.* 2014], *Lawsonia inermis* [Badoni *et al.* 2014 ; Li *et al.*2013], *Mangifera indica* [Bbosa *et al.* 2007 ; Jasminder *et al.* 2010], *Mimosa pigra* [(Mbatchou *et al.* 2011], *Ocimum sanctum* [(Rajesh *et al.* 2013; Kumar *et al.* 2015], *Parkia biglobosa* [(Abioye *et al.* 2013; Salit *et al.* 2014], *Piliostigma thonningii* [Egharevba *et al.* 2010; Ighodaro *et al.* 2012], *Psidium guajava* [Metwally *et al.* 2010; Sushmita *et al.* 2012], *Zanthoxylum zanthoxyloides* [Azando *et al.* 2011 ; Vyry *et al.*2013 ; Misra *et al.* 2013 ; Queiros *et al.*, 2006].

The presence of flavonoids was reported for some other plant species such as :

Allium cepa [Tedesco *et al.* 2015], *Allophyllus africanus* [Oladosu *et al.* 2013], *Annona senegalensis* [Emmanuel *et al.*2014; Ogbadoyi *et al.* 2007], *Citrus lemon* [Amit *et al.* 2011; Somayeh *et al.* 2012], *Combretum micranthum* [Toua *et al.* 2015], *Crescentia cujete* [Das *et al.* 2014], *Zingiber officinale* [(Shirin *et al.* 2010 ; Hiba *et al.* 2012 ; Marina *et al.* 2012)].

Apart from these phytochemical considerations,, a recent research paper described an amine calcium channel blocker once used to treat angina (bepridil; trade name Vascor) and an antidepressant (sertraline; trade name Zoloft) as potential pharmaceutical treatments of EVD leading each to a 100% survival rate for mice exposed to Ebola [Johansen *et al.*, 2015]. This suggests that plant species should be screened directly against the Ebola virus, rather than being screening for the treatment of symptoms.

Based on WHO recommendations [WHO, 2014] and the above considerations, undoubtedly, it is worth to document all available knowledge from traditional medicine about management of EVD and to evaluate systematically the anti-Ebola potential of Guinean plant species, particularly those rich in flavonoids or alkaloids and/or with significant biological activities such as antiviral, antidiarrheal, anti-vomiting and treatment of fever. A lot of international efforts are made to develop Ebola treatments and vaccines as soon as possible. In the midst of an extreme public health emergency, researchers, health workers and community facilitators in Guinea included 7,651 people in a trial to test the efficacy of rVSV-ZEBOV, a recombinant, replication-competent vesicular stomatitis virus-based vaccine expressing a surface glycoprotein of Ebola (Zaire). The authors conclude that the vaccine “might be highly efficacious and safe” [The Lancet, 2015]. If this trend continues, we can all hope that it will soon be time to look back at this Ebola epidemic as something from the past,

and for the public health community to assess lessons learned in preparation for the next epidemic of Ebola or other infectious diseases [Krauss, 2015].

However, no matter how effective a treatment might seem in clinical trials, it must be feasible to deliver and be made readily available in all EVD treatment Centers in Africa [Dunning and Fisher, 2015]. Even available, we must take into account that mutant viruses resistant to the existing antiviral agents readily arise upon treatment [Vanden Berghe, 1986]. Moreover, identification of the next Ebola virus, or the next outbreak of disease, will not be a simple task, but estimates of the diversity of viruses existing on the planet show that it is not impossible. Unfortunately, within the reality of poverty, a dysfunctional healthcare system, local customs and traditions. there are continuing threats of large viral and bacterial epidemics with high morbidity and mortality.

4. Conclusion

Guinea bore the brunt of Ebola through a high number of infections and deaths, which must be higher than estimated, since evidence exists of asymptomatic Ebola infected patients, along with the collateral damage generated by the outbreak. Based on the unavailability of specific treatments along with the fact that Guinea is endowed with a rich flora and a long-standing traditional medicine, ethnomedical and ethnobotanical investigations on the potential of Guinean traditional medicine in response to EVD were conducted in some localities of the 4 main Guinean regions. This resulted in the collection of 54 plant species proposed by 113 THPs. Only one THP assumed to be familiar with EVD symptoms before the present outbreak. Apparently, no deaths were recorded among the THPs living in the studied areas. The traditional management of the disease was mainly focused on the fever, diarrhea and vomiting symptoms. THPs were not adequately involved in the national response of EVD care and prevention. Among the 44 identified plant species, the traditional uses of some are in accordance with previous biological researches. But all the cited plant species must be studied in order to avoid false hope. Due to the prominent role that THPs can play in caring for people as well as in prevention activities, it is time to initiate a large training of THPs in order to reinforce their medical capacity and service and to study and valorize the potential of the pharmacopeia. Therefore there is a need for urgent investment and support of traditional healers and traditional medicine. Having in mind that ethnopharmacological screening provides an alternative avenue to discovery, an urgent action is needed for an *in vitro* screening against Ebola virus followed by phytochemical investigations of all the plant species traditionally used against the EVD symptoms, in particular those rich in flavonoids or alkaloids, and already known to exhibit significant biological activities such as antiviral, antidiarrheal and immunomodulatory.

