

Frontline recognition and referral readiness for selected priority zoonoses among health workers in southwestern Uganda: a One Health systems assessment

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Research Article

Keywords: Zoonotic diseases, One Health, health workers, referral readiness, outbreak preparedness, Uganda

Posted Date: September 29th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10939131/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background: Southwestern Uganda is a livestock-intensive region vulnerable to recurrent zoonotic disease outbreaks. Because confirmation of several priority zoonoses depends on higher-level or reference laboratories, preparedness requires both frontline recognition and effective specimen referral. We assessed recognition and referral readiness and related One Health implementation gaps among health workers in southwestern Uganda.

Methods

We conducted a cross-sectional survey among 345 health workers in Mbarara, Kazo, Kiruhura, and Ibanda districts. The study focused on Rift Valley fever (RVF), Crimean-Congo haemorrhagic fever (CCHF), Ebola, anthrax, and rabies. Participants were purposively recruited across facility levels based on frontline roles in recognition, specimen handling, referral, or reporting of suspected zoonoses. Recognition readiness was assessed using 11 disease-specific causative-agent and transmission/exposure items. Referral readiness was assessed using testing advice, specimen referral, result feedback, referral-to-result interval, and result communication. The primary outcome was a reported referral-linkage gap, defined as not reporting specimen referral elsewhere for testing. Modified Poisson regression with facility-clustered robust standard errors was used to estimate prevalence ratios.

Results

Almost all respondents had heard of the selected zoonoses (99.7%). Recognition was lower for RVF exposure through aborted fetuses or placentas (58.8%) and mosquito transmission (69.9%). Overall, 13.9% reported a referral-linkage gap, which was more common at lower-level facilities than at health centre IVs or hospitals (20.1% vs 6.8%; adjusted prevalence ratio [aPR]=2.74; 95% confidence interval [CI]=1.39–5.39; $p=0.004$). Among respondents reporting referral, 99.3% reported receiving results; the median referral-to-result interval was 10 days (IQR, 7–14). Commonly reported barriers were inadequate diagnostic resources (90.4%), unreliable transport (75.1%), and inadequate intersectoral collaboration (74.2%).

Conclusions

Frontline recognition of selected priority zoonoses was generally strong, but referral readiness was less consistent at lower levels of care. Strengthening peripheral specimen-referral connectivity, transport, information exchange, and One Health coordination should complement continued targeted disease-specific training.

Introduction

Uganda remains vulnerable to outbreaks of priority zoonoses, including anthrax, rabies, Rift Valley fever (RVF), Crimean-Congo haemorrhagic fever (CCHF), and Ebola [1]. Southwestern Uganda has experienced recurrent zoonotic disease transmission in livestock-keeping settings. Recent RVF outbreaks in the

Greater Mbarara area [2], recurrent CCHF in the cattle corridor [3], and anthrax linked to infected livestock [4, 5] illustrate this continuing risk. These recurring events underscore the importance of timely recognition, reporting, and response at the frontline of the health system.

Frontline detection of priority zoonoses depends on recognition of relevant clinical and exposure features and timely linkage of suspected cases and specimens to surveillance and laboratory systems [6]. This is especially important for viral haemorrhagic fevers, which often present nonspecifically and may require reference-level confirmation [7]. Evidence from East Africa indicates that high general zoonotic disease awareness can coexist with gaps in disease-specific recognition and reporting [8–10]. Preparedness therefore requires both knowledgeable health workers and functional referral, transport, information, and One Health coordination systems [11].

Despite Uganda's investments in One Health coordination, surveillance, and laboratory-referral systems, limited evidence exists on whether frontline health workers can consistently translate recognition of suspected zoonoses into specimen referral, particularly across different levels of care. Previous Ugandan studies have largely focused on individual outbreaks, specific zoonoses, or health-worker knowledge and practices [3–5, 12, 13]. We therefore assessed recognition and referral readiness for RVF, CCHF, Ebola, anthrax, and rabies among health workers in four districts of southwestern Uganda, described One Health implementation constraints, and identified factors associated with the reported referral-linkage gap.

