





# Malaria Morbidities Following Universal Coverage Campaign for Long-Lasting Insecticidal Nets: A Case Study in Ukerewe District, Northwestern Tanzania

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**Background:** Surveillance of the clinical morbidity of malaria remains key for disease monitoring for subsequent development of appropriate interventions. This case study presents the current status of malaria morbidities following a second round of mass distribution of long-lasting insecticidal nets (LLINs) on Ukerewe Island, northwestern Tanzania.

**Methods:** A retrospective review of health-facility registers to determine causes of inpatient morbidities for every admitted child aged <5 years was conducted to ascertain the contribution of malaria before and after distribution of LLINs. This review was conducted from August 2016 to July 2018 in three selected health facilities. To determine the trend of malaria admissions in the selected facilities, additional retrospective collection of all malaria and other causes of admission was conducted for both <5- and >5-year-old patients from July 2014 to June 2018. For comparison purposes, monthly admissions of malaria and other causes from all health facilities in the district were also collected. Moreover, an LLIN-coverage study was conducted among randomly selected households (n=684).

**Results:** Between August 2016 and July 2018, malaria was the leading cause of inpatient morbidity, accounting for 44.1% and 20.3% among patients <5 and >5 years old, respectively. Between October 2017 and January 2018, the mean number of admissions of patients aged <5 years increased 2.7-fold at one health center and 1.02-fold for all admissions in the district. Additionally, approximately half the households in the study area had poor of LLIN coverage 1 year after mass distribution.

**Conclusion:** This trend analysis of inpatient morbidities among children aged <5 years revealed an upsurge in malaria admissions in some health facilities in the district, despite LLIN intervention. This suggests the occurrence of an unnoticed outbreak of malaria admissions in all health facilities.

**Keywords:** malaria surveillance, inpatient morbidity, children <5 years old, Tanzania

## Background

Malaria infection remains a major public health challenge in most sub-Saharan African countries, despite the transmission decline in many other areas of the world.<sup>1</sup> About 231 and 228 million malaria cases were registered worldwide in 2017 and 2018, respectively, with sub-Saharan Africa contributing 92% of all cases.<sup>1,2</sup> Analysis shows that eleven high-burden countries (Burkina Faso, Cameroon, Democratic Republic of Congo, Ghana, India, Mali, Mozambique, Niger, Nigeria, Uganda, and Tanzania) account for >70% of global malaria cases and deaths.<sup>2</sup> Tanzania mainland ranks third in terms of largest population at risk of malaria in Africa, with 95% of its

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area located in stable transmission.<sup>3</sup> As a result of that, malaria has been the leading cause of morbidity and mortality among children aged <5 years in Tanzania.<sup>4,5</sup>

The introduction of intensive interventions against malaria has been impactful, particularly in reducing morbidity and mortality. However, despite these measures, some areas in Tanzania are still experiencing infection resurgence.<sup>6,7</sup> As evidence of that, prevalence of symptomatic parasitemia among children aged <5 years markedly declined from 18% in 2007–2008 to 9% in 2011–2012, before surging up to 14% in 2015–16.<sup>8</sup> In response to these changing transmission dynamics, the country's programs specifically for malaria control continue to spearhead the disease fight using five strategic interventions: integrated vector management; prompt diagnosis and treatment of cases; surveillance, monitoring, and evaluation; promotion of curative and preventive services; and program management, resource mobilization, and partnership.<sup>3</sup> These core interventions are in line with the World Health Organization (WHO) three global technical strategies (GTSs) for malaria for 2016–2030, which are to ensure universal access to malaria prevention, diagnosis and treatment, accelerate efforts toward elimination and attainment of malaria-free status, and transform malaria surveillance into a core intervention.<sup>9</sup>

