Environmental Factors and Preventive Methods against Malaria Parasite Prevalence in Rural Bomaka and Urban Molyko, Southwest Cameroon

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Abstract

Malaria remains a major public health problem in Cameroon. This work was aimed at determining the influence of environmental factors and control measures on malaria parasite prevalence, and anaemia in pupils in rural Bomaka and urban Molyko, Southwest Cameroon. A total of 303 pupils (174 and 129 from Bomaka and Molyko, respectively), aged 4-15 years were studied. Information on demographic data, environmental and anti-malarial measures was recorded. Malaria was diagnosed from Giemsa-stained blood smears. Packed Cell Volume (PCV) was determined. The overall malaria parasite prevalence was 33.0%, and children from Bomaka had a significantly higher value (38.51%) than those from Molyko (25.58%). Malaria parasite prevalence was significantly higher in males and highest in children aged ≤ 6 years. Overall location, age and stagnant water were associated with malaria parasite prevalence. Although malaria parasite prevalence was higher in pupils who had bushes around their homes, lived in plank houses, and did not use Insecticide Residual Spraying (IRS), the differences were, however, not significant. The overall prevalence of anaemia was 14.0%, with the ≤ 6 years old pupils having the highest anaemia prevalence. Parasite density was significantly higher in anaemic ((1369, CI=504.25-2511.89) than non-anaemic children (507, CI=313.74-603.32). A combination of environmental and preventive measures (especially in rural areas) as well as community participation will reduce malaria transmission.

Keywords: Influence; Environmental; Control; Factors; Malaria; Anaemia; Prevalence; Cameroon

Introduction

Malaria transmission is perennial in Southwest Cameroon with seasonal increases during the rainy season, and varies with levels of urbanization [1]. The disease is also a major contributor to anaemia and may have profound consequences on learning and educational achievement of school age children [2]. Some studies have suggested that poor environmental sanitation and housing conditions, as well as lack of appropriate control measures might be significant risk factors for malaria parasite burden [3]. Environmental factors such as the presence of bushes and stagnant water around homes, rainfall, low altitude and high temperatures favor the breeding of malaria vectors, as well as parasite reproduction within them [4], while increased urbanization tends to reduce the rate of Anopheles breeding. The key to addressing the challenge of reducing malaria parasite prevalence is an integrated approach that combines preventative measures, such as Insecticide Treated Bed Nets (ITNs), Indoor Residual Spraying (IRS), improved access to effective anti-malarial drugs [5], as well as proper environmental management.

Although malaria continues to put a heavy toll on human life and on fragile economies of many African countries, recent trends in some African countries like Kenya [6], Tanzania [7] and Cameroon [8], indicate that malaria morbidity and mortality is on a decline, as a result of scale up use of ITNs and increased availability of anti-malarial medicines. A combination of environmental manipulation and other control measures have also been shown to reduce the overall malaria incidence and mortality by 50% in Zambia [9].

There is no documented information on the influence of environmental factors and use of preventive measures on the malaria parasite prevalence in inhabitants of rural Bomaka and urban Molyko in Southwest Cameroon. This study was therefore aimed at evaluating the influence of environmental factors, as well as some control measures on malaria parasite prevalence, density and anemia in school children in these areas. The results of this study will help the National Malaria Control Programme in Cameroon to plan proper management strategies for malaria, while taking into consideration the levels of heterogeneities that exists within the same localities.

Materials and Methods

Study area

The study was carried out at two sites in Southwest Cameroon-Bomaka and Molyko. Bomaka is a new layout (rural) located at an altitude of 507 m above sea level (a.s.l.). The area was formerly a banana plantation owned by the Cameroon Development Corporation (CDC). The land was recently handed over to the natives (Bakweris) of the area, and a lot of construction work is presently taking place in the area. Many houses are surrounded by bushes, cultivated crops and stagnant water. There is a mixture of two major house types-plank and cement bricks. Molyko (600 m a.s.l.) is an urbanized area in the neighborhood of Bomaka, and hosts the first English-speaking university in Cameroon. There are few or no bushes around houses in Molyko, and the majority of houses are constructed with cement bricks. The two sites have an annual rainfall of about 4,000 mm and a relative humidity of over 80%.

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Temperatures range from 18°C-29°C. There are two seasons, the rainy and the dry seasons, which start from mid-March to October and November to mid-March, respectively.

**Study population**

Children aged 4-15 years and of both sexes were recruited from Government Schools, Bomaka and Molyko. The purpose and methodology of the survey were explained and planned with the teachers. Informed consent forms were sent to the parents/guardians through the pupils, explaining the purpose and benefits of the study, as well as the safety precautions that had to be taken to ensure the safety of the children. The forms were signed and returned through the children, and selection for participation in the study was based on acceptance of the parents/guardians and willingness of the children to take part in the study.

