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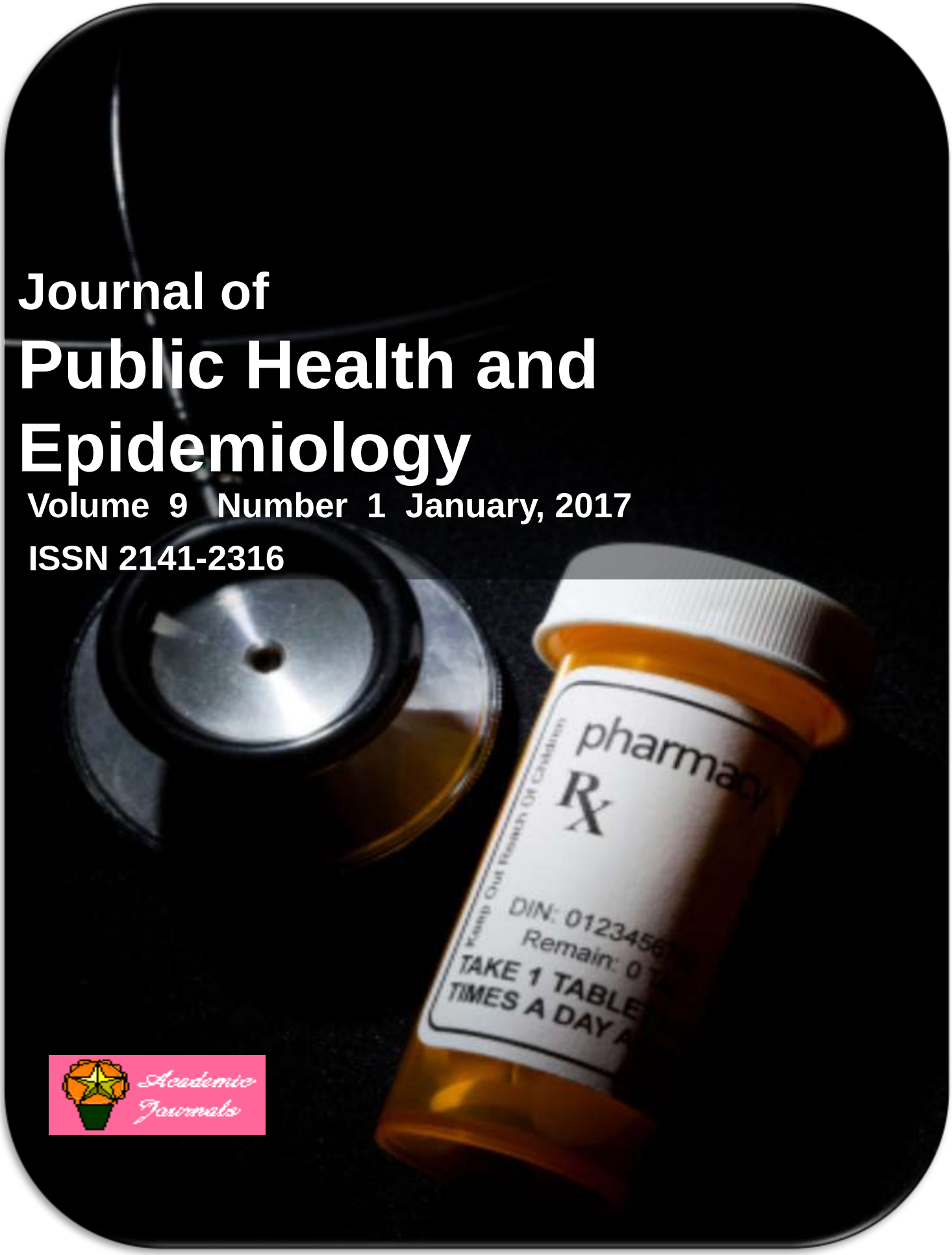

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Table of Content: Volume 9 Number 1 January 2017

ARTICLES

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Full Length Research Paper

Prevalence of occupational injuries and associated factors among construction workers in Addis Ababa, Ethiopia

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The present study aimed to determine the prevalence of occupational injuries and associated factors among building construction workers. A cross-sectional study was conducted in 15 licensed building construction companies in Addis Ababa, the capital city of Ethiopia. A multi-stage sampling was used to recruit 809 study participants. Data was collected using face to face interview and observational checklist. The data were analyzed using SPSS version 20 statistical software. Bivariate and multivariate logistic regression analyses were performed. A total of 683 (84.7%) respondents reported occupational injuries during the past 12 months giving an overall annual prevalence rate of 847 injuries per 1000 construction workers. Of the total 683 injured respondents, 74 (10.8%) were hospitalized. The odds of injuries were two times higher among males when compared with females (OR=2.17, 95%CI (1.47-3.19). Not having job satisfaction increased the odds of occupational injuries by about four folds as compared to those who are satisfied with their job (OR = 4.82, 95% CI (2.75-8.46). Working for more than 48 h per week, lack of vocational trainings, not using of personal protective equipment had significantly contributed to the higher risks of occupational injuries.

Key words: Construction, injury, health, occupational safety, prevalence.

INTRODUCTION

Occupational injuries have been rendered as one of the most important crippling factors contributing to disabilities and life threatening situations in the developed and developing countries (Majori et al., 2002). The International Labor Organization (ILO) estimates that there are over 270 million occupational accidents causing two million deaths annually (ILO, 2016). The cost of occupational accidents account to 4% of the world's gross domestic product (GDP) (USD 1.25 trillion). Occupational injuries can pose direct costs, like suffering, loss of employment, disability and loss of productivity, and indirect costs on families and society (Tadesse and Israel, 2016). Occupational injuries can generate significant costs to employers, place a burden on healthcare providers and potentially have a detrimental effect on the long-term health and socio-economic status

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of injured workers (Macdonald et al., 2012).

