The effect of malaria prevention and control interventions on malaria morbidity among children under 5 years and pregnant women in Kintampo North Municipality, Ghana

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ABSTRACT

Background: Malaria prevention and control interventions have been scaled-up in the last decade in Ghana. We analysed the malaria surveillance data to assess the trends and the association between some malaria prevention interventions and malaria incidence in Kintampo North Municipality (KNM). **Methods:** We extracted data on malaria indicators and interventions from the District Health Information Management System 2 database for 2012–2016. Proportions and cumulative incidence of malaria episodes were computed using STATA 14 software. We performed correlation analysis between malaria interventions and malaria morbidity. We used linear regression models to determine the association between Long-Lasting Insecticide-treated Nets (LLINS) distribution, Intermittent Preventive Treatment in Pregnancy (IPTp) and episodes of malaria in children <5 years old and pregnant women. **Results:** A total of 280,890 episodes of malaria were recorded in the KNM from 2012–2016. Of the total malaria episodes, 64,953 (23.1%) were children <5 years and 57.5% (161,486/280,890) were females. The incidence of malaria in KNM declined from 650/1,000 population in 2012 to 444/1,000 population in 2016. The proportion of confirmed malaria increased from 35.2% in 2012 to 80.7% in 2015, and subsequently declined to 77.5% in 2016. The malaria Case Fatality Rate decreased by 65% in 2012 to 0.04% (16/37646) in 2016. Long Lasting Nets distribution to children showed a weak negative linear relationship with malaria morbidity in children <5 years (R= –0.20). IPTp1, IPTp2 showed a weak negative linear relationship with malaria morbidity in pregnancy, IPTp3 showed a weak positive linear relationship while IPTp4 and IPTp5 showed a negative moderate linear relationship with malaria morbidity in pregnancy. A unit increase in LLINs distribution to pregnant women was significantly associated with a reduction in malaria in pregnancy episodes by 0.21 (R^2 = 0.19, 95% CI: -0.3 — -0.7). The IPTp first dose (IPTp1) coverage declined from 75.5% in 2012 to 69.0% in 2014, but rose to 80.9% in 2016. IPTp5 (fifth dose) increased from 0.7% in 2014 to 4.8% in 2016. A percentage increase in the coverage of only IPTp4 was associated with a reduction of malaria in pregnancy by two episodes (R^2 = 0.34, 95% CI = — 1.68 – (—0.78). **Conclusion:** Malaria morbidity trend declined in the municipality. Increase coverage in LLINs and IPTp were associated with declines in malaria episodes in children <5years old and pregnancy women. Coverage of IPTp4 and IPTp5 were relatively low. Health staff should intensify promotion of the use of malaria prevention interventions among pregnant women and children < 5 years old. Midwives should promote uptake of optimal IPTp doses through health education and community antenatal outreach services.

Introduction

Malaria is a major public health challenge especially in the tropical regions of the world. Globally, approximately 216 million malaria cases and 445,000 malaria-related deaths were reported in 2016 [**1**]. The sub-saharan African region accounts for about 90% of global malaria morbidity and 91% of malaria-related mortality. Pregnant women, children under 5 years as well as the elderly are at increased risk of malaria morbidity and mortality.

Ghana recorded 4.5 million confirmed malaria cases and 1264 malaria-related deaths in 2016 [**2**]. Malaria among pregnant women accounted for 8.4% (38286/4533431) of total confirmed malaria cases in the same year. In 2016, children under five years accounted for 46.7% of all the malaria-related deaths, case fatality rate = 0.3% [**2**]. Malaria transmission varies across Ghana with the northern parts characterised by intense transmission while the southern and coastal regions are characterised by low transmission [**3**].

To avert the high morbidity and mortality associated with malaria, proven preventive and control interventions have been recommended. The WHO recommended package of interventions include vector control, chemoprevention and prompt diagnosis and appropriate treatment [**4–6**].

Long Lasting Insecticide Nets (LLINs) distribution is one of the vector control interventions in moderate to high malaria transmission areas. In Ghana LLINs distribution is done mainly through mass distribution campaigns to the general public, distribution to children less than 5 years old at child welfare centres (CWC) or in schools, and distribution to pregnant women at antenatal care (ANC) facilities during registration [**7**]. Mass LLINs distribution campaigns were done in 2012 and between 201**4** and 2016 across the country. Routine distribution at CWC and ANC is ongoing in the country. intermittent preventive treatment (IPT) using sulfadoxine-pyrimethamine (SP) is given to pregnant women from the second trimester up to the time of delivery to prevent malaria during pregnancy or clear placental parasites [**4**]. Seasonal malaria chemoprophylaxis targeting children less than 5 years old is only being piloted in the northern part of the country.

The National Malaria Control Program (NMCP) strategic framework 2014 – 2020 sets out to reduce malaria morbidity and mortality in the country by 75% using 2012 data as a baseline (NMCP 2014). In Ghana, monitoring the progress in malaria control is mainly through data from a web-based database called the District Health Information Management System 2 (DHIMS2). The database collects aggregate data on malaria morbidity and mortality as well as malaria prevention interventions such as LLINs distribution and IPTp-SP coverage. Paper-based forms are used to capture malaria morbidity and mortality data daily at the out-patient departments and inpatient wards. The data are transmitted monthly from the sub-district levels to the district or municipal levels for entry into the DHIMS2, where they become accessible nationwide. Sub-district facilities with access to DHIMS 2 platform and internet service can also enter their data directly into the DHIMS2.