The transformation of surveillance into a core intervention constitutes the third pillar of the GTSs, which advocates establishing effective surveillance systems, has been published by the WHO.<sup>10</sup> The GTSs underscore the need for increasing universal access to all core malaria interventions and emphasize the usage of high-quality surveillance data for decision-making.<sup>11</sup> Recent reports on malaria status in Tanzania have shown that malaria is still the leading cause of morbidity and mortality, particularly among children aged <5 years, with notifications of infection-transmission resurgence in some areas.<sup>2,6,7,12,13</sup> Therefore, continued monitoring of malaria morbidity, particularly in individual health facilities, is imperative as we undertake elimination initiatives. The current study examined the present status of malaria-inpatient morbidity following accomplishment of the country's second universal coverage campaign for long-lasting insecticidal nets (LLINs) in 2017.

## Methods

### Study Area

The study was conducted in Ukerewe district (530 km<sup>2</sup>), one of the six districts in Mwanza region, northwestern

Tanzania. The district is composed of small and large islands: the largest settlement of people is on Ukerewe Island, the district capital of which is Nansio. Ukara Island is the second-largest island, located about 5 nautical miles north of Ukerewe Island (Figure 1). The district has one hospital, four health centers, and 18 dispensaries serving a population of approximately 422,000 people. Residents are mainly engaged in fishing and subsistence farming. The lake zone, of which Mwanza region and Ukerewe district are a part, shoulders the highest malaria burden in the country.<sup>13</sup> As such, regular mass distribution of LLINs is highly needed in this area. Based on this, a second round of LLIN mass distribution was conducted in July 2017, where one net was given freely per two individuals in each household.

### Study Design

#### Retrospective Review of Inpatient Morbidity

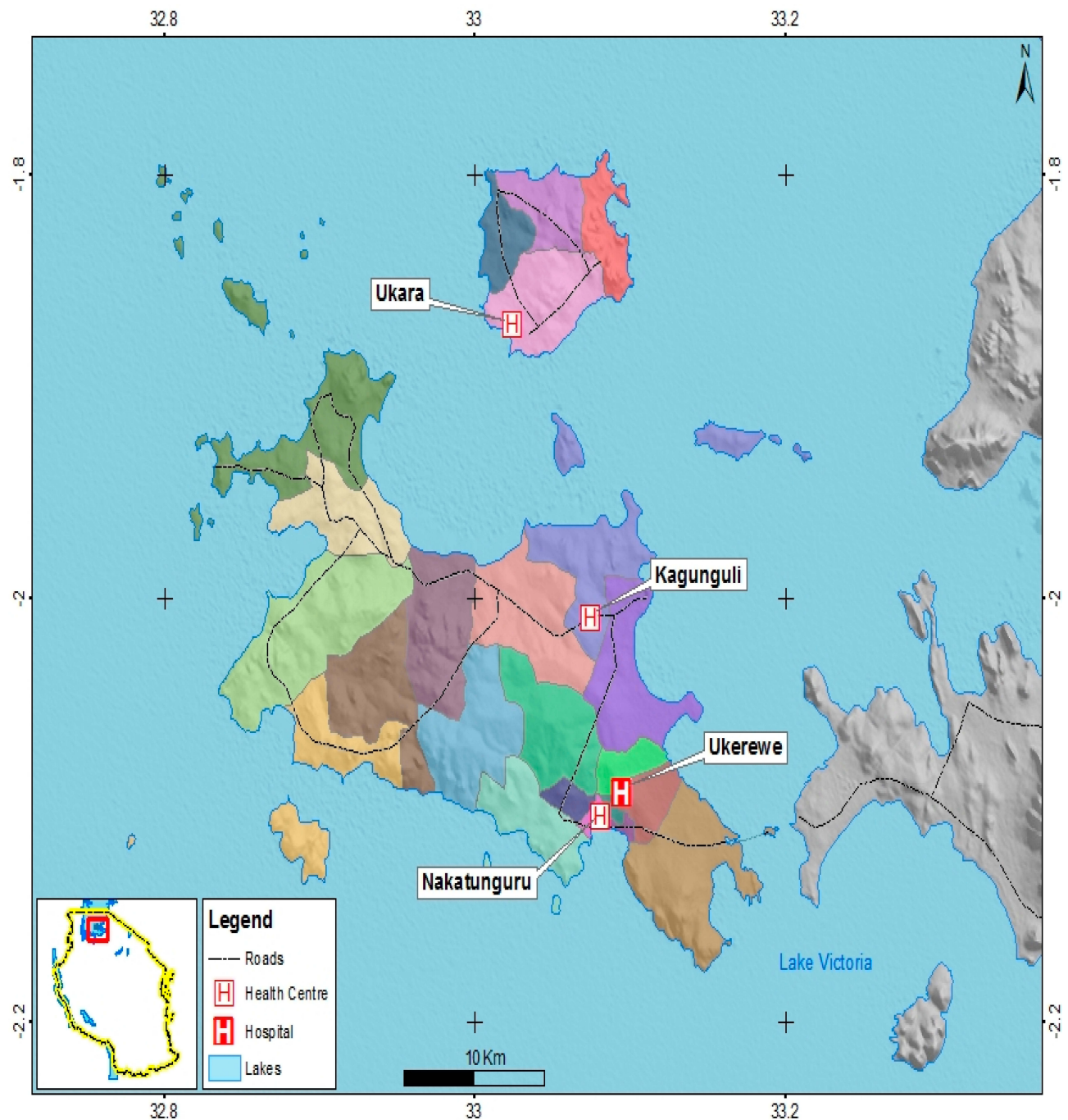
This was a retrospective cross-sectional review of inpatient malaria morbidities and mortalities using health-facility admission registers. Counting all causes admissions for all age groups was conducted, covering 24 months: 12 months before and after mass distribution of LLINs. To ascertain the long-term contribution of malaria for all inpatient age-groups, a retrospective review of all causes of admission was conducted in the selected health facilities for 48 months. Moreover, another retrospective review of monthly malaria-inpatient morbidities was conducted, covering 48 months in all health facilities in the district. This additional district-wide review of malaria admissions for all age-groups was conducted for comparison purposes.