Studies demonstrated that illnesses, traumatic injuries and fatalities are more prevalent among workers in the construction industry than in other occupational groups in developing and developed countries (Probst et al., 2008; Moore et al., 2013; Khosravi et al., 2014). Within the construction industry, the risk of fatality is five times higher than in manufacturing, whilst the risk of a major injury is two and half times higher (Sawacha et al., 1999). The construction industry is subject to high occupational risk and high rates of occupational accidents, occupational diseases and absenteeism at work. Workers in the construction sector are more exposed to mechanical, biological, chemical and ergonomic risk factors. Occupational injuries and fatalities within the construction industry have also been associated with considerable financial costs. It has been estimated that such injuries cost over 10 billion USD per year (Gittleman et al., 2010).

The impact of occupational health and safety hazards faced by construction workers in developing countries is 10 to 20 times higher than those in Industrialized countries (Dong, 2005). The poor occupational safety situation among construction workers in developing countries are because of unsafe working environments such as poor design of equipment and work stations; lack of personal protective equipment and inadequate training of workers. While unsafe working environments are the major cause of most workplace injuries, individual related factors such as young age, male sex, lack of formal education, lack of experience, job dissatisfaction, smoking, excess alcohol use, sleeping problems, lack of physical exercise, extended working hours, night work, physically demanding work, and non-use of personal protective equipment are essential factors (Wong, 1994; Huang and Chen, 2002; Chau et al., 2004; Bresciani et al., 2012, Dong et al., 2015). About three-fifth of construction workers are not sure whether they have to wear protective equipment on the construction sites. They felt that it is inconvenient and uncomfortable when wearing protective equipment at work (Griffin and Neal, 2000).

Moreover, studies have shown that young workers (<25 years) are more at risk than older workers regarding work-related injuries (Kjestveit et al., 2011; Adane et al., 2013). Similarly, overtime and long hours of work are presumed to affect the risk of occupational injuries by precipitating various intermediary conditions in affected workers, such as fatigue, stress and drowsiness (Dembe et al., 2005). In most developed countries, to prevent health hazards at work, safety regulations have been developed and there is a legal framework for enforcing those regulations. But in developing countries like Ethiopia, personal protective equipment might often be the only line of defense.

As the emerging sector of Ethiopian economy, the status of the construction workers particularly their health condition should be given emphasis and the safety of the working environment should be maintained. In spite of the significant rate of increment in the industry over the past decades, only few studies have been conducted to investigate the occupational health status of workers working in the construction industry (Adane et al., 2013; Tadesse and Israel, 2016). Therefore, the present study envisaged prevalence of occupational injuries among construction workers in Ethiopia.

MATERIALS AND METHODS

Study setting and period

This study was done in Addis Ababa (capital city of Ethiopia). The city has a population of 3,384,569 projected from the 2007 population census (CSA, 2007). The study was conducted from February 01, 2015 to March 20, 2015 in five sub-cities.

Study design and population

A cross-sectional study was conducted in higher grade (Grade one to five) 15 construction companies located in Lideta, Bole, Yeka, Nifas Silk Lafeto and Kirkos sub-cities, Addis Ababa city, Ethiopia. According to Ministry of Urban Development and Construction (MoUDC), the number of Grade one to five building construction companies in 2013 was estimated to be 2,014 (MoUDC, 2013). Source population was all construction workers in the selected construction industry while study participants were randomly selected workers working in the selected construction companies.

Sample size and sampling technique

The sample size was calculated using a formula for estimation of a single proportion assuming the prevalence of injury among building construction employees to be 50%, confidence interval 95%, marginal of error 5% and design effect 2. Considering 5% non-response rate, the final sample size was 809 (Daniel, 1993).

A multi-stage sampling technique was used to select the study participants. In the first stage, three condominium construction sites from each selected sub-city were randomly selected by the lottery method, making the total construction sites selected fifteen. In the second stage, the total of 809 study participants were proportionally allocated to each construction company using simple random sampling.

Data collection

A pre-tested and structured interview questionnaire and observational check list were used to collect the data. Detailed information on the socio-demographic, behavioral and environ-mental factors, awareness and practices towards occupational injuries among construction workers and episodes of injuries in the past one year were collected. Work environment observation checklist was also used to identify different workplace hazards, the availability and use of personal protective equipment and other facilities.

Measurements

The outcome variable of this study was a self-reported occupational

injury status. It was measured by asking respondents a question stated as, “Have you had any physical injury resulting from an accident in the course of construction work in the past 1 year?” to determine annual prevalence of injury. The type and causes of injuries were classified based on the International Classification of External Causes of Injuries (ICECI, 2004). Independent variables were socio-demographic variables (sex, age, religion, educational level, marital status, salary and working experience) and behavioral variables (drinking alcoholic, chat chewing, job satisfaction and use of personal protective equipment). In addition, work environment variables (job category, hours worked per week, workplace supervision, health and safety training and personal protective equipment availability) were also independent variables in this study.

Data analysis

Data was entered to, cleaned and analyzed by SPSS version 20. First, descriptive analysis was done. Then, bivariate analysis was done to identify factors associated with occupational injuries. Those variables in the bivariate analysis with P–value <= 0.25 were considered as candidates to be included in the multivariable logistic regression model. The multivariable logistic regression was performed by the backward stepwise variable selection method with probability of removal of 0.10. Finally, the adequacy of the model was checked by using Hosmer and Lemeshow goodness-of-fit test.

Data quality control

The questionnaire was first prepared in English and translated to Amharic and then back to English by different independent language experts to verify the consistency and content of translation. Finally, Amharic version was used. Three data collectors were involved in data collection after two days training. The training was focused on issues such as the data collection instrument, field methods, inclusion-exclusion criteria and record keeping. The interview questionnaire was pre-tested on 40 respondents in order to identify potential problems, unanticipated interpretations and objections to any of the questions. Based on the pre-test results, some modifications were made on the questionnaire before the actual data collection.

