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Influence of Housing Design and Urbanization on Malaria Transmission in some Communities in Ashanti Region, Ghana

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Abstract

A comparative study of the effects of house design and urbanization in malaria transmission was conducted in some communities in Ashanti region between December 2010 to December 2011 using pyrethrum spraying of randomly selected rooms and questionnaire administration. Rooms randomly selected for pyrethrum spray collection were classified into first class, middle class, low class and slum based on presence or absence of vector screening. A total of 23357 mosquitoes were collected: 5019 (21.49%) Anopheles, 12804 (54.82%) Culex, 30 (0.13%) Aedes and 5534 were males. Calculated infection rates showed variation in highly urbanized and least urbanized study areas. Ceiling, trap door, unscreened windows and number of occupants in a room influenced indoor density of mosquitoes. Respondents in the study areas, with or without education, heavily depended on synthetic drugs for their malaria treatment. Over 70% of respondents use synthetic drugs in the treatment of malaria. Respondents prefer the use of Insecticide Treated Net to mosquito coil and insecticide spray in mosquito bite prevention.

Keywords: *Housing design, Urbanization, Malaria transmission, Pyrethrum, Ashanti, Communities*

Introduction

Malaria is transmitted throughout Ghana and is responsible for more than 44% of outpatient visits and approximately 22% of deaths in children under the age of five.

Deaths associated with malaria rose from 3,378 in 2009 to 3,859 deaths in 2010[1, 2]. Also, according to WHO/UNICEF: African Malaria Report, 2003, malaria is responsible for approximately 40% of public- health expenditure, 30-50% of in-patients and up to 50% of out-patients visit in areas with high rates of malaria transmission [3]. Human activity such as agriculture and irrigation, draining of marshland, deforestation or urbanization can have an impact on the distribution of Anopheles, their vectorial capacity and thus the epidemiology of malaria. The modification of the environment by man can therefore increase or decrease his exposure to malaria [4]. It is commonly assumed that urbanization leads to a decrease in malaria prevalence because it results in fewer anopheles breeding sites, reduced biting rates due to higher ratio of humans to mosquitoes [5], better access to treatment and better mosquito-proof housing [6]. However, there is a concern that areas with rapid, unplanned urbanization, typically associated with low income, poor education, poor health care and poor housing/sanitation, may not experience such marked decrease in malaria transmission [7]. Poor housing increases human vector contact, and thus poses unique challenges for control of malaria [8]. Control programs of malaria is insecticide based (e.g. Insecticide Treated Net [ITN], Roll Back Malaria, National Malaria Control Program) against this threat that A. gambiae has shown increased prevalence of insecticide resistance [9]. In Ghana, pregnant women with ITN dropped from 52.5% to 30.2%, children under 5years using ITN also dropped from 55.3% to 40.5 [10].

This research seeks to collect data on urban and housing influence on indoor vector abundance and asses' knowledge, attitude and practices of residents on malaria transmission.

Materials and methods

Study Areas

The pyrethrum spray catch and questionnaire administration were done in three selected communities in the Ashanti region from October 2010 to December 2011. Adum which is in the heart of Kumasi and Ayeduase are suburbs in the Kumasi Metropolitan Assembly (KMA) and Akropong is within the Atwima district. Population sizes were as follows; Adum 1170270 (587012 males, 583258 females), Ayeduase 7438 (3760 males and 3678 females) and Akropong 4358 (2237 males and 2121 females) as at year 2000 [11].

Seasonal dynamics are same in the study areas; a major rainy season (which falls on March – August), minor rainy season (September - November) and dry season (November - March).

Gps mapped study areas

The study areas were mapped with Global Position System Device to show the geographical positions and randomly selected houses for pyrethrum spray collection.

