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# Factors influencing passive surveillance for *T. b. rhodesiense* human african trypanosomiasis in Uganda

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ABSTRACT

*Introduction:* Sleeping sickness or Human African Trypanosomiasis (HAT) is a neglected tropical disease of public health importance across much of Sub-Saharan Africa. In Uganda, chronic *T. b. gambiense* HAT (gHAT) and acute *T. b. rhodesiense* HAT (rHAT) occur in two large but discrete geographical foci. Both forms are difficult to diagnose, expensive to treat and ultimately fatal in the absence of treatment. The area affected by zoonotic rHAT has been steadily expanding, placing a high burden on local health systems. HAT is a disease of neglected populations and is notorious for being under-reported. Here we examine the factors that influence passive rHAT surveillance within the district health system in four Ugandan districts into which the disease had recently been introduced, focusing on staff knowledge, infrastructure and data management.

*Methods:* A mixed methods study was undertaken between 2011 and 2013 in Dokolo, Kaberamaido, Soroti and Serere districts to explore health facility capacity and clinical service provision, diagnostic capacity, HAT knowledge and case reporting. Structured interviews were undertaken with 86 medical personnel, including clinicians, nurses, midwives and technicians across 65 HC-II and HC-III medical facilities, where the health infrastructure was also directly observed. Eleven semi-structured interviews were undertaken with medical staff in each of the three designated HAT treatment facilities (Dokolo, Lwala and Serere HC-IV) in the area. HAT treatment centre case records, collected between 2009 and 2012, were analyzed.

*Results:* Most medical staff in HC-II and HC-III facilities had been made aware of HAT from radio broadcasts, newspapers and by word of mouth, suggestive of a lack of formal training. Key knowledge as regards the causative agent, clinical signs and that HAT drugs are provided free of charge was lower amongst HC-II than HC-III staff. Many respondents did not know whether HAT was endemic in their district. In rHAT specialist treatment centres, staff were knowledgeable of HAT and were confident in their ability to diagnose and manage cases. Between 2009–2012, 342 people were diagnosed in the area, 54% in the late stage of the disease. Over the period of this study the proportion of rHAT cases identified in early stage fell and by 2012 the majority of cases identified were diagnosed in the late stage.

*Conclusion:* This study illustrates the critical role of the district health system in HAT management. The increasing proportion of cases identified at a late stage in this study indicates a major gap in lower tier levels in patient referral, diagnosis and reporting that urgently needs to be addressed. Integrating HAT diagnosis into national primary healthcare programs and providing training to medical workers at all levels is central to the new 2030 WHO HAT elimination goal. Given the zoonotic nature of rHAT, joined up active surveillance in human and animal populations in Uganda is also needed. The role of the Coordinating Office for Control of Trypanosomiasis in Uganda in implementing a One Health approach will be key to sustainable management of zoonotic HAT.



## 1. Introduction

Human African Trypanosomiasis (HAT), also known as sleeping sickness, has plagued Sub-Saharan Africa over a century. With

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an estimated health burden of 1.6 million DALYs annually in Sub-Saharan Africa (SSA), HAT causes large socio-economic losses, minimizing efforts for sustainable poverty reduction (Hotez and Kamath, 2009; Fèvre et al., 2008b). Since the late 1990s, concerted global and national efforts have dramatically reduced the incidence of HAT, to a 50-year low of less than 10,000 cases reported to the World Health Organization (WHO) in 2009 (Simarro et al., 2010). If HAT elimination as a public health problem (defined as less than 1 case per 10,000 population at risk) is to be achieved by the new, revised target date of 2030 (Simarro et al., 2015), strengthening reliable diagnostic, disease management and referral systems in resource-poor contexts where HAT is endemic will be essential (Holmes, 2015; Welburn et al., 2016).

HAT management has been described a "failure of public health" (Molyneux, 2002). The tendency of HAT to exhibit long periods of endemicity followed by large-scale epidemics results in prolonged periods of neglect in disease management during endemic periods, with little or no action taken until human cases once again reach alarming levels (Welburn et al., 2016). Recent estimates suggest 70 million people live in areas at risk of contracting HAT (Simarro et al., 2012). HAT is a disease of the poorest people, affecting rural communities with weak social capital and physical infrastructure. Rural livelihood practices (fishing, fetching water, collecting firewood, preparing charcoal, garden work, hunting or herding) bring people into close contact with tsetse habitats. Across Sub-Saharan Africa, countries struggle with providing basic healthcare to their populations (Gyapong et al., 2010). Outside of the district hospitals, clinical care is provided by midwives, public health nurses, private pharmacists, traditional doctors and other health practitioners with limited training, equipment and support. Where HAT is endemic, weak education systems, poor healthcare services, inadequate communication and dysfunctional health planning deny people proper medical care (Matemba et al., 2010).

Uganda has a long history of HAT epidemics, being the only country with active foci of both chronic *Trypanosoma brucei gambiense* HAT (gHAT) and acute *Trypanosoma brucei rhodesiense* HAT (rHAT) - both of which are fatal without treatment (Welburn et al., 2001a,b). For over a century gHAT and rHAT have occurred in discrete foci that have periodically contracted and expanded, but have not merged (Picozzi et al., 2005; Welburn et al., 2016). HAT surveillance is concentrated within these disease foci and nature of the focus (gHAT or rHAT) defines the diagnostic method applied, the chemotherapeutic treatment and control methods deployed (Wastling and Welburn, 2011).

Following the social, political and economic upheavals in the 1970s and 1980s a large epidemic of rHAT (more than 40,000 reported cases) began in the traditional rHAT focus of Busoga. By 1987, the relatively stable pattern of expansion and contraction of the rHAT foci began to break down when a large rHAT epidemic began in Tororo, spreading over the following decade across Butaleja and Busia Districts.

