Community case management of lower chest indrawing pneumonia with oral amoxicillin in children in Kenya

Maricianah Onono (maricianah@gmail.com) 1, Mohammed Abdi 1, Kennedy Mutai 2, Elijah Asadhi 3, Rachel Nyamai 4, Peter Okoth 5, Shamim Ahmad Qazi 5

1. Kenya Medical Research Institute, Nairobi, Kenya
2. National AIDS Control Council, Nairobi, Kenya
3. UNICEF- Kenya Country Office, Nairobi, Kenya
4. Maternal, Newborn, Child and Adolescent Health Unit, Ministry of Health Kenya, Nairobi, Kenya
5. Department of Maternal, Newborn, Child and Adolescent Health, World Health Organization, Geneva, Switzerland

Keywords
Chest indrawing, Community health workers, Integrated community case management, Pneumonia, Sub-Saharan Africa

Correspondence
M Onono, MBChB MSc PhD(c), Kenya Medical Research Institute, P.O. Box 19464 - 00202, Nairobi, Kenya. Tel/Fax: +254732390992 | Email: maticianah@gmail.com

ABSTRACT
Aim: To determine the accuracy and effectiveness of community health workers (CHWs) when compared to trained nurses for management of pneumonia in Kenyan children.

Methods: In Homabay County in western Kenya, children 2–59 months of age with lower chest indrawing pneumonia were identified, classified and treated by CHWs with oral amoxicillin (90 mg/kg per day) for five days at home. Trained nurses visited the child within 24 hours to verify diagnosis; and on day 4 and 14 to assess treatment outcomes.

Results: CHWs identified 1906 children with lower chest indrawing pneumonia. There was an 88.7% concordance in classification and treatment for lower chest indrawing pneumonia by CHWs compared to nurses. Children with moderate malnutrition (OR 1.68; 95% CI: 1.22–2.10), comorbidities such as diarrhoea or malaria (OR 1.55; 95% CI: 1.32–1.81) or an additional day of delay in care seeking (OR 1.06; 95% CI: 1.02–1.10) were more likely to have an incorrect classification of lower chest indrawing by the CHW. Comorbidity (OR 1.66; 95% CI: 1.12–2.30) and fast breathing (OR 4.66; 95% CI: 1.26–17.27) were significantly associated with treatment failure on day 14.

Conclusion: CHWs can correctly manage lower chest indrawing pneumonia even in high-mortality settings, such as western Kenya, in sub-Saharan Africa.

INTRODUCTION
Despite the availability of low-cost treatment, pneumonia continues to be a major killer of children under five years of age, accounting for nearly 15% of child deaths globally; a large number are in sub-Saharan Africa (1,2). One major contributor to this situation is the lack of access (including distance and cost) to prompt and effective treatment (3–5). The World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF) recommend that where access to health facilities is not feasible, community health workers (CHWs) treat pneumonia through integrated community case management (iCCM) (6–8). iCCM of pneumonia has been shown to be a feasible and effective strategy in Asia, where up to 35% of pneumonia-related mortality in children can be prevented (9,10).

World Health Organization recommends treatment of lower chest indrawing pneumonia with oral amoxicillin on an outpatient basis (11). Evidence for this recommendation was provided from hospital and outpatient settings (12–14). In Kenya, just half of caregivers seek help for their children with suspected pneumonia from an appropriate healthcare worker, and of these, less than 50% receive antibiotics for pneumonia (15).

Key notes
- This study was conducted in response to policy-makers request for locally generated evidence on Integrated Community Case Management for pneumonia.
- We demonstrated that trained, supervised and well supplied community health workers (CHWs) in rural Kenya can correctly assess, classify and manage lower chest indrawing pneumonia at home.
- Pneumonia case management by CHWs should be a key component of increasing access to treatment of childhood pneumonia in sub-Saharan Africa.