Monitoring malaria morbidity and mortality trends is ongoing in Ghana through quarterly and annual reviews. However, assessing the association between malaria prevention and control interventions and malaria morbidity and mortality is rarely done at the district levels of the health system. The study, therefore, assessed the trends of malaria morbidity and mortality from 2012 through 2016 and the association between some malaria prevention and control interventions and the incidence of the disease in the Kintampo North Municipality.

Methods

Study design

We reviewed secondary data on malaria cases that reported to private and public medical facilities in Kintampo North Municipality from 2012 – 2016.

Study location

We reviewed malaria surveillance data in the Kintampo North Municipality (KNM). The Municipal population in 2016 was 109,448 with an estimated pregnant women population of 4,377 and children under five years' population of 21,889. The Municipality has a population growth rate of 2.31% (KNM Annual Report 2016). The municipality shares boundaries with Central Gonja district to the

north and Kintampo South and Pru districts to the south (**Figure 1**).

There are seven sub-districts in the municipality namely Kintampo, Busuama, Dawadawa, Kunsu, Kadelso, Gulumpe and New Longoro. There is one Municipal Hospital, four Private Clinics, four Health Centres and 19 functional Community-based Health Planning and Services (CHPS) compounds. The municipal hospital and New Longoro Health Centre had established laboratories where microscopy is done, in addition to Rapid Diagnostic Testing for malaria. The municipality experiences the tropical continental or interior savanna climatic conditions. It is also characterised by two rainy seasons. A minor rainy season (May to July) and a major season (September to October). The KNM has a general elevation of 60 – 150 meters above sea level.

Data collection: We extracted data from the District Health Information Management System 2 (DHIMS 2) using data extraction forms. The DHIMS 2 is a web-based database which houses aggregated routine surveillance data including malaria surveillance data. Reporting rates for DHIMS 2 and quality were constant throughout the period of review and health care seeking behavior is assumed to be unmeasurably constant throughout the period. The database also contains information on malaria intervention delivered at the facility level to children < 5 years and pregnant women. Malaria morbidity and mortality are recorded by sex and age groups while the interventions (LLINs and IPTp) are recorded according to the target recipient (children <5 years old and pregnant women). We abstracted data on malaria morbidity and mortality by sex and age from 2012 through 2016. We also reviewed data on LLINs distribution to children less than 5 years old and pregnant women as well as IPTp-SP coverage during the same period of the review.

Data Analysis: We extracted data from DHIMS2 and entered them into Microsoft Excel (Microsoft Corporation, 2013) spreadsheet for editing and coding. We grouped ages for malaria morbidities as <5 years and ≥ 5years for children. Total malaria cases were generated by summing the cases diagnosed with microscopy, cases diagnosed with malaria Rapid Diagnostic Test (RDT) and those not tested but treated as malaria. We used this sum as the denominator for computing the proportion of confirmed malaria cases. Similarly, we generated the laboratory confirmed malaria by adding those confirmed by RDT to those confirmed by microscopy. We then used the cumulative sum chart (CUSUM, C2) for threshold analysis. The CUSUM is a control chart which utilises the mean and standard deviation of previously collected data used to monitor small shifts in the process mean. It uses the cumulative sum of deviations from a target (threshold).

The data were then exported to Stata 14 software (STATA, College Station, TX, USA) for further descriptive and inferential analysis. We computed proportions of laboratory-confirmed malaria by sex and age groups for each year and presented it in graphs. We analysed the malaria morbidity in two broad categories: uncomplicated malaria and complicated (i.e., severe malaria) in accordance with the indicators of the National Malaria Control Program. In essence, total malaria cases for a particular period is the sum of both uncomplicated and complicated cases.

We performed correlation analysis using Pearson's correlation to determine the strnegth of the relationship between the malaria interventions and malaria morbidity in children <5 years of age and pregnant women. Linear regression was performed to test the association between ITN distribution and the incidence of malaria in children <5 years of age and pregnant women using ITN distribution as the explanatory variable (8). Multiple linear regression was used to determine the association between ITNs distribution, IPTp – SP uptake and the episodes of malaria among pregnant women. We used episodes of malaria in pregnancy as the response variable while ITN distribution and IPTp coverage were the explanatory variables. We also tested the effect of ITN distribution on episodes of malaria in pregnancy when combined with IPTp coverage.

Ethical consideration

We obtained written permission from the Kintampo Municipal Health Directorate to access the data. We ensured that the data extracted did not contain any identifiers to persons who reported to the facilities for health care and kept data in a password-protected computer.

Results

Malaria morbidity trends: A total of 280,890 episodes of malaria were recorded in the KNM from 2012 – 2016. The females accounted for 57.5% (161512/280890) of total malaria episodes during the period. The proportion of confirmed malaria increased from 35.2% in 2012 to 80.7% in 2015, and subsequently declined to 77.5% in 2016. From 2012 to 2016, the proportion of confirmed malaria increased by 54.6%. The burden of malaria peaked between May and October of every year. A threshold analysis showed that the municipality exceeded its morbidity threshold in 2016 between May and August (**Figure 2**).

The Kintampo sub-district recorded the highest malaria incidence of 1,643 episodes per 1000 population in 2013 which declined to 695 episodes per 1000 population in 2015 but rose to 887 episodes per 1000 population in 2016 (**Figure 3**). Kadelso sub-district recorded the lowest incidence of 26 episodes per 1000 population in 2012. The incidence increased to 128 episodes per 1000 population in 2014 but declined to 52 episodes per 1000 population (**Figure 3**). Overall, the incidence of malaria in the KNM decreased by 31.7% from 650 episodes per 1000 population in 2012 to 444 episodes per 1000 population in 2015 (**Figure 3**). The lowest overall malaria incidence (346/1000) in the municipality was recorded in 2015.

