

Risk Factors of Human African Trypanosomiasis in Mbuji Mayi, Eastern Kasai Province, Democratic Republic of the Congo

ABSTRACT

Aims: Our study is aimed at apprehending the risk factors of Human African Trypanosomiasis (HAT) in Mbuji Mayi, Eastern Kasai Province, Democratic Republic of the Congo and at assessing the extent of their respective influence on the incidence of HAT.

Study design: We use a case-control design.

Place and Duration of Study: Our multidisciplinary research team collected primary data on cases of HAT patients treated at the Referral and Treatment Center of Dipumba in Mbuji Mayi in 2012 and on their controls that reside in Mbuji Mayi but do not have HAT infection.

Methodology: We analyzed data, using both descriptive and analytical statistical procedures such univariate and multivariate methods of logistic regression. The association between the different factors studied and HAT infection has been determined by estimating the odds-ratio (OR) with a confidence interval (CI) of 95% and a p-value of less than 0.05.

Results: We interviewed 180 subjects (60 cases and 120 controls). The 60 cases were predominantly male (male-female ratio of 2.2:1) with the majority (53%) in the age group of 20-40 years. Subjects in the age group of 40 years or older represented 28.3% of the patients. The same patterns are seen on the control group. The age of interviewees varies from 11 to 65 years. HAT cases reported drawing water from wells (16.7% vs 6.7%; $P > .05$), walking along the river bed and in the peat lands (11.7% vs 9.2%; $P > .05$) at a higher rate than controls. The HAT cases reported involvement in various activities that put them in much closer proximity with water sources: bathing (8.3% vs 6.6%; $P > .05$), dishwasher and laundry (20% vs 37.5 %), fetching household water (50% vs 24.2 %; $P < .0001$), cassava retting roots (1,7 % vs 7.5%), diamond digging in the mines (51.7 % vs 21.6 %; $P < .0001$), trafficking or buying diamond from diggers (13,3 % vs 8.3 % ; $P > .05$).

Conclusion: Involvement in activities that connect with water sources increases the risk of acquiring HAT infection in Mbuji Mayi.

Keywords: African Human Trypanosomiasis, risk factors, Mbuji Mayi, Eastern Kasai Province, Democratic Republic of Congo

14 1. INTRODUCTION

15 Human African trypanosomiasis (HAT) also known as “sleeping sickness” is a rampant
 16 disease that affects some thirty sub-Saharan African countries where it is seen in its two
 17 forms according to the parasite that is responsible for the disease. The acute form due to
 18 *trypanosoma brucei rhodesiense* is geographically localized in the southern and Eastern
 19 parts of Africa; and the chronic, insidious form due to *trypanosoma brucei gambiense* is
 20 geographically encountered in the Western and central parts of Africa [1]. Most of the
 21 sleeping sickness in Africa is caused by *Trypanosoma brucei gambiense* [2]. According to
 22 the World Health Organization (2004), HAT caused the loss of ≈ 1.5 million disability-adjusted
 23 life years (DALYs) in 2002. Epidemics of sleeping sickness have been a significant public
 24 health problem in the past, but the disease is reasonably well-controlled at present, with
 25 7,000-10,000 cases reported annually in recent years.[3] According to CDC, over 95% of the
 26 cases of human infection are found in Democratic Republic of Congo (DRC), Angola, Sudan,
 27 Central African Republic, Chad, and northern Uganda. Of all the African countries affected
 28 by *Trypanosoma brucei gambiense*, the DRC is the country with the largest number of HAT
 29 cases [2] [4], but with one of the most resource-constrained national health care
 30 infrastructures to address this challenge. The poor standing of the DRC in terms of
 31 prevalence, incidence and response to HAT may present a real challenge for HAT
 32 eradication such as envisioned by HAT stakeholders and the World Health Organization at
 33 their 2014 meeting in Geneva, Switzerland [3]. This challenge may be exacerbated by the
 34 increasing observation of HAT in urban settings, a departure from its traditional presence in
 35 and its most dominant consideration as a disease affecting rural Africa. Indeed, HAT is
 36 increasingly observed in urban settings, particularly in “the suburban outskirts of cities,
 37 where there is a suitable tsetse habitat” and even within cities “when certain types of relic
 38 vegetation provide habitats for tsetse” [5], [6], [7], [8]. Most of the previous studies have
 39 focused on various clinical, epidemiological and social dimensions of this disease in the
 40 DRC. They include, but are not limited to studies that have explored the social history of
 41 sleeping sickness in the Northern area [9], the health care-seeking behavior and diagnostic
 42 delays [10], its patterns in a rural community [11] knowledge, behaviors, practices and
 43 beliefs regarding HAT [12], the distribution of *Glossina fuscipes quanzensis* and its risk of
 44 transmission in the peri-urban area of Kinshasa [13] (De Dekan, et al., 2005), the toxicity of
 45 HAT medicines and barriers against community participation in the control of HAT [14]), the
 46 characteristics of HAT in children [15] and the reemergence of HAT in the capital city of the
 47 DRC [16].

48 Whereas HAT due to *Trypanosoma brucei gambiense* is found in various communities in the
 49 DRC, prompting a number of studies aimed at gaining a better understanding of its
 50 configuration, this disease has, largely with the exception of Kinshasa the Capital City of the
 51 DRC, received little attention in terms of exploration and comprehension of its risk factors in
 52 other urban communities. Yet these urban communities have been increasingly growing
 53 demographically, still with the majority of their population living in conditions and engaging in
 54 behaviors that expose their health to greater risk of acquiring and suffering from HAT or
 55 other tropical diseases. Without the existence of an active and systematic screening and
 56 without adequate knowledge of risk factors in such urban communities, this last form of HAT
 57 may go ignored by the urban patient and undetected by the health care system for months or
 58 years, thus making the diagnosis to be performed only at a late neurological stage
 59 (meningitis-encephalitic) and thus making the condition difficult not only to prevent but also
 60 to treat [17] [18] HAT is a serious disease. It brings physical, mental and intellectual
 61 disability. When its treatment is delayed, the chances of recovery without neurologic
 62 sequelae are minimal. In the absence of adequate treatment, the patient evolves toward
 63 apathy, terminal sleeping cachexia, coma and death [19] [20] [21] [22].

