Impact of Improving Community-Based Access to Malaria Diagnosis and Treatment on Household Costs

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Background. Community health workers (CHWs) were trained in Burkina Faso, Nigeria, and Uganda to diagnose febrile children using malaria rapid diagnostic tests, and treat positive malaria cases with artemisinin-based combination therapy (ACT) and those who could not take oral medicines with rectal artesunate. We quantified the impact of this intervention on private household costs for childhood febrile illness.

Methods. Households with recent febrile illness in a young child in previous 2 weeks were selected randomly before and during the intervention and data obtained on household costs for the illness episode. Household costs included consultation fees, registration costs, user fees, diagnosis, bed, drugs, food, and transport costs. Private household costs per episode before and during the intervention were compared. The intervention’s impact on household costs per episode was calculated and projected to districtwide impacts on household costs.

Results. Use of CHWs increased from 35% of illness episodes before the intervention to 50% during the intervention (P<.0001), and total household costs per episode decreased significantly in each country: from US Dollars (USD) $4.36 to USD $1.54 in Burkina Faso, from USD $3.90 to USD $2.04 in Nigeria, and from USD $4.46 to USD $1.42 in Uganda (all P<.0001). There was no difference in the time used by the child’s caregiver to care for a sick child (59% before intervention vs 51% during intervention spent ≤2 days). Using the most recent population figures for each study district, we estimate that the intervention could save households a total of USD $29 965, USD $254 268, and USD $303 467, respectively, in the study districts in Burkina Faso, Nigeria, and Uganda.

Conclusions. Improving access to malaria diagnostics and treatments in malaria-endemic areas substantially reduces private household costs. The key challenge is to develop and strengthen community human resources to deliver the intervention, and ensure adequate supplies of commodities and supervision. We demonstrate feasibility and benefit to populations living in difficult circumstances.

Clinical Trials Registration. ISRCTN13858170.

Keywords. CHW; economics; access; ACTs; malaria.

It is estimated that approximately 214 million cases of malaria occurred in 2015, almost 90% in sub-Saharan Africa [1]. Children aged <5 years are at greatest risk of illness and death [1, 2]. Rapid diagnostic tests (RDTs) reliably diagnose malaria at the point of care and identify children to be treated with artemisinin-based combination therapy (ACT); rectal artesunate is recommended for patients who can no longer take oral drugs before transfer to a facility for continued management [3]. Data on the feasibility of providing an integrated package are essential, particularly in remote rural areas where malaria has not yet declined [3–5]. Evidence is needed about the potential health benefits as well as costs and savings of introducing such interventions in underserved areas.

Malaria can be successfully treated with existing medicines, but access to them is limited in affected populations. In rural Africa, households frequently rely on private, for-profit providers where they make direct payments for healthcare, due to long distances to public facilities, or because such facilities do not function adequately or do not have appropriate medicine and consumable stocks [6–8]. The burden of paying privately for healthcare is a major financial cost to the household, and is exacerbated by income lost from not being able to carry out normal activities because malaria often occurs in the rainy season, simultaneous with an increased need for labor on the farm. Ill
health and the associated costs tip families into catastrophic economic conditions, recovery from which may take considerable time [9, 10]. At the same time, there is an increasing literature on interventions using community health workers (CHWs) to successfully provide basic care [11–13]. A number of interventions have demonstrated the extent to which CHWs can substantially improve health when trained adequately and when provided with commodities and supervision [14, 15]. CHWs have been shown to be able to assess and diagnose children and improve access to healthcare by reaching the poorest in the most inaccessible areas. Several studies have shown a reduction in child mortality associated with CHWs’ provision of care [13–16].

As part of an implementation study that trained CHWs to assess sick children, diagnose malaria using RDTs, and treat with ACTs or rectal artesunate in 3 African countries (Burkina Faso, Nigeria, and Uganda) chosen because they are among the top 10 countries contributing 80% of global malaria cases [17], we studied the private household costs for a febrile case in a child before the intervention was launched, and after the CHWs’ training was completed and the intervention was in force. Our objective was to quantify the impact of this intervention improving access to malaria diagnosis and treatment on private household costs of illness, and to provide policy makers with reliable estimates of these costs if they were to consider scaling up the intervention at the district or national level.

METHODS

Study Sites

The main intervention study was carried out in 3 rural areas of Burkina Faso (health area of Sidéradougou, Health District of Mangodara), Nigeria (Ona-Ara local government area), and Uganda (Sheema district) in 2014, and consequently the pre-intervention household questionnaire was implemented between May and August, and sometimes tails off in November/December, and in the Ona-Ara area, Nigeria, malaria peaks between May and October. However, in Uganda, malaria is seasonal in Sheema district (between March and June/July and September/October) but stable through the whole year in Kayunga district.

