



## Characteristics and epidemiological profile of Buruli ulcer in the district of Tiassalé, south Côte d'Ivoire



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### ABSTRACT

Buruli ulcer (BU) is a cutaneous infectious disease caused by *Mycobacterium ulcerans*. It is the third most common mycobacterial disease in the world in the immunocompetent patient and second in Côte d'Ivoire after tuberculosis. This study aimed to assess the characteristics and epidemiological profile of BU in the district of Tiassalé, an important focus of the disease in south Côte d'Ivoire, in order to better direct actions for prevention and control. Retrospective clinical data of BU cases in the period 2005–2010 from all 19 district health centres were collected and linked with geographical and environmental survey data. A total of 1145 cases of BU were recorded between 2005 and 2010 in the district of Tiassalé. Children under the age of 15 years were the most affected (53.0%) with a higher prevalence among males compared to females (54.7% versus 45.3%). Among individuals aged 15–49 years, females had a higher prevalence than males (54.2% versus 45.8%). The villages of Ahondo, Léléblé and Taabo, located in close proximity to the man-made Lake Taabo that was constructed in the late 1970s by damming the Bandama River, and the village of Sokrogbo located downstream of the dam, showed the highest BU rates in the sub-prefecture of Taabo. In the sub-prefecture of Tiassalé, the villages of Affikro, Morokro and N'Zianouan, located near N'Zi River, a tributary of the Bandama River, were the most affected. The distribution of BU is associated with environmental patterns (*i.e.* distance between village and Lake Taabo or Bandama River and its tributary N'Zi River). Awareness campaigns, coupled with early diagnosis and improved clinical management of BU, have been implemented in the district of Tiassalé and the incidence of BU has declined.

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### 1. Introduction

Buruli ulcer (BU) is an infectious disease of the skin caused by *Mycobacterium ulcerans* (Junghanss et al., 2014). BU is the third most common mycobacterial disease in the world in the immunocompetent patient, after tuberculosis and leprosy (Darie, 2003; WHO, 2008a; Huang and Johnson, 2014). In Côte d'Ivoire, BU is the second most important mycobacterial disease after tuberculosis (Kanga and Kacou, 2001; Kanga et al., 2006; N'krumah et al., 2016). Although BU occurs at any age, the highest rates are observed among children aged below 15 years (Aujoulat et al., 1996; Kanga

and Kacou, 2001; Portaels et al., 2015), mainly in tropical and sub-tropical regions, in rural marshy areas (Marston et al., 1995; Amofah et al., 2002; Ahoua et al., 2009). According to the World Health Organization (WHO), the countries most affected by BU in the past 10 years are Benin, Côte d'Ivoire and Ghana in Africa, French Guyana in Latin America, and Australia and Papua New Guinea in Oceania (Raghunathan et al., 2005; WHO, 2015).

Despite a number of detailed epidemiological investigations, the exact mode of transmission of BU remains elusive (WHO, 2008a; Merritt et al., 2010). However, regular contact of individuals in endemic areas with stagnant or slow flowing freshwater bodies during agricultural activities (rice and vegetable farming, fishing, etc.) and activities such as laundry, dishwashing and bathing were identified as risk factors for the onset of BU (Raghunathan et al., 2005; Quek et al., 2007; Wagner et al., 2008; Ahoua et al., 2009; Kenu et al., 2014a; N'krumah et al., 2016). Additionally, the poten-

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tial role of insect bites in the transmission of *M. ulcerans* has been investigated (Marsollier et al., 2003; Johnson et al., 2007; Doannio et al., 2011; Benbow et al., 2014; Zogo et al., 2015). Wearing protective equipment (e.g. boots, gloves, sleeve pants and shirts) for agricultural activities and prior to contact open freshwater sources was associated with a lower odds of BU, showing a preventive fraction of over 70% (N'krumah et al., 2016). In Côte d'Ivoire, unlike the Savannah regions where the prevalence of BU is very low or even zero, a high prevalence is noted in the south, particularly in the pre-forest area (Kanga and Kacou, 2001; Brou et al., 2006). The district of Tiassalé is located in the 'V-Baoulé', a characteristic ecozone where the Savanna meets the tropical rainforest in the south of Côte d'Ivoire (N'Goran et al., 1997; Koné et al., 2015). The Bandama River crosses the district from north to south and the area is endemic for BU (Doannio et al., 2011; N'krumah et al., 2016).