The systematic and comprehensive screening of populations by specialized mobile teams modeled after the innovative screening approach that Jamot introduced in 1917, has contributed a great deal to the elimination of HAT as a public health problem in the 1960s. [23] [24] Director of the Pasteur Institute in Brazzaville, in 1917, Jamot is credited with devising “a system of mobile medical teams consisting of a French military doctor, seven African male nurses trained at the Pasteur Institute in Brazzaville, two white corporals, several African soldiers, and a large number of porters to carry all their equipment”. Jamot’s goal “was neither to treat the sick nor to eradicate the flies, but to kill the trypanosomes in the entire population, thereby reducing the risk of infecting the healthy.” Under this initiative, Jamot’s teams “went from village to village” and “in each village, the inhabitants were required (often at gunpoint) to submit to examination. The doctor and nurses palpated their neck glands for telltale swelling and examined their blood and lymph under a microscope” [23] [24] [25]. This strategy gained popularity and was eventually adopted by other colonial powers [17] [23]. In 1960, after 43 years of active campaigns, the annual incidence rate of HAT was 0.04 cases for 10,000 persons examined. This was a very significant achievement for HAT control.

Unfortunately this progress was followed by a period of disengagement and lack of interest, leading to a gradual disappearance of the structures to fight the disease and leaving the disease unchecked. Having such a free field, HAT extended in many areas where it was unknown, causing further devastation. In 1995, the situation has severely deteriorated, reaching the level of the 1920s [16] [26] [27].

In consideration of this overall decline of the fight against HAT, in order to achieve great effectiveness in the eradication of HAT, priority should be given to the situation of the most affected countries such as the DRC. This is a country where, according to the National Program for the Fight against HAT (DRC), nine of the eleven provinces are affected by the HAT, where gross estimates put the exposed population at 13 million people, where less than 20% of those exposed are under active surveillance and where nearly 8000 new infected patients are reported each year [27] [28]. The 2012 report on the HAT epidemiological situation in the countries that are parts of the HAT platform (Central African Republic, Chad, Sudan, Uganda, Angola, Republic of the Congo and the Democratic Republic of the Congo) shows that the DRC reported 84.4 per cent of the cases of HAT, or 5969 cases on a total of 7102 cases reported in all these countries [29]. The report for the previous year of the same platform indicates that in late 2011, the DRC had reported 85% of cases (5595 of a total of 6599) among these countries either $\frac{3}{4}$ of global cases. [28]

Compounding this issue is that in the DRC, HAT is no longer exclusively present in rural areas; it has extended to the large cities. From 1997 to 1999, cases of THA have been reported in four Congolese towns: 351 cases in Matadi, 1235 cases in Bandundu, 1307 cases in Mbuji-Mayi and 1571 cases in Kinshasa [27] [30].

Active search for cases by the mobile teams has resulted in a considerable reduction in the prevalence rate of HAT in the Congolese provinces of Equateur and Kinshasa; however the prevalence level has remained stagnant in the provinces of Bandundu and Kasai. Since 2001, the province of Kasai unfortunately has moved to the second worst rank (with an average of 2500 new cases of HAT each year on nearly 700,000 persons examined) among the areas known for their highest endemic level relative to the HAT following Bandundu (which province has reported an average of 4800 new cases of HAT each year on less than a million of persons examined). [31] [32]

The foregoing discussion underscores once again the need to examine the situation of the Congolese provinces that have the highest burden of HAT and to explore the risk factors at

112 play in the configuration of HAT infection therein. In doing so, the focus ought to be placed
 113 on the most populated, most impoverished and most at risk communities of these provinces,
 114 these being relatively new cities that have emerged without adequate pre-planning, that
 115 have not received adequate resources to establish solid public infrastructures for water
 116 supply and waste disposal, and that have served as places of refugee resettlement following
 117 the outbreak of ethnic cleansing in the Katanga province. Our study explores the risk factors
 118 of HAT in Mbuji Mayi, the Capital City of the Eastern Kasai province in the DRC. This is a
 119 city that has several of the aforementioned characteristics and whose history, geography,
 120 landscape, population, economy, health system and survival activities have indirectly or not
 121 contribute to greater exposure of its inhabitants to the HAT scourge.

122 2. STUDY SETTING

123 2.1. Geography: The city of Mbuji-Mayi is located in the intertropical convergence zone,
 124 where it rains abundantly, with precipitation which reaches approximately 1400 millimeters of
 125 water during the wet season. Two seasons are observed: a dry season, from May to
 126 September, and a rainy season, from October to April. The average annual temperature is
 127 25°C. [33] The city of Mbuji-Mayi is a geographic area that extends between 6°5' and 6°10'
 128 of the south latitude and 23°27' and 23°40' longitude east. It is located on the tray of the
 129 Kasai, slightly hilly; it is distant by 930 km from Kinshasa, the capital of the DRC. The city of
 130 Mbuji-Mayi (formerly known as Bakwanga until 1966) is the capital city of the eastern Kasai
 131 province; and it extends over an area of approximately 145.19 km². The site on which the
 132 city is built is drained by three rivers which constitute the natural limits of the city. It is
 133 bordered to the north by the territory of Lupatapata and the Muya river, on the south by the
 134 Kanshi river, on the east by the Mbuji-Mayi river, which constitutes its border with the
 135 territory of Katanda, and to the west by a line joining the confluence Kanshi Nzaba to the
 136 Muya and Bipemba. The proximity of these water systems offers the advantage of enabling
 137 easy water supply for city dwellers, but it comes also as a liability by being the most suitable
 138 biotope for the vectors of diseases such as tsetse and mosquitoes which multiply and then
 139 breed on the same dwellers [34].

140 2.2. Population: Mbuji-Mayi is the third largest city in the country, following the capital
 141 Kinshasa and second largest city Lubumbashi but ahead of Kisangani and Kananga. Its
 142 exact population is not known. In the absence of recent census, one can refer to three
 143 different sources that provide three different estimates: The 2010 CIA Factbook offers the
 144 lowest estimate of 1,480,000 inhabitants [35]; the National Institute of Statistics (INS) gives
 145 its estimate of 1,900,000 inhabitants [36]; and the United Nations offers the highest estimate
 146 which places the population of the city at the highest level with 3,500,000 inhabitants [37].
 147 The human population is formed by pygmies and Bantous. While pygmies form a minority
 148 that is confined to some districts in the Eastern Kasai province, Bantous represent the
 149 majority of the inhabitants of Mbuji Mayi. They are a mosaic of ethnic groups where the main
 150 groups are the Baluba, tetela, the songye and kanyoka. The most spoken languages are
 151 Tshiluba, Lingala, Swahili, Tetela and French. [38]