In 1999, rHAT moved into Soroti District and disease introduction was associated with a cattle market (Fevre et al., 2001). Imported cattle from districts endemic for rHAT were shown to have introduced *T.b. rhodesiense* parasites (Welburn et al., 2001a,b). From Soroti and Serere districts, rHAT progressed around the shores of Lake Kyoga to Dokolo and Kaberamaido (Fèvre et al., 2005; Batchelor et al., 2009; Wardrop et al., 2013). Each rHAT outbreak in each new district was preceded by large-scale restocking activities, importing cattle from rHAT endemic regions for traction and breeding (Selby et al., 2013). Acute rHAT was introduced to 9 new districts in as many years (Welburn and Coleman, 2015). HAT introductions place a large burden on the local health systems in affected districts and have had a major impact on human health and economic development around Lake Kyoga. Newly affected districts are ill equipped to diagnose cases and offer the specialist and complex clinical management needed for HAT patients. When HAT was introduced to Serere district in 1999, an estimated 30% of in-patient time was consumed by HAT, second only to malaria (Fèvre et al., 2008a).

HAT monitoring in Uganda is undertaken by the National HAT Control Program, situated in the Vector Control Division of the Ministry of Health (VCD-MoH). Should HAT incidence exceed 'normal endemic levels' VCD-MoH has a mandate to declare an outbreak and activate control efforts and/or active surveillance in affected districts. This mechanism is essential to enable prompt disease control efforts in the run-up to meeting the WHO's 2030 HAT elimination target. However, national reporting systems universally fail to recognize either the significant diagnostic deficiencies (Bukachi et al., 2009) or the cumulative reporting problems characteristic of diseases like HAT.

The national figures for gHAT and rHAT are known to be greatly underestimated in Uganda (Odiit et al., 2004; Odiit et al., 2005). An estimated 30% of HAT cases entering the official health system die undiagnosed in Uganda (Odiit et al., 2005). Several factors have been shown to influence under-reporting of HAT in Uganda. Firstly, since surveillance is passive, patients often fail to recognize symptoms of HAT and do not present at a hospital where they could obtain a diagnosis. These cases are not detected and not reported. Those that do attend a lower level health facility will be assessed for malaria and may be referred to a higher-level facility if severe malaria, HAT or a HAT relapse is actually suspected. Secondly, cases that do reach a hospital often fail to receive a diagnosis, depending on the knowledge, attitudes and practices of local health workers at the point-of-care, and the capacity for disease management at the centre.

HAT case reporting is ultimately dependent on health posts and HAT treatment hospitals feeding case data to the VCD-MoH. Only those hospitals designated as a HAT treatment centers, will include detection of trypanosomes in routine blood examinations. Until trypanosomes are observed, rHAT infected individuals will move from one healthcare provider to the next seeking a diagnosis, with many withdrawing from the health system and seeking the help of traditional/spiritual healers (Odiit et al., 2004; Bukachi et al., 2009). In Kenya and Uganda, 70% of HAT patients were incorrectly treated before being correctly diagnosed with HAT (Bukachi et al., 2009).

For both forms chronic gHAT, and acute rHAT a delay in diagnosis and treatment is frequently fatal. Delays in diagnosis increase the severity of infection and also increase morbidity. It is critical that patients are diagnosed quickly and receive appropriate treatment. HAT is cheaper to treat at the early rather than late stage and early treatment reduces the DALY burden (Fèvre et al., 2008b). Symptoms of Central Nervous System (CNS) damage associated with late stage HAT often motivate rural cases to seek solutions from herbal practitioners, with sufferers believing they are bewitched, further delaying early recognition of disease, with serious health consequences in terms of disability and death (Bukachi et al., 2009). A study of gHAT in the Democratic Republic of Congo (DRC) found that patients waited an average of four months before seeking medical care, and that diagnosis was further delayed for an average of 7 months due to failures in the health system (Hasker et al., 2011). In Cameroon, recovered gHAT child patients suffered from lower weight, height and mid-arm circumference and had more difficulties at school (Aroke et al., 1998). The burden of HAT extends beyond financial costs, impacting on food security, education, social status, wellbeing, key assets and household resilience.

The stage of HAT infection at diagnosis serves as an indicator for how effective the healthcare system is at recognizing the disease. A high ratio of early-to-late stage infections in case records indicates good healthcare seeking behavior of HAT patients and a well-functioning healthcare system. Any increase in early stage cases presenting in a community is indicative of active disease

**Table 1**
District statistics.

| District | Human population (2002 census data) | Land mass ($Km^2$) (District records) ± |
|---|---|---|
| Dokolo | 129, 385 | 1113 |
| Kaberamaido | 131, 650 | 1354 |
| Soroti/Serere§ | 369,789 | 2873 |
| TOTAL | 630,824 | 5340 |

All figures are taken from the Ugandan Bureau of Statistics.
§ Data for Soroti and Serere districts were not available separately since Serere separated from Soroti in 2010.
± Land mass data excludes open water areas (269 $km^2$ for Kaberamaido and 504 $km^2$ for Soroti/Serere—data for Dokolo is unavailable) but includes seasonal and permanent wetlands (144 $km^2$ for Kaberamaido and 418 $km^2$ for Soroti/Serere).

transmission and should trigger a program of active screening. In contrast, high numbers of patients presenting to HAT for diagnosis in the late stage indicates a lack of awareness of the disease in the community and a reluctance of patients to seek care until the illness has become severely debilitating. It is also indicative of poor surveillance, a failure to identify early stage symptoms at lower health service levels, poorly equipped and functioning diagnostic facilities, unskilled medical staff, and gaps in their knowledge of clinical staff (Odiit et al., 2004; Bukachi et al., 2009).

To make progress towards the WHOs 2030 elimination target, it is essential to understand the capacity of the local district health system to facilitate prompt identification of disease and effect prompt treatment. In this mixed methods study we have explored the quality of passive rHAT surveillance in district health system across four districts of Eastern Uganda (Dokolo, Kaberamaido, Soroti and Serere) endemic for rHAT. We also examined trends in patient records from 2009 to 2012 that can inform as to the effectiveness of the system.

## 2. Methodology

### 2.1. Study area

The study area comprised four districts in eastern Uganda north of the Lake Kyoga catchment area (Table 1). These areas are predominately rural where the economy is based on mixed crop-livestock farming and small-scale trades. Farming activities revolve around a variety of different main crops (cassava, millet, sorghum, beans, maize and others), which are based on two growing seasons corresponding with the bimodal rains. Wetlands are significant areas for grazing cattle herds (most are less than 80 cattle) while also facilitating the survival of a low to moderate tsetse challenge.

