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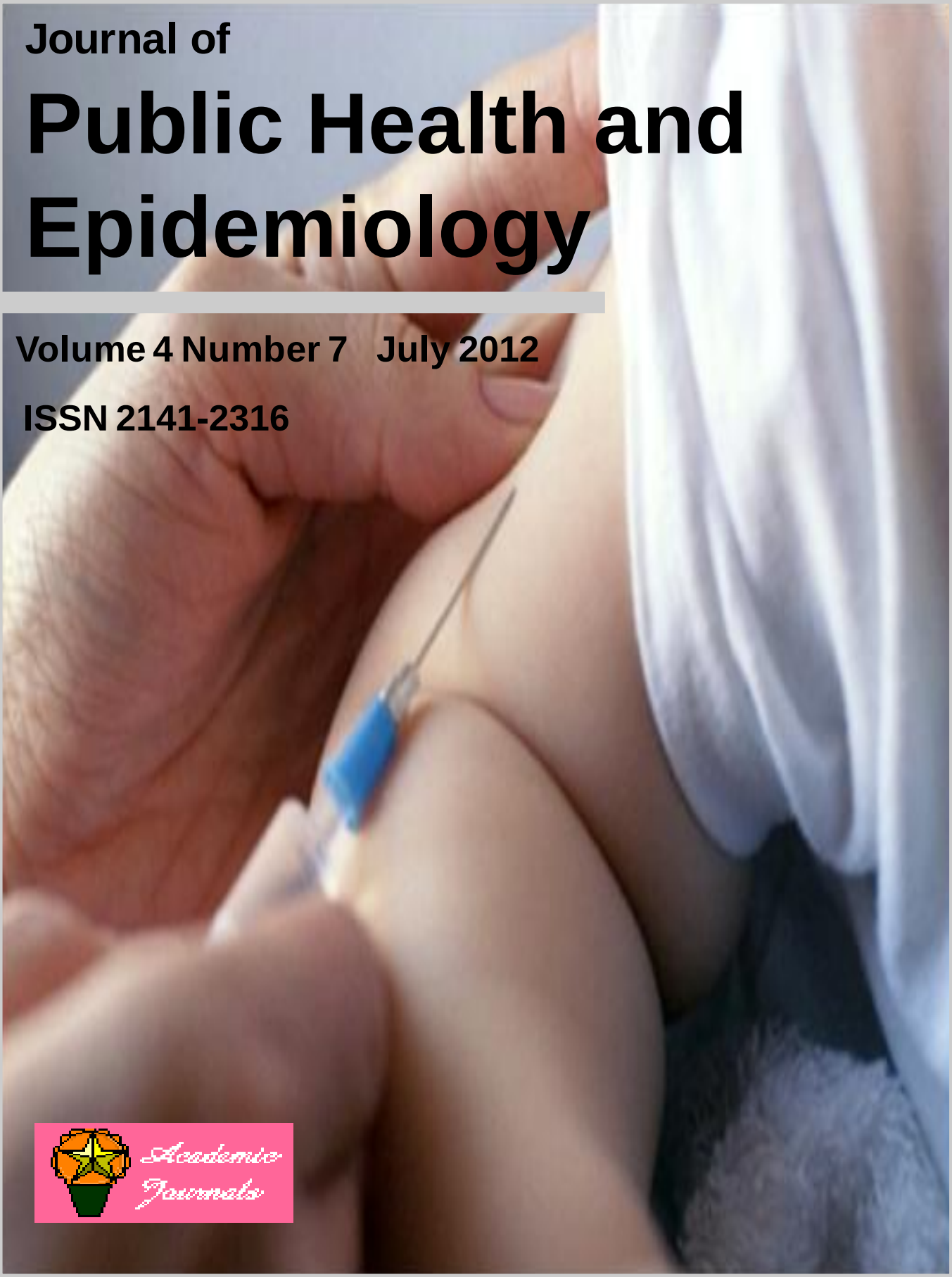

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Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing Escherichia coli in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

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Full Length Research Paper

Impact of entomological interventions on malaria vector bionomics in low transmission settings in Zambia

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Entomological interventions for malaria control are being scaled up in the context of the integrated vector management strategy in Zambia. This paper reports the continuous entomological monitoring of the operational impact of indoor residual insecticide spraying (IRS) and distribution of about 6 million insecticide-impregnated bed-nets (ITN) over two peak malaria transmission seasons. Mosquitoes were captured daily using exit window traps at monitoring sentinel sites and analyzed for species identification, densities, and sporozoite rates to assess the efficacy of the vector control tools. All the three major malaria vectors; *Anopheles gambiae* sensu stricto (s.s.), *Anopheles arabiensis* and *Anopheles funestus* were collected and identified. The intervention effect of IRS and ITNs was more pronounced on *A. gambiae* s.s. and *A. funestus* than *A. arabiensis* (χ^2 = 0.003, df = 1, P = 0.956), indicating that *A. gambiae* s.s. and *A. funestus are* amenable to control by IRS and ITNs. None of these vectors tested positive for *Plasmodium falciparum* sporozoites, thus, signifying their lack of transmission potential. This study demonstrates that entomological monitoring and evaluation is an indispensable underpinning for rational insecticide based malaria vector control. It provides compelling evidence for the need to integrate entomological parameters into routine surveillance systems, and also strongly substantiates the deployment of the integrated vector management strategy.

Key words: Zambia, malaria, impact, indoor residual spraying, insecticide treated nets, transmission.

INTRODUCTION

In sub-Saharan Africa, high malaria transmission rates are attributable to the strong vectorial capacity of *Anopheles gambiae* sensu stricto (s.s.), *Anopheles Arabiensis*, and *Anopheles funestus* (Gillies and Coetzee, 1987; Gillies and De Meillon, 1968). However, effective malaria control efforts, including vector control and case management (Bhattarai et al., 2007; Fegan et al., 2007; Sharp et al., 2007) has resulted in decreased malaria transmission in many areas (Guerra et al., 2007; Okiro et al., 2007; Rodrigues et al., 2008; Ceesay et al., 2008; O'Meara et al., 2008). In order to reduce disease transmission more rapidly, combinations of vector control tools have been deployed in the same malaria risk areas (Beier et al., 2008; Kleinschmidt et al., 2009).

The frontline malaria vector control interventions being harnessed for reducing vector daily survival rates in endemic countries are indoor residual spraying (IRS) and insecticide treated nets (ITNs) (Beier et al., 2008). Determining the spatial and temporal vector distribution, including monitoring of entomological risk factors and evaluating the impact of interventions on malaria transmission is essential for effective malaria control program policy development and management (Okara et al., 2010. To objectively evaluate options for malaria control, it is critical to have a thorough understanding of the ecological and epidemiological aspects of malaria and accurate estimates of malaria transmission intensity (Smith et al., 2007), as well as options for study designs to either strengthen the plausibility of findings, or establishing cause and effect.