152  Political Organization: The city of Mbuji-Mayi is made of 5 administrative communes:
 153 Bipemba, Dibindi, Diulu, Kanshi and Muya. Politically speaking, the province has endured its
 154 share of problems which have impacted its economy and the well-being of its population. At
 155 the end of the successive crises up to the culmination of the process of reconciliation with
 156 the elections held in 2006, the province has served as a place of great political turmoil where
 157 diamond, the natural resource of the province, has made the political leaders to seek and
 158 achieve great control of the province by appointing and controlling the leadership of the
 159 province and of the most important diamond mining company in the DRC (mining company
 160 of Bakwanga or MIBA). [38] Unfortunately most of the resources produced by MIBA during
 161 most of the 54 years of the Congolese Independence have been drained out to enrich the

barons of the Mobutu's era. They have also been looted during civil wars or misappropriated by political dignitaries without facing any penalties. This explains why very little has been invested in the construction of public infrastructures such as schools, water and electricity supply and road construction for the city or for the remainder of the province. [38]

2.4. Health Organization: From a health organization perspective, the city is divided into 10 urban health zones. [27] [39] The city serves as headquarter of the provincial coordination of the fight against HAT for the eastern Kasai province. The center of reference and treatment of the HAT-Dipumba (CRT-DIPUMBA) is located in the compound of the Dipumba hospital in Mbuji-Mayi. This is within the area served by the health zone of Bonzola. [27]

2.5. Economy: MIBA has been involved in the extraction of the diamond and its activity has significantly slowed down because of mismanagement, inept leadership and lack of working capital. The company is on the verge of bankruptcy. At the end of 2008, the drop in the prices of raw materials accordingly to the global financial crisis precipitated the closure of the Miba. Entire families of those who still claim to be Miba staff have been left in the cold without any other prospects. This cessation of activities has negatively impacted the city which used to serve as the economic lung of the province. The monthly wages of the Miba was of 2,500,000 U.S. dollars which were injected on the market. By ripple effect, the fall of the Miba and that of the diamond on the market has precipitated a decline of the economy of the city of Mbuji-Mayi, leading virtually to a devastating economic crisis. [38]

2.6. Living Conditions: A host of phenomena has contributed to making Mbuji Mayi a ghost-town: Irregular distribution of electricity and drinking water (sewage stations running on electricity), general decrease of economic activities and particularly decline in the exploitation and sale of diamond and exodus of the population to other regions and even other countries. Even the airlines that used to have regular and frequent flights to and from Mbuji Mayi, have slowed down their activities as they face reduced number of passengers and goods to transport. [38]

3. STUDY PROBLEM AND OBJECTIVES

3.1. Situation of HAT in eastern Kasai Province:

HAT due to *Trypanosoma brucei gambiense* is endemo-epidemic in Eastern Kasai-province. In 2009, 869 new HAT cases were declared. Since 2010 to this day, there is stagnation of the annual number of new cases of HAT, with an annual average of 533 cases of patients infected with trypanosoma declared. [27]

During 2012, a total of 95 cases of HAT infected patients (source population) has been identified and treated at HAT referral and treatment center of Dipumba (RTC) in Mbuji-Mayi. Among these patients, 60 (63.2 %) were residents of the city of Mbuji-Mayi. These 60 cases constitute our study sample. The other patients (35 or 36.8 per cent) were transferred to the Referral and Treatment Center (DIPUMBA) for intake and management. [27]

3.2. Study Justification and Aims:

This study is needed at this juncture for at least three major reasons. First, it focuses on the DRC, a country that is most affected by HAT. Second, it targets a Congolese province that is ranked as the second worst place in terms of HAT incidence. Third, it looks at a major city at a time where there is not yet a clear understanding of the risk factors that make cities particularly vulnerable to HAT infection. The mechanism through which HAT parasites move in Mbuji-Mayi is poorly known. No study on the social conditions, space occupation and

human behavior of HAT patients has been conducted up to this day. In the present study, we want to identify the risk factors of HAT infection in the city of Mbuji-Mayi, with particular emphasis on the socio-demographic characteristics and on the human factors that contribute to its transmission.

4. MATERIAL AND METHODOLOGY

4.1. Study Design, Population, and Case and Control Identification

Study Design: Case-Control Study. The study group consisted of 60 HAT cases and 120 healthy controls. The 60 HAT cases were selected on the basis of three criteria: (a) Having during the period going from January to December 2012 a confirmed pathological diagnosis of HAT - - diagnosis based on the results of the card agglutination test for trypanosomiasis (CATT) which is a rapid, simple assay for the detection of specific antibodies in patients with gambiense HAT [40], (b) having one's residence in Mbuji Mayi and (c) being of an age equal to or older than 10 years.

CATT is known for its simplicity, reliability and low cost and hence is "used in all control programmes for serological screening of populations at risk for T. b. gambiense infection" [41]. Each case was then paired with 2 HAT-free subjects. These controls were matched for the following assumed major risk factors for HAT infection: sex, residence, age, professional activity (with three modalities: farming, trading in rural areas, and diamond digging), involvement in activities connected with the river (modalities: dish or cloth washing, fetching water for domestic use, and diamond digging), environment of one's residence (proximity of diamond mining, of swamps and farming, of savanna or of river) and knowledge about HAT transmission mechanism (bite by tsetse fly). This matching process served to control for the possible confounding effect of these factors, and thereby served to maximize the analytical power of the study.

Besides primary data collected through the survey of cases and controls, additional data have been extracted from the annual reports of activities of the Referral and Treatment Center of DIPUMBA.

Inclusion Criteria; We have included in the study as cases all the trypanosome-infected patients detected actively during the active campaigns by the specialized mobile units and passively (screening which consists in receiving patients who present themselves in the health care facilities structures of care fixed and specialized centers for control of THA), residing in Mbuji Mayi-Mayi and receiving treatment at the Referral and Treatment Center of Dipumba (RTC-DIPUMBA) in 2012.

During this period of January to December 2012, 95 patients with HAT have been registered including 60 residents of Mbuji-Mayi. Only cases aged 10 years or older were considered. Each case was matched on age (≥ 10 years), sex and place of residence to two controls. These controls were individuals known to be free of THA after clinical examination, and presenting a negative serology test Card Agglutination Test for Trypanosomiasis (CATT-test) [46] in the course of the field survey of May 2012. There was no a single case of trypanosome-infected patient that has declared having changed place of residence. In the recruitment of controls, we have excluded any of the aforementioned patients as well as any persons who live together with the cases. This survey was approved by the local authorities and the provincial ethics committee. The cases and the controls were informed of the purpose and expectations of the study; they have all provided a verbal consent to be participants in the study.

The age of the cases and controls varied between 11 and 65 years. This choice was made to ensure that the subjects are able to properly answer the questionnaire.

