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Can lay community health workers be trained to use diagnostics to distinguish and treat malaria and pneumonia in children? Lessons from rural Uganda

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Summary

OBJECTIVE To determine the competence of community health workers (CHWs) to correctly assess, classify and treat malaria and pneumonia among under-five children after training.

METHODS Consultations of 182 under-fives by 14 CHWs in Iganga district, Uganda, were observed using standardised checklists. Each CHW saw 13 febrile children. Two paediatricians observed CHWs' assessment, classification and prescription of treatment, while a laboratory scientist assessed CHW use of malaria rapid diagnostic tests (RDTs). The validity of CHWs' use of RDTs to detect malaria and respiratory timers to diagnose pneumonia was estimated using a laboratory scientist's RDT repeat reading and a paediatrician's repeat count of the respiratory rate, respectively.

RESULTS From the 182 consultations, overall CHWs' performance was adequate in taking history (97%), use (following procedures prior to reading result) of timers (96%) and use of RDTs (96%), but inadequate in classification (87%). Breath readings (classified as fast or normal) were 85% in agreement with the paediatrician ($\kappa = 0.665$, $P < 0.001$). All RDT readings were in agreement with those obtained by the laboratory scientist. Ninety-six per cent (85/89) of children with a positive RDT were prescribed an antimalarial drug, 40% (4/10) with fast breathing (gold standard) were prescribed an antibiotic and 91% (48/53) with both were prescribed both medicines.

CONCLUSION Community health workers can be trained to use RDTs and timers to assess and manage malaria and pneumonia in children. We recommend integration of these diagnostics into community case management of fever. CHWs require enhanced practice in counting respiratory rates and simple job aides to enable them make a classification without thinking deeply about several assessment results.

keywords community health worker, performance, integrated community case management for malaria and pneumonia, diagnostics, rapid diagnostic test, respiratory rate timer, Uganda

Introduction

Malaria and pneunomia are leading causes of morbidity and mortality among under-five children in Africa (Black *et al.* 2003, 2010; Kinney *et al.* 2010). Malaria alone accounts for 21–26% of under-five mortality in Uganda (WHO 2006) with another 17–26% attributed to pneumonia (Black *et al.* 2003).

In spite of available cost-effective interventions for the two conditions, millions of children in low-income countries remain at risk because of poor access to health care, inadequate quality of health services and inappropriate or delayed care seeking, with most deaths occurring at home (Black *et al.* 2003; Rutebemberwa *et al.* 2009). Community health workers (CHWs) (WHO 2007) can play an important role in increasing coverage of essential interventions for child survival (Lewin *et al.* 2005; Haines *et al.* 2007). Community case management (CCM) is effective in reducing malaria and pneumonia mortality and morbidity among under-fives (Kidane & Morrow 2000; Sazawal & Black 2003; Sirima *et al.* 2003; Winch *et al.* 2005). CCM has been in place in Uganda since 2002 (MOH Uganda

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2002). Through CCM, CHWs provide pre-packaged antimalarial drugs presumptively to children with fever, initially chloroquine and sulfadoxine/pyrimethamine and since 2006, cost-free artemisinin-based combination therapy (ACT).

Introduction of this highly efficacious but expensive treatment at community level, with reliance on presumptive diagnosis, may lead to excessive use, increased costs and risk of development of resistance (D'Alessandro *et al.* 2005; Staedke *et al.* 2009). With presumptive treatment of fever, health workers and caregivers are less likely to look for other causes of fever, leading to delay in appropriate treatment and higher case fatality rates among non-malaria fevers (Kallander *et al.* 2004; Reyburn *et al.* 2004). Rapid diagnostic tests (RDTs) or dipsticks are now available with sensitivities comparable with routine microscopy in detecting malaria (Murray *et al.* 2003; Bell *et al.* 2006) and could be used to improve diagnosis and quality of care (Young 2003; Drakeley & Reyburn 2009).

