

ICASH-A17

TEACHERS AS AGENTS OF CHANGE: SCHOOL-BASED DIAGNOSIS AND TREATMENT OF MALARIA POSITIVELY IMPACTS CHILD MORBIDITY

Ronald Mukisa^{1,3}, Andrew Macnab^{1,2,*}, Sharif Mutabazi³, Rachel Steed⁴

¹Stellenbosch Institute of Advanced Study, Wallenberg Research Centre, 10 Marais Street, 7600 Stellenbosch, South Africa

²University of British Columbia, Vancouver, Canada

³Health and Development Agency, Uganda

⁴Hillman Medical Education Fund, Vancouver, Canada

*Corresponding author's email: Macnab. ajmacnab@gmail.com

ABSTRACT

Background: Teachers in developing countries traditionally send home children found sick in class. Yet infection due to malaria is the principal reason a child will miss school in sub-Saharan Africa and the leading cause of death in school-aged children. Rapid diagnostic testing (RDT) and treatment with artemisinin combination therapy (ACT) is the management for malaria recommended by the World Health Organization (WHO) but RDT/ACT are not available in schools.

Aims: To evaluate the impact on child morbidity from malaria of engaging teachers to provide RDT and administer ACT in primary schools in rural Uganda, using duration of absence from school as a surrogate measure of morbidity.

Methods: This was a 2 year project. Pre-intervention (year 1) we trained teachers to identify probable infectious illness, conduct RDT, and administer ACT; conducted baseline evaluation of malaria knowledge, and monitored days of absence from school. Intervention (year 2) trained volunteer teachers administered RDT to children found to be sick at school and treated those positive with ADT; data collection was ongoing.

Results: Teacher administered RDT/ACT was implemented and sustained in 4 rural schools (grades primary 1-5). Teachers participated willingly. Year 1 (pre-intervention) 953 of 1764 pupils were sent home due to illness; mean duration of absence from class was 6.5 (SD 3.17) school days. Year 2: (intervention with RDT/ACT) 1066 of 1774 pupils were identified as sick, 765/1066 (67.5%) tested positive by RDT for malaria and received ACT and their duration of absence fell to 0.59 (SD 0.64) school days ($p < 0.001$); and overall absence decreased to 2.55 days from 6.5 in year 1 ($p < 0.001$).

Conclusion: RDT/ACT use by teachers as a school-based health practice is novel and reduced child morbidity significantly. Our model of engaging and training teachers represents a community empowerment approach applicable to other low-resource settings worldwide where malaria is endemic and morbidity high.

Keywords: Artemisinin, Malaria, Rapid diagnostic testing, School-based intervention, Teachers

INTRODUCTION

In many countries worldwide malaria is the main reason a school-aged child will die and the principal reason why a child will be absent from school [1,2]. Teachers recognize that the duration of malaria-related absence, frequency of absence due to repeated infection, residual malaise from sub-optimal treatment or permanent neurological complications of falciparum malaria can all compromise a child's potential to learn [3-5]. Where malaria is endemic the burden of disease is greatest amongst

children in low resource settings. The World Health Organization (WHO) advocates early, accurate diagnosis of malaria and prompt, effective and affordable treatment within 24 hours of the onset of illness [6]. Validated measures to do this exist, but to date health resources to diagnose and treat malaria are scarce in most developing countries especially in rural and low resource communities, and have not been made available in schools.

A diagnosis of malaria is difficult to make because symptoms are not specific; a lack of knowledge about appropriate treatment and limited access to care also contribute to morbidity and mortality [7]. Hence, there is an urgent need for the simple, accurate and inexpensive diagnostic tools and effective therapeutic agents that now exist to be made available at a community level [8].

The combined use of Rapid Diagnostic Test kits (RDT) to accurately diagnose malaria and prompt administration of a locally effective therapeutic agent in those who test positive (Artemesisin Combination Therapy (ACT) in Africa and many other countries where *P. Falciparum* infection predominates) has improved both diagnostic accuracy and treatment efficacy. RDT kits are now available in many countries and the feasibility of using them in rural clinics without laboratory facilities has been demonstrated [9,10]. But deployment of RDT and ACT has been slow, especially in low resource settings as the engagement of the population necessary to spread the knowledge that this approach is effective and empower rural communities to use them has been missing [8]. Although RDT and ACT use is recommended by WHO, training low cadre health care workers, including school staff, in their use has not occurred.