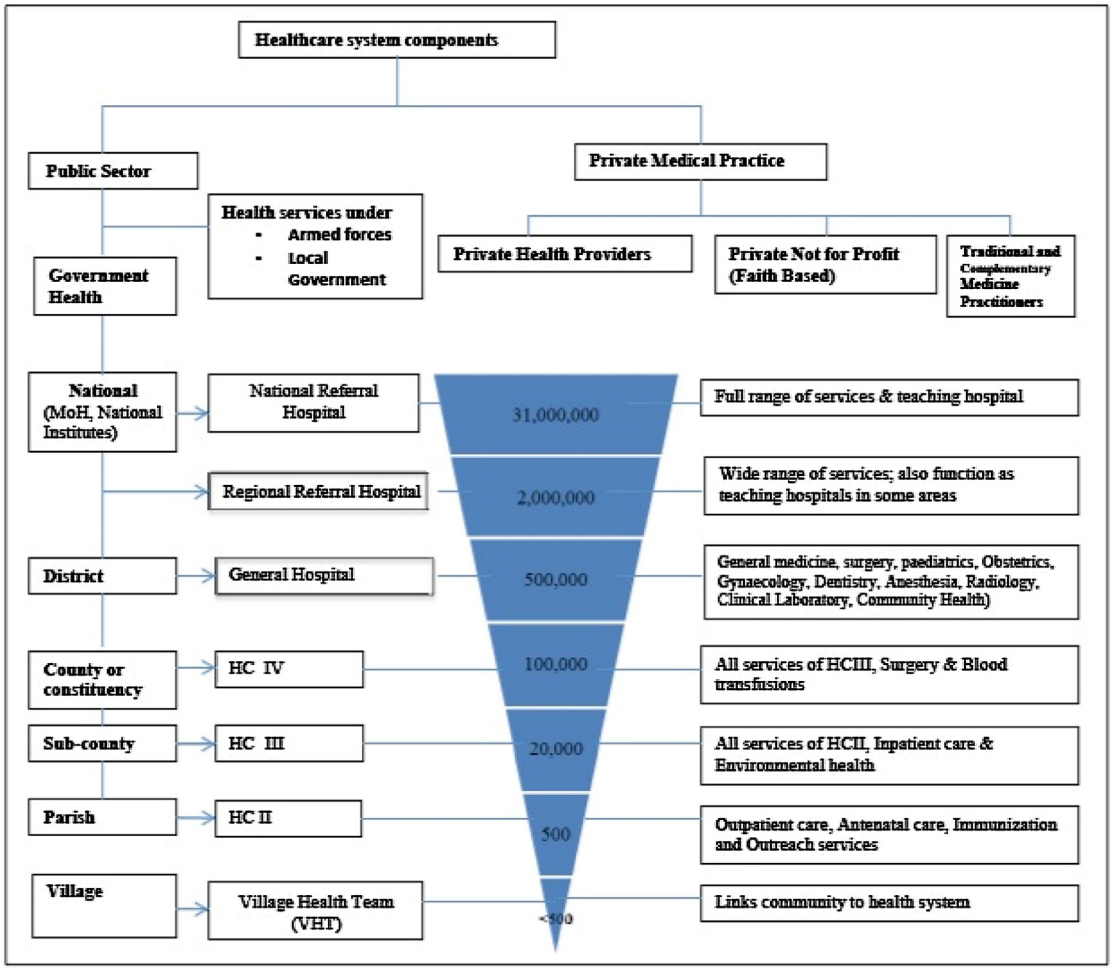


**Fig. 1.** Structure of the health system in Uganda.

As with much of Uganda, the area has a high population density and is mostly Christian. The major ethnic groups include the Lango, Iteso and Kumam.

### 2.2. Structure of the local health system

The government health service in Uganda is structured into national and regional referral public hospitals, general hospitals and, at district level, is divided into four levels (I–IV) - see Fig. 1. Health Centre Level I (HC-I) is the lowest level in the health system, and comprise a Village Health Teams (VHTs) or individual health volunteer (that may or may not be formally trained) serving to link the community to the National Health Service. Health Centre IIs (HC-II), also known as dispensaries, are parish level facilities that serve roughly 5000 people, these are led by an enrolled nurse who works with a midwife, and two nursing assistants. Health Centre III (HC-III) facilities serve a sub-county of approximately 20,000 people, and supervise community health workers and the HC-IIs within their jurisdiction. Health Centre level IV (HC-IV)/District Hospitals serve a county (approximately 100,000 people) and offer the highest level of service to the district. They offer inpatient care with wards for men, women, and children have an operating theatre for emergency surgery and a blood transfusion service. These facilities have a full complement of medical staff. This study focused mainly on HC-II and HC-III facilities in Soroti, Serere, Dokolo and Kaberamaido.

### 2.3. Fieldwork phase 1 (2011)

Fieldwork for this study was conducted in two phases between 2011 and 2013. The first phase was executed over three weeks in November 2011. Work in each district first involved a survey and direct observations at health centres at each level of the health system, identified with the assistance of the Coordinating Office for Control of Trypanosomiasis in Uganda (COCTU) and the Ministry of Health. All health facilities in Dokolo, Kaberamaido and Soroti and Serere districts were visited and co-ordinates captured using a handheld Global Positioning System device (GPS). One official was assigned for the period of the study, and acted as local guide and translator. In total, a questionnaire was administered to 86 medical personnel - clinicians, nurses, midwives and technicians - across 65 medical facilities at levels HC-II and HC-III (Fig. 2). Following a convenience sampling design, all staff present in the facility on the day researchers visited were invited to participate, and all volunteers were interviewed. Questions were divided under four themes:

**Fig. 2.** The study researcher (CA) administering a questionnaire with a nurse at Otuboi HC-III, Soroti district.

health facility capacity and clinical service provision; diagnostic capacity; knowledge of facility staff for HAT (causative agent, clinical signs and symptoms, mode of transmission); and data handling and reporting of HAT cases.

