

Care-Seeking Behavior, Access to Treatment, and Under- Five Mortality in Kapolowe, a Remote Rural District in DRC: Findings from a Population Based Survey prior to iCCM Strengthening with Rectal Artesunate and Amoxicillin

Tafadzwa Maseko

Tafadzwa.Maseko@uantwerpen.be

University of Antwerp

Deborah Bora Kanyamukenge

University of Lubumbashi

Flory Luzolo Khote

University of Kinshasa

Jérémie Sombola

University of Kinshasa

Baudouin Matela

National Malaria Control Program

Aimé Kakudji

University of Lubumbashi

Ghislain Kikunda

National Malaria Control Program

Vivi Maketa Tevuzula

University of Kinshasa

Augustin Mutombo Mulangu

University of Lubumbashi

Eric Mukumena Sompwe

University of Lubumbashi

Sebastian Hachizovu

National Health Research & training institute

Michael Nambozi

National Health Research & training institute

Shepherd Khondowe

National Health Research & training institute

Vito Baraka

National Institute for Medical Research (NIMR)

Hans Rietveld

MMV Medicines for Malaria Venture

Stephan Duparc

MMV Medicines for Malaria Venture

Katy Athersuch

MMV Medicines for Malaria Venture

Gwen Lemey

University of Antwerp

Hilde Bastiaens

University of Antwerp

Christine Manyando

National Health Research & training institute

Geofrey Makenga

University of Antwerp

JP Van geertruyden

University of Antwerp

Hypolite Muhindo Mavoko

University of Kinshasa

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Authors: Tafadzwa Maseko¹, Deborah Bora Kanyamukenge^{1,2}, Flory Luzolo Khote^{1,3}, Jérémie Sombola³, Aimé Kakudji², Baudouin Matela⁴, Ghislain Kikunda^{2,4}, Vivi Maketa Tevuzula³, Augustin Mutombo Mulangu², Eric Mukumena Sompwe², Sebastian Hachizovu⁶, Michael Nambozi⁶, Shepherd Khondowe⁶, Vito Baraka⁸, Hans Rietveld⁷, Stephan Duparc⁷, Katy Athersuch⁷, Gwen Lemey¹, Hilde Bastiaens^{1,5}, Christine Manyando⁶, Geoffrey Makenga^{1,8}, JP Van geertruyden¹, Hypolite Muhindo-Mavoko³

Affiliations

¹ Global Health Institute, University of Antwerp, Antwerp, Belgium

² University of Lubumbashi, Lubumbashi, Democratic Republic of the Congo

³ University of Kinshasa, Kinshasa, Democratic Republic of the Congo

⁴National Malaria Control Program, Ministry of Health, Kinshasa, Democratic Republic of the Congo

⁵ Primary and Interdisciplinary Care, University of Antwerp, Antwerp, Belgium

⁶ National Health Research & training institute, Zambia

⁷ MMV Medicines for Malaria Venture, Switzerland

⁸National Institute for Medical Research (NIMR), Tanzania

Abstract

Introduction:

Remote, high-transmission health districts of the Democratic Republic of Congo (DRC) continue to suffer high child mortality, much of it due to delays in accessing appropriate treatment for severe malaria and related illnesses. To inform planned strengthening of integrated community case management (iCCM) with rectal artesunate (RAS) and amoxicillin, we conducted a population-level survey in Kapolowe District to assess care-seeking, treatment access, and mortality among children under five.

Methods:

A population-based cross-sectional, two-stage cluster survey was conducted from March to April 2024. Eligible households had at least one child under five and a consenting caregiver. Standardized questionnaires captured demographics, care-seeking behaviours for illness in the preceding month, and under-five deaths in the preceding year. Survey-weighted analyses accounted for clustering and stratification.

Results:

Data from 906 households covered 1243 children under five. In the preceding month, 410 (33%) children

experienced danger signs; 317 (81%) sought care, but only 85 (32%) reached a formal provider within 24 hours. First contact was reported to be predominantly at public health posts 245 (79%), with hospitals 2 (<1%) and community health workers 7 (2%) rarely used. About one in five children were taken to informal providers, including drug shops and traditional healers. Among children testing positive for malaria, only 19 (9%) received the recommended injectable antimalarial followed by artemisinin-based combination therapy. Over one year, 58 under-five deaths were reported, corresponding to 53.8 per 1000 children (95% CI: 29.2–78.4).

Conclusions:

In Kapolowe, timely access to formal care is low, and severe childhood illness is often first managed at health posts—facilities mandated to refer severe cases. If referrals are not completed, children are unlikely to receive adequate care. Strengthening community-based case management and ensuring consistent availability of effective treatments at community level may offer a pragmatic pathway to improve child survival in remote settings.

Introduction

In sub-Saharan Africa, malaria is the leading cause of morbidity and mortality among children under five. In 2024, the World Health Organization (WHO) estimated 263 million malaria cases and 597,000 related deaths globally, with the African Region shouldering 94% of cases and 95% of deaths(1). Children under five account for approximately three-quarters of malaria-related mortality(1). The Democratic Republic of the Congo (DRC) is disproportionately affected, contributing 12% of global cases and 11% of deaths—second only to Nigeria(2).

Timely access to effective antimalarial treatment is critical to reduce mortality. However, for some children with severe malaria and living in remote areas, reaching appropriate care may be delayed by resources,

distance, transport barriers, and limited health system capacity. When referral to equipped facilities is not immediately possible, WHO recommends pre-referral medication with either a single parenteral dose or rectal artesunate suppositories (RAS), especially for children unable to take oral medications(3). WHO guidelines support the use of RAS within an Integrated Community Case Management (iCCM) strategy by community health workers (CHWs) and primary care providers when injectable antimalarials are unavailable. This strategy has also been adopted by the Congolese National Guidelines(4, 5).

Evidence from randomized trials has demonstrated that pre-referral RAS can significantly reduce mortality from severe malaria(6). Nonetheless, in real-world conditions, ensuring the full continuum of care—from RAS administration to completion of referral and definitive treatment—remains a major challenge in remote health systems. Incomplete referral, treatment delays, and limited follow-up can undermine the potential benefits of RAS and leave children at continued risk of severe outcomes. Recent expert review prompted WHO to update its guidance in 2023, reaffirming that RAS remains a recommended pre-referral intervention for children under six with suspected severe malaria where prompt referral is possible and feasible(3).