Malaria and pneumonia share several characteristics including both initial symptoms and signs of severe illness (O'Dempsey *et al.* 1993). In the absence of laboratory investigations, it is difficult to distinguish between the two conditions (Kallander *et al.* 2004). Pneumonia has not been integrated into CCM, yet the strongest evidence of mortality reduction has been reported from community-based pneumonia case management in Asia where oral antibiotics are delivered by CHWs (Sazawal & Black 2003). In situations where febrile children also have cough and rapid breathing, WHO/UNICEF now recommend integrating malaria and pneumonia care in the community (WHO/UNICEF 2004).

Practical experience of using CHWs to implement the WHO/UNICEF recommendation on integrated malaria and pneumonia CCM is lacking. It is not clear whether CHWs can be trained to acquire competence in the full range of more complex integrated guidelines that include use of diagnostics. We assessed the competences of CHWs to use diagnostics to assess, classify and prescribe treatment for malaria and pneumonia immediately after an 8-day training in CCM.

Materials and methods

Study area

The study was conducted in the rural Ugandan district of Iganga as part of a larger study on the feasibility of deploying RDTs at the community level (Clinical Trials.gov Identifier NCT00720811). Uganda has an estimated population of 34 million, about 80% of whom live in rural areas. Iganga district is located in south-eastern Uganda, approximately 112 km from Kampala. Its population of approximately 600 000 consists mainly of subsistence farmers. Iganga has high transmission rates for malaria (MARA/ARMA 2001). CHWs in this study were drawn from Namungalwe subcounty, which is comprised of seven parishes and 19 villages with a population of 32 911. Namungalwe subcounty was selected as the site for the intervention study that introduced RDTs and respiratory timers for management of malaria and pneumonia by CHWs. Three health centres were used: Namungalwe HC III, Busesa HC IV and Bugono HC IV.

Study population

We enrolled all 14 CHWs of Namungalwe subcounty that participated in the intervention arm of the trial.

Study design and data collection

Training was conducted in September 2009 for 8 days, by three experienced national CCM trainers and one laboratory scientist. Topics covered are shown in Figure 1. After the training, CHWs were provided with supplies and materials including job aides.

Several studies have conducted observations of patient–provider interactions. Some observe care at facilities for a certain time period, with a wide range from 3 days (Arifeen *et al.* 2005) to 14 days (Krause *et al.* 1998). Others use a certain number of consultations per facility, ranging from two to six per condition per facility (Armstrong Schellenberg *et al.* 2004; Ehiri *et al.* 2005). CHW performance evaluations using lot quality assurance (LQA) technique have used consultations as small as 6 (Valadez *et al.* 1995). A total of 13 consultations for each CHW was considered adequate to measure CHW performance, giving a total of 182 consultations.

Tools were pretested and any ambiguities addressed in developing the final version. Evaluation started 3 days after training and lasted for 2 weeks. Any under-five with fever or history of fever without danger signs was enrolled into the study. Under-fives were enrolled as they arrived at the health centres after registration at the outpatient department and consent by their caregivers. Enrolled children were managed by the study paediatricians at the end of their participation.

Using standardised checklists[1] two paediatricians observed CHWs' performance on child assessment (history

[1]Available at www.afenet.net/english/publications/Peadiatrician_evaluation_toolv09-10-09.doc and www.afenet.net/english/publications/Laboratory_scientist_evaluation_toolv09-10-09.doc or upon request from the corresponding author.