4.2. Data Collection

These 60 HAT patients (cases) and the 120 healthy subjects (controls) have responded to a structured questionnaire. The questionnaire had been previously pretested on 20 sick HAT patients who were under treatment in 2012 and on 40 controls, and it was then revised before the start of the study survey. For each case and each control, we collected general demographic characteristics as well as beliefs, knowledge and practices and activities considered as potential enabling and risk factors for HAT. The interviews were held at their respective homes. A copy of the survey questionnaire is available and can be provided on request.

4.3. Data Processing and analysis

The data has been entered on a spreadsheet before its analysis using STATA, a statistical analysis software (version IC 12.0). The association between the different factors studied and HAT infection has been determined by estimating the odds-ratio (OR) with a confidence interval (CI) of 95% and a p-value of less than .05. This has been achieved by using the univariate and multivariate methods of logistic regression analyses.

5. RESULTS

5. 1. General Characteristics of Cases and Controls

Pertinent features of the study and control groups are compared in table 1. All HAT patients residing in the city of Mbuji-Mayi, identified and treated at TRC-DIPUMBA in 2012 were eligible. The study involved a total of 180 subjects (60 cases and 120 controls) who were interviewed. The 60 cases were predominantly male (male-female ratio of 2.2:1) with the majority (53%) in the age group of 20-40 years. The next age group in terms of percentage is 40 years and older with 28.3% of the subjects in this group. The same pattern is seen on the control group. In accordance with the design of the study, the male-female ratio and the distribution of the subjects according to age corresponded closely to those of the controls. The age of interviewees varies from 11 to 65 years. The average age of the trypanosomes was 33.5 years (SD = 12.8 years). Among the cases, subjects in the most economically productive age group (20-40 years) were the most affected.

Table 1: General Characteristics of Cases and Controls in the 2012 Survey on Risks factors of Human African Trypanosomiasis (HAT)

289

Characteristics and Modalities	HAT Cases (n = 60)	Control Group (n = 120)
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Sex		
Female	19 (31,7%)	38 (31,7%)
Male	41 (68,3%)	82 (68,3%)
Age Group		
>20 Years	11 (18,3%)	17 (14,2%)
20-40 Years	32 (53,4%)	59 (49,1%)
<40 Years	17 (28,3%)	44 (36,6%)
Disease Stage		
Hémolymphatic Stage	2 (3,3%)	NA
Meningico-encephalitic Stage	58 (96,7%)	NA
Screening Mode		
Active	11 (18,3%)	NA
Passive	49 (81,7%)	NA
Professional Activities		
Farming	16 (26,6%)	33 (27,5%)
Trading in Rural Areas	38 (63,3%)	56 (46,7%)
Diamond Mine Diggers	31 (51,7%)	40 (33,3%)
Water-Related Activities		
Dish/Cloth Washing	12 (20%)	45 (37,5%)
Water Fetching for Household	30 (50%)	29 (24,2%)
Mine Diggers	31 (51,7%)	26 (21,7%)
Proximity of Housing		
Diamond Mining	10 (16,7%)	17 (14,2%)
Swamps and plantation fields	10 (16,7%)	15 (12,5%)

Savannahs	24 (40%)	31 (25,8%)
Rivers/creeks/Water Streams	16 (26,7%)	57 (60,8%)
Knowledge of Transmission Modality		
Tsetse bite	45 (75%)	64 (53,3%)

290

291 The HAT cases were found throughout the entire city, that is in all the 5 municipalities of the
 292 city: 20 cases in the commune of Dibindi, 18 in Bipemba, 11 in Muya, 6 in Diulu and 5 in
 293 Kanshi. The average household size is 7.1 persons (SD = 2.8 persons). The data of the
 294 survey showed that 78.3% of the cases and 82.5% of the controls belonged to households of
 295 very large size exceeding 5 persons ($p > .05$). In HAT patients, those born in Mbuji-Mayi
 296 represent the majority (66.7%). This proportion is 75% among the controls. Among the
 297 respondents, 33.3% of the cases are of migrants, that is to say the persons born elsewhere
 298 who then have settled in Mbuji-Mayi. The analysis of the religious affiliation leads to the
 299 finding of a city heavily Christianized with 91.7% of Christians against 8.3% of the Muslims.
 300 Catholic and Protestant affiliations represent respectively 25 and 15% for cases vs 27.5 and
 301 16.7% for the controls. Among the 60 HAT patients, 19 (31.7%) compared to 49 (35 %) controls
 302 had a low level of education (non-school and primary level), 68.3 per cent of the sick
 303 trypanosomes have reached the lower secondary level. The main activities (agriculture,
 304 livestock, trade in rural areas and diggers of diamond in the mines) in which the majority of
 305 HAT cases (45%) are involved are risk prone activities. The practice of secondary activities
 306 to supplement one's income is very frequent in Mbuji-Mayi. Trade in rural areas and
 307 diamond digging activity remain the largest secondary activities practiced by the cases
 308 (63.3% and 51.7% vs 46.5% and 33.3%; $p = .034$ and $p = .018$). The majority of cases 44
 309 (73.3%) and controls 95 (79.2%) have already heard of the existence of the HAT in Mbuji-
 310 Mayi.

311 Among the 60 HAT patients, 58 subjects (or 96.7%) were known to be at the meningitis-
 312 encephalitic stage or neurological (stage 2). Two patients (or 3.3%) were at the
 313 hematolymphatic stage (stage 1). Five HAT patients (8.4%) were detected in a passive way
 314 by the fixed health facilities (hospitals, health centers), 55 patients (91.6%) have been
 315 diagnosed by the specialized mobiles units that target elimination of HAT.

316 In regard to activities connected with water supply for household needs, HAT positive
 317 subjects reported drawing water from wells (16.7% vs 6.7%; $P > .05$), walking along the
 318 river bed and in the peat lands (11.7% vs 9.2%; $P > .05$). The HAT cases reported
 319 involvement in various activities that put them in much closer proximity with the
 320 watercourses: bathing (8.3% vs 6.6 %; $P > .05$), dishwasher and laundry (20% vs 37.5%),
 321 fetching household water from household (50% vs 24.2 %; $P < .0001$), cassava retting roots
 322 (1.7% vs 7.5%), digger diamond in the mines (51.7% vs 21.6%; $P < .0001$), trafficker or
 323 buyer of diamond from diggers in mines (13,3% vs 8.3%; $P > .05$).

324 The data on dwelling space have been collected. The environment of the habitat, especially
 325 its proximity to risky sites for contact between humans and tsetse flies has been examined.
 326 More than half of the cases (55.1%) and more than half of the witnesses (68.4 %) resided
 327 close to wells, diamond mines, water streams and marshy areas, 45% against 31.6% of the
 328 controls in the vicinity of the savannahs, pig farming (existence of a herd in the
 329 neighborhood) and various plantations.