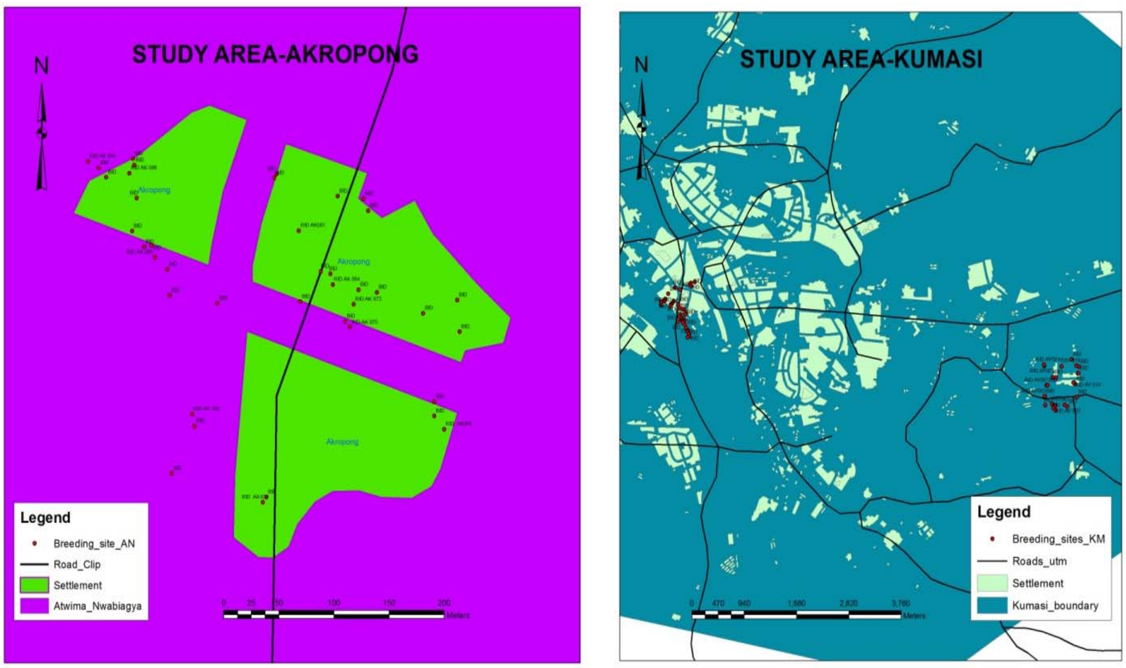


Figure 1: GPS Mapped Study Areas

Classification of Rooms

Selected rooms for pyrethrum spray collection (PSC) were categorised as first class, middle class, low class and slum. Rooms with screened windows, net gate, ceiling (and fan or air-condition) are classified as first class. Middle class rooms lack one of these: ceiling, net gate, screened windows, low class lacks any two and a slum lacks all.

Vector Collection

Insecticide aerosol containing tetramethrin 0.15%, beta-cypermethrin 0.08%, propoxur 0.32% from a pressurized can (pyrethrum) was sprayed inside a room for five to ten seconds, doors and windows closed for ten to fifteen minutes. Before spraying, food stuffs and utensils were removed from the room and a white sheet of cloth spread over the floor and furniture. Spraying was done between the hours of 4:30am to 10:00am. With the aid of a torch light, mosquitoes were collected into transparent plastic tubes and labelled with self-developed identification numbers, location, date and time of collection, house number or household's name, type of structure. A day catch was kept in a flask containing ice covered with cotton wool and transported to the entomology laboratory. Fed female Anopheles were dissected and salivary glands were examined in wet mount under light microscope for the presence of sporozoites.

Housing survey through designed questionnaire

Questionnaires were administered randomly to six hundred residents (200 in each study area) who have spent more than three months in the study area. It is designed to obtain personal information such as type of housing material (brick, mud or block), presence/ absence of ceiling, net gate, screened windows, fan/ air-condition, occupation, level of education and preventive practices from respondents. Mosquito entry points were also identified in the sampled houses.

Ethical Considerations

Ethical approval was obtained from Komfo Anokye Teaching Hospital Research Development Unit, Kumasi, Ghana.

Results

House characteristics and pyrethrum spray collection

A total of 23,387 mosquitoes were collected, of which 17,823 were females and 5,564 were males. The sex ratio of male and female mosquitoes caught by pyrethrum spray collections in the early mornings was 1:3 and of these, 5019 (21.49%) were Anopheles, 12804 (54.82%) were Culex and 30 (0.13%) Aedes. The mean number of mosquitoes in slums is statistically higher than the mean number of mosquitoes in First class rooms, irrespective of the season.

The abundance of mosquitoes collected from the classes of rooms in the study areas are presented in Table 1.

Table 1: Class of Room and Mosquito Abundance

SITE		NUMBER OF MOSQUITOES			
	CLASS OF ROOM	Anopheles (Female)	Culex (Female)	Aedes (Male)	Male Anopheles / Culex
	First Class	89	405	1	108
ADUM	Middle Class	235	937	4	267
	Low Class	640	1539	4	729
	Slum	865	2522	3	1046
	First Class	143	284	0	82
AYEDUASE	Middle Class	417	1158	2	409
	Low Class	501	1281	0	581
	Slum	787	1928	0	954
	First Class	64	85	0	29
AKROPONG	Middle Class	165	183	0	57
	Low Class	523	1087	5	487
	Slum	791	1392	11	787

House characteristics and malaria vector abundance

Assessment of Entry Points in Middle Class Rooms and Mosquito Abundance

Of the 963 female Anopheles collected in middle class rooms, 494 (51.30%) were collected in rooms without ceiling, 184(19.11%) in rooms without trap door and 284 (29.49%) in rooms without screened windows. Thus houses without ceiling were associated with elevated densities of malaria vectors as shown in Table 2**.**

