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Who Stays and Who Goes: Predictors of Admission among Patients Presenting with Febrile Illness and a Positive Malaria Rapid Diagnostic Test in a Rural Ugandan Health Center

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Abstract. Not much is known about clinical decision-making in rural, low-resource settings regarding fever, a common reason for presentation to care. In this prospective cohort study of patients presenting with febrile illness to a rural Ugandan health center, we examined demographic and clinical factors predictive of an initial disposition of inpatient admission after clinical evaluation, but before laboratory testing. We then assessed the association of laboratory results and system factors with a change between initial and final disposition plans. Four thousand nine hundred twenty-four patients with suspected febrile illness were included in the primary analysis. The strongest predictors for an initial disposition of admission after clinical examination were impaired consciousness (adjusted risk ratio [aRR], 3.21; 95% confidence interval [CI]: 2.44–4.21) and fever on examination (aRR, 2.27; 95% CI: 1.79–2.87). Providers initially planned to discharge patients with significant vital sign abnormalities, including tachypnea (3.6%) and hypotension (1.3%). Anemia strongly predicted a final disposition of admission after an initial disposition of discharge (aRR, 48.34; 95% CI: 24.22–96.49); other laboratory abnormalities, including hypoglycemia and acidosis, did not change disposition planning. In those with an initial disposition of admission, living farther than the two neighboring villages was associated with a final disposition of discharge (aRR, 2.12; 95% CI: 1.10–4.12). A concerning number of patients with abnormal vital signs and laboratory results were not admitted for inpatient care. Geographic factors may influence a patient's final disposition contrary to a provider's initial disposition plan. Future work should assess longer term outcomes after discharge and a broader study population.

INTRODUCTION

Acute febrile illness is a common reason patients seek care at peripheral health facilities in sub-Saharan Africa.[1–3] The etiology of fever is varied, including malaria, respiratory tract infections, bacterial meningitis, HIV-related opportunistic infections, and enteric fever.[4–6] Although it is often difficult to distinguish between these conditions in a setting with limited diagnostic laboratory capability, an accurate diagnosis is critical to ensure proper and timely treatment.

One major advance has been the development and widespread deployment of malaria rapid diagnostic tests (RDTs).[7,8] Compared with light microscopy, RDTs require little laboratory infrastructure and can be quickly performed by nonprofessional health-care staff.[9] However, a positive RDT simply reflects the presence of a malaria antigen in a patient's blood and, by itself, cannot distinguish between an asymptomatic, uncomplicated, severe, or recently cleared malarial infection,[10,11] each scenario necessitating a different treatment and disposition plan. Despite the existence of clinical criteria[12] intended to facilitate recognition of severe malaria in settings with limited laboratory capability, assessment still requires physical examination and clinical reasoning skills that nonphysician providers who staff peripheral health centers may lack.[13,14]

Better understanding of the clinical decision-making process regarding febrile illness at peripheral health facilities can inform the design of targeted training programs and system-based interventions aimed at improving short-term health outcomes, following a clinical encounter. We used data from a prospective cohort study of severe malaria to determine the demographic, clinical, laboratory, and system factors associated with admission decisions at a peripheral health center in rural western Uganda. We investigated three distinct components of the outpatient visit. First, we explored the demographic and clinical factors associated with the planned disposition following the initial patient encounter but before laboratory testing. Second, we examined the association between laboratory test results and a change in disposition among those with a positive histidine-rich protein 2 (HRP2) RDT. Finally, we explored what factors were associated with a final disposition of discharge among patients meeting a modified systemic inflammatory response syndrome (SIRS) criteria.

MATERIALS AND METHODS

Setting. Bugoye Health Center is a rural level III health center located in the Kasese District of Uganda (Figure 1). Its catchment area includes the 50,000 residents of Bugoye subcounty and many residents of the neighboring Maliba subcounty. The health center has both inpatient and outpatient departments staffed by clinical officers and nurses. Clinical officers have undergone 3 years of medical post-secondary training and 2 years of medical internship. There are no physicians at level III health centers in Uganda. Bugoye experiences year-round malaria transmission with semiannual peaks at the end of rainy seasons. The two most recent malaria indicator surveys in the region estimated a decline in the prevalence of parasitemia from 48.4% to 17.6% from 2009 to 2014.[15,16]

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Study design. The RDTs for severe malaria study was a prospective cohort study that enrolled patients of all ages presenting to a rural primary health center with suspected febrile illness from May to November 2015. Full details of the study design have been published elsewhere.[13] Briefly, individuals presenting to the outpatient department with a reported history of fever, fever at the time of presentation (axillary temperature ≥ 38°C), or other symptoms suspicious for malaria as determined by the attendant provider were eligible for inclusion. Study staff recorded demographic information, clinical history, and vital signs using study-specific encounter forms. Health facility staff then performed clinical evaluations of all patients guided by local protocols, which are generally patterned after Uganda Clinical Guidelines. At this point, providers were asked to record initial disposition plans (i.e., discharge, admit, or refer) assuming a malaria RDT was going to be positive. Individuals were then referred to the health center laboratory, where an RDT was performed. Individuals with a positive RDT result underwent further laboratory evaluation as shown in Supplemental Appendix Figure 1.[12] The provider was informed of the laboratory results, and the final disposition plan of the patient was recorded. Of the laboratory tests, only RDTs, hemoglobin, and urine dipstick testing are routinely available at the health center. For the other tests, study staff led a 3-day training course before study implementation. All staff were also provided with a laminated reference copy of normal values.