Despite clear protocols, effective referral and completion of the antimalarial treatment sequence may remain a challenge in poor and remote DRC settings like Kapolowe. Some children may experience substantial delays or are unable to reach referral health facilities, leaving them at continued risk for poor outcomes. In this context, qualitative research from the same health zone has shown that mothers often delay seeking biomedical care, starting instead with self-medication, traditional remedies and prayers, with decisions strongly constrained by distance, transport difficulties, costs and cultural norms (7). To address this, strategies such as the SEMA ReACT study propose offering RAS plus a full course of artemisinin-based combination therapy (ACT) at the community level when referral cannot be materialized, aiming to increase access to lifesaving care and reduce under-five mortality.

To inform the design and evaluation of such community-based interventions, robust population based baseline data are needed. This paper presents findings from a population-based, cross-sectional survey conducted in Kapolowe District prior to community-level RAS implementation. The survey characterizes caregiver care-seeking practices, barriers to timely treatment, current treatment pathways, and under-five mortality patterns—establishing a critical reference point for assessing the impact of innovative malaria management strategies in remote settings.

Materials and Methods

Study setting

Kapolowe Health District is a rural area located in Haut-Katanga province, in the southeastern part of the DRC. The district lies approximately 100 kilometers from Lubumbashi, the provincial capital, and is situated around Lake Tshangalele, intersected by the Lufira River. The local economy is primarily sustained by agriculture, fishing, and artisanal mining.

Administratively, Kapolowe is subdivided into 16 Health Areas within 5 distinct Axes, each serving as a catchment zone for health service delivery. Across these Health Areas, the district is served by a total of 65 public health posts, 10 community health sites, and 4 hospitals. In terms of management of severe malaria, health posts and CHWs are required to refer all suspected severe (malaria) cases to hospitals for definitive care. Figure 1 below shows the distribution of surveyed Villages and Health Service Delivery Points (CHWs, Health Posts, and Hospitals) in Kapolowe District.

In 2024, the under-five population in the district was 69,991 children. In 2024, the health system recorded 15902 malaria cases among children under five, including 1391 classified as severe. The reported incidence

was 1596 cases per 1000 children. Kapolowe is recognized as one of the sentinel surveillance sites of the National Malaria Control Programme due to its high burden of malaria.

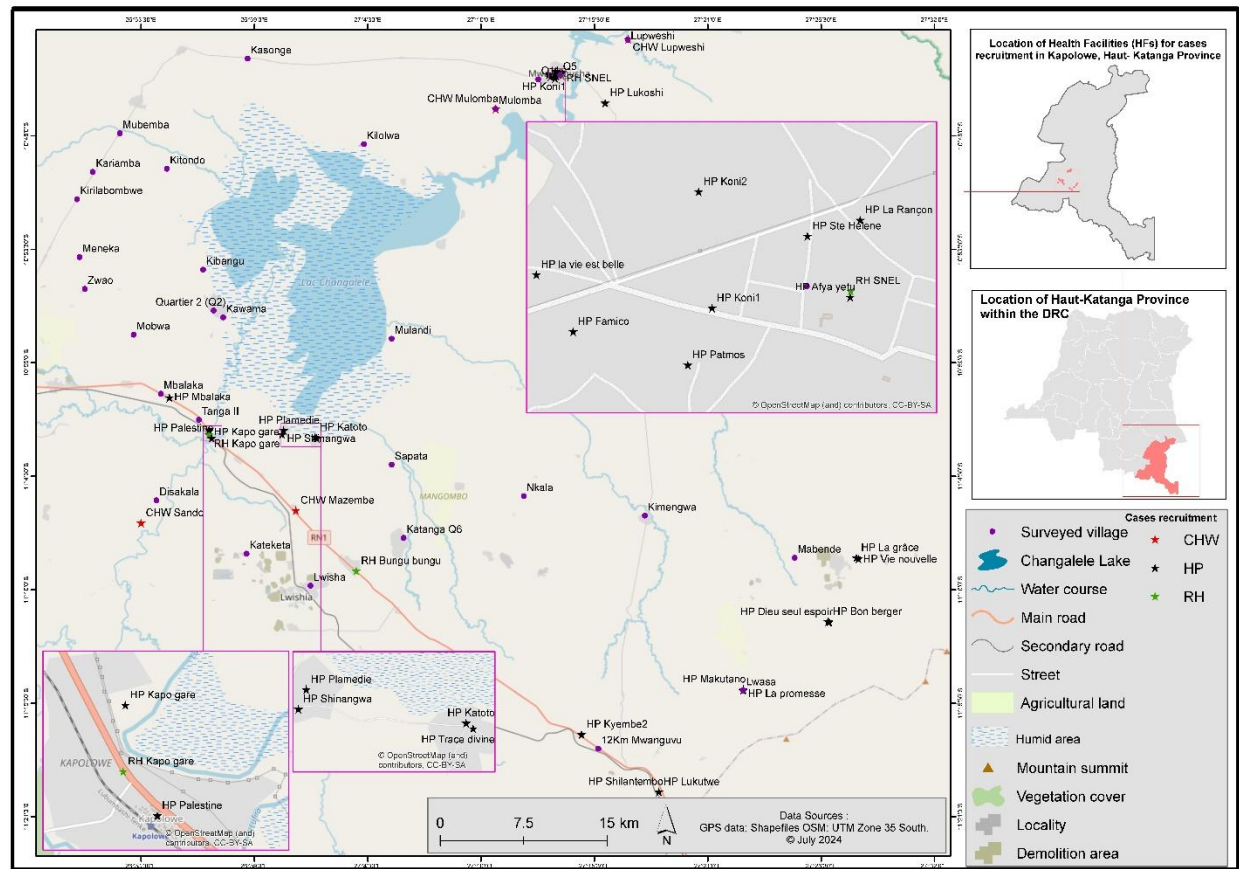


Figure 1 Surveyed villages and service delivery points (CHWs, Health Posts, Hospitals) in Kapolowe District, DRC

Study design

As part of the SEMA ReACT study, a two-stage 30-by-30 cluster survey was conducted, with 30 clusters—each corresponding to a village—randomly selected in the first stage. In the second stage, a minimum of 30 households were systematically selected within each cluster. The sample size was determined using the Oxfam Practical Health Guide to achieve ± 5 percentage point precision for prevalence estimates (8). In the

first stage, 30 villages were selected from a total of 181 across 16 health areas within 5 distinct Axes using probability proportional to size (PPS) sampling. Village population data were obtained from the district Ministry of Health's annual mosquito net distribution lists, and selection was stratified by health area. Random selection was performed using Excel's RAND() function. In the second stage, a minimum of 30 households per village were selected via systematic random sampling. The sampling interval was calculated by dividing the total number of households in a village (obtained from village leaders) by the target sample size of 30 households (e.g., every fourth household in a village of 120 households). A random starting household was then selected by drawing a number (1–10) from numbered papers, followed by selecting every *n*th household based on the calculated interval. Households were then selected at regular intervals (e.g., every fourth household in a village of 120 households). Villages with fewer than 50 households were combined with the nearest neighboring village and treated as a single cluster. Households were eligible if they included at least one child aged 0–5 years and a caregiver (aged ≥18 years, residing in the household during the recall period) provided informed consent. Ineligible or non-consenting households were replaced by the next adjacent household.

