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# "We might have been prescribing antibiotics to clients who do not need them": a mixed-methods study of knowledge, attitudes, and practices related to antibiotic use for pediatric acute respiratory illness among community health workers in Uganda

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## Abstract

**Background** In many resource-constrained settings, community health workers (CHW) often provide the initial care for children under five years of age. As part of integrated community case management (iCCM) programs, CHW frequently diagnose and treat acute respiratory illness (ARI), a leading cause of pediatric mortality and indication for antibiotic use globally. Yet knowledge and perceptions of antibiotic prescribing for ARI among CHW are not well-studied. The goal of this study was to assess knowledge, attitudes, and practices related to antibiotics among CHW implementing a stepped-wedge trial of an enhanced iCCM algorithm for children with ARI in rural Uganda to inform future antimicrobial stewardship strategies.

**Methods** We conducted a nested mixed methods study with a convergent parallel design, administering surveys before and after the stepped wedge trial and individual semi-structured interviews at study end. We employed descriptive statistics, Wilcoxan rank sum tests, and thematic content analysis methods.

**Results** A total of 63 of 67 (94.0%) CHW completed both baseline and follow-up surveys, and 15 CHW were interviewed. The median age of the full cohort was 40 (IQR: 35–47) years with 9.5 years of CHW experience (IQR: 4.0–14.0 years). Almost all CHW (95.2%) identified amoxicillin as an antibiotic at baseline, and most associated antibiotics with treating bacterial diseases (baseline: 82.5%, follow-up: 93.7%, $p = 0.05$). Most perceived antibiotics as harmful to patients when prescribed unnecessarily. At follow-up, more CHW disagreed that antibiotics should be prescribed

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when in doubt. They welcomed additional education about antimicrobial resistance and diagnostic tools to advance antimicrobial stewardship (AMS).

**Conclusion** CHW were overall familiar with antibiotics and their potential harms. They were eager to gain knowledge regarding AMS and AMR and share it with their communities. CHW represent an underutilized resource for AMS interventions and should be included in their design and implementation.

**Keywords** Community health workers, Antimicrobial stewardship, Integrated community case management, Acute respiratory illness, Pediatrics, Uganda

## Background

Globally, acute respiratory illness (ARI) is one of the most common reasons for care seeking among children under 5 years of age. Ample data suggest that a large proportion of these episodes are caused by self-limited viral infections [1]. Yet antibiotics are frequently prescribed in upwards of 85–95% of cases [2, 4–7]. In low-and-middle-income countries (LMIC), where access to healthcare facilities is limited, community health workers often serve as the first line of care [8]. In Uganda specifically, teams of community health workers (CHW; known locally as Village Health Teams or VHTs) are trained to diagnose and treat malaria, pneumonia, and diarrhea using Integrated Community Case Management (iCCM) guidelines from the World Health Organization [9, 10]. These algorithms use a standardized clinical assessment, including the respiratory rate, to diagnose pneumonia and determine the need for antibiotic treatment. This dependence on syndromic diagnosis for ARI likely contributes to an overuse of antibiotics, which can drive antimicrobial resistance (AMR) [11, 12]. AMR in turn represents a significant and growing threat to health and development globally [13].

The factors influencing antibiotic prescribing practices are complex and include clinical provider knowledge and beliefs related to disease, antimicrobial resistance, patient and caregiver expectations, and the antibiotic medications themselves [14–16]. In resource-limited settings like sub-Saharan Africa (SSA) and Uganda specifically, it has been noted that providers often lack knowledge of AMR [17, 18] and view AMR as primarily driven by external factors such as patient demand, overburdened healthcare systems, and the easy availability of antibiotics in pharmacies as opposed to inappropriate provider prescribing [18].

To date, few studies have assessed knowledge, perceptions, and practices related to antibiotics, and specifically their use for treatment of ARI, among providers in LMIC [17, 18]. Even fewer have involved CHW despite the large role they play in care provision to children under 5 years of age [11]. This information is critical to the design and implementation of contextually appropriate strategies to reduce unnecessary antibiotic use. We therefore conducted a mixed methods study of CHW who were implementing a larger trial of clinical biomarker measurement to inform antibiotic treatment decisions for ARI in rural western Uganda.

## Methods

### Study design

We performed a mixed methods study with a convergent parallel design, employing quantitative surveys and individual semi-structured interviews. It was nested as a substudy of a stepped wedge, cluster randomized trial called the STewardship for Acute Respiratory illness (STAR) study conducted November 2021-May 2022 that has been previously published [19]. In brief, the trial compared the local guideline for evaluation and treatment of ARI among children under 5 years by village health workers (CHW) based on the World Health Organization's Integrated Community Case Management (iCCM) program (herein referred to as the iCCM Sick Child Job Aid [SCJA]) to an enhanced iCCM algorithm (STAR SCJA) that leveraged measurement of C-reactive protein to inform antibiotic treatment decisions.

