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The Impact of Malaria Control Interventions on Malaria and Anaemia in Children under Five after Ten Years of Implementation in the Hohoe Municipality of Ghana

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Abstract

Background: Malaria remains a dominant health issue among children in Ghana. We monitored the trend of long lasting insecticide net (LLIN) ownership and use and its impact on malaria and anaemia among children under five over the past decade in an area of intense, prolonged and seasonal malaria transmission. **Methods:** A total of 1717, 2155 and 1915 children were surveyed in June and 1717, 2155 and 1697 in November in 30 communities of the Hohoe Municipality in 2006, 2010 and 2015 respectively. The primary outcomes monitored were the trend of LLIN ownership, use and prevalence of malaria and anaemia through cross-sectional surveys. **Findings:** Results showed a significantly positive trend ($p < 0.001$) in ownership of LLIN at 20.8%, 64.8% and 83.2% for 2006, 2010 and 2016 respectively. The sharp increase in ownership between 2006 and 2010 accounted for a highly significant departure from trend ($p < 0.001$). Similarly, the prevalence of LLIN use was 15.1%, 42.2% and 68.3% for 2006, 2010 and 2016 respectively with a significant positive trend ($p < 0.001$). The prevalence of malaria parasitaemia in June showed no significant drop over the three years studied. Anaemia prevalence was 7.9%, 5.3% and 11.1% for 2006, 2010 and 2015 respectively—Anaemia significantly increased ($p < 0.001$) between 2010 and 2015 accounting for a significant departure from the initially decreasing trend ($p < 0.001$). Malaria parasitaemia over the November surveys was 40.4%, 33.2% and 26.6% for

2006, 2010 and 2016 respectively, depicting a significant decline over the years of the study ($p < 0.001$). A significant decrease ($p = 0.006$) in anaemia was observed at 12.0%, 4.3% and 8.9% for 2006, 2010 and 2015 respectively. A significant departure from the decreasing trend ($p < 0.001$) was noted with increasing anaemia between 2010 and 2016. **Interpretation:** Ownership of LLIN and its use together with other indicators of malaria prevalence generally improved five years after the implementation of a malaria control programme. Ten years after programme implementation, consistent improvement was only in LLIN ownership and use. Also malaria prevalence indicators improved in the post as compared to the pre-rainy season in the study communities.

Keywords

Malaria, Anaemia, Long Lasting Insecticide Treated BedNets, Children under Five Years, Hohoe Municipality, Ghana

1. Background

Malaria is a focal problem of sub-Saharan Africa and for that matter Ghana. The condition is endemic in Ghana with *Plasmodium falciparum* (*pf*) as the predominant species causing the disease [1] [2]. Malaria is defined as a fever with any parasitaemia; and anaemia that requires treatment as haemoglobin (Hb) concentration of less than 8.0 gram/deciliter (g/dl) [3]. Globally, malaria and anaemia are major causes of morbidity and mortality among children under five years of age. A complication of malaria, anaemia is responsible for about 95% of malaria deaths worldwide with a mortality rate of 1% - 3% [4]. As of 2007, the population attributable risk percentage of *pf-induced* anaemia in Ghana was 16.5% [5]. Between 2000 and 2015, malaria incidence rates fell by 37% globally, and 42% in Africa. During this same period, malaria mortality rates fell by 60% globally and 66% in the African Region [2].

Though indicators point to a drop in its occurrence, malaria remains a dominant health issue in Ghana. Some 2200 deaths out of about 3.5 million cases of malaria reported in Ghana in 2015 were significantly lower than figures from 2013 [2]. Malaria still tops most Out Patient Department (OPD) cases and kills 3 children every day in Ghana [6]. In the Hohoe Municipality in 2014, malaria was a leading cause of OPD attendance and overall deaths at 28% and 19.4% respectively. Out of the 40,092 cases of malaria seen at the Hohoe Municipal Hospital OPD, 3452 (8.6%) were admitted. Children under 5 years of age constituted 42.1% (1452) of the cases admitted [7].

The Millennium Development Goals (MDGs) and the Abuja Declaration set targets of achieving 60% coverage of malaria interventions in pregnant women and children below 5 years of age by 2010 [8] and reducing malaria deaths and illness by 75% by 2015 [9]. Malaria control programmes premised on the above targets have facilitated reductions in deaths and illness attributable to malaria.