Methods

Study design and setting

We conducted a cross-sectional survey of frontline health workers from 4 December 2024 to 20 January 2025 in Mbarara, Kazo, Kiruhura, and Ibanda districts in southwestern Uganda. The four districts were selected because of their predominantly agricultural and agro-pastoral setting, substantial livestock production, and close human–animal interactions. The districts have experienced recurrent zoonotic disease events, including RVF in Mbarara, CCHF, and livestock-associated anthrax [2, 4, 5].

Uganda operates a tiered laboratory system in which facilities without specialized testing capacity refer specimens through a hub-and-spoke network to higher-level and reference laboratories and receive results [14]. This arrangement is particularly important for priority zoonoses: peripheral facilities are expected to recognize suspected cases, collect and refer appropriate specimens, and link them to laboratories with the necessary confirmatory capacity. Consequently, definitive testing for several priority zoonoses is performed at higher-level or national reference laboratories rather than routinely at the facility of first presentation [15].

Study population and participant selection

We included health workers whose routine responsibilities placed them within the frontline recognition-to-referral pathway for suspected zoonotic diseases, including clinical assessment, diagnostic testing or specimen handling, referral, and reporting. Participants were purposively recruited based on these roles from dispensaries, health centre IIs, health centre IIIs, health centre IVs, and hospitals across the four study districts. The number recruited from each facility varied according to facility size, staffing structure, and the availability of eligible frontline health workers. The parent survey targeted 406 health workers using a Kish–Leslie calculation based on an estimated 40% prevalence for the knowledge, attitudes, and practices outcome used in the parent study and a 10% allowance for non-response [8]. The present analysis included 345 health workers with completed survey data. Because this analysis focused on the recognition-to-referral framework rather than the original overall KAP construct, no *post hoc* power calculation was performed.

Data collection

Data were collected using a structured, English-language questionnaire administered in printed hard-copy format. Health workers completed the paper questionnaire, after which trained research staff entered the completed responses into KoboCollect using tablet devices for electronic data capture and subsequent data management. The questionnaire was not adopted verbatim from a single standardized or previously validated instrument. For this sub-analysis, we selected items covering participant and facility characteristics, One Health concepts, disease-specific recognition, information sources, testing advice, specimen referral and result feedback, and perceived health-system barriers. The relevant questionnaire items are provided in **Additional file 1**. Field staff were trained on questionnaire content, administration procedures, data entry, and use of the electronic platform.

The questionnaire was pretested among 10 health workers at Mbarara Regional Referral Hospital and the Mbarara Regional Emergency Operations Centre, to assess clarity, comprehensibility, sequencing, and feasibility of administration and subsequent data entry. Feedback from the pretest was used to refine the questionnaire before the main survey.

The instrument captured sociodemographic and professional characteristics; awareness and recognition of Rift Valley fever, Crimean-Congo haemorrhagic fever, Ebola, anthrax, and rabies; testing and specimen-referral practices; receipt and communication of referral results; sources of zoonotic-disease information and access to guidelines; One Health concepts and cross-sectoral information exchange; and perceived barriers to diagnosis and management. It specifically assessed whether respondents referred specimens elsewhere for testing, referral destinations, receipt of results, the usual time to receive results, how results were received, and whether results were subsequently communicated to patients.

Recognition readiness

Recognition readiness was summarized using an 11-item disease-specific recognition score defined *a priori* from questionnaire items addressing established causative agents and transmission or exposure pathways for the five selected zoonoses. The score comprised five causative-agent items and six exposure/transmission items: contact with aborted fetuses or placentas and mosquito transmission for RVF; tick transmission for CCHF; consumption of inadequately cooked meat for anthrax; exposure through the bite of an unvaccinated pet for rabies; and rejection of the misconception that rabies is transmitted through menstrual blood.

Each correct response contributed one point, producing a score ranging from 0 to 11, with higher scores indicating greater recognition. The score was calculated for respondents with complete data on all 11 items. We did not categorize respondents as having “good” or “poor” knowledge and did not construct an overall KAP score because the questionnaire domains represented distinct constructs rather than a single validated scale.

Referral readiness and primary outcome

Referral readiness was assessed using the sequence of reported actions following suspicion of a priority zoonosis: advice to test, referral of specimens for testing elsewhere, referral destination, receipt of results, time to receipt of results, and communication of results to patients. This approach reflects the function of specimen-referral networks described in Uganda, in which peripheral or “spoke” facilities send specimens to higher-capacity hub or reference laboratories and results are returned to the referring facility [14, 16].