Ethical consideration

Ethical clearance was obtained from Institutional Review Board of Health Science College, Jimma University. Permission was also obtained from local administrative bodies and construction companies. Before starting the interview, oral informed consent was obtained from each respondent. Respondents were assured that individual information would be kept confidential.

Operational definitions

Excessive dust

This is when the workers eye brows, hair, nostrils and cloths are observed by assessor to be covered with dust particles.

Excessive heat

The heat is recorded as excessive if a worker is found sweating when naked or with light clothing.

Excessive noise

Noise that makes it difficult to communicate with your neighbor without shouting.

Health and safety training

Trainings given to a worker on health and safety to construction workers.

Injury

The reported work related physical damage to body tissues caused by accident or by exposure to environmental stressor in the last one year.

Job satisfaction

A state of pleasurable emotional feeling reported by the worker as the result of one’s job. It is a subjectively perceived response of study participants to their job (Yiha and Kumie, 2010).

Occupational health risk

This refers to any source of potential damage, harm or adverse health effects on something or someone under certain conditions at work.

Occupational injury

This is any injury that occurred on worker in connection with the performance of his or her work in construction site.

Personal protective equipment

This include items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests and full body suits worn to minimize exposure to serious workplace injuries and illnesses resulting from contact with chemical, radiological, physical, electrical, mechanical or other workplace risks.

RESULTS

A total of 806 construction workers participated in this study, making the response rate of 99.6%. From the total participants, 323 (40%), 261 (32.4%), 92 (11.4 %), 83 (10.3%) and 47 (5.8%) were working in construction grade one, two, three, four and five, respectively.

Socio-demographic characteristics of respondents

Of the total of 806 respondents, majority: 514 (63.8%) were males. The age of respondents ranged from 16 to 58 years with a mean age (±standard deviation) of 22.61±5.08. Among the total respondents, 413 (51.2%) and 393 (48.8%) were unmarried and married, respectively. About half of the respondents (53.1%), had

Table 1. Socio demographic characteristics of selected construction site workers in Addis Ababa, Ethiopia, March, 2015 (n=806).

Variable	Frequency	Percentage
Sex		
Male	514	63.8
Female	292	36.2
Age		
≤26	391	48.5
>26	415	51.5
Marital status		
Unmarried	413	51.2
Married	393	48.8
Religion		
Christian	601	74.6
Muslim	189	23.4
Others	16	2.0
Educational status		
Illiterate	51	6.3
Primary school (Grade 1-8)	525	65.1
secondary school (Grade 9-12)	190	23.6
University/ College	40	5.0
Working experience in years		
1-5 years	608	75.4
>5 years	198	24.6
Monthly salary (in Ethiopian Birr)		
200-500	273	33.9
501-1000	428	53.1
1001-1500	64	7.9
>1500	41	5.1

monthly salary of between 501 and 1000 Ethiopian birr (Table 1). From the total of 806 respondents, 532 (66.0%) were daily laborers, 76 (9.4%) were plasterer, 46 (5.7%) were carpenters and 44 (5.5%) were masonry workers (Figure 1).

Prevalence of occupational injury

A total of 683 (84.7%) respondents had reported occupational injuries during the past 12 months giving an overall annual prevalence rate of 847 injuries per 1000 construction workers. From which 471(68.9%) respondents sustained more than one injury. In this study, the main types of injuries reported were cut, 36.2% and abrasions, 26.6%. The three leading causes of injuries were hurt by sharp instrument (46.1%) followed by fall accidents (37.3%) and injuries caused by falling, splinting or splashing objects (8.9%) (Table 2).

Most occupational injuries occurred on fingers of the study participants, 38% followed by arm (hand), and 28.8% (Figure 2). Of the total injured respondents, 74 (10.8%) were hospitalized, from which 31 (41.9%) were hospitalized for more than 24 h. Most of them were absent from work for 7 days or less, 86.7% (Table 3).

Determinants of occupational injuries

From the socio-demographic variables, sex of respondents remained statistically significant after controlling for confounders. The odds of having work related injury

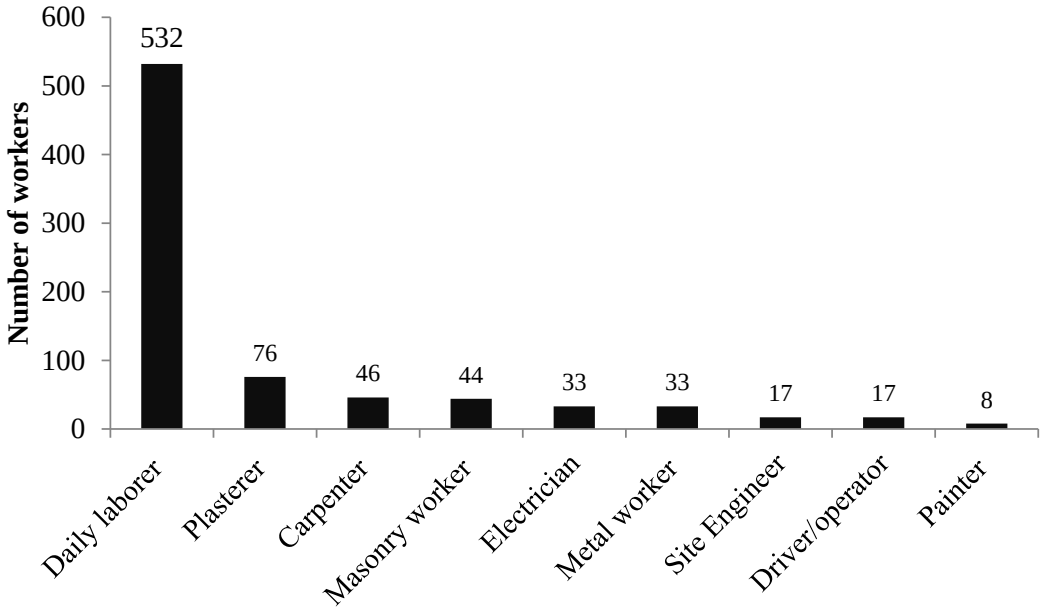

Figure 1. Job category of selected construction site workers in Addis Ababa, Ethiopia, 2015.