Malaria RDTs provide a diagnosis in minutes by detecting the presence of malaria parasites in human blood. RDT kits vary, but the principles of how they work are similar [11]. Most are for individual use and include a lancet to obtain blood from a finger-prick. A drop of blood from a sick patient is put onto a reagent strip to test for the presence of specific proteins (antigens) produced by malaria parasites. If malaria antigens are present, they bind to the dye-labeled antibody reagent in the kit, creating a colour change in the results window. The sensitivity and specificity of RDTs is good enough for them to replace conventional testing for malaria [12].

WHO recommends ACTs as the first-line therapy for *P. falciparum* malaria worldwide [13, 14]. Originally sourced from the natural herb artemisinin can now be made synthetically. ACTs combine artemisinin which kills the majority of parasites in a few hours, with a longer half-life partner drug of a different class which eliminates the remaining parasites in a single fixed-dose tablet. Benefits of genuine ACTs include high efficiency, fast action, few adverse effects, low cost and the potential to lower the rate at which resistance emerges and spreads [13]. Care must be taken in the choice of preparation in developing countries as counterfeit products with little or no efficacy are widespread.

Since 2006 we have established Health Promoting School (HPS) using the WHO model in rural Uganda to deliver low cost health education in schools [15]. We learned from teachers that absence from school due to malaria is high, and on investigation found that most children sent home due to febrile illness do not then get taken to a clinic for diagnosis and treatment; reasons for this include the distance to a clinic, cost, and lack of awareness that care is important. Hence, as a logical and medically expedient response, we designed a trial where diagnosis and treatment using RDT/ACT would be provided in schools by trained volunteer teachers to address the challenge and burden of malaria amongst children in rural resource-poor settings.

The hypothesis was that with engagement of teachers to provide school-based rapid diagnostic testing, all sick children normally just sent home with presumed infectious illness would be screened for malaria using RDT and those who tested positive given ACT, and as a result child

morbidity due to malaria would improve, as measured by a significant reduction in days absent from school.

METHODS

This was a community outreach health education project conducted in 4 newly established health promoting schools by the Health and Development Agency (HEADA) Uganda. HEADA is a non-governmental agency funded by the Hillman Medical Education fund to implement comprehensive health education, treatment, and support programs in Western Uganda [16]. The project followed the principles of participatory action research and incorporated related process to promote participation and achieve trust in the communities engaged [17]. The full protocol and sequence for community engagement has been described previously [16]. Key elements included Teachers and HEADA staff and Community leaders (teachers and elders).

The teachers in the schools were central to this intervention. Teachers and HEADA staff held public forums to inform and engage members of the community. These included presentations with question and answer sessions where teachers explained how absence from school due to malaria was having a negative impact on the education of a large number of children; that the current practice of sending children home who were sick was problematic, as although many were assumed to have malaria, once home their parents often did not take any action to get a diagnosis or treatment; and that many children were absent for more than a week due to illness, and then often remained unwell for days or even weeks after they returned, so consequently were unable to benefit fully from being back in school. HEADA staff then summarized current knowledge about the benefits of interventions available to help manage malaria and the practicalities of delivering them, particularly the use of RDT kits in government clinics for prompt diagnosis and benefits of early treatment with ACT.

Community leaders (teachers and elders) subsequently chose a school-based intervention to address malaria absenteeism and HEADA coordinated data gathering and problem-solving discussions on implementation. These included establishing if teachers would invest the time to take the training required, be prepared to sustain a school-based program, and perform testing involving collection of blood from a finger prick.

Teachers in the schools then invited parents to participate in community-wide sessions, allow dialogue regarding the process and obtain consent; no parents wanted their child excluded. It was explained that for evaluation purposes data on absenteeism would be recorded by the school, and in those children who became sick and were sent home from school with signs suggestive of an infectious illness additional data would be collected. Each school signed an agreement to follow the co-developed action protocol for a trained teacher to evaluate all children identified as sick who would normally be sent home, conduct the RDT and administer ACT in those positive.