A total of 3,252 episodes of severe malaria were recorded in the municipality between 2012 and 2016. More, 1567 (48.2%) episodes of severe malaria were recorded in 2013 while the least, 7 (0.2%) was recorded in 2015. The incidence of severe malaria increased from 141 cases per 10000 in 2012 to 152 per 10000 in 2013. There was a sharp decline to approximately one case per 10000 in 2015 but increased to 14 cases per 10000 in 2016.

From 2012 to 2016, a total of 124 malaria-related deaths occurred in the municipality with males accounting for 62/124 (50.0%). More than half (52.4% [65/124) occurred among people aged five years and above. The median malaria-related mortality during the period was 23 deaths (range: 13 – 46). Malaria-related case fatality rate (CFR) was 0.20% (46/22890) in 2012 and 0.08% (23/29885) in 2015. The malaria CFR decreased by 65% in 2012 to 0.04% (16/37646) in 2016.

Association between malaria prevention interventions and episodes of malaria in children <5 years old and in pregnancy: The number of LLINs distributed to children <5 years old and pregnant women during the 5-year period was 13872. Generally, the coverage of LLINs distribution to children under five years rose from 0% in 2012 to 84.6% (3367/3980) in 2016. Children <5 years old accounted for an average of 36.7% (SD±4.5%) of the total malaria episodes recorded during the 5year period. The proportion of malaria in children < 5 years increased by 23.5% from 31.9% (20708/64953) in 2012 to 41.7% (15442/37025) in 2015. From 2012 to 2016, malaria in children < 5 years increased by 11.4% from 31.9% (20708/64953) to 36.0% (17487/48554).

Long Lasting Insecticide Nets distribution to children <5 years old showed a weak negative (R= –0.20) linear relationship with the malaria morbidity in children <5 years old. When the distribution of the LLINs to children <5 years old increased by one net, malaria in children <5 years old decreased by approximately one episode (R^2 = 0.04, p = 0.130) (**Table 1**).

The number of LLINs distributed to pregnant women during the 5-year period was 7122. Ninety-two per cent (6555/7122) was distributed between 2015 and 2016 (**Figure 5**). The distribution to pregnant women increased from 0.2% (8/4738) in 2012 to 84.9% (4214/4964) in 2016. A total of 4, 095 episodes of malaria in pregnancy was recorded from 2012 to 2016. Most of the cases, 1,825 (44.6%) occurred in 2013 declining to 240 (5.9%) in 2016 (**Figure 5**). The data showed moderate negative (R= –0.44) linear relationship between LLINs distribution to pregnant women and the malaria episodes in pregnancy. In the linear regression analysis, an increase in the LLIN distribution to pregnant women by one net resulted in a reduction in malaria in pregnancy by less than one (0.21) episode (R^2 = 0.19, p<0.001) (**Table 1**).

The average coverage of IPTp was 76.8% (SD±4.8) in the first dose (IPTp1) and 2.6% (SD±2.1) in the fifth dose (IPTp5). The coverage of the fourth dose (IPTp4) and IPTp5 peaked in September 2016. Subsequently, IPTp4 declined to 64% in December 2016 while IPTp5 declined to 16% in the same period (**Figure 6**).

IPTp1 and IPTp2 showed a weak negative linear relationship with malaria in pregnancy episodes. There was, however, a weak positive (R= 0.05) linear relationship between the coverage of IPTp3 and malaria in pregnancy episodes. IPTp4 and IPTp5 had a moderate negative linear relationship with malaria in pregnancy episodes. The multiple linear regression analysis showed that when coverage of IPTp4 increased by 1% episodes of malaria in pregnancy reduced by 1.23 (R^2 = 0.34, p<0.001) (**Table 1**). Similarly, an increase in coverage of IPTp5 by 1% reduced episodes of malaria in pregnancy by 3.69 (R^2 = <0.01, p=0.001). The model, however, explained <1% of the variance (**Table 1**)

Discussion

The study examined 5-year trends of malaria morbidity and mortality from 2012 to 2016 and the association between some malaria prevention and control interventions and the incidence of the disease in the Kintampo North Municipality. We found that the increase in the distribution of LLINs was observed to have a decrease in the episodes of malaria in the vulnerable group – children <5 years old and pregnant women. The reduction in malaria episodes among children <5 years old was, however, not significant. The distribution of Insecticide Treated Nets to pregnant women and children <5 years old was scaled-up between 2011 and 2016. Apart from the observed increased in LLIN distribution from 2012 to 2016, the municipality benefited two mass LLINs distribution campaigns in 2012 and 2014. The proportion of households in the Brong Ahafo region who had access to LLINs was 70% in 2014 [**9**]. In addition to providing personal protection against infectious mosquito bites, LLINs use can reduce vector survival, decrease vector density and also reduce feeding frequencies and biting success [**10**]. This reduces the rate of exposure by non-users thereby suppressing malaria transmission across the communities [**11**]. Intensifying health education to overcome the barriers to LLIN usage is critical in deriving the communal benefits of LLINs. Shared and communal use of the LLINs result in not only a reduction in malaria morbidity and mortality among the risk groups [**12**] but also in the general population [**13**].

We also found that malaria morbidity and mortality had declined by >30% in the municipality from 2012 to 2015. Ghana has witnessed malaria morbidity and mortality declines in the last decade since 2010 [**14**,**15**]. This decline is partly in response to the scale-up of malaria prevention and control interventions [**7**,**16**]. The first line medicine of choice for the treatment of uncomplicated malaria is artemisinin-based combination therapy (ACTs) [**17**]. The ACTs are effective in clearing peripheral blood parasitaemia, reduces the potential for reinfection within four weeks of treatment and reduces malaria-related mortalities [**18**]. Malaria in children <5 years old has also declined. The proportion of malaria in children <5 years in Kintampo North Municipality is however, higher than that of the Brong Ahafo region[**12**]. This could be due to different transmission patterns across sub-ecological zones within the region [**19**]. Sustaining the decline in malaria especially among children has the potential of reducing the overall under-five mortality [**20**].