#### Long-Lasting Insecticidal Net Study

A household-based cross-sectional study (n=684)<sup>13</sup> was conducted in the study area to determine coverage, ownership, and use of LLINs.

### Sampling

To determine causes of inpatient morbidity 1 year before and after mass distribution of LLINs (August 2016 to July 2018), convenience sampling of three health facilities with high volumes of both inpatients and outpatients was conducted. These facilities were Kagunguli and Bwisya health centers and Ukerewe District Hospital. For determination of long-term trends of inpatient-malaria morbidity, data for 48 months (July 2014 to June 2018) were selected based on availability and completeness. For comparison



**Figure 1** Map of the study area showing the studied health facilities in Ukerewe district, northwestern Tanzania.

purposes, data on monthly admission from all health facilities in the district were also collected alongside the three sampled health facilities. To understand uptake of interventions tailored to malaria, a systematic random selection of households was conducted to determine coverage and use of LLINs. A list of registered households from three randomly picked villages was obtained from local leaders before commencement of the sampling process.

## Data Collection

### Causes of Inpatient Morbidity a Year Before and after Mass Distribution of LLINs

All individual admissions of aged <5 years and >5 years were recorded for 12 months before and after LLIN mass distribution. These data were obtained from health-facility inpatient registers. Information on admission date (month), age, and cause of admission was collected for every registered patient

from August 2016 to July 2018. For comparison purposes, data of all inpatient malaria morbidity and all other causes of admission among those aged >5 years in the whole district were collected within the same time frame.

### Long-Term Monitoring of Inpatient Malaria Morbidity among Admissions aged <5 years and >5 years

For the purpose of trend monitoring, monthly numbers for all malaria and other causes of admission were counted from register books. These data were clustered on a monthly basis for a 48 months from July 2014 to June 2018. Monthly data on inpatient malaria and other causes of admission for all health facilities in the district were also collected covering the same period. These data were obtained from a district-wide combined inpatient register covering all health centers in the study area.