### Study setting and population

We conducted this study in the Bugoye sub-county of Kasese District in the highlands of western Uganda. The main public health facility for the sub-county is Bugoye Level Health Centre III, which, due to the region's mountainous terrain, is a distance of up to three hours walking for some residents (Figure S1) [19]. In 2013, the Government of Uganda, with support from a long-standing collaboration between the Mbarara University of Science and Technology and the Massachusetts General Hospital, implemented an iCCM program in Bugoye sub-county consisting of 4–5 CHW in each village who are elected by the community [20]. The CHW receive a total of eight days of comprehensive training per Ugandan Ministry of Health guidelines on iCCM program responsibilities and the diagnosis, treatment, and/or referral of children under age five with diarrhea, pneumonia, and malaria using the iCCM SCJA [21]. All CHW are fluent and literate in English and the local language, Lukhonzo.

For the parent study, we purposefully selected 15 out of the 34 total villages in the sub-county that have robust and well-established CHW programs supported both by the Ugandan government and external organizations [19]. All CHW from those villages were approached regarding participation in both the parent trial and sub-study.

### Data collection

Participating CHW completed a survey about their perceptions, knowledge, and practices related to antibiotics and antimicrobial resistance (herein "baseline" survey) immediately prior to undergoing the initial training for the parent study. The CHW then completed an abbreviated version of the same survey when they presented for final reporting at the time of study closure (herein "follow-up" survey). Both surveys were self-administered in English on paper with bilingual (English-Lukhonzo) study staff available to clarify terminology and answer questions.

Within six weeks of the completion of the parent study, we selected one CHW from each village ($n = 15$) by purposive sampling to complete an individual semi-structured, in-depth interview. The interview opportunity was first offered to the Village Health Team leader from each village. If he or she was not able or willing to participate, another CHW from the same village was selected based on their willingness and availability. Previous research in West Africa has demonstrated that saturation occurs between 6 and 12 interviews within a homogenous sample [22]. The interviews were conducted by author GN and two other local trained research technicians with experience in qualitative interviewing. They took approximately 45 min to 1 h and were conducted in Lukhonzo. The audio recordings of the interviews were then translated into English at the time of transcription.

### Measures

The baseline survey asked about sociodemographic characteristics, occupation, activities as a CHW including details about antibiotic use, knowledge of antibiotics, and perceptions of antibiotic use in their community and its health impacts (Table 1; Supplementary Material 1). It included multiple choice questions and the presentation of 18 statements related to antibiotic use and antimicrobial resistance, asking respondents to select how much they agreed or disagreed with each one. These responses were coded on a 5-point Likert scale with 1 being "strongly agree" and 5 representing "strongly disagree." The follow-up survey consisted just of the questions regarding knowledge of antibiotics and their appropriate use per iCCM guidelines and the 18 statements regarding perceptions of antibiotic use in their community and its health impacts (Table 1; Supplementary Material 2). We designed the interview guide to address in more depth the concepts queried in the surveys while also soliciting additional thoughts related to the acceptability, feasibility, and utility of the STAR algorithm and C-reactive protein test (Table 1; Supplementary Material 3).

**Table 1** Topics addressed in the baseline and follow-up surveys and in-depth interviews. Full survey tools and the in-depth interview guide are included as Supplementary Material.

| Topic | Baseline Survey | Follow-up Survey | Semi-structured Interview |
|---|---|---|---|
| Knowledge of antibiotics and their appropriate use | X | X | |
| Antibiotic use practices | X | | X |
| Perceptions of antibiotics and their use | X | X | X |
| Caregiver and community dynamics | X | X | X |
| STAR algorithm engagement | | | X |
| Recommendations for the future | | | X |

### Data analysis

We used descriptive statistics to report the quantitative results of the baseline and follow-up surveys. Wilcoxan signed-rank tests were employed to compare the results of the baseline and follow-up surveys, and p-values are reported. One question ("Based on the Sick Child Job Aid, would you give amoxicillin to the following children?" in Supplementary Materials 1 and 2) was excluded from the analysis as the responses were inadvertently written in a way that did not accurately reflect the iCCM algorithm.

In addition, we conducted a thematic content analysis of the 15 semi-structured interviews on antibiotic perceptions, practices, and caregiver dynamics. Feedback collected during field testing informed the questions in the final interview guide (Supplementary Material 3). A codebook of thematic areas was assembled prior to initiating data analysis in accordance with topics explored by interview questions (Table 1). A transcript-based analysis was performed by AG using Atlas.Ti. Themes identified throughout data analysis further refined the final thematic categories in an iterative process. Finally, analytic memos were developed to group and summarize major findings from the semi-structured interview data analysis. Our analysis confirmed that the 15 interviews were enough to identify all the most prevalent themes within the dataset and reach saturation.