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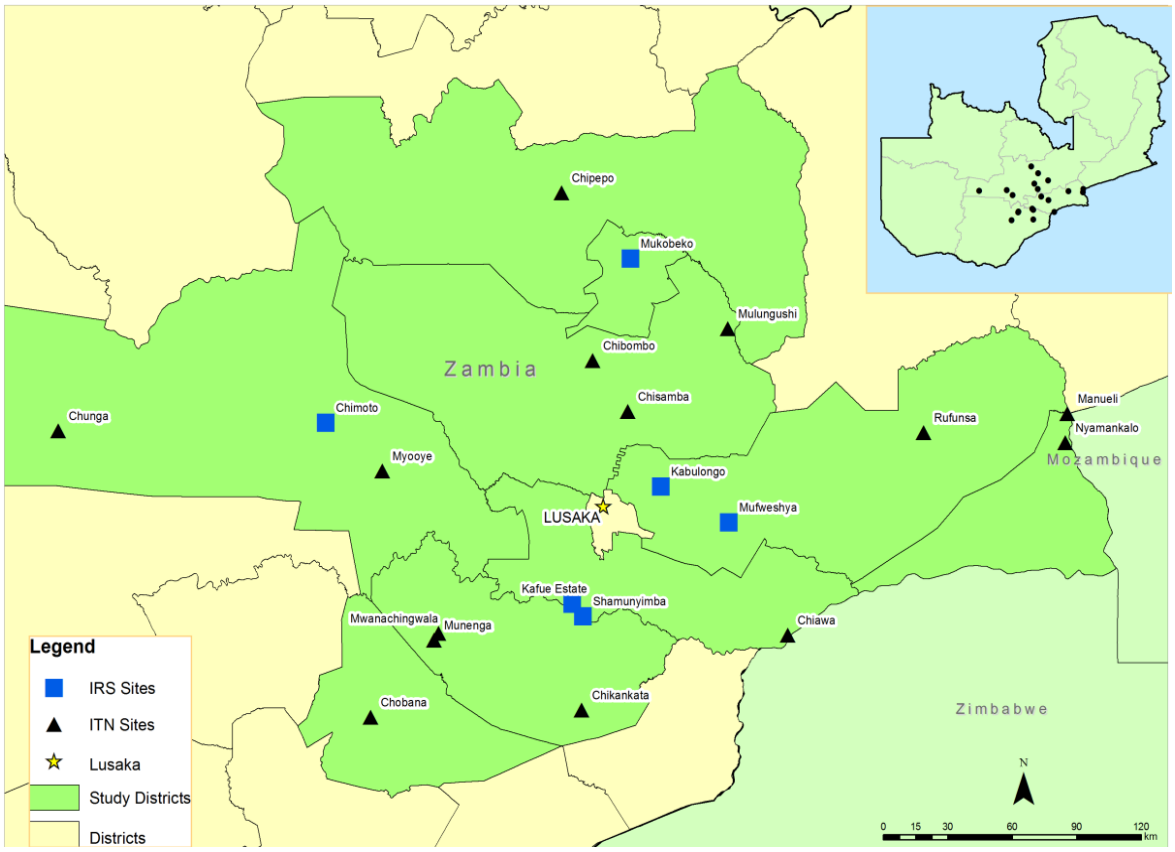

Figure 1. Map showing the location and spatial distribution of sentinel sites in Zambia (Chanda et al., 2011).

Available evidence indicates that malaria prevalence, incidence, morbidity, and mortality increase with transmission intensity (Molineaux, 1997; Lengeler et al., 2007; Beier et al., 1999). As such, they have frequently been used as indicators for impact of control interventions. However, measurable impacts of specific interventions on the vector population, sporozoite rates, and insecticide resistance have been observed in the field (Macdonald, 1957; Molineaux, 1997; Killeen et al., 2000; Protopopoff et al., 2007; Sharp et al., 2007).

In the past, malaria was broadly endemic across Zambia (MoH, 2000). However, significant scale-up in coverage rates of malaria control, including vector control using IRS and ITNs over the last ten years has culminated in a dramatic shift in the epidemiology of malaria (MoH, 2010). Presently, Zambia can be stratified into three malaria epidemiological zones: very low transmission areas with <1% parasite prevalence; low transmission with 10% prevalence in young children at peak transmission; and persistent high transmission with parasite prevalence of >20% at peak transmission season (MoH, 2006, 2008, 2010). This entails that malaria vector species composition; densities and infectivity are unlikely to have remained constant.

Herein, we report on the monitoring of the relative index for transmission through species abundance and infectivity over two malaria peak transmission seasons in Zambia.

MATERIALS AND METHODS

Study sites and interventions

Zambia is situated in the Southern African region between 8 and 18° south latitude and between 20 and 35° east longitude with a population of approximately 13 million (CSO, 2000). Topographically, the country consists largely of a highland plateau with elevations ranging from 915 to 1,520 m above sea level. There are three distinct seasons: a cool and dry season from April to August, a hot and dry season from August to November and a warm and rainy season from November to April. The average temperatures range from 16 to 27°C in the cool dry season and from 27 to 38°C in the rainy and hot season, and vary as a function of altitude. Rainfall decreases from north to south with an average annual rainfall from 600 mm in the south to 1400 mm in the north per year. Malaria is endemic across the entire country with transmission peaks coinciding with the rainy season. The intervention consists of vector control deployment in a low malaria transmission area (Figure 1). A detailed description of interventions was presented elsewhere (Chanda et al., 2011).

Mosquito species identification

Mosquitoes were collected by the window exit trap method from

April 2008 to May 2010 in both IRS and ITN operational areas. *Anopheles* mosquitoes were identified morphologically as *A. gambiae* complex and *A. funestus* group (Gillies and De Meillon, 1968; Gillies and Coetzee, 1987). Sibling species were identified using polymerase chain reaction (PCR) (Koekemoer et al., 2002; Scott et al., 1993).

Mosquito species abundance, infectivity, and transmission

The numbers of malaria transmitting anopheline mosquitoes caught were compared over time with respect to species abundance, infection rates, transmission index, and available vector control interventions. During the collections, the number of culicines caught was recorded to ensure that in the absence of anopheline catches, the traps were being successfully operated.

Data management and statistical analysis

Data was collected and entered in 2007 Excel spread sheets (Microsoft Corporation®) and statistically analyzed by employing the Statistical Package for the Social Sciences (SPSS) software version 17.0. Chi-square test was used to determine the reduction in vector abundance.

Ethics consideration

Ethical clearance for this study was sought from the University of Zambia Biomedical Research Ethics Committee (Assurance No. FWA00000338, IRB00001131 of IOR G0000774 reference code 002-07-07). Written informed consent was obtained from all householders who participated in this study.

RESULTS

Mosquito species identification

During the period of April 2008 to May 2010, mosquitoes were trapped for 85,320 nights from 18 sentinel sites (Figure 1). *A. gambiae* s.s. was detected in two ITN sites (Chipepo and Nyamankalo) and one IRS area (Manueli). *A. arabiensis* was detected at thirteen sites; ten ITN sites (Chiawa, Chikankata, Chibombo, Chobana, Chipepo, Manueli, Mulungushi, Munenga, Nyamankalo, and Rufunsa) and three IRS sites (Kabulongo, Mukobeko, and Shyamunyimba). *A. funestus* s.s. was predominantly detected at four ITN sites (Chiawa, Chibombo, Manueli, and Nyamankalo) than those with IRS (Kabulongo and Mukobeko) (Figure 1). Chanda et al. (2011) reported the details of the numbers of *A. gambiae* sensu lato (s.l.) and *A. funestus* s.l. collected and identified to species.