Rapid diagnostic test, microscopy, and laboratory tests. We used the 05FK60 Malaria Ag P.f/Pan assay (Standard Diagnostics, Hagal-Dong, Korea) to assess for RDT positivity. Individuals with a negative RDT did not undergo microscopy, except for 15% of individuals who underwent microscopy for the purpose of quality control. Smears were fixed with methanol and stained in 10% Giemsa. Microscopists who had undergone validation testing (Shoklo Malaria Research Unit) and were blinded to the RDT results reviewed all slides in accordance with World Health Organization or Tropical Disease Research guidelines.[5] Two independent microscopists read all slides. A third, senior microscopist reviewed slides when there were discrepancies between the first two reads in the presence of parasitemia, species identification, or differences (> 10%) in parasite density. Dried blood spots were obtained from a subset of participants over a 1-month period, and real-time polymerase chain reaction was performed to assess the accuracy of microscopy.[6]

Hemoglobin levels were measured using the Hemocue Hb 201+ analyzer (Hemocue, Brea, CA), whereas serum chemistry and venous blood gas values were obtained using the Abbott iStat analyzer (Abbott Laboratories, Princeton, NJ) with the CHEM8+ and CG4+ cartridges. Estimates of hemoglobinuria were made using a UroColor 11 dipstick urinalysis assay (Standard Diagnostics). All point-of-care tests were calibrated daily by study staff and performed in accordance with the manufacturers' instructions.

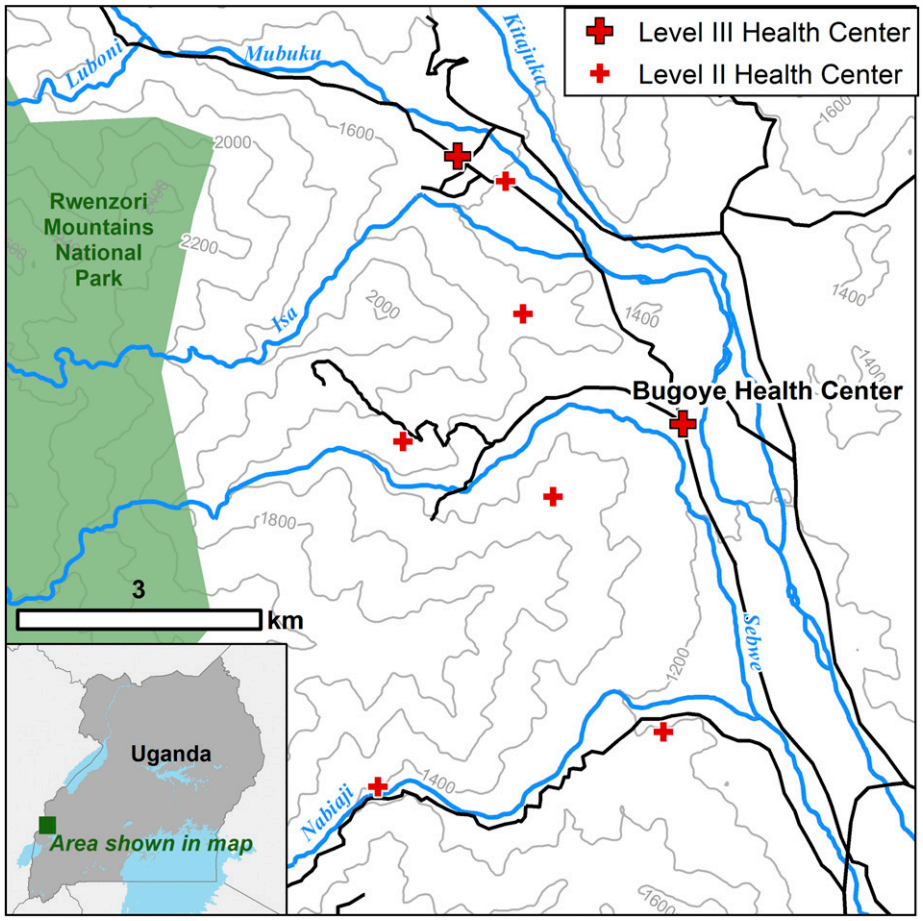

FIGURE 1. Bugoye Health Center and surrounding region. This figure appears in color at www.ajtmh.org.

Variable definitions. Our outcomes of interest were the initial and final disposition plans as recorded by the attendant provider (i.e., the disposition plans before and after laboratory evaluation, respectively). We treated referrals as admissions, as it communicated a perceived need for higher level care. Table 1 displays age-specific definitions of physical examination findings, laboratory abnormalities, and the modified SIRS criteria. Subjective fever was defined as self-reported fever or that reported by a guardian. The rainy season was defined as the months of May, September, October, and November and the dry season as June, July, and August. Clinic census was defined as the number of patients enrolled in the study for that day. We stratified patient's self-reported home village into three categories: those from Bugoye and Kanyamigho (where the health center is located), other villages ≤ 2 kilometers (km) from the health center, and villages > 2 km from the health center, where the elevation begins to rapidly increase.

Statistical analyses. We calculated summary statistics for the study cohort stratified by the initial disposition of discharge versus admission. We compared variables across the two strata using Wilcoxon rank-sum tests for continuous variables; Pearson's, χ^2 and Fisher's exact tests for binary variables; and Kruskal–Wallis tests for variables with three or more categories. For our primary analysis, we fit univariable and multivariable modified Poisson regression models[17] to estimate associations between an initial disposition of admission with demographic, clinical, and system-level covariates. To assess for potential overadjustment, we conducted sensitivity analyses excluding covariates that could be potential mediators for exposures of interest based on a priori knowledge. We also conducted adjusted stratified analyses by categories of age (< 5 years, 5–15 years, and > 15 years).