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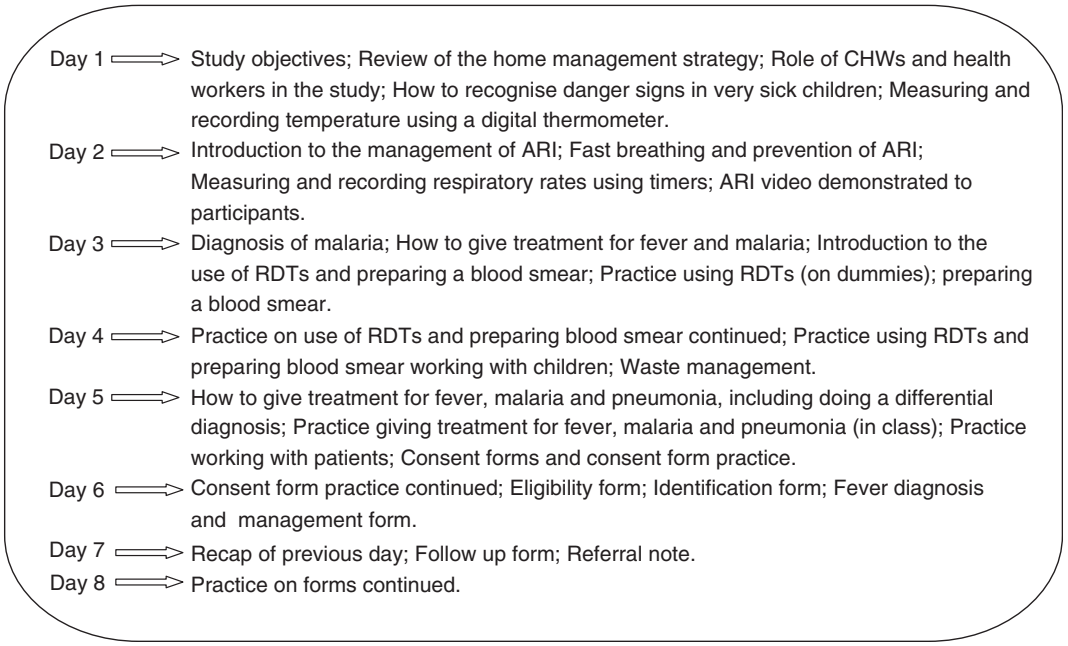

Figure 1 Content of training provided to community health workers on integrated malaria and pneumonia community case management.

taking, signs and symptoms, temperature reading and rapid breathing), classification and treatment prescription, while a laboratory scientist assessed the use of RDTs. Each CHW was observed by one paediatrician and laboratory scientist, who had been trained in the use of the diagnostics and observation checklists. One CHW was observed at a time. CHWs with a score of <90% (cut-off for adequate performance) on any part of the algorithm were retrained on that part before deployment into the field. The ability of CHWs to use RDTs to detect malaria and respiratory timers to diagnose pneumonia was estimated using a laboratory scientist's RDT repeat reading and a paediatrician's repeat count of the respiratory rate, respectively.

Definition of indicators and variables

Sixteen indicators were used for history including the following: CHW asked and recorded age and location of child's home; asked whether child had fever, cough, cold and danger signs (convulsions, difficulty drinking or feeding, and vomiting everything); looked for signs of dehydration, severe anaemia, chest in-drawing, prostration and altered mental state; and he/she asked whether child has received any treatment in past 7 days. CHW temperature reading was compared with paediatrician's.

Four indicators were used to assess ability to use a respiratory timer including counting rate before taking off blood, ensuring child is settled before beginning to count, following instructions (looks at child's lower part of the chest, start the timer by pressing centre circle, start counting at the beep and stop counting after two beeps indicating a minute) on how to take the count and recording rate.

Fourteen indicators were used to assess RDT use: ensuring all inputs required are available before start, correctly wearing gloves, selecting correct finger to puncture, cleaning finger with alcohol swab, allowing finger to dry, puncturing finger correctly, drawing blood at this point using a pipette, wiping finger with cotton after collecting blood, labelling child's ID number on cassette, putting five drops of buffer into appropriate hole, recording time after adding buffer, waiting 15 min after adding buffer to read results and recording test results. Classification/diagnosis made by CHW, and treatment prescribed were compared with that by the paediatrician.

Data analysis

Data were entered into EpiData (EpiData Association, Odense, Denmark) statistical software and analysed using Stata version 10 (Stata Corp., College Station, TX, USA). The proportion of CHWs who complied with the entire algorithm, as well as each part of the algorithm, was

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calculated. Indicators were measured for each part and given a uniform score of 1 for correct and 0 for incorrect. The total score for each part of the algorithm was computed. A cut-off of 90% was set as adequate performance based on lessons from LQA techniques that use thresholds of 80%.The kappa statistic (Cohen 1960) was used to estimate the proficiency of CHWs in reading RDT results, as well as counting respiratory rates. Bivariate analysis was used to assess the association between overall performance of CHWs and CHW social demographic characteristics.