### Long-Lasting Insecticidal Net Study 1 Year after Mass Distribution

Heads of randomly selected households were interviewed using a structured questionnaire. Information on number of members per sampled household, number of available LLINs, and their usage the night before were obtained.

### Data Analysis

Malaria-inpatient morbidity was calculated as a ratio of all malaria admissions over the total number of admissions during the specified period. Malaria-related case-fatality rates were computed by summing all patients who had died due to malaria with or without other comorbidities over total malaria admissions. Line graphs are used to present the monthly number of confirmed malaria cases for admissions aged <5 years and >5 years. The monthly mean number of admissions for 48 months was compared with mean admissions of 4 months (period suspected to have inpatient-morbidity upsurge) using Student's *t*-test. Mosquito-net coverage was computed as the proportion of households with at least one LLIN presently available for use for every two individuals over the total number of households in the study. Use of LLINs was calculated as the proportion of households with all members sleeping under mosquito nets over the total number of households. Statistical significance was considered when  $p < 0.05$ . Data analysis was done using SPSS version 25 (IBM, Armonk, NY, USA).

## Results

### Malaria-Inpatient Morbidity a Year Before and after Mass Distribution of LLINs

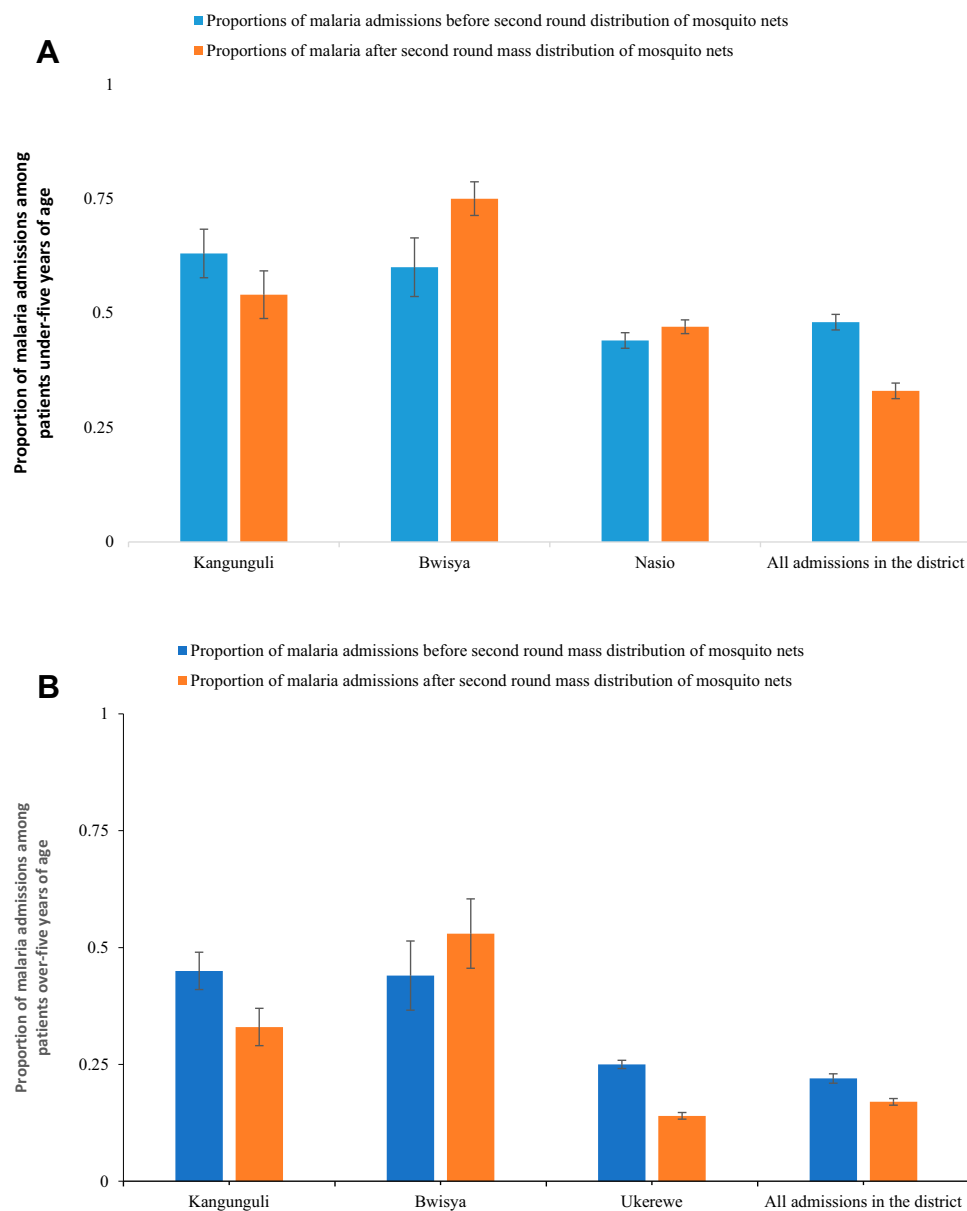
Totals of 1,176 (40%) and 1,566 (47.3%) children aged <5 years were admitted due to malaria in the three health facilities a year before and after mass distribution of LLINs, respectively. This shows a significant increment in malaria admissions after LLIN distribution ( $p < 0.001$ ). This observation was not consistent in all health facilities: Kagunguli Health Centre showed a significant decline ( $p = 0.03$ ) in malaria admissions among children aged <5 years (Figure 2A). Considering total admissions in the district, 1,566 (47.8%) and 1,553 (46.5%) children aged <5 years were admitted due to malaria in all health facilities 1 year before and after mass distribution of LLINs, respectively. These data show that malaria admissions among children aged <5 years did not change, despite the LLIN mass-distribution campaign ( $p = 0.29$ ). Moreover, malaria admissions consistently declined among patients aged  $\geq 5$  in all health facilities, except Bwisya Health Centre (Figure 2B). Combined data from all health facilities in the district also showed a decline in admissions following LLIN distribution (Figure 2B).