Health Provision in the Study Area

In all 3 countries, people typically go for advice and care for suspected malaria to traditional healers, faith homes (churches), CHWs, traditional birth attendants (Nigeria), drug shops/ patent medicine sellers, drug hawkers, maternity attendants, dispensaries (not in Nigeria), health centers, or private clinics (Nigeria and Uganda). The closest hospital is situated 25 km away from the study area in Burkina Faso, approximately 8 km (private hospital) or between 20 and 22 km (public hospital) away in Nigeria, and 36 km away for Sheema district (Uganda); in Kayunga district (Uganda), it takes about 2–3 hours walking from Kayunga’s Grade IV health center to the hospital.

In Burkina Faso, healthcare at any public facility is fee-based. Consultation costs about 200 West African CFA francs (XOF; US Dollars [USD] $3.33) and when admitted, patients pay for their bed. In Nigeria and Uganda, consultations, drugs, and bed costs at public facilities are theoretically provided free of charge for children <5 years old, but caregivers still have to pay for a registration card and injections (Nigeria) or an exercise book and drugs bought outside the hospital (Uganda). In all 3 countries, shops and pharmacies sell quinine, antibiotics, and antimalarials without prescription.

Before the intervention, no RDTs, ACTs, or rectal artesunate were available to the communities in the public sector. CHWs were available but relatively dormant as a means of providing healthcare. During the intervention, RDTs and drugs were provided free of charge in the study areas of Nigeria and Uganda. However, in Burkina Faso, RDTs and rectal artesunate were free of charge, but ACT was sold (as per public policy) to CHWs at a cost of 70 XOF (USD $1.12; 6 tablets per blister pack) for children aged <37 months and 150 XOF (USD $2.25; 12 tablets per blister pack) for children aged 37–59 months. Each CHW was authorized to make a nominal profit by charging parents these costs plus a nominal profit of 30 XOF (USD $0.50) for each young child treated with 6 ACTs and 50 XOF (USD $0.80) for each older child treated with 12 ACTs.

Household Questionnaires on Costs

The purpose of the study questionnaire was to determine treatment-seeking behavior and expenditure for a recent childhood illness by households randomly selected from the villages before and during the intervention. In all 3 countries, a visit was made to households, and if they had a child who was between 6 and 59 months of age and had a fever in the preceding 2 weeks, questions were asked regarding the illness, healthcare received, and their healthcare expenses. Households that did not have children who were ill, or whose caregiver was not present during
the illness or who refused to give consent, were excluded from interview.

**Questionnaire Content, Selection of the Interviewers, and Data Collection**

Two questionnaires (one for each phase) were developed: in French for Burkina Faso and in English for Nigeria and Uganda. In Nigeria and Uganda, these questionnaires (hereinafter called case report forms [CRFs]) were translated into local languages (Yoruba in Nigeria, and Luganda in Kayunga district and Lunyankole in Sheema district, Uganda) and pilot tested for comprehension before use. For the pre-intervention phase, there were 10 interviewers in Burkina Faso and Nigeria and 8 in Uganda; for the intervention phase, there were 10 in Burkina Faso, 13 in Nigeria, and 20 in Uganda. Interviewers were fluent in local languages and had good education and prior experience in research/data collection. Most interviewers were used for both pre-intervention and the intervention phase. In all 3 countries, interviewers were trained for at least 1 day. Training sessions were interactive with question-and-answer sessions and role plays. Each interviewer was tested through completing CRFs before certification.

Each interview lasted between 20 minutes and 1 hour. Although the pre-intervention and intervention CRFs were adapted to the country, they contained the same main questions on general sociodemographic context of the household, clinical course of the episode (timing, symptoms, actions taken, healthcare providers visited), costs incurred (for transportation, medicines, registration/consultation fees, laboratory/diagnostic tests, accommodation, and food for each consultation) and what happened during a consultation visit to a health provider (RTDs, treatments). The CRF during intervention was identical to the pre-intervention CRF but attempted to capture additional information on reasons for not going to a CHW where relevant.

**Sampling Strategy**

In calculating our sample size for household surveys, we assumed that the average number of children <5 years of age per household was 2, except in Uganda, where the average was assumed as 1.4. Requiring a precision of ±5% points for the point estimates of proportions, a minimum sample size would be 384 for the worst-case scenario of 50%. Accounting for a design effect of 2 for clustering on household level would give us a total sample hold was 2, except in Uganda, where the average was assumed as

1 USD = 487.80 XOF (Burkina Faso); 1 USD = 161.76 Nigerian naira (NGN); 1 USD = 2631.58 Ugandan shilling (UGX) for the pre-intervention phase; and the average exchange rate between April and October 2015: 1 USD = 598.09 XOF; 1 USD = 200.36 NGN; 1 USD = 3472.22 UGX for the intervention phase (www.oanda.com).