### 2.4. Fieldwork phase 2 (2013)

The study area was re-visited in 2013, where semi-structured interviews were conducted with a range of clinicians, nurses and laboratory staff (11) at the three HAT treatment centres north of Lake Kyoga: Dokolo Health Centre IV (Dokolo district); Serere Health Centre IV (Serere district) and Lwala Hospital IV (Kaberamaido district) on all aspects of clinical presentation, diagnosis and treatment for HAT. Again, we followed a convenience sample study design, and all staff present in the facility during our visit were invited to participate. Respondents were asked questions as regards data recording and handling and all rHAT records collected between 2009 and 2012 from these three diagnosing centers. A rapid assessment of the data recording systems present was also made. Questions included: who is responsible for managing case data? How is sleeping sickness data recorded, shared, and reported at this facility? Who is responsible for managing case data? Is there an electronic/digital record keeping system? What challenges are there to data management at the facility?

Records were obtained from Dokolo HC-IV and Serere HC-IVs (available as hand written registries in log books) and from a computerized HAT database at Lwala Hospital. Available rHAT data were entered into an Excel spreadsheet. Hand written cases were found to be incomplete and/or information was illegible, and these were excluded. Data retrieved from the national archive was compared to that from these treatment facilities. Cases that did not appear in the list from the three health facilities but which appeared in the national archive were included in the spreadsheet. The final database comprised (i) patient demography (i.e. name, age and sex) (ii) residence (i.e. village, parish, sub-county and district), (iii) date of admission, (iv) disease stage at diagnosis and (v) treatment outcome.

### 2.5. Data analysis and ethical clearance

Quantitative data was entered and analyzed using Excel (Microsoft Office Excel 2007). Qualitative data was entered into Microsoft Word and analyzed manually based on accepted methods of coding (Padgett, 2012). The study was coordinated by COCTU and the National Sleeping Sickness Control Program of the Ministry of Health. The Ministry of Health Vector Control Division ethical committee reviewed the proposal and made recommendation for approval to the Uganda National Council for Science and Technology (VCD: Ref: IRC/10). The Uganda National Council for Science and Technology issued ethical clearance (UNCST Ref: HS 858).

## 3. Results

### 3.1. Characteristics and diagnostic capacity of the health system

Seventy health facilities were identified across Dokolo, Kabaramiado, Serere and Soroti Districts in 2011: 36 HC-IIs; 29 HC-IIIs; 6 HC-IVs and 2 Hospitals (Fig. 3). In November 2011, these facilities employed 451 staff in HC-II – HC-IV facilities: 29 clinicians; 260 nurses; 68 midwives; 53 laboratory staff and 41 other support staff. Questionnaires were undertaken with 55% of clinicians, 20% of nurses, 18% of midwives and 40% of laboratory staff employed in these health facilities. Data relating to specific diseases could only be obtained from notebooks and/or information charts on facility walls. Data was inconsistent in some areas and largely limited to results from laboratory-based diagnostics. Across

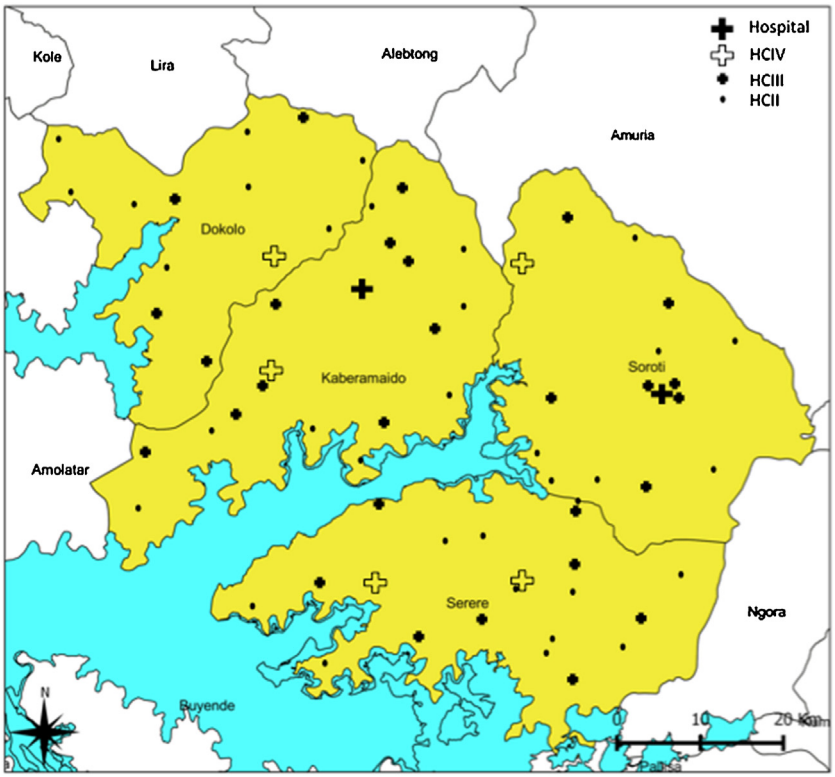


**Fig. 3.** The geospatial distribution of medical facilities in Dokolo (top left), Kaberamaido (middle) and Soroti (right). Serere (right bottom) was divided from Serere in 2010.

the study area, reliable records were only kept at facilities with fully functioning laboratories.

We identified 36 HC-IIs, in Dokolo (8), Kaberamaido (10) and Soroti/Serere (18) districts. Facilities employed 110 medical staff, including clinicians (1), nurses (80), midwives (14), laboratory technicians (7) and others (8). HC-IIs run outpatient clinics for treatment of common diseases, antenatal care, immunization, and outreach and serve as the main link to the VHTs. Patients attend HC-II as the primary point-of-care. HC-II see between 20–100 patients per day, and rely on a combination of clinical examination and one-step diagnostic kits for diagnosis of common health issues (malaria, hepatitis, HIV and pregnancy). Fourteen percent of HC-IIs had a functioning laboratory. Major conditions reported by the medical staff included: malaria, respiratory infections, helminthiosis, fevers, diarrhea, abdominal pains, vomiting, urinary tract infections, sexually transmitted infections, skin rash, convulsions, jaundice and ear, nose and throat infections.