Table 2. Distribution, causes and types of occupational injuries among selected construction site workers in Addis Ababa, Ethiopia, March, 2015 (n=806).

Variable	S/N	Percentage
Occupational injuries in the last 12 months		
Yes	683	84.7
No	123	15.3
Number of occurrence	806	100
Once	212	31.1
More than once	471	68.9
Type of injury		
Abrasion	182	26.6
Cut	247	36.2
Puncture	133	19.5
Burn	16	2.3
Dislocation	59	8.6
Fracture	27	3.5
Suffocation	6	0.9
Electrocutions	9	1.5
Chemical poisoning	4	0.9
Cause of injury		
Fall accident	255	37.3
Hurt by sharp instrument	315	46.1
Injury caused by chemical/poisoning	14	2.1
Falling, Splinting or splashing objects	61	8.9
Lifting heavy objects	29	4.3
Fire	3	0.4
Electric	6	0.9

Table 3. Severity of occupational injuries among selected construction site workers in Addis Ababa, Ethiopia, 2015 (n=806).

Variable	S/N	Percentage
Hospitalized		
Yes	74	10.8
No	609	89.2
No. of days of hospitalization		
≤1 day	43	58.1
>1 day	31	41.9
No. of days of absentees from work		
≤7 days	592	86.7
7-30 days	79	11.6
>30 days	12	1.8

Table 4. Determinants occupational injuries construction workers, Addis Ababa, Ethiopia, March, 2015.

Variables	Crude OR (95% CI)	Adjusted OR
Sex		
(Male, Female[@])	2.17 (1.47-3.19)*	4.16 (1.55-11.12)*
Hours worked/week		
(≤48, >48[@])	0.06 (0.03-0.11)*	0.43 (0.19-0.97)*
Supervision		
(Yes, No[@])	0.06 (0.03-0.10)*	0.35 (0.16-0.76)*
Vocational training		
(Yes, No[@])	0.05 (0.03-0.10)*	0.15 (0.07-0.31)*
PPE availability		
(Yes, No[@])	0.036 (0.02-0.07)*	0.13 (0.06-0.31)*

Adjusted for educational status, job category and PPE use. Note: * = significantly associated at p<0.05; @=reference group.

among male workers were 4 times higher as compared to female workers [aOR=4.157, 95%CI (1.554-11.120)]. From working environment variables, hours worked per week, supervision of workplace, vocational training and PPE availability were found significant and associated with occupational injury. Working for 48 h or less per week decreased occupational injury by 58.1% as compared to working for more than 48 h [aOR= 0.429, 95%CI (0.187-0.967)]. Injury and work place supervision are inversely associated [aOR= 0.353, 95%CI (0.164-0.757)]. Vocational training decreases the odds of injury by 85.5% [aOR= 0.145, 95%CI (0.068-0.307)]. Workers with available PPE were 0.145 times less likely to have occupational injury than their counterparts [aOR= 0.145, 95%CI (0.068-0.3070] (Table 4). In this study, the grade of construction industry was not statistically significant in association with the occurrences of injuries among construction workers.

DISCUSSION

The study result showed that out of the total participants, 84.7% of construction site workers experienced occupational injuries at least once in a year time. This finding is higher than that of the studies done in Gondar and Addis Ababa, where the prevalence rate of injury was about 38%. This variation in prevalence of occupational injuries might be related to differences in

sample population; in this study, a minimum of a year experience in construction worker is mandatory to be recruited as study participants, whereas nothing has been mentioned in both studies (Adane et al., 2013; Tadesse and Israel, 2016).

This study depicted that the most frequent causes of occupational injuries were hurt by sharp instrument followed by fall accidents. This result is relatively similar to the study done in Egypt where accidents related to fall represents a significant portion of occupational injuries among building construction workers (Alazab, 2004). In this study, the main types of injuries were cut and abrasions commonly occurring on fingers and arm. These were the most active body parts and also were directly exposed to machines and sharp hand tools. This result is consistent with report from USA (Jeong, 1998; Jackson and Loomis, 2002; Welch et al., 2005; Cheng et al., 2012).

According to this study, the assessment of severity of occupational injury revealed that 74 (10.8%) were hospitalized, from which 31 (41.9%) were hospitalized for more than 24 h. Most 592 (86.7%) were absent from work for seven days or less. Similar result was reviewed from study conducted on small and medium scale industries in North Gondar Zone (Adane et al., 2013).

Based on this study, the occurrence of occupational injuries was higher in male workers than females. This finding is similar to a study done in Gondar city, Ethiopia. This might be because of the difference in tasks assigned; males commonly do harder tasks leading to severe injuries (Dong et al., 2015; Adane et al., 2013; Welch et al., 2005). When other variables are held constant, construction workers working for shorter duration had significantly lower work-related injuries. Similar results were reported by other studies, the risk of injury is associated with occupations of long working hours (Dong, 2005; Dong et al., 2015).

This study also demonstrated that most of the workers do not have the requisite health and safety training and it is possible that they are unaware of the role of personal protective equipment. The result showed that only few, 15.4% of the respondents took trainings. In addition, only 34.7% respondents reported that their work place was supervised. In line with this, 61.3% of the participants stated that PPEs were not available in their work setting. These factors could add up and put these construction company workers in a huge risk towards various dangers and injuries occurring in their work place. These results are similar to a case study conducted on construction projects in Kenya on health and safety management on construction project sites (Wong, 1994; Cattledge et al., 1996, Huang and Chen, 2002).