Abbreviations
CHEW, Community health extension worker; CHW, Community health worker; CI, Confidence interval; iCCM, Integrated community case management; IQR, Interquartile range; KEMRI, Kenya Medical Research Institute; k, Kappa statistic; MUAC, Mid-upper arm circumference; OR, odds ratio; UNICEF, United Nations Children’s Fund; WHO, World Health Organization.
In a Kenya Ministry of Health- and WHO-supported exercise in 2011, Kenyan experts (academics, clinicians and policy-makers) generated and systematically scored research questions for maternal, newborn and child health interventions to reduce child mortality in Kenya using Child Health and Nutrition Research Initiative methodology. During this exercise, iCCM of pneumonia was identified as a top priority for research in Kenya. iCCM of lower chest indrawing pneumonia using oral amoxicillin has been successfully demonstrated in Asia (16,17), but no such data exist for Africa (18). WHO and UNICEF currently do not recommend treatment of lower chest indrawing pneumonia with oral amoxicillin by CHWs as part of iCCM, as no evidence is available from Africa. To address this gap, we trained CHWs in rural western Kenya to manage lower chest indrawing pneumonia using oral amoxicillin as part of iCCM to increase access to pneumonia treatment. We conducted this implementation research in the existing county government health system.

METHODS

Study design
This observational intervention study was conducted in Homabay County in western Kenya between January 2014 and March 2015. Our primary objective was to determine the accuracy and effectiveness of CHW classification, treatment and treatment outcomes of lower chest indrawing pneumonia when compared to trained nurses.

Study setting
Homabay is a rural county with a population of approximately one million and has eight administrative sub-counties: Homabay, Rangwe, Ndhiwa, Mbita, Suba, Kabondo, Kasipul and Rachuonyo North. Children under five years account for 16% of the population. The county is characterised by high levels of poverty and the highest HIV prevalence in Kenya (19), as well as one of the highest under-5 mortality rates in the entire country (20). Despite an adequate number of health facilities in Homabay, almost half of the population finds distance and poor road access as serious barriers to health care. Those living on islands in Lake Victoria must travel very long distances over water and land to reach health facilities.

Study participants
Children aged 2–59 months with a cough and/or difficulty breathing during regular home visits by CHWs, or whose caregiver sought care from a CHW, were assessed, classified and treated according to the WHO algorithm for pneumonia for health facilities (Box 1) (21). The CHW recorded the findings on a WHO standardised sick child recording form.

Study procedures
Training
The study procedures were implemented through already-existing CHWs in 241 community health units linked to existing health facilities in all of Homabay County. The CHWs had been previously selected and trained over six weeks using the national community health strategy curriculum to provide a wide variety of preventive and promotive health services. Ministry of Health Community Health Extension Workers (CHEWS) supervised the CHWs. CHWs were trained in iCCM for six days to enable them to identify, classify and treat pneumonia, malaria and diarrhoea in children 2–59 months of age. The CHWs gained skills that allowed them to counsel caregivers, manage stocks of drugs and supplies, and accurately complete relevant registers and data collection forms. CHEWs were trained on how to use these forms in supervision. The national Kenyan iCCM training programme, adapted from WHO/UNICEF materials, was used. A team of CHW trainers of trainers experienced in iCCM and integrated management of childhood illness (IMCI) conducted the training. The methodologies used included lectures, presentations, discussions, case studies, clinical demonstrations, practice, role plays, video shows and facility-based clinical attachments. Pre- and post-training assessments were conducted. In order to support, supervise and evaluate the CHWs during the implementation of the study, diploma holding nurses in the study area underwent training in the WHO adapted Kenya IMCI curriculum as well as the iCCM curriculum. The training was performed at the link health facilities and was facilitated by national, county and sub-county IMCI trainers.

Classification and management
Children were eligible for inclusion in the study if they were 2–59 months of age and presented with fast

Box 1. WHO classification of severity of pneumonia (21)

| Pneumonia          |                          |
|--------------------|--------------------------|
| Fast breathing     | 50 breaths/min in a child aged 2–11 months |
|                    | 40 breaths/min in a child aged 12–59 months |
| Chest indrawing    | The child has chest indrawing if the lower chest wall goes IN when the child breathes IN |

Severe pneumonia
Cough or difficulty in breathing with:

