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Delivering Integrated Community Case Management During Conflict: Service Delivery, Medicine Availability and Routine Data Quality in Yemen

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Abstract

Background

Integrated community case management (iCCM) depends on more than the presence of trained community health workers (CHWs); it also requires reliable commodities, functioning referral pathways and trustworthy routine information. This study examined service delivery, referral, medicine readiness and routine-data quality as interconnected components of a conflict-affected community child-health platform in Yemen.

Methods

We conducted a retrospective descriptive repeated-measures analysis of aggregate weekly service and medicine reports submitted by 33 programme personnel (30 CHWs and three community health supervisors) in four programme districts (Al Khawkhah and Hays, Al Hudaydah governorate; Khanfar, Abyan governorate; and Al Azarq, Al Dhala'e governorate) from November 2025 to July 2026. Data were cleaned before aggregation to CHW-month level. Desk-based data-quality checks assessed identifiers, duplicates, referral-case consistency and inventory balance; source-register or physical-stock verification was not undertaken. We summarised monthly trends, district referral rates and descriptive, hypothesis-generating comparisons of referral rates according to reported commodity zero-balance status.

Results

The cleaned datasets contained 999 weekly service reports, 1,008 weekly medicine reports and 256 observed CHW-months. The 33 programme personnel recorded 9,708 illness episodes: respiratory tract infection (RTI) 44.4%, fever 34.3% and diarrhoea 21.3%. There were 690 recorded referrals (7.1%); referral rates ranged from 2.9% in Hays to 20.9% in Al Azarq and increased in the final study months. At least one available weekly report recorded a zero remaining balance in 207/256 CHW-months (80.9%) for zinc, 105/256 (41.0%) for amoxicillin and 89/256 (34.8%) for oral rehydration salts (ORS). Zinc zero-balance occurrence remained high in every study month. Referral counts exceeded recorded case counts in at least one illness-age-sex stratum in 142/999 weekly service reports (14.2%).

Conclusions

Community-based iCCM recorded substantial service activity in conflict-affected Yemen, but frequent reported zero medicine balances, marked referral variation and material routine-data inconsistencies constrain interpretation of programme performance and may limit treatment readiness. The findings support integrated attention to commodity management, referral continuity, supportive supervision and

routine-data quality, while emphasising that a reported zero balance is not equivalent to a verified or month-long stock-out.

Introduction

Pneumonia, diarrhoea and febrile illness remain important causes of preventable illness and death among children, concentrated where timely assessment, essential medicines and referral care are least accessible [1, 2]. Armed conflict intensifies each barrier through damage to facilities and roads, population displacement, insecurity, interrupted salaries and disrupted procurement and transport.

Integrated community case management (iCCM) seeks to close this access gap by training CHWs to assess common childhood illnesses, provide protocol-based treatment, counsel caregivers, identify danger signs and refer children needing facility-based care. Community case management extends child-health service reach when supported by appropriate training, reliable commodities, supervision, referral linkages and usable information systems [3–5]. Consequently, iCCM performance depends on the functioning of an interconnected system of service delivery, commodity supply, referral pathways and information flow-not on CHW presence alone.

Yemen's protracted conflict has weakened health-system infrastructure, constrained humanitarian access and increased the cost and difficulty of reaching care. National and subnational analyses document marked geographical inequalities in access to functioning services and medicines [6–9]. Yemen-specific implementation research nevertheless shows that community approaches can remain operational during crisis while depending heavily on the surrounding system. A qualitative study of iCCM implementation in Lahj and Taiz identified supply-chain interruptions, supervision and travel constraints, and weak integration with the national health system [10]. Earlier qualitative studies of Integrated Management of Childhood Illness (IMCI) in Lahej similarly identified poor supervision, deficient drug and equipment supply, referral and integration challenges, and limited community awareness of the model [11, 12]. More recent quantitative work on community health and nutrition volunteers in Hajjah documented associations with childhood vaccination, diarrhoea and fever outcomes, but did not examine routine iCCM service activity, referral, medicine status and data quality together [13].

Evidence from other fragile and humanitarian settings reinforces the need to study these components together. A South Sudan iCCM case study showed that community treatment continued during acute conflict and recovered faster than the formal health sector, while supervision and displacement affected programme operations [14]. A humanitarian-setting scoping review similarly identified commodities, supervision, referral, integration and information systems as recurring requirements for effective community health delivery [15]. Across low- and middle-income countries, medicine stock-outs among CHWs are common, with supply-chain assessments identifying product availability, resupply capacity and transport as important constraints [16, 17]. Broader reviews identify feedback, workforce capacity, data-system design and organisational support as important influences on the quality and use of routine health information [18, 19]. Studies in Somalia, South Sudan and Sudan further demonstrate that

completeness, accuracy, timeliness and reporting continuity can deteriorate in fragile or conflict-affected systems [20–22].