There is marked spatial heterogeneity of BU from one village to another. Hence, the use of a geographical information system (GIS) might facilitate a deeper understanding of the spatial distribution and transmission of BU (Blanton et al., 2006; Zhou et al., 2009). The present study intended to (i) investigate the spatial distribution of BU in the district of Tiassalé and (ii) identify hotspots of the disease in the district, which in turn will guide spatial targeting of interventions.

**2. Material and methods**

**2.1. Study area**

The district of Tiassalé is located in the south of Côte d'Ivoire, in the Savannah-forest transition zone and is crossed by Bandama River and its tributary, N'Zi River. Located between 5°32 and 6°24 N latitude and 4°29 and 5°14 W longitude, the district consists of two sub-prefectures, namely Tiassalé and Taabo. In this district, building of a hydroelectric dam in the late 1970s has led to the creation of an artificial lake from the Bandama River with an area of approximately 69 km<sup>2</sup> (N'Goran et al., 1997, 2003; Sanyu Consultants Inc & JICA, 2001; Koné et al., 2015; N'krumah et al., 2016).

The population of the department of Tiassalé was estimated at 263,495 inhabitants in 2014 according to the general census of population and housing (Institut National Statistique, 2014). The climate is tropical and humid. The average annual precipitation is 1740 mm with an average temperature of 26.6°C (Brou, 2005; Goula et al., 2007). The people of the department of Tiassalé live mostly in rural areas and depend on subsistence agriculture.

**2.2. Data collection**

**2.2.1. Epidemiological data**

Collection of retrospective BU case data was performed at the health district directorate of Tiassalé, where all epidemiological records from the health centres of the district are archived. Data from all 19 health facilities (15 rural health centres and four urban health centres) were extracted by nurses in August and September 2012 (N'krumah et al., 2014). Clinical features (reporting year, clinical forms and categories based on WHO (2008a) classification, location of lesions, etc.) and sociodemographic parameters (age, sex, village/city of residence, etc.) of registered BU patients were collected.

BU cases were defined as any BU patient diagnosed according to WHO clinical definition (WHO, 2008b), and confirmed by IS2404 polymerase chain reaction (PCR) analysis (WHO, 2014) conducted at the Institut Pasteur in Abidjan. Of note, our retrospective data collection took place in 2012, and covered the period 2005–2010. We did not collect older data, since the health district of Tiassalé only

**Table 1** Annual distribution of BU cases and incidence in the district of Tiassalé, south Côte d'Ivoire, stratified by sub-prefecture and village in the period 2005–2010.