## Results

### Study population

We enrolled 67 CHW from the 15 villages. All participants completed the baseline survey, and 63 (94.0%) completed the follow-up survey. Two CHW withdrew from the parent study after completion of the baseline survey, and two others were not available at the time the follow-up survey was administered. A subset of fifteen CHW completed the individual semi-structured interviews.

Sociodemographic characteristics and the experience of the participating CHW are detailed in Table 2. In brief, the median age was 40 years (interquartile range (IQR): 35–47) and 61.2% (41/67) were female. They had a median of 9.5 (IQR: 4.0–14.0) years of experience as a CHW and saw a median of 10 (IQR: 7–15) children per month. The full cohort and interview subgroup were similar in age, sex, and educational level. The interview subgroup had slightly fewer years of experience (8.0 [IQR: 4.0-12.0]), saw slightly more children per month (12.5 [IQR: 8–20]), and had a higher proportion of individuals with primary occupations other than subsistence farmer.

## Knowledge of antibiotics

Knowledge of antibiotics was assessed at baseline and follow-up, the results of which are summarized in Table 3. At baseline, the majority of CHW identified amoxicillin as an antibiotic (60/63, 95.2%), associated antibiotics with treatment of bacterial as opposed to viral infections (52/63, 82.5%) and knew that antibiotics should be stopped only after the full prescribed course has been taken (57/63, 90.5%). Over two-thirds were able to identify at least one of the risks of antibiotics (44/63, 69.8%). For all questions, the proportion who answered correctly increased on the follow-up survey, except for the question focused on differentiating antibiotics from anti-inflammatory drugs (51/62, 82.3% v. 41/63, 65.1%; $p = 0.03$).

## Antibiotic use practices

At baseline, all CHW reported giving antibiotics at most or some patient visits. When specifically asked about children presenting with cough, 26.9% (18/67) reported giving antibiotics at most visits and 67.2% (45/67) at some visits. When asked about resources used to make antibiotic treatment decisions, all who responded ($n = 66$)

**Table 2** Baseline characteristics of participating village health workers (CHW) treating children with acute respiratory illness (ARI) in the 15 study villages in Western Uganda

| Characteristics | | Full Cohort (*n* = 67) | Completed Baseline & Follow-up Surveys (*n* = 63)* | CHW Participating in Semi-structured Interviews (*n* = 15)[#] |
|---|---|---|---|---|
| Age | | | | |
| | **Median** | **40.0** | **40.0** | **37.0** |
| | Q1 | 35.0 | 35.0 | 33.0 |
| | Q3 | 47.0 | 48.0 | 40.0 |
| Years of Experience as CHW | | | | |
| | **Median** | **9.5** | **10.5** | **8.0** |
| | Q1 | 4.0 | 4.3 | 4.0 |
| | Q3 | 14.0 | 14.0 | 12.0 |
| | Missing | 5 | 5 | 1 |
| Children Seen per Month | | | | |
| | **Median** | **10.0** | **10.0** | **12.5** |
| | Q1 | 7.0 | 7.0 | 8.0 |
| | Q3 | 15.0 | 15.0 | 20.0 |
| | Missing | 5 | 5 | 1 |
| | | **n (%)** | **n (%)** | **n (%)** |
| Gender | Male | 26 (38.8) | 24 (38.1) | 5 (33.3) |
| | Female | 41 (61.2) | 39 (61.9) | 10 (66.7) |
| Marital Status | Single | 3 (4.5) | 3 (4.8) | 0 (0) |
| | Married | 62 (92.5) | 58 (92.1) | 14 (93.3) |
| | Widowed | 2 (3.0) | 2 (3.2) | 1 (6.7) |
| Education Level | Primary School | 9 (13.4) | 9 (14.3) | 2 (13.3) |
| | Secondary School | 56 (83.6) | 52 (82.5) | 12 (80.0) |
| | University | 2 (3.0) | 2 (3.2) | 1 (6.7) |
| Primary Occupation | Subsistence Farmer | 56 (83.6) | 54 (85.7) | 11 (73.3) |
| | Business Owner | 2 (3.0) | 1 (1.6) | 0 (0) |
| | Teacher | 1 (1.5) | 1 (1.6) | 0 (0) |
| | Tailor | 2 (3.0) | 2 (3.2) | 2 (13.3) |
| | Other | 6 (9.0) | 5 (7.9) | 2 (13.3) |

* Two CHW withdrew from the study prior to starting enrollment for the parent study and two CHW did not complete the follow-up survey

[#] All interviewees also completed both the baseline and follow-up surveys.