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Table 1 : GUINEAN TRADITIONAL RECIPES AGAINST SOME EBOLA SYMPTOMS

Recipe	Source	Plant species	Family	Voucher specimen	Plant part (preparation form)	Indication
1	KINDIA	<i>Adansonia digitata</i> L.	Bombacaceae	20HK60	Leaves (decoction)	Fever
2	KINDIA/LABÉ/ KANKAN/LOLA	<i>Alchornea cordifolia</i> (Schumach.& Thonn.) Müll.Arg.	Euphorbiaceae	52HK503	Leaves (decoction)	Fever ; diarrhea
3	KINDIA	<i>Alchornea cordifolia</i> L.	Euphorbiaceae	52HK503	Leaves (decoction)	fever
		<i>Allium cepa</i> L.	Liliaceae	116 HK32		
		Honey				
4	LABÉ	<i>Alchornea cordifolia</i> (Schumach.& Thonn.) Müll.Arg.	Euphorbiaceae	52HK503	Leaves (decoction)	Diarrhea
		<i>Dialium guineense</i> Willd.	Caesalpiniaceae	27HK440	leaves	
		<i>Psidium guajave</i> L.	Myrtaceae	93HK628	Leaves (young)	

5	KINDIA	<i>Allophyllus africanus</i> P. Beauv.	Sapindaceae	125HK690	Root/ Leaves (decoction)	Diarrhea
6	KINDIA	<i>Annona senegalensis</i> Pers.	Annonaceae	6HK29	Fruit (maceration)	Fever
7	LABÉ	<i>Annona senegalensis</i> Pers.	Annonaceae	6HK29	Root (decoction)	Diarrhea/ vomiting
		<i>Gardenia ternifolia</i> Schumach. &Thonn.	Rubiaceae	121HK682	Root	
		<i>Ocimum gratissimum</i> L	Lamiaceae	67HK107	Leaves	
8	LABÉ	<i>Bridelia micrantha</i> (Hochst.) Baill.	Euphorbiaceae	52HK504	Leaves (decoction)	fever
9	LABÉ	<i>Bridelia ferruginea</i> Benth.	Euphorbiaceae	52HK503	leaves	fever
		<i>Harungana madagascariensis</i> Hook.f.	Hypericaceae	63HK562	Leaves (decoction)	
		<i>Piliostigma thonningii</i> (Schumach.) Milne-Redhead	Caesalpiniaceae	27HK441	Stem-bark	
10	LABÉ	<i>Bridelia ferruginea</i> Benth.	Euphorbiaceae	52HK503	Leaves (decoction)	fever

		<i>Khaya senegalensis</i> (Desr.) A.Juss.	Meliaceae	82HK586	Leaves	
		<i>Terminalia albida</i> Sc.Elliot	Combretaceae	38HK473	Leaves	
11	KINDIA	<i>Bridelia ferruginea</i> Benth.	Euphorbiaceae	52HK503	leaves	fever
		<i>Ocimum gratissimum</i> L.	Lamiaceae	67HK107	Leaves	
		<i>Psidium guajava</i> L.	Myrtaceae	93HK628	Leaves (decoction)	
12	LOLA	<i>Carica papaya</i> L.	Caricaceae	31HK432	Leaves (decoction)	fever
		<i>Elaeis guineensis</i> Jacq.	Arecacea	146HK7	Green fruit	
13	KANKAN	<i>Citrus lemon</i> Burn.	Rutaceae	122HK689	Leaves and fruits (decoction)	Fever
14	KINDIA	<i>Citrus lemon</i> Burn.	Rutaceae		Fruits/maceration	External antiseptic
15	KINDIA	<i>Citrus lemon</i> Burn.	Rutaceae		Fruit (decoction)	Fever

		<i>Allium cepa</i> L.	Liliaceae		Bulb	
		Honey				
16	KANKAN	<i>Citrus lemon</i> Burn.	Rutaceae		juice	Diarrhea (« donkafèlè »)
		« Colphedrine »	Chemical product			
		<i>Combretum micranthum</i> G.Don	Combretaceae	38HK472	Leave (decoction)	
17	KANKAN	<i>Citrus lemon</i> Burn.	Rutaceae		Green fruit	External antiseptic
		<i>Lawsonia inermis</i> L.	Lythraceae	76HK574	Leaves (decoction)	
18	KANKAN	<i>Citrus lemon</i> Burn.	Rutaceae		Green fruit (decoction)	Convulsions
		“WaroSömö”			Stem-bark	
19	LABÉ	<i>Cola nitida</i> (Vent.) Scott & Endl.	Sterculiaceae	131HK700	Leaves (decoction)	Diarrhea