Despite this relevant literature, published quantitative evidence on the day-to-day functioning of iCCM programmes in Yemen remains limited. In particular, we identified no published Yemen study that jointly examined CHW service utilisation, referral patterns, essential-medicine status and the internal quality of routinely generated community-level programme data within the same operational platform. The contribution of this study is therefore not simply to report several descriptive indicators, but to examine how service activity, referral, commodity readiness and routine-information-system quality interact as components of a conflict-affected community child-health system.

This analysis addresses that gap using nine calendar months of routine reports from four conflict-affected districts of Yemen. The primary objective was to describe the volume and composition of recorded RTI, diarrhoea and fever episodes and their referral patterns, including monthly trends and district variation. The second objective was to describe reported amoxicillin, zinc and ORS status and to explore, descriptively and non-causally, whether referral patterns differed according to reported commodity zero-balance status. The third was to document routine-data quality problems affecting interpretation and programmatic use of CHW reports. Reporting follows STROBE and the RECORD extension for observational studies using routinely collected health data [23, 24].

Methods

Study design and setting

This was a retrospective descriptive repeated-measures analysis of aggregate routine CHW programme data, designed as an operational epidemiological assessment rather than an evaluation of intervention effectiveness. There was no comparison group, random allocation, patient follow-up or measurement of clinical outcomes; the analysis therefore does not estimate causal programme effects.

The programme operated in four districts across three governorates: Al Khawkhah and Hays in Al Hudaydah, Khanfar in Abyan and Al Azarq in Al Dhala'e. These were RISE programme implementation areas rather than districts selected for this research. Programme documentation characterises the targeted communities as remote or underserved and affected by combinations of insecurity, difficult terrain, dispersed settlement, transport barriers and constrained access to primary health care. The formal scoring or site-selection rubric used at the programme's original design stage was not available for this secondary analysis; the four districts should therefore be understood as a purposive programme footprint, not a probability sample of Yemeni districts. District differences are interpreted as context-specific operational signals rather than nationally representative estimates. The programme was implemented by the Field Medical Foundation (FMF), and the lead author served as Project Manager.

Programme description

The underlying activities formed part of the UK Foreign, Commonwealth & Development Office (FCDO)-funded RISE Consortium, for which the International Rescue Committee (IRC) served as consortium lead and technical partner and FMF implemented services in the study areas. The 33-person programme roster used in the analysis comprised 30 CHWs and three community health supervisors. The 30 CHWs were nominated through Ministry of Public Health and Population (MoPHP) and District Health Office processes and worked as incentive-supported community workers. The three community health supervisors were nominated by the MoPHP, had previously completed iCCM training and had experience in field supervision; they therefore did not attend the July 2025 refresher course. For continuity with the routine dataset and CHW-month analytic terminology, all 33 rostered personnel are referred to collectively as CHWs in the analysis, while their different operational roles are acknowledged here. The 30 CHWs received a four-day iCCM refresher training delivered by FMF at the FMF hall in Aden from 27 to 30 July 2025, before the study period. The training used structured lectures, role-plays and case studies covering malaria, fever, diarrhoeal disease and acute respiratory infection management; rapid diagnostic testing for malaria; treatment protocols for amoxicillin, paracetamol, ORS and zinc; referral procedures; and community health awareness. Average assessment scores increased from 51% before training to 89% after training. No additional refresher training was delivered during the November 2025–July 2026 study period. CHWs used standardised iCCM tools and national iCCM protocols to manage common childhood respiratory illness, diarrhoea and fever and to identify severe illness or danger signs requiring referral.

The weekly medicine form tracked paracetamol, amoxicillin, zinc and ORS, including opening balance, quantities received, quantities consumed and remaining balance. These medicines therefore define the commodity information available for analysis; the complete equipment/kit list issued to each worker was not available in a form that could be reliably linked to all 33 rostered personnel and is not inferred. Programme documentation indicates that iCCM medicine supply and stock monitoring were supported through FMF programme systems with IRC consortium/technical support. Medicines were physically delivered and replenished by FMF staff through a routine monthly resupply cycle. However, the analytic dataset did not capture worker-specific delivery dates, quantities requested, emergency replenishment or reorder triggers. Supervision was delivered through routine FMF programme and MEAL monitoring and supportive supervision, with engagement of health authorities; however, worker-specific supervision frequency and checklist completion were not captured in the analytic dataset, so no fixed supervision exposure is assumed in the analysis.