330 The data on the types of toilet used show that defecation in the open (in the surrounding
331 undergrowth, near or in a river or creek) is still the type of toilet used by a non-negligible
332 proportion of the cases (10% vs 5.8%; $P > .05$).

333 The proportion of people who know HAT and the tsetse fly as a vector of this diseases is
334 relatively high (86.7% of cases vs 77.5% of the controls) in both groups. The mode of HAT
335 transmission was mentioned by 75% of the cases and 53.3% of the controls (bite by
336 infected/contaminated tsetse). The path of blood transfusion and the vertical transmission
337 (from mother to child during pregnancy/before birth have not been mentioned. Some modes
338 of erroneous transmissions have been cited such as physical contact with HAT patients.

339 The manifestations of HAT that are most known by the cases are, in descending order of
340 importance, sleep disorders (daytime sleepiness and insomnia night) cited by less than half
341 of the cases (31.7%) and controls (40.8 %); slimming (30% vs 22.5 %) and mental disorders
342 (23.3% vs 17.5%). Nobody among HAT cases and their controls has cited cervical
343 adenopathy. The majority of HAT cases are aware that THA reaches the entire world (71.7
344 % vs 68.3 %); they also know that the HAT is curable (83.3% vs 72.5 %). Less than half of
345 the controls (48.3%) are favorable to a close contact (eating and sleeping together) with HAT
346 patients. A non-negligible proportion of the cases (23.3%) and cases (28.3%) believe in the
347 mystical origin of the THA (witchcraft).

348 The majority of cases (76.7% vs 54.2%; $p = .03$) are favorable to HAT screening. A low
349 proportion of cases (33.3% vs 25%) have cited the fixed health structures as a place
350 recommended for HAT screening.

351 Concerning the health care facilities, the majority of HAT patients (83.3% vs 55%; $P = .004$)
352 were aware of and cited the specialized centers of fight, treatment and control of HAT. Less
353 than half of the cases (41.7%) are aware that prevention of the THA is possible. Barely 32%
354 of the cases and 36% of the controls mentioned the trap to tsetse flies as a means of
355 primary prevention of HAT.

356 5. 2. Risk Factors

357 The results of the univariate logistic regression analysis (OR non-adjusted) show the factors
358 significantly associated with HAT infection in the city of Mbuji-Mayi. Based on the computed
359 odd ratios (OR), the following factors emerge as having a significant influence on HAT
360 infection:

361 The activity of fetching water from the river to satisfy household needs increased the risk of
362 contracting HAT by a factor of 1.9 (OR = 1.9; 95%CI: 1.5 -2.6; $P < .0001$).

363 The activities in relation with or in close proximity with watercourses are significantly
364 associated with HAT infection: diamond digging in the mines (OR 3.86 ; 95%CI: 1.98 - 7.53;
365 $p < .0001$); draw water to the river (OR = 3.13; 95%CI: 1.62 - 6.04; $P = .001$) ; dishwasher/
366 laundry (OR = 1.4; 95 %CI: 1.1 - 1.8; $P < .004$); retting fresh cassava roots to the river (OR =
367 3.1; 95 %CI: 2.1 - 4.9; $P < .0001$); travel for trade in rural areas (OR = 1.97; 95%CI: 1.04 -
368 3.72 ; $P = .036$); the existence of hog farms in one's entourage (OR = 2.3 ; 95%CI: 1.7 -3.1;
369 $P < .0001$) and the proximity of the habitat agenda with the savannas (OR = 2.4 ; 95%CI:
370 1.7 -3.3; $P < .0001$).

371

372

373 Table 2: Determining Factors of HAT Infection in Mbuji Mayi

Determining Factors	Adjusted Odd Ratio	95% Confidence Interval (CI)	p-value
Fetching water for household needs	3,5	1,2 – 10,7	.05
Diamond Digging	4.13	1.89 - 9.00	.001
Closeness of Hog Farms	2,6	1,3 – 5,2	.01
Dish and Cloth Washing	1,7	1,1 – 2,6	.05
Trading in rural areas	2,32	1,07 – 5,02	.032

374

375 Using the logistic regression multivariate analysis, we got the following results (also
 376 displayed in Table 2): The supply of water to household and activities carried out in close
 377 proximity with a river multiplied by 3.5 the risk of HAT (Adjusted OR = 3.5; 95%CI: 1.2 -10.7,
 378 P = .05). The activity of digging diamond multiplied by 4.13 (Adjusted OR = 4.13; 95 %CI:
 379 1.89-9.00; P < .0001) the risk of HAT. The proximity of a hog farm multiplied by a factor of
 380 2.6 the risk of acquiring HAT (Adjusted OR = 2.6; 95 %CI: 1.3 - 5.2, P = .01). Dish and cloth
 381 washing in the water stream multiplied the risk of acquiring HAT by a factor of 1.7 (Adjusted
 382 OR = 1.7; 95 %CI, 1.1 - 2.6, P = .05). Engaging in trade activities that involve traveling to
 383 rural areas multiplied the risk of acquiring HAT by a factor of 2.32 (Adjusted OR =2.32; 95
 384 %CI: 1.07 - 5.02, P = .032).

385

386 6. CONCLUSION

387 In the Democratic Republic of the Congo, research published in the medical literature on the
 388 risk factors of the HAT has been very limited. Tshimungu et al. (2010) conducted a case-
 389 control study in Kinshasa, capital of the DRC, in an endemic area to Trypanosoma brucei
 390 gambiense. [28] As this was the case in Tshimungu's study, the present study shows that
 391 some groups, some activities and some environments increase the risk of acquiring HAT.
 392 HAT equally infects men and women. Among the diagnosed and treated HAT cases, there
 393 was 68.3% of men and 31.7% of women and this difference was not significant (p> 0.05).
 394 These results corroborate previous findings [11] [28] [30] [42] [43] which indicate that this
 395 disease reaches people of both genders.

396 HAT does equally infect subjects of all age groups. The majority of subjects infected with
 397 HAT are aged 20 to 40 years, an age group known as made of those who are professionally
 398 and economically active. This finding has already been reported by several authors which
 399 indicate that the active persons are the most affected. [17] [28] [44]

400 Active screening provided by the specialized mobile units regarded as effective means to
 401 identify the maximum number of HAT cases had contributed in 18.3% of the cases to the
 402 detection of new cases during the period of our study. Passive screening provided by the
 403 fixed health structures working independently from the national program of fight against HAT
 404 (PNLTHA) contributed only 8.4%. The majority of HAT cases (73.3%) have thus been
 405 identified by specialized HAT screening mobile units.