**Projecting Impact of Intervention on Household Costs at the Whole District Level**

To project the impact of intervention on household costs at district level, external data were used for the number of children <5 years old in each district and the number of malaria episodes per year and per child <5 years old. Estimates of the impact per child and per episode are presented and mean cost savings were then calculated for malaria episodes per year. Overall cost impacts were converted into USD.

**Statistical Methods**

For each phase and each country separately, all data were double entered in EpiData 3.1 and analyzed using Stata software, version 13.0 (StataCorp, College Station, Texas). A Student t test was performed on the equality of means with a level of significance of P = .05 and a confidence level of 95%, and a test for heterogeneity was used to compare baseline characteristics of participating households before and during the intervention by country and overall.

**Ethical Considerations**

The research protocol of the main study was approved by the National Health Research Committee, the University of Ibadan/University College Hospital Institutional Review Committee, and Oyo University College Hospital Institutional Review Committee, and Oyo University College Hospital Institutional Review Committee.
State Ministry of Health in Nigeria; the National Ethics Committee for the Research on Health and the National Regulatory Authority in Burkina Faso; the National Council for Science and Technology in Uganda; and the World Health Organization Research Ethics Review Committee. In addition, Nigeria obtained permission from the local government secretariat as well as

Table 1. Characteristics of Children, Caregivers, Caregivers’ Households, and Childhood Illness in the Study

| Category                                             | Before Intervention | During Intervention |
|------------------------------------------------------|---------------------|---------------------|
|                                                      | Burkina Faso        | Nigeria             | Uganda              | Total            |
|                                                      | No. %               | No. %               | No. %               | No. %            |
| Total No. of children/cases                         | 514 29              | 775 45              | 457 26              | 1746 100         |
| Child characteristics                                |                     |                     |                     |                  |
| Child’s age                                         |                     |                     |                     |                  |
| <36 mo                                               | 327 64              | 448 58              | 282 62              | 1057 60          |
| ≥36 mo                                               | 178 34              | 326 42              | 175 38              | 679 39           |
| Caregiver and household characteristics             |                     |                     |                     |                  |
| Caregiver’s gender                                  |                     |                     |                     |                  |
| Male                                                 | 220 43              | 62 8                | 14 14               | 346 20           |
| Female                                               | 294 57              | 713 92              | 393 86              | 1400 80          |
| Caregiver’s age, y                                  |                     |                     |                     |                  |
| 15–24                                                | 82 16               | 123 16              | 92 20               | 297 17           |
| 25–35                                                | 225 44              | 461 59              | 226 50              | 912 52           |
| 36–50                                                | 153 30              | 137 18              | 100 22              | 390 22           |
| >50                                                  | 34 7                | 32 4                | 37 8                | 103 6            |
| Education                                           |                     |                     |                     |                  |
| No education                                        | 408 80              | 189 25              | 55 12               | 652 37           |
| ≤7 y                                                 | 43 8                | 312 40              | 281 62              | 636 36           |
| >7 y                                                 | 21 4                | 273 35              | 121 26              | 415 24           |
| Occupation                                           |                     |                     |                     |                  |
| Unemployed                                           | 11 2                | 27 4                | 9 2                 | 47 3             |
| Agriculture only                                     | 470 92              | 270 35              | 370 81              | 1110 63          |
| Employed (only or + agriculture)                    | 2 0                 | 27 4                | 17 4                | 46 3             |
| Self-employed (only or + agriculture)               | 30 6                | 415 53              | 59 13               | 504 29           |
| Othersb                                              | . . .               | . . .               | 34 4                | 2 0              |
| Food problems                                        |                     |                     |                     |                  |
| Never                                                | 357 70              | 188 24              | 246 54              | 791 45           |
| Seldom                                               | 57 11               | 300 39              | 91 20               | 448 26           |
| Sometimes                                            | 57 11               | 237 30              | 79 17               | 373 21           |
| Often                                                | 25 5                | 37 5                | 27 6                | 89 5             |
| Always                                               | 2 0                 | 34 4                | 2 0                 | 36 2             |
| No. of working people over 10 y of age in household  |                     |                     |                     |                  |
| ≤2                                                  | 41 8                | 656 85              | 397 87              | 1094 62          |
| 3–5                                                 | 176 34              | 116 15              | 54 12               | 346 20           |
| 6–10                                                | 198 39              | 3 0                 | 6 1                 | 207 12           |
| >10                                                 | 88 17               | . . .               | . . .               | 88 5             |
| Illness characteristics                               |                     |                     |                     |                  |
| Danger signs                                         |                     |                     |                     |                  |
| No                                                   | 437 85              | 588 76              | 290 63              | 1315 75          |
| Yes                                                  | 77 15               | 187 24              | 167 37              | 431 25           |
| No. going to trained CHWsac                          | 105 20              | 515 66              | . . .               | 620 35           |
| Other providers                                       | 409 80              | 260 34              | 457 100             | 1126 65          |

Missing data: child’s age: 10 before and 18 during; caregiver’s gender: 3 during; caregiver’s age: 44 before and 65 during; education: 43 before and 28 during; occupation: 3 before and 13 during; food problems: 29 before and 32 during; number of working people >10 years of age in household: 11 before and 1 during.