Twenty-nine HC-III facilities were located in Dokolo (4), Kaberamaido (8) and Soroti/Serere (17) districts. HC-III employed 258 medical staff clinicians (34), nurses (124), midwives (41), laboratory technicians (32) and others (27) - a greater number of staff than HC-II facilities due to the larger number of patient visits and more specialized services available. HC-IIIs provide first referral services for the sub-county in basic preventive and curative care, they offer in-patient services, maternity care and laboratory diagnosis. Most facilities were staffed with at least: a clinical officer, enrolled nurse, two enrolled midwives, a nursing assistant, a health assistant, a laboratory assistant, and records officer.

HC-IIIs reported treating >100 patients each day with the most commonly treated infection being malaria. All facilities above HC-II, should have a laboratory to diagnose health complaints. A laboratory (with centrifuge and microscope) was present and functional in most facilities (in only 4 were these absent). Most facilities relied on solar power, with a few having access to mains power or a generator.

HC-IV/Hospital level facilities (one in Dokolo, two in Kaberamaido three in Serere and three in Soroti) had between 30 and 150 employees. These facilities had functioning diagnostic equipment for identification of blood borne-parasites (microscopy and centrifuges) and employed laboratory technicians. Soroti Hospital, the eastern region referral hospital was better resourced, with more staff and better medical infrastructure offering a wider range of medical diagnostic services, including radiology, than the other facilities.

Three IV health facilities operated as HAT treatment centres, able to diagnose and treat HAT cases. Their catchment area comprised 11 districts; Mbale, Butaleja, Kumi, Soroti, Katakwi, Kaberamaido, Dokolo, Lira, Amolatar, Apac and Busoga. Identification of trypanosome infections in blood was offered as part of the routine diagnostic work and for any referred patients. Serere Health Centre IV (established in 1934) was equipped to diagnose and treat HAT in 1998 in order to manage the growing emerging epidemic in the district. Between 1999 and 2012, Serere Health Centre IV diagnosed 539 patients (no cases were reported in 2012). Lwala Hospital (also called Lwala Missionary Hospital and Lwala Health Centre IV) is a regional HAT center, offering regional referral and national training. Lwala treated its first HAT patient in 2004. Cases presenting at Lwala increased rapidly, as rHAT emerged in Dokolo, Amolatar, Apac and Lira Districts. By December 2012, Lwala Hospital had diagnosed 700 HAT cases. Dokolo Health Centre IV started managing HAT patients care in December 2008 and by June 2012, 30 patients had been diagnosed and treated.

### 3.2. *Knowledge of HAT diagnosis and treatment*

A HAT case can only be formally diagnosed and receive free treatment from Serere HC-IV, Lwala Hospital and Dokolo HC-IV. Lower levels in the health system (HC-II, HC-III and other HC-IVs) remain important nodes, especially for referring suspected patients to these treatment facilities.

**Table 2**
Knowledge of HC-II AND HC-III staff on HAT.

| Respondent | | District | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dokolo | | Kaberamaido | | Serere | | Soroti | | Total | |
| | | HC-II | HC-III | HC-II | HC-III | HC-II | HC-III | HC-II | HC-III | HC-II | HC-III |
| Where did you get your information about HAT? | Past training | 6/8 | 5/6 | 1/8 | 9/14 | 0/10 | 7/19 | 5/9 | 3/12 | 34% | 47% |
| | Word of mouth | 4/8 | 3/6 | 5/8 | 5/14 | 2/10 | 10/19 | 1/9 | 2/12 | 34% | 39% |
| | Radio/newspaper | 1/8 | 0/10 | 7/8 | 1/14 | 5/10 | 4/19 | 1/9 | 8/12 | 40% | 26% |
| | Experience | 1/8 | 2/6 | 1/8 | 9/14 | 3/10 | 6/19 | 2/9 | 6/12 | 20% | 45% |
| | District reports | 0/8 | 0/6 | 0/8 | 0/14 | 0/10 | 1/19 | 0/9 | 0/12 | 0% | 2% |
| Respondents believing HAT was endemic in the district | | 6/8 | 2/8 | 4/8 | 14/14 | 4/10 | 13/19 | 3/9 | 6/12 | 49% | 69% |
| Respondents knowing at least one clinical sign of HAT | | 6/8 | 5/6 | 4/8 | 14/14 | 1/10 | 9/19 | 7/9 | 10/12 | 51% | 75% |
| Respondents knowing HAT is transmitted by trypanosomes | | 0/8 | 5/6 | 2/8 | 12/14 | 5/10 | 15/19 | 5/9 | 9/12 | 40% | 80% |
| Respondents knowing HAT is transmitted by tsetse flies | | 5/8 | 6/6 | 6/8 | 14/14 | 10/10 | 19/19 | 9/9 | 12/12 | 86% | 100% |
| Respondents confirming that HAT is fatal if untreated | | 5/8 | 5/6 | 5/8 | 12/14 | 10/10 | 19/19 | 5/9 | 10/12 | 71% | 90% |
| Respondents confirming that HAT treatment is free | | 2/8 | 6/6 | 3/8 | 12/14 | 2/10 | 13/19 | 0/9 | 8/12 | 20% | 77% |
| Respondents confident they could identify a HAT case | | 4/8 | 3/6 | 4/8 | 14/14 | 6/10 | 12/19 | 4/9 | 8/12 | 52% | 73% |
| Respondents that had experienced a HAT case at their facility in the past | | 1/8 | 1/6 | 1/8 | 9/14 | 0/10 | 6/19 | 0/9 | 2/12 | 6% | 35% |

To explore knowledge gaps around HAT transmission, diagnosis and treatment, 86 structured interviews were undertaken with HC-II – HCIII heath-care workers (35 health workers from HC-II facilities in Dokolo (8), Kaberamaido (8), Serere (10) and Soroti (9) and 51 health workers at HC-IIIs in Dokolo (6), Kaberamaido (14), Serere (19) and Soroti (12)).

There were a number of knowledge gaps across HC-II and HC-III facility staff, which did not differ by district but which were higher among staff in HC-II (Table 2). While 96% of HC-III staff had heard of HAT only 70% of staff had heard of HAT among the HC-II respondents. HC-III staff reported receiving information on HAT from training events (47%); from practical experience (45%) and from word of mouth (45%). Radio and newspapers were the most common source of information about HAT among HC-II staff (40%) followed by training events (34%) and word of mouth (34%). Only 2% of staff reported hearing about HAT from district reports. Most respondents were aware that HAT was transmitted by tsetse flies (94%) and that the disease was fatal if left untreated (83%). More precise knowledge - that the causative agent was a trypanosome, knowledge of at least one clinical sign and that HAT drugs were free was low among HC-II staff (40%, 51% and 20% respectively) but was much higher among HC-III staff (80%, 75% and 77%).