**Table 3** Knowledge of antibiotics. Proportion of CHW who answered questions regarding knowledge of antibiotics correctly before and after participating in the STAR study, limited to observations where responses were available for both time points ($n = 63$)

| Assessment | Baseline | | Follow-Up | | *p*-value* |
|---|---|---|---|---|---|
| | ***N*** | **%** | ***N*** | **%** | |
| Identified Amoxicillin as an antibiotic | 60 | 95.2 | 63 | 100.0 | |
| Differentiated antibiotics from anti-inflammatory drugs | 51 | 82.3 | 41 | 65.1 | 0.03 |
| *Missing* | 1 | | | | |
| Associated antibiotics with treating bacterial, and not viral, diseases | 52 | 82.5 | 59 | 93.7 | 0.05 |
| Recalled the length of time for administering amoxicillin to treat pneumonia as 5 days | 62 | 98.4 | 63 | 100.0 | |
| Identified the appropriate time when caregivers should stop giving antibiotics | 57 | 90.5 | 63 | 100.0 | |
| Identified the risks associated with taking antibiotics[#] | 44 | 69.8 | 50 | 79.4 | 0.04 |

* P-values not generated for questions where the entire sample responded correctly or incorrectly.

[#] Considered a correct response if CHW selected "Patient's health complications/side effects" or "Emerging of new diseases/antibiotic drug resistance".

selected the SJCA, which they often referred to as "the bible" in the semi-structured interviews [ID: 10, 40, 48, 55, 57]. During the interviews, the CHW described that, they mostly relied on "counting the breathing rate of a child depending on their age group" [ID: 15] and prescribing amoxicillin if the rate was high, the technique that is outlined in the iCCM SCJA.

In total, 14 of the 15 CHW interviewed as part of this study expressed challenges or concerns associated with relying on breathing rate as an antibiotic prescription tool. They shared anecdotes of children "push[ing] the timer while you are trying to count", disturbing the test "by shaking themselves", or altering their breathing rate upon starting to cry, affecting their ability to properly diagnose [ID: 50, 57, 03]. Some also noted that there are multiple causes of fast breathing other than pneumonia, including malaria, fever, crying, or fear. This complicated the use of this diagnostic tool for identifying pneumonia and may have led to unnecessary antibiotic use. "A high temperature can lead to fast breathing. In such cases, I would give them amoxylin (sp) when am also doubting. I would also think that the amoxylin (sp) is not appropriate because it could be the high temperature that causes fast breathing." [ID: 03].

**Antibiotic perceptions**

Overall, CHW perceived antibiotics as harmful when used incorrectly, both at baseline and follow-up. Over 80% recognized prescribing antibiotics if a patient does not need them as potentially harmful to the patient (Table 4 and S1), and >90% agreed that excessive consumption of antibiotics was bad for health (Table 4) at both time points. Ten of the 15 interviewed CHW mentioned this viewpoint as well. As one CHW stated, "I think, if I give or if a person takes antibiotics when they don't need them, they might damage their life because, instead of the antibiotics curing the illness, they might fight with the body cells that are actually responsible for protection of the body against yet their body disease. It's because the person will have taken antibiotics for a wrong illness. So I still think that the antibiotics will cause harm on the person's health." [ID: 26] Relatedly, over 90% of CHW thought it was "not ok to obtain" antibiotics without seeing a CHW or clinician in a healthcare facility at both baseline and follow-up (Table 4).

Discussion of the consequences associated with antimicrobial overuse, including antimicrobial resistance, emerged during semi-structured interviews, as noted by a CHW with 7 years of experience sharing, "if the child takes antibiotics when they are not sick, the child may get used to the medicine, and when they get sick in the future, the medicine may not treat them" [ID: 11]. Health concerns elevated by CHW in association with antibiotic overconsumption included liver damage, harm to the body's immune response, longer recovery times and increased incidence of subsequent illnesses [ID: 22, 26, 10, 15]. In total, 13 of the 15 CHW interviewed acknowledged appropriate patient health concerns stemming from antibiotic overuse. When asked if they agreed that bacteria developing resistance to antibiotics presented a major problem in Uganda on the surveys, slightly over half of CHW either agreed or strongly agreed with this statement (baseline mean score 2.64; Table 4, S1, and S2).

CHW also noted the potential benefits of antibiotic use with 5 of the 15 interviewed CHW commenting that they can be effective for treatment of respiratory illness. "I find these antibiotics helpful because when children take this medicine, they get well and that becomes helpful to us since it shows that we are doing a great job. So I don't see any problem with using these antibiotics." [ID: 50] However, CHW shifted their perspective on prescribing antibiotics as standard practice between before and after the STAR study. The proportion of CHW who believed amoxicillin is a useful treatment for all respiratory infections decreased between baseline and follow-up (Table 4 and S1). As one CHW stated during the interview, "we learn that it's not everybody that has cough has got a bacterial infection." [ID: 03].

