A Mixed Outbreak of Epidemic Typhus Fever and Trench Fever in a Youth Rehabilitation Center: Risk Factors for Illness from a Case-Control Study, Rwanda, 2012

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Abstract. In August 2012, laboratory tests confirmed a mixed outbreak of epidemic typhus fever and trench fever in a male youth rehabilitation center in western Rwanda. Seventy-six suspected cases and 118 controls were enrolled into an unmatched case-control study to identify risk factors for symptomatic illness during the outbreak. A suspected case was fever or history of fever, from April 2012, in a resident of the rehabilitation center. In total, 199 suspected cases from a population of 1,910 male youth (attack rate = 10.4%) with seven deaths (case fatality rate = 3.5%) were reported. After multivariate analysis, history of seeing lice in clothing (adjusted odds ratio [aOR] = 2.6, 95% confidence interval [CI] = 1.1–5.8), delayed (≥ 2 days) washing of clothing (aOR = 4.0, 95% CI = 1.6–9.6), and delayed (≥ 1 month) washing of beddings (aOR = 4.6, 95% CI = 2.0–11) were associated with illness, whereas having stayed in the rehabilitation camp for ≥ 6 months was protective (aOR = 0.20, 95% CI = 0.10–0.40). Stronger surveillance and improvements in hygiene could prevent future outbreaks.

INTRODUCTION

Epidemic typhus fever is a disease caused by *Rickettsia prowazekii*. It is usually spread through an arthropod, typically the human body louse.¹ Human body lice transmit when they feed on the blood of an infected host. People become infected when infected lice feces or crushed infected body lice infect broken skin, such as those caused by scratching the bite.² It is the infected feces, not the bite of the louse that spreads illness to humans, and the feces of arthropods can remain infectious for months.^{3,4} Because body lice are also vectors for *Bartonella quintana*, outbreaks of epidemic typhus associated with trench fever may occur in similar settings.^{4,5} Epidemic typhus occurs most commonly among people living in overcrowded settings with suboptimal hygiene conditions.^{6,7} The most affected populations are those living in impoverished conditions, areas of war or natural disasters, refugee camps, and areas with colder mountainous regions.^{4,8}

Epidemic typhus is rare but severe when it occurs. Globally, more than 1 million cases occur annually with a case fatality ratio ranging from 10% to 40% where treatment is not available. The clinical course of treatment ranges between 10 and 28 days.^{5,6} Epidemic typhus is characterized by high fever, severe headache, cough, severe muscle pain, rash, chills, low blood pressure, a high sensitivity to light, delirium, and coma in advanced stage.⁷ It can be confused with severe malaria, leptospirosis, and other infectious diseases that cause high fever. Delays in diagnosis are common, mainly due to

limited surveillance and diagnostic resources where endemic typhus occurs.⁸

In mid-August 2012, the Rwanda Ministry of Health (MoH) was notified of an increase of cases of an unknown febrile illness among residents of a youth rehabilitation center in western Rwanda. Initial laboratory investigations conducted at the local district hospital and the national reference laboratories ruled out common etiologies for fever including malaria and typhoid. Subsequent tests conducted in Centers for Disease Control and Prevention (CDC) reference laboratories within 2 weeks after initial notification suggested epidemic typhus.

After the notification, the MoH deployed multidisciplinary teams to conduct investigations and support the outbreak response including epidemiologic and environmental assessments. This article describes the epidemiology of the outbreak and presents the risk factors for illness from a case-control study that was conducted during this response.

MATERIALS AND METHODS

Setting. Iwawa Youth Rehabilitation and Vocational Center is located in an island in Lake Kivu in western Rwanda. It is home to 1,910 male residents, mostly between 16 and 30 years of age. It was established in 2009 to support the rehabilitation of young drug addicts and promote their learning of skills and competencies in craftsmanship. The center is currently overcrowded with most of the youth sharing beds or mattresses meant for one person. Each of the nine halls hosts approximately 250 youth, nearly twice the ideal number.

Case definition and case detection. A case was defined as fever or history of fever from April 1, 2012, not due to confirmed malaria or other common causes of febrile illness in a resident of the rehabilitation center. Common causes of fever

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like malaria, typhoid, meningitis, and pneumonia were ruled out through clinical evaluation and routine laboratory tests. A confirmed case was a suspected case with whole blood or serum specimen that was positive for *R. prowazekii* and/or *B. quintana* through serology or polymerase chain reaction (PCR). Case finding was conducted through interviews with health workers and review of medical records and registers at the two health facilities that provide health care to the center's residents. During the outbreak, a standard line-listing form was used to collect data on demographics, symptoms, and date of onset of illness of the patients. All patients were treated presumptively with doxycycline.