- Oxygen saturation <90% or central cyanosis
- Severe respiratory distress (e.g. grunting, very severe chest indrawing)
- Signs of pneumonia with a general danger sign (inability to breastfeed or drink, lethargy or reduced level of consciousness, convulsions)
breathing and/or lower chest indrawing pneumonia. Children who had WHO-defined severe pneumonia (with any danger sign) were not enrolled. For a child classified with chest indrawing pneumonia, the CHW treated the child with oral amoxicillin (90 mg/kg per day in two divided doses) for five days. The CHW educated the caregiver on danger signs and advised the caregiver to take the child to the nearest health facility if any danger sign became apparent or if the child was unable to take the oral antibiotic. For children with severe pneumonia (with danger signs), the CHW referred the patient using a written referral slip to the nearest health facility for further management, and where possible accompanied the patient. If the child was able to take the oral antibiotic, a prerereferral dose of oral amoxicillin was given. Children were followed up by the CHWs either in the patient’s home or at the CHW’s house on day 3 (after 48 hours) and day 6 as per national iCCM guidelines. At each visit, caregiver self-reported adherence to the oral antibiotic was assessed, as well as the child’s clinical status and the presence of any danger sign and adverse events. Malnutrition was assessed using a colour-coded mid upper arm circumference (MUAC) strip. Normal nutrition status was coded as green, moderate malnutrition as yellow and severe malnutrition as red. A child was regarded as lost to follow-up if contact could not be made after day 3 of initiation of treatment.

Data collection
As this was the first time CHWs were involved in curative services, each case of pneumonia needed to be tracked and verified within 24 hours. We created a free 24/7 decision support hotline to give assistance to the CHWs treating pneumonia. The hotline was a specialised telephone service that provided an effective way to communicate with and link the pneumonia case to a trained nurse for physical case confirmation. The hotline utilised the existing widespread cellular phone coverage linked to a web-based platform, which had a preprogrammed diagnostic algorithm for pneumonia assessment, classification and treatment based on the WHO sick child recording form. Two attendants staffed the hotline. Whenever a CHW identified and treated a case of pneumonia, she/he sent a ‘Please Call Me’ message to a study hotline number. The attendant called the CHW to record what the CHW had diagnosed in an online study database. The online system then compared the CHW’s classification against the system algorithm and regardless of the diagnosis, sent an automatic SMS with the child’s key location details to the nearest nurse for confirmation. The nurse traced the child within 24 hours and independently assessed and classified the child. After determining eligibility, the nurse obtained written consent from the caregiver to conduct subsequent follow-ups and document treatment outcomes. The nurses recorded their pneumonia classification through a mobile phone application, and their data were synchronised into the central online database. The nurse classification was used as the gold standard to measure the accuracy of classification and appropriateness of treatment administered by the CHW. Children who were not eligible for enrolment were provided appropriate care, including facilitated referral to hospitals as needed.

The study nurse subsequently followed up enrolled children on days 4 and 14 to assess for treatment outcomes (Box 2), and used a standardised questionnaire to gather information on follow-up visits by CHWs and assess caregivers’ perceptions on the quality of care provided. If the nurse suspected treatment failure or relapse during the follow-up visit, he/she referred the child to the nearest health facility. Adverse drug reactions were also monitored during these visits.

Statistical methods
Sample size
Sample size was calculated to assess the primary outcome of treatment failure at day 4 of treatment. We assumed (i) no seasonality of pneumonia incidence; (ii) average duration of pneumonia symptoms of one week; (iii) estimated pneumonia incidence of 300 cases per 1000 children per year in low- and middle-income countries, which translated to a two-week period prevalence of approximately 2% (22,23); (iv) at least 20% of children with pneumonia have lower chest indrawing pneumonia; and (v) approximately 10% of children suffer treatment failure (24). A precision of 0.5% around the treatment failure estimate and 95% confidence interval (CI) was used. The level of implementation was at the sub-locations (clusters) in the community, so necessary adjustments in were made using an intra-cluster correlation of 0.16, resulting in a sample size of 1673. A factor of 15% loss to follow-up yielded a total sample size of 1924.

Exposure and outcomes
The primary outcomes were (i) concordance between CHWs and nurses in identification and classification of lower chest indrawing pneumonia; and (ii) treatment failure at day 4. The explanatory variables included child’s age, sex, comorbidity, moderate or severe malnutrition and CHW characteristics.
Statistical analysis
Frequencies with percentages were used to summarise categorical variables. Means and medians reporting the respective standard deviations and interquartile ranges (IQR) were used to summarise continuous variables. The comparison of pre- and postintervention outcomes was carried out using cluster-adjusted t-tests for continuous and chi-square tests for categorical variables. Univariate, bivariate and multivariate logistic regression models were adjusted for clustering. Variables significant at $p < 0.2$ in the bivariate models were included in the multivariate (adjusted) model. Proportions, coefficients or odds ratios were reported as appropriate with respective 95% CIs. Sampling weights were incorporated in all the survey data analysis as appropriate to account for the survey sampling strategy. Cohen’s kappa statistic ($k$) test was utilised to measure the level of agreement between the CHWs and nurses (25). Analysis was carried out using Stata version 13.1 College Station, TX: StataCorp LP.