Mosquito species abundance, infectivity, and transmission

In this study, the relative abundance of house exiting *A. gambiae* s.s., *A. Arabiensis*, and *A. funestus* s.s. during the peak malaria transmission season showed marked heterogeneity (Table 1). The intervention effect over the main malaria transmission season of October to April, was stronger on *A. gambiae* s.s. and *A. funestus,* as compared to *A. arabiensis* (χ^2 = 0.003, df = 1, P = 0.956). There was insignificant reduction in the number of *A. arabiensis* from 2.14 to 0.91 (χ^2 = 0.496, df = 1, P = 0.481) with no *A. gambiae* s.s. collected in this time period. The ITNs reduced the calculated number of *A. arabiensis* caught per window trap per 100 nights from 2.11 to 0.18 (χ^2 = 0.579, df = 1, P = 0.447) than *A. funestus* s.s. *from* 0.16 to 0.05 (χ^2 = 0.058, df = 1, P = 0.810) (Table 1 and Figure 2). In the IRS areas, there was a small increase of *A. arabiensis* from 0.03 to 0.10 (χ^2 = 0.038, df = 1, P = 0.846) during the same periods (Table 1 and Figure 3). No *A. funestus* were trapped during the peak transmission season in IRS sites. Overall, there was no significant change in the numbers of vectors caught between the ITN and IRS areas (χ^2 = 0.147, df = 1, P = 0.701) in both transmission periods. The ITNs reduced the calculated number of *A. arabiensis* to a minimum, but IRS brought them to below detectable levels (Figures 2 and 3). No *Plasmodium falciparum* sporozoites were detected in *A. gambiae* s.s., *A. arabiensis or A. funestus.* Thus, no transmission index could be calculated for the three major malaria vectors during this peak transmission season (Table 1). The culicine numbers varied between sentinel sites, with densities ranging from <1 to 255.9 and from <1 to 56.0 per trap per 100 nights in 2008 and 2010, respectively. The culicines indicated that traps were being successfully operated.

DISCUSSION

Major malaria vectors co-exist much in sub-Saharan Africa with marked variations in their malaria transmission potential (Gillies and Coetzee, 1987; Bruce-Chwatt, 1985; Coluzzi, 1984; Fontenille and Simard, 2004). Sound knowledge of their distribution and bionomics is critical in guiding and monitoring vector control efforts (Okara et al., 2010). Pioneering entomological work in Zambia implicated *A. gambiae* s.s., *A. Arabiensis*, and *A. funestus* s.s. as the principle vectors of malaria (DeMeillon, 1937; Adams, 1940; Watson, 1953; Pielou, 1947; Paterson, 1963; Shelly, 1973; Bransby-Williams, 1979). The present findings corroborate these studies as all the three major malaria vectors were detected. However, additional Afro tropical vectors of malaria, *A. funestus*-like, *Anopheles rivulorum*, and *Anopheles nili* have recently been described in the country. This necessitates assessment of their transmission potential in Zambia (Chanda et al., 2011).

To effectively manage malaria vector populations and prevent, reduce or eliminate transmission, Zambia implements an Integrated Vector Management (IVM) strategy for vector control using IRS and ITNs as main thrust interventions supplemented with larval source management in areas with amenable eco-epidemiological

Table 1. Vector abundance, infectivity, and transmission index by period of time and intervention.

Year	October to April (All sites)		October to April (ITN sites)		October to April (IRS sites)	
	10/08 - 4/09	10/09 - 4/10	10/08 - 4/09	10/09 - 4/10	10/08 - 4/09	10/09 - 4/10
***A. gambiae* s.l.**						
No. caught	187	38	186	31	1	7
No. analyzed for species id	187	38	186	31	1	7
A. arabiensis propn (%)	43.9	92.1	43.6	100	100	57.1
A. gambiae s.s propn (%)	0	0	0	0	0	0
***A. gambiae* s.s.**						
No. Estimated	0	0	0	0	0	0
No per trap per 100 nights	0	0	0	0	0	0
Sporozoite rate	0 (n = 0)	0 (n = 0)	0 (n = 0)	0 (n = 0)	0 (n = 0)	0 (n = 0)
Transmission index*	0	0	0	0	0	0
Transmission index$^{\infty}$	1	0	1	0	1	0
A. arabiensis						
No. Estimated	82	35	81	31	1	4
No per trap per 100 nights	2.14	0.91	2.11	0.81	0.03	0.10
Sporozoite rate	0 (n = 82)	0 (n = 35)	0 (n = 81)	0 (n = 31)	0 (n = 1)	0 (n = 4)
Transmission index*	0	0	0	0	0	0
Transmission index$^{\infty}$	1	0	1	0	1	0
***A. funestus* s.l.**						
No. caught	74	38	69	38	5	0
No. analyzed for species id	74	38	69	38	5	0
No. *An. funestus* s.s.	6	2	6	2	0	0
A. funestus s.s. propn (%)	8.11	5.26	8.70	5.26	0.00	0.00
***A. funestus* s.s.**						
No. Estimated	6	2	6	2	0	0
No per trap per 100 nights	0.16	0.05	0.16	0.05	0.00	0.00
Sporozoite rate	0 (n = 6)	0 (n = 2)	0 (n = 6)	0 (n = 2)	0 (n = 0)	0 (n = 0)
Transmission index*	0	0	0	0	0	0
Transmission index$^{\infty}$	1	0	1	0	1	0

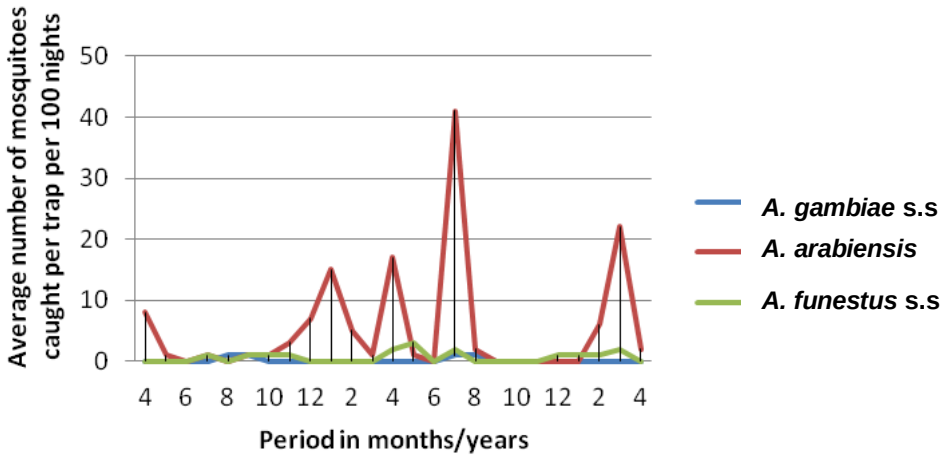

Figure 2. Average number of *A. gambiae* s.s., *A. arabiensis* and *A. funestus* s.s. per window trap per 100 nights collected, all ITN sites combined.