**Study design and ethical considerations**

The study was cross-sectional and was carried out for 4 months-March to June, 2011. The investigative methods included the use of questionnaires, clinical evaluation and laboratory methods. A field questionnaire form was administered to the pupils, to obtain important demographic data such as age, sex and area of residence. The questionnaire also sort to obtain information on environmental factors, such as house type, the presence of stagnant water and bushes around the residence, as well as use of preventive methods like use of indoor residual spraying and insecticide treated bed nets. The axillary temperature was determined using a mercury thermometer.

An ethical clearance for the study was obtained from the Ethical Review Committee of the South West Regional Delegation of Public Health, while an administrative clearance was obtained from the South West Delegation of Basic Education, Cameroon.

**Collection of blood samples and preparation of blood films**

Capillary blood was collected from a finger prick, and thin and thick blood films were prepared by the method of Cheesbrough [10], for the detection and speciation of malaria parasites, respectively. Heparinized capillary tubes were filled with blood for the determination of Packed Cell Volume (PCV).

**Staining and microscopic examination of blood films**

After fixing thin blood films with absolute methanol, both thick and thin blood films were stained with 10% Giemsa for 20 minutes and examined under the 100X (oil immersion) objectives of a UNICO® light microscope, for the detection and identification of malaria parasites, respectively, using the bench aids of Cheesbrough [10]. Slides were declared negative if no asexual parasites were found after examining 100 high-power fields. Slides were read by two independent parasitologists, and in the case of any disparity, they were read again by a third person. Malaria parasites were counted against 200 leucocytes in thick blood films, and parasite density was expressed as number of parasites per microlitre (μL) of blood, assuming a White Blood Cell (WBC) count of 8,000 leucocytes per μL of blood [10].

**Determination of packed cell volume**

Blood-filled heparinized capillary tubes were centrifuged for 5 minutes at 10,000 rpm, and the PCV values were read using a microhaematocrit reader. PCV values of <15% were classified as severe anaemia, while values of 15-20% and 21-30% were classified as moderate and mild anaemia, respectively. PCV values of ≥ 31% were considered normal [10].

**Statistical analysis**

Data was recorded into spread sheets using Microsoft Excel and analyzed with the Statistical Package for Social Sciences (SPSS) version 17. Haemogloblin and patient’s ages are normally distributed and therefore, were presented as means ± SDs. Proportions were compared using the chi-square test. Means were compared using independent sample t-test and Fisher’s (F-Test). Odds Ratios (OR) was calculated to determine the important factors that were associated with malaria parasite prevalence. Pearson's correlation coefficient was used to evaluate relationship between variables. Significant levels were measured at 95% confidence level, with significant differences recorded at P<0.05.

**Results**

**Baseline characteristics of the study population**

Out of a total of 550 informed consent forms given out, only 303 pupils brought back signed forms and were all included in the study. A total of 174 and 129 pupils were from Bomaka and Molyko, respectively. Out of the 303 blood samples collected, the identity numbers of 10 blood samples got missing during transportation from the field to the University of Buea Malaria Research Laboratory. Thus, PCV values were analyzed on 293 samples. The study consisted of more females (189) than males (114), and the majority of pupils examined were in the 7-10 years age group. The overall malaria parasite prevalence in the study population was 33.0%. The prevalence of pyrexia was 26.7%, while that of anaemia was 14.0% (Table 1).

**Malaria parasite prevalence and density with respect to sex**

The prevalence of malaria parasites was significantly higher (χ²=8.23, d.f.=1, P=0.01) in males (43%), when compared with females (27%). On the contrary, geometric mean parasite density was higher in females (614.45 parasites/μL of blood, CI=321.55-807.30) than in males (607.66 parasites/μL of blood, CI=355.90-786.85), but the difference was not statistically significant (F=0.0013, d.f.=1, P=0.9709).

**Malaria parasite prevalence as affected by environmental factors, control measures, house type, age and location**

The prevalence of malaria parasites was higher in pupils who had stagnant water around their homes (42.9%), when compared with those who did not have stagnant water around their homes (23.38%). The presence of stagnant water around homes showed a significant association with the prevalence of malaria parasite (OR=2.47, P=0.0003) as seen in table 2. The highest prevalence of malaria parasites was recorded in pupils in the youngest age group, ≤ 6 years (50.00%), while the lowest was recorded in pupils of the oldest age group, 11-15 years (23.76%). Age was associated with malaria parasite prevalence (OR=0.31, P=0.0012). Those who lived in Bomaka had a significantly higher malaria parasite prevalence (38.51%), when compared with those who lived in Molyko (23.76%).