Methods employed by malaria control programmes globally include the use of long lasting insecticide nets (LLINs), and early detection of malaria and appropriate and prompt management with artemisinin-based combination therapy (ACT) [10]. Others are indoor residual spraying (IRS) and the use of effective chemoprophylaxis or intermittent preventive treatment (IPT) [11]. ITN ownership and use among pregnant women and children under five years have improved over the past decade [10]. Tropical Africa has generally been identified as having a high coverage of combined malaria control interventions [12] [13]. Findings from malaria control programs using LLINs, ACT or IRS have shown a drastic decline in malaria deaths, malaria positive cases and malaria prevalence over the past decade [14] [15] [16]. Furthermore, the scale-up of LLINs and ACT use in case management has reduced the burden of malaria anaemia in children under five years of age [14] [17]. Long lasting Insecticide Nets have ultimately contributed to the reduction in malaria infections; malaria morbidity and mortality in children under five years of age [18] [19] [20] [21]. Owning a LLIN does not protect an individual from malaria but rather its effective use and ability of the LLIN to kill or prevent mosquitoes from biting individuals [19]. Also mosquito survival and numbers of sporozoite-positive mosquitoes reduced significantly in whole communities provided with LLINs [12].

Important roll back malaria (RBM) indicators that help in monitoring changes in malaria incidence and prevalence are the proportion of households that own one or more LLINs and the proportion of under-five children who sleep inside a LLIN [10]. LLIN ownership and utilization assess the effectiveness of distribution channels and the desired epidemiological impact respectively of the RBM programme [10]. Other indicators are the prevalence of fever, anaemia, *P. falciparum* parasitaemia and gametocytemia [10].

In line with attaining MDG targets of reducing malaria illness and deaths, the Ghana NMCP introduced LLINs, IPTs and ACTs into the Hohoe Municipality. Ahead of implementing the intervention, baseline surveys were carried out in June and November 2006 [22]. Follow up surveys were carried out in 2010 and 2015 to assess the influence of the intervention of LLINs, IPTs and ACTs use, as well as changes in malaria incidence and prevalence in the Municipality. The current manuscript reports on trends in LLIN use and malaria prevalence in children aged 6 to 59 months over the course of the surveys between 2006 and 2015.

2. Methods

2.1. Study Design

The design of the three surveys was cross-sectional in nature. The surveys were carried out at the beginning of the rainy season (pre-rainy season) in June and the end (post-rainy season) in November) of the high transmission period for malaria in 2006, 2010 and 2015 respectively.

2.2. Study Area

The study was undertaken in the Hohoe Municipality of Ghana. The municipality is one of the twenty-five administrative districts of the Volta Region with a population of 167,000 people. It has two main seasons—the wet and the dry. The major wet season is from April to July and the minor one from September to November each year. The rest of the year is relatively dry. The climate is tropical with temperatures varying between 22˚C and 37˚C. The average annual rainfall in the municipality is 1592 mm with approximately 1296 mm of rain falling between April and October [23]. Malaria is hyperendemic in the study area but with seasonal peaks. The entomological inoculation rate (EIR) of malaria for the study area is approximately 65 (95% CI: 0 - 143) infectious bites per person per year [3]. Malaria transmission occurs throughout the year with seasonal peaks, coinciding with the period of the rains (high malaria transmission begins from June and ends in November).

2.3. Study Population

The study population was all children in the municipality aged 6 to 59 months. To be eligible for the study, the child should be aged 6 - 59 months and the parents/guardians consented to participate.

2.4. Sampling and Sample Size Calculation

For the initial survey in 2006, thirty communities were selected from a sample frame of all villages and communities in the municipality. The number of children living in each community was determined from the 2000 census. Thirty communities with the required number of children for the study (2125) were randomly selected by probability proportional to the number of children living in each community. This sampling approach was used to ensure a fair representation of communities in the municipality in the study. The sample size was estimated on the basis of the following: 95% confidence level (Z) and power of 80%, the prevalence (P) of malaria in children aged less than 5 years in June 2006 (end of dry season) was 8.6%. The least acceptable prevalence of malaria was 5.0%. Using OpenEpi software version 3 [24], the sample size calculated for each of the cross sectional studies was 1648 children aged less than 5 years [25].