Children with severe illness, danger signs or needs beyond community-level management were referred to the nearest supported health facility. The wider RISE programme maintained referral coordination between communities, supported facilities and higher-level hospitals, but the weekly CHW dataset did not retain the receiving-facility identifier or referral-completion outcome. RISE operated in coordination with the Ministry of Public Health and Population (MoPHP), Governorate Health Offices and DHOs through routine review, technical consultation and joint supervision; DHO involvement in CHW nomination/replacement provides an additional link to local health-system structures. Third-party monitoring of RISE-supported primary-care services reported that consultations and medicines were

generally provided free of charge; the CHW analytic files themselves did not contain a fee variable. A consistent catchment-population or under-five denominator for the 33 CHWs across the full study period was not available, so population coverage and utilisation rates could not be calculated.

Data source and study population

The source files comprised weekly iCCM service reports and weekly medicine-stock reports associated with the 33 named programme personnel in the analytic roster (30 CHWs and three community health supervisors). The service form recorded counts of RTI, diarrhoea and fever episodes and referrals, disaggregated by sex and by two programme age groups: younger than 12 months and 12–59 months. The medicine form recorded opening balance, quantities received, quantities consumed and remaining stock for paracetamol, amoxicillin, zinc and ORS.

The unit recorded in the service dataset was an illness episode. The dataset did not contain a stable patient identifier, clinical examination findings, treatment outcome, or confirmation that referrals reached a facility. Totals therefore cannot be interpreted as numbers of unique children: the same child may have appeared more than once across weeks or illness categories. The source category "respiratory tract infection" was retained because the available data did not permit validation against the WHO clinical classification of pneumonia, which requires age-specific respiratory rate and assessment of chest indrawing and danger signs [25].

CHW names were used only to link weekly service and medicine files during cleaning, including a normalisation step to reconcile minor Arabic orthographic variants (for example hamza forms) referring to the same individual, and were then replaced with study identifiers. No child names, addresses, telephone numbers or other patient-level identifiers were present in the analytic dataset.

Study period and data processing

The reporting period was November 2025-July 2026. Cleaning was undertaken before aggregation. District labels were harmonised, including consolidation of "Al_Azarq" and "Al Azarq" after confirming that they represented the same district. Three service records and one medicine record labelled "Week 7" were excluded because the programme reporting structure allowed Weeks 1–5 only.

The raw medicine file contained 248 exact duplicate rows, removed so that identical submissions did not contribute twice to consumption or stock calculations. One additional duplicate CHW-week key contained conflicting values; the more complete record was retained and the conflict was documented. Negative values, balance errors and statistical outliers were retained as quality flags rather than corrected, because replacing them without access to the source register could introduce analyst-generated error.

Weekly service records were aggregated to CHW-month level by summing illness episodes and referrals. For medicine indicators, a CHW-month was classified as having a reported weekly zero remaining balance when at least one available weekly medicine report for that CHW-month recorded remaining balance = 0 for the specified commodity. This occurrence-based definition matches the information available in the routine reports and does not imply that the commodity was unavailable for the entire month. Aggregation was performed only after duplicate removal and identifier standardisation. Because the number of available weekly reports could vary within a CHW-month, the indicator may also be affected by incomplete weekly reporting.

Coverage and missingness

The data covered each calendar month in the nine-month study period, but not every CHW contributed a record in every month. A static roster of 33 CHWs would yield 297 possible CHW-months; 256 were represented in the analytic dataset (86.2%). This coverage estimate assumes a constant 33-CHW roster throughout and may underestimate true completeness if workers joined, left or were temporarily inactive; a time-varying roster and expected weekly reporting calendar were not available, so weekly completeness and timeliness could not be calculated. No statistical imputation was applied to missing CHW-months.

Data-quality assessment

A desk review was conducted using WHO routine-data quality principles [26, 27]. Checks included missing CHW, district, month and week identifiers; missing or negative count values; exact duplicate rows; duplicate CHW-week keys; referral counts exceeding recorded case counts within at least one illness-age-sex stratum; and inventory-balance discrepancies, defined as opening balance plus receipts not equalling consumption plus remaining stock. Extreme weekly case totals were flagged using a conservative 3xIQR rule; flags were counted and reported rather than automatically corrected.

This review assessed structural completeness of available fields and internal consistency only. It was not a verification exercise against paper registers, dispensing records, supervisor checklists or patient records and therefore cannot measure concordance with the source register, over- or under-reporting, diagnostic accuracy, correct treatment or referral completion.

Outcome definitions and statistical analysis

The primary analytic unit was the CHW-month. A 'CHW-month with ≥ 1 reported weekly zero remaining balance' was defined as a CHW-month in which at least one available weekly report recorded remaining stock of zero for the specified commodity. Operationally, the remaining-balance field was intended to represent the quantity recorded as on hand after reported opening stock, receipts and consumption. A value of zero therefore indicates that the form recorded no units remaining at that reporting point; it does

not, without source-register or physical-stock verification, prove the duration or cause of non-availability, continuous absence throughout the month, or lack of treatment at a particular patient encounter. A zero could also be affected by resupply timing, missing reports or reporting error. The composite indicator 'any essential iCCM commodity zero balance' was positive when at least one weekly zero was reported for amoxicillin, zinc or ORS during the CHW-month. Paracetamol was excluded from this composite because the study focused on the core disease-specific medicines for the three syndrome groups analysed.