Data Collection

Data were collected from March to April 2024 through structured household interviews conducted in French or Swahili by trained enumerators. Interviews were conducted with caregivers, defined as individuals aged ≥18 years, residing in the household during the recall period, and able to provide accurate information on demographics, health-seeking behaviors, and mortality for children under five. The questionnaire was adapted from validated instruments: Sections A–C (demographics, household composition, malaria knowledge) from (9, 10), and Sections D–F (health-seeking behaviors) from the Malaria Indicator Survey Woman's Questionnaire (11). The questionnaire was piloted in non-sampled households. Mortality data were collected for January 2023 to the survey date, with a one-year recall

period (March 2023–February 2024) applied during analysis. Health-seeking behavior data covered the one-month period prior to the survey, per the Malaria Indicator Survey protocol. For each village, a single GPS coordinate was recorded at the first surveyed household and used to represent the village location for distance calculations.

Statistical analysis

All analyses were performed in R (version 4.4.3) and accounted for the multi-stage sampling design using survey weights. Survey weights were constructed as follows:

Steps to Calculate Survey Weights:

1. The probability of selecting an Axis (P_{axis}) and health area (P_{ha}). All 5 Axes and 16 Health Areas were included in the survey, thus the probability was all equal to 1.

2. Probability of Selecting a Village within a Health Area:

$$P_{village} = \frac{\text{Number of villages selected in a Health Area}}{\text{Total number of villages in that Health Area}}$$

3. Probability of Selecting a Household within a Village:

$$P_{hh} = \frac{n_h}{N_h} \quad \text{where } n_h \text{ is the number of households surveyed in the a village and } N_h \text{ is the total number of households in that village.}$$

4. The Overall Probability of Selection for Each Household:

The overall probability of selecting a household (P) is the product of the probabilities at each stage:

$$P = P_{axis} * P_{ha} * P_{village} * P_{hh}$$

5. Survey Weight

The survey weight (W) for each household is the inverse of the overall probability of

$$\text{selection: } W = \frac{1}{P_{axis} * P_{ha} * P_{village} * P_{hh}}$$

Finally, the weights were rescaled so that the total number of households matched administrative figures obtained from the Kapolowe District Health Office, specifically household counts that received mosquito nets. A weighted survey design, incorporating clustering at village and household levels and stratification by health area, was specified using the `svydesign(4.4-2)` function from the R survey package and applied to all analyses, including mortality, prevalence, and regression models.

Since all under-five children within a sampled household were interviewed, individual-level sampling probabilities were identical to the household selection probability. Accordingly, individual-level weights were set equal to the household weights.

Descriptive statistics were used to summarize household and caregiver characteristics. Categorical variables were summarized using unweighted frequencies and unweighted proportions, as well as survey-weighted proportions with 95% confidence intervals. Weighted estimates are the primary results for inference, while unweighted proportions are presented for transparency and comparison with the raw sample distribution. Continuous variables were summarized using medians and interquartile ranges.

Distance between each surveyed villages and the nearest health facility was calculated using GPS coordinates, applying the Haversine formula(12).

A care-seeking cascade was constructed to visually represent the health-seeking behavior of under-five children who had malaria-related symptoms or danger signs in the month preceding the survey. Danger signs were considered a proxy for suspected severe malaria. The cascade included symptom recognition, treatment-seeking, type of provider, diagnostic testing, and treatment received.

Survey-weighted logistic regression was used to identify factors associated with timely care-seeking, defined as seeking care from the formal health system (health posts, CHWs, or government hospitals) within 24 hours of symptom onset—based on the operational definition used by Salim et al(13).

Explanatory variables included socio-demographic characteristics, household assets, malaria-related knowledge and perception, and healthcare access barriers. These were informed by Andersen’s Behavioral Model of Health Services Use (14) and supplemented by existing literature(13, 15-18).

Information on household assets commonly used for constructing socio-economic status indices(19)—including access to electricity, and ownership of a radio, mobile phone, bicycle, motorbike, car or truck, television, and livestock— was collected to derive a composite wealth index using Principal Component Analysis (PCA). PCA scores were then divided into three socio-economic categories (low, middle, and high).

Univariate models were first fitted to explore bivariate associations, and variables with p-values ≤ 0.05 were included in the multivariable model. Adjusted odds ratios (AORs) and 95% confidence intervals were reported from the final model. For this analysis, formal facilities were defined as public or accredited providers integrated into the government health system (health posts, community health workers, and government hospitals), whereas informal providers included street drug sellers, private pharmacies, traditional healers, and other non-accredited sources of care.

Under-five mortality (U5MR) was estimated using the standard demographic formula for calculating mortality rates in a closed population over a fixed time period:

$$U5MR = \frac{D}{P_{mid}}$$

where D represents the number of under-five deaths recorded between March 2023 and March 2024, and P_{mid} is the mid-period population at risk of death. The mid-period population was calculated as

$$P_{mid} = N + 0.5D - 0.5B$$

Where:

- N is the number of surviving children under five years at the time of the survey

- D is the number of under-five deaths during the reference period (March 2023–March 2024),
- B is the estimated number of live births during the same period

The $0.5D - 0.5B$ adjustment assumes that deaths and births occurred uniformly over the period. This allows for an approximation of person-time at risk: children who died contributed partial exposure time before death, and newly born children were only partially exposed to the full period under observation.