The teachers in the 4 schools were orientated on the action protocol by HEADA staff who visited each school weekly to support the teachers, collect data sheets documenting the pupils absent from school and the sick, tested and treated children and deliver supplies (RDT kits, ACT medication, and sharps boxes for used blood lancets and biohazard bags for safe waste disposal. Ninety km separated the 4 schools; a motorcycle and fuel costs were included in the budget.

In year one the action protocol included data collection on sick pupils sent home and subsequently absent. Absence for reasons other than presumed infectious illness was excluded. HEADA trained the teachers who volunteered to conduct RDT and administer ACT in one day interactive workshops supervised by a physician and run by two trained laboratory staff and two nurses. One teacher was trained from each school as the primary evaluator and one as a back-up.

Instruction included: how to evaluate a child for a presumed infectious illness; the theory and practice for conduct of RDT and administration of ACT; record keeping; needle safety and waste disposal techniques [16]. Practical competency was evaluated and a refresher course given in year 2. The RDT kits used were: Malaria Ag pan/Pf Malaria test kits ‘Malarascan’ (Zephyr Biomedical Systems) which targets HRP2 and Pan Aldolase of Plasmodium falciparum and other less common Plasmodium species (*P. vivax*, and *P. ovale*); sensitivity (96.3%) and specificity (98%) are high (16).

In year two the action protocol added screening with RDT by teachers and treatment of those testing positive for malaria with ACT [18]. A single dose ACT preparation was used to ensure a full course of treatment was completed; this was to avoid the potential for partial treatment bias if any of the five additional doses that would have had to be given at home were missed had a conventional 3 day 12 hourly regimen been used. The ACT given was Arco (Artemisinin-Naphthoquine) (Midas Care Uganda, Ltd). The drug was taken with milk or juice to aid tolerance under teacher supervision. Children were observed for at least 1 hour for side effects; the protocol called for another dose to be given if vomiting occurred [16].

Throughout the 2 year intervention HEADAs and the schools maintained community-based dialogue to sustain the school-based action and promote new knowledge and behavioral change community wide. In the schools classroom education was added to increase knowledge and develop practices and behaviours to benefit the children in the context of malaria. A pre-assessment of children’s knowledge preceded new HPS activities and post-intervention assessment followed for comparison. In the community HEADAs provided feedback via workshops reporting on the conduct and efficacy of the intervention.

RESULTS

Four primary schools were engaged in geographically separate low resource settings in south western Uganda [16]. Table 1 shows the demographic data, and results from Year 1 (pre-intervention) and Year 2 (intervention). Total pupil enrollment was 1764 in year 1 and 1774 in year 2 across classes primary 1-7.

Table 1. Study demographics and diagnostic, treatment and absenteeism data for the 4 participating schools: Year 1 - Pre-intervention - Year 2 - Intervention by teachers using RDT and ACT. Modified from Macnab et al. *IJLTER*. 2016 5(7);20-37 (16)

	Year 1					Year 2				
Children	1764					1774				
Age-years	5-13					5-13				
Gender M/F	49/51%					49/51%				
Schools		1	2	3	4		1	2	3	4
Children at each school		412	451	189	712		422	451	189	712
Children found to be sick at school	953					1066				
Sick/per school		221	200	218	314		263	201	300	302
Sick/per term							56/127/80	27/97/77	55/135/110	70/133/99
Sick sent home	953									
Sick tested RDT						1066				
Sick positive RDT result						715	27/92/49	20/74/57	28/68/106	35/98/62

MALARIA										
Sick treated ACT						715	27/92/49	20/74/57	28/68/106	70/133/99
Absence (Days) Sick sent home TOTAL (mean)	6.5 (3.2)	6.2	6.5	6.7	6.6	2.55 (3.35) p < 0.001	2.4	2.8	3.0	2.5
Absence (Days) Sick sent home RDT POSITIVE for MALARIA						0.59 (0.64) p < 0.001	0.49	0.66	0.72	0.48
Absence (Days) Sick sent home RDT NEGATIVE						4.62 (3.54)	4.1	6.1	4.5	3.8