The incidence of malaria was highest in the Kintampo sub-district. The municipal hospital which serves as a referral point for other sub-districts and adjoining districts. This could be responsible for the high incidence of the disease in the sub-district. Patients may as well prefer the municipal hospital as the first point of call since they may perceive to get advanced diagnostic services compared to the lower levels of the health care system.

We also found that increases in the coverage of only the fourth (IPTp4) and fifth doses (IPTp5) of IPTp-SP reduced episodes of malaria in pregnancy. Updated guidelines for IPTp-SP recommends more than three doses of the drug to achieve optimal protection from malaria [**21**]. The current study found coverage of IPTp4 was below 20% and that of IPTp5 below 5%. The coverage has been increasing steadily since 2013. In a recent study in an urban facility in Ghana, IPTp4 coverage was 55.7%, and IPTp5 was 14.5% [**22**]. This may explain an increasing trend in the coverage since the new recommendation of IPTp-SP was implemented in Ghana [**4**]. Several factors including late ANC registration, commodity shortages, staff attitude, and health delivery structure could also affect optimal uptake of IPTp-SP [**22**–**26**].

Coverage in IPTp3 showed a positive linear relationship with episodes of malaria in pregnancy. This implies as coverage of the intervention increases, episodes of malaria in pregnancy also increases and vice versa. This finding is in contrast to other studies which have shown that receipt of atleast three doses of IPTp-SP (IPTp3) effectively reduces malaria in pregnancy [**22**, **27**, **28**]. The current findings may highlight the quality of routinely collected data.

The study used aggregated secondary data for the analysis. The data did not provide a direct linkage about malaria interventions such as ITNs ownership or use, IPTp-SP uptake and the episodes of malaria in children and pregnant women. Therefore, interpretation of the declines in malaria morbidity cannot be solely attributed to the LLINs and IPTp. This is an ecological study with the association of the interventions measured at the population level. There may be other malaria prevention intervention which could not be explored. There may also be contextual factors such as socio-economic, climate and health services which may interact to impact on the incidence of malaria in the municipality but could not be explored. The IPTp-SP is administered as Directly Observed Therapy (DOT) in which coverage connotes usage. Moreover, licensed over-the-counter (OTC) medicine shops who also have antimalarial accessible to the populace do not report on malaria. These situations may lead to underestimation of malaria incidence. However, we believe that these limitations did not invalidate the findings in the current study.

Conclusion

There was a steady decline in malaria morbidity and mortality with major decline in recent times among children <5 years old and pregnant women. The distribution of LLINs and provision of IPTp-SP were shown to significantly reduced malaria in pregnancy. The increased LLIN distribution, however, did not significantly reduce episodes of malaria in children <5 years. The linear relationship between the malaria interventions and the malaria morbidity were shown to be either weak or moderate with IPTp3 even showing a positive correlation. The study also revealed a markedly low coverage of IPTp4 and IPTp5. Health personnel should promote the use of Long Lasting Insecticide Nets and Intermittent Preventive Treatment among children and pregnant women as well as encourage early booking of pregnant women at ANC to enable the mothers receive optimal doses of IPTp.

Competing interests

The authors declare that they have no competing interests.

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Authors´ contributions

CT and CK conceptualised the study and designed the study protocol. CT did the data collection, cleaning, analysis and interpretation. CK contributed to data analysis and interpretation. DAB, MO, EK, EAA, SOS, DKA, PN, TL, AL, CG and AI contributed to data interpretation and revised the manuscript for intellectual content. All authors read and approved the final manuscript.

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Tables and figures

Table 1: Association of Long Lasting Nets and Intermittent Preventive Treatment in pregnancy on the incidence of malaria in children <5 years and in pregnancy, Kintampo, 2012 – 2016

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Figure 4: Association between Long-Lasting Insecticide-treated Nets (LLIN) distribution and

episodes of malaria in children under-five years in Kintampo North Municipality, Ghana 2012 – 2016
Figure 5: Association between the distribution of Long-Lasting Insecticide-treated Nets (LLINs) and episodes of malaria in pregnancy in Kintampo North Municipality, Ghana 2012 – 2016
Figure 6: Association between IPTp coverage and episodes of malaria in pregnancy in Kintampo North Municipality, 2012 – 2016

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Table 1: Association of Long Lasting Nets and Intermittent Preventive Treatment in pregnancy on the incidence of malaria in children <5 years and in pregnancy, Kintampo, 2012 - 2016

Variable	Co-efficient (β)	R	R^2	p-value	95% CI
LLINs distribution					
Children < 5 years	─ 0.86	─ 0.20	0.041	0.130	─ 1.20 – 0.26
Pregnant women	─ 0.21	─ 0.44	0.194	0.001	─ 0.32 – (─0.10)
IPTp-SP coverage					
IPTp1	─ 0.07	─ 0.08	0.006	0.551	─ 0.30 – 0.16
IPTp2	─ 0.09	─ 0.09	0.007	0.517	─ 0.39 – 0.20
IPTp3	0.07	0.05	0.003	0.704	─ 0.32 – 0.47
IPTp4	─ 1.23	─ 0.58	0.341	<0.001	─ 1.68 – (─0.78)
IPTp5	─ 3.69	─ 0.43	0.001	0.001	─ 5.72 – (─1.67)

R = Correlation coefficient R2 = coefficient of determination CI = Confidence Interval LLINs = Long Lasting Insecticide-treated Nets

IPTp-SP = Intermittent Preventive Treatment (of malaria) with Sulfadoxine Pyrimethamine during pregnancy.