Abbreviation: CHW, community health worker.

- Test for heterogeneity: during intervention vs before intervention: P < .05.
- Combination of agriculture, employed, and self-employed.
- In Nigeria, CHWs as well as shop owners were trained as part of the intervention.
- In Nigeria, pre-intervention data included patients who went to a health center, hospital, or maternity center. None went to a CHW during this period.

Impact and Household Costs  •  CID 2016:63 (Suppl 5)  •  S259

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Table 2. Mean Private Costs (in US Dollars) per Episode of Illness Before and During Interventiona

| Category          | Before Intervention | During Intervention | Total |
|-------------------|---------------------|---------------------|-------|
|                   | No. | Mean (SD) | No. | Mean (SD) | No. | Mean (SD) | No. | Mean (SD) |
| Costs (in USD)*   |     |           |     |           |     |           |     |           |
| Registration      | 26  | 0.65 (0.9) | 26  | 1.69 (1.3) | 53  | 1.15 (1.2) |      |           |
| Consultation      | 101 | 0.51 (0.8) | 4   | 4.15 (2.2) | 106 | 0.69 (1.2) | 184 | 0.35 (0.1) |
| User fee          | 1   | 1.03 (...) |      |           | 1   | 1.03 (...) |      |           |
| Diagnosis         | 3   | 8.68 (11.5)| 10  | 3.20 (2.7) | 32  | 1.10 (1.0) | 45  | 2.07 (3.5) |
| Drugsb            | 297 | 3.17 (5.2) | 568 | 3.77 (6.1)| 233 | 6.36 (6.8)| 1098| 4.15 (6.9)|
| Bed               | 4   | 2.31 (1.0) | 3   | 32.92 (30.7)| 7   | 2.31 (1.9)| 14  | 8.87 (17.8)|
| Food              | 45  | 1.16 (1.7) | 2   | 1.14 (1.0) | 54  | 1.23 (2.1)| 101 | 1.20 (1.9)|
| Informal          |      |           |     |           | 1   | 0.19 (...) | 1   | 0.19 (...) |
| Transport         | 120 | 3.41 (8.0)| 103 | 1.87 (1.4)| 98  | 2.03 (1.5)| 321 | 2.49 (5.1)|
| Other             |      |           |     |           | 1   | 0.58 (...) | 1   | 0.58 (...) |
| Total costs for those who paid something | 302 | 4.99 (10.9)| 578 | 4.37 (9.2)| 283 | 6.37 (9.8)| 1163| 5.02 (9.8)|
| Total costs for all completed episodesc | 346 | 4.36 (10.3)| 648 | 3.90 (8.8)| 404 | 4.46 (8.7)| 1398| 4.18 (9.2)|
| Total costs, uncomplicated episodes | 293 | 4.31 (10.7)| 492 | 3.60 (6.7)| 258 | 4.49 (7.4)| 1043| 4.02 (8.2)|
| Total costs, severe episodes | 53  | 4.62 (7.8)| 156 | 4.84 (13.5)| 146 | 4.42 (10.5)| 355 | 4.64 (11.6)|
| No. of children still sick at interviewd | 168 | ... | 127 | ... | 53  | ... | 348 | ... |
| Households that incurred cost | 87% | ... | 89% | ... | 70% | ... | 83% | ... |
| Difference in households paying: intervention vs pre-intervention | ... | ... | ... | ... | ... | ... | ... | ... |

| Abbreviations: SD, standard deviation; USD, US dollars. |
| -----------------------------------------------------|
| a Mean costs are presented for completed episodes. Data on children who were still sick at the time of the interview were excluded as their episode costs were incomplete. Numbers of children still sick at the time of interview and percentage of households who paid something for the illness are provided in the table. |
| b Nigeria: Artemisinin-based combination therapies were normally provided at no cost by drug shop owners trained for the study. However, when someone stated they went to a drug shop, they did not know whether the person was trained or not. |
| c Two hundred thirty-five patients in the pre-intervention period and 568 patients in the intervention period did not incur any costs for a completed episode. |
| d Intervention: Outcome missing for 6 children in Burkina Faso and 3 children in Uganda. |
| e Test for heterogeneity in distributions during intervention vs before intervention: $P < .0001$ for Burkina Faso, $P = .0166$ for Nigeria, $P = .0039$ for Uganda, $P < .0001$ for total. |

* $P < .0001$; ** $P < .001$; *** $P < .01$. 