Ethical clearance

Ethical approval for the study was obtained from Institutional Review Boards of WHO, the Makerere University School of Public Health, and the Uganda National Council for Science and Technology. Permission was obtained from the Iganga District Health Office, the health centre incharges and from local authorities to conduct the study. Individual (signed or thumb print) informed consent was obtained from each caregiver.

Results

Socio-demographic characteristics of community health workers and children

Median age of the 14 CHWs was 42.5 years (range 28–50), and their mean duration in service was 3 years (SD 1.14). Eight of the 14 were women; 11 had attained at least primary education (1st 7 years of school), while the other three had not gone beyond primary school; 13 were married; 11 were self-employed (business and farming); two were teachers; and one was a nursing assistant. Mean age of the children was 21.3 months (SD 13.9); 51.5% (104/202) were girls. Of 202 children, 20 were excluded as they were too ill to participate in the study.

Overall performance of community health workers in assessing, classifying and treating children with malaria and pneumonia

Overall performance of CHWs in taking history was 96.7% (Table 1). Three CHWs scored <90% in temperature reading. All CHWs scored above 90% in using timers

Table 1 Performance of CHWs in assessing, classifying and treating children with malaria and pneumonia

CHW no. (Each saw 13 children) *n* = 182	Paediatrician (Assessor)	History* (score and %) *n* = 208	Actual temp reading Vs gold standard (score and %) *n* = 13	Using timer for Resp. Rate* (score and %) *n* = 52)	RDT preparation† (*n* = 182)	Classification *vs.* gold standard* (score and %) *n* = 13	Prescribing treatment *vs.* gold standard diagnosis (score and %) *n* = 26
1	1	206 (99)	12 (92)	48 (92)	177 (97)	11 (85)	24 (92)
2	1	201 (97)	12 (92)	52 (100)	178 (98)	11 (85)	24 (92)
3	2	204 (98)	12 (92)	49 (94)	180 (99)	12 (92)	25 (96)
4	2	200 (96)	12 (92)	47 (90)	180 (99)	12 (92)	25 (96)
5	2	201 (97)	12 (92)	48 (92)	178 (98)	12 (92)	25 (96)
6	1	200 (96)	12 (92)	51 (98)	176 (97)	6 (46)	22 (85)
7	2	198 (95)	11 (85)	52 (100)	178 (98)	13 (100)	25 (96)
8	2	208 (100)	11 (85)	51 (98)	179 (98)	11 (85)	24 (92)
9	2	187 (90)	10 (77)	48 (92)	158 (87)	12 (92)	24 (92)
10	1	199 (96)	13 (100)	51 (98)	180 (99)	12 (92)	24 (92)
11	1	200 (96)	12 (92)	51 (98)	159 (87)	12 (92)	24 (92)
12	1	201 (97)	13 (100)	48 (92)	175 (96)	10 (77)	23 (88)
13	1	206 (99)	12 (92)	51 (98)	175 (96)	11 (85)	24 (92)
14	2	205 (99)	13 (100)	52 (100)	180 (99)	13 (100)	26 (100)
Overall by area		96.7%	91.8%	96.0%	96.3%	86.8%	93.1%

CHW, community health worker; RDT, rapid diagnostic test.
n, number of observations for each CHW (=number of indicators multiplied by 13 children for each CHW). We used the following indicators for the different variables: history, a total of 16 indicators (A3–7, 9, 11, 13, 14, 16 and 18–23); temperature reading, 1 indicator (A32) *vs.* A35 (gold standard); using timer, 4 indicators (A36–39); RDT preparation, 14 indicators (P3–8, P12, P14, R4–5, R7–10); Classification, 1 indicators (C13) *vs.* C14 (gold standard); Prescribing, 2 indicators (T2 Coartem, T2 Amoxyl – CMD) *vs.* (T2 Coartem, T2 Amoxyl – gold standard).
*Refer to checklist at http://www.afenet.net/english/publications/Peadiatrician_evaluation_toolv09-10-09.doc
†Refer to checklist at http://www.afenet.net/english/publications/Laboratory_scientist_evaluation_toolv09-10-09.doc