**Table 4** Perception of antibiotics. tTop panel shows proportion of CHW participating in both baseline and follow-up surveys ($n=63$) who either strongly agreed or agreed with each statement at baseline and follow-up. Frequency of each of the five possible responses is included in Table S1 . Mean likert scores for each statement at baseline and follow-up are reported and compared by Wilcoxon signed rank test in Table S2 . Bottom panel shows frequency of responses to three additional multiple choice questions regarding perceptions of antibiotic use

| Statement | Baseline | | Follow-up | |
|---|---|---|---|---|
| | N | % | N | % |
| Antibiotics are over-prescribed by CHW in Uganda | 46 | 75.4 | 9 | 14.8 |
| *Missing* | 2 | | | |
| When in doubt, it is better to prescribe antibiotics just in case they have pneumonia caused by bacteria | 30 | 49.2 | 4 | 6.4 |
| *Missing* | 2 | | | |
| I think that prescribing antibiotics if the patient does not need them causes harm to the patient | 51 | 83.6 | 51 | 80.9 |
| *Missing* | 2 | | | |
| Amoxicillin is useful for treating all respiratory infections seen by CHW | 40 | 63.5 | 17 | 27.0 |
| Bacteria developing resistance to antibiotics is a major problem in Uganda | 34 | 55.7 | 35 | 55.6 |
| *Missing* | 2 | | | |
| Antibiotics are often prescribed because caregivers want them | 7 | 11.1 | 7 | 11.1 |
| If a CHW or clinician does not prescribe an antibiotic when a child is sick, the caregiver often gets it from the pharmacy on their own | 40 | 63.5 | 27 | 42.9 |
| Caregivers often purchase antibiotics on their own from the drug shops without seeing a VHT or clinicians | 41 | 65.1 | 45 | 71.4 |
| I welcome more training programs or reference materials about antibiotics | 62 | 98.4 | 63 | 100 |
| It would be helpful to have more diagnostic tests to help determine what is causing a child's illness | 63 | 100 | 63 | 100 |
| **Question** | **Baseline** | | **Follow-up** | |
| | **N** | **%** | **N** | **%** |
| What is your opinion regarding obtaining antibiotics without seeing a VHT or clinician in a healthcare facility? | | | | |
| Ok to obtain | 1 | 1.6 | 4 | 6.4 |
| Not ok to obtain | 61 | 98.4 | 59 | 93.7 |
| *Missing* | 1 | | | |
| What is your opinion regarding excessive consumption of antibiotics? | | | | |
| It's bad for health | 61 | 96.8 | 59 | 93.7 |
| It's not bad for health | 2 | 3.2 | 2 | 3.2 |
| I've no opinion | | | 2 | 3.2 |
| How confident are you in your ability to accurately give antibiotic treatment? | | | | |
| Very confident | 45 | 71.4 | 49 | 77.8 |
| Confident | 17 | 27.0 | 14 | 22.2 |
| Unsure | 1 | 1.6 | | |

At baseline, 49.2% of CHW agreed or strongly agreed that prescribing antibiotics "when in doubt" was good practice just in case the patient had pneumonia (mean response score 3.13; Table 4, S1, and S2). This number dropped to 6.4% agreement or strong agreement in the follow-up survey (mean response score 3.98). This shift coincided with a slight increase in confidence in CHW's ability to prescribe antibiotics correctly, 77.8% of whom felt "very confident" at follow-up compared to 71.4% at baseline (Table 4). Interestingly, despite 75.4% of study participants believing that antibiotics were overprescribed by CHW in Uganda at baseline, just 14.3% held this view during follow-up (Table 4 and S1). Multiple CHW reported in the interviews that the use of the STAR SCJA (including the CRP test) and/or participation in the study and its associated trainings directly led to shifts in their practice - "I knew I was using the knowledge I had acquired during the trainings and not guess my work." [ID: 30].

### Caregiver and community dynamics

Caregiver expectations and the therapeutic relationship between the caregiver and provider can affect antibiotic treatment decisions. When asked to assess caregiver influence, over 80% of CHW disagreed that antibiotics were prescribed solely because caregivers desired them in both baseline and follow up-surveys. The interviews overall suggested that CHW are valued and respected by the community, with a CHW sharing, "the parents appreciate me a lot and thank me for treating their child" [ID: 43]. The majority of CHW (11 of 15) expressed appreciation in return, as noted by a CHW who shared, "I wanted to help my community members so that they do not always struggle moving long distances to go and look for medical services" [ID: 64], and another who described, “The community entrusted me and raised my name and said they want me to work as a VHT. So when they shared that idea with me, I accepted it and agreed to work for the people.” [ID:03] Despite this mutual respect, six CHW described caregivers attempting to influence their care, including coercion and accusations of inadequate or insufficient care, and others did report some initial mistrust of the study treatment algorithm. Furthermore, over 40% agreed or strongly agreed that caregivers get antibiotics from the pharmacy on their own if a CHW or clinician does not prescribe one (Table 4 and S1). However, two CHW reported gaining caregiver trust in the STAR SCJA once they witnessed a child heal without antibiotics.