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from the head of the communities. In Burkina Faso, additional approvals were obtained from the community via their leader by signing a written consent, and in Uganda, from the district heath officer and the local council I (village level). Finally, in Burkina Faso as well as in Uganda, oral consent was obtained from caregivers while written consent was obtained in Nigeria.

RESULTS

Baseline Characteristics

The majority of children in the study were <36 months of age (60% before and 63% during intervention) (Table 1). Respondents were mainly female (80% before and 96% during intervention), most being <36 years old (69% before and 77% during intervention). In Burkina Faso, most of the caregivers had never been to school (80% before and 89% during intervention) while in Nigeria and Uganda, the caretakers were better educated and many had completed primary school (Nigeria: 40% before and 35% during intervention; Uganda: 62% before and 61% during intervention). Income was mainly based on agriculture in Burkina Faso and Uganda, and most of the households declared they did not have food problems (Burkina Faso: 70% before and 74% during intervention; Uganda: 54% before and 44% during intervention), while in Nigeria, households sometimes had food problems (30% before and 43% during intervention). In Nigeria, a large proportion of caregivers were self-employed (57% before and 71% during intervention). Most episodes were without danger signs (75% before vs 82% during intervention). Before the intervention, 35% of caretakers went to a CHW while 50% went during the intervention (P < .0001). For those who did not go to a CHW during the intervention, the main reasons were that parents believed that their child was not very sick (18%), were not aware of the presence of the CHW in their community (13%), believed that CHWs cannot treat well (8%), or because the CHW was often not at home (7%) (Supplementary Table 1).

Household Out-of-Pocket Costs for Illness Episode

Table 2 presents the out-of-pocket costs incurred by caregivers of sick children before and during the intervention split into different cost categories. During the intervention, total household costs per episode were lower in all 3 countries, about 3 times lower in Burkina Faso: USD 1.54 vs USD 4.36 (difference, USD 2.82 [95% confidence interval (CI), USD 2.09–USD 3.55]; P < .0001), twice lower in Nigeria: USD 2.04 vs USD 3.90 (difference, USD 1.86 [95% CI, USD 1.01–USD 2.70]; P < .0001), and 3 times lower in Uganda: USD 1.42 vs USD 4.46 (difference, USD 3.04 [95% CI, USD 2.29–USD 3.79]; P < .0001). Similar decreases were observed for total costs for those who incurred some costs, with the largest reductions observed in drug and transport costs (drugs: USD 1.74 during vs USD 4.15 before intervention; transport: USD 1.42 vs USD 2.49, respectively). The percentage of households that paid something during the episode decreased for both Nigeria (12% less) and Uganda (15% less) but slightly increased for Burkina Faso (+2%). Comparing those who went to a CHW during the intervention with those who did not, those who went had lower costs: USD $1.32 vs USD $2.03 (difference, USD $0.71 [95% CI, USD $0.34–USD $1.09]; P < .0001) (Supplementary Table 2), and more than half of them had a RDT (94% in Burkina Faso, 55% in Nigeria, and 66% in Uganda; unpublished data). There was no difference in time spent by the guardian in caring for the sick child (59% before vs 51% during intervention spent ≤ 2 days; Table 2).

Cost Savings Due to the Intervention at Household and District Levels

Table 3 presents estimates of the total household costs saved per year due to the intervention. With 1.18 (Burkina Faso [18]), 3.5 (Nigeria [19]), and 0.98 (Uganda [20]) malaria episodes per year per child and a private household cost savings per episode of USD $2.82 (Burkina Faso), USD $1.86 (Nigeria), and USD $3.04 (Uganda), the projected total mean household cost savings at district level per year were USD $29 965 for Mangodara (Burkina Faso), USD $254 268 for Ona-Ara (Nigeria), and USD $303 467 for Sheema and Kayunga (Uganda).