The primary outcome was a reported referral-linkage gap, defined as a “No” response to the questionnaire item, *“Do you refer samples elsewhere for testing?”* Respondents answering “Yes” were considered to report an available referral linkage. The outcome therefore represents the individual health worker’s reported access to or awareness of specimen-referral linkage; it was not an audit of whether the facility objectively possessed a functioning referral pathway. The term “referral-linkage gap” is a study-specific operational definition rather than a previously validated binary measure, but is conceptually consistent with published evaluations of specimen-referral systems that assess whether peripheral sites refer specimens to higher-level laboratories [14, 16].

For the primary comparison, facilities were grouped as peripheral facilities (private clinics/medical centres, HCIIIs and HCIIIs) and HCIVs/hospitals, reflecting their relative position within Uganda’s tiered health and laboratory system [17]. Among respondents reporting referral, free-text referral destinations were subsequently classified as national/reference laboratory, regional referral hospital, district/HCIV/hub pathway, private laboratory, or other/multiple destinations.

The reported referral-to-result interval was the respondent-reported number of days between referral and receipt of the result. We deliberately did not describe this as laboratory turnaround time because the measure could include specimen preparation and transport, laboratory processing, result transmission,

and receipt by the originating facility. Published evaluations of Uganda's specimen-referral systems have similarly distinguished specimen transport, laboratory processing, and result delivery as separate components of the broader sample-to-result pathway [14].

One Health and health-system indicators

One Health indicators included recognition of the linkage among human, animal, and environmental health; recognition of collaboration among medical, veterinary, and public-health professionals; veterinary officials as a source of zoonotic-disease information; and perceived barriers to zoonotic-disease diagnosis and management. The questionnaire explicitly assessed partnerships among medical, veterinary, and public-health professionals and linkage of human, animal, and environmental health. These concepts are consistent with Uganda's multisectoral One Health framework [1]. Training program and/or continuing medical education (CME) was analysed specifically as a reported source of zoonotic-disease information, not as receipt of a standardized training intervention.

Statistical analysis

Participant, recognition, referral, and One Health characteristics were summarized using frequencies and percentages for categorical variables and medians with interquartile ranges (IQRs) for continuous variables. Disease-specific recognition items were described individually in addition to the 11-item recognition score.

We estimated prevalence ratios (PRs) and 95% confidence intervals (CIs) for the reported referral-linkage gap using modified Poisson regression with a log link and robust standard errors, an established approach for estimating prevalence ratios for binary outcomes [18]. Standard errors were clustered at the health-facility level to account for correlation among health workers from the same facility. The principal exposure was facility tier (lower versus higher level). The adjusted model included district, professional cadre, and training/CME reported as an information source, selected *a priori* as contextual and professional characteristics potentially related to referral awareness or access. A sensitivity model additionally included the recognition score to assess whether the facility-level association was explained by measured disease recognition.

The association between training/CME as an information source and the continuous recognition score was assessed using linear regression adjusted for district and professional cadre. Analyses used complete observations for variables included in each model; missing values were not imputed. All tests were two-sided, and $p < 0.05$ was considered statistically significant. Analyses were conducted using R version 4.6.1 (R Core Team, Vienna, Austria) [19].

Results

Participant and health-facility characteristics

A total of 345 health workers were included. The median age was 30 years (IQR 26–36), 201 (58.3%) were female, and participants had spent a median of 5 years (IQR 2–10) in their current position and 2 years (IQR 1–4) at their current workstation. Nurses comprised 192/345 (55.7%) of respondents; among them, 129 (67.2%) were certificate-trained, 53 (27.6%) diploma-trained, and 10 (5.2%) degree-trained. Health centre III staff represented the largest facility group (39.1%), followed by hospital (24.6%) and health centre IV staff (22.0%). Training programmes and/or continuing medical education (CME) were reported as a source of information on the selected zoonoses by 258/335 (77.0%) respondents, while 312/345 (90.4%) reported owning a smartphone (Table 1).