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and RDT preparation. Overall CHW performance in classification was 86.2%, with 6 scoring <90%. Regarding prescribing treatment against gold standard classification of child's illness, we analysed CHW decision in giving correct treatment for malaria and pneumonia for each child. Expected total score was 26 (13 for ACT and 13 for antibiotic). Overall performance was 93% with only two CHWs below 90%. There was no significant correlation between the paediatricians and overall performance of CHWs (pairwise coefficient = 0.408 and $P = 0.147$), which means performance was not a function of the paediatrician.

Community health worker assessment and diagnosis

Community health workers took axillary temperature for all 182 children not referred and used the thermometer correctly as per instructions in 179 instances (98%). Only six CHWs repeated the temperature reading as per training. The mean temperature reading for the CHWs was 37.25 °C, while that for the paediatricians was 37.31 °C with a mean difference in paired observations of −0.060 °C ($t = -1.834$, $P = 0.068$). The categorical classification of temperature readings (below 37.5, or 37.5 and above) between CHWs and paediatricians for each child was strongly correlated (concordance in 167 of 182 readings; pairwise coefficient = 0.803 and $P < 0.001$).

Using timers for measuring respiratory rate

When comparing classification of respiratory rates (normal and fast breathing) between CHWs and paediatricians for each child, six of the 14 CHWs had 12 or more readings in concordance, while the others had concordances ranging from 7 to 11.

No CHW repeated a respiratory rate count as per training guidelines. As shown in Table 2, CHW readings (classified as fast breathing or not) were 84.6% (154/182) in agreement with the paediatrician ($\kappa = 0.665$ and $P < 0.001$); 64% (116/182) of CHW respiratory rates were within ±2 breaths/minute of the paediatrician's. Differences in CHWs respiratory rates were because of child changing posture during counting (most common), breastfeeding, crying or restlessness.

Table 2 Classification of children by CHW with or without fast breathing against gold standard

	Gold Standard	
CHW	Fast Breathing	Normal Breathing
Fast Breathing	51	16
Normal Breathing	12	103

CHW, community health worker.
$\kappa = 0.665$, $P < 0.001$.

Using a rapid diagnostic test for malaria

Community health workers RDT readings were all (182/182; 100%) in agreement with the laboratory scientist – 138 were positive, 40 were negative and four were invalid. The four invalid results were repeated and found to be positive. Malaria prevalence in this population of children was therefore 78% (142/182).

Community health worker performance in classifying children with fever

Results in Table 3 show that agreement between CHWs and paediatrician classification was 86.8% (158/182) ($\chi^2 = 303.3$, df 9 and $P < 0.001$). CHWs correctly classified 88 of 89 children as being infected with malaria, five of 10 children as having pneumonia and 47 of 53 children as having both malaria and pneumonia.

Association between CHW characteristics and performance in classification of children with fever

At bivariate analysis using performance cut-off scores at 80% and 90% as the dependent variable, there was no association between socio-demographic characteristics and CHW performance in classification of children. The small number of CHWs (14) inhibited meaningful analysis at bivariate level.

Table 3 CHW performance in classifying children with fever compared with a paediatrician

	Gold standard (RDT and paediatrician)			
CHW (Row)	Malaria only	Pneumonia only	Both malaria and pneumonia	Neither malaria nor pneumonia
Malaria only	79	0	4	0
Pneumonia only	0	4	1	2
Both malaria and pneumonia	9	1	47	0
Neither malaria nor pneumonia	1	5	1	28

CHW, community health worker; RDT, Rapid diagnostic test.
$\chi^2 = 303.3$, $df^2 = 9$, $P < 0.001$.