### Long-Term Analysis of Inpatient Malaria Morbidity among Patients aged <5 years

Malaria-inpatient morbidity for 48 months showed a monthly mean admission of  $19 \pm 05$  and  $150 \pm 24$  children aged <5 years at Bwisya Health Centre and all health facilities combined, respectively. Nevertheless, between October 2017 and January 2018, the mean number of admissions aged <5 years typically rose 2.7-fold at Bwisya Health Centre and increased 1.02-fold for all admissions aged <5 years in the district ( $51 \pm 16$  vs  $155 \pm 93$ ). A surge in malaria admissions unnoticed at the time at Bwisya Health Centre was observed (Figure 3A), whilst the other health facilities, including the combination all admissions in the district, showed normal trends of inpatient morbidity (Figure 3B–3D).

### Long-Term Analysis of Inpatient Malaria Morbidity among Patients aged >5 years

The trend in malaria admission between October 2017 and January 2018 was similar to preceding years (Figure 4). A decline in inpatient morbidity at Kagunguli Health Centre and Ukerewe District Hospital was noted



**Figure 2 (A)** Proportions of malaria admissions among children aged <5 years and **(B)** shows the proportions of malaria admissions among patients aged >5 years.

(Figure 4B and 4C). At Bwisya Health Centre, however, a slight upsurge in cases was observed (Figure 4A). In 48 months, malaria accounted for 21.2% all admissions aged >5 years at all health facilities in the district (Figure 4D).