Ethical clearance
The study protocol was reviewed and approved by the KEMRI National Ethical Review Committee, Kenya National Pharmacy and Poisons Board and WHO. All serious adverse events were reported to the KEMRI Ethical Review Committee and WHO. Community leaders and village headmen were approached through village health committees, briefed on the project, and their verbal consent and approval solicited. Written consent in the preferred local language (Dholuo or Swahili) was obtained from caregivers of children who were followed up after receiving treatment from the CHWs to allow collection of data to assess the effectiveness of the intervention.

Quality assurance
Community health workers underwent an accreditation and standardisation process 8–10 weeks after the first training. This process included evaluation of CHW performance and standardisation of assessment, classification and treatment. Monitoring of adherence to the protocols, including human subject’s protection, was conducted by a designated KEMRI ethics officer not directly involved in the study as well as by an independent WHO monitor experienced in performing such work in low-resource settings.

RESULTS
Infant characteristics
Of the total of 161 290 children assessed and classified by CHWs, 57 230 presented with cough and/or difficulty breathing (Figure 1). Of the latter, 25 448 had only cough and 8520 had only fast breathing pneumonia. CHWs identified and classified 1906 children as having lower chest indrawing pneumonia and treated them with oral amoxicillin. Treatment was successful in 1759 (92.3%) children, 40 (2.1%) failed therapy and 107 (5.6%) were lost to follow-up (Figure 1). Among these 1906 children, 52% were male; the median age was six months (IQR 4–8) and 10 months (IQR 19–42) for children aged 2–11 months and ≥12–59 months, respectively (Table 1). The majority of children presented with a history of cough (1901, 99%), fever (1556, 71%) and fast breathing (1788, 94%). The mean duration of illness was 2.5 days (range 2.0–3.5) at the time of enrolment. The majority had received pneumococcal vaccine (1457, 76%), and 96 (5.8%) had moderate or severe malnutrition (Table 1).

Main outcomes
Concordance in identification and classification of lower chest indrawing between CHWs and nurses
Comparison between CHWs and nurses for concordance in identification, classification and treatment of lower chest indrawing showed an agreement of 88.7% with a Kappa coefficient of 0.65 (95% CI: 0.57–0.62; exact p-value <0.001).

Factors associated with treatment failure at day 4 and day 14
The multivariate model did not identify any factors associated with treatment failure on day 4 (Table 2). However, CHWs who had management experience with more than five children (odds ratio [OR] 0.51; 95% CI: 0.30–0.84) or had secondary education (OR 0.55; 95% CI: 0.32–0.95) were less likely to report treatment failure on day 4. The multivariate model identified comorbidity (OR 1.66; 95% CI: 1.12–2.48) and fast breathing (OR 4.66; 95% CI: 1.26–17.27) to be significantly associated with treatment failure on day 14 (Table 3).

We documented five deaths in the course of the study. No serious adverse events related to amoxicillin were identified.

Factors associated with incorrect chest indrawing classification by CHW
Children with moderate malnutrition (OR 1.68; 95% CI: 1.22–2.30), with comorbidities such as diarrhoea or malaria (OR 1.55; 95% CI: 1.32–1.81) or those with an additional day of delay in presenting to the CHW (OR 1.06, 95% CI: 1.02–1.10) were more likely to have an incorrect classification of lower chest indrawing by the CHW.