Community-based dialogue (May – September 2013) led to the collaborative decision to introduce school-based teacher-administered RDT and ACT to address absence from school due to malaria. Statements made by Head Teachers included: a) “This is exactly what we need, testing and treating malaria at school. We are ready to collaborate”. b) “Our children suffer from fever and malaria, but we send them home where they are given local herbs and paracetamol. Malaria affects children’s brains and ability to learn; it is a great opportunity for us to be trained to prevent this from continuing to happen”. c) Our teachers are enthusiastic about being involved in testing and treating children after they have undergone training. Our School Board Chairman has endorsed the idea. We are grateful for this initiative” [16].

Logistic planning, baseline assessment and teacher training (September 2013 - August 2014 – Year 1) and was followed by action/intervention with ongoing evaluation (September 2014 - August 2015 – Year 2). This allowed a 2 year evaluation where pre and post intervention data were collected over comparable 3 term periods during 2 consecutive school years, recognizing the seasonal nature of malaria.

Knowledge and awareness about malaria causation, transmission, prevention, diagnosis and management amongst the children was assessed in classroom sessions. Pre-intervention less than 20% of the children knew mosquitos transmitted malaria, the role of bed nets in prevention, how malaria can be diagnosed and why prompt and effective treatment is important. By early year 2 virtually all children had this knowledge, and understood how infection would probably make them feel and how to access diagnosis and treatment.

Questionnaires established that all teachers (except one) wanted training to do RDT for malaria and administer ACT. All agreed to take on the additional work of evaluating sick children and follow the action protocol. To provide the 2 trained teachers the 4 schools asked for to conduct the duties required (one as primary evaluator and one as a back-up) eleven volunteers were trained over 2 years; their performance and a refresher course evaluation confirmed all retained the necessary knowledge and practical competency.

We also identified that for the majority of sick children sent home in year 1 with symptoms compatible with malaria parental management was not in keeping with WHO recommendations [6]. Only 26% were taken for clinic-based diagnostic and/or anti-malarial treatment measures and the majority (42%) were only given an anti-pyretic (e.g. paracetamol/Tylenol); other care included local herbal remedies (19%), being taken to church (8%), or to a traditional healer (6%) [18].

Children identified by their classroom teachers as being sick and needing to be sent home using the school's regular criteria numbered 953 in year 1 (pre-intervention) and 1066 in year 2 (intervention). These 1066 were evaluated by a trained teacher and an RCT performed; 715/1066 (67.5%) tested positive and all 715 of them received immediate treatment at school with a single dose ACT preparation (Artemisinin-Napthoquine).

The mean duration of absence in children sent home with a presumed infectious illness in year 1 was 6.5 school days from onset of illness to return to class. In year 2 mean duration of absence overall decreased to 2.55 days ($p < 0.001$), and fell to 0.59 days in the 715 children RDT positive for malaria who were treated immediately with ACT ($p < 0.001$). In those RDT negative duration of absence was 4.62 days. Many treated children felt well enough to ask to return to class within hours of receiving ACT, and consequently had no days when they were absent from school. Some very small variations in absenteeism rates were evident over the 2 years between schools, across classes (grades) and from term to term (season). But overall, absence from school was reduced by 60.8% during this teacher-driven intervention using RDT/ACT. If the same percentage of children sent home in year 1 had malaria as were diagnosed using RDTs in year 2 this would equate to 1358 cases in 1775 children over the 2 years - a malaria incidence rate of 79% across the 4 schools. No adverse events occurred in the context of RDT screening and no adverse reactions resulted from administration of the single dose ACT preparation which was well tolerated. No children died from malaria during the intervention year.

Post-intervention the consensus in the community was that participating children had derived both health and educational benefits from having school-based RDT/ACT provided by teachers. Also, that new knowledge was now resulting in behavioral change over how suspected malaria was managed in the broader community. It was agreed that teachers in the 4 schools would continue to offer RDT/ACT, but via a modified intervention where RDT positive children would now be given a conventional and 3 day ACT regimen (Artesunate-Amodiaquine) as the cost was less. Knowledge transfer was also extended beyond the community to engage the Health Ministry.