Table 1
Participant and health-facility characteristics

Characteristic	Overall (N = 345), n (%)
Age, years, median (IQR)	30 (26–36)
Sex	
Female	201 (58.3)
Male	144 (41.7)
Years in current position, median (IQR)	5 (2–10)
Years at workstation, median (IQR)	2 (1–4)
District	
Ibanda	69 (20.0)
Kazo	92 (26.7)
Kiruhura	82 (23.8)
Mbarara	102 (29.6)
Health-facility type	
Private clinic/Medical centre	35 (10.1)
Health centre II	14 (4.1)
Health centre III	135 (39.1)
Health centre IV	76 (22.0)
Hospital	85 (24.6)
Professional cadre	
Medical/clinical	54 (15.7)
Nursing	192 (55.7)
Nursing qualification (n = 192)	
Certificate	129 (67.2)
Diploma	53 (27.6)
Degree	10 (5.2)
Laboratory	52 (15.1)
Other	47 (13.6)
IQR = interquartile range; CME = continuing medical education	

Characteristic	Overall (N = 345), n (%)
Training programme and/or CME reported as an information source	258 (77.0)
Owns smartphone	312 (90.4)
IQR = interquartile range; CME = continuing medical education	

Frontline recognition and One Health linkage

General awareness was very high: 344/345 (99.7%) respondents had heard of the selected priority zoonoses. The median disease-recognition score was 9 of 11 (IQR 8–10). Recognition was strongest for the causative agent of Ebola (96.8%), rabies exposure through a bite from an unvaccinated pet (93.0%), and anthrax exposure through inadequately cooked meat (92.5%). Important gaps remained for recognition of RVF exposure through contact with an aborted fetus or placenta (58.8%), rejection of the rabies menstrual-blood misconception (60.9%), mosquito transmission of RVF (69.9%), and tick transmission of CCHF (75.7%) (**Supplementary Figure S1**).

Understanding of One Health integration was less consistent than general disease awareness. Overall, 205/338 (60.7%) correctly identified linkage of human, animal, and environmental health as a core One Health concept, and 254/338 (75.1%) recognised medical-veterinary-public-health partnership. Only 94/335 (28.1%) reported veterinary officials as a source of information on the selected zoonoses (Table 2). Training/CME reported as an information source was associated with a 1.12-point higher recognition score (95% CI 0.50–1.73; $p < 0.001$) after adjustment for district and professional cadre; district and cadre estimates did not show clear evidence of association with the recognition score (**Supplementary Table S2, Panel A**).

Table 2
Selected recognition, referral-readiness, and One Health indicators

Indicator	Result
Recognition readiness	
Heard of selected priority zoonoses	344/345 (99.7%)
Disease-recognition score, median (IQR), range 0–11	9 (8–10); n = 344
RVF: recognises aborted fetus/placenta exposure	203/345 (58.8%)
RVF: recognises mosquito transmission	241/345 (69.9%)
CCHF: recognises tick transmission	261/345 (75.7%)
Rabies: rejects menstrual-blood misconception	210/345 (60.9%)
Referral readiness	
Advises testing when zoonosis is suspected	338/345 (98.0%)
Reports specimen referral elsewhere for testing	297/345 (86.1%)
Reported referral-linkage gap	48/345 (13.9%)
Receives referral feedback, among respondents with referral data	294/296 (99.3%)
Referral-to-result interval, median (IQR), days	10 (7–14); n = 279
Referral-to-result interval $\geq$ 14 days	134/279 (48.0%)
Communicates results to patients, among respondents reporting referral	294/297 (99.0%)
One Health and system context	
Correct core One Health linkage (human-animal-environment)	205/338 (60.7%)
Recognises medical-veterinary-public-health partnership	254/338 (75.1%)
Veterinary officials reported as an information source	94/335 (28.1%)
Inadequate/lack of diagnostic resources reported as a barrier	312/345 (90.4%)
Unreliable transport reported as a barrier	259/345 (75.1%)
Inadequate collaboration with other relevant sectors reported as a barrier	256/345 (74.2%)
Paper-based system reported as a barrier	230/345 (66.7%)
<p><i>Note.</i> Percentages use available denominators. Recognition indicators were prespecified; no good/moderate/poor knowledge threshold or composite One Health score was used. The referral-to-result interval is the health-worker-reported interval to receipt of results and should not be interpreted as analytic laboratory turnaround time.</p>	

Referral readiness and completion of the referral pathway

Nearly all respondents (338/345; 98.0%) reported advising testing when they suspected one of the selected zoonoses. Overall, 297/345 (86.1%) reported referring specimens elsewhere for testing, whereas 48/345 (13.9%) reported no specimen-referral linkage. Among respondents reporting referral, feedback was almost universal: 294/296 (99.3%) reported receiving results. The median reported interval from referral to receipt of results was 10 days (IQR 7–14; $n = 279$), and 134/279 (48.0%) reported intervals of at least 14 days. Results were reported as communicated to patients by 294/297 (99.0%) respondents who referred specimens (Fig. 1).