DISCUSSION
Our study demonstrates that CHWs were able to identify, classify and treat lower chest indrawing pneumonia in children aged 2–59 months with a five-day course of oral amoxicillin with low treatment failure rates in a real programme setting in Kenya. Our observed treatment failure rate was lower (2.1%) than the 9% reported from Haripur, Pakistan, and 8% from Matiari, Pakistan, the only two community trials that have reported iCCM for lower chest indrawing pneumonia(12,13,16,17). Our loss to follow-up was comparable to the 5.3% reported from Matiari and 2.4% from Haripur(12,13,16,17). Taking a very conservative view, even if we were to combine the 5.6% loss...
161,290 children Screened by the CHWs

Excluded 124,060 (84%)
- 20,277 Malaria
- 54,358 Diarrhea
- 49,425 Not sick

37,230 with Cough and/or difficulty in breathing

Excluded: 35,324
- 8,520 with fast breathing pneumonia
- 25,448 Cough only
- 1,250 Referred for danger signs
- 106 Not eligible by age

Children with Chest in drawing treated by CHWs N=1,906 (18%)

Follow up on Day 4 N=1,860 (98%)

Recovered N=164 (94%)
10 (6%) Lost to follow-up

Missed visit 174

Improved; Amoxil continued = 1,651

46 Lost to follow up

51 Lost to follow-up

Recovered N=1,595 (97%)
Treatment Failure
2 Relapse
3 Died

Treatment Failure
23 Changed treatments
2 died
10 worsened

Total Recovered N= 1,759/1,906 (92.3%)

Total Treatment Failure N=40 (2.1%)
Antibiotic changed = 23
Worsened at anytime = 10
Relapse on day 14 = 2
Died = 5
Total lost to follow up N= 107/1906 (5.6%)
to follow-up with the 2.1% treatment failure rates, the overall potential treatment failure rate would be similar to the Haripur and Matiari studies.

Critics of iCCM for pneumonia have noted that CHWs may not be able to correctly identify chest indrawing (26). In our study, the concordance for classification of lower chest indrawing between CHWs and nurses showed 88.7% agreement (k = 0.593), which was comparable to the 93.7-7% in Haripur (16). We can attribute this success to the close supervision of the CHWs as well as to the periodic accreditation and standardisation of skills. CHWs who had more experience (seen more than five children) were better at identifying and classifying lower chest indrawing. As in other higher-level trained healthcare workers, clinical competence is often a function of self-confidence and self-efficacy (27). It is likely that CHWs who had seen five children or fewer with pneumonia lacked experience, which might have led to missed or incorrect classification of lower chest indrawing. Trainers and supervisors need to identify strategies to help CHWs build self-confidence as well as motivation. Such strategies may include supervisory mentoring, standardisation exercises for clinical skills and accreditation, and sessions in which CHWs share experiences with each other. On exploratory analysis we found that CHWs were more likely to misclassify lower chest indrawing in children with comorbidities such as malaria and diarrhoea, those with moderate malnutrition or those whose caregivers delayed care seeking. This subset of children likely represents sicker children for whom extra care is needed in disease assessment and classification. This challenge in classification of sicker children has also been reported among higher-level trained healthcare workers (28,29). This finding has implications for programmatic implementation and scale-up of iCCM. CHWs should be able to identify and refer children with any danger sign and those with malnutrition. Training of CHW needs to emphasise prompt identification and referral to nurses and other trained health care workers. Additionally, caregivers need to be educated and motivated to seek appropriate care early.

Our study had several strengths. First was its research design, its innovative use of mobile phone technology and implementation in a rural high mortality context, with its potential to be scaled up and catalyse a policy change in Kenya. Second, the study was integrated into the existing community health delivery structures and used mobile phones already owned by CHWs to obtain real-time notification of all pneumonia cases in the county and to trigger case verification within 24 hours. Finally, Ministry of Health staff and administrators developed the implementation, monitoring and evaluation framework, trained CHWs and their supervisors and supervised implementation, thus increasing the generalisability and sustainability of our findings to other parts of the country. The inherent limitation of this study was that although the nurses were only provided with the name and location of the child, it is still possible that the nurse was able to deduce the CHW assessment and classification based on the caregiver report about treatment. To avoid this bias, one could have had CHWs send a ‘Please call me’ message for all children regardless of their classification. However, this would have increased the number of children requiring follow-up and the number of nurses to consult, which would be challenging in a setting of limited human resources. The second limitation was that no laboratory or radiological investigation was undertaken for the enrolled children. It is likely that this criteria selected children with respiratory signs of those children with probable pneumonia who would benefit from antibiotics as well as those without probable pneumonia who would not benefit from antibiotics. However, this iCCM approach to classification and management of pneumonia is similar to the current standard of care at most primary health care facilities where classification of pneumonia is algorithm based. In many of these primary health care facilities, both laboratory and radiological services are not available. Moreover, even when available, radiological confirmation of pneumonia is difficult and only 5–20% of cases have bacteraemia. In addition, viral pathogens, which preclude use of antibiotics, are probable causes of