To explore laboratory and system factors associated with a change in the initial disposition plan, we fit univariable and multivariable modified Poisson regression models to estimate the association between laboratory and system-level covariates (home village location, day of week seen, and clinic census) and a final disposition of admission, restricted to those with an initial disposition of discharge. We included in the multivariable model all covariates that reached a significance of $P = 0.20$ in the univariable models, additionally adjusting for age and gender. We fit similar univariable and multivariable models for a change from an initial disposition of admission to a final disposition of discharge.

Finally, we fit univariable and multivariable modified Poisson regression models for final disposition, restricted to those meeting the modified SIRS criteria, and in a subanalysis, additionally restricting to those less than 15 years old. Covariates were included in the multivariable model if they reached a significance of $P = 0.20$ in univariable models. We did not consider fever on examination, tachycardia, or tachypnea for inclusion, as they are components of the modified SIRS criteria. To assess the effect of missing outcome data, we calculated summary statistics for the whole cohort stratified by missingness of provider's initial plan and statistics stratified by missingness of final patient disposition, restricted to those who were RDT+ and having nonmissing data for their provider's initial plan. We performed all analyses using Stata SE version 14.2 (StataCorp, College Station, TX).

Ethics approval or role of funding sources. The institutional review boards of the University of North Carolina at Chapel Hill, the Mbarara University of Science and Technology, and the Uganda National Council for Science and Technology approved the study. We obtained written informed consent from all study participants. Funding sources had no role in the design, execution, analysis, or submission of the study.

TABLE 1
Definitions of physical examination and laboratory findings

Variable	Definition
Fever on exam	Axillary temperature ≥ 38°C
Tachycardia	Participants aged < 18 years: age-specific SIRS definitions of tachycardia[32] Participants aged ≥ 18 years: resting heart rate > 100 beats/minute
Hypotension	Systolic blood pressure < 70 mm of Hg
Hypoxia	SpO_2 < 92%
Tachypnea	Participants aged < 1 years: ≥ 50 breaths/minute Participants aged ≥ 1 and < 5 years: ≥ 40 breaths/minute Participants aged ≥ 5 years: ≥ 30 breaths/minute
Impaired consciousness	Participants aged < 5 years: Blantyre coma scale score < 5 Participants aged ≥ 5 years: Glasgow coma scale score < 15
Positive RDT	RDT was considered positive if the HRP2 band was positive RDT was considered "dual band" positive if both the HRP2 and *Plasmodium* lactate dehydrogenase bands were positive
Anemia	Participants aged < 12 years: hemoglobin ≤ 5 g/dL Participants ≥ 12 years: hemoglobin ≤ 7 g/dL
Hyponatremia	Serum sodium < 130 mmol/L
Hyperkalemia	Serum potassium ≥ 5 mmol/L
Hypoglycemia	Serum glucose ≤ 40 mg/dL
Hyperlactatemia	Serum lactate > 5 mmol/L
Acidosis	Serum bicarbonate ≤ 15 mmol/L
Proteinuria	1 + or greater on dipstick (≥ 30 mg/dL)
Hematuria	4 + on dipstick (≥ 250 red blood cells/μL)
Modified SIRS criteria	A participant aged < 18 years was considered to have SIRS if they met two of the following three criteria (must have the first criteria): 1. Axillary temperature > 38.5°C or < 36°C 2. High respiratory rate, based on age-related SIRS cutoffs[32] 3. High or low heart rate, based on age-related SIRS cutoffs[32] A participant aged ≥ 18 years was considered to have SIRS if they met two of the following three criteria: 1. Axillary temperature > 38°C or < 36°C 2. Respiratory rate > 20 breaths/minute) 3. Heart rate > 90 beats/minute
Severe malaria	As defined by the WHO criteria for severe malaria for research and epidemiological studies[12] and described in a previous study[24]

dL = deciliter; g = gram; HRP2 = histidine-rich protein 2; L = liter; mg = milligram; mm of Hg = millimeters mercury; mmol = millimole; RDT = rapid diagnostic test; SIRS = systemic inflammatory response syndrome; SpO_2 = peripheral capillary oxygen saturation; μL = microliter.

RESULTS

Over the six-month study period, 6,681 patients were enrolled (Figure 2). Of these, 4,924 (73.7%) patients had a recorded disposition plan and were included in the primary analysis.

Of these, 2,881 (60.4%) were female and the median age was 13 (interquartile range, 6–26). There were 969 (19.7%) patients younger than 5 years, 1,766 (35.9%) between 5 and 15 years, and 2,189 (44.5%) older than 15 years.