While the number of deaths (D) and surviving children (N) were directly reported by households, births (B) were not collected during the survey. Therefore, we obtained annual birth from the district's civil registration system and adjusted for under-registration assuming 40% completeness, based on World Bank estimates for DRC (20). Under-five mortality rates were estimated as the number of deaths per 1000 children per year, with 95% confidence intervals. In addition, we calculated an unweighted crude under-five mortality rate based only on the numbers of surviving children and deaths observed in the sample, approximating the mid-period population as $n + 0.5d$ and assuming a closed population with uniformly distributed deaths over the period. In this expression, n denotes the number of surviving children under five recorded in the sample at the time of the survey, and d is the total number of under-five deaths reported in the sample.

Results

Household and Caregiver Characteristics

A total of 906 households were surveyed from 30 villages, corresponding to 906 caregivers and 1,243 children under the age of five. Table 1 presents the socio-demographic and household characteristics of respondents. The majority of caregivers were female (85%; 95% CI: 83%–87%) and married (94%; 95% CI:

223 93%–96%). One in five caregivers (20%; 95% CI: 15%–25%) had no formal education, while 50% (95% CI:
 224 45%–55%) had completed primary education. The median age of caregivers was 29 years (IQR: 24–37).
 225 The median household size was six members (IQR: 4–8). Asset ownership was limited: 12% (95% CI: 6.8%–
 226 20%) of households had electricity, 16% (10%–23%) had a television, and 1% (0.29%–2.1%) owned a car
 227 or truck, while mobile phone (48%; 41%–55%) and radio (43%; 36%–49%) ownership were more common.
 228 Approximately one-third of households reported owning livestock (34%; 29%–40%), and about one-third
 229 owned a bicycle (31%; 25%–38%). The main sources of household income were fishing, agriculture or
 230 cash-crop sales (80%; 68%–88%), with smaller proportions relying on commerce (7%; 3.6%–12%), salaried
 231 employment such as teaching or health services (4%; 2%–6%), or other income sources (10%; 5%–21%)
 232 Caregivers most commonly reported a public health post as the nearest health provider (65%; 51%–76%),
 233 followed by private or other drug sellers (24%; 16%–34%), community health workers (9%; 4%–19%), and
 234 public hospitals (2%; 0.9%–4%). Walking was the predominant mode of transport to health facilities (81%;
 235 70%–89%), with fewer households using public transport or motorcycle (15%; 9%–25%) or bicycles (4%;
 236 2%–8%).
 237 In terms of geographic accessibility, over half of households (53%; 95%CI: 32%–72%) lived in villages
 238 located within 2 kilometers of the nearest formal health facility. Approximately one-fifth (23%; 95% CI:
 239 10%–44%) resided in villages 2-5 kilometers away, and 24% (95%CI: 15%–36%) in villages more than 5
 240 kilometers away. When focusing on public hospitals, 30% of households (95% CI: 13%–55%) lived in villages
 241 within 5 km, 11% (95% CI: 4%–31%) in villages 5–10 km away, and 18% (95% CI: 4%–51%) in villages 10–
 242 15 km away. Notably, 41% of households (95%CI: 23%–62%) lived in villages located more than 15
 243 kilometers from a public hospital.
 244 Fifty-three percent (95%CI: 48%–58%) of caregivers reported having heard a malaria-related message.
 245 Most caregivers perceived malaria as a very serious health problem (83%; 95% CI: 79%–87%), were able

to mention at least one malaria symptom (83%; 95% CI: 80%–85%), and believed malaria is treatable (81%; 95% CI: 77%–85%).

In health areas where community health workers were available (n=537), 43% (95% CI: 27%–61%) of caregivers reported knowing a CHW, and among those, 98% (95% CI: 95%–99%) stated they would seek care from a CHW in the event of child illness.

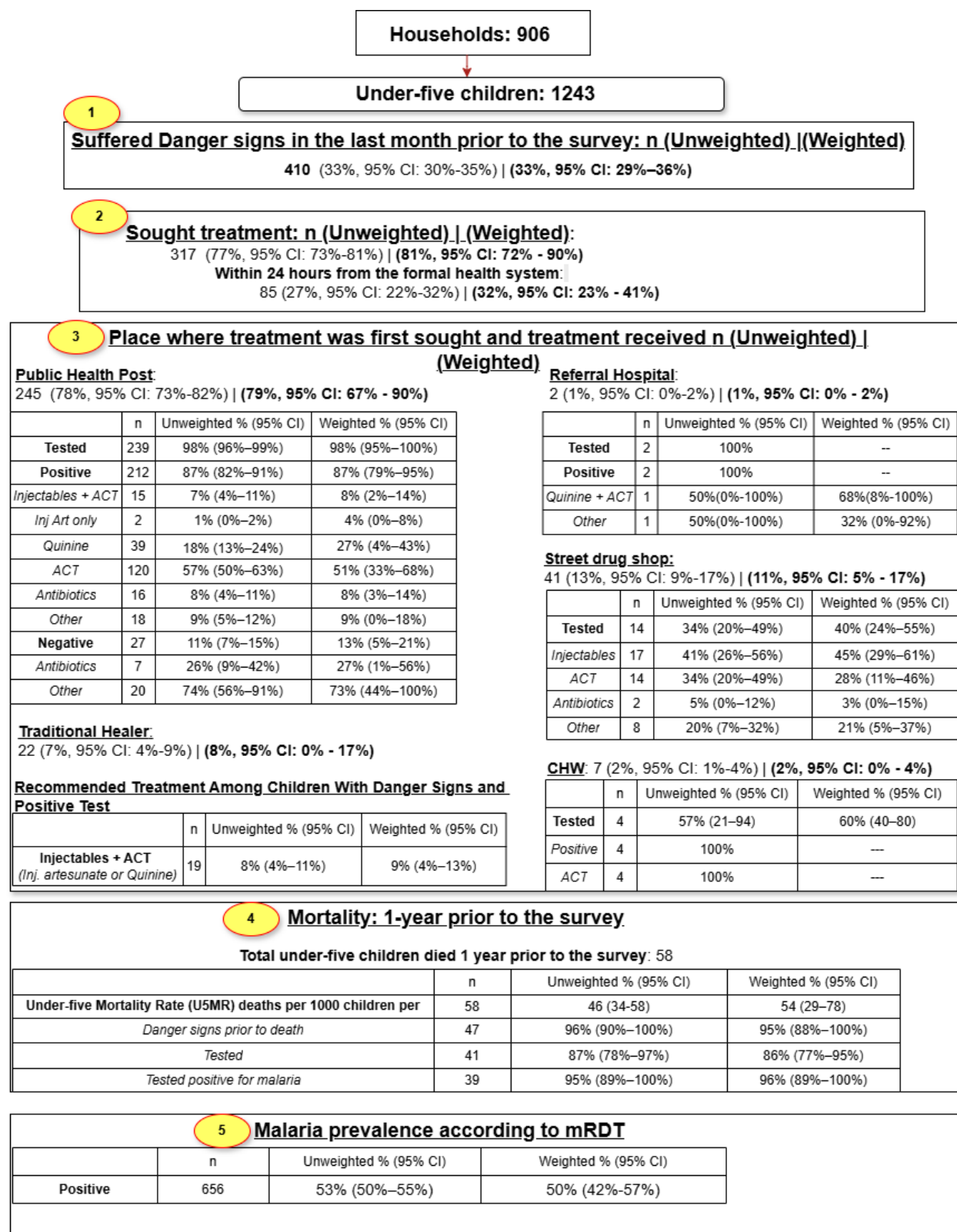
Care-Seeking and Treatment Access for Suspected Severe Malaria