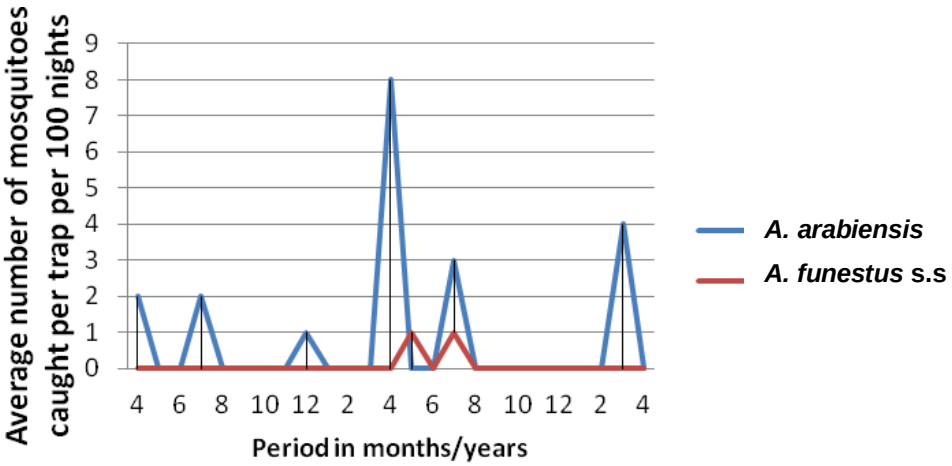

Figure 3. Average number of *A. arabiensis* and *A. funestus* s.s. per window trap per 100 nights collected, all IRS sites combined.

attributes. This has resulted in a marked drop in malaria morbidity and mortality (MoH, 2006, 2008, 2010). An IVM-based approach should be cost-effective, have indicators for monitoring efficacy with respect to impact on vector populations and disease transmission (WHO, 2004). Several studies on comparative operational impact of IRS and ITNs upon malaria transmission have been conducted (Neville et al., 1996; Lengeler and Sharp, 2003; Maharaj et al., 2005). Nevertheless, the potential of routine entomological surveillance data, that is, vector abundance, infectivity, and insecticide resistance have not been fully exploited in evaluation studies (WHO, 2009). Rigorous impact evaluation of the IVM is pivotal despite the limited resources and minimal time allocation. This has invariably resulted in the utilization of less rigorous study designs for establishing causal inference.

Year round tracking of entomological indicators is crucial for accurate monitoring and evaluation of ITN and IRS impact on malaria transmission. In this study, two malaria peak seasons were compared in a low transmission operational setting. This facilitated for comparison between surveys conducted in different seasons with less bias. Deployment of IRS and ITNs during high transmission season is expected to significantly reduce the densities of malaria vectors. However, community sensitization through enhanced Information, Education and Communication/Behavior Change Communication (IEC/BCC) to scale-up acceptance of IRS and ITN utilization and adherence is critical for maintaining the efficacy of ITNs and IRS.

In Zambia, the end of the rainy season coincides with the peak in abundance of the three major vectors (Rogers et al., 2002; Gillies and De Meillon, 1968; Smith et al., 1993). The estimated numbers of *A. arabiensis* also peaked during this period. However, the relative abundance of malaria vectors was significantly reduced

Table 2. Indoor resting malaria vector abundance and sporozoite rates.

Reference	Site	Ecotype	Abundance of indoor resting malaria vectors			Sporozoite rates of indoor resting malaria vectors			
			A. gambiae s.s.	*A. arabiensis*	*A. funestus*	*A. gambiae* s. l	*A. arabiensis*	*A. gambiae* s.s.	*A. funestus*
Paterson (1963)	Chirundu	Hot riverine valleys	-	-	-	2.3	-	-	-
Zahar (1985)	Chirundu	Hot riverine valleys	-	-	-	3	-	-	0
	Ndola	Savanna plateaus	-	-	-	1.6	-	-	1.6
	Livingstone	Hot riverine valleys	-	-	-	2.4	0.18	-	-
Shelly (1973)	Chirundu	Hot riverine valleys	-	-	-	1.2	-	-	-
Bransby-Williams (1979)	Chipata	Savanna plateaus	-	981	-	-	1.1	-	-
	Lusaka	Savanna plateaus	-	-	-	-	0	-	-
Chimumbwa (2000)	Lukwesa	Luapula river valley	271	29	648	-	0	5.9	4.4
	Kapululila	Hot riverine valleys	21	119	167	-	5.6	0	0
Siachinji et al. (2001)	Chibombo	Savanna plateaus	29	115	13	-	-	-	-
	Ndola	Savanna plateaus	127	5	23	-	-	-	-
	Chingola	Savanna plateaus	20	0	0	-	-	-	-
Siachinji et al. (2002)	Macha	Savanna plateaus	-	-	-	-	4.23	-	-
Kent et al. (2007)	Chidakwa	Savanna plateaus	-	-	-	-	1.6	-	-
	Lupata	Savanna plateaus	-	-	-	-	18.3	-	-

in IRS areas relative to ITN areas. This reduction concurs with findings from earlier studies that ITNs and IRS suppress the density of malaria vector populations (Neville et al., 1996; Lengeler and Sharp, 2003; Maharaj et al., 2005). Earlier data on malaria vector abundance and infectivity collected in the country exhibit markedly diverse results (Table 2). However, the lack of infectivity and thus transmission potential for *A. gambiae* s.s., *A. Arabiensis*, and *A. funestus* observed in this study could be ascribed to the low numbers of mosquitoes caught and a change in the population structure of the vectors, particularly in relative densities of *A. arabiensis*, coupled to the effective case management using artemisinin-based combination therapy (ACTs) and the improved health care seeking behaviour of residents.

There is mounting evidence that combining IRS and ITNs affords enhanced protection to exposed populations compared to using one method alone (Kleinschmidt et al., 2009). However, it remains unclear whether the use of these interventions can reduce transmission intensity and result in malaria elimination. To achieve this goal, these core interventions can be supplemented in specific locations, by larval source management (LSM) strategies and maximize their impact (Utzinger et al., 2001; Killeen et al., 2002; Utzinger et al., 2002; Keiser et al., 2005; Townson et al., 2005). Nevertheless, the implementation of IVM approaches and evaluation of their impact does not only require a large financial investment in commodities and implementation, but an investment in human resources for planning, targeting, monitoring, and evaluating the various

control interventions (Beier et al., 2008).

The present results validate the findings of Lengeler and Sharp (2003) that *A. gambiae* s.s. *and A. funestus* are characteristically more amenable to control by IRS and ITNs than *A. arabiensis.* However, the predominance of *A. arabiensis* that followed in the wake of effective interventions may be as a result of its exophilic nature and its catholic feeding behavior, thus, rendering it evasive to the effects of indoor targeted control interventions. These findings further substantiate the premise that vector control potentially results in a shift in species composition, as reported previously (Shelly, 1973; Bransby-Williams, 1979; Lindsay et al., 1998). The study also explains the low transmission levels of malaria in these areas, as well as authenticating the assumption that IRS has a more prompt and powerful impact than ITNs.

Earlier studies established that *A. arabiensis,* a vector associated with unstable malaria transmission, was the one driving transmission in the country (Shelly, 1973; Bransby-Williams, 1979; Zahar, 1985). The observed predominance of this species implies that it may be the one still perpetuating malaria transmission in Zambia. This necessitates scaled up implementation of LSM strategies, including environmental management and larviciding to facilitate the complete control of this behaviourally facultative malaria vector. The continued presence of both *A. arabiensis* and *A. funestus* in intervention areas may have implications of possible failure of the malaria control programme. It may also indicate that insecticide resistance could have been selected within the populations of these vectors, thus, making resistance surveillance imperative for the malaria control programme.