Referral rate was calculated as recorded referrals divided by recorded illness episodes for the corresponding illness category. Because some weekly reports contained referral counts exceeding case counts within a stratum, referral rates are presented as programme-reporting indicators rather than verified clinical referral probabilities.

Descriptive statistics included totals, proportions, medians and IQRs. Monthly trends in recorded episodes, referrals and the proportion of observed CHW-months with ≥ 1 reported weekly zero remaining balance were tabulated to use the longitudinal structure of the data and to assess whether pooled findings reflected persistent conditions or particular months. District comparisons of referral rates were presented with both numerator (recorded referrals) and denominator (recorded illness episodes).

As an exploratory, hypothesis-generating analysis, disease-specific referral rates were compared descriptively between CHW-months with and without ≥ 1 reported weekly zero remaining balance for the corresponding commodity: zinc and ORS for diarrhoea, and amoxicillin for RTI. The available aggregate extracts support comparison of counts, rates and percentage-point differences, but not a robust clustered inferential model. We therefore did not report chi-squared p-values. CHW-months are repeated within workers, and both referral and medicine status vary by district and month; the comparisons are ecological, non-causal and potentially confounded by district, time, caseload, case mix and unmeasured CHW-level factors. No hypothesis tests or regression models were applied to the primary descriptive results.

Reporting framework and ethics

The manuscript was prepared using STROBE and RECORD principles [23, 24]. A completed combined STROBE-RECORD checklist should accompany journal submission.

This study used retrospective, de-identified, aggregate routine programme data and involved no direct contact with children or caregivers. The author did not have access to individual patient identifiers. The Research Ethics Committee, Department of Public Health, Faculty of Dentistry, University of Aden, Aden, Yemen, determined that this secondary analysis was exempt from full ethical review (reference: 2026005). Publication of the anonymised programme data was authorised by FMF.

Results

Data coverage and cleaning

The cleaned service dataset contained 999 weekly records and the cleaned medicine dataset contained 1,008 weekly records. The analytic dataset comprised 256 CHW-months of the 297 expected under a static 33-CHW roster assumption (86.2%). Weekly service reports were distributed unevenly across districts: Hays contributed 323 (32.3%), Al Khawkhah 315 (31.5%), Al Azarq 259 (25.9%) and Khanfar 102 (10.2%); Khanfar accounted for seven of the 33 CHWs but only 10.2% of weekly reports, reinforcing the need for a time-varying roster before formal completeness comparisons are made (Table 1).

Table 1
Study area and service-report coverage.

Governorate	District	Reporting personnel	Weekly service reports	Months in period
Al Hudaydah	Al Khawkhah	9	315	9
Al Hudaydah	Hays	10	323	9
Abyan	Khanfar	7	102	9
Al Dhala'e	Al Azarq	7	259	9
Total	—	33	999	9

Illness episodes and referral patterns: overall and monthly trends

CHWs recorded 9,708 illness episodes, with a median monthly caseload of 34 episodes per CHW-month (IQR 20–54). RTI was the most commonly recorded syndrome (4,309 episodes; 44.4%), followed by fever (3,334; 34.3%) and diarrhoea (2,065; 21.3%). Recorded episode counts were similar for male and female children (4,866 and 4,842, respectively). Infants younger than 12 months accounted for 1,725 episodes (17.8%), while children aged 12–59 months accounted for 7,983 (82.2%); this pattern partly reflects the wider age span of the older category, and incidence or utilisation rates cannot be estimated without population denominators (Table 3).

A total of 690 referrals were recorded (7.1% of all illness episodes). Monthly trends showed considerable variation in both recorded caseload and referral proportion across the nine-month period, rather than a stable pattern. Recorded referral proportion was lowest in March 2026 (0.6%) and rose sharply from April 2026 onward, reaching 20.1% in July 2026. This rising trend coincided with a general decline in recorded monthly caseload after February 2026, suggesting that the pooled 7.1% referral figure obscures a distinct later-period pattern that warrants separate programmatic attention rather than being treated as a single stable estimate (Table 2).

Table 2
Monthly trend in recorded illness episodes and referrals, November 2025-July 2026.

Month	RTI cases	Diarrhoea cases	Fever cases	Total cases	Referrals	Referral rate (%)
Nov-2025	309	165	257	731	66	9.0
Dec-2025	797	314	634	1,745	47	2.7
Jan-2026	685	264	564	1,513	78	5.2
Feb-2026	724	298	583	1,605	27	1.7
Mar-2026	476	183	317	976	6	0.6
Apr-2026	385	287	310	982	155	15.8
May-2026	396	239	306	941	82	8.7
Jun-2026	255	165	148	568	99	17.4
Jul-2026	282	150	215	647	130	20.1

Table 3
Recorded illness episodes by illness type, age group and sex.

