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Engaging schools in diagnosis and treatment of malaria: Evidence of sustained impact on morbidity and behavior

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ABSTRACT

Background: In low and middle income countries (LMICs) teachers send home children found sick in class devolving subsequent care to parents; where malaria is endemic, morbidity is high as the most parents fail to access WHO-endorsed rapid diagnostic testing (RDT and prompt treatment with artemisinin combination therapy (ACT). Consequently malaria is the principal reason a child misses school; so, we trained teachers to use RDT to evaluate all sick pupils and give ACT promptly to those positive.
Aims: Pre, intra and post intervention evaluation of impact of using the WHO Health Promoting School (HPS) model to empower teachers to provide RDT and ACT and engage and inform pupils about malaria in 4 schools in rural Uganda.
Methods: Documenting duration of absence from school as a surrogate measure for morbidity and change in children's knowledge and reported behaviors regarding malaria. Pre-intervention (year 1) baseline evaluation of days of absence and children's malaria knowledge/behavior; Intervention (year 2) trained teachers administered RDT in all sick children and treated those positive with ADT; Post-intervention (end of year 3) after schools independently continued RDT/ACT and education on malaria.
Results: Pre-intervention <1:5 pupils had basic knowledge about malaria (caused by mosquitos; can be prevented; requires rapid diagnosis and prompt medication). In year 1: 953 of 1764 pupils were sent home due to illness. Mean duration of absence was 6.5 (SD 3.17) school days. In year 2: 1066 of 1774 pupils were sick, all had RDT, 765/1066 (68%) tested positive and received ACT; their duration of absence fell to 0.59 (SD 0.64) school days ($p<0.001$). By year 2 all children knew the signs and symptoms of malaria and had essential epidemiological knowledge. Twelve months post intervention the universality of this knowledge had been sustained and the whole-school focus on malaria continued. Children reported better health, more consistent attendance and improved academic achievement, and had become proactive in prevention strategies; 6% fewer tested positive for malaria; and key health knowledge was being passed to new pupils.
Conclusion: Teacher administered RDT/ACT reduced child morbidity from malaria significantly; essential knowledge was generated and new health practices acquired that changed behaviors. Our WHO HPS model is applicable to other LMICs where malaria is endemic and morbidity high

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INTRODUCTION

In many low and middle income countries (LMICs) 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 and temporary or permanent neurological complications of falciparum malaria can all compromise a child's potential to learn [3-5]. The burden of disease from malaria morbidity and mortality is greatest among 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 health resources to diagnose and treat malaria are scarce in most LMICs, especially in rural and low resource communities, and to date diagnostic and treatment measures have not been made available in schools.

A diagnosis of malaria based on history and examination alone 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 testing 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 diagnose malaria and prompt administration of a locally effective therapeutic agent such as Artemisinin Combination Therapy (ACT) in those who test positive 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 LMICs 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 by their parents; 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. A secondary benefit anticipated was that children's knowledge about malaria would increase and that changes in their behavior would occur particularly related to prevention and treatment.

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].

The teachers in the schools and leaders in the community 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. The community came to understand 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. Also because many children were absent for a week or two 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. Current knowledge about the benefits of interventions available to help prevent, diagnose and treat malaria and the practicalities of delivering them were explained; particularly the use of RDT kits in government clinics for prompt diagnosis and importance of early treatment with ACT.

When community leaders (teachers and elders) subsequently chose a school-based intervention to address malaria absenteeism HEADA coordinated discussions to facilitate 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 which allowed dialogue regarding the process and the obtaining of consent; no parents wanted their child excluded. 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 then visited each school weekly during the project 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 protocol included data collection on all 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. 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 two. 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 protocol added RDT screening by teachers of all children identified as sick 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-Napthoquine) (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 HEADA 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 and behaviors related to malaria preceded new HPS activities; assessment was repeated for comparison early in the intervention year; and again 12 months post-intervention when the schools were operating the RDT/ACT program independently.

RESULT

Four primary schools (classes primary 1-7) were engaged in geographically separate low resource settings in south western Uganda [16]. Table 1 shows pupil enrollment (1764 in year one and 1774 in year two) and demographic data, and the impact on absence from school comparing Year one (pre-intervention) and Year two (intervention).

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 in Year one) and was followed by action/intervention with ongoing evaluation (September 2014 - August 2015 in Year two). 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 two virtually all children had this knowledge, and understood how infection would make them feel unwell 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 one 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 one (pre-intervention) and 1066 in year two (intervention). These 1066 were evaluated by a trained teacher and an RDT 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).