Referral-linkage gaps across health-system levels

The reported referral-linkage gap was concentrated at lower-level facilities. It was reported by 37/184 (20.1%) respondents working at dispensaries, health centre IIs, or health centre IIIs compared with 11/161 (6.8%) working at health centre IVs or hospitals. At individual facility levels, the prevalence was 42.9% at health centre IIs, 25.7% at dispensaries, 16.3% at health centre IIIs, 6.6% at health centre IVs, and 7.1% at hospitals (Fig. 2).

In crude analysis, respondents at lower-level facilities were 2.94 times as likely to report no referral linkage as those at health centre IVs or hospitals (PR 2.94, 95% CI 1.43–6.07; $p = 0.003$). The association persisted after adjustment for district, professional cadre, and training/CME reported as an information source (adjusted PR [aPR] 2.74, 95% CI 1.39–5.39; $p = 0.004$). There was no significant association between district, cadre, or training/CME and the referral-linkage gap (Table 3).

A sensitivity model additionally adjusting for the disease-recognition score produced an almost identical facility-tier estimate (aPR 2.73, 95% CI 1.40–5.31; $p = 0.003$). The recognition score itself was not associated with the referral-linkage gap (PR 1.08 per one-point increase, 95% CI 0.84–1.39; $p = 0.547$), and training/CME remained unassociated with referral linkage (PR 0.81, 95% CI 0.38–1.73; $p = 0.580$) (**Supplementary Table S2, Panel C**).

Table 3
Factors associated with the reported referral-linkage gap

Variable	cPR (95% CI)	p-value	aPR (95% CI)	p-value
Facility group				
HCIV/hospital	1.00 (Ref)	—	1.00 (Ref)	—
Peripheral facilities (private clinic/medical centre, HCII, HCIII)	2.94 (1.43–6.07)	0.003	2.74 (1.39–5.39)	0.004
District				
Mbarara	1.00 (Ref)	—	1.00 (Ref)	—
Ibanda	1.58 (0.61–4.09)	0.342	1.35 (0.54–3.33)	0.521
Kazo	0.87 (0.27–2.81)	0.818	0.76 (0.26–2.22)	0.612
Kiruhura	0.71 (0.26–1.92)	0.500	0.85 (0.35–2.09)	0.728
Professional cadre				
Medical/clinical	1.00 (Ref)	—	1.00 (Ref)	—
Nursing	1.09 (0.49–2.42)	0.832	0.95 (0.43–2.11)	0.898
Laboratory	0.52 (0.15–1.79)	0.300	0.48 (0.14–1.59)	0.231
Other	0.72 (0.24–2.16)	0.556	0.78 (0.23–2.64)	0.687
Training programme/CME reported as an information source				
No	1.00 (Ref)	—	1.00 (Ref)	—
Yes	0.78 (0.35–1.72)	0.540	0.86 (0.39–1.91)	0.710
Additional participant characteristics (crude analyses only)				
Age, per 1-year increase	1.01 (0.97–1.04)	0.797	—	—
Sex				
Male	1.00 (Ref)	—	—	—
Female	1.19 (0.68–2.10)	0.537	—	—

Variable	cPR (95% CI)	p-value	aPR (95% CI)	p-value
Facility group				
<i>Education level</i>				
College/university	1.00 (Ref)	—	—	—
Primary/secondary	0.79 (0.25–2.52)	0.696	—	—
Years in current position, per 1-year increase	0.98 (0.93–1.04)	0.496	—	—
Years at workstation, per 1-year increase	0.95 (0.84–1.07)	0.377	—	—

cPR = crude prevalence ratio; *aPR* = adjusted prevalence ratio; *CI* = confidence interval; *Ref* = reference category; *CME* = continuing medical education; *HCII* = health centre II; *HCIII* = health centre III; *HCIV* = health centre IV.