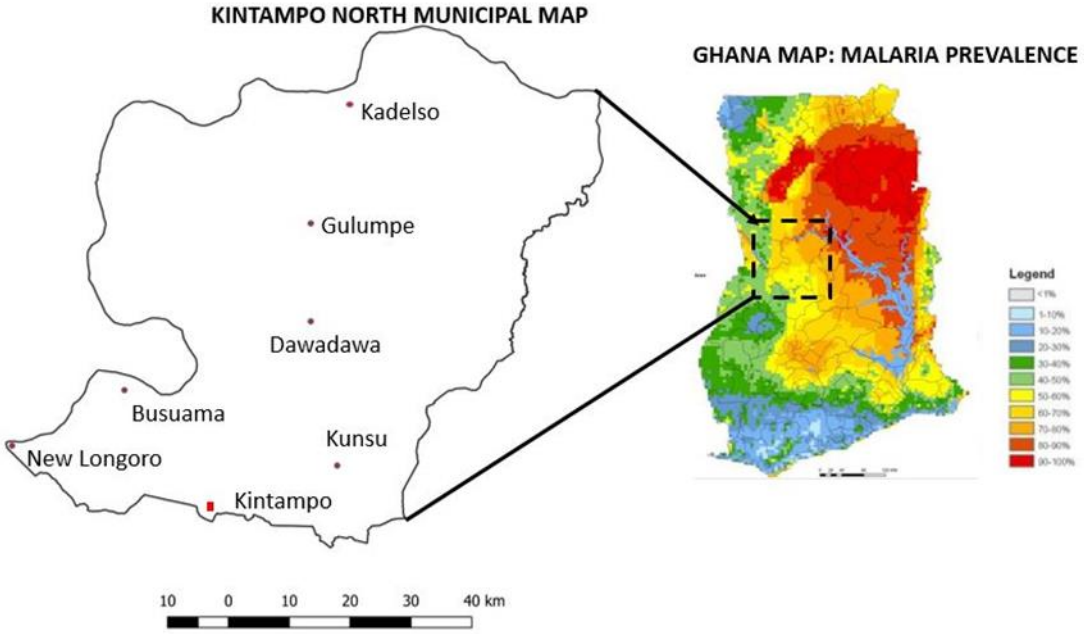

Figure 1: Map of Kintampo North Municipality.
Adapted from the Ghana Statistical Service [27]

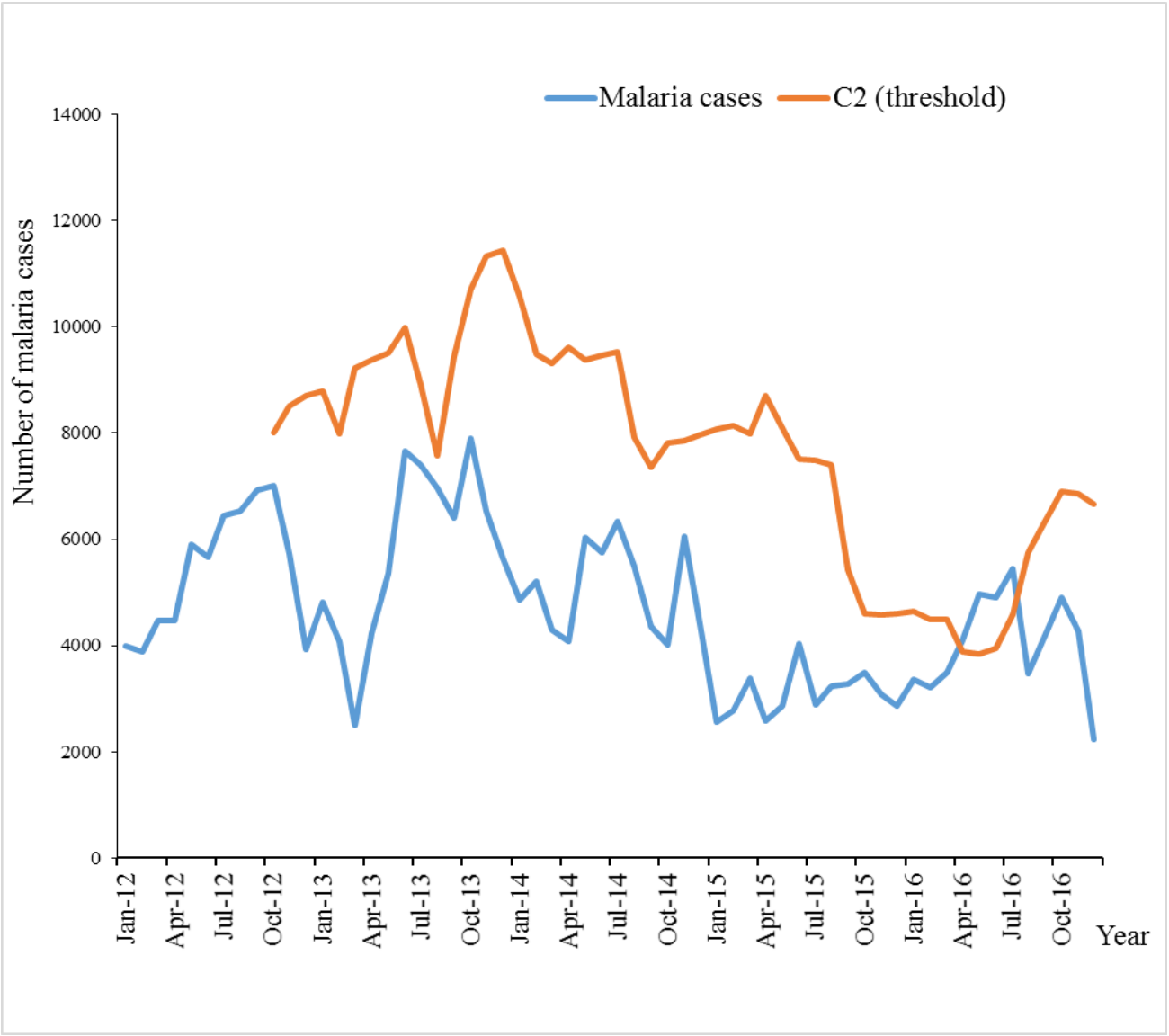

Figure 2: Trends of uncomplicated malaria morbidity in Kintampo North Municipality, 2012 – 2016