### Table 1: Sociodemographic and clinical characteristics of children assessed with lower chest indrawing

| Characteristic | Children with chest indrawing N = 1906 | n/N (%) or median (IQR) |
|---------------|---------------------------------------|-------------------------|
| Child’s gender (male) | 992/1906 (52) |
| Age (months), median (IQR) | |
| <12 | 6 (4–8) |
| 12–59 | 30 (19–42) |
| History of cough | 1901/1906 (99) |
| Duration of cough (days), median (IQR) | 3 (2–4) |
| History of fever | 1356/1906 (71) |
| Duration of fever (days), median (IQR) | 3 (2–3) |
| Fast breathing present* | 1788/1906 (94) |
| Breathe rate, median (IQR) | |
| <12 months of age | 54 (52–58) |
| 12–59 months of age | 46 (45–51) |
| Duration of illness | 2.5 (2.0–3.5) |
| Nutritional status† | |
| Normal | 1521/1617 (94) |
| Moderate | 83/1617 (5) |
| Severe | 13/1617 (0.8) |
| Comorbidity | 567/1906 (30) |
| Diarrhoea | 443/1906 (23) |
| Malaria | 164/1906 (9) |
| Pneumococcal vaccine received | 1457/1906 (76) |
| Primary caregiver | |
| Father/mother | 1786/1906 (94) |
| Grandmother | 83/1906 (4) |
| Other | 37/1906 (2) |

*Fast breathing: ≥50 breaths/min in a child aged 2–11 months
≥40 breaths/min in a child aged 12–59 months.
†Nutrition was assessed using a colour-coded MUAC strip.
respiratory signs and can occur concomitantly with or precede bacterial infections(30).

CONCLUSION
Our data have contributed to the evidence that CHWs can manage lower chest indrawing pneumonia with oral amoxicillin at community level. With these results, we call for further action at the country level to step up training, supply of necessary commodities and supervision of CHWs to provide iCCM for pneumonia (including lower chest indrawing pneumonia) in Kenya. Future implementation research should focus on the implications of pneumonia home case management by CHWs on antimicrobial resistance and consider setting up sentinel sites to carry out antimicrobial surveillance.