2.5. Data Collection

Data collection for each study was in three phases:

Phase 1: Parents/guardians of the sampled children were interviewed using a close-ended questionnaire to gather information among others on LLIN ownership and use.

Phase 2: Temperature and weight measurements were taken of the sampled children. Temperature was measured using electronic thermometers (MODE: ZC, SURGILAC Digital Thermometer, UK). Weight was measured using SECA weighing scales (Hamburg, Germany).

Phase 3: Finger-prick blood samples were collected from the sampled children to assess malaria parasitaemia (mps) and Hb levels. Two technicians examined thick blood films for mps. A sample was considered negative only after 200 high power fields had been read. Parasite counts were converted to parasites per micro-liter (μl), assuming a white blood cell count of 8000 leukocytes per μl of blood. If there was a discrepancy in the findings of a slide between the two technicians (positive or negative or a 50% or more difference in parasite density) a third, more senior microscopist provided a conclusive result. A senior microscopist from the School of Public Health of the University of Health and Allied Sciences examined all the positive blood films and a 20% random sample of negative blood slides for quality control. Haemoglobin was measured using URIT-12 Hemoglobin Meter (URIT Medical Electronic, UK).

2.6. Data Management, Measures and Statistical Analysis

Data collected from the study subjects were recorded on specified forms and checked by field supervisors and a data manager for consistency and accuracy. The data were double entered into a database using the EPI Data software version 3.1. The accuracy of data input was checked and validated using customized validation programmes. The cleaned data were exported into the STATA statistical software version 12 for analysis.

The main variables of interest were malaria prevalence measured by any malaria parasitaemia (asexual parasite count 40/μ*l* and above), high density parasitaemia (asexual parasite count ≥7000/μl, gametocytemia (sexual parasites), fever (axillary temperature ≥ 37.5˚C) and anaemia (Hb < 8.0 g/dl) [26]. Other variables included age groupings in months, temperature and weight measurements, LLIN ownership and usage.

Analysis of the outcomes was carried out on an intention-to-treat basis, which implies that children screened were included in the analysis. Pre-rainy and post-rainy season measures of malaria parasitaemia, gametocytaemia, fever and anaemia in 2010 and 2015 were compared with those of the same periods of 2006. For each outcome a regression of its proportion was run using the Stata command ptrend. It reports the slope, standard error and z-score of the regression line, a chi square test for trend and a chi square test for departure from trend together with their corresponding p-values. All analyses were done with STATA software version 12.0. A negative slope was referred to as a negative trend, which implies a reduction in prevalence compared to the previous years. A positive slope was referred to as a positive trend, which implies an increase in prevalence over the previous years.

2.7. Ethical Considerations

Ethical approval for the study was obtained from the Ethical Review Committee (ERC) of the Ghana Health Service/Ministry of Health (GHS/MOH). The identification number for the clearance was ETHICS APPROVAL-ID NO: GHS-ERC: 14/05/15. Before the commencement of the study, permission was sought from the Municipal Health Management Team (MHMT), the Municipal Administration and the chiefs and elders of the selected communities. Parents/guardians of the participating children signed a written informed consent form before the start of the study.

3. Results

3.1. Background Characteristics of the Study Population

The sample population of the study in 2015 was one thousand nine hundred and fifteen (1915) and one thousand six hundred and ninety-seven (1697) children less than five years in the pre-rainy and post-rainy seasons respectively. The population for June and November 2006 was 1717 and 1435 respectively, and that for 2010, 2155 and 1778 children respectively. Overall, sex, mean age and mean weight distribution were similar in all groups (Table 1).

3.2. Trend of LLIN Ownership

Table 2 shows that ownership of LLIN was 357 (20.8%), 1396 (64.8%) and 1593 (83.2%) respectively for 2006, 2010 and 2016. The test of trend between 2006 and 2015 showed a significant positive trend (p < 0.001). On the other hand the highly significant result for the departure from trend (p < 0.001) is due to the high difference in ownership between 2006 and 2010 compared to that between 2010 and 2016. The prevalence of LLIN use was 15.1%, 42.2% and 68.3% respectively for 2006, 2010 and 2016. The test of trend between 2006 and 2015 showed a significant positive trend (p < 0.001) with no departure from it.