While this study has shown that entomological monitoring and evaluation is an indispensable tool for rational large scale malaria vector control using IRS and ITNs, the low numbers of malaria vectors collected may indicate a compromise in the progress and efficiency of window exit traps in low transmission zones by non-compliance of householders. Therefore, monitoring of indoor vector densities could be streamlined by replacing or complimenting the window exit traps with a more robust collection tool like the Centers for Disease Control (CDC) light trap coupled with the involvement of dedicated technical staff for close monitoring of their operations.

The recent shift in strategic emphasis from malaria control to elimination and eradication has highlighted major gaps in knowledge that need to be addressed before such achievement is contemplated (Feachem and Sabot, 2008; Feachem et al., 2009; Mendis et al., 2009). This study was conducted in low transmission settings achieved primarily by successful malaria vector control. The fact that transmission index is below 1 (Table 1), means that the disease will keep reducing. However, any strategy that targets reduction of transmission down to the level where elimination is within reach will need to strengthen its surveillance systems through very effective decision support with respect to evaluation of current vector control programmes. Furthermore, very different rigorous study designs are needed, and multiple indicators used to either establish cause and effect, or assess the strength of plausible causality.

Conclusion

Though basic knowledge in vector bionomics is well appreciated, the demonstrated impact of IRS and ITNs provides compelling evidence for the need to integrate entomological parameters into routine surveillance systems, and strongly substantiates the deployment of an integrated vector management strategy.

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Full Length Research Paper

Progress towards eradication of poliomyelitis in Ghana: A review of the Eastern Region of Ghana from 1997 to 2010

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Poliomyelitis is a highly-infectious viral disease affecting children under 15 years. One in 200 infections leads to irreversible paralysis and in 5 to 10% of such case, patients die from paralyzed breathing muscles. Ghana is at the verge of polio certification and the only reported case of wild polio virus in the Eastern Region was in 2003. We reviewed AFP data in the Eastern-Region to assess the progress towards interruption of polio virus transmission and identified opportunities for surveillance improvement. We reviewed records and conducted secondary data analysis of all AFP cases reported to the Region from 1997 to 2010. We assessed data quality, calculated AFP surveillance indicators, and described AFP cases by person, place, time and polio vaccination status. Completeness of case-based-forms was 90%. Of 306 AFP-cases reported, one wild polio virus was recorded; 59.2% were males aged < 5 years; 26.5% had right lower limb paralysis; 14% occurred in October and 52.6% had received 4 doses of oral polio-vaccine. The non-polio AFP rate ranged from 0.12 to 4.3/100,000 population and stool adequacy from 60 to 100%. The period prevalence of non-polio entero-viruses was 8.5% (26/306). There is sustained progress towards interruption of polio virus transmission in the region. However, opportunity remains to improve the completeness of case-based forms and the non-polio AFP rate.

Key words: Acute flaccid paralysis, poliomyelitis, surveillance, eradication, vaccination, Ghana.

INTRODUCTION

Poliomyelitis is a crippling viral disease caused by poliovirus serotypes 1, 2 and 3. It is a highly infectious disease, which affects mainly children under five years. The virus is transmitted through contaminated food and water, and multiplies in the intestine, from where it can invade the nervous system. Many infected people have no symptoms, but do excrete the virus in their faeces, hence transmitting infection to others. Initial symptoms of polio include fever, fatigue, headache, vomiting, stiffness in the neck, and pain in the limbs. One in 200 poliomyelitis infections leads to irreversible paralysis usually in the lower extremities. Among those paralyzed, 5 to 10% die when their breathing muscles become immobilized. The morbidity and mortality from polio can be prevented through vaccination.

In 1988, the World Health Assembly Resolution 41.28 earmarked polio for eradication and established the polio

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eradication programme as a global initiative to rid the world of poliomyelitis (World Health Assembly, 1988). Significant progress has been made as polio cases have decreased by 99.6%, from an estimated 350 000 cases in 1988 to 1349 reported cases in 2010 (Schoub et al., 2001; Bonu et al., 2004; http://en.wikipedia.org/wiki/Poliomyelitis_eradication#cite_ref). The reduction is the result of the global effort to eradicate the disease through the use of the oral poliovirus vaccine (OPV). Serotype 2 appears to have been eliminated globally but serotypes 1 and 3 still persist in several African countries and Asia. Since poliovirus is not the only agent that causes acute flaccid paralysis (AFP), a broad surveillance case definition that captures all AFP is used including Guillain Barre Syndrome, transverse myelitis and transient paralysis associated with non polio enterovirus (NPEV) infections among children aged less than 15 years and all cases of suspected poliomyelitis among persons of any age.

The AFP surveillance system in Ghana was established in 1996. It is part of the general frame-work of the Integrated Disease Surveillance and Response (IDSR) system which operates within the decentralized government health service delivery.

The AFP surveillance system is used to monitor and document the progress towards interruption of polio transmission with the following objectives:

i) To detect, investigate and report all AFP cases using case-based forms.
ii) To collect 2 stool specimens >24 h apart from each AFP case within 14 days of onset of paralysis.
iii) To conduct follow–up examination of all AFP cases after 60 days of onset of paralysis and report to national level.

The core AFP surveillance indicators are as follows:

i) Non-polio AFP Rate per 100, 000 population of children under 15 years of age (target ≥2.0).
ii) Percentage of AFP cases with two adequate stool specimens collected at least 24 hours apart and within 14 days of onset of paralysis (target ≥80%).

The AFP surveillance system in Eastern Region was established in 1997. The system has similar objectives and procedures as the national level surveillance system. All the 21 districts in the region report on AFP surveillance activities on weekly and monthly basis. The AFP surveillance system is incorporated into the integrated disease surveillance and response system in the region with reasonable patronage of health and non health workers.

AFP surveillance, with its more sensitive case definition, is used to monitor and document the presence or absence of wild polio virus. Ghana has remained polio-free since 2009 and is at the verge of polio certification. The only reported case of wild polio virus in the Eastern Region was in 2003. We therefore reviewed and analyzed the 1997 to 2010 AFP data in the Eastern Region to assess the progress towards interruption of polio virus transmission based on surveillance indicators. We also identified opportunities for surveillance improvement.

METHODOLOGY

Study area

Eastern Region of Ghana had an estimated population of 2,354,538 with a growth rate of 1.4% in 2010. It is the sixth largest region with a land area of 19,323 km^2, thus representing about 8% of the total land area of the country (Figure 1).

The region is bounded on the East by the Volta Region, South by Greater Accra region, West by Central Region and on the North by Ashanti Region. It has 21 districts, with the largest number of public health facilities in the country. All the public health facilities have AFP focal persons who report weekly to the district-level that in turn reports monthly to the regional-level on AFP and other diseases under surveillance. When a case of AFP is identified by a clinician at the health facility or by a community-based surveillance volunteer, the sub-district or district level surveillance focal person is notified, who then conducts a detailed investigation of the case. The investigation entails completing an AFP case investigation form in triplicate, followed by initiation of the process of collection of 2 stool specimens 24 to 48 h apart, and transporting the specimen to the polio laboratory, Noguchi Memorial Institute for Medical Research (NMIMR) in the capital, Accra. Stool samples are transported to the polio laboratory under reverse cold chain in a surveillance vehicle within three days of dispatch accompanied by one copy of the filled AFP case investigation form.