Care-Seeking and Treatment Access for Suspected Severe Malaria are summarized in Figure 2. Among 1243 children under five years of age across 906 surveyed households, 33% (95% CI: 29%–36%) were reported to have experienced at least one danger sign in the month preceding the survey. Of these, 81% (95% CI: 72%–90%) were reported to have sought treatment from any provider, but only 32% (95% CI: 23%–41%) accessed the formal health system within 24 hours of symptom onset.

Among those who sought care, the majority of caregivers reported first seeking treatment at public health posts (79%, 95% CI: 67%–90%), followed by street drug sellers or pharmacies (11%, 95% CI: 5%–17%), community health workers (CHWs) (2%, 95% CI: 0%–4%), and government hospitals (1%, 95% CI: 0%–2%). Traditional healers and other informal providers were reported in 8% of cases (95% CI: 0%–17%).

At public health posts, 98% (95% CI: 95%–100%) were reportedly tested for malaria, of whom 87% (95% CI: 79%–95%) tested positive. Among those testing positive, ACT was the most commonly reported treatment (51%, 95% CI: 33%–68%), followed by quinine (27%, 95% CI: 4%–43%), injectable artesunate (4%, 95% CI: 0%–8%) and 8% (95% CI: 2%–14%) reportedly received an injectable antimalarial (quinine or injectable artesunate) in combination with ACT. Antibiotics were given to 8% (95% CI: 3%–14%), and 9% (95% CI: 0%–18%) received no medication. Among children who tested negative (13%, 95% CI: 5%–21%), 27% (95% CI: 1%–56%) reportedly received antibiotics and 73% (95% CI: 44%–100%) received no medication.

269 At the CHW level, 60% (95% CI: 40%–80%) of children were reportedly tested; all tested positive and all
270 received ACT (100%). At hospitals, children were reportedly tested and found positive, with 68% (95% CI:
271 8%–100%) receiving quinine. Across all provider types, among children with danger signs who sought care
272 and tested positive for malaria, only 9% (95% CI: 3%–14%) received the recommended full treatment—an
273 injectable antimalarial followed by an ACT.



** Numbers in yellow circles are for navigation only. They label the sections within the figure (1–5). Abbreviations: ACT, artemisinin-based combination therapy; Inj Art, injectable artesunate.

Figure 2 Cascade of Health-Seeking Behaviour, Treatment Pathways, and Mortality Among Under-Five Children.

Factors associated with prompt health-seeking of care among children under-five with signs of malaria or danger signs are shown in Additional file 1: Table 1. In adjusted analyses, children of non-married caregivers had significantly lower odds of receiving timely care compared with those of married caregivers (aOR: 0.21, 95% CI: 0.05–0.87; $p = 0.03$). Caregivers who reported a formal health provider as the nearest facility had higher odds of seeking care within 24 hours than those whose nearest provider was an informal drug seller (aOR: 6.94, 95% CI: 2.18–22.1; $p < 0.001$). Knowledge that fever is a symptom of malaria was also associated with timely care-seeking (aOR: 2.96, 95% CI: 1.26–6.99; $p = 0.02$), as was exposure to a malaria-related message (aOR: 2.69, 95% CI: 1.12–6.46; $p = 0.03$). Other caregiver and household characteristics, including sex, age, education, socio-economic status, distance to the health facility, and perceived seriousness or treatability of malaria, were not significantly associated with timely care in the adjusted model.

Under-Five Mortality

A total of 58 under-five deaths were reported to have occurred in the year preceding the survey (Figure 2). This translates to an estimated under-five mortality rate (U5MR) of 53.8 deaths per 1,000 children per year (95% CI: 29.2–78.4). Among those who died, 47 (95%, 95% CI: 88%–100%) reported had experienced danger signs for suspected severe malaria prior to death. Of these, 41 (86%, 95% CI: 77%–95%) reported tested for malaria, and 39 (96%, 95% CI: 89%–100%) tested positive.

Discussion

This study described care-seeking patterns, access to treatment, and under-five mortality in a remote, high-transmission district of the DRC prior to community-level iCCM strengthening. Using caregiver-reported illness episodes and danger signs as a proxy for severe illness, we examined care pathways and treatment received, defining timely access as reaching a formal health provider within 24 hours of symptom onset. Weighted and unweighted estimates were very similar across most variables, suggesting that the achieved sample is generally consistent with the population structure implied by the sampling design, at least for the variables used to construct and scale the weights.

One in three children under five had experienced danger signs in the preceding month, yet only about a third of these reached a public health facility within 24 hours. This pattern is consistent with regional evidence: a meta-analysis of 36 sub-Saharan African countries reported that only 26% of febrile children received treatment within 24 hours, with delays most pronounced in rural and poor areas(21). In Kapolowe, qualitative work from the same health zone has shown that mothers often delay biomedical care while first using self-medication, traditional remedies and prayers, with decisions shaped by transport difficulties, treatment costs and local norms around illness and care-seeking (7). Reliance on informal providers was also common in our data, with about one in five severely ill children taken to drug shops/pharmacies (11%) or traditional healers (8%). Such practices are well-documented in the DRC(22) and across Africa (23-25). Evidence from Uganda further suggests that reliance on home-based remedies and traditional herbs is strongly associated with delayed treatment-seeking (26). In settings like Kapolowe, such delays may critically determine survival.