DISCUSSION

Teachers can be effective agents for change in the context of malaria. This community-based health promotion intervention has confirmed the feasibility of school-based RDT kit use by teachers to screen children for malaria, and the efficacy of accurate diagnosis combined with prompt treatment with ACT at school.

Amongst sick primary school children who would otherwise just have been sent home 67.5% tested positive for malaria and received ACT. Subsequently, many felt well enough to choose to go back to class rather than be sent home, presumably because their malaria was diagnosed soon after symptoms developed, promptly treated and the ACT rapidly cleared their blood of parasites [19].

For these children, their duration of absence from diagnosis to return to class fell 60.8% when compared to the duration of absence overall in the pre-intervention cohort sent home with a presumed infective illness - from more than a week (6.5 school days) to < 1 day.

Knowledge and awareness related to malaria also improved among the children, and behaviours related to malaria management in the broader community also showed evidence of change. Children now knew how malaria was caused, the symptoms that suggest infection, that prompt diagnosis and effective treatment are available and the importance of both; and parents learned that malaria can be rapidly diagnosed and that there are benefits from early treatment. This later change is significant as this was a low resource rural setting where prior to this school-based initiative, less than

a third of febrile children sent home from school received management for malaria that met WHO recommendations for prompt, accurate diagnosis and comprehensive treatment within 24 hours of the onset of illness [6].

Although use of school-based RDT and ACT by appropriately trained teachers is a novel approach to managing malaria in children our findings are broadly in agreement with previous findings in Uganda related to RDT kit and ACT use. Importantly, studies indicate that kits can be stocked and used appropriately outside formal health facilities [20], and that training comparable to ours enables individuals without a health care background to use them reliably [21, 22].

While the overall incidence and number of deaths from malaria are decreasing worldwide the disease is still a major cause of mortality and morbidity especially among children [11,13]; 50% of deaths occur in school-aged children [3]; up to 50% of preventable school absenteeism is due to malaria [1]; the potential to reduce morbidity and achieve educational benefits and infection with *Plasmodium falciparum* is associated with permanent loss of cognitive and fine motor function in children where diagnosis is delayed and/or treatment is sub-optimal [23,24]. Hence, where teachers are engaged to provide school-based intervention with RDT/ACT, there is the potential worldwide for child morbidity to be reduced and educational benefits achieved. This applies even where efforts to promote preventive measures exist, as in many developing countries < 50% of households own a mosquito net and most children do not sleep under insecticide treated nets.

As our intervention took place in 4 geographically separated rural schools in low resource communities, and all children identified to be sick with a presumed infectious illness were included, we believe our results and the benefits we describe can be generalized to other areas with a similar endemic setting for malaria. Hence, our model of school-based diagnosis and treatment is probably applicable worldwide, provided RDT kits and treatments appropriate for the locally endemic strains of malaria are used [18], and has worldwide relevance as malaria remains the most prevalent parasitic disease that affects human beings worldwide. It is endemic in 108 countries, with >3 billion people estimated to be at risk, among whom the burden of disease is highest or children in low resource communities [24].

The development of RCT/ACT is an example of health promotion that successfully integrates technology and health care policy. It is effective, affordable and easy to use, and has the potential to reduce malaria transmission within communities, because each treated individual's malaria episode will be shorter, less severe, and hence less likely to result in mosquito-borne transmission to others [13,19]. However, the missing link to date has been the lack of social engagement to make this technology accessible to rural populations [8], but now deploying school-based programs run by volunteer teachers offers a logical response to the burden of malaria in resource poor settings and is an approach that our initiative indicates is both feasible and effective.

The cost and cost-benefit of RDT/ACT are relevant; the cost of ACTs especially has been identified as a potential barrier to scale up of initiatives that use them. [8,22]. Our cost for RDT was about US\$ 0.50 per kit. We chose to use a relatively expensive (US\$ 2.2) single dose ACT formulation to eliminate any partial treatment bias during our evaluation phase. Now a conventional 3 day 6 dose ACT preparation (Artesunate-Amodiaquine) is being used which is considerably cheaper (US\$ 1.0). Other teacher-driven school-based health intervention programs have been proven to be valuable and cost-effective, including nationwide anti-helminth treatment in Uganda [25], provision of intermittent anti-malarial therapy in Kenya [26,27] and prophylactic chloroquine in Sri Lanka [28], and analysis shows that health program delivery costs can be reduced by having teachers implement care [29].