In Uganda, there is a robust network of mostly unlicensed drug shops that sell antibiotics without a prescription [23]. When asked whether caregivers obtain antibiotics on their own from the drug shops without seeing a VHT or clinician, over 60% in the baseline survey and 70% in the follow up-survey either agreed or strongly agreed. (Table 4 and S1). Five of 15 CHW also described caregivers purchasing antibiotics from drug shops if the CHW does not prescribe them or in place of presenting to the health facility when referred there by the CHW.

#### STAR algorithm engagement

Semi-structured interviews suggested the STAR SCJA was easy to use, improved treatment accuracy, aided decision-making and facilitated communication with caregivers. One CHW shared, “it has clear instructions; it guides you on how to treat children with fast breathing and also how to handle those that don’t have fast breathing” [ID: 10]. Another CHW added, “it was so easy to understand because some information in the STAR study was also in the ICCM Sick Child Job Aid” [ID: 43].

Decision making was improved through the STAR SCJA by reminding CHW of diagnostic steps they may have skipped, guiding them on how and when to administer medication, and helping them account for concurrent symptoms or complications. When caregivers insisted on receiving antibiotics, CHW reported leveraging the CRP test results as evidence for their decision-making, helping them navigate caregiver dynamics. One CHW shared, “sometimes you find a parent insisting that even if their child has no pneumonia, I should still give him or her medication but now for us we had already undergone training on how you can sit down with a care giver and explain to them on how risky that can be to a child and indeed if you explained to them so well about the risks then they would get convinced” [ID: 30]. As described by another male CHW with more than 10 years of experience, “my tests showed that the child does not require antibiotics at that point. I then explained to the caregiver that, even if the child is coughing, they do not require antibiotics at this time” [ID: 26].

The effects of the STAR algorithm on antimicrobial resistance also emerged during qualitative interviews. A CHW with 11 years of experience reflected on the algorithm as having “widened [his] knowledge that sometimes, [CHW] prescribe antibiotics to people who do not require them” [ID: 26]. Another CHW added, “I got more skills on how to treat children with cough and I even started understanding that even if a child is coughing, it may not necessarily imply that the child has pneumonia” [ID: 43]. Moreover, a CHW recalled how, “the CRP test changed [her] ability to diagnose patients in a way that [she] started to realize that sometimes [CHW] might have been prescribing antibiotics to clients who do not need them, yet the patient could have healed without any antibiotics” [ID: 003]. The CHW with 11 years of experience also acknowledged the value of the CRP test by saying, “the CRP test is good…it guides us to give antibiotics to children who actually need them” [ID: 26].

As such, CHW favored the CRP diagnostic test and the STAR SCJA for its perceived improved accuracy. As summarized by one CHW, “any other illnesses can cause fast breathing among children when using a timer, so I felt that a CRP test is more accurate because you are testing an illness directly”. He continued, “it changed my ability in a way that I was confident in the test” [ID: 35].

#### Recommendations

Recommendations from CHW included further training and tools for evaluating sick children (both with ARI and other illnesses not currently covered by iCCM), increased availability of CRP test kits, initiation of community discussions on antibiotic use and antimicrobial resistance, and adoption of the STAR SCJA indefinitely through its integration with the iCCM SCJA.

All CHW completing the baseline and follow-up surveys welcomed more training or reference materials on antibiotics (Table 4 and S1). The cohort also all either agreed or strongly agreed that it would be helpful to have more diagnostic tests to help determine what causes a child’s illness (Table 4 and S1). The proportion who strongly agreed about both these statements increased at follow-up compared to baseline (TableS1 ). Similar sentiments were expressed in the semi-structured interviews. As shared by one CHW, “the new job aid would also include diagnosing and treating flu among children since most caregivers bring to us children with high fever, and they turn out negative for both malaria and cough, so we suspect that sometimes the fever might be caused by flu” [ID: 15]. Another stated, “…if they can introduce more tests like the CRP test then we shall be able to overcome making the mistakes we were always doing in the past” [ID: 64]. The desire to keep using the CRP test kits was also captured by a CHW who explained, "we can never be accurate when using the timer…but then the CRP test may instead give me accurate results since I don't have to worry about a child disturbing me" [ID: 30].

Nine CHW elevated the idea of community discussions to create awareness of antibiotic resistance and explain the purpose of the job aids used by CHW. One CHW commented how the community "should be advised on the effects of taking medicine without being sure of what illness you are sick of" [ID: 57]. This sentiment was echoed by another CHW sharing, "sensitization is needed because now ignorance is causing more diseases to us" [ID: 30]. One even proposed that "if we as CHWs can always be trained with the community members in attendance too then they can also understand the way we do our work as far as treatment of children is concerned" [ID: 43]. Lastly, nine CHW interviewed expressed a desire to adopt the STAR SCJA indefinitely, as outlined by one CHW who shared, "this study should not stop here so that all the other people that have not yet benefited from the study can also benefit so that we can all receive this knowledge." [ID: 26].