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Table 4 Treatment prescribed by CHWs to children as per paediatrician and CHW classification

	Gold standard classification (RDT and paediatrician)			
Treatment prescribed by the CHW	Malaria only (n = 89)	Pneumonia only (n = 10)	Both malaria and pneumonia (n = 53)	Neither malaria nor pneumonia (n = 30)
Antimalarial drugs only	77	0	4	1
Antibiotic only	0	4	1	2
Both medicines	8	0	48	0
Neither of the medicines	4	6	0	27
	Classification by CHW			
Treatment prescribed by the CHW	Malaria only (n = 83)	Pneumonia only (n = 7)	Both malaria and pneumonia (n = 57)	Neither malaria nor pneumonia (n = 35)
Antimalarial drugs only	80	0	2	2
Antibiotic only	0	7	0	0
Both medicines	2	0	54	0
Neither of the medicines	1	0	1	33

CHW, community health worker; RDT, Rapid diagnostic test.

Community health worker performance in prescribing treatment

Based on gold standard diagnosis (RDT and paediatrician), 95.5% (85/89) of children with malaria only were prescribed an antimalarial drug by the CHW, 40% (4/10) with pneumonia only prescribed an antibiotic, while 90.6% (48/53) with both conditions were prescribed both medicines (Table 4). Among those with neither condition, 10% (3/30) were prescribed one of the two medicines.

Based on CHW classification of the children, 99% (82/83) with malaria only were prescribed an antimalarial drug, 100% (7/7) with pneumonia only an antibiotic and 94.7% (54/57) with both conditions were prescribed both medicines.

Discussion

For remote and poor communities without access to health services, CHWs often are the only option for the survival of febrile children. Little has been reported on the implementation of the WHO/UNICEF recommendation on iCCM for malaria and pneumonia. Our results provide evidence that it is possible to train CHWs to provide diagnostic-based iCCM for malaria and pneumonia.

Community health worker performance in taking history, and using RDTs and timers

The performance of CHWs was adequate in history taking, following correct procedures prior to reading off result of RDT and using a timer. The need for CHWs to repeat their temperature and respiratory count measurement needs to be emphasized in training, as this point was often forgotten. Although only 64% of CHW respiratory rate counts were within two breaths of the paediatrician's, classification of children as having fast or normal breathing was 85% in agreement with the paediatrician. Therefore, only 15% of paired breath count observations between the CHW and paediatrician fell on opposite sides of the cut-offs for age. In some situations, this was a result of borderline counts. A kappa of 0.67 reported in this study denotes good agreement between CHWs and paediatricians (Landis & Koch 1977). Emphasis needs to be made regarding counting respiratory rates when the child is settled and not breastfeeding. A study from Western Uganda evaluated the ability of CHWs to assess rapid breathing among under-fives and found that 71% of 96 CHWs were within ±5 breaths/min from the gold standard and 79% classified the breathing rate correctly (Kallander *et al.* 2006).

Community health workers were excellent in interpreting RDT results as all readings were in agreement with those obtained by the laboratory scientist. This is likely a result of intensive practice during training. Reports from South America (Cunha *et al.* 2001; Pang & Piovesan-Alves 2001), Asia (Yeung *et al.* 2008) and Africa (Premji *et al.* 1994; Harvey *et al.* 2008; Elmardi *et al.* 2009; Hawkes *et al.* 2009) describe successful use of CHWs to diagnose and treat malaria in remote villages using RDTs. In Cambodia, village malaria workers have provided acces-

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sible malaria diagnostic and treatment services in remote communities since 2001 (Yeung *et al.* 2008). There is a growing body of evidence that suggests use of RDTs by CHWs is likely to be acceptable by community members in other countries, including Democratic Republic of Congo (Hawkes *et al.* 2009), Zambia (Yeboah-Antwi *et al.* 2010) and Uganda (Mukanga *et al.* 2010).

Lessons from this study also show that CHW vision (optics) needs to be assessed to ensure that those with poor vision are assisted. In practice sessions with RDTs during training, two CHWs were unable to differentiate between a positive and negative RDT result because of visual problems. The study supported (on the recommendation of trainers) them to take optical examinations, and they were provided with free reading glasses.