HAT is endemic in all of the study districts, but only 60% of respondents were aware that HAT was endemic in their own district. Few respondents reported having a HAT patient at their facility (6% amongst HC-II and 35% among HC-III staff). Despite having little experience of HAT case management, 52% of staff interviewed in HC-II facilities and 73% in HC-III facilities believed they could identify a HAT case. A common opinion was that HAT was equivalent to recurrent and severe malaria, which is not true. Most HC-II and HC-III respondents were unaware that diagnosis of HAT requires examination of cerebral spinal fluid (CSF); most thought that blood only should be examined for trypanosomes.

Eleven structured interviews were conducted with heath care workers in HC-IV/HAT treatment facilities/centres in Dokolo (2); Kaberamaido (3), Soroti (1) and Serere Districts (5). All medical workers interviewed from Dokolo, Lwala and Serere HCIV, and Soroti Regional Referral Hospital, were knowledgeable about sleeping sickness and were confident in their capacity to diagnose and manage cases.

### 3.3. HAT data recording and data management

The WHO criteria of 1998 is still followed for detecting trypanosomes in Uganda. A diagnosis of HAT is made following identification of a trypanosome using microscopy on samples of blood, lymph fluid or chancre exudates, despite the low sensitivity of this method (Cattand and de Raadt, 1991). First stage HAT is defined as either the presence of a trypanosome in the sample and a CSF white blood cell (WBC) count of $\leq$5WBC/mm$^3$ and the absence of trypanosomes in CSF. Second stage HAT is indicated by the presence of trypanosomes and/or an elevated WBC count in CSF of a least $\geq$5WBC/mm$^3$ and/or presence of parasite in the CSF. Correctly staging HAT defines the chemotherapeutic choice. Patients with second stage HAT have a poorer prognosis in terms of both morbidity and mortality and 5–10% of patients suffer from encephalopathic reactions to Melarsoprol (MelB, melarsen oxide-BAL, Arsobal®) treatment (Fèvre et al., 2008a,b).

HAT records were accessed from the three specialist HAT treatment centres in the study area (Dokolo Health Centre IV, Lwala Hospital and Serere Health Centre IV). Information detailing HAT patient care was hand-written in a logbook (Fig. 4), HAT records include: patient's name, age, sex, residence (village, parish, Sub County and district), date of admission, stage of illness and date of discharge/death. Additional remarks on treatment, outcome and patient referral status may be recorded but no consistent system was identified. This is an inexpensive form of record keeping, but reliability is dependent on the accuracy of information as detailed by the staff member capturing the patient information and does not generate a permanent record. There were reports of records being damaged by water and insects. Where data were feed into an electronic database there were concerns of coding errors being carried forward (Lwala hospital). The facilities make a weekly report to the sub-county office, which feeds up to the district administration. It is the responsibility of the district health office (or HAT treatment hospitals) to report case data to the MoH. The national HAT control program updates an electronic archive and assimilates country-wide records pooled from both diagnosing and treating healthcare providers across HAT endemic districts.

Between 2009 and 2012, in districts north of Lake Kyoga (Soroti, Kaberamaido, Dokolo, Lira, Amolatar and Apac) 342 people were diagnosed with rHAT (108 cases in 2009; 104 in 2010; 70 in 2011; and 60 in 2012). Over this 4-year period, 39% of HAT cases were reported between January and March (133). HAT incidence follows the seasonal bimodal rainfall pattern with increased man-fly contact during the hot, dry season followed by case emergence and case numbers falling during wet seasons. Fifty-five percent (190/342) of reported cases were from male patients. The age category most commonly infected with rHAT was between 20 and 29 years (17% of reported cases), followed by 15–19 years (15% cases) and 10–14 years (15% cases). Young children (5%) and babies (0.6%) showed the lowest number of cases. A similar age group and infection distribution was observed across the four years.