Sub-prefecture	Village	2006			2007			2008			2009			2010		
		BU cases (incidence/100,000 inhabitants)	Incidence 95% CI	BU cases (incidence/100,000 inhabitants)	Incidence 95% CI	BU cases (incidence/100,000 inhabitants)	Incidence 95% CI	BU cases (incidence/100,000 inhabitants)	Incidence 95% CI	BU cases (incidence/100,000 inhabitants)	Incidence 95% CI	BU cases (incidence/100,000 inhabitants)	Incidence 95% CI	BU cases (incidence/100,000 inhabitants)	Incidence 95% CI	
Taabo	Ahéremou	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	3 (71.8)	(14.8–209.6)	0 (0.0)	–	
	Ahondo	8 (133.9)	(57.9–263.8)	31 (560.9)	(381.4–795.2)	25 (389.0)	(251.9–573.7)	24 (356.0)	(228.2–529.2)	29 (340.7)	(228.3–488.9)	29 (340.7)	(228.3–488.9)	23 (262.9)	(166.7–394.2)	
	Koniéssou	18 (397.4)	(235.7–627.4)	3 (76.6)	(15.8–223.7)	2 (40.9)	(0.0–147.8)	3 (59.0)	(12.2–172.2)	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	
	Léfiébé	35 (805.9)	(562.0–1,119.0)	29 (781.7)	(524.1–1,121.0)	26 (545.1)	(356.4–797.6)	35 (717.9)	(500.6–997.1)	45 (675.9)	(493.4–903.3)	45 (675.9)	(493.4–903.3)	55 (805.4)	(607.3–1,047.0)	
	Pacobo	2 (15.2)	(0.0–54.8)	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	
	Sokrogbo	28 (247.6)	(164.6–357.6)	41 (357.1)	(256.4–482.2)	35 (279.1)	(194.5–387.9)	48 (373.2)	(275.3–494.5)	40 (431.6)	(308.5–587.2)	40 (431.6)	(308.5–587.2)	39 (406.5)	(289.2–555.3)	
	Taabo	41 (378.9)	(272.1–513.8)	35 (320.1)	(223.1–444.9)	30 (255.7)	(172.6–364.8)	21 (170.7)	(105.7–260.9)	10 (70.3)	(33.7–129.3)	10 (70.3)	(33.7–129.3)	9 (62.2)	(28.5–118.1)	
	Affikro	3 (28.6)	(0.0–83.5)	9 (85.1)	(38.9–161.6)	7 (60.2)	(24.2–124.1)	4 (33.5)	(0.0–85.9)	6 (43.5)	(16.0–94.6)	6 (43.5)	(16.0–94.6)	10 (71.0)	(34.1–130.6)	
Tiassalé	Attiguéhi	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	1 (10.9)	(0.0–60.8)	0 (0.0)	–	
	Binao	2 (16.6)	(0.0–59.9)	1 (8.1)	(0.0–45.2)	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	1 (10.9)	(0.0–60.8)	0 (0.0)	–	
	Bodo	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	
	Broubrou	1 (10.4)	(0.0–57.8)	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	1 (17.2)	(0.0–95.6)	2 (33.0)	(0.0–119.2)	
	Kondiébouma	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	0 (0.0)	–	
	Morokro	20 (147.4)	(90.0–227.5)	13 (92.9)	(49.5–158.7)	9 (60.3)	(27.6–114.5)	15 (99.3)	(55.6–163.6)	48 (279.8)	(206.4–370.8)	10 (65.4)	(31.4–120.2)	8 (50.7)	(21.9–99.8)	
	N'Douci	2 (5.9)	(0.0–21.5)	0 (0.0)	–	0 (0.0)	–	8 (34.5)	(0.0–41.0)	14 (34.5)	(18.9–58.0)	48 (279.8)	(206.4–370.8)	17 (96.0)	(56.0–153.7)	
	N'Zianouan	32 (195.4)	(133.7–275.7)	9 (52.5)	(24.0–99.7)	4 (22.2)	(0.0–56.8)	14 (75.8)	(41.5–127.1)	28 (136.7)	(90.8–197.5)	28 (136.7)	(90.8–197.5)	10 (47.6)	(22.8–87.5)	
Tiassalé	7 (20.7)	(0.0–42.6)	0 (0.0)	–	0 (0.0)	–	3 (7.8)	(0.0–22.8)	5 (14.9)	(0.0–34.7)	5 (14.9)	(0.0–34.7)	2 (5.8)	(0.0–20.9)		
BU cases and incidence	199 (96.8)	(83.8–111.2)	171 (81.4)	(69.7–94.6)	138 (59.6)	(50.1–70.4)	186 (78.0)	(67.3–90.1)	259 (105.7)	(93.3–119.4)	259 (105.7)	(93.3–119.4)	192 (76.2)	(65.9–87.9)		

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