		<i>Ocimum gratissimum</i> L	Lamiaceae	67HK107	leaves	
20	KINDIA	<i>Craterispermum laurinum</i> (Poir.) Benth.	Rubiaceae	122HK680	Leaves and roots (decoction)	Diarrhea
21	KINDIA	<i>Crescentia cujete</i> L.	Bignoniaceae	18HK205	Leaves (decoction)	Diarrhea
22	KINDIA	<i>Crossopteryx febrifuga</i> (Afzel. ex G. Don) Benth.	Rubiaceae	121HK681	Leaves (decoction)	Fever
23	KINDIA	<i>Dialium guineense</i> Willd.	Caesalpiniaceae	27HK440	Leaves and fruits (decoction)	Diarrhea/fever
24	LABÉ	<i>Euphorbia hirta</i> L.	Euphorbiaceae	52HK505	Whole plant (decoction)	Diarrhea stained with blood
25	LABÉ	<i>Euphorbia hirta</i> L.	Euphorbiaceae	52HK505	Whole plant (decoction)	Diarrhea
		<i>Ficus</i> sp.	Moraceae		Stem-bark	
26	KINDIA	<i>Euphorbia prostrata</i> Ait.	Euphorbiaceae	52HK506	Whole plant (decoction)	Dysentery
27	LABÉ	<i>Erythrina senegalensis</i> DC	Fabaceae	53HK526	stem-bark	fever

		<i>Hymenocardia acida</i> Tull.	Hymenocardiaceae	62HK534	Leaves (decoction)	
		<i>Mangifera indica</i> L.	Anacardiaceae	3HK38	leaves	
28	LABÉ	<i>Harungana madagascariensis</i> Hook.f.	Hypericaceae	63HK562	Leaves (decoction)	Fever/diarrhea
		<i>Khaya senegalensis</i> (Desr.) A.Juss.	Meliaceae	82HK586	Leaves	
		<i>Terminalia albida</i> Scott-Elliot	Combretaceae		Leaves	
29	KINDIA/LABÉ	<i>Jatropha curcas</i> L.	Euphorbiaceae	52HK507	Leaves (maceration)	Fever/haemorrhage
30	KINDIA	<i>Jatropha gossypifolia</i> L.	Euphorbiaceae	52HK508	Leaves (maceration)	Fever
31	KINDIA	<i>Khaya senegalensis</i> (Desr.) A.Juss.	Meliaceae	82HK586	Leaves (decoction)	Fever
32	KINDIA	<i>Mimosa pigra</i> L.	Mimosaceae	86HK608	Leaves	Diarrhoeae
33	KANKAN	<i>Musa cavendishii</i> Lambert ex Paxton	Musaceae	90HK624	Grated marrow (decoction)	“koba”

		« Biyaki »			Leaves	
34	KINDIA	<i>Ocimum sanctum</i> L.	Lamiaceae	67HK106	Leaves (maceration; pasta)	
35	KANKAN	<i>Parkia biglobosa</i> (Jacq.) Benth.	Mimosaceae	86HK609	Stem-bark (decoction)	bloody diarrhea
		« Trena »			Stem-bark (maceration)	
36	KINDIA	<i>Piliostigma thonningii</i> (Schumach.) Milne-Redhead	Caesalpinaceae	27HK441	Leaves (decoction)	Fever
37	KINDIA/KANKAN/LABÉ	<i>Psidium guajava</i> L.	Myrtaceae	93HK628	Leaves (decoction)	diarrhea
38	KINDIA	<i>Tamarindus indica</i> L.	Caesalpinaceae	27HK442	Stem-bark (decoction)	diarrhea
39	KANKAN	<i>Uapaca guineensis</i> Müll. Arg.	Phyllanthaceae	112HK642	Stem-bark (decoction)	diarrhea
40	KINDIA	<i>Vernonia amygdalina</i> Del	Asteraceae	13HK181	Leaves (maceration)	fever
41	KANKAN	<i>Zanthoxylum zanthoxyloides</i> (Lam.) Zepernick & Timber	Rutaceae	122HK692	Roots/leaves (maceration or decoction)	diarrhea

42	LABÉ	<i>Zingiber officinale</i> Rosc.	Zingiberaceae	141HK718	Root (decoction)	Vomiting
43	KANKAN	« Blakio »			Leaves (decoction)	Diarrhea/fever
		« Tyawo »			Leaves (decoction)	
44	KANKAN	« Dinö »			Leaves (decoction)	Headache/fever
45	LOLA	« Kagöma Gèlèn »			Stem bark and root (decoction)	Diarrhea
46	KANKAN	“Köyiran”			Leaves (Maceration or decoction)	Ebola-like Disease (diarrhea, fever, haemorrhagy)
		« Terounèn »				
		“Wo”				
47	LOLA	« Tofololè »			Whole plant (decoction)	Diarrhea

NB : « vernacular name »

FIGURE 1: Map of Guinea showing the investigated areas, THPs contacted and EVD affected patients.

Red number : EVD affected patients (from 12/2013 to 08/2015) ; Blue number : THPs contacted