WHO has always placed community participation at the centre of ‘health for all’ strategies [30]. It was the school teachers in the community who identified the burden malaria was causing on children’s education; they co-developed a realistic school-based ‘action’, and their ongoing active participation was integral to the success of the intervention. Teachers were readily trained to conduct RDTs, maintained practical competency and followed the ‘action’ protocol consistently. Teachers have also administered diagnostic and treatment protocols successfully in Tanzanian schools [31].

We recognize limitations in what we report. Principally that we chose absence from onset of illness to return to school as the outcome measure as a surrogate for malaria morbidity. Also, that we can only compare year 2 data from the RDT positive and ACT treated children with year 1 data from the cohort where infectious illness was presumed, but the actual number of malaria cases is unknown. This is because it was not feasible to follow each child sent home for parental care in the community during year 1 to establish if a diagnosis of malaria was made and if so what treatment resulted. However, the >10 fold difference in the duration of absence strongly suggests benefit from the school-based RDT/ACT initiative trialed in these 4 rural schools. And, the burden of illness from malaria was significantly reduced as 67.5% of sick children who would otherwise have been sent home were accurately diagnosed and promptly treated, as per WHO guidelines, in a community where the majority would not have been taken for appropriate care by their parents based on documented pre-intervention behavior.

In addition to the improvement in malaria morbidity evident from reduced duration of absence, it is likely that in the longer term the learning potential and educational outcomes of children managed with school-based RDT/ACT will also improve. While children diagnosed and treated in this initiative missed less school as they recovered quickly, it is also probable that they recovered more completely and with fewer, or no long term consequences. Malaria in Uganda is predominantly caused by *Plasmodium falciparum*. This infection is known to be associated with brain related consequences, especially when treatment is delayed, incomplete or absent, and functional impairment occurs that involves all cognitive spheres: language, attention, memory, visuospatial skills and executive functions [5,24,28,32,33].

It should also be stated that, although not directly measured, our belief is that this action research project has also broadened community knowledge about malaria, probably because the initiative was co-developed and collaboratively delivered by the communities where the 4 schools were located. If so, this is a secondary benefit of importance. Prior research has identified that improved health knowledge and health-related behaviors are often evident in the community as a whole where comprehensive school health promotion programs are delivered [34,35].

Importantly, even though the provision of RDT and ACT has not happened previously in schools this approach to malaria diagnosis and treatment is recommended by WHO and endorsed by many governments worldwide. The low complexity and diagnostic reliability of RDT and efficacy and reliability of ACT invite their use by personnel without formal medical training. And, as malaria remains a priority area for governments, aid foundations, health care providers and educators worldwide [11,13,27,36] novel and effective avenues for enhancing intervention are constantly being sought. Because schools are being used increasingly as platforms for delivering simple, safe and cost-effective health interventions [26,29,37], and our intervention now provides evidence of the feasibility and efficacy of school-based RDT/ACT in reducing child morbidity due to malaria, we suggest our teacher-driven community empowerment model is applicable in low resource settings worldwide where morbidity from malaria is high.

CONCLUSION

RDT/ACT use by teachers as a school-based health practice is novel and reduced child morbidity significantly. Our model of engaging and training teachers represents a community empowerment approach applicable to other low-resource settings worldwide where malaria is endemic and morbidity high.

ACKNOWLEDGEMENTS

This project was funded by the Hillman Medical Education Fund (HMEF), Canada, and we gratefully acknowledge the teachers, parents and children who participated. A.M and R.M thank the Stellenbosch Institute for Advanced Study for their invitations to work at the Wallenberg Research Centre in Stellenbosch.