### Table 3. Estimated Household Savings (in US Dollars) for Malaria Due to the Intervention for the Whole District of the Study Areas

| Category                                      | Mangodara, Burkina Faso | Ona-Ara, Nigeria | Sheema and Kayunga, Uganda |
|-----------------------------------------------|-------------------------|-----------------|---------------------------|
| No. of malaria episodes per year, per child <5 y old | 1.18                    | 3.50            | 0.98                      |
| No. of children <5 y old                     | 9.005                   | 39.058          | 101.882                   |
| Mean household costs (USD) per episode (SD) before intervention | 4.36 (10.3)             | 3.90 (8.8)      | 4.48 (6.7)                |
| Mean household costs (USD) per episode (SD) during intervention | 1.54 (3.6)              | 2.04 (6.6)      | 1.42 (3.6)                |
| Savings per child (USD) per episode (SE)     | 2.82 (0.8)              | 1.86 (0.4)      | 3.04 (0.5)                |
| Total mean savings (USD) per child and per year (SE) | 3.33 (0.7)              | 6.51 (1.5)      | 2.98 (0.5)                |
| Before intervention: total mean costs (USD) per year for malaria for the whole district | 46.329                   | 533.142         | 448.218                   |
| During intervention: total mean costs (USD) per year for malaria for the whole district | 16.364                   | 278.874         | 141.751                   |
| Total mean savings (USD) per year for malaria for the whole district | 29.965                   | 254.268         | 303.467                   |

Abbreviations: SD, standard deviation; SE, standard error; USD, US dollars.

a References [18–20]

b References [21–23]

c For Mangodara, Sheema, and Kayunga: To calculate the number of children <5 years of age in the district, we used the total population in the district and the percentage of children <5 years in the country (based on the number of children <5 years and the total population in the country).

d Mean costs (SD) per completed episode.

The number of malaria episodes/child was assumed to be fixed (ie, without uncertainty).
DISCUSSION

In this study in 3 malaria-endemic African countries, we quantified household costs incurred in managing an episode of febrile illness before and after integrated provision of RDTs, ACTs, and rectal artesunate by CHWs. There was a >2-fold reduction in household private costs per illness episode as a consequence of the intervention—from USD $4.18 before to USD $1.64 during the intervention. The findings were separately significant for each country, although the magnitude was larger in Burkina Faso and Uganda (two-thirds reduction) than in Nigeria (reduction of approximately 40%). Cost categories with largest reductions were drug costs (reducing from USD $4.15 to USD $1.74 for those reporting such costs) and transport (from USD $2.49 to USD $1.42, respectively).

CHWs were located closer to patients; consequently, caregivers were more likely to seek care faster, and we expected this to halt the progression of the disease and decrease the length of the illness episode. We found evidence of this through a significant reduction in the proportion of children with danger signs requiring referral to hospital during the intervention: 24.7% vs 18.1% [17]. The illness recovery was shorter during the intervention, reducing from 3.69 to 3.47 days [17]. Those who went to a CHW during the intervention incurred significantly lower out-of-pocket costs compared with those who did not do so. Household private costs per episode during the intervention for those who went to a CHW was approximately 63% lower in Burkina Faso and approximately 44% lower in Uganda, but remained similar in Nigeria, where drug costs were substantial even during the intervention.

Mean household savings per child per year due to the intervention constitutes an important component of household budgets as the money saved through more rapid access to diagnosis and treatment can be used for other household needs. On a district basis, the cost savings would be expected to be considerable, depending on the number of children who become ill (illness frequency was less but the child population was greater in the study areas of Uganda compared with the study areas of Burkina Faso and Nigeria), making the cost reduction substantial in all 4 study districts.

CHWs were located closer to patients and were provided either with free (or low-cost) drugs and diagnostics; both of these features of the intervention may have changed caregivers’ behavior. A parallel qualitative study on the acceptability of the intervention indicated that during the intervention caregivers stated that they were more likely to choose the CHW because they were aware that CHWs had diagnostics and free drugs and they were more likely to go where there were commodities instead of seeking other alternatives [24]. Second, there is evidence that early treatment of uncomplicated malaria reduces the risk of severe malaria and hence hospital referral and associated transport costs [8]. Nevertheless, some caretakers did not go to a CHW during the intervention (55% in Burkina Faso, 32% in Nigeria, and 56% in Uganda). The main reasons were a belief that their child was not sufficiently sick, not being aware of the CHW presence in their community, or the CHW not being at home because of farm duties. Many participants in Uganda also mentioned stockout of drugs at the CHW during the intervention [24]. To ensure better use of CHWs and access to care at the community level, future implementations should aim to better sensitize communities, provide advance information of the presence of the CHWs and symptoms of malaria, and improve stock management. Compensation for CHWs’ time might be explored as motivation for CHWs to be more available when needed.