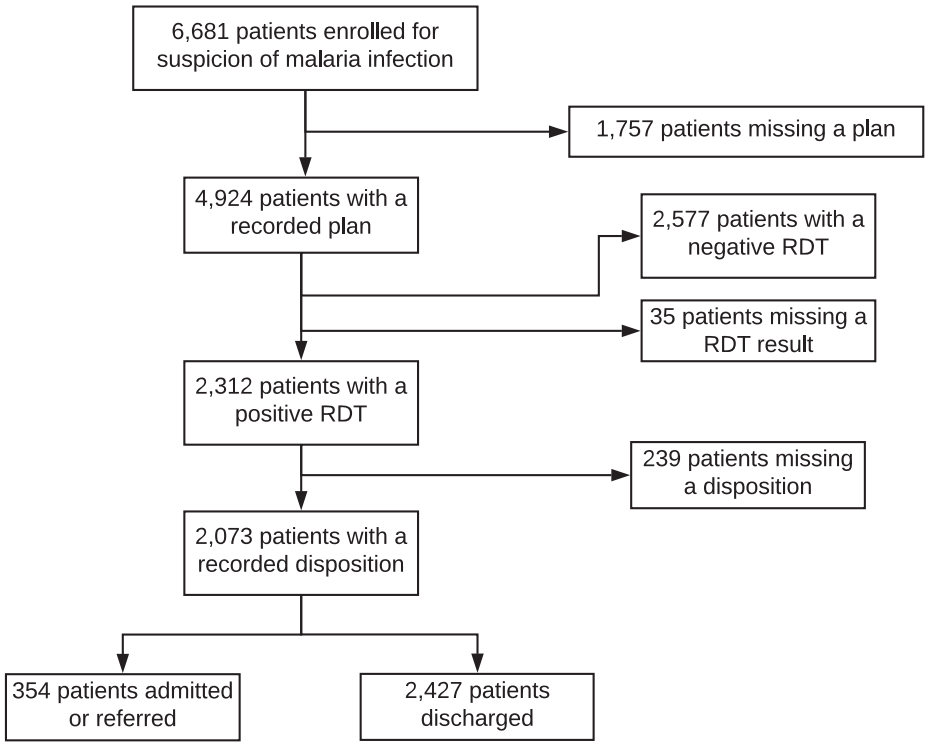

FIGURE 2. Flow diagram for selection of cohort for analysis. This figure appears in color at www.ajtmh.org.

Approximately half (2,312 of 4,924; 47.0%) had a positive malaria HRP2 + RDT result, of which 1,454 (70.8%) of the 2,053 participants with microscopy data had microscopy-confirmed *Plasmodium falciparum* parasitemia and 2,073 (90.0%) had a final disposition recorded. Of the 2,073 patients with a recorded final disposition, 354 (17.0%) were admitted or referred.

Predictors of an initial disposition of admission. Providers planned to admit 557 (11.3%) and discharge 4,367 (88.7%) patients after the initial clinical evaluation. Of those planned to be discharged, 604 (14.2%) patients were tachycardic, 54 (1.3%) hypotensive, 146 (3.6%) tachypneic, and 234 (5.5%) hypoxic (Table 2).

In adjusted models, covariates associated with a planned admission included impaired consciousness (adjusted risk ratio [aRR], 3.21; 95% confidence interval [CI]: 2.44–4.21; Table 3), fever on examination (aRR, 2.27; 95% CI: 1.79–2.87), a history of seizure (aRR, 1.96; 95% CI: 1.20–3.20), tachycardia (aRR, 1.50; 95% CI: 1.19–1.88), tachyphnea (aRR, 1.43; 95% CI: 1.05–1.96), and hypoxia (aRR, 1.36; 95% CI: 1.02–1.81).

Presenting to the health center on Friday, Saturday, or Sunday was inversely associated with a plan to admit (aRR, 0.72; 95% CI: 0.52–1.00). A history of cough was also inversely associated with a plan to admit (aRR, 0.70; 95% CI: 0.58–0.86), a finding that was most pronounced among adults (aRR, 0.51; 95% CI: 0.33–0.79; Supplemental Appendix Table 1). We did not observe an association between hypotension and admission plan (aRR, 1.10; 95% CI: 0.59–2.06); however, in age-stratified analyses, hypotension strongly predicted admission plan in 5- to 15-year-old patients (aRR, 2.77; 95% CI: 1.30–5.92; Supplemental Appendix Table 1). Estimates from the primary model remained qualitatively similar in sensitivity analyses, excluding covariates that were potential mediators (Supplemental Appendix Table 2).

Predictors of a change from an initial disposition of discharge to a final disposition of admission. Providers changed the disposition plan from discharge to admission in 110 (7.0%) of the 1,582 RDT+ patients following laboratory testing (Supplemental Appendix Table 3). In adjusted analyses restricted to those with an initial plan to discharge, anemia was very strongly associated with predicted admission of the patient (aRR, 48.34; 95% CI: 24.22–96.49; Table 4). When the adjusted analysis was modeled with hemoglobin level as a continuous variable, every 2 g/dL decrease in hemoglobin was associated with a 50% increase in the relative risk of admission (aRR, 1.50; 95% CI: 1.23–1.82). The presence of both HRP2 and *Plasmodium* lactate dehydrogenase–positive antigen bands compared with a single HRP2 band (aRR, 2.08; 95% CI: 1.29–3.36) and 1+ proteinuria or greater on dipstick (aRR, 1.86; 95% CI: 1.29–2.68) were also associated with admission. Being seen on a Wednesday, as compared with Monday, was inversely associated with the risk of admission (aRR, 0.54; 95% CI: 0.29–1.01). All 11 patients with hypoglycemia, all seven with acidosis, and 19/22 (86%) with hyperlactatemia were discharged.