REFERENCES

- [1] Brooker S, Guyatt H, Omumbo J, Shretta R, Drake L, Ouma J. Situation analysis of malaria in school-aged children in Kenya—what can be done? *Parasitology Today*. 2000;16(5):183-86.
- [2] Jukes MCH, Drake LJ, Bundy DAP. Challenges for child health and nutrition. In: *School health, nutritional and education for all: levelling the playing field*. CAB international Publishing, Cambridge, USA. Chapter 2, pages 11-31. 2008 www.cabi-publishing.org
- [3] Snow RW, Craig MH, Newton CR, Steketee RW. The public health burden of Plasmodium falciparum malaria in Africa. Fogarty International Center, National Institutes of Health. Working Paper 11, Disease Control Priorities Project, Bethesda, Maryland, USA. pages 1-80 2003
- [4] Jukes MC, Pinder M, Grigorenko EL, Smith HB, Walraven G, Bariau EM et al. Long-term impact of malaria chemoprophylaxis on cognitive abilities and educational attainment: follow-up of a controlled trial. *PLOS Clinical Trials*. 2006;1(4):e9
- [5] Kihara M, Carter JA, Newton CR. The effect of Plasmodium falciparum on cognition: a systematic review. *Tropical Medicine and International Health*. 2006;11(4):386-97.
- [6] World Health Organization. *World malaria report 2014*. Geneva, World Health Organization. 2014.
- [7] Källander K, Nsungwa-Sabiiti J, Peterson S. Symptom overlap for malaria and pneumonia—policy implications for home management strategies. *Acta Tropica*. 2014;90(2):211-214.
- [8] Mutabingwa TK. Artemisinin-based combination therapies (ACTs): best hope for malaria treatment but inaccessible to the needy! *Acta Tropica*. 2005;95(3):305-15.
- [9] Kilian AH, Kabagambe G, Byamukama W, Langi P, Weis P, Von Sonnenburg F. Application of the ParaSight™-F dipstick test for malaria diagnosis in a district control program. *Acta Tropica*. 1999;72(3):281-93.
- [10] Guthmann JP, Ruiz A, Priotto G, Kiguli J, Bonte L, Legros D. Validity, reliability and ease of use in the field of five rapid tests for the diagnosis of Plasmodium falciparum malaria in Uganda. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 2002;96(3):254-57.
- [11] World Health Organization. *Malaria 2015*. Geneva, World Health Organization. 2015.
- [12] Abba K, Deeks JJ, Olliaro PL, Naing CM, Jackson SM, Takwoingi Y et al. Rapid diagnostic tests for diagnosing uncomplicated P. falciparum malaria in endemic countries. *The Cochrane Library*. Jan 1 2011.
- [13] Malaria Consortium 2015; <http://www.malariaconsortium.org/pages/112.htm>. Accessed Dec 30 2016.
- [14] International Artemisinin Study Group. Artesunate combinations for treatment of malaria: meta-analysis. *The Lancet*. 2004;363(9402):9-17.
- [15] Macnab AJ, Stewart D, Gagnon F. Health Promoting Schools: Initiatives in Africa. *Health Education*. 2014;114(4):246-59.
- [16] Macnab AJ, Mutabazi S, Mukisa R, Eliab AM, Kigozi H, Steed R. The impact on absence from school of rapid diagnostic testing and treatment for malaria. *International Journal of Learning Teaching and Educational Research*. 2016;15(7):20-37.
- [17] Baum F, MacDougall C, Smith D. Participatory action research. *Journal of Epidemiology and Community Health*. 2006;60(10):854-57.
- [18] Macnab AJ, Mukisa R, Mutabazi S, Steed, R. Malaria in Uganda: School-based rapid diagnostic testing and treatment. *International Journal of Epidemiology*. 2016 Nov 17;dyw2262.
- [19] Benjamin J, Moore B, Lee ST, Senn M, Griffin S, Lautu D et al. Artemisinin-naphthoquine combination therapy for uncomplicated pediatric malaria: a tolerability, safety, and preliminary efficacy study. *Antimicrobial Agents and Chemotherapy*. 2012;56(5):2465–71.
- [20] Chandler CI, Hall-Clifford R, Asaph T, Pascal M, Clarke S, Mbonye AK. Introducing malaria rapid diagnostic tests at registered drug shops in Uganda: limitations of diagnostic testing in the reality of diagnosis. *Social Science & Medicine*. 2011;72(6):937-44.
- [21] Kyaabayinze DL, Asimwe C, Nakanjko D, Nabakooza J, Counihan H, Tibenderana JK. Use of RDTs to improve malaria diagnosis and fever case management at primary health care facilities in Uganda. *Malaria Journal*. 2010;9(1):1.
- [22] Mbonye AK, Magnussen P, Lai S, Hansen KS, Cundill B, Chandler C et al. A cluster randomized trial introducing rapid diagnostic tests in registered drug shops in Uganda: Impact on appropriate treatment of malaria. *PLoS one*. 2015;10(7):e0129545.
- [23] Fernando SD, Rodrigo C, Rajapaske S. The 'hidden' burden of malaria: cognitive impairment following infection. *Malaria Journal*. 2010;9(1):1.
- [24] White N, Pukrittayakarn S, Hien TT, Faiz MA, Mokuolu OA, Dondorp AM. Malaria. *The Lancet*. 2014;383(9998):723-35.
- [25] Brooker S, Clarke S, Snow RW, Bundy DAP. Malaria in African schoolchildren: options for control. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 2008;102:304-05.
- [26] Temperley M, Mueller DH, Njagi JK, Akhwale W, Clarke SE, Jukes MC et al. Costs and cost-effectiveness of delivering intermittent preventive treatment through schools in western Kenya. *Malaria Journal*. 2008;7(1):1.