The condition of the stool samples was assessed in the laboratory for adequacy in terms of quantity, appropriate storage temperature, and whether there was any leakage. The stools are analyzed for the presence of any polio virus; if virus is present, whether it was the wild type and also sequencing of the virus. Also, the laboratory examines for non-polio enteroviruses. The results of AFP stools analysis are communicated to the district through the National Disease Surveillance Department.

The detailed information is entered into a database which is analyzed to determine whether the surveillance indicators are being met. For all AFP cases in which viruses were isolated or samples were inadequately collected, a 60-day follow up examination is carried out to find out if the case has residual paralysis. A National Polio Expert Committee meets quarterly to classify all AFP cases and advise on surveillance gaps that need to be addressed. Since the inception of the surveillance system in eastern region, only one wild polio case has been detected and numerous non- polio enteroviruses. The oral polio vaccination coverage (OPV3) has consistently been above the target of 90% (Table 1).

Study design

This was a fourteen-year retrospective review of secondary data on all reported AFP cases, undertaken in June to July 2011. We reviewed AFP surveillance electronic data-set in Microsoft Excel, case-based forms and case investigation forms from 1997 to 2010 at the Eastern Regional Disease Control Unit of the Ghana Health Service. Key data elements extracted were age, sex, district, date of birth, date of onset of paralysis, OPV doses, date of investigation and stool collection, stool adequacy, laboratory result and 60 days follow up results. Data on the case based forms were reviewed for

Figure 1. Map of Eastern Region.

Table 1. Trend of OPV3 coverage, Eastern Region, Ghana, from 2008 to 2010.

Year	2008	2009	2000	2010
OPV3 Coverage %	93.2	92.9	94.2	96.4

missing data points, validated, and used to update the electronic database for all the AFP cases reported. The MS Excel data base was imported into SPSS version 16 and analyzed. Univariable analysis of key socio demographic, case- investigation and administrative data by person, place and time were expressed as frequency-distributions, percentages and crude rates. We identified AFP-cases with wild polio virus isolated and calculated three periodic AFP surveillance indicators using the case investigation data. Of the three indicators, the non-polio enterovirus prevalence was obtained by pooling all NPEVs isolated during the period under study and divided by the total number of AFP cases reported (306); the non-polio AFP rate was obtained by dividing the reported non polio AFP cases with the number of expected AFP cases in children <15 years as pre-determined for the region based on annual population data, and the percentage stool adequacy was obtained as the proportion of AFP cases with stools meeting WHO criteria out of the total number of AFP cases investigated during each year.

Ethical issues

This project was conducted as part of health system process improvement and service-based learning in the Eastern Region. Official consent was obtained from the Regional Director of Health Services and the Deputy Director for Public Health supervised the work. The Head of Disease Control and the Regional Disease Surveillance Officer collaborated in the study. We protected the confidentiality of the AFP case-patients through the use of de-identified and coded data.

RESULTS

Ninety six percent (294/306) of the AFP case based forms reviewed were completely filled with a few missing data on date of birth, date of investigation, and laboratory result as obtained from laboratory staff feedback. Between 1997 and 2010, there were 306 reported cases that met the WHO case definition for AFP, of which one was due to confirmed wild polio virus serotype P1.The non- polio AFP rate (NPAFPR) was above the national target of 2/100,000 population of children below 15 years from 2000 to 2003, then it declined to 1.54/100,000 in 2007. Between 2008 and 2009, the required AFP target

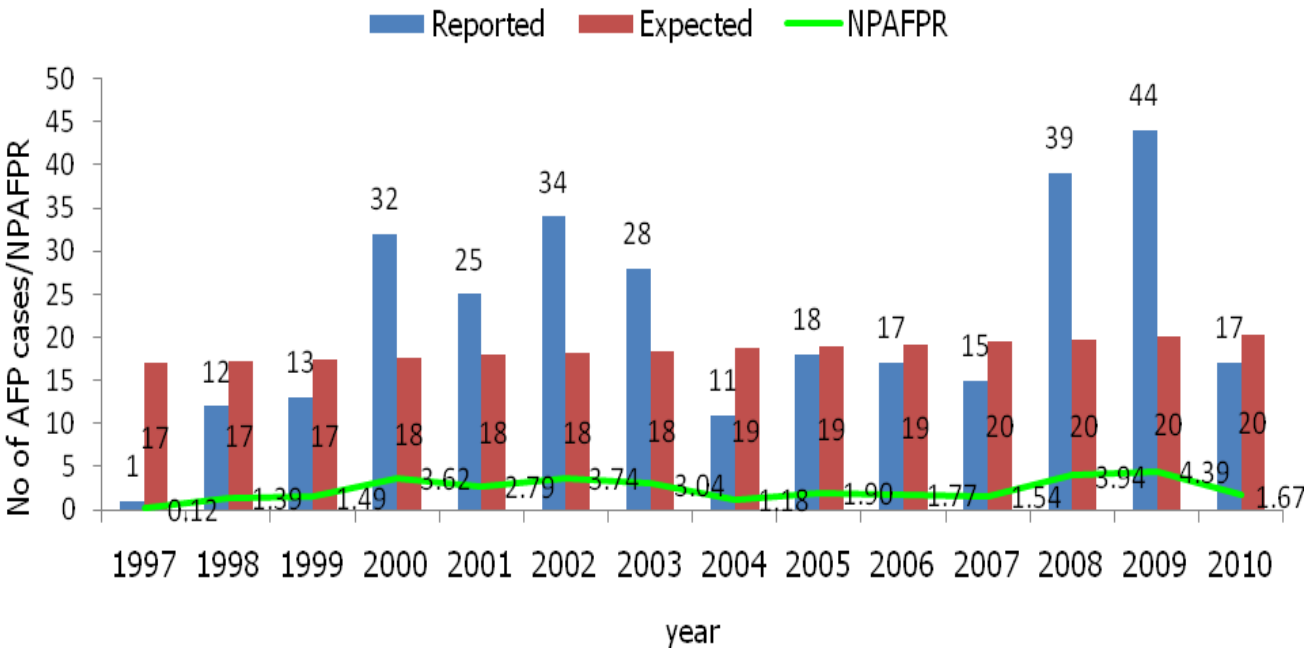

Figure 2. AFP cases and non-polio AFP rate, Eastern Region (1997 - 2010).