Table 1. Characteristics of children in all surveys.

Variable	Pre-rainy season		
Age groups (in months)	2006 (N = 1717) [n (%)]	2010 (N = 2155) [n (%)]	2015 (N = 1915) [n (%)]
6 - 11	321 (18.7)	389 (18.0)	258 (13.5)
13 - 23	435 (25.3)	510 (23.7)	428 (22.3)
24 - 35	399 (23.2)	454 (21.1)	480 (25.1)
36 - 47	319 (18.6)	436 (20.2)	377 (19.7)
48 - 59	243 (14.2)	366 (17.0)	372 (19.4)
Mean weight (kg) [SD]	12.8 (2.7)	11.3 (3.3)	11.8 (3.2)
Mean age (in months) [SD]	27.3 (15.4)	27.8 (15.5)	30.6 (15.6)

Table 2. Trend of LLIN ownership and use at the beginning of the rainy season for years 2006, 2010 and 2015.

Variable	2006 (N = 1717) [n (%)]	2010 (N = 2155) [n (%)]	2015 (N = 1915) [n (%)]	X_1^2, P (Trend)	X_1^2, P (Depart.)
Own LLIN	357 (20.8)	1396 (64.8)	1593 (83.2)	1422, < 0.001_a	90.6, <0.001
Use LLIN	260 (15.1)	910 (42.2)	1307 (68.3)	2.1, < 0.001_b	0.155, 0.693

a: Slope = 0.309, std. error = 0.008, z = 37.72; b: Slope = 0.265, std. error = 0.008, z = 32.30.

Table 3. Trend of the primary and key secondary outcomes at the beginning of the rainy season for the years 2006, 2010 and 2015.

Variable	2006 (N = 1717) [n (%)]	2010 (N = 2155) [n (%)]	2015 (N = 1915) [n (%)]	X_1^2, P (Trend)	X_1^2, P (Depart.)
Fever (temp. ≥ 37.5)	42 (2.4)	25 (1.2)	50 (2.6)	0.2, 0.637_a	12.8, <0.001
Any malaria parasitaemia	156 (9.1)	156 (7.2)	148 (7.7)	2.1, 0.145_b	2.5, 0.113
High density malaria parasitaemia	50 (2.9)	49 (2.3)	43 (2.2)	1.6, 0.203_c	0.5, 0.469
Gametocytaemia	14 (0.8)	3 (0.1)	7 (0.4)	4.1, 0.043_d	6.7, 0.010
Anaemia (Hb < 8.0 g/dl)	135 (7.9)	114 (5.3)	212 (11.1)	14.1, $<0.001_e$	32.1, <0.001

a: Slope = 0.001, std. error = 0.002, z = 0.472; b: Slope = −0.002, std. error = 0.001, z = 2.021; c: Slope = −0.003, std. error = 0.003, z = 1.273; d: Slope = −0.002, std. error = 0.001, z = 2.021; e: Slope = 0.017, std. error = 0.005, z = 3.756.

3.3. Pre-Rainy Season Malaria Parasitaemia, Fever, Anaemia and Gametocytaemia

In Table 3, the proportions of children with fever in 2006, 2010 and 2016 were 2.4%, 1.2% and 2.6% respectively. The chi square test for trend showed that there was no significant linear trend between 2006 and 2015 (p = 0.637), but there was a significant drop between 2006 and 2010 and a rise between 2010 and 2016 (p < 0.001).

The prevalence of "any parasitaemia" was 9.1%, 7.2% and 7.7% respectively for 2006, 2010 and 2016. The test of trend between 2006 and 2015 showed that even though there was a negative trend, it was not significant (p = 0.145).

The prevalence of "high density parasitaemia" was 2.9%, 2.3% and 2.2% respectively for 2006, 2010 and 2015. The test of trend between 2006 and 2015 showed that even though there was a negative trend, it was not significant (p = 0.203).

The prevalence of gametocytemia was 0.8%, 0.1% and 0.4% respectively for 2006, 2010 and 2015. The test of trend between 2006 and 2015 showed that there was a negative trend and it was significant (p = 0.043). The drop in prevalence between 2006 and 2010 and the rise in prevalence between 2010 and 2015 was a significant departure from the trend (p = 0.010).