Laboratory investigations. Whole blood and serum samples were collected from the patients for full blood counts, clinical chemistry such as liver and renal tests, total protein, and amylase. Malaria blood smears were collected to rule out malaria. Twenty-three sets of acute and convalescent sera from 21 surviving suspected case patients were sent to reference laboratories (CDC-KEMRI Nairobi, CDC-Atlanta) to test for multiple pathogens (including arboviruses, *Brucella*, *Bartonella*, *Leptospira*, and *Rickettsia*) using serology, molecular tests, and indirect immunofluorescence assays (IFAs). Blood samples were considered confirmed if positive for one or more of the specific pathogen(s) by real-time PCR, DNA sequencing of nested PCR products, or by 4-fold change in IgG titers by IFA in paired sera. Patients with positive IgG titers (1:64), but with a less than 4-fold change in IgG titers, were considered probable cases.

Case-control study. An unmatched case-control study was conducted during September 2–7, 2012. In addition to all the 21 patients from whom acute and convalescent sera had been collected, a random sample of suspected case patients occurring after April 1, 2012, was enrolled as cases. Controls were randomly selected from the pool of residents of the youth rehabilitation center who had no history of fever during the period of reference (April 1–August 31, 2012). Random selection of cases and controls was conducted from spreadsheets of eligible participants using computer-generated random algorithms. A sample size of 70 cases and 140 controls was targeted based on the following assumptions: alpha of 5%; 80% power, with assignment of two controls per case.

A structured questionnaire was used to collect data on demographics, signs and symptoms, and potential exposures. Additional clinical information was obtained from treatment registers.

Data analyses were carried out using STATA version 11 (Copyright 1984–2007 StataCorp, College Station, TX). Descriptive statistics are displayed as proportions and frequencies. Bivariate analysis was conducted to assess the association between suspected cases and potential exposures (environmental and behavioral) and case status. Variables with *P* values below 0.1 at bivariate level were included in a multivariate analysis model, and backward elimination was used to identify the independent risk factors for illness. A final parsimonious model showing the significant associations at the multivariate level, with adjusted odds ratios (aOR) and 95% confidence intervals (CI) was obtained.

Ethical considerations. Informed consent was obtained from all human study participants. The protocol for this study was approved as human subjects' research by the University of Rwanda, College of Medicine and Health Sciences, School of Public Health Institutional Review Board.

RESULTS

Descriptive epidemiology. A total of 199 suspected cases were reported from a population of 1,910 male youth (attack rate = 10%) from April to August 2012. Overall, 68% of the suspected cases were 21–30 years of age. Seven deaths (case fatality rate = 3.5%) were reported. All seven deaths were preceded by coma and occurred within the first 48 hours of admission, before the etiology of the outbreak had been confirmed. The outbreak rose to a peak of 21 cases during the week ending August 19, 2012, and then declined (Figure 1).

Among the 76 cases in the case-control study for whom more detailed clinical information was available, all (100%) presented with fever or history of fever. Other major symptoms reported included joint and muscle pains (55%), headache (47%), weight loss (46%), abdominal pain (43%), and chest pains (34%). Only 26% of the cases had a skin rash.

The initial biochemistry results of tests conducted at the district hospital (primary facility of care) showed hypoglycemia, high urea and creatinine levels, and high transaminases levels. The malaria blood smear was negative for all tested patients and white blood cell count was normal. Samples that were sent to CDC-Kenya and tested for dengue, yellow fever, Rift Valley fever, chikungunya, and O'nyong nyong virus were negative. After these negative tests, specimens were sent to CDC-Atlanta for additional testing. Results on specimens from 21 patients (23 specimens in total) were as follows: 19% (4/21) were confirmed *R. prowazekii*, 14% (3/21) confirmed mixed *R. prowazekii* and *B. quintana*, 5% (1/21) confirmed *R. prowazekii* and probable *Bartonella* group, 14% (3/21) probable *Bartonella* group, and 5% (1/21) probable typhus group. Samples from eight patients (38%) were probable for both typhus and *Bartonella* groups, and only one (5%) was negative for either *Rickettsia* or *Bartonella*. All other tests for arboviruses, leptospirosis, brucellosis, and typhoid were negative.