We also examined predictors of timely care-seeking. In adjusted models, timely access was more likely when caregivers were married, had heard a malaria-related message, recognized fever as a symptom of malaria, and reported a formal health provider as the nearest source of care. In particular, the association

between exposure to malaria messages and timely care-seeking underscores the importance of sustained, community-level sensitization efforts that emphasize early care-seeking for danger signs and where to obtain appropriate treatment. The findings are consistent with multicountry evidence that household decision-making support, symptom knowledge, and physical proximity to services increase the likelihood of early treatment (21, 23, 24). The absence of associations with other demographic factors was unsurprising given the socioeconomic homogeneity of Kapolowe, where most caregivers are peasant farmers engaged in subsistence agriculture, fishing, or artisanal mining.

Hospitals—although the only facilities equipped to provide definitive treatment for severe illness—were the first point of care for fewer than 1% of children in Kapolowe. This finding is consistent with other settings; for example, a study of 784 children admitted with severe febrile illness to Kisantu District Hospital in DRC reported that fewer than 1% had initially sought care directly at the hospital (27). The very low reliance on hospitals in Kapolowe is likely explained, at least in part, by the limited availability of such facilities—only four hospitals serve the entire district—making them geographically and financially inaccessible for most households.

CHWs were also rarely the first point of contact in Kapolowe (2%). This low reliance on CHWs for severe disease reflects a broader regional pattern: in sub-Saharan Africa, the proportion of malaria cases diagnosed and treated by CHWs remains far lower than in other regions such as Southeast Asia, where more than half of cases are managed by CHWs compared with just 1% in Africa (28). Although CHWs are essential for improving access to care and reducing malaria incidence, their role in Kapolowe appears constrained by systemic and operational challenges. The district has only eight CHWs serving a widely dispersed population, and fewer than half of caregivers reported knowing a CHW in their community. Evidence from other African settings suggests that additional challenges—such as frequent stock-outs of essential commodities, high workload, and insufficient system support—further constrain CHW involvement in community-based malaria diagnosis and treatment (29).

Our survey in Kapolowe revealed that nearly 80% of the caregivers reported first seeking treatment for children with malaria danger signs at public health posts within the past month. This proportion is substantially higher than the 28% reported nationally, where 72% of caregivers initially relied on informal sources such as self-medication or traditional healers for uncomplicated malaria (22). The observed discrepancy may partly reflect methodological differences between the two surveys. Our retrospective, home-based approach, which required caregivers to recall health-seeking actions from the preceding month, may have led to over-reporting of formal health system use due to social desirability bias, as respondents tend to report the appropriate behaviour of attending formal facilities. In contrast, the facility-based design of Kayiba et al. (22) may have led to over-reporting of informal care, since caregivers presenting at health facilities often emphasize prior attempts with herbs or over-the-counter medicines to demonstrate that they had tried everything before seeking professional care.

The high reported use of health posts in Kapolowe is nevertheless consistent with the local health system structure, as these facilities represent over 80% of public health institutions in the district. However, according to national guidelines (5), health posts are expected to refer children with danger signs to hospitals because they lack the capacity to manage severe malaria. In practice, health posts in Kapolowe function similarly to community health workers—serving as initial points of contact where prompt referral is essential but definitive treatment remains unavailable. This means that the vast majority of severely ill children in Kapolowe begin their treatment journey at the community level, where referral is essential but definitive treatment is not formally available.

One concerning manifestation of health system weakness in Kapolowe is the off-guideline administration of injectable antimalarials by health workers at health posts. National guidelines restrict the use of injectables to hospitals, with community-level providers expected to refer severe cases (5). Despite this, caregivers reported children receiving injectable treatment at health posts. Such practices are likely driven by failed referrals, caregiver demand for perceived stronger medicines, and, in some cases, informal

payments, as has also been documented in Uganda (30, 31). Empirical injectable use at health posts and drug shops often occurs alongside polypharmacy (25). Polypharmacy raises multiple concerns, including increased risk of adverse drug reactions, drug–drug or drug–disease interactions, emergence of resistant strains, and poor adherence (32). It also imposes unnecessary costs on households through the purchase of redundant drugs. These off-protocol practices compromise safety, quality, and equity of care, underscoring the need to strengthen community case management with accessible, guideline-aligned options such as RAS followed by ACT.

Malaria testing using RDTs (finger or heel prick) among children who sought care in the public health system exceeded 95%, a level consistent with national estimates. According to the WHO Malaria Country Profile for the DRC (2024), malaria testing of febrile under-five children in public facilities increased from below 50% in 2010 to over 90% in 2023 (33). This high coverage reflects both the provision of free RDT-based diagnosis and the availability of RDT commodities within the public health system.

However, diagnostic uncertainty continues to complicate case management at the community level. Only a small fraction of danger-sign cases reported a negative malaria test, while survey malaria RDTs showed that roughly half of all under-five children were parasitemic—reflecting the high background prevalence of asymptomatic malaria in intense transmission settings. In such contexts, severely ill children may present with non-malarial febrile illnesses accompanied by incidental parasitemia (34, 35), which risks masking bacterial infections such as pneumonia or sepsis. This reinforces the rationale for administering pre-referral RAS to all danger-sign cases irrespective of malaria confirmation, and—where referral is not feasible—combining it with an oral antibiotic such as amoxicillin when the child can swallow to cover common bacterial pathogens (36, 37).

Coverage of definitive severe malaria treatment is low in Kapolowe: About 1 in 5 children reported with danger signs sought care and tested positive for malaria received effective treatment, consistent with

391 other African settings where fewer than half of severe cases receive full guideline-concordant therapy (38).
392 This under-treatment likely contributes to the high annualized under-five mortality rate in Kapolowe (53.8
393 per 1,000 live births), which is comparable to national estimates for DRC (57–85 per 1,000) (39, 40).
394 This study has several limitations that should be considered when interpreting the findings. First, distance
395 to care was approximated at the village level rather than at the individual households level. Straight-line
396 (“as-the-crow-flies”) distances between village GPS coordinates and the nearest health facility were
397 calculated using the Haversine formula. This approach was not triangulated with other social determinants
398 of health (e.g., education access, economic stability) or with additional barriers, such as within-village
399 variation, road networks, terrain, river crossings, seasonal flooding, or transport availability. As a result,
400 true geographic accessibility and may have been misclassified and travel barriers underestimated,
401 potentially attenuating any observed association between distance and timely care-seeking.
402 Second, the survey did not assess the feasibility of referrals or the reasons why they may not be completed.
403 This is an important gap, particularly as most children first sought care at health posts, which are mandated
404 to refer severe case. Evidence from other African countries highlights referral challenges (31, 41, 42).
405 Ongoing active surveillance in the same study area is assessing referral feasibility and barriers, and
406 forthcoming findings from that work will provide deeper insights into where and why referral pathways
407 fail.
408 Third, all information on illness episodes, symptoms (danger signs), care-seeking behavior, and treatments
409 received was reported by caregivers, introducing the possibility of recall bias—especially for the
410 one-month danger sign recall period—and misclassification bias, as caregiver interpretation of “danger
411 signs” may differ from clinical definitions. This is supported by our finding that over half of children
412 reported with danger signs who sought treatment and tested positive were said to have received only oral
413 ACT, suggesting potential over-reporting of severity.