## Discussion

In a nested, mixed methods study of CHW participating in a stepped wedge cluster randomized trial of a clinical decision-making algorithm (STAR SCJA) that incorporated point-of-care measurement of CRP to inform antibiotic treatment decisions for children presenting with acute respiratory illness, we found that knowledge of antibiotics, their use, and their potential harms was relatively high even prior to study participation. Participation in the study led to changes in CHW perceptions of antibiotic use with fewer agreeing that prescribing antibiotics "when in doubt" was good practice and that antibiotics were useful for treating all respiratory illnesses. Finally, CHW identified many limitations of the respiratory rate counters used for antibiotic decisions in the iCCM SCJA and overall felt positively about the STAR SCJA with a majority hoping it would be adopted permanently. They were overall eager for more resources and tools to optimize targeting of antibiotic treatment. Overall, these findings suggest that CHW could play an important role in improving antibiotic stewardship.

It is important to study CHW specifically as they are often volunteer community members with more limited medical training. As such, findings from facility-based studies assessing formally trained healthcare workers may not be generalizable. Despite their large role in the care of children under 5 years in LMIC, to our knowledge, there is only one other study that included an assessment of CHW knowledge of and views on antibiotic prescribing in SSA that was conducted in Zambia [11]. Its primary goal was to quantitatively assess adherence to antibiotic prescribing guidelines for pneumonia per iCCM, but it also included focus groups and in-depth interviews of the CHW and caregivers. Although difficult to compare directly, knowledge of the treatment of pneumonia per iCCM appeared to be slightly higher in our study than in the Zambian study. This may be because the assessment was done in 2012, shortly after the rollout of iCCM programs in Zambia, whereas the CHW in our study had a median of 9.5 years of experience. Our findings are consistent with a retrospective review demonstrating high quality of care and adherence to iCCM guidance for pneumonia by the CHW in Bugoye [24].

Most of the CHW in our study did not agree that antibiotics were prescribed solely because caregivers requested them, consistent with what was noted in Zambia [7]. In the community, however, it is often thought that this is a common occurrence, one that was also noted frequently in a study of drug shops in the region [23]. Our data do support that caregivers may try to influence the CHW decision-making at times, requesting antibiotics even if the respiratory rate does not reach the threshold for a diagnosis of pneumonia per iCCM. The impact of caregiver/patient expectations on antibiotic prescriptions is well-documented [25–29]. This emphasizes the importance of including community members and caregivers in educational efforts related to antibiotic resistance and appropriate antibiotic use, a recommendation that was also highlighted by the CHW in the interviews.

The limitations of the respiratory rate counters for pneumonia diagnosis have been noted numerous times in the literature, and several devices meant to improve the accuracy of RR measurement have been developed and studied [30–33]. However, regardless of the accuracy of the measurement, reliance on the respiratory rate to diagnose pneumonia likely leads to overuse of antibiotics, as fast breathing is not specific to bacterial infection [34]. In the parent STAR study, the addition of the CRP test as an adjunct to RR measurement greatly decreased antibiotic prescribing without a concomitant increase in adverse clinical outcomes, consistent with previous research in healthcare facilities [19]. Understanding the views of the providers implementing the test and algorithm is therefore critical to facilitating its implementation and expanded use outside of research. Overall, the STAR SCJA was very well received by the CHW in this study. They noted that it was easy to use, improved treatment accuracy, aided decision-making, and facilitated communication with caregivers as they had an objective test result to support their treatment recommendation. They also noticed increased personal satisfaction as they perceived that the test allowed them to more accurately target antibiotic treatment only to the children who need it, improving upon the care they were providing to their community. These findings complement the previously published efficacy results and provide further evidence to support expansion of CRP test use for improving antimicrobial stewardship among children with febrile illness in LMIC.

Interestingly, we noted some changes in the views and perceptions of the CHW between before and after the study. Specifically, the mean Likert scale response score was higher for the statements that it is better to prescribe antibiotics just in case and that amoxicillin is useful for all respiratory infections, indicating more disagreement in the follow-up survey. These changes in opinion were likely influenced by CHW participation in the study and its associated trainings. Conversely, there was more disagreement with the statement "Antibiotics are overprescribed by CHW in Uganda" at follow-up. Based on the CHW's impression that the STAR SCJA improved treatment accuracy that was noted in the semi-structured interviews, we hypothesize this increase in disagreement reflects that CHW felt the STAR SCJA helped them to overprescribe less. This is supported by our finding that algorithm adherence in the parent study was higher with the STAR as opposed to iCCM SCJA [19].