Predictors of a change from an initial disposition of admission to a final disposition of discharge. Providers changed the disposition plan from admission to discharge in 86 (34.3%) of the 245 RDT+ patients following laboratory testing. In adjusted analyses restricted to those with a planned admission, a positive dual-band RDT was inversely associated with the final discharge (aRR, 0.62; 95% CI: 0.43–0.89; Table 5). Compared with those living near the health center, patients living in more distant villages had greater than a 2-fold increased risk of discharge (aRR, 2.12; 95% CI: 1.10–4.12 for

TABLE 2
Summary statistics stratified by plan to discharge vs. plan to admit for study population

Variable	Discharge (*N* = 4,367)	Admit/refer (*N* = 557)	*P* value
Age (years), median (IQR)	13 (7, 27)	8 (3, 18)	< 0.001
Female, *n* (%)	2,568 (60.4%)	313 (56.6%)	0.087
Home village, *n* (%)	–	–	0.070
Bugoye or Kanyanamigho	836 (20.7%)	100 (19.6%)	–
Other villages ≤ 2 km away	1,063 (26.4%)	159 (31.2%)	–
Villages > 2 km away	2,132 (52.9%)	251 (49.2%)	–
Day of week seen	–	–	0.14
Monday	1,334 (30.7%)	176 (31.8%)	–
Tuesday	738 (17.0%)	102 (18.4%)	–
Wednesday	807 (18.6%)	95 (17.1%)	–
Thursday	774 (17.8%)	112 (20.2%)	–
Friday/Saturday/Sunday	697 (16.0%)	69 (12.5%)	–
Census, median (IQR)	63 (46, 84)	63 (47, 89)	0.93
Rainy season, *n* (%)	1,596 (36.6%)	199 (35.7%)	0.69
Duration of symptoms (days), median (IQR)	3 (2, 3)	2 (2, 3)	0.11
Symptoms, *n* (%)			
Subjective fever	3,873 (88.7%)	511 (91.7%)	0.030
History of cough	1,973 (45.2%)	226 (40.6%)	0.040
History of rash	123 (2.8%)	12 (2.2%)	0.37
History of rhinorrhea	870 (19.9%)	105 (18.9%)	0.55
History of myalgias	1,111 (25.4%)	115 (20.6%)	0.014
History of diarrhea	473 (10.8%)	78 (14.0%)	0.025
History of seizure	16 (0.4%)	24 (4.3%)	< 0.001
Vital signs, *n* (%)			
Fever on exam	456 (10.9%)	193 (35.9%)	< 0.001
Tachycardia	604 (14.2%)	163 (30.7%)	< 0.001
Hypotension	54 (1.3%)	11 (2.2%)	0.11
Tachypnea	146 (3.6%)	49 (9.9%)	< 0.001
Hypoxia	234 (5.5%)	64 (11.8%)	< 0.001
Impaired consciousness	57 (1.4%)	57 (11.1%)	< 0.001
Severe malaria	55 (1.3%)	35 (6.3%)	< 0.001

IQR = interquartile range; km = kilometer.

villages ≤ 2 km away; aRR, 2.44; 95% CI: 1.27–4.70 for villages > 2 km away). When we used tertiles of motorcycle transportation costs as a surrogate measure of clinic access, we observed no association between costs and discharge ($P > 0.30$; Supplemental Appendix Table 4). A low clinic census was inversely associated with the risk of discharge when compared with the busiest day (aRR, 2.28; 95% CI: 1.56, 3.34).

Predictors of a final disposition of admission in those meeting the modified SIRS criteria. Of the 2,241 RDT+ patients with data for final disposition, 592 (26.4%) met our modified SIRS criteria. Of the 592, 460 (77.7%) were discharged. Of the 460 discharged, 166 (36.3%) were tachycardic, 17 (3.9%) had a high respiratory rate, 28 (6.2%) had hypoxia, and four (0.9%) had hypotension. Seventeen (3.7%) patients had a significant laboratory abnormality (Supplemental Appendix Table 5). In adjusted analyses restricted to those meeting our modified SIRS criteria, living > 2 km away, visiting the clinic on a Wednesday, a history of rash, and a creatinine > 3 mmol/L were significantly associated with increased risk of discharge (Table 6). Decreasing hemoglobin and a dual-band RDT were significantly associated with a decreased risk of discharge.

DISCUSSION

In this large prospective cohort of patients presenting to a rural health center with suspected febrile illness, we found that 1) providers planned to and did discharge patients with concerning vital sign and laboratory abnormalities; 2) certain laboratory findings such as hemoglobin level, a dual-band RDT, and proteinuria influence perceptions of disease severity and change the final disposition plan; and 3) system factors, such as geographic distance to home, day of week seen, and daily clinic census appear to play a role in determining final patient disposition. These data suggest potential areas of intervention and can also inform future system-level policies. To our knowledge, this is the first prospective study to examine nonphysician provider decision-making in a peripheral health center.

Our most notable findings regard the discharge of patients with physiologic abnormalities suggestive of severe illness. We found that providers planned to discharge numerous patients with clinically significant vital sign abnormalities, including tachypnea, hypoxia, and hypotension. That hypotension strongly predicted admission in children of 5–15 years but had a null association with children younger than 5 years may be a result of measurement error due to the use of inappropriately large pediatric cuffs in the youngest population. In a recent meta-analysis of prognostic indicators in children with severe malaria, patients with respiratory distress (defined as breathing abnormalities including increased respiratory rate) had three times the odds of mortality compared with those without respiratory distress.[18] In the same study, shock was associated with four times the odds of mortality. Training providers to recognize objective, numerical "red flag" cutoffs for vital signs and laboratory tests may improve disposition planning and lead to decreases in mortality. These results also suggest that adapting system-based quality improvement initiatives developed in high-resource settings[19–21] (e.g., recognizing and tagging charts with red flag values) may lead to improved outcomes in a rural health center environment, a hypothesis that can be tested in future studies.