414 Fourth, although reported malaria testing was linked to caregiver recall of results, there remains potential
415 for diagnostic misclassification, particularly in this high-transmission setting where incidental parasitaemia
416 is common; some children diagnosed as having “severe malaria” may have had severe non-malarial febrile
417 illnesses.

418 Finally, under-five mortality estimates relied partly on official district birth data adjusted for
419 under-registration, using national-level completeness assumptions. While we corrected for
420 incompleteness, sub-national variation in birth registration rates could lead to under- or over-estimation
421 of the true mortality rate at district level. In addition, because the survey only included households with
422 surviving children under five, households that had lost all young children were not captured, which may
423 further underestimate mortality.

424 Despite these limitations, our study highlights important gaps within Kapolowe’s health system, including
425 delayed access to formal care, management of severe cases at the community level, and reliance on
426 informal treatment for severe childhood illness. Addressing these gaps will require strengthening
427 community-level case management, ensuring that public health posts are functional and well-supplied,
428 and improving caregiver recognition of danger signs. Integrated approaches that address both malaria and
429 potential bacterial co-infections—through the provision of pre-referral RAS and antibiotics when referral
430 is not feasible—are particularly crucial in high-transmission, remote settings. Experiences from Malawi
431 demonstrate that integrating malaria RDTs with pre-referral RAS at the community level, alongside
432 targeted caregiver sensitization, can dramatically improve access and appropriateness of care. In
433 intervention areas, use of CHWs for childhood illness increased from 34% to 90%, while reliance on
434 inappropriate or informal providers declined markedly (43). In light of WHO/UNICEF estimates that
435 well-implemented iCCM can reduce overall under-five mortality by up to 40% and malaria-specific
436 mortality by 60% when paired with effective sensitization and uninterrupted RAS/ACT supply chains (4),

437 scaling up these proven strategies in Kapolowe’s context offers a clear, evidence-based pathway to
438 substantial survival gains.

439 Conclusion

440 This study shows that in Kapolowe, timely access to formal care is low, with only one in three children
441 reaching a provider within 24 hours of symptom onset. Most children first present to public health posts,
442 which are mandated to refer severe cases but are not equipped to provide definitive treatment. When
443 referrals are not completed, many children are unlikely to receive adequate care. Strengthening iCCM
444 through the provision of community-level RAS, followed by ACT and antibiotics, alongside caregiver
445 education, may present a pragmatic approach to reducing preventable deaths in such settings.

446 List of abbreviations

447 ACT – Artemisinin-based Combination Therapy
448 aOR – Adjusted Odds Ratio
449 CHW – Community Health Worker
450 CI – Confidence Interval
451 DRC – Democratic Republic of the Congo
452 FGD – Focus Group Discussion
453 iCCM – Integrated Community Case Management
454 IQR – Interquartile Range
455 OR – Odds Ratio
456 PPS – Probability Proportional to Size
457 RAS – Rectal Artesunate
458 RDT – Rapid Diagnostic Test

459 SD – Standard Deviation
460 SEMA ReACT – Severe Malaria treatment with Rectal artesunate and Artemisinin-based Combination
461 Therapy in remote areas: Closing the Evidence Gap
462 U5MR – Under-Five Mortality Rate
463 WHO – World Health Organization

464 Declarations

465 Ethics approval and consent to participate

466 The general protocol of this study has received approval by the DRC National Committee of Health Ethics
467 (Reference n°502, amended to version 1.1. The approval letter n°567/CNES/BN/N°567/PMMF/2024, dated
468 28.08.2024. Amended to V 2.1. The approval letter n°668/CNES/BN/PMMF/2025, dated 29.05.2025).
469 Participation was voluntary, and investigators explained the purpose of the study to caregivers before data
470 collection. Written informed consent was obtained from all participants. Prior to each interview,
471 enumerators read the consent form in Swahili, outlining the study objectives, survey procedures and
472 duration, optional participation in focus group discussions, and collection of small blood samples from
473 children for malaria testing. The form also emphasized voluntary participation, the right to withdraw
474 participation or decline questions at any time, the absence of financial compensation, and strict
475 confidentiality. Contact details of the investigators and the ethics committee were provided.

476 Consent for publication

477 Not applicable.

478 Availability of data and materials

479 Data and codes are available from the corresponding author on reasonable request.

480 Competing interests

481 The authors declare no competing interests.

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488 Authors' contributions

489 TM, AK, BM, GK, VM, AM, EM, MN, CM, HB, GM, JPV and HM conceived and designed the study. TM, JS,
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496 Authors' information

497 ¹ Global Health Institute, University of Antwerp, Antwerp, Belgium. ²University of Lubumbashi,
498 Lubumbashi, Democratic Republic of the Congo. ³University of Kinshasa, Kinshasa, Democratic
499 Republic of the Congo. ⁴National Malaria Control Program, Ministry of Health, Kinshasa,
500 Democratic Republic of the Congo. ⁵ Primary and Interdisciplinary Care, University of Antwerp,
501 Antwerp, Belgium. ⁶ National Health Research & training institute, Zambia. ⁷ MMV Medicines for
502 Malaria Venture, Switzerland. ⁸National Institute for Medical Research (NIMR), Tanzania.
503 Tafadzwa Maseko², Deborah Bora Kanyamukenge^{1,2}, Flory Luzolo Khoté^{1,3}, Jérémie Sombola³,
504 Aimé Kakudji², Baudouin Matela⁴, Ghislain Kikunda^{2,4}, Vivi Maketa Tevuzula³, Augustin Mutombo
505 Mulangu², Eric Mukumena Sompwe², Sebastian Hachizovu⁶, Michael Nambozi⁶, Shepherd
506 Khondowe⁶, Vito Baraka⁸, Hans Rietveld⁷, Stephan Duparc⁷, Katy Athersuch⁷, Gwen Lemey¹, Hilde
507 Bastiaens^{1,5}, Christine Manyando⁶, Geoffrey Makenga^{1,8}, JP Van geertruyden¹, Hypolite Muhindo-
508 Mavoko³