### Long-Lasting Insecticidal Net Study 1 Year after Mass Distribution

Of 688 sampled households, 624 (90.7%) owned at least one mosquito bed net available for use. Approximately a third of all households reported that at least one of their members slept without a mosquito net the night

before the interview. Moreover, approximately half (46.8%) of the households studied had poor coverage of mosquito nets (Table 1).

### Discussion

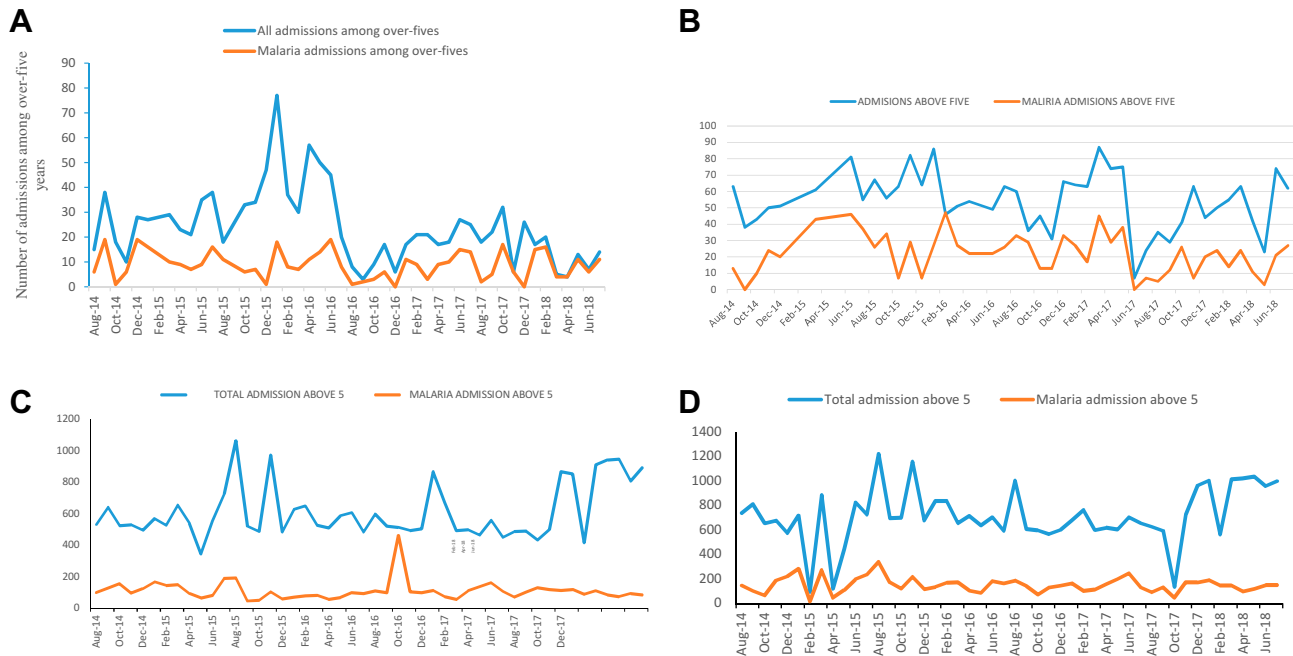
Monitoring malaria-inpatient morbidity and mortality is vital for planning and evaluation of available interventions. The current study found that there was still a high level malaria morbidity, despite the second round of mass distribution of LLINs. This suggests high infection transmission in all age-groups. Of all admissions aged <5 years, malaria was the leading cause of inpatient morbidity. This



**Figure 3** (A) Admission pattern at Bwisy Health Centre on Ukara Island; (B) admission pattern at Kagunguli Health Centre on Ukerewe Island; (C) admission pattern at Ukerewe District Hospital; (D) admissions for all health facilities in the district.

finding is consistent with another study conducted in 2015 in Tanzania, where approximately 50% of all admissions aged <5 years were due to malaria.<sup>14</sup> Similar findings were reported by another study suggesting that the disease

burden is still high in East Africa, despite several rounds of LLIN mass distribution.<sup>15</sup> Therefore, malaria surveillance should be enhanced for the purpose of monitoring responses to ongoing interventions.<sup>16</sup> This will enable the



**Figure 4** (A) Admission pattern at Bwisy Health Centre on Ukara island; (B) admission pattern at Kagunguli Health Centre on Ukerewe Island; (C) admission pattern at the Ukerewe District Hospital; (D) admissions at all health facilities in the district.