Illness	< 12m male	< 12m female	12-59m male	12-59m female	Total
Respiratory tract infection	407	370	1,763	1,769	4,309
Diarrhoea	168	180	854	863	2,065
Fever	329	271	1,345	1,389	3,334
Total	904	821	3,962	4,021	9,708

District variation in referrals

The overall recorded referral rate of 7.1% masked substantial district variation, ranging more than seven-fold from 2.9% in Hays to 20.9% in Al Azarq (Table 4). The pattern was not confined to one illness category: Al Azarq recorded the highest disease-specific referral rate for RTI (11.8%), diarrhoea (47.3%) and fever (26.9%) (Table 5). These figures demonstrate a consistent district-level difference in the routine reports, but do not by themselves establish its cause.

Programme documentation provides context but not a definitive explanation for Al Azarq's higher recorded referral rate. Al Azarq is described as mountainous, hard to reach and affected by localised security sensitivities that can complicate supervision, transport and referral, while other study districts

also faced distinct access constraints. Plausible mechanisms therefore include differences in referral-facility accessibility or functionality, disease severity or case mix, medicine status, supervision, referral thresholds or documentation practices. Because the study dataset cannot distinguish these mechanisms, the Al Azarq pattern is treated as a priority for targeted programme review rather than evidence of better or worse district performance.

Table 4
Recorded illness episodes, referrals and referral rate by district (total and denominator shown together).

District	Recorded illness episodes	Recorded referrals	Referral rate (%)
Al Azarq	1,932	403	20.9
Khanfar	1,203	84	7.0
Al Khawkhah	2,798	94	3.4
Hays	3,775	109	2.9
Total	9,708	690	7.1

Table 5
Disease-specific referral rate by district (supplementary breakdown).

Illness	Al Azarq	Al Khawkhah	Hays	Khanfar
RTI referral rate (%)	11.8	3.3	2.5	6.8
Diarrhoea referral rate (%)	47.3	5.6	3.8	7.5
Fever referral rate (%)	26.9	2.2	2.8	6.8

Reported medicine status and monthly zero-balance trends

At least one available weekly report recorded a zero remaining balance for zinc in 207/256 observed CHW-months (80.9%), for amoxicillin in 105/256 (41.0%) and for ORS in 89/256 (34.8%) (Table 7). At least one weekly zero for any of these three commodities was recorded in 230/256 CHW-months (89.8%). These are occurrence indicators based on routine reports; they do not measure the duration or cause of zero stock, establish continuous unavailability during the month, or show whether a particular child did not receive treatment.

Monthly trends showed that the zinc indicator was not confined to one short period: the proportion of observed CHW-months with ≥ 1 reported weekly zero zinc balance ranged from 64.3% to 100.0% across all nine study months. The corresponding proportions for amoxicillin ranged from 20.7% to 60.7%, and for ORS from 20.7% to 72.4%. These trends suggest recurrent reporting of zero balances, especially for zinc, while incomplete weekly reporting and the absence of physical-stock verification limit inference about duration or true medicine availability (Table 6).

Table 6
Monthly proportion of observed CHW-months with ≥ 1 reported weekly zero remaining balance, by commodity.

Month	Personnel reporting	Zinc: ≥1 weekly zero (%)	Amoxicillin: ≥1 weekly zero (%)	ORS: ≥1 weekly zero (%)
Nov-2025	29	100.0	55.2	72.4
Dec-2025	29	96.6	41.4	24.1
Jan-2026	29	100.0	27.6	20.7
Feb-2026	29	75.9	20.7	20.7
Mar-2026	28	64.3	57.1	32.1
Apr-2026	28	64.3	25.0	21.4
May-2026	28	71.4	28.6	21.4
Jun-2026	28	71.4	60.7	57.1
Jul-2026	28	82.1	53.6	42.9

Table 7
Observed CHW-months with ≥ 1 reported weekly zero remaining balance, by commodity.

Commodity	CHW-months with ≥ 1 reported weekly zero balance	Denominator	Percentage
Zinc	207	256	80.9%
Amoxicillin	105	256	41.0%
ORS	89	256	34.8%
Any of zinc, amoxicillin, or ORS	230	256	89.8%

Exploratory descriptive comparison of commodity zero-balance status and referral rate

In descriptive exploratory comparisons, diarrhoea referral rate was 9.0% in CHW-months with ≥ 1 reported weekly zinc zero balance and 26.1% in CHW-months without such a report, a difference of -17.1 percentage points. For ORS, diarrhoea referral rate was 21.2% in CHW-months with ≥ 1 reported weekly zero balance and 8.1% in those without, a difference of + 13.1 percentage points. For amoxicillin, RTI

referral rate was 10.7% in CHW-months with ≥ 1 reported weekly zero balance and 3.8% in those without, a difference of + 6.9 percentage points (Table 8).