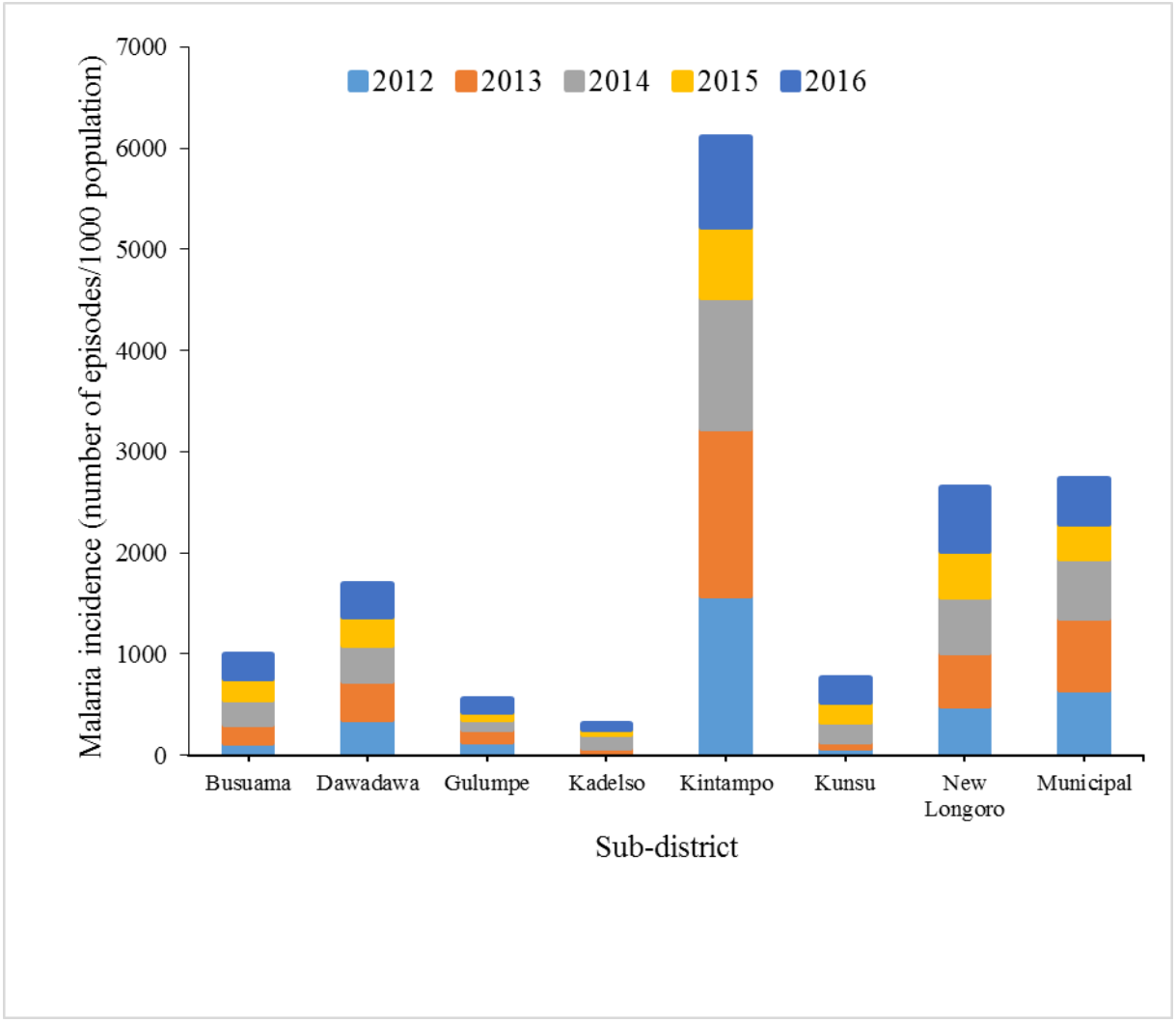

Figure 3: Malaria incidence by sub-districts in the Kintampo North Municipality, Ghana 2012 – 2016