406 Most of the HAT cases (58/60 or 96.7%) were in meningitis-encephalitic stage (stage 2). This

means at an advanced stage of the infection. The ratio stage 2 on stage 1 was 29 in favor of stage 2. This ratio is 7.4 times higher than that found in Kinshasa. [56] Our results confirm findings by Miaka et al. [45] which indicate that the passive screening performed by the non-personal forms to the diagnosis of THA, represented only 37 cases (2.75 %) of 1345 cases detected in two years (1998-1999). These results corroborate the data described elsewhere according to which active screening is no longer more efficient in urban areas.[30] [45] [46] This observation also confirms the results of previous work conducted in the DRC [12] [30] [46] and elsewhere [47] [48]. According to which, screening in an urban environment has not the same effectiveness as that achieved in rural areas. As has been noted in other studies [31] [45] [49], the negative organizational features such as weak logistical means and shortage of specialized mobile teams could explain this lack of effectiveness of the active campaigns in urban areas. The Eastern Kasai province has only four specialized HAT screening mobile teams. Mpanya (2009) mentioned that the stagnation of HAT prevalence in the provinces of Bandundu and Kasai is explained by the low rate of participation of the population exposed in the active screening. [50]

The city of Mbuji-Mayi is experiencing a very severe drinking water shortage. The study shows that the HAT cases are involved at a greater rate into activities involving presence of or proximity of water streams, particularly those activities aimed at fetching and supplying water to their households. These HAT cases also practice certain activities in relation with water streams such as dish or cloth washing and digging diamond in the mines. One 1993 study in the Ivory Coast shows that the use of a water point for natural/collective needs (wells, river etc.) by a group creates a high risk. [51]

Most of the HAT cases resided near savannah (40%); water wells (20%); diamond mines (16.7%); marshy areas (11.7%). Others [34] [52] mention that the proximity of the habitat with some areas such as hog farms and wells constituting a favorable biotope/conducive to the multiplication of vectors is a risk factor.

Through the univariate logistic analysis, diamond diggers constitute the group at high risk of HAT infection. This observation corroborates the results of previous work [32] [50] [52], according to which, the socio-economic and cultural contexts of the population at risk in the two provinces, Bandundu and the Eastern Kasai are different. In the province of Bandundu, the at-risk population lives in the savannah mainly on agriculture, by contrast to the Eastern Kasai, one finds a population that lives in the camps of diamond mines and along water streams.

The water factor, more precisely, the water supply in the point of natural water significantly increases the risk of HAT infection. According to Meda et al. (1993), the vector of THA (*Glossina palpalis* flies) is particularly abundant near the water points frequented by the human beings from which it gets its food. [51]

The data on the dwelling space show that the persons residing close to Savannah are more exposed. The presence of pigs around the habitat appears as a risk factor. Meda and his colleagues (1993) mention that the presence of pigs around the habitat plays two contradictory roles, a protective role by way of diverting the tse-tse flies from the human bait and a role of potential reservoir of the zymodemes which have been isolated in this animal in the Ivory Coast and which are infectious for humans. [51]

The analysis using a logistic multivariate regression model shows that the risk of infection increases in response to digging diamond in the mines. More clearly, HAT cases engage much more in this type of activity than their controls (Adjusted OR = 4.13). So far no study

has been conducted in Mbuji-Mayi or on this at risk group, a situation one is less likely to encounter in urban areas, and especially not in the world capital of diamond. This investigation has linked water as a risk factor of HAT. It has pinpoint the negative role that fetching water in natural collective sources (wells, water course) is playing in the transmission chain. At these places where healthy individuals daily come unsuspecting of anything, they come across infected tsetse flies; at these places where infected tsetse flies roam, unsuspecting healthy individuals connect with the vector of HAT as they engage unsuspectingly dish and cloth washing. Moreover proximity of a hog farms and trading in peripheral urban and urban settings increase the risk of acquisition of the THA. This finding has already been reported by other authors [46] [47][51]. This observation corroborates the data of various entomological investigations which located the biotopes favorable to tsetse flies along the course of water. [45] [52] [53]

The results of this study reflect the reality of the current importance of HAT in Mbuji-Mayi. The study has identified a higher risk of transmission linked to the activity of artisanal diamond digging, to the water source related activities, to the localization of human residences in savannah, to the presence of hog farms in the midst of human agglomerations and to the involvement in trade in peripheral and rural areas. It has pointed out disconcerting delays in the detection of cases. It has highlighted the importance of integrating effective mass screening in the fixed health structures in the city of Mbuji-Mayi. When it is adopted, such integration will be accompanied by the information and the education of the populations as well as the training of health personnel in Mbuji-Mayi who are not seasoned to the principles and practices of HAT screening and eradication. A specific program of active screening in diamond mines along with the establishment of a sustainable and permanent system for safe water supply can significantly reduce the incidence of HAT in Mbuji Mayi.

The most enduring solution to the HAT plight necessarily calls for a comprehensive community development plan and an improvement in the living conditions and the well-being of the population in general, and more particularly of the rural population. The HAT is a real public health challenge in Mbuji-Mayi in particular and the DRC in general. It calls for a very special attention on the part of the Congolese authorities at both national and provincial levels. These authorities would need to work in synergy with other international stakeholders who, at this juncture, are considering developing and implementing a more robust program which will hopefully lead to the complete eradication of HAT.

Although this study has only dealt with 180 subjects and although its results cannot be generalized to the whole population of Mbuji-Mayi, it does provide a glimpse of the reality facing the population of a Congolese city in the context of a country under a chronic political instability. There is a definite need to launch extensive epidemiological studies in which a much larger number of HAT cases would be involved. Such extensive studies will have the greater advantage of leading to more robust findings to instruct HAT program development and implementation.

494

495 **10. CONSENT (WHERE EVER APPLICABLE)**

496

497 All authors declare that verbal informed consent was obtained from the patients and the
498 controls.

499

500 **11. ETHICAL APPROVAL (WHERE EVER APPLICABLE)**

501

502 All authors hereby declare that all interviews have been performed in accordance with the
503 ethical standards laid down in the 1964 Declaration of Helsinki.