The study was not free of limitations. First of all, studying the dynamics of work-related injuries and associated factors require a prospective study, while this study is a cross-sectional. Second, the relatively long recall period of 12 months may have led to under-reporting of injury, especially if they were minor injuries.

Conclusion

In conclusion, the overall annual prevalence rate of occupational injuries was high. Employees working for more than 48 h per week, absence of vocational trainings, lack of PPE, lack of work place supervision and no use of PPE had significantly higher risks of work-related injury among construction workers. Each construction companies should arrange appropriate health and safety training for employees using qualified professionals.

Conflict of Interests

The authors declare that they have no conflict of interest.

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Full Length Research Paper

A Community-sensor index as a tool for public health surveillance of malaria drug resistance

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Infectious diseases like tuberculosis, malaria and the human immunodeficiency virus are both preventable and curable but cause about half of the deaths in the developing world. They affect people in the prime of their productive lives, inflicting a very heavy impact on development, opportunities and livelihood. Poverty is the end result with an enormous toll on the economy of developing nations. As such, the community goes for the cheapest medications that work and therefore can report on the effectiveness of drugs as an effect of many activities upstream that cause parasite unresponsiveness to therapy. The aim of this study was to investigate the relationship between community auto-medication and molecular markers of drug resistance in malaria to detect and provide evidence for when the community feels a drug is not or no longer effective. This would propose a better management policy towards decreasing drug resistance. This would be achieved by promoting proper therapy-seeking habits and thus ensure a higher quality of life and a higher productive capacity of workers. A survey was first carried out in 8 localities to observe various aspects of therapy-seeking behaviour. The knowledge and practice of malaria management and prevention were quite poor, favouring the prevalence of drug resistant parasites. To establish an index for community-sensing of drug resistance, the prevalence of the mutation of the *dhfr* gene at position 108 in parasites was used in which Y = -2.5X + 48, where Y = prevalence of mutations (P_m) and X = level of self-prescription. This was confirmed by the extrapolation of the self-prescription of Fansidar (12%) against a value of 18%. This study shows that the therapy-seeking habits of a community can be used to demonstrate the prevalence of mutations to Fansidar and hence possibly to other antimalarial drugs presenting resistance.

Key words: Therapy-seeking behaviour, auto-medication, community-sensing, molecular markers, surveillance indicators, drug resistance.

INTRODUCTION

Highly endemic mostly in the tropics, malaria is caused by protozoan parasites of the genus *Plasmodium*, 5 species of which affect humans (Kantele and Jokiranta, 2011). The seriousness and gravity of this vector-borne disease cannot be overemphasized, given that about 3.4 billion people are at risk, of which 1.2 billion are at high risk. This led to an estimated 207 million clinical cases which resulted in about 627 000 deaths in 2012, 90% of

which occurred in sub-Saharan Africa (WHO, 2013). Malaria is a huge socio-economic problem in tropical countries. Its treatment and control require large sums of money, both for individuals and for the government. The socio-economic consequences at the personal level are numerous and result in reduced productivity as a whole. A striking correlation has been shown between malaria and poverty. The fact that malaria-endemic countries also have lower rates of economic growth adds to the burden, hence the conclusion that where malaria prospers most, human societies have prospered least. Its effects on fertility, population growth, saving and investment, worker productivity, absenteeism and school performance, premature mortality and medical costs have been cited as some of the ways by which malaria impedes development (Rollback Malaria, 2013).

Chemotherapy remains the best intervention measure against the malarial parasite (Sanz et al., 2012). However, the occurrence and increasing resurgence of resistant strains of the parasites and vectors to drugs and insecticides respectively have greatly weakened the use of these tools as the main strategies for the control of the disease. This makes the need for new and alternative control measures a matter of utmost importance and urgency which has therefore not brought the desired dramatic decrease in prevalence. Presently, combination therapy is the most effective measure against uncomplicated malaria (Nosten and White, 2007). The uptake of interventions is tricky in poor settings and the low rates are as a result of preference for cheap or community-wide perceived effectiveness of certain therapies. This prompted the need to study the therapy-seeking behaviour and practices in an area known for anti-malaria drug resistance.

The aim of the study was therefore to relate therapy-seeking behaviour to prevalence of biochemical markers of resistance by establishing the frequency of mutations to Fansidar-metabolising drugs. It is believed that this will set baseline data for monitoring programmes and for educating populations on habits that would disfavour drug resistance. It is assumed that the study will provide tools for the monitoring of resistance and thus contribute to a better understanding of the epidemiology of malaria in view of better management policies.

METHODOLOGY

Study populations

An overall of 498 persons in urban and rural settings responded to the questionnaire in the towns of Yaounde, Djuttitsa, Kumba, Limbe, Buea, Nkambe and Ndu. For the molecular analyses, a temporary malaria laboratory was set up in the absence of a diagnostic laboratory at the Djuttitsa Health Centre. Blood samples were collected by venupuncture from consenting individuals visiting the health clinics with complaints of fevers. Written informed consent was obtained from all the participants after an explanation of the aim and methods of the study according to the Declaration of Helsinki.

Surveys on therapy-seeking behaviour

A questionnaire designed to determine therapy-seeking behaviour was administered and either filled out by the participants or interpreted into the local languages and filled out by trained field staff. Commonly used anti-malarial drugs were displayed for the participants to identify which ones they had previously taken or prefer.

Sample collection

Two drops of blood were collected by finger prick to prepare thick and thin smears for microscopy. For the other analyses, more drops of blood were then collected on filter paper, air dried, put in mini-grip plastic bags containing silica gel and preserved at room temperature. The haematocrit and complete blood cell count were also determined. Anthropometric data including weight, temperature, age, gender and medication previously taken or preferred were recorded.