Case-control study. Seventy-six suspected cases (including eight confirmed to have epidemic typhus only, and three confirmed to have both epidemic typhus and trench fever) and 118 controls were included in the case-control study. Fifty (66%) cases and 76 (64%) controls were 20 and 29 years of age. Thirty-one (41%) of the cases and 82 (70%) of the controls had lived in the camp for more than 6 months. There were no statistically significant differences in the ages of and educational levels attained by case patients and controls (Table 1).

FIGURE 1. Incident cases of acute febrile illness during a mixed outbreak of epidemic typhus fever and trench fever by "week ending" in a youth rehabilitation center in western Rwanda, 2012.

TABLE 1

Bivariate and multivariate analysis of risk factors for acute febrile illness from a case control study of 76 cases and 118 controls during a mixed outbreak of epidemic typhus fever and trench fever in a youth rehabilitation center in western Rwanda, 2012

Variable	Cases (N = 76)		Controls (N = 118)		Bivariate analysis		Multivariate analysis	
	n	%	n	%	Crude OR	95% CI	aOR	95% CI
Age*								
10–19	10	13	18	15	1.1	0.34–3.65	–	–
20–29	50	66	76	61	1.3	0.55–3.19	–	–
30 and above	11	15	22	19	Ref.	–	–	–
Education level*								
No formal education	63	83	97	82	1.0	0.44–2.31	–	–
Completed primary school or higher	13	17	20	17	Ref.	–	–	–
Duration in the youth rehabilitation center								
Spent 6 months or more in the camp	31	41	82	70	0.3	0.16–0.55	0.15	0.06–0.37
Infestation								
History of seeing lice on clothing	62	82	67	57	3.17	1.6–6.3	2.6	1.1–5.8
History of being bitten by rats	25	33	12	10	4.46	1.9–6.7	–	–
Hygiene								
Delayed washing of clothing (≥ 2 days)	64	84	81	69	4.55	2.4–8.7	4.0	1.6–9.6
Sleeping on a mattress on the floor	59	78	51	43	1.7	0.92–3.2	–	–
Delayed washing of beddings (≥ 1 month)	54	71	69	59	5.39	2.9–10	4.6	2.0–11
Itching	50	66	31	26	3.18	1.5–6.7	–	–
Taking a bath irregularly	23	30	16	14	1.03	0.35–3.0	–	–
Bed sharing								
Two persons sleeping on the same bed/mattress	46	61	70	59	1.23	0.48–3.1	–	–
More than three persons sleeping on the same bed/mattress	12	16	13	11	1.73	0.54–5.6	–	–
BMI								
Lean BMI < 18.5	25	21	41	34	3.81	2.0–7.3	–	–
Overweight $25 \leq \text{BMI} \leq 30$	14	12	1	1.3	0.16	0.02–1.3	–	–

aOR = adjusted odds ratio; BMI = body mass index; CI = confidence interval; OR = odds ratio; Ref. = reference.

*There was nonresponse on age for five cases and two controls, and on education level for one control.

In bivariate analysis, case patients were more likely to report history of seeing lice in their clothing (odds ratio [OR] = 3.24, 95% CI = 1.6–6.3), being bitten by a rat (OR = 4.5, 95% CI = 1.9–6.7), washing clothes after 2 days or less frequently (OR = 4.6, 95% CI = 2.4–8.7), washing beddings once a month or less frequently (OR = 5.4, 95% CI = 2.9–10.1), and having a body mass index < 18.5 (OR = 3.8, 95% CI = 2.0–7.3).

After multivariate analysis, the following demographic, behavioral, and environmental factors were independently associated with symptomatic illness (Table 1): history of seeing lice in clothing (aOR = 2.6, 95% CI = 1.1–5.8), washing clothes after 2 days or less frequently (aOR = 4.0, 95% CI = 1.6–9.6), and washing beddings once a month or less frequently (aOR = 4.6, 95% CI = 2.0–11). Having stayed in the rehabilitation camp for at least 6 months (aOR = 0.15, 95% CI = 0.06–0.37) was protective.