- [27] Okello G, Ndegwa SN, Haliday KE, Hanson K, Brooker SJ, Jones C. Local perceptions of intermittent screening and treatment for malaria in school children on the south coast of Kenya. *Malaria Journal*. 2012;11(1):1.
- [28] Fernando D, De Silva D, Carter R, Mendis KN, Wickremasinghe R. A randomized, double-blind, placebo-controlled, clinical trial of the impact of malaria prevention on the educational attainment of school children. *The American Journal of Tropical Medicine and Hygiene*. 2006;74(3):386-93.
- [29] Drake TL, Okello G, Njagi K, Halliday KE, Jukes MC, Mangham Let al. Cost analysis of school-based intermittent screening and treatment of malaria in Kenya. *Malaria Journal*. 2011;10(1):1.
- [30] Lasker RD, Weiss ES. Broadening participation in community problem solving: a multidisciplinary model to support collaborative practice and research. *Journal of Urban Health*. 2003;80(1):14-47.
- [31] Magnussen P, Ndawi B, Sheshe AK, Byskov J, Mbwana K. Malaria diagnosis and treatment administered by teachers in primary schools in Tanzania. *Tropical Medicine and International Health* 2001;6(4):273-79.
- [32] Fernando SD, Gunawardena DM, Bandara MR, De Silva D, Carter R, Mendis KN et al. The impact of repeated malaria attacks on the school performance of children. *The American Journal of Tropical Medicine and Hygiene*. 2001;69(6):582-88.
- [33] Birbeck GL, Molyneux ME, Kaplan PW, Seydel KB, Chimalizeni YF, Kawaza K et al. Blantyre malaria project epilepsy study (BMPES) of neurological outcomes in retinopathy positive pediatric cerebral malaria survivors: a prospective cohort study. *Lancet Neurology*. 2010;9(12):1173-81.
- [34] Macnab AJ, Gagnon FA, Stewart D. Health Promoting Schools: Consensus, challenges and potential. *Health Education*. 2014;114(3):170-85.
- [35] Tang KC, Nutbeam D, Aldinger C, St Leger L, Bundy D, Hoffmann AM et al. Schools for health, education and development: a call for action. *Health Promotion International*, 2009;24(1):68-77.
- [36] World Health Organization Regional Office for Africa. Health Promotion Strategy for the African region. Sixty-second session, WHO Regional Office for Africa, 2013. Final report document AFR/RC62/9 2013; 58-62.
- [37] Brooker S, Kabatereine NB, Fleming F, Devlin N. Cost and cost-effectiveness of nationwide school-based helminth control in Uganda: intra-country variation and effects of scaling-up. *Health Policy and Planning*. 2008;23(1):24-35.