In patients for whom providers planned to discharge, several abnormal laboratory results, including hypoglycemia and acidosis, failed to reverse their decision and prompt admission. Although point-of-care laboratory tests have potential to help guide case management of febrile illnesses in the future,[22,23] our results suggest that further training is needed for providers to recognize "red flag" laboratory values in RDT+ patients. Conversely, we found that some laboratory results appear to have strongly influenced admission decisions after an initial plan to discharge. For example, the presence of anemia very strongly predicted admission after a plan to discharge the patient. This may reflect the providers' familiarity with hemoglobin testing, which is routinely available at the health center, even though blood transfusion services are not. A dual-band RDT also predicted a change from initial to final disposition; this may reflect the association of dual-band positive RDT with more severe disease,[24] which was the hypothesis for the primary study objective or simply a perception that the presence of multiple bands indicates more severe disease.

This study also highlights the importance of system factors in the admission patterns of patients with suspected febrile illness. The location of a patient's home village, day of week, and clinic census were significantly associated with a reversal in the provider's plan. Most notably, patients were more likely to be discharged if they lived farther from the health center, as measured by straight

TABLE 3
Association between covariates and plan to admit

Variable	Unadjusted RR (95% CI)	*P* value	Adjusted RR (95% CI)	*P* value
Age (years)				
> 15	REF	–	REF	–
5–15	1.04 (0.89–1.22)	0.623	1.20 (0.95–1.53)	0.124
< 5	1.93 (1.64–2.28)	< 0.001	1.49 (1.12–1.97)	0.005
Female	0.87 (0.74–1.02)	0.086	1.09 (0.89–1.32)	0.407
Home village				
Bugoye or Kanyanamigho	REF	–	REF	–
Other villages ≤ 2 km away	1.23 (1.03–1.47)	0.021	1.04 (0.81–1.36)	0.741
Villages > 2 km away	0.88 (0.75–1.03)	0.118	0.95 (0.74–1.21)	0.669
Day of week seen				
Monday	REF	–	REF	–
Tuesday	1.09 (0.89–1.34)	0.393	0.99 (0.73–1.33)	0.936
Wednesday	0.92 (0.75–1.13)	0.424	0.94 (0.70–1.26)	0.664
Thursday	1.15 (0.95–1.40)	0.161	1.09 (0.84–1.42)	0.505
Friday/Saturday/Sunday	0.77 (0.60–0.98)	0.032	0.72 (0.52–1.00)	0.050
Clinic census				
Fourth quartile (most busy)	REF	–	REF	–
Third quartile	1.19 (1.01–1.41)	0.036	1.25 (0.61–2.54)	0.537
Second quartile	0.73 (0.58–0.91)	0.006	0.84 (0.59–1.21)	0.351
First quartile (least busy)	1.39 (0.87–2.23)	0.169	1.20 (0.95–1.51)	0.119
Rainy season	0.99 (0.84–1.17)	0.923	0.91 (0.73–1.14)	0.400
Subjective fever	1.37 (1.03–1.83)	0.033	1.33 (0.93–1.91)	0.123
Cough	0.85 (0.72–0.99)	0.040	0.70 (0.58–0.86)	0.001
Rash	0.78 (0.45–1.35)	0.375	0.90 (0.43–1.87)	0.775
Rhinorrhea	0.94 (0.77–1.15)	0.551	0.94 (0.72–1.22)	0.635
Myalgias	0.78 (0.65–0.95)	0.015	0.92 (0.72–1.17)	0.501
Diarrhea	1.29 (1.03–1.61)	0.024	1.01 (0.76–1.33)	0.971
Seizure	5.50 (4.22–7.17)	< 0.001	1.96 (1.20–3.20)	0.007
Fever on exam	3.51 (3.00–4.10)	< 0.001	2.27 (1.79–2.87)	< 0.001
Tachycardia	2.32 (1.96–2.74)	< 0.001	1.50 (1.19–1.88)	0.001
Hypotension	1.58 (0.92–2.72)	0.100	1.10 (0.59–2.06)	0.760
Tachypnea	2.44 (1.89–3.16)	< 0.001	1.43 (1.05–1.96)	0.024
Hypoxia	2.03 (1.61–2.56)	< 0.001	1.36 (1.02–1.81)	0.036
Impaired consciousness	4.91 (4.00–6.01)	< 0.001	3.21 (2.44–4.21)	< 0.001

CI = confidence interval; km = kilometer; REF = reference level; RR = risk ratio.

line distance, but no association was found when using taxi fare as a surrogate measure. This contributes to the growing literature on the impact of geographic barriers on accessing care[25–29] by suggesting that geographic distance may not only be a barrier for initial access to care but also for remaining in inpatient care; future studies should examine possible mechanisms for this association. A previous study has also shown an association between longer travel time and increased risk of mortality in children at a Tanzanian district hospital.[30] A patient who was to be discharged was significantly less likely to ultimately be admitted on Wednesday, perhaps reflecting patterns in staffing or a cap in the clinic's capacity in the middle of the week. However, providers were also twice as likely to discharge patients after planning to admit them on days with the least busy clinic census compared with the busiest, perhaps reflecting the need to quickly triage patients, thus resulting in more admissions on busier days. It is also of concern that the health center only admitted patients during daytime weekdays, as a prior study has shown an association between patients presenting after normal hours and increased severity of illness.[31]