### Study strengths and limitations

The strengths of this study include the comprehensive assessment of the CHW experience with prescribing antibiotics for ARI based on the iCCM and the STAR SCJA, leveraging a mixed methods methodology. The study is novel in its focus on CHW, who are often the first providers to whom caregivers present when their child is ill in many low-resource settings and therefore play an important role in the provision of antibiotics in the community. However, the generalizability of our findings outside of Uganda may be limited as the training of CHW and the exact services that they provide likely vary by geographic region. The CHW who participated in this study are also part of a well-established program and have many years of experience with both clinical care and research. This may not be the case for CHW in other locations as there are often barriers to sustaining high-functioning programs [35, 36].

It is important to note that social desirability bias may have influenced CHW responses, particularly regarding the appropriateness of their antibiotic prescription practices. Additionally, at the time of taking the baseline survey, the CHW had completed an informed consent process and were aware of the purpose of the study, which may have influenced their responses. However, they had not yet undergone the full study training, and the consent form does not contain the information about antibiotics queried in the survey. We did not enroll other key partners such as facility-based health care providers or program coordinators who work closely with CHW but may have different perspectives. Finally, the analyses comparing baseline and follow-up surveys were exploratory, so we did not conduct a power analysis. The significance of the resulting p-values should therefore be interpreted with caution.

## Conclusions

In conclusion, CHW in western Uganda are valued members of their community who play a key role in the care of sick children under 5 years of age. They have a significant fund of knowledge related to antibiotics and are eager to receive further training on antimicrobial resistance, antibiotic stewardship, and the potential role of point-of-care diagnostics to target their use. As such, CHW are uniquely positioned to improve antibiotic stewardship through expanded access to guideline-informed care, decreased community reliance on drug shops, and education of caregivers and community members. Research on the efficacy and implementation of antibiotic stewardship interventions in LMIC should include CHW in addition to other healthcare providers.

### Abbreviations

| | |
|---|---|
| AMR | Antimicrobial resistance |
| AMS | Antimicrobial stewardship |
| ARI | Acute respiratory illness |
| CHW | Community health worker |
| iCCM | Integrated community case management |
| LMIC | Low-and-middle-income country |
| SCJA | Sick Child Job Aid |
| SSA | Sub-Saharan Africa |
| STAR | Stewardship for Acute Respiratory illness |
| VHT | Village health team |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-24712-x.

Supplementary Material 1. Baseline survey tool

Supplementary Material 2. Follow-up survey tool

Supplementary Material 3. Semi-structured interview guide

Supplementary Material 4. Figure S1. Map of participating villages in Bugoye sub-county, Kasese District, Uganda

Supplementary Material 5. Table S1. Perceptions of Antibiotics. Frequency of responses on the Likert scale at baseline and follow-up (n=63)

Supplementary Table 6. Table S2. Perceptions of Antibiotics. Mean Likert scores at baseline and follow-up.

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### Authors' contributions

EJC conceived of and designed the study, acquired funding, analyzed and interpreted the data, and drafted and substantively revised the manuscript. ATBG analyzed and interpreted the data and drafted and substantively revised the manuscript. GN acquired the data and drafted and substantively revised the manuscript. VS assisted with study design, interpreted the data, and substantively revised the manuscript. GK acquired the data and revised the manuscript. FM acquired the data and revised the manuscript. EB acquired the data, supervised the implementation of the study, and revised the manuscript. RR assisted with data interpretation and substantively revised the manuscript. JJJ assisted with study design and acquisition of funding and revised the manuscript. RMB assisted with study design and acquisition of funding and substantively revised the manuscript. MN interpreted the data and substantively revised the manuscript. EMM assisted with study design and acquisition of funding, interpreted the data, and substantively revised the manuscript.

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**Data availability**
Data from this study are jointly owned by the University of North Carolina (UNC) and Mbarara University of Science and Technology (MUST). Data cannot be shared publicly because institutional research ethics boards require individual permission for data sharing. Deidentified participant data that support the results are available provided the investigator proposes a methodologically sound analysis of the data, has approval from an Institutional Review Board (IRB), Independent Ethics Committee (IEC), or Research Ethics Board (REB), as applicable, and executes a data use/sharing agreement with UNC and MUST. Researchers may apply for data access by contacting the UNC IRB at [irb_questions@unc.edu] (mailto: irb_questions@unc.edu).

## Declarations

**Ethics approval and consent to participate**
This study adhered to the ethical principles for medical research involving human participants as outlined in the Declaration of Helsinki. It was approved by the University of North Carolina Institutional Review Board (#18-2803), Mbarara University of Science and Technology Research Ethics Committee (14/03–19), and Uganda National Council on Science and Technology (HS 2631). All enrolled individuals provided written free and informed consent for participation in both the parent and nested sub-study.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

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## Publisher's Note