509 Corresponding author

510 Tafadzwa Maseko

511 Email address of the corresponding Author

512 Tafadzwa.Maseko@uantwerpen.be

513 Author information

514 Tafadzwa Maseko and Deborah Bora Kanyamukenge contributed equally to this work

515 **Authors Affiliations**

516 **Global Health Institute, University of Antwerp, Antwerp, Belgium**

- 517 Tafadzwa Maseko, Deborah Bora Kanyamukenge, Flory Luzolo Khote, Gwen Lemey, Hilde Bastiaens,
518 Geoffrey Makenga and JP Van Geertruyden
- 519 **University of Lubumbashi, Lubumbashi, Democratic Republic of the Congo**
- 520 Deborah Bora Kanyamukenge, Aimé Kakudji, Ghislain Kikunda, Augustin Mutombo Mulangu and Eric
521 Mukumena Sompwe
- 522 **University of Kinshasa, Kinshasa, Democratic Republic of the Congo**
- 523 Flory Luzolo Khote, Jérémie Sombola, Vivi Maketa Tevuzula and Hypolite Muhindo-Mavoko
- 524 **National Malaria Control Program, Ministry of Health, Kinshasa, Democratic Republic of the Congo**
- 525 Baudouin Matela and Ghislain Kikunda
- 526 Primary and Interdisciplinary Care, University of Antwerp, Antwerp, Belgium
- 527 Hilde Bastiaens
- 528 National Health Research & Training Institute, Zambia
- 529 Sebastian Hachizovu, Michael Nambozi, Shepherd Khondowe and Christine Manyando
- 530 Medicines for Malaria Venture (MMV), Switzerland
- 531 Hans Rietveld, Stephan Duparc and Katy Athersuch
- 532 National Institute for Medical Research (NIMR), Tanzania
- 533 Vito Baraka and Geoffrey Makenga

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650

	N	n	Unweighted proportion (95% CI)	Weighted proportion (95% CI)
Sex of caregiver	906			
Female		768	85% (83%–87%)	85% (83%–87%)
Male		138	15% (13%–17%)	15% (13%–17%)
Marital status of caregiver	904			
Married		856	95% (93%–96%)	94% (93%–96%)
Divorced		24	3% (2%–4%)	3% (2%–4%)
Single		11	1% (1%–2%)	1% (1%–2%)
Widowed		13	1% (1%–2%)	1% (1%–3%)
Education of caregiver	906			
No education		188	21% (18%–23%)	20% (15%–25%)
Primary education		460	51% (48%–54%)	50% (45%–55%)
Secondary/Tertiary education		258	28% (26%–31%)	31% (25%–37%)
¹Age of caregiver	906		29 (24, 37)	29 (24, 37)
¹Number of people in the household	899		6 (4, 8)	6(4, 8)
Assets for the household	906			
electricity		90	10% (8%–12%)	12% (7%–20%)
radio		366	41% (38%–44%)	43% (36%–49%)
mobile phone		405	45% (42%–49%)	48% (41%–55%)
bicycle		286	32% (29%–35%)	31% (25%–38%)
motorbike		104	12% (10%–14%)	11% (8%–15%)
car or truck		10	1% (0.4%–2%)	1% (0.3%–2%)
television		126	14% (12%–16%)	16% (10%–23%)
livestock		329	37% (34%–40%)	34% (29%–40%)
Main income of the household income	906			
Fishing/Agriculture/Cash Crop Sales		746	82% (80%–85%)	80% (68%–88%)
Commerce/Shop		53	6% (4%–7%)	7% (4%–12%)
Medical/Teacher/Government		30	3% (2%–5%)	4% (2%–6%)
Other		77	9% (6.7%–10%)	10% (5%–21%)
Nearest health facility	900			
Private/Other drug sellers		204	23% (20%–25%)	24% (16%–34%)
Public health post		578	64% (61%–67%)	65% (51%–76%)
Public hospital		15	2% (1%–3%)	2% (1%–4%)

Community health worker	103	11% (9.3%–13%)	9% (4%-19%)	
Mode of transport to health facility	903			
Bicycle	38	4% (3%–6%)	4% (2%-8%)	
On foot	713	79% (76%–82%)	81% (70%-89%)	
Public transport/motorcycle	152	17% (14%–19%)	15% (9%-25%)	
Distance to the nearest formal health care				
<2 km	906	388	43% (40%–46%)	53% (32%-72%)
2–5 km		266	29% (26%–32%)	23% (10%-44%)
>5 km		252	28% (25%–31%)	24% (15%-36%)
Distance to the nearest Public Hospital	906			
<5 km		181	20% (17%–23%)	30% (13%-55%)
5–10 km		132	15% (12%–17%)	11% (4%-31%)
10–15 km		153	17% (14%–19%)	18% (4%-51%)
>15 km		440	49% (45%–52%)	41% (23%-62%)
Heard malaria message	902			
No		425	47% (44%–50%)	47% (42%-52%)
Yes		477	53% (50%–56%)	53% (48%-58%)
Perception of malaria severity	906			
Not a serious health/ Somewhat serious		146	4% (2.5%–5.0%)	17% (13%-21%)
Very serious		756	84% (82%–86%)	83% (79%-87%)
Mention symptoms	906			
No		163	18% (16%–21%)	17% (15%-20%)
Yes		743	82% (79%–84%)	83% (80%-85%)
Is malaria treatable	893			
No		163	18% (16%–21%)	19% (15%-23%)
Yes		730	82% (79%–84%)	81% (77%-85%)
² Do you know any CHW around	540			
No		291	54% (50%–58%)	57% (39%-73%)
Yes		249	46% (42%–50%)	43% (27%-61%)
² Will you visit the CHW in the event of illness	248			
No		7	3% (0.8%–5%)	2% (0.7%-5%)
Yes		241	97% (95%–99%)	98% (95%-99%)

N = total number of respondents who answered the question; n = number of respondents in each category. Proportions and 95% confidence intervals are survey-weighted. ¹n; Median (Q1, Q3); ²The denominator only include participants from health areas where there are CHWs.

654 Table 1 Socio-demographic and Household Characteristics of Caregivers and Surveyed Households (n =
655 906).

656

Supplementary Files

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