Microscopy

Thick and thin blood smears were dried and the thin smear fixed in methanol for 15 s. Both smears were stained with Eosin (Solution I) followed by Methylene Blue (Solution II) for 15 s each. The slides were then rinsed with distilled water, dried and observed under a microscope at a magnification of 1000. The thick smear was used for the diagnosis of malaria and the thin blood smear for speciation. Parasitaemia was determined by:

Parasitaemia (μl^{-1}) = Number of parasites counted × Estimated WBC count (8,000) / Number of WBC counted (200)

where WBC is the white blood cell.

DNA extraction and molecular genotyping

Parasite DNA was extracted from filter paper whole blood samples by the Chelex method and stored at -20°C. Genotyping for prevalence of mutations was done by Polymerase Chain Reaction-Restriction Fragment Length Polymorphism (PCR-RFLP). DNA amplification was done using 1X PCR buffer, 2.5 mM $MgCl_2$, 1.0 mM dNTPs, 1.7 pmols of primers, 1 unit/µl of *Taq* DNA Polymerase, DNA-free water and DNA at a final reaction volume of 25 µl. Deoxynucleotide triphosphates (dNTPs) were used at a final concentration of 0.5 µl. The *dhfr* gene mutation was genotyped using two sets of primers: for the outer PCR, Forward 5'-TTTATGATGGAACAAGTCTGC-3' and Reverse 5'-AGTATATACATCGCTAACAGA-3'; and for the nested PCR, Forward 5'-GAAATGTA ATTCCCTAGATATGgAATATT3' and

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Table 1. Self-prescription of anti-malarial drugs.

Drugs % prescription	Nk	Ftm	Dsc	Bot
Amodiaquine	20	01	13	26
Artesunate	02	0	0	0
Chloroquine	36*	16	27	38*
Doxycycline	02	0	0	0
Halofantrine	02	0	0	05
Mefloquine	0	0	0	0
Pyrimethamine	0	0	0	0
Fansidar	0	08	20	02
Quinine derivatives	18	78*	40*	29
Herbs	20	01	13	0

Nk-Nkambe, Ftm-Fontem, Dsc-Dschang, Bot-Bota. *Most used antimalarial drugs varied between the towns.

Reverse 5'-TTAATTTCCCAAGTAAAACT ATTAGAgCTTC-3'. The PCR was carried out for the outer PCR at 94°C for 3 min (primary denaturation), followed by 40 cycles of 94°C for 1 min (denaturation), 50°C for 2 min (primer annealing), 72°C for 2 min (primer elongation), and a final extension of 72°C for 10 min. For the nested PCR: 94°C for 2 min (initial pre-heating), followed by 35 cycles of 94°C for 1 min, 45°C for 1 min (primer annealing), 72°C for 2 min (primer elongation), and a final extension of 72°C for 10 min.

A RFLP was performed to detect the presence of mutations on the *dhfr* gene with 5 µl of each sample digested either with *AluI* or *BsrI* restriction enzymes respectively to determine which of the "S" wild type or "N" mutants were present. The HB3 sensitive strain of *Plasmodium falciparum* served as the positive control. The digested amplicons from the nested PCR were analyzed by agarose gel electrophoresis using a 3% agarose gel. The resulting bands were visualized over a UV transilluminator.

Statistical analyses

A database was created for all the surveys using the Epi Info 2000 statistical software. Frequencies of occurrences or responses generated were used to describe the self-prescription trends. Chi-square analysis was used to compare groups of responses in order to obtain the levels of significance.

RESULTS

Survey analysis

The predominant age range was 21 to 30 and the rest were mainly older. The general state of health reported by the participants showed that malaria was a common chronic disease from which some suffered from time to time. Fever was the main symptom, sometimes accompanied by body pains, nausea, rigours, dizziness and fatigue. Auto-medication was the method preferred by more than 80% of the respondents both before and/or after testing. Self-prescription of anti-malarials was also accompanied by anti-fever drugs. Two-thirds of participants would really decide to go to health facilities only when other treatments failed. A variety of anti-malaria drugs were consumed by the participants but there was no outstanding medication of preference though Quinine-sulfate ranked first followed by Maloxine and Fansidar. One-quarter of the participants also preferred Quinine-sulfate as the choice drug for prophylaxis. More than half of the respondents said they completed their drug prescription while many stopped when they felt better. A small proportion of the respondents (6%) in Djuttitsa practiced the use of bednets in the prevention of malaria. There was a high tendency for self-prescribing of malaria and/or fever medications among the participants once they were ill, even without being sure what the problem was (Table 1). Most of the respondents took their drugs to completion. For a few, fever was the main disease symptom observed by the medical personnel, closely followed by headache, then body pains.

When tested for malaria, *P. falciparum* was found to be the predominant species (98%) and the only other species was *Plasmodium malariae*. The results shown in Table 1 also demonstrate that chloroquine and quinine derivatives were the most self-prescribed antimalarial drugs in the towns indicated.

Prevalence of mutations

The frequency of mutations so far established for chloroquine and Fansidar demonstrated a high prevalence of mutations on the *pfcrt* gene and variable levels on the *dhfr* gene.

The results in the *BsrI* digestible and the *AluI* & *BsrI* digestible boxes were used to determine the relationship between self-prescription and frequency of mutations (Table 2).

Presence of mutants and mixed parasite populations

Band migration distances were measured and recorded

Table 2. Susceptibility of *pfcrt* and *dhfr*-amplified products to digestion with restriction enzymes.

Genes	Properties	Sites			
		Dschang (%) n=109	Nkambe (%) n=87	Fontem (%) n=95	Bota (%) n=134
Dhfr S108N	*AluI* digestible	90	43	94	4
	BsrI digestible	4	44	17	40
	AluI & *BsrI* digest.	2	7	3	4
Pfcrt K76T	*ApoII* digestible	16	17	11	19
	Resistant mutants	84	83	89	81

AluI, BsrI and *ApoII* are restriction enzymes, n = the number of samples used in experiments.

and product sizes were determined from a standard curve. The prevalence of mutations (Pm) was quantified as the absence of a digested product for *AluI* or the presence of a confirm mutation by digestion with *BsrI*.