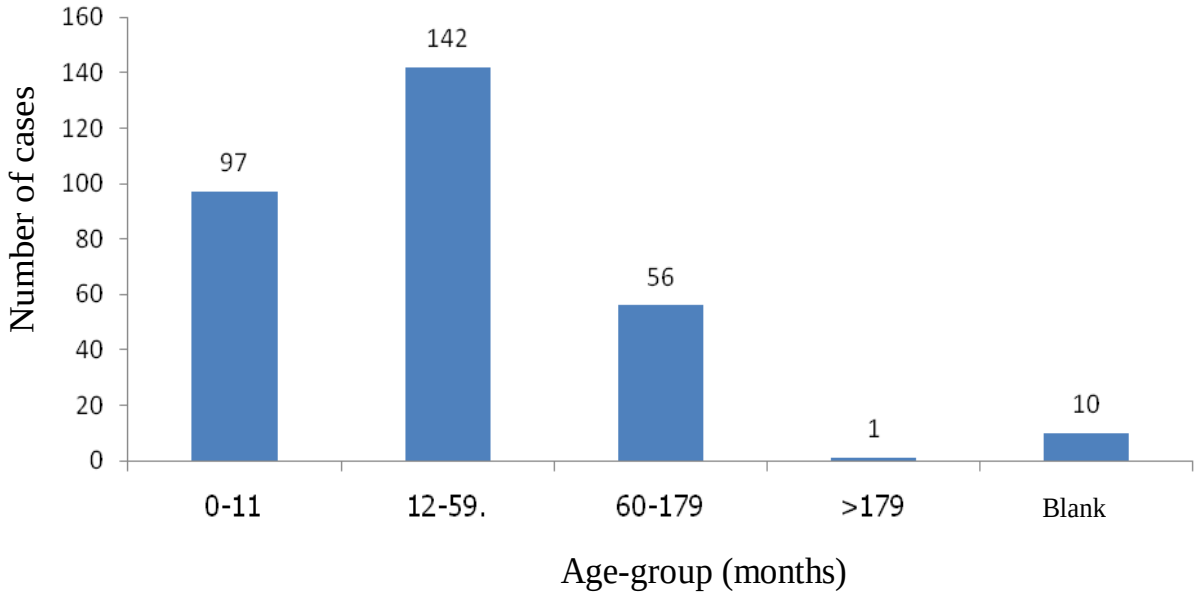

Figure 3. Age group distribution of AFP cases, Eastern Region (1997-2010).

was exceeded, but was followed by another sharp decline in 2010. The highest NPAFPR was recorded in 2009 (4.39) and the least in 1997 (0.12) (Figure 2). The rate of AFP cases reported followed the same trend as the NPAFPR.

Most of the AFP cases were males (181/306) and almost half (46.4%) of the AFP cases were between the ages of 12 and 59 months (Figure 3).

The percentage stool adequacy target of 80% was achieved during most of the years plateauing at 100% from the year 2009. The lowest percentage stool adequacy (50%) was recorded in 1999 (Figure 4). However, only in 31.1% of the AFP cases were two stool samples collected between 24 and 48 h apart within 14 days of onset of paralysis.

The prevalence of non polio enteroviruses among the

Figure 4. Percentage of AFP Stool Adequacy, Eastern Region (1997-2010).

AFP cases was 8.5 (26/306). All the 306 AFP cases were followed up for 60 days. Residual paralysis was found in 25% of them, 42% were free from paralysis, 12 (3.9%) died and 29.1% were lost to follow-up. The commonest site of paralysis was the right lower limb (81/306) (26.5%) and this was found mostly in males (42/81) (52%). The coverage for 4 doses of oral polio vaccine was 52.6%. Majority of the cases were found between the rainy season in Ghana (April to November) compared to the dry season (December to March) (Figure 5). Of the 21 districts, Suhum Kraboa – Coaltar reported the highest number of AFP cases (32/306), while Akyeamansa reported the least. Only 25% of the districts achieved the required target of collecting 2 stool samples between 24 and 48 h apart within 14 days on onset of paralysis.

DISCUSSION

The primary mission of the acute flaccid paralysis surveillance as a strategy of the World Health Organization–led polio eradication initiative is to detect, investigate, report, disseminate and inform prompt implementation of control measures. Since the inception of the AFP surveillance system in the Eastern Region of Ghana in 1997, only one paralytic poliomyelitis case had been detected of the 306 AFP cases identified through the system. However, the importation or reintroduction of poliovirus from endemic countries remains a threat, since the region is one of the major transit points to neighboring countries like Nigeria. This underscores the importance to continue and sustain surveillance for AFP in children less than 15 years until global eradication and certification is achieved. A recent situation in the country where after over 5 years of being polio-free, 8 cases of wild-polio virus were suddenly identified in the Northern region, lends credence to the need for continued surveillance in the Eastern Region even in the absence of wild polio virus isolation. Countries or regions with previous history of interruption of polio transmission have been known to have importation of the virus from yet polio endemic countries as was the case in Ivory Coast (CDC, 2009-2010a, b). Also, the WHO's documentation 'facts sheet on poliomyelitis' (CDC, 2009) and Park (2000) observed that the polio virus may infect the central nervous system in a very small percentage (<1%) of cases resulting in varying degree of paralysis, and possible death. This observation also depends on the offending serotype (Nathanson and Martin, 1982) and implies that there might be more circulating polio viruses with no clinical symptoms hence the need for continued surveillance with great attention to stool quality in order to isolate any remaining wild polio viruses in the region. The serotype detected in the only case of paralytic polio reported

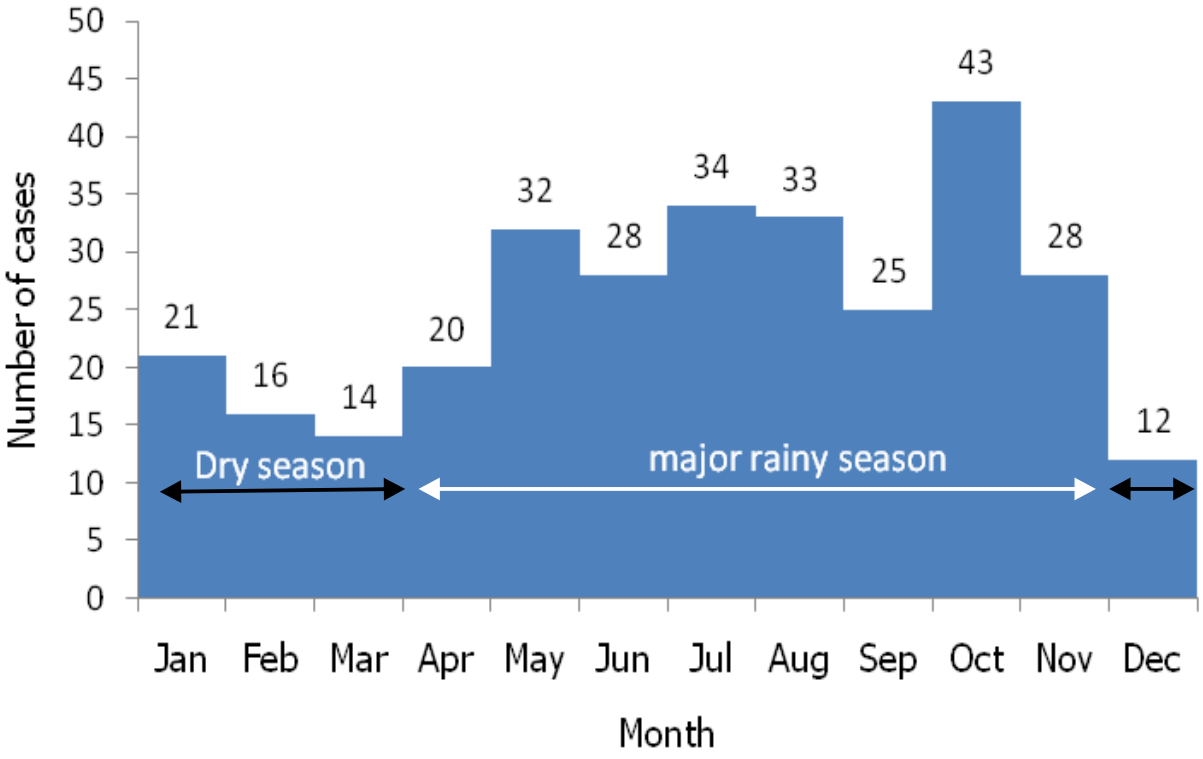

Figure 5. Cumulative monthly distribution of AFP cases, Eastern Region (1997-2010).

in the Eastern Region was P1, which is most neurovirulent.