Table 1. Study demographics and diagnostic, treatment and absenteeism data for the 4 participating schools: Year 1 indicates Pre-intervention, while Year 2 shows data after Intervention by teachers using RDT and ACT. Modified from Mukisa *et al*., 2016 [16]

Variables	**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										
Term 1							56	27	55	70
Term 2							127	97	135	133
Term 3							80	77	110	99
Sick: sent home	953									
Sick: tested RDT						1066				
Sick: RDT +ve for MALARIA										
Term 1							27	20	28	35
Term 2							92	74	68	98
Term 3							49	57	106	62
Total						715				
Sick: RDT +ve treated with ACT										
Term 1							27	20	28	70
Term 2							92	74	68	133
Term 3							49	57	106	99
Total						715				
Absence (Days)	6.5	6.2	6.5	6.7	6.6	2.55	2.4	2.8	3.0	2.5
Sick sent home	(3.2)					(3.35)				
TOTAL (mean)						**p < 0.001**				
Absence (Days)						0.59	0.49	0.66	0.72	0.48
Sick sent home						(0.64)				
RDT POSITIVE MALARIA						**p < 0.001**				
Absence (Days)						4.62	4.1	6.1	4.5	3.8
Sick sent home						(3.54)				
RDT NEGATIVE						**p < 0.001**				

The mean duration of absence in children sent home with a presumed infectious illness in year one was 6.5 school days from onset of illness to return to class. In year two 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. Overall, absence from school was reduced by 60.8% during this teacher-driven intervention. If the same percentage of children sent home in year one had malaria as were diagnosed using RDTs in year two 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 as the cost was less. Knowledge transfer was also extended beyond the community to engage the Health Ministry. Repeat evaluation after the schools had maintained the program independently for one year indicated that the whole-school focus on malaria continued, school children still had comprehensive knowledge about malaria and that community commitment to prevention and altered care practices had been sustained. Children reported better health, more consistent attendance and improved academic achievement, they were also passing key health knowledge to new pupils and had become proactive in prevention strategies. Overall, 6% fewer now tested positive for malaria.

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 and prevention 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 had learned that malaria can be rapidly diagnosed and there are benefits from early treatment. Importantly, re-evaluation post intervention, when the schools had been maintaining the program independently for one year, indicated that the schools' focus on malaria continued, children's knowledge was retained and the community was still committed to practices to promote diagnosis and treatment. Children reported better health, more consistent attendance and improved academic achievement, and had become proactive in prevention strategies. The change in parental attitudes and behavior 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], and there is the potential to reduce morbidity and achieve educational benefits as 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]. Fernando et al. have reported that an attack of even uncomplicated malaria causes significant short term impairment of cognitive performance, with impairment persisting for around two weeks and appearing to be cumulative with repeated attacks [25]. 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 approach is relevant 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 global 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].

This initiative using RDT/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]. The reduction by 6% in the number of infected children when the schools were re-evaluated probably reflects this. However, to date the 'missing link' in the RDT/ACT equation has been the lack of social engagement to make test kits and treatment accessible to rural populations [8]; but now deploying RDT/ACT through school-based programs offers a logical solution to the burden of malaria and lack of diagnostic and treatment capacity 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 to their deployment; 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 is being used which is considerably cheaper (US$ 1.0).

WHO has always placed community participation at the centre of 'health for all' strategies [26]. 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. This teacher-driven initiative to address absence from school due to malaria morbidity is an example of the type of innovative, content specific, school-based intervention called for by the WHO Commission on Social Determinants of Health to support health behaviors and empower young people to take control of their lives [27]. Teachers have also successfully administered a number of other health programs in schools in LMICs which have been proved to be both valuable and cost-effective, including nationwide anti-helminth treatment in Uganda [28], provision of intermittent anti-malarial therapy in Kenya [29, 30] and prophylactic chloroquine in Sri

Lanka [31, 32]; cost-benefit analysis shows that health program delivery costs can be reduced by having teachers implement care [33].

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 two data from the RDT positive and ACT treated children with year one 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 one 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 we trialed. The burden of illness from malaria in these 4 rural schools was significantly reduced; 67.5% of sick children who would otherwise just 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, 34, 35].

It should also be stated that, although not directly measured, our belief is that this 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 [36, 37].

Importantly, even though RDT kit use and ACT provision in schools has not happened previously, this is the approach to malaria diagnosis and treatment 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, 38, 39] 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, and our school-based RDT/ACT model is a feasible and effective means of reducing child morbidity due to malaria, we suggest this teacher-driven approach 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 from malaria 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. In addition to being simple to implement and low cost this model uses WHO endorsed testing and treatment and is in keeping with the call by the WHO Commission on Social Determinants of Health for innovative school-based interventions to tackle health challenges faced by young people.

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CONFLICT OF INTERESTS

None declared.

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