The mixed directions caution against a simple interpretation that a reported medicine zero automatically increases referral. The contrasts may reflect true treatment constraints, district or monthly confounding, differences in caseload or severity, CHW referral thresholds, supervision, resupply timing or reporting practice. Because the same CHWs contribute repeated months and the aggregate files do not support adjustment for these factors, the analysis is strictly descriptive and hypothesis-generating; it should not be interpreted as evidence that medicine availability causes changes in referral practice.

Table 8
Exploratory descriptive comparison of disease-specific referral rate by reported weekly commodity zero-balance status; no causal or inferential interpretation is intended.

Comparison	CHW-months	Recorded cases	Recorded referrals	Referral rate (%)
Diarrhoea - ≥1 weekly zinc zero	207	1,628	146	9.0
Diarrhoea - No weekly zinc zero reported	49	437	114	26.1
Diarrhoea - ≥1 weekly ORS zero	89	713	151	21.2
Diarrhoea - No weekly ORS zero reported	167	1,352	109	8.1
RTI - ≥1 weekly amoxicillin zero	105	1,372	147	10.7
RTI - No weekly amoxicillin zero reported	151	2,937	111	3.8

Routine-data quality findings

Of 999 weekly service reports, 142 (14.2%) contained referral counts exceeding case counts in at least one illness-age-sex stratum. The raw medicine file contained 248 exact duplicates (19.7% of 1,258 raw rows), one conflicting duplicate CHW-week key, and 25 inventory-balance discrepancies after cleaning (2.5% of 1,008 cleaned weekly medicine records). One medicine record contained a negative ORS opening balance, and five weekly service reports (0.5%) were flagged as statistical outliers. These findings indicate internal-consistency problems that should be addressed during data entry and supervisory review, not only during retrospective analysis (Table 9).

Table 9
Data-cleaning and internal-consistency summary.

Metric	Value
Raw weekly service records	1,002
Invalid Week 7 service records excluded	3
Final weekly service records	999
Raw weekly medicine records	1,258
Exact duplicate medicine rows removed	248
Conflicting duplicate medicine key resolved	1
Invalid Week 7 medicine record excluded	1
Final weekly medicine records	1,008
Service reports with ≥ 1 referral/case inconsistency	142/999 (14.2%)
Medicine records with inventory-balance discrepancy	25/1,008 (2.5%)
Final CHW-months	256

Discussion

Principal findings

Across nine calendar months, 33 CHWs recorded 9,708 episodes of RTI, diarrhoea and fever and 690 referrals in four conflict-affected Yemeni districts. The results are best understood as an interconnected operational system rather than isolated indicators: recorded service activity, referral practice, medicine status and information quality varied over time and across districts. At least one weekly zinc zero balance was reported in 80.9% of observed CHW-months; referral rates varied more than seven-fold by district and rose sharply in the final study months; and 14.2% of weekly service reports contained at least one referral-case inconsistency. Together, these findings show both the operational importance of community delivery and the systems constraints that limit treatment readiness and confidence in routine programme indicators.

Service volume, referral trends and district variation

The recorded service volume reinforces the operational relevance of community-based iCCM in settings where insecurity, travel cost, damaged infrastructure and limited facility functionality can delay care [3, 4, 6–10, 14, 15]. Yemen's earlier qualitative iCCM and IMCI studies similarly describe the importance of community delivery while identifying supervision, supply, referral and integration constraints [10–12]. However, recorded activity should not be interpreted as population coverage: the data lack a consistent

catchment-population denominator, and repeated illness episodes cannot be distinguished from unique children.

The RTI category accounted for 44.4% of recorded episodes but should not be interpreted as pneumonia burden, because WHO pneumonia classification requires age-specific respiratory rate, chest indrawing and danger-sign assessment that were unavailable in this dataset [1, 25]. Similarly, near-equal male and female episode counts are reassuring at a descriptive level but cannot establish gender-equitable access without sex-specific denominators, and the larger number of episodes among children aged 12–59 months partly reflects the wider age span of that category.

The rise in recorded referral rate from 0.6% in March 2026 to 20.1% in July 2026, alongside a lower recorded caseload than in December-February, is programmatically important because it would be obscured by the pooled 7.1% estimate. Possible explanations include changes in disease severity or seasonality, referral thresholds following supervision or feedback, medicine status, access to referral facilities, or recording practice; the present data cannot separate these. The more than seven-fold district variation, from 2.9% in Hays to 20.9% in Al Azarq, was present across all three illness categories. Programme documentation identifies Al Azarq as mountainous and hard to reach, which is relevant context, but it does not establish that geography or insecurity caused the higher referral rate. Targeted review of referral registers, receiving facilities, supervision records, medicine status and district implementation history is needed before comparative performance conclusions are drawn.