| Table 2 Factors associated with treatment failure at day 4 among children assessed with lower chest indrawing | Treatment failure on day 4 n/N (%) or median (IQR) | Crude OR (95% CI) | Adjusted OR (95% CI) |
|--------------------------------------------------|-----------------------------------------------|-------------------|---------------------|
| **Characteristics n = 1906**                      |                                               |                   |                     |
| Child’s age (months)                              |                                               |                   |                     |
| <12                                               | 20/506 (4.0)                                  | Ref               |                     |
| 12–59                                             | 61/1400 (4.4)                                 | 1.11 (0.66–1.87)  |                     |
| Child’s gender                                    |                                               |                   |                     |
| Male                                              | 40/992 (4.0)                                  | Ref               |                     |
| Female                                            | 41/914 (4.5)                                  | 1.12 (0.68–1.83)  |                     |
| Primary caregiver                                 |                                               |                   |                     |
| Father/mother                                     | 5/83 (6.0)                                    | Ref               |                     |
| Grandmother                                       | 1/37 (2.7)                                    | 0.43 (0.07–2.63)  |                     |
| Other                                             | 75/1786 (4.2)                                 | 0.68 (0.26–1.77)  |                     |
| Nutritional status § n = 1617                      |                                               |                   |                     |
| Normal (green)                                    | 63/1521 (4.1)                                 | Ref               |                     |
| Moderate (yellow)                                 | 7/83 (8.4)                                    | 2.13 (0.81–5.58)  |                     |
| Severe (red)                                      | 1/13 (7.7)                                    | 1.93 (0.25–14.68) |                     |
| Comorbidity                                       |                                               |                   |                     |
| No                                                | 57/1339 (4.3)                                 | Ref               |                     |
| Yes                                               | 24/567 (4.2)                                  | 0.99 (0.62–1.59)  |                     |
| Missed medication                                 |                                               |                   |                     |
| No                                                | 77/1865 (4.1)                                 | Ref               |                     |
| Yes                                               | 4/41 (9.8)                                    | 2.51 (0.57–11.15) |                     |
| Fever                                             |                                               |                   |                     |
| No                                                | 19/550 (3.5)                                  | Ref               |                     |
| Yes                                               | 62/1356 (4.6)                                 | 1.34 (0.81–2.22)  |                     |
| Fast breathing                                    |                                               |                   |                     |
| No                                                | 4/118 (3.4)                                   | Ref               |                     |
| Yes                                               | 77/1788 (4.3)                                 | 1.28 (0.46–3.58)  |                     |
| CHW gender n = 1846                               |                                               |                   |                     |
| Female                                            | 58/1301 (4.5)                                 | Ref               |                     |
| Male                                              | 20/545 (3.7)                                  | 0.82 (0.47–1.43)  |                     |
| CHW age (years) § n = 1799                        |                                               |                   |                     |
| <35                                               | 19/544 (3.5)                                  | Ref †             | Ref †              |
| 35–44                                             | 31/851 (3.6)                                  | 1.04 (0.57–1.92)  | 1.03 (0.55–1.92)   |
| ≥45                                               | 24/404 (5.9)                                  | 1.75 (0.89–3.43)  | 1.73 (0.90–3.33)   |
| CHW education level † n = 1806                    |                                               |                   |                     |
| Primary or less                                   | 32/533 (6.0)                                  | Ref ‡             | Ref ‡              |
| Secondary                                         | 39/1223 (3.2)                                 | 0.52 (0.29–0.91)  | 0.55 (0.32–0.95)   |
| Tertiary                                          | 3/50 (6.0)                                    | 1.0 (0.25–4.0)    | 3.64 (0.58–22.75)  |
| Number children seen by CHW ‡ n = 1905           |                                               |                   |                     |
| ≤5                                                | 36/535 (6.7)                                  | Ref ‡             | Ref ‡              |
| 5                                                 | 45/1370 (3.3)                                 | 0.47 (0.30–0.75)  | 0.51 (0.30–0.84)   |
| Duration of illness (days)                        | 2.5 (2.0–3.5)                                 | 1.10 (1.00–1.20)† | 1.09 (0.99–1.20)   |

*Adjusted for variables significant at bivariate analysis (p-values <0.2), that is, infant’s age, MUAC, comorbidity, number of children seen by CHW and duration of illness.
†Crude OR significant at α = 0.20 (criteria for variable inclusion in the multivariate model).
‡Significant at α = 0.05 in the multivariate model.
§Malnutrition was assessed using a colour-coded MUAC strip.
¶Missing data from the denominator.
The table below presents the factors associated with treatment failure at day 14 among children assessed with lower chest in-drawing. The table includes the following characteristics: child's age, child's gender, primary caregiver, nutritional status, comorbidity, missed medication, fever, fast breathing, CHW gender, CHW age, CHW education level, number of children seen by CHW, duration of illness, and other variables. The table also includes the treatment failure rate, crude OR, and adjusted OR for each characteristic. The data was collected among 1906 children, with 38/506 (7.5%) of children having treatment failure on day 14. The crude OR and adjusted OR were calculated for each characteristic, with significant levels at p-values < 0.2.