From the PCR and RFLP experiments, the electrophoregram showed that there were some mixed type reactions of both sensitive and mutant parasites (Figure 1). The prevalence of mutations on *dhfr* 108N was at 18% for 108N and 3% represented the mixed type of S108N.

Extrapolation of the prevalence of mutation Dhfr 108N

Data obtained from mutational studies of the genes involved in folate metabolism in *Plasmodium* provided us with a measure of self-reporting and the presence of mutations in a given locality. The correlation between self-prescription and prevalence of mutations (Figure 2) resulted in establishing an equation for the best straight line through the data points. The straight line was established to be:

$$Y = -2.5x + 48$$

where Y = prevalence of mutations and x = self-prescription of Fansidar.

From the investigation on the Djuttitsa population, the level of Fansidar intake by self-prescription/preference was reported to be 12%. By applying this to the equation, this gave a value of Y = -2.5x 12 + 48 = 18.0% for the prevalence of the *dhfr* 108N mutation. By the PCR and RFLP experiments, a value of 21% was found for the mutations in Djuttitsa (cf 18%).

DISCUSSION

This study demonstrated that within margins of error the habits of a people can be indicative of the extent to which drugs might be perceived as effective or not. Sensing equation has been established for this purpose and used it to demonstrate the closeness of scores with field data. Previously, in an attempt to establish an index of resistance, Diourte et al. (2003) had defined P_m to be P_m/P_R = I, where P_R = prevalence of resistance. However, current data shows that it is not possible for it to be an index because of variations in prevalence and practice.

The microscopic analysis of the blood samples collected from subjects in one of the sites (Djuttitsa) gave a prevalence of 76.47% attributable to human and environmental factors which enhanced the breeding of mosquitoes. Environmental management and the hygiene of the inhabitants to avoid mosquito bites were not very encouraging. Very little sensitization on basic methods of prevention of transmission went on at all levels and could account for the poor knowledge of the prevention guidelines that emphasize the use of insecticide-treated bednets (CDC, 2015). Cameroon has also been reported to be highly endemic for malaria due to several socio-economic, environmental and climatological factors (Mbenda et al., 2014). Though the general state of health was declared good, the presence of malaria was such that participants could habitually assume from the symptoms that one was coming down with the disease. This was probably because of the frequency of the attacks and may explain why so few went for laboratory diagnosis, thereby making self-prescription and auto-medication common practice. Self-medication in malaria is supported by government agencies in Cameroon only in places that are quite inaccessible. Previously, in malaria-prone areas, if fever did not subside in 5 days after taking routine antibiotics, patients were encouraged to take Chloroquine. However, this medication has been taken off the shelf and is used only for other conditions like rheumatoid arthritis. It is also no longer used because of its monotherapeutic composition as opposed to the current recommended combined therapy.

This intake of drugs when not needed could also be a fundamental cause of drug resistance, with the body getting used to drugs that are not necessary (Talisuna et al., 2004). The population therefore needs to be educated on the absolute necessity to test before treatment and to

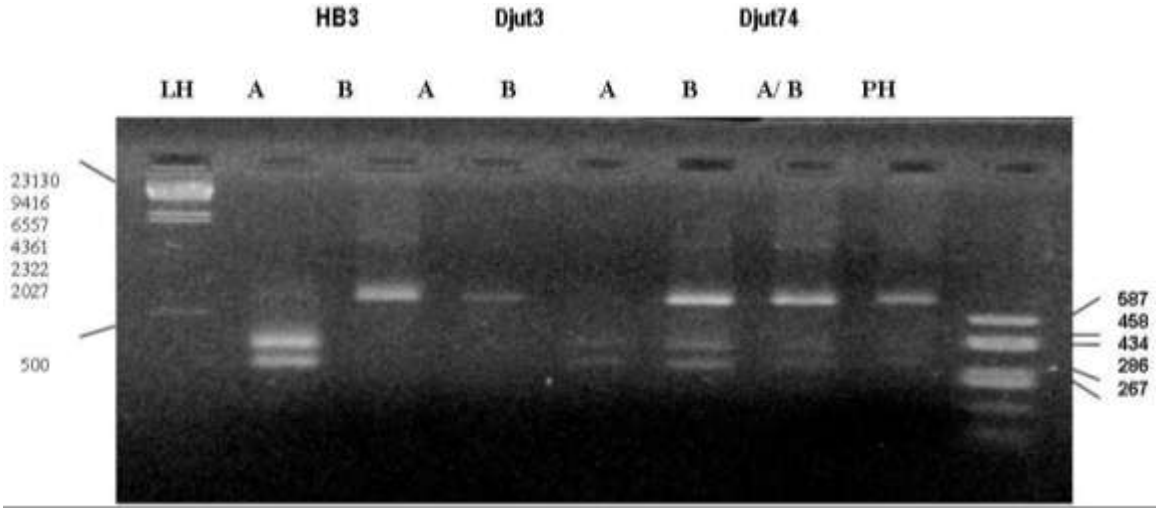

Figure 1. Wild type and mutant forms of *P. falciparum dhfr* gene conferring resistance to Pyrimethamine. LH: Molecular markers from a *HindIII* digest of Lambda DNA; PH: molecular markers from a *HaeIII* digest of *pUC19* DNA; A: product of digestion with *AluI;* B: product of digestion with *BsrI;* HB3: wild type/sensitive parasite strain; Djut3: resistant/mutant parasite. Sample *Djut74* could be digested with both *AluI and BsrI,* indicating a mixed line.