**Table 1: Baseline Characteristics of the Study Population.**

<table>
<thead>
<tr>
<th>Characteristic Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic</td>
<td></td>
</tr>
<tr>
<td>Age Groups (Years)</td>
<td></td>
</tr>
<tr>
<td>5-6</td>
<td>37.6%</td>
</tr>
<tr>
<td>7-10</td>
<td>16.5%</td>
</tr>
<tr>
<td>11-15</td>
<td>50.2%</td>
</tr>
<tr>
<td>Mean Age (Years)</td>
<td>9.29 ± 0.55 (range: 4-15) years</td>
</tr>
<tr>
<td>Mean Temperature at Enrolment (OC)</td>
<td>37.12 ± 0.55 (range: 35.5-38.7)</td>
</tr>
<tr>
<td>Mean PCV ± SD (%)</td>
<td>35.85 ± 3.32 (range: 24-48)</td>
</tr>
<tr>
<td>Overall Prevalence of Malaria</td>
<td>33.0% (100/303)</td>
</tr>
<tr>
<td>Anaemic Status</td>
<td>Anaemic (PCV&lt;31%) 14% (41/293)</td>
</tr>
</tbody>
</table>

The presence of stagnant water around homes showed a significant association with the prevalence of malaria parasite (OR=2.47, P=0.0003) as seen in table 2. The highest prevalence of malaria parasites was recorded in pupils in the youngest age group, ≤ 6 years (50.00%), while the lowest was recorded in pupils of the oldest age group, 11-15 years (23.76%). Age was associated with malaria parasite prevalence (OR=0.31, P=0.0012). Those who lived in Bomaka had a significantly higher malaria parasite prevalence (38.51%), when compared with those who lived in Molyko (23.76%). The prevalence of malaria parasites was higher in pupils who had stagnant water around their homes (42.9%), when compared with those who did not have stagnant water around their homes (23.38%). The presence of stagnant water around homes showed a significant association with the prevalence of malaria parasite (OR=2.47, P=0.0003) as seen in table 2. The highest prevalence of malaria parasites was recorded in pupils in the youngest age group, ≤ 6 years (50.00%), while the lowest was recorded in pupils of the oldest age group, 11-15 years (23.76%). Age was associated with malaria parasite prevalence (OR=0.31, P=0.0012). Those who lived in Bomaka had a significantly higher malaria parasite prevalence (38.51%), when compared with those who lived in Molyko (23.76%).
Anemia status as affected by site, gender and age

The prevalence of anemia was similar at the study sites ($\chi^2=1.79$, d.f. =1, $P=0.18$) and in the sexes ($\chi^2=0.82$, d.f. =1, $P=0.37$). The highest prevalence of anemia (27.3%) was recorded in the ≤ 6 years age group, while the lowest (9.9%) was recorded in the oldest age group, and the difference was statistically significant ($\chi^2=6.02$, $P=0.02$) as shown in figure 1. Among children with anemia, the majority were moderately anemic (80.5%), when compared with the mild anemic cases (19.5%). No case of severe anemia was recorded in the study population.

PCV Levels and anemia status as affected by malaria parasite prevalence and density

Children infected with malaria parasites had a significantly (t= 2.47, $P=0.01$) lower mean PCV level (35.16 ± 3.52), when compared with malaria negative children (36.17 ± 3.17). More so, a negative correlation (r= -0.20), was observed between PCV levels and malaria parasitaemia, which approached significance ($\chi^2= 7.99$, d.f.=2, $P=0.05$), as shown in figure 2. Anaemic children had a significantly (F=6.537, d.f.=1, $P=0.0122$) higher geometric mean malaria parasite density (1369, CI=504.25-2511.89), than non anaemic children (507, CI=313.74-603.32).

Discussion

This study investigated the influence of environmental factors, as well as control measures on malaria parasite prevalence, density and anemia in school children from two Government primary schools, located at sites with different levels of urbanization in the Mount Cameroon Region. The overall prevalence of malaria parasites in the study population was low, when compared to values of similar studies located at sites with different levels of urbanization in the Mount Cameroon Region. The overall prevalence of malaria parasites in the study was similar at the study sites ($\chi^2=1.79$, d.f. =1, $P=0.18$) and in the sexes ($\chi^2=0.82$, d.f. =1, $P=0.37$). The highest prevalence of anemia (27.3%) was recorded in the ≤ 6 years age group, while the lowest (9.9%) was recorded in the oldest age group, and the difference was statistically significant ($\chi^2=6.02$, $P=0.02$) as shown in figure 1. Among children with anemia, the majority were moderately anemic (80.5%), when compared with the mild anemic cases (19.5%). No case of severe anemia was recorded in the study population.