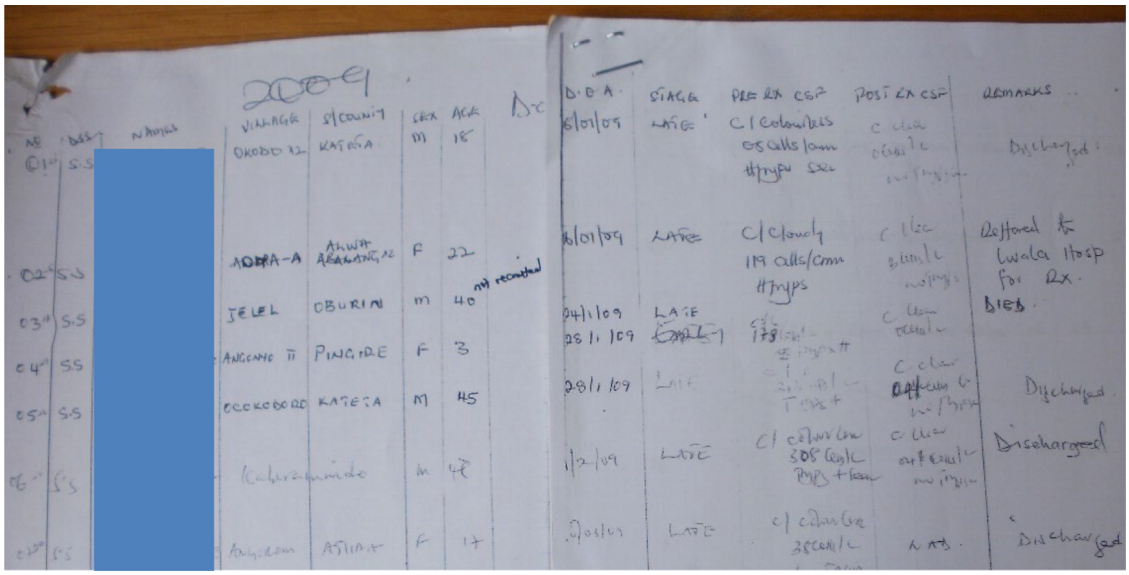

**Fig. 4.** Patient sleeping sickness record in Serere HC-IV. Names are blanked.

The majority of HAT cases came from Kaberamaido district (220), followed by Dokolo (69), Soroti/Serere (22), Lira (18), Apac (12) and Amolatar (1) districts. One patient from Western Uganda was excluded from the analysis. Over 50% of HAT patients (184) were diagnosed in the late stage of disease in late stage, 157 patients were detected in the early stage, and 1 patient was recorded with unknown disease stage. Soroti district recorded the highest proportion of cases diagnosed in the late-stage - only 5% HAT cases recorded as early stage (Almost all cases examined came from Serere district which was part of Soroti district until 2010). Only 9% of patients from Apac and 18% from Lira were diagnosed in the early stage, these districts were geographically distant from a HAT treatment centre. The single case coming from Amolatar District was in the late stage of disease. Despite proximity to a large HAT treatment centre (Lwala hospital), up to 70% of cases from Kaberamaido district were also diagnosed as late stage. Early HAT case presentation was greater in Dokolo district with 51% of all cases recorded as early stage.

Based on reported cases of HAT, in 2012 the HAT incidence rate was: 3.57 per 10,000 persons at risk in Kabermaido district (47/131,650 or 1 case per 2801 people at risk); 0.77 per 10,000 in Dokolo district (10 cases in 129,385 or 1 case 12,939). No cases were reported in Soroti and Serere districts (0/369,789). The incidence rates reported do not account for the issue of under-reporting.

Over the four-year period of this study, the proportion of cases being identified in the early stage fell, and by 2012 the majority of cases were being diagnosed in the late stage of disease (Fig. 5). This is suggestive of a lack of community awareness of HAT and substantial level of under-reporting of HAT in the area. This reduction in early-to-late stage ratio may have been due to diminishing funds from donors and the central government following the initial outbreaks, resulting in reduced community outreach, trainings for medical staff and enhanced surveillance.

## 4. Discussion

This study focused on the passive surveillance system for rHAT in health facilities in the proximity of Lake Kyoga. We identified shortcomings in knowledge and practices of lower tiers health workers. Our analysis of case data showed that between 2009 and 2012, 54% of reported cases of rHAT in Serere, Kaberamaido and Dokolo were diagnosed in the late stage of disease (when parasites had already migrated to the CNS). There has been little improvement in patients reporting early and being diagnosed in the first stage of HAT since the epidemic in Tororo in the late 1980s (Odiit et al., 1997) and in Soroti in the late 1990s (Fèvre et al., 2008a; Odiit et al., 2005). The reluctance of HAT patients to seek help and spend money on their care also contributes to the high number of late stage patients (Odiit et al., 2005).

That the majority of cases are only identified at late stage illustrates a gap in HAT awareness at the community level that needs to be addressed. It is also evidence of poor diagnostic capacity and shortcomings in the referral service in the health system - greater awareness of HAT promotes early case reporting. Strengthening the referral system so that rHAT patients are recognized and are referred as early as possible would greatly improve early stage disease identification.

A strong health system that extends to community-level is vital. This study highlights the need for formal training on all aspects of HAT diagnosis and treatment for lower tier medical workers in HC-II and HC-III facilities in districts endemic for HAT. Awareness campaigns, among communities and healthcare providers, that engage with the lower tiers of the Health System (including the HC-I, the VHTs) would increase vigilance and improve reporting. During the large sleeping sickness epidemic in Busoga in the 1980, VHTs, known as Sleeping Sickness Orderlies, were essential to the control campaign, picking up cases of rHAT, mobilizing communities, collecting samples and retracing positive cases for treatment. Enabling the VHTs and HC-IIs to undertake syndromic surveillance in the community would greatly improve rHAT referral. To be most effective, this should be integrated with other major infectious disease problems in the area, such as malaria, pneumonia and diarrheal disease prevention (Strachan et al., 2014).

Extending HAT diagnostic screening to all medical facilities with a laboratory in endemic districts would serve to fast-track removal of infectious people. Improving the availability of diagnostic equipment and materials, and regularly training medical staff employed in facilities serving communities that are reporting cases for sleeping sickness would improve detectability (and reporting) of the disease (Palmer et al., 2014). Enhanced reporting and timely investigation of all suspected cases provides clinical benefits and minimizes disease spread (Odiit et al., 2004). Since up to 72% of