The non polio AFP rate remained above the accepted national target of 2/100,000 population of children less than 15 years of age during half of the period under review with a median of 1.98/100,000, excluding the year of inception. However, this performance indicator which reflects the quality of the surveillance system by its ability to identify the rather common circulating entero-viruses was below the target during 1998, 1999, 2004 to 2007, and 2010, which constitutes another half of the period reviewed. This observation, with the exception of the performance in 2010, could be attributed to two factors; firstly, the challenges of starting a new complex surveillance system in the region and the learning curve for regional, district and community level staff during 1997 to 1999. Secondly, the 2005 to 2007 nationwide reductions in the number of national immunization days (NIDs) with the concomitant drop in opportunities and resources for AFP active case search during those years. The 2010 drop in this indicator could be due to system fatigue given that the last and only wild polio-virus in the region was isolated over 7 years ago coupled again with the drop in the NIDs after the 2008 to 2009 surge that responded to the finding of 8 wild polio-virus cases in northern Ghana.

Another core indicator of surveillance quality is the percentage of stool adequacy, which is defined as percentage of AFP cases with two adequate stool specimens collected at 24 to 48 h apart and within 14 days of onset of paralysis. To a large extent, it determines the chance of isolating the common entero-viruses including polio when present. This indicator, with a national target of 80%, gradually increased over the years, reaching a plateau at 100% from 2009. Possibly reflecting the effectiveness of the stool management trainings conducted for surveillance officers in the region periodically. The periodic prevalence of non polio enterovirus (NPEV) determined from the isolation of these viruses in AFP stool samples is a complementary surveillance indicator also used to evaluate the integrity and viability of stool specimen dispatched to the laboratory for viral isolation. It is expected that at least 10% of all stool specimens dispatched to the laboratory should yield NPEV. Our study showed that percentage of enterovirus isolation in the region for the period was 8.5%. This observation is close to the findings reported in a similar study conducted in Bahawalpur, Pakistan, where NPEV isolation was 8.5% (Ameer and Abdul, 2007). It is however lower than the 34, 17.6 and 14.6% reported in India (Kapoor et al., 2001; Deivanayagam et al., 1994), Egypt (Afifi et al., 2009) and Nigeria (Oderinde et al., 2007), respectively. The variations observed may be attributed to factors such as differences in the specificity and sensitivity of laboratory methods and test kits; inter-observer reliability; stool specimen collection,

handling and transportation; and the level of sanitation and hygiene in the societies.

While the percentage stool adequacy exceeded the required target, the NPEV isolation in the region remained below target. The relative inconsistence in these two complementary AFP surveillance indicators might suggest a closer look at the actual practices of regional and district surveillance officers especially with respect to timeliness and procedural authenticity of stool collection from AFP cases. This is borne out by the rather low rate of AFP investigation and stool collection within 14 days of onset. Also, the very low number of districts achieving this for early AFP case investigation with stool collection confirmed the need for action.

Most of the AFP cases (78.1%) were under five years of age and predominated by males. This proportion was lower than the 90% reported in India (Singh et al., 2004). Similarly, another study in Ibadan, southwestern Nigeria, also reported a lower prevalence (74.3%) among this age group of children (Tal-hatu and Temiloluwa, 2006), while a much lower prevalence of 37% was reported in Marches region, Italy (Marcello et al., 2008). It is however crucial to observe proper sanitary conditions in the home and environments with many children under five years to avoid fecal contamination of food and water which serve as vehicles for polio infection.

Most of the AFP cases were found in three districts - Suhum Kraboa Coatar, Birim South and New Juaben, with relatively populated peri-urban settlements. Although poor sanitation could be one of the reasons for this observation, there could be other factors yet to be known.

The majority of the AFP cases were noted between May and November and peaked in October, which is consistent with the pattern of occurrence of AFP during the rainy seasons in the tropical countries. Over the past years, national immunization days had run parallel with active case search for AFP cases, and that could account for the increase in AFP cases at the beginning and end of the year. Moreover, in the last quarter of 2008, there were series of outbreak of poliomyelitis in the northern part of Ghana, which also resulted in the organization of a series of “mop up” polio immunization campaigns in some of the regions in Ghana, including the Eastern Region.

In 2008, and up to July 2009, Eastern Region recorded most of the AFP cases compared to the notified cases over the past years. This could be explained by the enhanced surveillance in the country as a response to the 2008 polio outbreak in the Northern Region. In the process, there was an improved community awareness of polio and the subsequent “mop up campaign” provided resource opportunity for intensified active AFP surveillance.

It was realized that about a quarter of the AFP cases after the 60 day follow up developed residual paralysis, in which 62% were asymmetrical, and 4% of all the AFP cases died. Males, who were the majority, however had the right leg mostly affected. Poliomyelitis is most often recognized by the acute onset of flaccid paralysis. The paralysis of poliomyelitis is characteristically asymmetric. The legs are affected more often than the arms. A similar finding was also reported by Chin (2000).

WHO recommends only three doses of oral polio vaccine (OPV) but over half of the AFP cases in our study had received 4 OPV doses. However, another 30.7% had unknown vaccination status and 2.6% had zero OPV doses. There have been reports of unsuccessful vaccination and of suboptimal sero conversion with three doses of OPV in India and Africa (John, 1972). The antibody response to five doses of OPV in India was roughly equal to the response to two doses in the United States and Europe (Oduntan et al., 1978). In many countries, wild polioviruses were eliminated only after young children received an average of 10 to 15 doses of OPV (John, 1976). To ensure an effective immunity among infants in the region, routine immunization should be intensified to augment the massive patronage during national immunization days.

A few of the case based forms of the AFP cases were incompletely filled; date of birth, date of investigation of AFP cases and inadequate laboratory data feedback were observed. A similar finding was also observed by Hockstra et al. (2000) in AFP data analysis in China. This could affect data analysis and interpretation for any meaningful action in the near future.

Conclusions

Overall, AFP surveillance has remained an effective strategy in monitoring and documenting the progress towards polio eradication in the Eastern Region of Ghana since its inception in 1997. Analysis of data from the past 14 years has shown that there has been consistent absence of wild polio virus isolation in the region after the one and only case that was identified in 2003. The trend of the key WHO recommended AFP surveillance indicators reflect good quality surveillance with some opportunity for improvement in the completion of case-based forms and closer support and monitoring of timeliness and procedural authenticity of case-investigation practices of surveillance focal persons at regional and district levels. Frequency and intensity of active AFP case search in the region is essentially driven by the supplemental mass immunizations activities (NIDs) with most cases of AFP identified during the period of these NIDs mostly among children aged <5 years. Despite high oral polio vaccine (OPV) coverage and non isolation of wild polio virus in the region for over seven years now, it is essential to maintain high quality AFP surveillance and continued routine and supple-mentary immunization activities until polio eradication is achieved and certified in Ghana and the world as a whole.

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