Reported specimen-referral destinations

Among 273 respondents who named a referral destination, 121 (44.3%) described a national/reference laboratory pathway, 70 (25.6%) a regional referral hospital, and 58 (21.2%) a district/health centre IV/hub pathway. Private laboratories accounted for 20 (7.3%), while 4 (1.5%) reported other or multiple referral levels (**Supplementary Table S1, Panel A**).

One Health and health-system constraints

Health workers reported multiple constraints that could affect recognition and referral. The most frequent was inadequate or absent diagnostic resources (90.4%), followed by inadequate community awareness (86.4%) and late presentation to health facilities (86.4%). Unreliable transport (75.1%), nonspecific clinical signs and symptoms (74.5%), inadequate collaboration with other relevant sectors (74.2%), and inadequate knowledge and skills (73.3%) were also common. Two-thirds (66.7%) identified paper-based systems as a barrier (**Supplementary Figure S2**).

Result exchange remained partly paper-dependent. Among respondents receiving referral feedback, 52.1% reported physical collection of results on paper, 38.4% digital technology, and 37.0% phone call/SMS; these modes were not mutually exclusive. For communication of results to patients, 64.5% reported physical paper collection, 49.8% phone call/SMS, and 8.5% digital technology (**Supplementary Table S1, Panel C**).

Discussion

In this multi-district survey of frontline health workers in southwestern Uganda, three findings stand out. First, frontline awareness and recognition of the selected zoonoses were generally high, despite specific gaps in RVF-related exposure recognition. Second, the reported referral-linkage gap was concentrated at lower-level facilities. Third, once referral was initiated, result feedback and communication were nearly universal. These findings suggest that the main operational bottleneck lies in linking lower-level facilities to existing diagnostic systems. Overall recognition was strong, but specific gaps remained, particularly for RVF-related exposures and transmission. This pattern is consistent with evidence from pastoral settings in Tanzania, where broad zoonotic awareness coexisted with weaker disease-specific knowledge [8]. In our study, health workers who reported training/CME as an information source had higher recognition scores, indicating that targeted education may be useful for reinforcing epidemiologic cues relevant to early suspicion.

The most notable finding was the strong association between facility level and reported referral linkage. Health workers at lower-level health facilities were almost three times as likely as those at HCIVs or hospitals to report no specimen-referral linkage. This distinction matters because peripheral facilities are not expected to provide confirmatory testing for many high-consequence zoonoses; their critical role is to recognize suspected cases and connect them to centralized diagnostic services. Uganda has established reference laboratory and specimen-transport systems for this purpose [20, 21]. Our findings therefore identify a potential last-mile connectivity gap between lower-level health facilities and an existing higher-level diagnostic network.

Once specimens entered the referral pathway, the system appeared to close the loop effectively. Nearly all respondents who referred specimens reported receiving results and communicating them to patients, suggesting that feedback mechanisms were generally functional. The more important concern was the time required to complete this pathway: the median referral-to-result interval was 10 days, and almost half of respondents reported 14 days or longer. This measure reflects the combined effects of transport, testing, result transmission, and receipt rather than laboratory turnaround alone; nevertheless, the reported interval warrants closer evaluation to identify where time is spent along the referral-to-result pathway. Evidence from Uganda indicates that organized specimen-transport and referral systems can improve access to diagnostic services [14, 16].

Measured recognition did not explain the referral-linkage gap. Training/CME reported as an information source was associated with higher recognition scores, but neither recognition nor training/CME explained the facility-level association. This suggests that preparedness depends not only on what frontline workers recognize, but also on whether referral pathways, specimen transport, handling support, and communication systems are functional. The findings therefore reinforce the need to complement training with stronger subnational One Health and referral infrastructure [11].

The One Health findings suggest that national coordination structures may not yet be consistently reflected in frontline practice. Only about three in five respondents recognized the human-animal-environment linkage, veterinary officials were infrequently reported as an information source, and

inadequate intersectoral collaboration was a common barrier. Diagnostic, transport, and information-system constraints were also prominent. These findings align with previous assessments in Uganda showing that, despite progress in establishing national One Health structures, implementation challenges persist at subnational levels [11, 21, 22]. Addressing these gaps will likely require a combination of targeted refresher training, clear referral pathways, reliable specimen transport, stronger cross-sector information exchange, and systems for tracking specimens and results. Electronic tools may support these functions if integrated into existing surveillance and referral systems rather than introduced as parallel platforms [23].