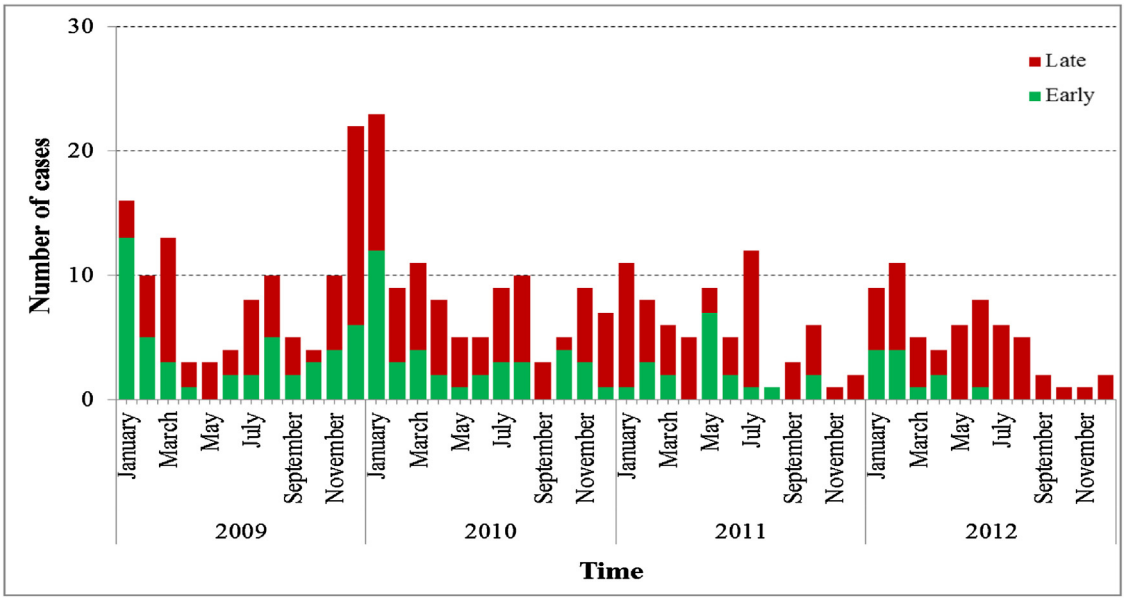


**Fig. 5.** *T.b. rhodesiense* HAT cases and classification of stage of infection at point of diagnosis between 2009 and 2012 in affected districts north of Lake Kyoga (Soroti, Serere, Kaberamaido, Dokolo, Lira, Apac and Amolatar). The majority of cases over this period presented from Kabaramaido and Dokolo.
Red bars indicate a diagnosis of late stage disease, while green show the number of infections identified as early stage disease.

households in Uganda are located within 5 km of a health facility and with 100% of Uganda's population covered by the mobile phone network and an increasing proportion own a mobile phone, opportunities for mHealth applications to address HAT reporting and patient care (Aranda-Jan et al., 2014) may be an option.

In a decentralized heath system, empowering district level surveillance for HAT is essential. However, funds distributed to the district are often earmarked for specific uses and since a district cannot divert funds to meet local need unless directed to do so, there exists an "incomplete" de-centralisation or "re-centralisation" (Ssengooba, 2004). In this system, 'unforeseen' and unbudgeted local priorities, such as disease outbreaks of HAT, can often be difficult to accommodate.

Management of an expanding rHAT endemic focus at the scale observed is a strain for the district health system. While the district can recruit, deploy, develop and manage human resources, develop local health by-laws and monitor health sector performance, central government is responsible for the salaries of health workers. Absenteeism rates are high, for the financial year 2011/12 these were 25% for HC-IIs; 30% in HC-IIIs and 50% in HC-IVs (UBOS Annual Panel Survey 2011/12). Leakage of resources can be a major issue. Asiimwe et al. (1997) reported significant leakage of funds at health unit level where on average 70% of drugs and supplies were assimilated by staff, for personal gain, in compensation for low pay. These larger political economy issues clearly influence quality of care and the ability for prompt diagnosis and treatment regimes in HAT foci.

Control of HAT in Uganda does not only involve human treatment but also demands targeting removal of the human infective parasite from animals and vector control (Welburn et al., 2016). Uganda is one of only a few only countries in Africa that has experienced large-scale, debilitating HAT outbreaks and managed to operationalize large-scale control operations (Maudlin, 2006). An expanding zoonotic rHAT focus makes coordinating control of HAT in Uganda particularly complex, demanding a combined medical and veterinary approach (Welburn et al., 2001a,b; Welburn et al., 2006). Uganda is also unique in having established a One Health body, COCTU, for joined up management of HAT and animal trypanosomiasis after the major HAT epidemic in Busoga. Given the dramatic expansion of the rHAT focus in Uganda, implementation of a One Health approach to livestock and human health in the community will be key for rHAT containment and disease control (Okello and Welburn, 2014).

In 2006, a mass cattle treatment campaign, Stamp out Sleeping Sickness (SOS) (http://www.stampoutsleepingsickness.com/), reduced the prevalence of trypanosomes in cattle by 75% in seven districts north of Lake Kyoga. The prevalence of *T.b. rhodesiense* in cattle in treated districts decreased by 85.7% (0.75% to 0.11%) with a single round of mass treatment (Welburn and Coleman, 2015). The further spread of *T.b. rhodesiense* in cattle to districts north of Lake Kyoga could have been prevented by enactment of a directive from the Ministry of Agriculture for mandatory treatment of cattle at point of sale (Wendo, 2002), but this was not effectively implemented within endemic districts (Selby et al., 2013).

With the progressive migration of the rHAT focus towards the gHAT focus there are plans to remove the *T. b. rhodesiense* reservoir of rHAT from livestock across all high-risk districts in Uganda using an innovative funding model, a Development Impact Partnership (Centre for International Development and Social Finance, 2013). The programme would implement large-scale mass cattle treatments with trypanocides to remove the parasites, and promote greater use of veterinary pyrethroid-based insecticides by livestock keepers to prevent reinfection. This would not only impact on rHAT but also impact on animal trypanosomiasis and tick-borne diseases which negatively impact livestock productivity (Bardosh et al., 2013; Bardosh, 2015). Identification of infected animal hosts in the community carrying *T.b. rhodesiense* parasites and removal of those infections from the animal reservoir, enables management of the risk posed by these infected animals to humans in the community (von Wissmann et al., 2014). This approach offers the opportunity to align with VHT mobilization for early stage HAT surveillance. FTA card technology makes it possible to screen large numbers of people and animals in at-risk communities. Given that rHAT case reporting shows a seasonal pattern, a case for heightened active community surveillance at key periods can be made. Removing infection from domestic livestock combined with improved surveillance to identify early stage infection in humans offers hope for elimination of rHAT in Uganda (Welburn et al., 2006; Welburn et al., 2016).

Across Africa, reported cases of gHAT have been falling with a 76% decrease in prevalence since 2000; only 7000 cases were reported between 2010 and 2013 (Franco et al., 2014). However, allowing for under-reporting, WHO estimates that the number of gHAT cases remains around 20,000 per annum. Human surveillance for gHAT must continue to improve. Administering '*the last strike to the dying beast*' (Simarro et al., 2011a) is compromised by weak national health systems (Simarro et al., 2011b) and the WHO target was revised from elimination by 2020 to *'stopping transmission by 2030'* (Simarro et al., 2015). Unless the issues of under-reporting for both forms of HAT are addressed by investment in strengthened community surveillance there can be little confidence that this can even be achieved by 2030 (Welburn et al., 2016). It is time for local and national governments, donors and the international community to commit to this goal.

## Author contributions

CAA, KB and SCW prepared and finalized the paper. All authors contributed to the study conception, design, acquisition of data, data analysis and interpretation, and critically revised the paper. All authors read and approved the final manuscript.

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