504 12. REFERENCES

- 505
506 1. Brun R, Blum J, Chappuis F, Burri C. Human African trypanosomiasis. *Lancet*. 2010;
507 375(9709):148–159.
- 508 2. Center for Disease Control and Prevention (CDC). African sleeping sickness. Accessed
509 September 9, 2014.
510 Available: <http://www.cdc.gov/parasites/sleepingsickness/epi.html>
- 511 3. World Health Organization. First WHO stakeholders meeting on gambiense human
512 African trypanosomiasis elimination. Accessed September 7, 2014. at Available:
513 http://www.who.int/trypanosomiasis_african/meeting_declaration_2014/en/
- 514 4. Simarro PP, Cecchi G, Franco JR, et al. Mapping the capacities of fixed health facilities
515 to cover people at risk of gambiense human African trypanosomiasis. *Int J Health*
516 *Geogr*. 2014;13:4. Accessed on August 16, 2014.
517 Available: <http://www.ij-healthgeographics.com/content/13/1/4>
- 518
519 5. World Health Organization. WHO Expert Committee on human African trypanosomiasis.
520 WHO Technical Report. 2013. Series 984.
- 521 6. Truc P., Grébaut P., Lando A., Makiadi Donzoau F., Penchenier L., Herder S., et al.
522 Epidemiological aspects of the transmission of the parasites causing human African
523 trypanosomiasis in Angola. *Annals of Tropical Medicine & Parasitology*. 2011; 105, 3,
524 261-265.
- 525 7. Fournet F., Traoré S., Hervouët J.P. Effects of urbanization on transmission of human
526 African trypanosomiasis in a suburban relict forest area of Daloa, Côte d'Ivoire. *Trans. R.*
527 *Soc. trop. Med. Hyg*. 1999. 93, 130-132.
- 528 8. Courtin, F., Jamonneau, V., Duvallet, G., Garcia, A., Coulibaly, B., Doumenge, J. P.,
529 Cuny, G. and Solano, P. Sleeping sickness in West Africa (1906–2006): changes in
530 spatial repartition and lessons from the past. *Tropical Medicine & International Health*.
531 2008, 13: 334–344. doi: 10.1111/j.1365-3156.2008.02007.x
- 532 9. Lyons, M. The colonial disease: a social history of sleeping sickness in northern Zaire,
533 1900-1940. Cambridge [England]: Cambridge University Press, 1992.
- 534 10. Hasker E, Lumbala C, Mbo F, Mpanya A, Kande V, Lutumba P, Boelaert M: Health care-
535 seeking behaviour and diagnostic delays for human African trypanosomiasis in the
536 Democratic Republic of the Congo. *Trop Med Int Health* 2011, 16(7):869–874.
- 537 11. Lutumba P, Makieya E, Shaw A, Meheus F, Boelaert M. Human african trypanosomiasis
538 in a rural community, Democratic Republic of Congo. *Emerg Infect Dis* 2007; 13: 248-54.
- 539 12. Tshimungu K, kalambayi BB, Kiyombo M, Okenge NL, De Mol P. Knowledge,
540 behaviours, practices and beliefs regarding human african trypanosomiasis (HAT) among
541 inhabitants of Kinshasa (Democratic Republic of Congo). *Cahiers d'études et de*
542 *recherches francophones / Santé*. 2008; 18: 141-47. French
- 543 13. De Deken R, Sumbu J, Mpiana S, et al. Trypanosomiasis in Kinshasa: distribution of the
544 vector, *Glossina fuscipes quanzensis*, and risk of transmission in the peri-urban area. *Med*
545 *Vet Entomol* 2005; 19: 353-9.

- 546 14. Robays J., Lefevre P., Lutumba P. et al. (2007) Drug toxicity and cost as barriers to
547 community participation in HAT control in the Democratic Republic of Congo. *Trop. Med.*
548 2007;12, 2, 290-298.
- 549 15. Kazumba M, Kazadi K, Mulumba MP. Des caractéristiques de la trypanosomiose chez
550 l'enfant. A propos de 19 rapports de cas au CNPP (Centre Neuro-Psycho-Pathologie),
551 hôpitaux universitaires de Kinshasa, Zaïre. *Annales de la Société Belge de Médecine*
552 *Tropicale*, 1993, 73:253–259. French
- 553 16. Tshimungu K, Okenge NL, Mukeba NJ, De Mol P. Réémergence de la trypanosomiose
554 humaine africaine dans la province ville de Kinshasa, République démocratique du
555 Congo (RDC). *Médecine et maladies infectieuses*. 2010; 40, pp.462-7. French
- 556 17. Burke J. La Trypanosomiose Humaine Africaine. Fometro Kinshasa, Août 1972. French
- 557 18. Programme National de lutte contre la THA-RDC (PNLTHA-RDC). 2002. French
- 558 19. Burke J. La trypanosomiose humaine africaine, Fonds Médical Tropical. Bruxelles, 2è
559 édition, 2000. 3-39. French
- 560 20. Murray M, Morrison WI, Whitelaw DD. Host susceptibility to African trypanosomiasis:
561 trypanotolerance. *Adv Parasitol*. 1982; 21: 1–68.
- 562 21. Checchi F, Filipe JA, Barrett MP, Chandramohan D. The natural progression of
563 Gambiense sleeping sickness: what is the evidence? *PLoS Negl Trop Dis*. 2008;
564 2(12):e303.
- 565 22. World Health Organization. The history of sleeping sickness. Accessed September 18,
566 2014.
567 Available:http://www.who.int/trypanosomiasis_african/country/history/en/index7.html.
- 568 23. Headrick DR. Sleeping Sickness epidemics and colonial responses in East and Central
569 Africa, 1900–1940. *PLoS Negl Trop Dis*. 2014; 8(4): e2772.
570 doi:10.1371/journal.pntd.0002772.
- 571 24. Headrick R. Colonialism, health and illness in French Equatorial Africa, 1885–1935.
572 Atlanta: African Studies Association Press. 1994. pp. 53–54, 69–93, 223–234, 311–381.
- 573 25. Bado J-P. Eugène Jamot 1879–1937. Le médecin de la maladie du sommeil ou
574 trypanosomiose. Paris: Karthala. 2011. French
- 575 26. Jannin J, Louis FJ., Lucas P., Simarro PP. Lutte Contre la Trypanosomiose Humaine
576 Africaine : La Boucle Bouclée ? *Med. Trop*. 2001. 61. 437-440. French
- 577 27. Programme national de lutte contre la trypanosomiose humaine africaine (PNLTHA).
578 République démocratique du Congo (RDC), Rapport annuel 2004. French
- 579 28. Ebeja AK. (2012), Situation épidémiologique de la Trypanosomiose Humaine Africaine.
580 Plateforme THA, Bulletin d'information, n°11, pp. 3 – 4. French
- 581 29. Olaf VM. (2013), Situation épidémiologique de THA dans les pays de la Plateforme
582 THA. Bulletin d'information Plateforme THA. 2013:13, pp. 3-4. French