The Global Fund from which most malaria-endemic countries apply for commodities has, during the past 5 years, indicated that essential items for malaria control can be secured through successful applications; these include training and salary costs for community health workers, RDTs for malaria diagnosis, ACTs for malaria treatment, supportive supervision, supply chain system strengthening, and health information system strengthening (http://www.rollbackmalaria.org/files/files/resources/HWG-2014-country-briefing-note.pdf). The Global Fund still continues to encourage applicants to include community system strengthening initiatives in proposals wherever relevant to improve health outcomes (www.theglobalfund.org/documents/core/infonotes/Core_CSS_InfoNote_en/). Consequently, our results provide governments with an understanding of how the system can work in their countries in support of the role advocated by the Global Fund and provide a strong economic rationale for scaling up the intervention in underserved areas to improve the speed of malaria diagnosis and treatment. The main barriers that can be anticipated, as identified in this study, are underuse of CHWs because of a lack of awareness, financial constraints (mainly transport to a CHW), beliefs about the etiology of disease, and limited autonomy of caregivers.

Our study has several limitations. Perhaps the most important is that data on costs are for all febrile illnesses in children both before and during the intervention. Few RDTs were used before the intervention, and therefore, costs before the intervention would necessarily include any febrile illness. Consequently, the cost reduction could not exclude costs of managing nonmalaria illnesses. However, during the study, the vast majority of cases seen by CHWs were malaria-positive (81.2%), and there were no differences in household costs per episode between malaria-positive and malaria-negative cases overall and separately in the 3 participating countries. Second, we kept cost calculations to documented costs provided by the caretaker for the episode of the child. We did not calculate the lost income due to time taken to look after the sick child. Third, in Burkina Faso, in the period before intervention, for cultural reasons, fathers of sick children answered the questionnaire as would be culturally normal in the district; during the intervention period, the study
team explained that the primary caretaker, usually the mother, should answer questions. In the localities in which the study was conducted, it was probable that both parties might be present during the interview, but it is not possible to rule out bias in the answers provided on costs. Finally, all costs were based on interviews and were therefore dependent upon participants' recollection of costs incurred within the 2 weeks prior to interview.

**Supplementary Data**

Supplementary materials are available at http://cid.oxfordjournals.org. Consisting of data provided by the author to benefit the reader, the posted materials are not copiededit and are the sole responsibility of the author, so questions or comments should be addressed to the author.

**Notes**

**Acknowledgments.** We thank the participants in this study and all interviewers for their collaboration in the collection of the data. We are also grateful to village leaders for their permission to carry the research in their communities, and appreciate the efforts of J. Bwoye, L. Ojanduru, G. Ouattara, B. Orimolade, A. Suberu, and J. Wandera who led fieldwork and provided intellectual and administrative support. L. Ojanduru was responsible for data management onsite. A. Adewale, M. Ainemukama, I. Akorede, H. Barigye, O. Kayode, M. Namanya, R. Ngabirano, O. Ojo, E. Oyeniran, P. Tou, and J. J. Wembabazi supported data entry.

**Author contributions.** J. C., J. N.-S., I. O. A., M. S., C. A., A. B., L. S., A. K. S., A. B. T., S. B. S., C. O. F., and M. G. conceived, designed, led, implemented, and supervised the study. C. A., B. S. S., and V. K. coordinated the data entry. J. C. did the statistical analysis. J. C., J. S., and M. G. contributed to the design and conduct of the data analysis. C. A., A. B., L. S., A. K. S., V. K., and J. K. implemented and coordinated the fieldwork. B. M., S. M. A. A. E., A. T. G. P., and M. P. reviewed analytical plans and provided expert support in economic and statistical analysis of data and wroteup. J. C. and M. G. prepared the manuscript, which was then reviewed by all authors.

**Financial support.** This work was supported by UNICEF/UNDP/World Bank/WHO/Special Programme for Research & Training in Tropical Diseases, World Health Organization, Geneva, Switzerland (project ID numbers A80553 [Burkina Faso], A80556 [Nigeria], and A80560 [Uganda]) through funds made available by the European Commission (FP7) for research to improve community access to health interventions in Africa.

**Supplement sponsorship.** This article appears as part of the supplement “Malaria in Highly Endemic Areas: Improving Control Through Diagnosis, Artemisinin Combination Therapy, and Rectal Artesunate Treatment,” sponsored by the World Health Organization.

**Potential conflicts of interest.** All authors: No reported conflicts. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