**Table 3** Factors associated with treatment failure at day 14 among children assessed with lower chest in-drawing

| Characteristics | Treatment failure on day 14 n/N (%) or median (IQR) | Crude OR (95% CI) | Adjusted OR (95% CI) |
|-----------------|-----------------------------------------------------|--------------------|----------------------|
| Child’s age (months) | 38/506 (7.5) | Ref | Ref |
| <12 | 109/1400 (7.8) | 0.96 (0.57–1.63) | 1.24 (0.70–2.20) |
| 12–59 | 81/992 (8.2) | Ref | Ref |
| Child’s gender | 66/914 (7.2) | 0.88 (0.61–1.26) | 0.96 (0.64–1.44) |
| Male | 1/37 (2.7) | 0.36 (0.06–2.24) | 0.37 (0.06–2.40) |
| Female | 1/1786 (0.6) | 1.09 (0.45–2.62) | 1.45 (0.50–4.22) |
| Primary caregiver | 114/1521 (7.5) | Ref | Ref |
| Father/mother | 11/83 (13.3) | 1.89 (0.85–4.20) | 1.61 (0.70–3.71) |
| Grandmother | 1/13 (7.7) | 1.03 (0.13–8.01) | 0.45 (0.05–3.81) |
| Other | 96/1339 (7.2) | Ref | Ref |
| Nutritional status n = 1617 | 11/83 (13.3) | 1.89 (0.85–4.20) | 1.61 (0.70–3.71) |
| Normal (green) | 1/13 (7.7) | 1.03 (0.13–8.01) | 0.45 (0.05–3.81) |
| Moderate (yellow) | 1/13 (7.7) | 1.03 (0.13–8.01) | 0.45 (0.05–3.81) |
| Severe (red) | 1/13 (7.7) | 1.03 (0.13–8.01) | 0.45 (0.05–3.81) |
| Comorbidity | 1/13 (7.7) | 1.03 (0.13–8.01) | 0.45 (0.05–3.81) |
| No | 96/1339 (7.2) | Ref | Ref |
| Yes | 51/567 (9.0) | 1.28 (0.88–1.85) | 1.66 (1.12–2.48) |
| Missed medication | 142/1865 (7.6) | Ref | Ref |
| No | 5/41 (12.2) | 1.69 (0.55–5.19) | 1.79 (0.70–4.56) |
| Yes | 9/950 (0.7) | 1.13 (0.74–1.73) | 1.04 (0.57–1.92) |
| Fast breathing | 5/118 (4.2) | Ref | Ref |
| No | 142/1788 (7.9) | 1.95 (0.80–4.76) | 4.66 (1.26–17.27) |
| Yes | 98/1301 (7.5) | Ref | Ref |
| CHW age (years) n = 1799 | 146/545 (8.4) | 1.13 (0.65–1.96) | 1.35 (0.76–2.40) |
| <35 | 34/544 (6.3) | Ref | Ref |
| 35–44 | 70/851 (8.2) | 1.34 (0.77–2.36) | 1.45 (0.78–2.69) |
| ≥45 | 36/404 (8.9) | 1.47 (0.80–2.69) | 1.71 (0.92–3.20) |
| CHW education level n = 1806 | 59/533 (11.1) | Ref | Ref |
| Primary or less | 78/1223 (6.4) | 0.55 (0.34–0.87) | 0.42 (0.25–0.70) |
| Secondary | 3/50 (6.0) | 0.51 (0.13–2.01) | 0.36 (0.07–1.97) |
| Tertiary | 52/535 (9.7) | Ref | Ref |
| Number children seen by CHW n = 1905 | 95/1370 (6.9) | 0.69 (0.46–1.05) | 0.85 (0.53–1.36) |
| <5 | 2.5 (2.0–3.5) | 1.08 (1.00–1.16) | 1.08 (0.99–1.17) |

*Adjusted for variables significant at bivariate analysis (p-values < 0.2), that is, CHW age, CHW educational level, number of children seen by CHW and duration of illness.

†Crude OR significant at α = 0.20 (criteria for variable inclusion in the multivariate model).

‡Significant at α = 0.05 in the multivariate model.

§ Malnutrition was assessed using a colour-coded MUAC strip.

¶ Missing data from the denominator.

## ACKNOWLEDGEMENTS

We thank the Kenyan mothers, fathers and their children and CHWs who participated in this study. We acknowledge the technical support of the World Health Organization, the Kenya Ministry of Health Neonatal Child and Adolescent Health Unit, the director and health management team of Homabay County, members of the Kenya integrated community case management technical working group and the Director, Kenya Medical Research Institute.

## CONFLICT OF INTEREST

All authors declare no conflict of interest.

## DISCLAIMER

Shamin A Qazi is a former staff member of the World Health Organization. The author alone is responsible for the views expressed in this publication and they do not necessarily represent the views, decisions or policies of the World Health Organization.
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**FUNDING**

This study was funded by the Alliance for Health Policy and Systems Research, with support from the Norwegian Government Agency for Development Cooperation, the Swedish International Development Cooperation Agency and the United Kingdom Department for International Development. UNICEF also contributed financial support and provided support for the country-level planning, implementation, monitoring, and assessment of activities along with WHO/MCA.

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