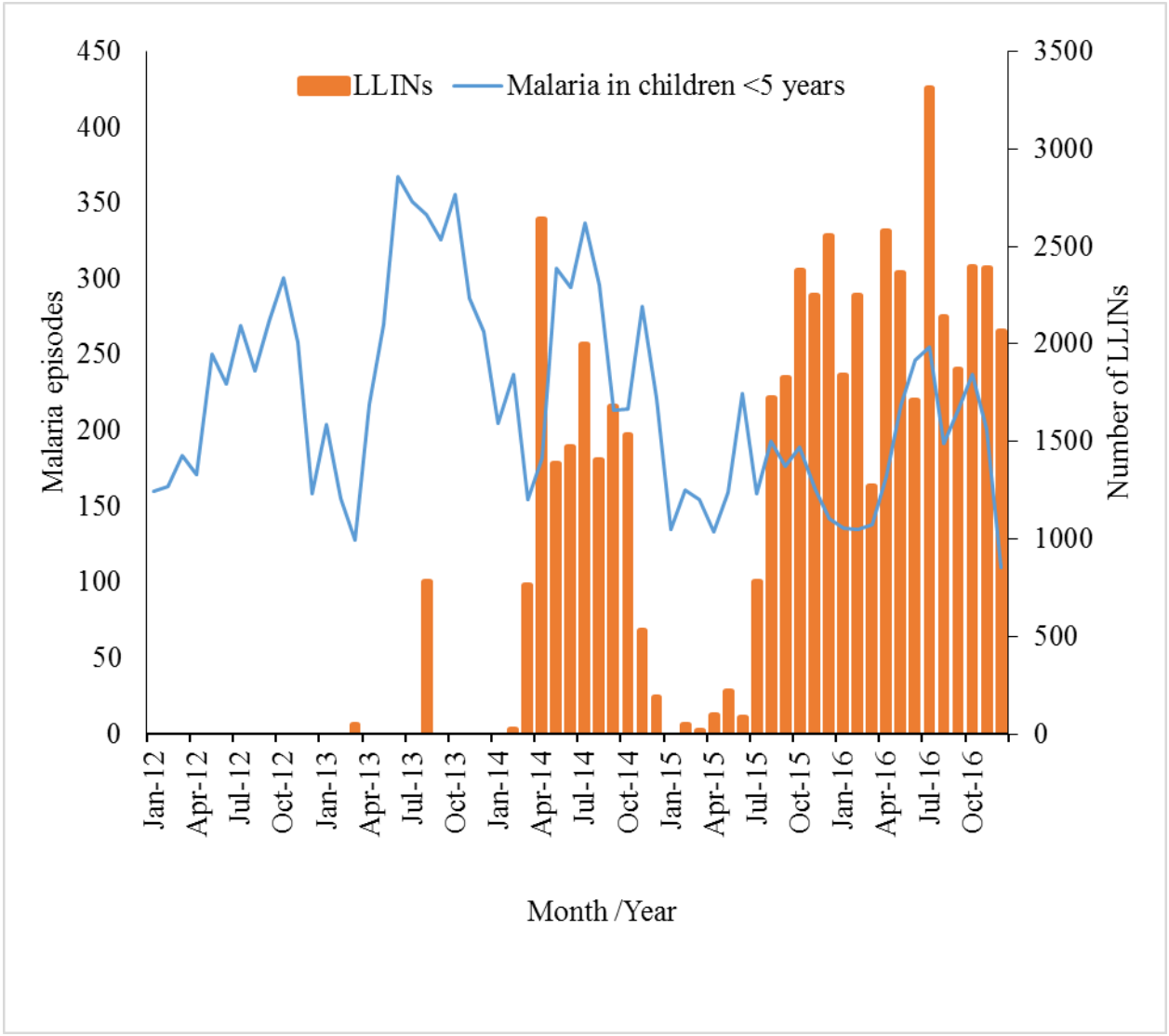

Figure 4: Association between Long-Lasting Insecticide-treated Nets (LLIN) distribution and episodes of malaria in children under-five years in Kintampo North Municipality, Ghana 2012 – 2016