Table 2: Entry Points and Mosquito Abundance in middle class houses

SITE	ENTRY POINT	NUMBER OF MOSQUITOES		
		ANOPHELES	CULEX	AEDES
	No Ceiling	164	363	1
ADUM	No Trap door	18	174	2
	No Net Screened Windows	68	307	2
	No Ceiling	224	353	1
AYEDUASE	No Trap door	80	279	0
	No Net Screened Windows	152	331	2
	No Ceiling	107	122	0
AKROPONG	No Trap door	86	61	0
	No Net Screened Windows	64	79	0

Relationship between number of occupants in rooms and mosquito density

Assessment of number of people in the classes of rooms in all the study areas shows a strong relationship between the number of people in a room and mosquito abundance. The more people there are in a room the more the number of Culex and Anopheles mosquitoes in the room.

Table 3: Number of People in a Room and Mosquito Abundance

No. OF ROOMS	No. OF PEOPLE	NUMBER OF MOSQUITOES

	IN A ROOM	CULEX spp.	ANOPHELES spp.
25	I	650	181
39	2	1033	326
45	3	1448	527
65	4	2655	995
52	5	3167	1153
53	6	2863	1356
21	≥7	1528	606

Comparative vector infection rate in the study areas

Man biting rate, sporozoites rate and entomological inoculation rate increased from majority of first class rooms to slums as shown in Table 4.

Table 4: Man Biting Rates and Entomological Inoculation rates of Anopheles Mosquitoes for the different classes of rooms sampled in the study areas

Site	Class of house	Fed Anopheles	No. of occupants	Man biting rate	Sporozoite rate (%)	EIR/year
ADUM	FIRST	89	82	1.085	0	0
	MIDDLE	235	86	2.733	1.7	4.652
	LOW	598	109	5.486	1.003	5.504
	SLUM	816	111	7.351	1.103	8.108
AYEDUASE	FIRST	120	97	1.237	0	0
	MIDDLE	385	97	3.969	0.52	2.062
	LOW	472	105	4.495	0.212	0.952
	SLUM	693	89	7.18	0.289	2.072
AKROPONG	FIRST	62	91	0.681	0	0
	MIDDLE	149	100	1.49	0	0
	LOW	476	119	4	1.05	4.202
	SLUM	727	87	8.356	0.825	8.356

A total of 4,852 Anopheles out of 23,387 sampled mosquitoes were dissected during the study period. Sporozoites were seen in the salivary glands of only 35 (0.72%). Akropong recorded the highest sporozoite rates whiles Ayeduase recorded comparatively lowest sporozoite and Entomological Inoculation Rates (EIR) (Table 5). Wet season recorded higher man biting rates in all the study areas.

Table 5: Results of Infection Rates in wet and dry seasons

Site	Season	Fed Anopheles	Man Biting Rate	Sporozoite Rate (%)	EIR/ Season
ADUM	Dry season	399	1.03	1.75	1.8
	wet season	1339	3.45	0.9	3.1
AYEDUASE	Dry season	364	0.94	0.37	0.35
	Wet season	1336	3.44	0	0
AKROPONG	Dry season	322	0.81	0.46	0.37
	Wet season	1092	2.75	1.86	5.12

In all study sites, rainfall was followed by an increase in the mosquito population although mean monthly rainfall in wet and dry seasons has no statistical significance on Anopheles abundance ($p=0.556$, $p>0.05$), dry season ($p=0.281$, $p>0.05$). *Anopheles gambiae* was the principal species collected, followed by very low densities of *A. funestus*. Comparison of *Anopheles* species distribution across the study areas showed *A. gambiae* to be predominant. Akropong was the only study area which recorded presence of sporozoite in *A. funestus* caught (Table 6). 95.8% of Anopheles mosquitoes dissected were *A. gambiae* and only 4.2% of *A. funestus*. Sporozoites were present in 0.7% of *A. gambiae* and 0.49% of *A. funestus*.

Table 6: Sporozoite rates among *Anopheles gambiae and A. funestus* in the study areas