**Table 1** Mosquito-net ownership and use among residents of Ukerewe district, northwestern Tanzania

	Response	Frequency (n=688)	Percentage
<b>Ownership</b>	Yes	624	90.7
	No	64	9.3
All household members slept under net	Yes	454	66.0
	No	234	34.0
Coverage	Yes	366	53.2
	No	322	46.8

local health authorities to implement timely and cost-effective evidence-based decisions.

Findings from this study demonstrate that aggregated malaria data monitored at the regional or district level may not accurately monitor infection-transmission dynamics in discrete health facilities. This underscores the need for every district and health facility to have a dashboard to monitor dynamics of malaria morbidity. By so doing, all three core recommended interventions will be effectively implemented.<sup>9</sup> This will enable execution of timely and coordinated interventions, as recommended by the WHO malaria surveillance, monitoring, and evaluation reference manual.<sup>16</sup> In Tanzania, however, analysis and interpretation of malaria data in individual health facilities have been not widely implemented.<sup>17</sup> As health departments strive to improve integrated disease surveillance and response in Tanzania and sub-Saharan Africa, district and health facility-based analysis and interpretation of malaria data should also be intensified.<sup>18–20</sup>

The upsurge in inpatient malaria morbidities on Ukara Island (Bwisya Health Centre) happened concomitantly with a campaign against illegal fishing activities in Lake Victoria. This operation was conducted by the Tanzanian government.<sup>21</sup> As a result of this campaign, most fishermen abandoned fishing activities and remained indoor to avoid government operations. The increase in malaria cases may be attributable by the fact that migrating fishermen who normally worked during the night stayed in camps. This may have possibly intensified malaria transmission to the most susceptible group: children aged <5 years. In support of this contention, previous studies have reported Lake Victoria fishing islands in East Africa being high-transmission areas for malaria.<sup>22–24</sup>

## Strengths and Limitations

The current study reports malaria morbidity in disease ecology before and after the second round of the LLIN universal coverage campaign. However, this report utilized data from hospital registries that could be unrepresentative, as there might have been underreporting, and thus the burden of malaria on these islands may be underestimated.<sup>25</sup>

## Conclusion

Malaria-inpatient morbidity declined inconsistently a year after the second round of the LLIN universal coverage campaign. The morbidity trend using district-aggregated data among children aged <5 years showed a declining number of inpatient cases in some health facilities only. An upsurge in malaria admissions suggestive of an outbreak on Ukara Island was observed at Bwisya Health Centre among children aged <5 years. This upsurge could be attributed to low uptake of LLINs in the mobile population of fisherfolk during the rainy season. With that observation, malaria is thus still a public threat, particularly to children aged <5 years. Therefore, continued monitoring of malaria morbidity at the district level alone may still be insufficient if no analysis and interpretation of data in discrete health facilities is undertaken. Moreover, local studies evaluating coverage and use of mosquito nets after every round of the mass-distribution campaign are highly recommended.

## Ethical Approval and Consent to Participate

This study was approved by a joint research and ethics committee of the Bugando Teaching and Consultant Hospital and the Catholic University of Health and Allied Sciences. Consent to review the medical records was sought from the regional and district authorities, and informed consent sought from all respondents before their participation. Data obtained from the study participants and hospital registries are kept confidential and compliant with the Declaration of Helsinki.

## Acknowledgments

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## Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data, took part in drafting the article and revising it critically for important intellectual content, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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## Disclosure

All authors declare that they have no competing interests in this work.

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