- 583 30. Miaka CM, Meso VK, Louis FJ, Lucas P. Human African trypanosomiasis in the urban
584 milieu: the example of Kinshasa, Democratic Republic of Congo, in 1998 and 1999. *Med*
585 *Trop* 2001; 61: 445-8.
- 586 31. Mbo KF. Vers un renforcement du dépistage passif et sa contribution à la lutte contre la
587 THA : cas de la province de Bandundu en RDC. Mémoire « Master of Science » en
588 contrôle des Maladies, IMT, Antwerpen, Belgique. 2007 : 28 p. French
- 589 32. Lumbala C. (2009), Déterminants de l'efficacité de la lutte contre la THA: cas du Kasai
590 en RDC. Mémoire de Master en Santé Publique-contrôle des Maladies, IMT, Anvers,
591 Belgique. 2009. 34 p. French
- 592 33. World Weather Online. Mbuji Mayi Climate. Accessed September 20, 2014.
593 Available:
594 [http://www.worldweatheronline.com/Mbuji-Mayi-weather-averages/Kasai-](http://www.worldweatheronline.com/Mbuji-Mayi-weather-averages/Kasai-Oriental/CD.aspx)
595 [Oriental/CD.aspx](http://www.worldweatheronline.com/Mbuji-Mayi-weather-averages/Kasai-Oriental/CD.aspx).
596
- 597 34. Ebeja, A.K., Lutumba, P., Molisho, D., Kegels, G., Bilenge, C.M.M. & Boelaert, M.
598 Sleeping sickness in Kinshasa: Retrospective analysis of data collected from 1996 to
599 2000. *Tropical Medicine and International Health*, 2003.8 (10): 949–955.
- 600 35. Central Intelligence Agency (CIA). The World Factbook. CIA. Retrieved May 30, 2011.
601 Accessed September 19, 2014.
602 Available: <https://www.cia.gov/library/publications/the-world-factbook/geos/cg.html>
- 603 36. Institut National de la Statistique (INS). Rapport - synthèse sur les Projections
604 démographiques, Kinshasa, 2007, RDC. French
- 605 37. UN Integrated Regional Information Networks (Feb 25, 2008), "Congo-Kinshasa;
606 Neglect, Deaths in Prison Condemned", Africa News
- 607 38. République Démocratique du Congo. Ministère du Plan. Unité de pilotage du processus
608 DSRP Kinshasa / Gombe. Monographie de la Province du Kasai – Oriental. French
- 609 39. Bukonda, NKZ, Chand, M, Disashi, TG, Lumbala, CWB & Mbiye, B. Health care
610 entrepreneurship in the Democratic Republic of the Congo: An exploratory study.
611 *Journal of African Business*. 2012; 13 (2): 1-14.
- 612 40. Magnus E, Vervoort T, van Meirvenne N. A card-agglutination test with stained
613 trypanosomes (CATT) for the serological diagnosis of T. b. Gambiense
614 Trypanosomiasis. *Annales de la Société Belge de Médecine Tropicale*, 1978, 58:169–
615 176.
- 616 41. World Health Organization. Control and Surveillance of Human African Trypanosomiasis
617 Report of a WHO Expert Committee WHO Technical Report Series 984. Geneva,
618 Switzerland: World Health Organization; 2013.
- 619 42. Robays J, Lefevre P, Lutumba P, Lubanza S, Kande Betu Ku Mesu V, et al. Drug toxicity
620 and cost as barriers to community participation in HAT control in the Democratic
621 Republic of Congo. *Trop Med Int Health*. 2007 ;12: 290–298doi:[10.1111/j.1365-](https://doi.org/10.1111/j.1365-3156.2006.01768.x)
622 [3156.2006.01768.x](https://doi.org/10.1111/j.1365-3156.2006.01768.x) [PubMed]

- 623 43. Camara M, Kaba D, Kagba DM, Sanon JR, Ouendeno FF, Solano P. La THA en zone
624 de mangrove en République de Guinée : caractéristiques épidémiologiques et cliniques
625 de deux foyers voisins. *Médecine Tropicale* 2005 ; 65 : 155-61.
- 626 44. Grebaut P, Bena JM, Manzambi P, Khande et al. Characterization of sleeping sickness
627 transmission sites in rural and periurban areas of Kinshasa (Republique Democratique
628 du Congo). *Vector-Borne and Zoonotic Diseases*, 2009, 9:631–636.
- 629 45. Mulumba MP, Lutumba P, Mwambalelu M, Kande BKV, Miaka MBC. Perte d'efficacité
630 du dépistage actif dans la lutte contre la THA en milieu urbain. *Ann Afr Med*, juin 2009.
- 631 46. Robays J, Ebaja AK, Lutumba P, and al. Resident Human African trypanosomiasis
632 amongst urban in Kinshasa: has compartment - control study. *Tropical Medicine and
633 International Health* on 2004; 9: 869-75
- 634 47. Grébaut P., Bodo J.M., Assona A., Foumane Ngane V., Njiokou F., Ollivier G., Soula G.,
635 Laveissière C. Recherche des facteurs de risque de la trypanosomose humaine
636 africaine dans le foyer de Bipindi au Cameroun. *Méd. trop.*, 2001, 61, pp 377-383.
- 637 48. Kakou A, Assemian P, Aholie S et al. Aspects cliniques et thérapeutiques de
638 laméningoencéphalite à Trypanosoma gambiense en milieu hospitalier. *Médecine
639 d'Afrique Noire* 1999; 46: 147-52.
- 640 49. Courtin F., Dupont S., Zézé D.G., Jamonneau V., Sané B., Coulibaly B., Cuny G. &
641 Solano P., *Trypanosomose Humaine Africaine*: Transmission urbaine dans le foyer de
642 Bonon (Côte d'Ivoire). *Tropical Medicine & International. Health*, 2005, 10:340–346.
643 French
- 644 50. Mpanya (2009). Perception de la maladie du sommeil au Kasai-Oriental, mémoire de
645 licence en Santé Publique, Faculté de Médecine, Université de Lubumbashi. French
- 646 51. Meda AH, Laveissiere C, De Muynck A, Doua F & Diallo PB. Risk factors for human
647 African trypanosomiasis in the endemic foci of Ivory Coast. *Medicine Tropicale*. 1993.
648 53, 83–92.
- 649 52. De Deken R, Sumbu J, Mpiana S, et al. Trypanosomiasis in Kinshasa: distribution of the
650 vector *Glossina fuscipes* *quanzensis* and risk of transmission in the peri-urban area. *Med
651 Vet Entomol* 2005; 19: 353-9.
- 652 53. Simo G, Mansinsa PD, Kande V, et al. Human African Trypanosomiasis transmission,
653 Kinshasa, Democratic Republic of Congo. *Emerg Infect Dis*. 2006; 12 : 1968-70.
- 654