**References**

1. World Health Organization. World malaria report 2015. Geneva, Switzerland: WHO, 2015.
2. World Health Organization. Severe malaria. Trop Med Int Health 2014; 19(supp 1):7–131.
3. World Health Organization. Guidelines for the treatment of malaria. 3rd ed. Geneva, Switzerland: WHO, 2015.
4. Lubell Y, Reyburn H, Mbakilwa H, et al. The cost-effectiveness of parasitologic diagnosis for malaria-suspected patients in an era of combination therapy. Am J Trop Med Hyg 2007; 77:128–32.
5. McIntyre D, Thiede M, Dahlgren G, Whitehead M. What are the economic consequences for households of illness and of paying for health care in low- and middle-income country contexts? Soc Sci Med 2006; 62:858–65.
6. D’Acremont V, Kahama-Marco J, Swai N, Mutsiva D, Genton B, Lengeler C. Reduction of anti-malarial consumption after rapid diagnostic tests implementation in Dar es Salaam: a before-after and cluster randomized controlled study. Malar J 2011; 10:107.
7. de Savigny D, Mayombana C, Mwageni E, et al. Care-seeking patterns for fatal malaria in Tanzania. Malar J 2004; 3:27.
8. Tawfik Y, Nsungwa-Sabiti J, Greer G, Ower J, Kesande R, Pryor-Jones S. Negotiating improved case management of childhood illness with formal and informal private practitioners in Uganda. Trop Med Int Health 2006; 11:967–73.
9. Xu K, Evans DB, Kabakata K, Zeramndini R, Klavus J, Murray CJ. Household catastrophic health expenditure: a multicountry analysis. Lancet 2003; 362:111–7.
10. Milis A, Ataguba JE, Akazili J, et al. Equity in financing and use of health care in Ghana, South Africa, and Tanzania: implications for paths to universal coverage. Lancet 2012; 380:126–33.
11. Bhutta ZA, Lassi ZS, Parvio G, Huicho L. Global experience of community health workers for delivery of health related Millennium Development Goals: a systematic review, country case studies and recommendations for integration into National Health Systems. Geneva, Switzerland: World Health Organization/Global Health Workforce Alliance, 2010.
12. Haines A, Sanders D, Lehmann U, et al. Achieving child survival goals: potential contribution of community health workers. Lancet 2007; 369:2121–31.
13. Sazawal S, Black RE. Pneumonia Case Management Trials Group. Effect of pneumonia case management on mortality in neonates, infants, and preschool children: a meta-analysis of community-based trials. Lancet Infect Dis 2003; 3:547–56.
14. Kidane G, Morrow RH. Teaching mothers to provide home treatment of malaria in Tigray, Ethiopia: a randomised trial. Lancet 2000; 356:550–5.
15. Gilroy K, Winch P. Management of sick children by community health workers: intervention models and programme examples. Geneva, Switzerland: United Nations Children’s Fund, World Health Organization, 2006.
16. Sirima SB, Konaté A, Tiono AB, Convelbo N, Cousens S, Pagnoni F. Early treatment of childhood fevers with pre-packaged antimalarial drugs in the home reduces severe malaria morbidity in Burkina Faso. Trop Med Int Health 2003; 8:133–9.
17. Ajayi IO, Nsungwa-Sabiti J, Siribé M, et al. Feasibility of malaria diagnosis and management in Burkina Faso, Nigeria, and Uganda: a community-based observational study. Clin Infect Dis 2016; 63(suppl 5):S245–55.
18. Tiono AB, Kangoye DT, Rehman AM, et al. Malaria incidence in children in south-west Burkina Faso: comparison of active and passive case detection methods. PLoS One 2014; 9:e86936.
19. United Nations Children’s Fund. UNICEF says malaria still number-one killer of children under five in Nigeria. Available at: http://www.unicef.org/nigeria/media_4221.html. Accessed 6 July 2016.
20. Orem JN, Kirigia JM, Azizire R, Kastrey I, Walker O. Impact of malaria morbidity on gross domestic product in Uganda. Int Arch Med 2012; 5:12.
21. Ministère de l’Économie et des Finances, Comité National du Recensement, Bureau Central du Recensement. Recensement Général de la Population et de l’Habitation (RGPH) de 2006 du Burkina Faso—Résultats définitifs. Burkina Faso, 2008. Available at: http://www.insd.bf/documents/publications/insd/publications/results_enquêtes/autres%20enq/Resultats_definitifs_RGPH_2006.pdf. Accessed 16 July 2016.
22. Federal Republic of Nigeria, National Population Commission. 2006 population and housing census, priority table volume IV, population distribution by age and sex (state and local government area). Available at: http://www.population.gov.ng/index.php/publications/141-population-distribution-by-age-and-sex-2006-census-priority-tables–vol-4. Accessed 12 July 2016.
23. Uganda Bureau of Statistics. National Population and Housing Census 2014—main report. Kampala, 2016. Available at: http://www.ubos.org/onlinelfiles/uploads/ubos/NPHC2014%20National%20Census%20Main%20Report.pdf. Accessed 16 July 2016.
24. Jegede AS, Oshiname FO, Sanou AK, et al. Assessing acceptability of a diagnostic and malaria treatment package delivered by community health workers in malaria-endemic settings of Burkina Faso, Nigeria, and Uganda. Clin Infect Dis 2016; 63(suppl 5):S306–11.