Strengths of this study include the large sample size and the assessment of disposition before and after laboratory tests were performed. We also examined clinical measures and included point-of-care laboratory tests routinely available at peripheral health centers, which may promote the generalizability of our study to other malaria-endemic regions of sub-Saharan Africa.[22,23] Our study does have a number of limitations. First, we do not have longitudinal data to associate abnormal clinical characteristics or laboratory results with clinical outcomes, including mortality. Second, because our study was conducted in a single center, this may limit its applicability to other health centers. Bugoye Health Center has engaged in multiyear partnerships with U.S. academic centers and, thus, may have more training and resources than other level III health centers in the region. Also, because inferential analyses for the laboratory testing and final disposition are only limited to those with a positive RDT, our findings may not be generalizable to any patient who presents with a fever. We also introduced a triage desk to measure vital signs in a uniform manner, which may have resulted in more accurate assessments compared with those performed by providers, thus potentially limiting generalizability of our findings. However, given the paucity of data on factors related to disposition in low-resource settings, these results are useful to inform future studies and interventions. Third, 26% of participants enrolled were missing data regarding the provider's initial plan, which may make our results less representative of the population of patients presenting at the health center with suspected febrile (descriptive differences between those with plan data and those without shown in Supplemental Appendix Table 6). Twelve percent of RDT+ participants with a provider plan were also missing data regarding the provider's final disposition; however,

TABLE 4
Association between covariates and admission in those with a plan to discharge

Variable	Unadjusted RR (95% CI)	*P* value	Adjusted* RR (95% CI)	*P* value
Age (years)				
> 15	REF	–	REF	–
5–15	1.13 (0.79–1.63)	0.496	2.03 (1.23–3.35)	0.006
< 5	2.63 (1.72–4.00)	< 0.001	4.38 (2.37–8.09)	< 0.001
Female	1.27 (0.88–1.84)	0.197	1.48 (0.99–2.20)	0.056
Home village				
Bugoye or Kanyanamigho	REF	–	REF	–
Other villages ≤ 2 km away	1.15 (0.77–1.73)	0.483	0.87 (0.52–1.46)	0.592
Villages > 2 km away	0.76 (0.52–1.12)	0.173	0.77 (0.47–1.26)	0.298
Day of week seen				
Monday	REF	–	REF	–
Tuesday	0.95 (0.59–1.52)	0.817	0.71 (0.40–1.25)	0.239
Wednesday	0.62 (0.35–1.09)	0.100	0.54 (0.29–1.01)	0.055
Thursday	0.88 (0.53–1.47)	0.629	0.77 (0.44–1.36)	0.367
Friday/Saturday/Sunday	0.92 (0.56–1.52)	0.758	0.64 (0.36–1.14)	0.126
Clinic census				
Fourth quartile (most busy)	REF	–	–	–
Third quartile	0.86 (0.57–1.30)	0.471	–	–
Second quartile	0.86 (0.51–1.45)	0.568	–	–
First quartile (least busy)	0.94 (0.31–2.84)	0.907	–	–
Dual-band RDT	2.28 (1.48–3.52)	< 0.001	2.08 (1.29–3.36)	0.003
Anemia	14.63 (12.19–17.55)	< 0.001	48.34 (24.22–96.49)	< 0.001
Hyperkalemia	0.96 (0.25–3.73)	0.958	–	–
Hyperlactatemia	2.02 (0.69–5.89)	0.196	1.73 (0.67–4.51)	0.260
≥ 1+ proteinuria	1.84 (1.10–3.07)	0.020	1.86 (1.29–2.68)	< 0.001
4+ hematuria	0.96 (0.25–3.70)	0.950	–	–

CI = confidence interval; km = kilometer; RDT = rapid diagnostic test; REF = reference level; RR = risk ratio.
* Adjusted for covariates that reached a significance of $P < 0.20$ in unadjusted analysis; did not fit unadjusted models with hyponatremia, hypoglycemia, acidosis, or high creatinine level due to the presence of zero cell counts.

most demographic, clinical, and laboratory characteristics were similar between patients with and without data on disposition (Supplemental Appendix Table 7). Fourth, we opted to use more parsimonious model selection techniques in the restricted analyses because of smaller sample sizes and, thus, risk our models not being as accurately specified.

CONCLUSION

Significant efforts are needed to improve nonphysician providers' recognition of patients with clinical and laboratory abnormalities that have been associated with adverse outcomes in a rural Ugandan health center. The introduction of

TABLE 5
Association between covariates and discharge in those with a plan to admit