Performance in classification

Community health workers performance in classification was 86%. Some CHWs appeared to have difficulty linking diagnostic results to classification. They had difficulty relating assessment results and classification alternatives. Interpretation of thermometer readings in relation to the RDT might have confused some CHWs, particularly what classification to make of a child with a positive RDT with temperature below 37.5 °C (no fever). Traditionally, CHWs are trained to use fever as a proxy for malaria. How can a child with malaria not have fever? The job aide needs to clearly indicate that the RDT is the only guide to deciding whether a child has malaria or not. The importance of making a correct classification needs to be conveyed to CHWs using examples that highlight the risk to children of wrong classification.

This session requires more time and practice during training, and an improved and simplified job aide that allows CHWs to follow through from assessment to classification. Similar experiences with job aides have been reported from Integrated Management of Childhood Illness (IMCI) programmes (Osterholt *et al.* 2009). A study in Bolivia showed that CHWs are capable of acquiring skills needed to effectively manage acute respiratory illness, but highlighted the importance of training emphasis on how to count the respirations of children with fast breathing (Zeitz *et al.* 1993).

Performance in prescribing treatment

In spite of misclassification problems, a high proportion of children with a positive RDT were prescribed appropriate treatment, whereas a substantial proportion of children with pneumonia (paediatrician) were not. However, based on CHW classification of children, a reasonably high proportion of children with malaria and/or pneumonia were prescribed the correct treatment. This demonstrates the potential for improved treatment if CHWs can be enabled to become more accurate in their classification.

Osterholt *et al.* 2009 in IMCI evaluation found that incorrect diagnosis was a key problem which preceded two-thirds of all treatment errors. However, once pneumonia was correctly diagnosed, failure to prescribe an antibiotic was unusual. Other studies from Tanzania, Bangladesh and Burkina Faso show poor health worker performance in history taking, physical examination and consultation time at primary healthcare facilities (Krause *et al.* 1998; Nsimba *et al.* 2002; Arifeen *et al.* 2005). Putting our results into context, performance of CHWs was very satisfactory.

Pariyo *et al.* 2005 show that while high-quality training can lead to improved performance and quality of care, it is not enough and other factors such as supervision play a key role. Therefore, programmes need to invest into support structures for community programmes such as these to be effective. If appropriately used, these diagnostic tools will greatly improve access to and use of medicines, lower the risk of development of microbial resistance and improve the quality of care for febrile children.

Methodological limitations

The entire evaluation lasted 2 weeks. It is possible that CHWs' performance could be influenced by this longitudinal approach with those evaluated later not performing as well, having lost some of the skills or forgotten issues. On testing this relationship, there was no correlation (coefficient = −0.091 and $P = 0.756$). The observation of consultations could have influenced CHW practices, perhaps overestimating performance in real life. However, the intent of this study was to measure CHW competence after training, although this may not be replicated in real life.

This was a facility-based study with an environment different from the CHWs' home where they practice, and this could have influenced CHW performance. At home, they have other pressures from work and family that could affect performance. Results may seem promising but need confirmation in a real-world setting. The small number of CHWs is a limitation in this study, and because of this, we did not have sufficient power to detect associations between performance and CHW attributes. The ability of CHWs to correctly interpret RDTs in a low-prevalence area, when many tests are negative, may be quite different from what we saw in this study. We recommend that similar studies be replicated in these settings with larger numbers of CHWs.

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The observers were not blinded to the results of the CHWs before they undertook their own readings. This may have influenced their own readings. We tried to minimise this by using highly qualified observers and training them prior to the observations. The observers were also closely supervised by the study team. All indicators used were awarded uniform weight. Although desirable, weighting of indicators could have made this analysis much more complex than it already is, and difficult to explain.

Conclusion

Findings of this study show that it is possible to train lay CHWs to use RDTs and timers to assess and manage malaria and pneumonia in children. The integration of these diagnostics into CCM is therefore recommended. CHWs need more practice on use of timers to count respiratory rates. In addition, provision of simple job aides will enable CHWs to make a classsification based on diagnostic results without having to think about several assessment results, minimising misdiagnosis.

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