DISCUSSION

Although epidemic typhus fever outbreaks have previously been reported in the African Great Lakes region,^{4,8–10} this article describes the epidemiology of the first outbreak reported in Rwanda after nearly 20 years. It is also the first time an outbreak of epidemic typhus associated with trench fever has been confirmed in Rwanda. However, it is probable that the detection of this outbreak may have been in part due to the improvement of infectious disease surveillance capacities that have occurred in Rwanda during the last 6 years, and not necessarily due to nonoccurrence of similar outbreaks in the past. Laboratory tests of specimens from 21 patients confirmed single or mixed infections with epidemic typhus or trench fever with only one specimen con-

sidered negative. The occurrence of the mixed outbreak in a youth rehabilitation center in western Rwanda showed the vulnerability of residents in such settings to louse-borne infections. This outbreak resulted in nearly 200 cases of significant illness (attack rate of 10%) and seven deaths over a 5-month period from a population of 1,910 residents. Given that case detection was likely less than 100%, the true caseload may have been higher than this. The absence of reported epidemic typhus in Rwanda for nearly 20 years and the nonspecific symptoms and weaknesses in diagnostic capabilities probably contributed to the delay in confirmation of the outbreak. Differentiating clinical signs of epidemic typhus from other febrile illnesses is difficult. Although previous clinical studies have identified a rash in over 50% of cases,⁶ only about a quarter of the patients presented with a rash during this outbreak, highlighting the limited value of the rash in enhancing clinical suspicion. All seven reported deaths occurred earlier in the outbreak. Once epidemic typhus was suspected, doxycycline was used to presumptively treat symptomatic patients, and a single prophylactic dose was given to the residents of the rehabilitation center. Other interventions that were implemented included delousing with insecticides and disinfection of bedding and clothing. The precipitous reduction in cases was more suggestive of disruption of transmission rather than depletion of susceptible persons. The outbreak therefore highlighted the need for greater awareness about the susceptibility of residents in similar settings to louse-borne illnesses, and the effectiveness of known intervention measures. A cluster of patients presenting with fever of unknown etiology in congregate settings should raise the possibility of louse-borne infections.

The risk factors for illness identified during this outbreak were mainly related to weaknesses in personal hygiene. Case

patients were more likely to report history of lice infestation and infrequent washing of their clothes and beddings. Louse infestation has been documented to occur mainly in environments associated with overcrowding and poor hygiene.^{9,10} Critical social conditions have been shown to be among the main factors influencing the reemergence of epidemic typhus.^{11,12} This was probably the case for the youth rehabilitation center in western Rwanda. Environmental assessments carried out during the outbreak response revealed evidence of poor hygiene and infestation of lice in the clothing and bedding of the residents in the camp.

People who had been in the camp for more than 6 months were less likely to have become ill during the outbreak. One hypothesis could be that the youth who had been in the camp longer may have developed immunity from exposure before the outbreak. Another hypothesis is that the new residents may have entered the camp already infected with lice, since many of them were living on the street in conditions with compromised hygiene. This would emphasize the need to conduct screening of incoming residents for lice infestation and providing appropriate delousing.

Brill-Zinsser disease is a recrudescence form of *R. prowazekii* infection that can occur years after an untreated or subclinical epidemic typhus fever.^{5,13} The outbreak of epidemic typhus fever therefore points to the need for a high index of suspicion for Brill-Zinsser disease in patients presenting with undifferentiated fever who may have lived in settings with a high risk of exposure to *R. prowazekii* in Rwanda. Although unrelated to louse infestation, such recrudescence cases can potentially act as foci for new epidemic typhus fever outbreaks in settings favorable for louse infestation.

In addition to the difficulties in precisely assessing the hygiene practices and vector infestation by interview, limitations of the study included difficulties in establishing a temporal link between exposures and case classification, since the study was conducted 16 weeks after the first recognized case. In addition, laboratory testing was not conducted for all study participants. The possibility of some of the controls having subclinical disease or noncases meeting the case definition may have resulted in misclassification in the case-control study. Despite these limitations, this study provided vital evidence that linked weaknesses in individual hygiene practices to symptomatic illness during a mixed outbreak of epidemic typhus and trench fever.

In conclusion, this outbreak caused morbidity and mortality in a youth rehabilitation center. Challenges in clinical case identification and laboratory diagnosis may have contributed to the delayed detection of the outbreak, thereby compromising the timely initiation of effective interventions. The outbreak was most likely exacerbated by less than adequate hygiene and sanitation in the rehabilitation center. Because of the potential risk in similar settings, suspicion and surveillance for louse-borne infections should be heightened in similar settings. Continuous measures should be carried out to promote hygiene and environmental sanitation in communal residential settings.

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