Malaria parasite prevalence (OR=1.82, $P=0.0180$). Although malaria parasite prevalence was higher in pupils who had bushes around their homes, lived in plank houses, and did not use IRS, the differences were however not significant (Table 2). None of these factors was associated with malaria parasite density.

The study showed that children in the youngest age group, ≤ 6 years, had significantly high malaria parasite prevalence, when compared to the older ones. This agrees with the report of Bodker et al. [13] who stated that acquired immunity is both exposure- and age-dependent, and the older children are likely to have developed some degree of immunity, as a result of repeated infections.

The study showed a significantly higher prevalence of malaria parasites in school children in Bomaka, when compared to Molyko. Molyko is an urbanized area, while Bomaka is more of a rural area. Some reports have stated that the level of malaria transmission in any area is generally higher in rural than in urban settings [1], due to environmental factors. Generally, it is considered that suitable breeding places are scarce in highly populated urban areas, and this leads to a reduction in the frequency and transmission dynamics of malaria [1]. However, evidence of the adaptation of malaria vectors to the African urban environment has been reported [14]. The finding also suggests that malaria parasite prevalence increases with a decrease in altitude [12,15]. In Africa, lowland generally has a higher malaria transmission, when compared with highland [16]. This is probably due to the fact that temperatures are generally higher at lower altitudes, thus, encouraging a faster growth rate and abundance for the malaria vectors, and consequently, a higher entomological inoculation rate.

The association of Bomaka with malaria parasite prevalence is not surprising, since Bomaka is a 'new layout' with a lot of bushes in many unoccupied plots in-between homes. A lot of farming and house construction works are going on in this area, thus, creating potholes for stagnant water. These probably increase additional breeding sites for malaria vectors. This work was carried out in the rainy season, which probably influenced the presence of breeding sites in the area [17], leading to an increase in vector density, man-vector contact, higher inoculation rates and consequently, higher transmission intensity. Mattys et al. [18] and Klinkenberg et al. [19] reported similar findings in Cote d’Ivoire and Ghana, respectively. Guthmann et al. [20] also reported seasonal malaria during the months of agricultural activity in Peru. Interestingly, Bomaka shares a boundary with Molyko in the Mount Cameroon region and shows such differences in malaria parasite prevalence. Major heterogeneities in malaria transmission [21], and other malariometric indices [20,22-25] between different areas of the same villages, town and between cities have been reported, and these have been attributed to major differences in access to health structures and a variety of environmental factors.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Category</th>
<th>Malaria parasite</th>
<th>Prevalence</th>
<th>OR</th>
<th>CI</th>
<th>$\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>House type</td>
<td>Block</td>
<td>Positive</td>
<td>36%</td>
<td>0.86</td>
<td>Reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plank</td>
<td>Negative</td>
<td>86%</td>
<td>0.35</td>
<td>0.13</td>
<td>0.30</td>
<td>0.2900</td>
</tr>
<tr>
<td>Bushes around the house</td>
<td>No</td>
<td>Positive</td>
<td>31%</td>
<td>0.89</td>
<td>1.48</td>
<td>0.89-2.46</td>
<td>2.28</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>Negative</td>
<td>89%</td>
<td>36.13</td>
<td>1.44</td>
<td>0.86</td>
<td>0.5800</td>
</tr>
<tr>
<td>Use of ITN</td>
<td>Yes</td>
<td>Positive</td>
<td>20%</td>
<td>35.62</td>
<td>Reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Negative</td>
<td>74%</td>
<td>32.17</td>
<td>0.86</td>
<td>0.49-1.49</td>
<td>0.30</td>
</tr>
<tr>
<td>IRS</td>
<td>Yes</td>
<td>Positive</td>
<td>17%</td>
<td>27.87</td>
<td>Reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Negative</td>
<td>83%</td>
<td>34.30</td>
<td>1.35</td>
<td>0.73-2.51</td>
<td>0.91</td>
</tr>
<tr>
<td>Presence of water bodies</td>
<td>No</td>
<td>Positive</td>
<td>36%</td>
<td>23.38</td>
<td>Reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>Negative</td>
<td>64%</td>
<td>42.95</td>
<td>2.47</td>
<td>1.51-4.05</td>
<td>13.13</td>
</tr>
<tr>
<td>Age group (years)</td>
<td>6</td>
<td>Positive</td>
<td>25%</td>
<td>50.00</td>
<td>Reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-10</td>
<td>Negative</td>
<td>51%</td>
<td>33.55</td>
<td>0.51</td>
<td>0.26-0.97</td>
<td>4.34</td>
</tr>
<tr>
<td></td>
<td>11-15</td>
<td>Negative</td>
<td>24%</td>
<td>33.76</td>
<td>0.73</td>
<td>0.15-0.64</td>
<td>10.50</td>
</tr>
<tr>
<td>Location</td>
<td>Molyko</td>
<td>Positive</td>
<td>33%</td>
<td>25.58</td>
<td>Reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bomaka</td>
<td>Negative</td>
<td>87%</td>
<td>38.51</td>
<td>1.82</td>
<td>1.11-3.00</td>
<td>5.80</td>
</tr>
</tbody>
</table>