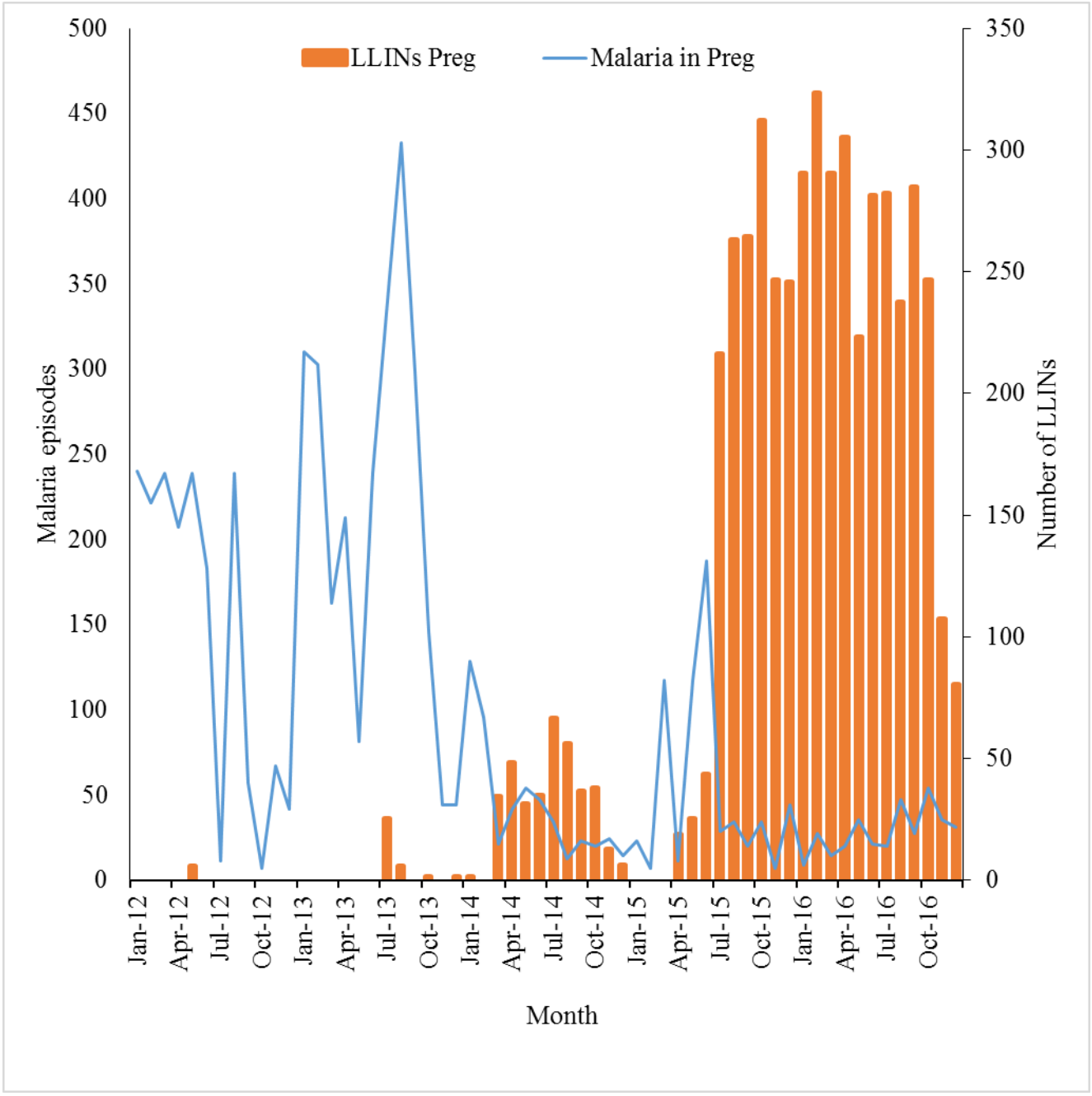

Figure 5: Association between the distribution of Long-Lasting Insecticide-treated Nets (LLIN)and episodes of malaria in pregnancy in Kintampo North Municipality, Ghana 2012 – 2016

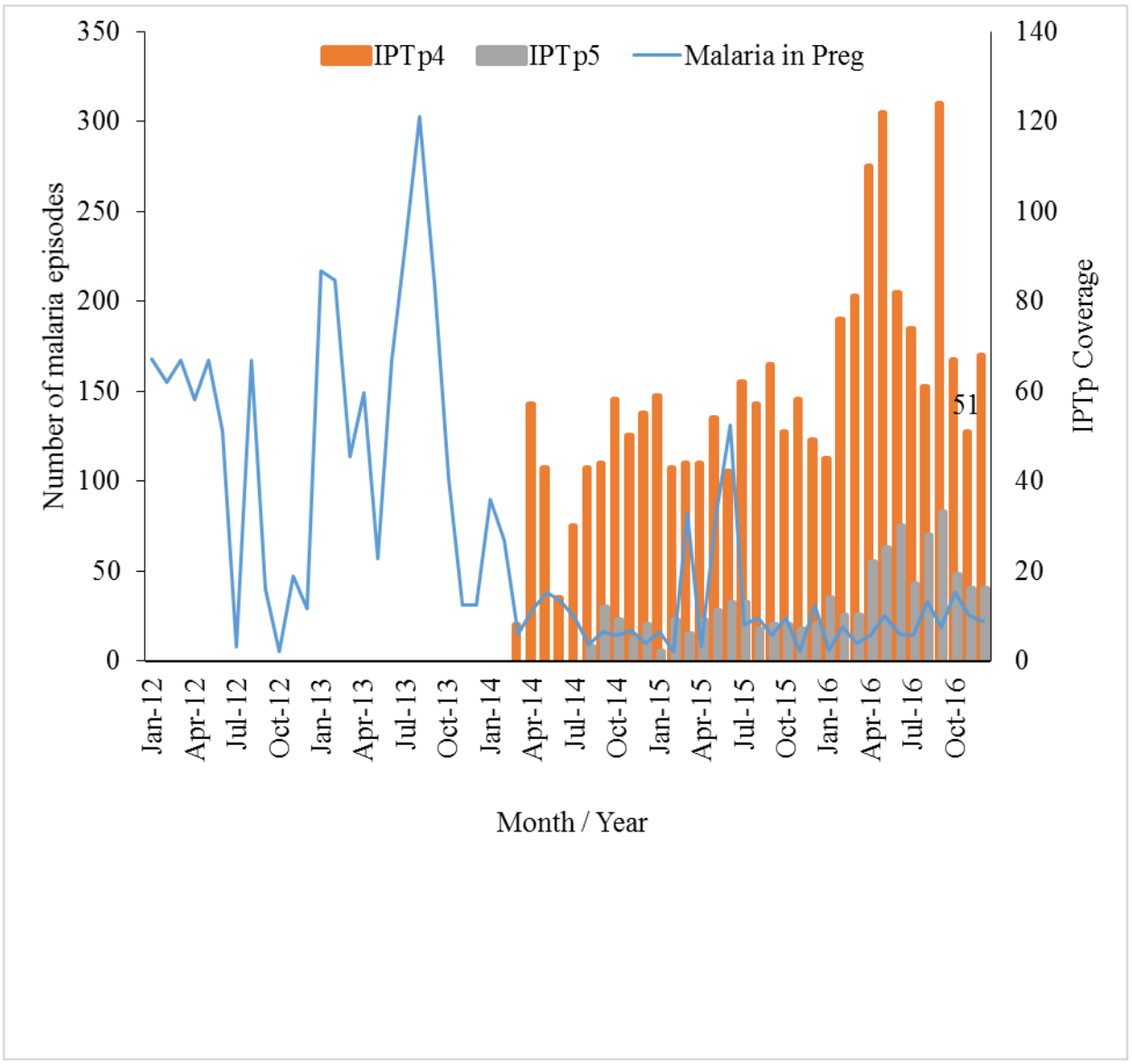

Figure 6: Association between IPTp coverage and episodes of malaria in pregnancy in Kintampo North Municipality, 2012 – 2016