Variable	Unadjusted RR (95% CI)	*P* value	Adjusted* RR (95% CI)	*P* value
Age (years)				
> 15	REF	–	REF	–
5–15	1.21 (0.85–1.71)	0.286	1.22 (0.81–1.85)	0.335
< 5	0.60 (0.33–1.09)	0.096	0.71 (0.36–1.42)	0.338
Female	1.05 (0.74–1.49)	0.766	1.06 (0.72–1.56)	0.757
Home village				
Bugoye or Kanyanamigho	REF	–	REF	–
Other villages ≤ 2 km away	1.14 (0.80–1.63)	0.464	2.12 (1.10–4.12)	0.026
Villages > 2 km away	1.38 (0.98–1.95)	0.067	2.44 (1.27–4.70)	0.008
Day of week seen				
Monday	REF	–	REF	–
Tuesday	1.11 (0.73–1.69)	0.613	–	–
Wednesday	1.31 (0.84–2.05)	0.229	–	–
Thursday	1.11 (0.75–1.65)	0.596	–	–
Friday/Saturday/Sunday	0.70 (0.38–1.31)	0.265	–	–
Clinic census				
Fourth quartile (most busy)	REF	–	–	–
Third quartile	0.78 (0.52–1.16)	0.224	0.92 (0.60–1.40)	0.693
Second quartile	1.39 (0.93–2.07)	0.110	1.22 (0.82–1.82)	0.331
First quartile (least busy)	1.94 (1.07–3.52)	0.028	2.28 (1.56–3.34)	< 0.001
Dual-band RDT	0.64 (0.45–0.93)	0.019	0.62 (0.43–0.89)	0.010
Anemia	1.43 (0.35–5.79)	0.617	–	–
Hyperkalemia	0.32 (0.05–2.03)	0.224	–	–
Hyperlactatemia	0.72 (0.21–2.43)	0.600	–	–
≥ 1+ proteinuria	0.94 (0.55–1.62)	0.830	–	–
4+ hematuria	1.23 (0.51–2.96)	0.640	–	–

CI = confidence interval; km = kilometer; RDT = rapid diagnostic test; REF = reference level; RR = risk ratio.
* Adjusted for covariates that reached a significance of $P < 0.20$ in unadjusted analysis; did not fit unadjusted models with hyponatremia, hypoglycemia, acidosis, or high creatinine level due to the presence of zero cell counts.

TABLE 6
Association between covariates and final discharge restricted to those meeting the modified SIRS criteria

Variable	All ages*		Only those aged < 15 years†	
	Adjusted RR (95% CI)	*P* value	Adjusted RR (95% CI)	*P* value
Age (years)				
> 15	REF	–	–	–
5–15	1.04 (0.95–1.15)	0.399	–	–
< 5	0.81 (0.64–1.04)	0.094	–	–
Home village				
Bugoye or Kanyanamigho	REF	–	REF	–
Other villages ≤ 2 km away	1.04 (0.90–1.20)	0.574	1.03 (0.86–1.24)	0.739
Villages > 2 km away	1.16 (1.03–1.31)	0.018	1.11 (0.95–1.30)	0.193
Clinic census				
Fourth quartile (most busy)	REF	–	REF	–
Third quartile	0.97 (0.87–1.07)	0.520	0.99 (0.86–1.15)	0.929
Second quartile	1.07 (0.96–1.18)	0.206	1.04 (0.90–1.19)	0.623
First quartile (least busy)	1.08 (0.91–1.28)	0.395	1.05 (0.78–1.42)	0.732
Day of week seen				
Monday	REF	–	REF	–
Tuesday	1.13 (0.98–1.32)	0.098	1.13 (0.92–1.39)	0.234
Wednesday	1.19 (1.06–1.33)	0.002	1.19 (1.01–1.41)	0.038
Thursday	1.02 (0.88–1.17)	0.834	0.97 (0.78–1.20)	0.766
Friday/Saturday/Sunday	1.10 (0.96–1.26)	0.156	1.15 (0.95–1.40)	0.149
Subjective fever	0.91 (0.80–1.02)	0.112	0.84 (0.75–0.94)	0.002
Rash	1.13 (1.02–1.27)	0.026	1.09 (0.97–1.23)	0.153
Myalgias	1.05 (0.95–1.17)	0.354	1.04 (0.90–1.20)	0.572
Seizure	0.90 (0.50–1.63)	0.737	0.87 (0.52–1.46)	0.603
Hypoxia	0.91 (0.70–1.17)	0.463	0.87 (0.62–1.21)	0.400
Impaired consciousness	0.47 (0.22–1.00)	0.051	0.30 (0.06–1.56)	0.154
Dual-band RDT	0.91 (0.84–0.99)	0.027	0.90 (0.80–1.01)	0.065
Hemoglobin (every 2 g/dL decrease)	0.92 (0.88–0.97)	0.001	0.91 (0.85–0.98)	0.010
Hyponatremia	0.68 (0.30–1.52)	0.345	0.67 (0.30–1.46)	0.309
Creatinine > 3 mmol/L	1.67 (1.36–2.04)	< 0.001	–	–
Hyperlactatemia	0.98 (0.69–1.41)	0.928	0.97 (0.61–1.55)	0.911
≥ 1+ proteinuria	0.87 (0.71–1.06)	0.172	0.70 (0.43–1.12)	0.134
4+ hematuria	0.75 (0.44–1.26)	0.277	0.58 (0.23–1.51)	0.269

CI = confidence interval; g/dL = grams/deciliter; km = kilometer; mmol/L = millimole/liter; RDT = rapid diagnostic test; REF = reference level; RR = risk ratio; SIRS = systemic inflammatory response syndrome.

* Adjusted for covariates that reached a significance of $P < 0.20$ in unadjusted analysis. Fever on examination, tachycardia, and tachypnea were not considered for inclusion, as they are part of the modified SIRS criteria.

† Adjusted for covariates included in the pooled analysis except for age; creatinine could not be included in the model due to the presence of zero cell counts.

additional diagnostic laboratory capacity without extensive provider training is unlikely to resolve these challenges. Future studies should examine the effect of educational interventions and novel diagnostic tools and should incorporate longitudinal outcomes. Future studies should also elucidate optimal strategies to overcome the observed adverse impact of geographic barriers so as to maintain critically ill patients in care.

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