Commodity availability, referral association and treatment readiness

The most striking commodity finding was the recurrently reported zinc zero balance: ≥1 weekly zero was recorded in at least 64.3% of observed CHW-months in every study month and in all observed CHW-months in two months. Because WHO guidance recommends ORS and zinc together for childhood diarrhoea management [2], the discordance between zinc and ORS reporting warrants programme verification of quantification, resupply, consumption recording and treatment-package readiness. As described in the Methods, medicines were physically delivered and replenished by FMF staff through a routine monthly resupply cycle. However, the routine data cannot establish that zinc was physically unavailable for the full periods represented, determine whether emergency replenishment occurred, or show the timing of deliveries within individual CHW-months.

The exploratory commodity-referral comparison produced mixed directions. Diarrhoea referral was lower in CHW-months with a reported zinc zero balance, whereas diarrhoea referral was higher with a reported ORS zero balance and RTI referral was higher with a reported amoxicillin zero balance. Because zinc zero-balance status was very common, the zinc comparison is based on a relatively small group of CHW-months without a reported zero; all three contrasts are vulnerable to confounding by district, month, caseload, severity and reporting practice. The appropriate interpretation is therefore hypothesis-generating: the results justify prospective or facility-linked investigation of commodity-referral pathways, but do not demonstrate that commodity status causes referral behaviour.

Repeated reported amoxicillin and ORS zero balances also raise concerns about treatment readiness, although this study cannot determine stock-out duration, treatment substitution, facility availability after referral or clinical eligibility for specific medicines. Published studies using their own stock-out definitions show that medicine availability is a common CHW-system constraint: a systematic review estimated stock-outs among CHWs at approximately 29% overall and higher in more recent evaluations [16], while baseline assessments in Ethiopia, Malawi and Rwanda found more than half of CHWs lacked at least one tracer product on the assessment day [17]. These external estimates are not directly comparable with this study's occurrence-based weekly zero-balance indicator, but they support investigation of last-mile commodity systems rather than treating the Yemen pattern as an isolated issue.

Routine-data quality in comparative context

The quality findings should be understood as programme findings in their own right, not merely technical limitations of this manuscript. Duplicate medicine rows can inflate consumption and distort resupply calculations; referral counts above case counts undermine confidence in referral indicators; and an impossible "Week 7" value indicates that the reporting tool did not adequately restrict invalid entries.

Comparable routine-data challenges have been documented in fragile and conflict-affected settings, although the metrics differ from those used here. In Somalia's Banadir region, 65.3% of assessed departments met the study's combined data-quality threshold, with feedback, refresher training and user-friendly reporting formats associated with better quality [20]. South Sudan's humanitarian surveillance experience shows how instability can challenge reporting while investments in electronic early-warning systems can improve completeness and timeliness [21]. In Sudan, analysis of DHIS2 malaria indicators before and after the 2023 conflict documented disruption to reporting completeness and surveillance functionality [22]. These studies support the broader interpretation that routine-information systems are themselves an operational component of resilient service delivery; they do not imply direct numerical equivalence with this study's 14.2% referral-case inconsistency or 19.7% raw medicine-row duplication rates.

WHO guidance recommends combining desk review, system assessment and verification against source documents [26, 27]; this study completed only the desk-review component. The next operational step should be a targeted verification exercise sampling CHWs and comparing source registers, weekly reports, medicine cards and the consolidated database, focused on the indicators with the highest decision value and error risk: illness totals, referrals, consumption, receipts and closing balances.

Implications for policy and programme management

Four linked priorities follow. First, programme managers should verify the repeated commodity zero-balance signals against stock cards, physical counts, supply records and resupply procedures, then strengthen forecasting and coordinated availability of the complete iCCM treatment package where genuine gaps are confirmed. Second, supervision should integrate clinical support, stock reconciliation

and data review, with targeted attention to Al Azarq and to the late-period rise in referrals. Third, referral systems should capture whether referrals were accepted, reached the receiving facility and received care, ideally through a shared identifier linking CHW and facility records. Fourth, point-of-entry controls should block invalid week values and duplicate CHW-week keys, require non-negative quantities, flag referrals exceeding recorded cases and automatically calculate expected closing balances while requiring explanation of discrepancies.

These priorities are particularly important in a protracted crisis, where conflict can simultaneously increase childhood illness, reduce household ability to travel, interrupt supply routes and weaken data systems [28]. Beyond their immediate role in maintaining access during conflict, community-based delivery platforms may represent an asset for health-system recovery: investments in CHW competencies, supervision structures, referral relationships, commodity-distribution mechanisms and community-level information systems should, where feasible, be designed to strengthen rather than operate separately from district and national health-system structures, so that this locally embedded capacity can support future primary healthcare recovery and reconstruction in Yemen [29].