The prevalence of anaemia was 7.9%, 5.3% and 11.1% respectively for 2006, 2010 and 2015. The test of trend between 2006 and 2015 showed a significant rise in cases of anaemia (p < 0.001). Even though there was a significant fall between 2006 and 2010, the rise between 2010 and 2015 was a significant departure from the trend (p < 0.001).

3.4. Post Rainy Season Prevalence of Malaria, Fever, Anaemia and Gametocytaemia

In Table 4, the prevalence of "fever" (temperature ≥ 37.5˚C) was 4.9%, 4.3% and 2.6% respectively for 2006, 2010 and 2015. The test of trend between 2006 and

Table 4. Analysis of trend of the primary and key secondary outcomes at the three studies during the post rainy season.

Variable	2006 (N = 1717) [n (%)]	2010 (N = 2155) [n (%)]	2015 (N = 1915) [n (%)]	X_1^2, P (Trend)	X_1^2, P (Depart.)
Fever (temp. ≥ 37.5)	71 (4.9)	77 (4.3)	44 (2.6)	11.8, 0.001	0.9, 0.331
Any malaria parasitaemia	580 (40.4)	590 (33.2)	451 (26.6)	67.3, <0.001	0.05, 0.822
High density malaria parasitaemia	151 (10.5)	56 (3.1)	71 (4.2)	54.0, <0.001	37.4, <0.001
Gametocytaemia	12 (0.8)	3 (0.2)	5 (0.3)	5.1, 0.023	4.4, 0.036
Anaemia (Hb <8.0 g/dl)	172 (12.0)	76 (4.3)	151 (8.9)	7.7, <0.006	57.6, <0.001

a: Slope = −0.012, std. error = 0.003, z = 3.441; b: Slope = −0.069, std. error = 0.008, z = 8.207; c: Slope = −0.030, std. error = 0.001, z = 2.268; d: Slope = −0.003, std. error = 0.001, z = 2.257; e: Slope = −0.014, std. error = 0.005, z = 2.772.

2015 showed a significant reduction of cases of fever over the years studied (p = 0.001).

The prevalence of "any parasitaemia" was 40.4%, 33.2% and 26.6% respectively for 2006, 2010 and 2016. The test of trend between 2006 and 2015 showed a significant reduction of "any parasitaemia" over the years of the study (p < 0.001).

The prevalence of "high density parasitaemia" was 10.5%, 3.1% and 4.2% respectively for 2006, 2010 and 2015. The test of trend between 2006 and 2015 showed a significant decrease in "high density parasitaemia" over the years studied (p < 0.001). However, there was a fall between 2006 and 2010 and then a rise between 2010 and 2016 but not up to the level of 2006. The fall in prevalence between 2006 and 2010 and the rise between 2010 and 2015 formed a significant departure from the linear trend (p < 0.001) (**Table 4**).

The prevalence of "gametocemia" was 0.8%, 0.2% and 0.3% respectively for 2006, 2010 and 2016. The test of trend between 2006 and 2015 showed a significant reduction over the study period (p = 0.023). The fall in prevalence between 2006 and 2010 and the rise between 2010 and 2015 formed a significant departure from the linear trend (p = 0.036) (**Table 4**).

The prevalence of anaemia was 12.0%, 4.3% and 8.9% respectively for 2006, 2010 and 2015. The test of trend between 2006 and 2015 showed a significant decrease in cases of anaemia (p = 0.006). The fall in prevalence between 2006 and 2010 and the rise between 2010 and 2016 formed a significant departure from the linear trend (p < 0.001) (**Table 4**).

4. Discussions

The study determined changes in indicators related to malaria prevalence among children below five years of age in the Hohoe Municipality of Ghana after interventions were introduced in 2006. This study has the unique quality of two five-year follow-ups post intervention. This has provided a longer-term view of the intervention effect in its immediate and long-term aftermath. There was a general increase in LLIN ownership and use. LLIN use consistently lagged behind LLIN ownership. Malaria parasitaemia, fever and anaemia levels fell within the first five years of the malaria control interventions, but were not sustained five years on.