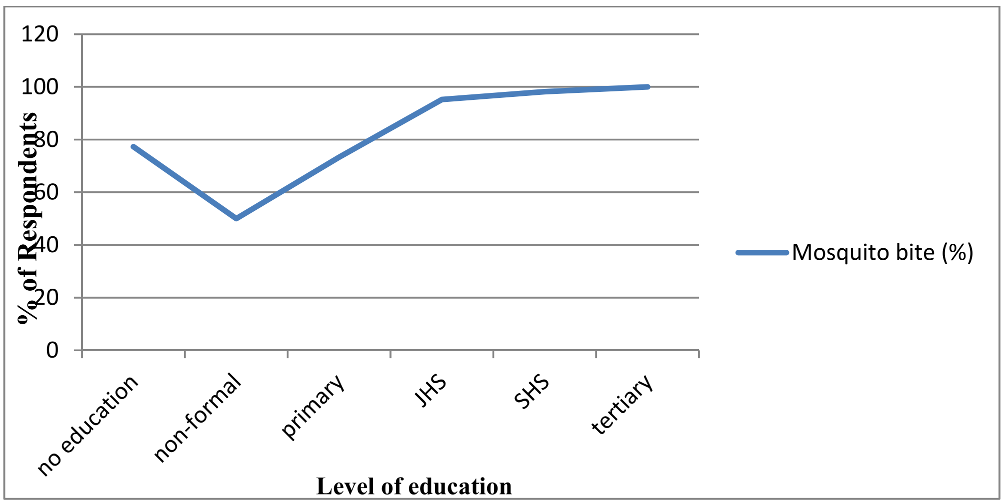
	A. gambiae	***A. funestus***

SITE	No. Dissected	No. with Sporozoite	Sporozoite Rate (%)	No. Dissected	No. with Sporozoite	Sporozoite Rate (%)
ADUM	1669	19	1.14	69	0	0
AYEDUASE	1647	5	0.3	53	0	0
AKROPONG	1331	10	0.75	83	1	1.21

Knowledge, perceptions, and practices of respondents in malaria

Education beyond primary school level increases the probability of respondents attributing the cause of malaria to mosquito bites (Table 3.5).

Figure 2: Knowledge of respondents on mosquito bite as cause of malaria



Practices Regarding Malaria

The most frequently reported first response by respondents was hospitals (35.8%) followed by self-medication (26.8%). 74 percent of respondents will use synthetic antimalaria drugs, 19.2 percent will use herbs, only 0.3 percent will take spiritual/ritual waters for cure, with 6.5 percent of the respondents indicating that they will ignore the signs.

Discussion

A. gambiae, A. funestus and Culex were among the species of man-biting mosquitoes caught indoors. *A. funestus* found in Akropong were probably due to the presence of two rivers (Nwabi and Ahenkoro) with a large swamp. Comparatively, *A. Funestus* unlike *A. gambiae* occurred in only very small numbers. This is supported by [12], *A. Funestus* group breeds in the lake waters so it is predominant all the year round. The results from this current study revealed that the main prevalent malaria vectors may be *A. gambiae* and *A. funestus* with *A. gambiae* predominating the collection although statistically, difference between number of *A. gambiae* with sporozoite and number of *A. funestus* with sporozoite were insignificant. [13, 14]; states that the most efficient vectors of human malaria in Africa in general, Sub- Saharan Africa and Nigeria in particular are member of the *A. gambiae* complex and *A. funestus* group.

Culex mosquitoes collected were more than double the number of Anopheles. Culex mosquitoes are not of major public health significance in Ghana, although they may be involved in transmission of *Wuchereria bancrofti* which causes elephantiasis [15]. [16], reported that Culex accounts for more than 90% of all mosquito bites in urban areas and this confirms what was observed in this study. Pyrethrum spray catch recorded statistically low mosquito samples in first class rooms throughout the collection period in all the selected study areas. Rooms with intact vector screening structures (i.e. first class room) recorded statistically low Anopheles samples compared to middle, low and slum rooms. According to [17], partial mosquito-proofing of houses with screens and ceilings has the potential to reduce indoor densities of malaria mosquitoes. Rooms without ceiling recorded high Anopheles samples compared to rooms without net gate and screened windows. Therefore, it is important to include ceiling and screened windows which are the most effective in vector screening in house designs to reduce vector entry [17, 18].

In this current study, the results revealed that all first class rooms sampled recorded no sporozoites rate and entomological inoculation rate (EIR). However, there was an increase in man biting rate, sporozoites rate and entomological inoculation rate (EIR) from first class rooms to slums [19]. It was also observed during the study that deteriorating infrastructure contributes to the development of conditions for malaria transmission [20]. Majority of respondents with or without education use synthetic drugs in the treatment of malaria. This probably may be due to effectiveness and readily availability of the drugs. It may also be due to cheap medical care due to National Health Insurance Scheme (NHIS). Since most respondents have adopted the use of synthetic drugs for malaria treatment, it was not surprising that in the choice of facility for malaria treatment, most (35.8%) choose hospitals and 26.8% reported use of self-medication.

Conclusion

Urbanization increases man vector contact as observed in this current study where the highly urbanized study areas recorded high percentages of adult mosquitoes compared to the least urbanized areas recording low percentages. This therefore, suggests that, process of urbanization could increase malaria transmission.

Room design, such as ceilings, trap door and net screened windows should be considered as part of an integrated vector management approach due to its capacity to prevent entry of anthropophagic mosquitoes into homes.

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