Strengths and limitations

Strengths include nine calendar months of operational data from 33 CHWs across geographically separated conflict-affected districts, joint analysis of service delivery and medicine reporting, explicit reporting of cleaning decisions, use of the longitudinal structure of the data through monthly trend analysis, and an exploratory but appropriately caveated examination of commodity-referral linkage. The manuscript also distinguishes internal consistency from source-data verification throughout.

The limitations are substantial. The dataset records aggregate illness episodes rather than unique children, so repeated visits and coexisting illnesses cannot be identified. The RTI category could not be clinically validated as pneumonia. Referral completion, treatment correctness, recovery, mortality, caregiver experience and adverse events were unavailable. A time-varying CHW roster and expected weekly reporting calendar were unavailable, so formal weekly completeness and timeliness could not be calculated and missingness may not have been random. A reported weekly zero remaining balance is an occurrence indicator: it does not measure duration or cause, and source-register or physical-stock verification was not undertaken. Referral-case inconsistencies affect confidence in disaggregated referral rates. The commodity-referral comparison is ecological, repeated within CHWs and susceptible to confounding by district and month; only descriptive contrasts were therefore reported. Only four programme districts were included, with no consistent population denominators, facility comparison group, seasonal covariates or conflict-intensity measures. Some implementation details, particularly individual-level supervision intensity, worker-specific resupply timing and referral completion, could not be linked consistently to the analytic dataset. Findings are descriptive, context-specific and hypothesis-generating rather than causal or nationally representative.

Future research should prospectively define the expected reporting denominator, maintain a time-varying CHW roster, link CHW and receiving-facility records, validate a sample against source registers and stock

cards, measure stock-out duration, and capture treatment and referral outcomes. Prospective programme documentation should also retain CHW recruitment and training records, supervision frequency, resupply rules, equipment lists, catchment denominators and receiving-facility linkages so that routine-data analyses can assess not only activity but service readiness and continuity of care.

Conclusions

Across four conflict-affected districts of Yemen, 33 CHWs recorded 9,708 episodes of RTI, diarrhoea and fever and 690 referrals between November 2025 and July 2026. Service delivery, medicine readiness, referral practice and routine-data quality were closely interconnected: referral rates varied markedly by district and rose in the final study months, weekly zero remaining balances—especially for zinc—were repeatedly reported, and referral and medicine records contained material internal inconsistencies. These findings demonstrate substantial community-level activity while also showing why pooled utilisation totals alone are insufficient for evaluating iCCM performance in a conflict-affected health system.

Priorities include verifying reported medicine zero balances against source records, strengthening routine-data validation and integrated supervision, and investigating district and temporal variation in referrals. Linking CHW and receiving-facility records would support assessment of referral completion and continuity of care.

Declarations

Ethics approval and consent to participate

The Research Ethics Committee, Department of Public Health, Faculty of Dentistry, University of Aden, Aden, Yemen, determined that this secondary analysis of de-identified aggregate routine programme data was exempt from full ethical review (reference: 2026005). The study involved no direct contact with participants and no access to individual patient identifiers. Publication of the anonymised programme data was authorised by FMF.

Consent for publication

Not applicable. The manuscript contains no individual-level identifiable information.

Competing interests

MA served as Project Manager and KZ as Health and Nutrition Team Leader for FMF during programme implementation and therefore had contextual knowledge of programme operations. To reduce the risk of interpretive bias, data-cleaning rules were specified before the main interpretation where possible, anomalous values were retained as quality flags rather than selectively corrected, and findings were

framed as descriptive programme indicators rather than estimates of programme effectiveness. MBB was independent of programme implementation and provided an additional perspective on the methodology and interpretation of the findings. The authors declare no other competing interests.

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Author Contribution

M.A. conceived the study, contributed to the study design and methodology, led programme implementation and data collection, curated and analysed the data, interpreted the findings, prepared the figures and tables, and drafted the manuscript. K.Z. contributed to the study design and methodology, data analysis, interpretation of the findings, and critical revision of the manuscript. M.B.B. contributed to the study design and methodology, interpretation of the findings, and critical revision of the manuscript. All authors contributed to the scientific development and finalisation of the manuscript, reviewed and approved the submitted version, and agreed to be accountable for their contributions and for ensuring that questions concerning the accuracy or integrity of the work are appropriately investigated and resolved.

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Data Availability

The de-identified CHW-month analytic dataset, data dictionary and cleaning rules are available from the corresponding author on reasonable request, subject to authorisation by the programme data owner and applicable data-protection and safeguarding requirements.

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