Table 2: Influence of environmental factors, control measures, house type, age, and study site on malaria parasite prevalence between sites.

It is also worth noting that Molyko inhabitants are mostly university students and lecturers who are well educated, and are probably more able to afford protective measures against malaria. It has also been reported that the wealthy and educated households [26], often live in clean environments, and are able to afford better mosquito-bite preventive measures, and good medical attention when afflicted with malaria. The major victims are usually the poor, less privileged and economically downtrodden people, who often have dirty environments, and most often, have no means of acquiring better mosquito-bite preventive measures, and no access to modern treatment.

Stagnant water around residences was associated with significantly higher malaria parasite prevalence, when compared to those who did not have stagnant water around their home. This suggests that the presence of stagnant water around homes constitutes a risk factor that needs to be taken into consideration, when planning control measures against malaria, as malaria vectors need water for the survival of the immature stages.

Overall, there was lower malaria parasite prevalence in the participants that were using IRS, when compared with those not using IRS, although the difference was not significant. The use of IRS normally leads to a reduction in man-vector contact and reduces the transmission of malaria. A comparative study done in Kenya showed that sleeping in a room sprayed with insecticide reduced the risk of infection by 75%, while sleeping under an ITN reduced the risk of infection by 63% [27]. The efficacy of IRS has also been demonstrated in several studies in Peru [20], and Ethiopia [28]. Surprisingly, those using ITNs instead had a higher prevalence of malaria parasites. May be the ITNs were torn and the owners were still exposed to mosquito bites.

Although malaria parasite prevalence was higher in those living in plank than brick houses, the difference was, however, not significant. This agrees with the report of Peterson et al. [16], who did not find any association with malaria incidence and housing quality. It however disagrees with that of Protopopoff et al. [17], who reported that mosquitoes can easily enter houses constructed of poor materials with open eaves (such as plank houses, which usually have crevices on the walls), and these are associated with higher risks of malaria, as mosquitoes can easily enter and remain in the sleeping rooms during the night.

The significantly high prevalence of anaemia recorded in children aged 6 years and below, agrees with findings of Ekvall et al. [29], who observed that anaemia was determined by cumulated P. falciparum parasite densities in Tanzanian children. Sumbele et al. [30] reported similar findings.

Malaria parasite status had a significant impact on PCV levels, while anaemic children showed a significantly high parasite density. These could be due to the destruction of the red blood cells by the parasites, as they feed on haemoglobin of red blood cells, accelerated removal of both parasitized and non-parasitized red blood cells, as well as depressed and ineffective erythropoiesis, hence, reducing haemoglobin levels leading to anaemia [31]. More so, a negative correlation was observed between PCV levels and malaria parasitaemia, which approached significance.

The limitation of this study is that data was not collected on the vector population and man-biting habits of the population. The household size and presence of other animals in homes, which serve as alternative sources of blood meals for vectors was not also assessed.

Due to the heterogeneities that exist between village, town and city centers, it is necessary to target malaria control interventions in specific urban and rural populations and areas. Therefore, detailed information on malaria indices from these areas can help in planning effective control measures and allocation of health resources. Our study also indicates that if malaria control targets stagnant water around homes, in combination with other preventive measures (especially in rural areas), the breeding sites for malaria vectors will be eliminated and transmission will decrease. Therefore, community participation is very necessary for such a programme to succeed.

Acknowledgements

We are grateful to all the parents/guardians for their consent and the children who participated in this study.

References


Figure 1: Variation in mean PCV Levels (%) and anaemia prevalence with respect to age groups.

Figure 2: Variation in mean PCV Levels (%) and anaemia prevalence with respect to malaria parasite category.