This study shows an increase in LLIN ownership and use in the Hohoe municipality between 2006 and 2015 in the pre-rainy season. The findings are similar to surveys carried out in 2003, 2008 and 2014 that showed a consistent increase in ownership and use of LLINs in Ghana as a whole and in the Volta Region in particular (Ghana Demographic and Health Survey [GDHS], 2008 & 2014). Just as in the current study population, LLIN use has been consistently lower than its ownership across populations in some earlier studies [27] [28] [29] [30] [31]. Scarcity of nets, hot and dry weather and "being too hot in the net" were some reasons for low LLIN use [28] [30]. A community-based participatory intervention in Ghana improved LLIN use in the study populations [32].

Significant reductions in *pf* and anaemia were observed in children below 5 years after introduction of LLIN in Zanzibar ($p < 0.001$) [13] and Western Kenya ($p < 0.0001$) [33] respectively. Also malaria prevalence in children under five years of age decreased in Rwanda after the implementation of a programme that provided ACT and LLINs [14]. In the current study, fever, any parasitaemia, high-density parasitaemia, gametocytaemia and anaemia were the indicators used in assessing malaria prevalence. Significant improvements in malaria prevalence indicators were observed in the post-rainy than the pre-rainy season in the current study population between 2006 and 2010. These observed differences may lead to the suggestion that national malaria control programmes should further investigate the implementation of different interventions to suit each of the seasons. The improvements of malaria prevalence indicators between 2006 and 2010 were however not sustained between 2010 and 2015. Reports have shown that implementation of control activities decreases malaria from the baseline, but removing such control activities results in a return to baseline. Such a pattern has been observed in many locations where malaria control interventions have been successfully implemented and then halted. A review identified 75 different historical situations in which malaria resurged after it had been controlled [34]. Many of these resurgence events occurred at least in part because the reduction of malaria to very low levels led to an impression that transmission was no longer a threat, whereas the potential for transmission still existed. Sri Lanka and Zanzibar both experienced this kind of resurgence [10]. Possible reasons for the non-sustainability could also be due to delayed re-treatment of nets as identified in a study in Kenya [35]. Further investigations will be required into this situation.

The increasing LLIN ownership and use observed in this study did correspond to a continuous reduction in malaria prevalence during the high transmission but not the low transmission season. Studies in Kenya also made similar observations [27].

The effectiveness of LLIN reduces over time. However, the net does not need to be sprayed periodically with insecticide over time to maintain its effectiveness. After a period of time, the net needs to be replaced. This fact could be the reason why despite an increase in LLIN ownership and usage in the current study, there was still an increase in gametocytaemia and anaemia. However, information on maintenance of LLIN was not collected from the net owners during the current study.

Limitations of the Study

This was a cross-sectional survey at one point of the end of the high transmission season and not a cohort study that can determine malaria incidence throughout the wet and dry seasons. Information on LLIN ownership and usage was obtained from parents of the children without observation to confirm the availability and use. Since this was not a cohort study, our interest was not to study a particular sample of children over the period of the study. However, there might be some overlap between the selected samples over the period of the study as measures were not put in place to ensure that different sets of children were evaluated in the three different periods of the study.

5. Conclusion and Recommendations

Long Lasting Insecticide Treated Net ownership and use together with other indicators of malaria prevalence generally improved five years after the implementation of a malaria control programme in the Hohoe Municipality. Ten years after program implementation consistent improvement was only in LLIN ownership and use. Also malaria prevalence indicators improved better in the post as compared to the pre-rainy season.

Considering the fact that LLIN ownership and use showed consistent improvement, there is the need to further investigate factors that contributed to other malaria prevalence indicators. In the meantime other measures such as seasonal malaria chemoprevention (SMC) and indoor insecticide paints among others should be employed by the Municipal Health Directorate in consultation with other stakeholders to improve malaria control indicators.

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Conflict of Interest

All authors report no conflict of interest in this study.

Authors' Contributions

MK worked on the 2006 and 2015 projects and 2010 post-rainy season survey, supported EA on the 2010 pre-rainy season study who worked on this project for his MPH. MK, EA conceived the study. MK, YE, MA, WT, ET and JG were responsible for the initial draft of the manuscript. All authors reviewed and approved the final version of the manuscript.

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