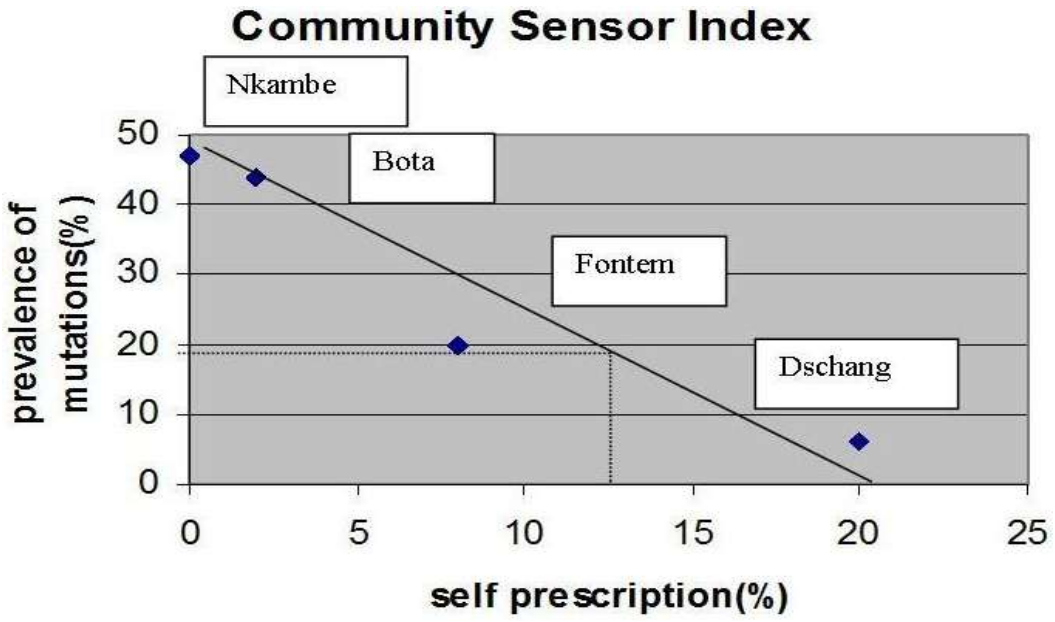

Figure 2. Community sensing for anti-folate resistance.

complete treatment regardless of how they feel. In endemic areas, effective malaria management relies on accurate diagnosis and prompt treatment of suspected or confirmed infected individuals based on microscopic diagnosis or RDT testing of blood samples (Reyburn et al., 2007; Azikiwe et al., 2012). This is particularly important for the most vulnerable population groups, such as young children and non-immune populations, in whom life-threatening falciparum malaria can develop and be rapidly fatal within hours (WHO, 2015).

A few medications were outstanding, and preference depended on the local practices. This was because the drug sellers had no formal training and therefore had erroneous, little or no idea of the physical and chemical methods of drug preservation, dosage, toxicity and compatibility, but supplied them to patients without complying with accepted specifications. The level of Fansidar intake by self-prescription and preference was

12% in Djuttitsa. By extrapolating on the graph, this corresponded to a mutational prevalence (P_m) of the *dhfr* gene in malaria parasites of 18%. This implied that resistance to Fansidar was low in this area. This level was similar to that found in Fontem (20%), but higher than that of Dschang (7%) and Yaounde (12%) during the same period (Basco and Ringwald, 2000). This difference between Djuttitsa and neighbouring Dschang could be due to the difference in self-prescription of the drug, being at 12 and 20%, respectively. From this, it was apparent that the higher the self-prescription, the lower the P_m.

Low drug resistance in the area could be attributed to the development of partial immunity to the illness, because of the constant presence of infection. It could secondarily be attributed to the low self-prescription of the drug. Mackinnon and Hastings (1998) stated that the rate of change of frequency of drug resistance is primarily a function of the number of people receiving that particular treatment. Ndo et al. (2011) also demonstrated that resistance to anti-malarial drugs is likely to occur with large scale anti-malaria drug use, self-prescription and inadequate doses from unreliable sources. Mbacham (1998) and Laxminarayan et al. (2006) observed that human habits in therapy matters such as inadequate dosing, incomplete courses and indiscriminate and inappropriate drug use have contributed to the emergence and spread of resistant strains.

Conclusion

The investigation was geared towards contributing to a better understanding of the epidemiology of malaria and the possibility of proposing public health management policies through establishing a relationship between a bio-diagnostic marker and a community-related index. This was achieved by relating self-reporting of auto-medication to molecular markers of drug resistance. There was an inverse relationship between self-prescription habits in an area and the prevalence of drug resistance markers, thereby providing a community sensor equation for predicting drug resistance from behavior.

Conflict of interests

The authors have not declared any conflict of interest.

Abbreviations: *Alu*I, *Arthrobacter luteus* I; ***Apo*II,** *Arthrobacter protophormiae* II; ***Bsr* I,** *Bacillus stearothermophilus* I; **CDC,** Centers for Disease Control and Prevention; **CTE,** Cameroon Tea Estate; ***dhfr*,** dihydrofolate reductase gene; **DNA**, deoxyribonucleic acid; **dNTP,** deoxynucleotide triphosphate; ***Hae*III,** *Haemophilus aegyptius* III; ***Hin*dIII,** *Haemophilus influenzae* III; **HIV,** human immunodeficiency syndrome; ***P. falciparum*,** *Plasmodium falciparum*; **PCR,** polymerase chain reaction; **PCR-RFLP,** polymerase chain reaction-restriction fragment length polymorphism; ***Pfcrt*,** *Plasmodium falciparum* chloroquine resistance transporter gene; **Pm,** prevalence of mutations; **P_R,** prevalence of resistance; **RDT,** rapid diagnostic tests; **RFLP,** restriction fragment length polymorphism; **Taq,** *Thermophilus aquaticus*; **UV,** ultraviolet; **WBC,** white blood cell; WHO, World Health Organization.

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