The key public health implication is that early zoonotic detection depends on whether recognition can be converted into action. Health workers may identify a suspected case, but preparedness is incomplete if lower-level facilities cannot reliably access specimen referral, laboratory confirmation, and result-feedback systems. The persistence of the facility-level association after accounting for recognition suggests that referral connectivity is an independent component of readiness. Priority should therefore be given to the lower-level health facilities, where referral limitations may most directly affect early outbreak detection and response.

Strengths and limitations

This study has several strengths. It included frontline health workers from four zoonosis-prone districts, multiple professional cadres, and facilities spanning the peripheral to hospital levels of the health system. Several limitations should be considered. First, the cross-sectional design precludes causal inference. Participants were selected because their routine roles involved frontline recognition, assessment, testing, specimen handling, referral, or reporting of suspected zoonoses; consequently, findings may not generalize to all health workers. Second, referral measures were self-reported and were not independently verified against facility registers, courier logs, or laboratory records. Indeed, respondents within some facilities disagreed about whether specimens were referred, emphasizing that the outcome reflects individual health-worker awareness of or access to referral linkage, rather than an audited facility characteristic. Third, the reported referral-to-result interval was based on recall and did not distinguish transport time from laboratory processing or result transmission; it also was not disease-specific. Fourth, training/CME represented a reported source of information and did not capture the content, timing, intensity, or quality of training. Finally, the 11-item recognition score was designed to summarize selected disease-specific recognition items rather than to represent a validated latent knowledge scale.

Conclusion

Frontline recognition of selected priority zoonoses was generally strong, but the ability to translate suspicion into diagnostic referral was less consistent at lower levels of care. Once referral occurred, reported receipt and communication of results were nearly universal. The priority for strengthening preparedness is therefore to improve peripheral connectivity to specimen transport, confirmatory testing,

result-feedback systems, and One Health coordination while maintaining targeted disease-specific training. Future studies could use prospective facility- and laboratory-linked data to determine where breakdowns occur along the recognition-to-result pathway and which system interventions most effectively improve referral completion and timeliness.

Abbreviations

aPR

Adjusted prevalence ratio

CCHF

Crimean-Congo haemorrhagic fever

CI

Confidence interval

CME

Continuing medical education

HC

Health centre

HCII

Health centre II

HCIII

Health centre III

HCIV

Health centre IV

IQR

Interquartile range

KAP

Knowledge, attitudes, and practices

KOFIH

Korea Foundation for International Healthcare

PR

Prevalence ratio

RVF

Rift Valley fever

SMS

Short message service

Declarations

Ethics approval and consent to participate

The study was reviewed and approved by the Makerere University School of Public Health Research Ethics Committee (SPH-2024-671) and registered with the Uganda National Council for Science and Technology (HS5420ES). Written informed consent was obtained from all participants before participation. Participation was voluntary, and respondents could decline to answer individual questions or withdraw from the study at any time without penalty. All study procedures were conducted in accordance with the approved protocol and applicable ethical guidelines.

Clinical trial number

Clinical trial number: not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was conducted as part of the Zoonotic One Health Engagement and Communication (ZOHEC) project, supported by the Korea Foundation for International Healthcare (KOFIH) through the KOFIH Global Alumni (KGA) programme. The funder had no role in the analysis or interpretation of the data, preparation of the manuscript, or decision to submit the manuscript for publication.

Author Contribution

RM, CM, DA, AB, AM, PDK, SA, AWW, and ARA contributed to the conceptualization and/or design of the study. DA and AM contributed to field implementation and data collection. RM led data management and statistical analysis, interpreted the findings, and drafted the initial manuscript. FM contributed to interpretation of the findings from an animal-health and One Health perspective and critically revised the manuscript for important intellectual content. All authors approved the final version for submission. All authors agree to be accountable for the work.

Acknowledgements

The authors thank the health workers who participated in the study and the district health authorities and leadership of participating health facilities in Mbarara, Kazo, Kiruhura, and Ibanda districts for facilitating study implementation. We also acknowledge the research assistants and field teams who supported questionnaire administration, data entry, and quality assurance.

Data Availability

The de-identified dataset used and analysed for this study is available from the corresponding author on reasonable request.

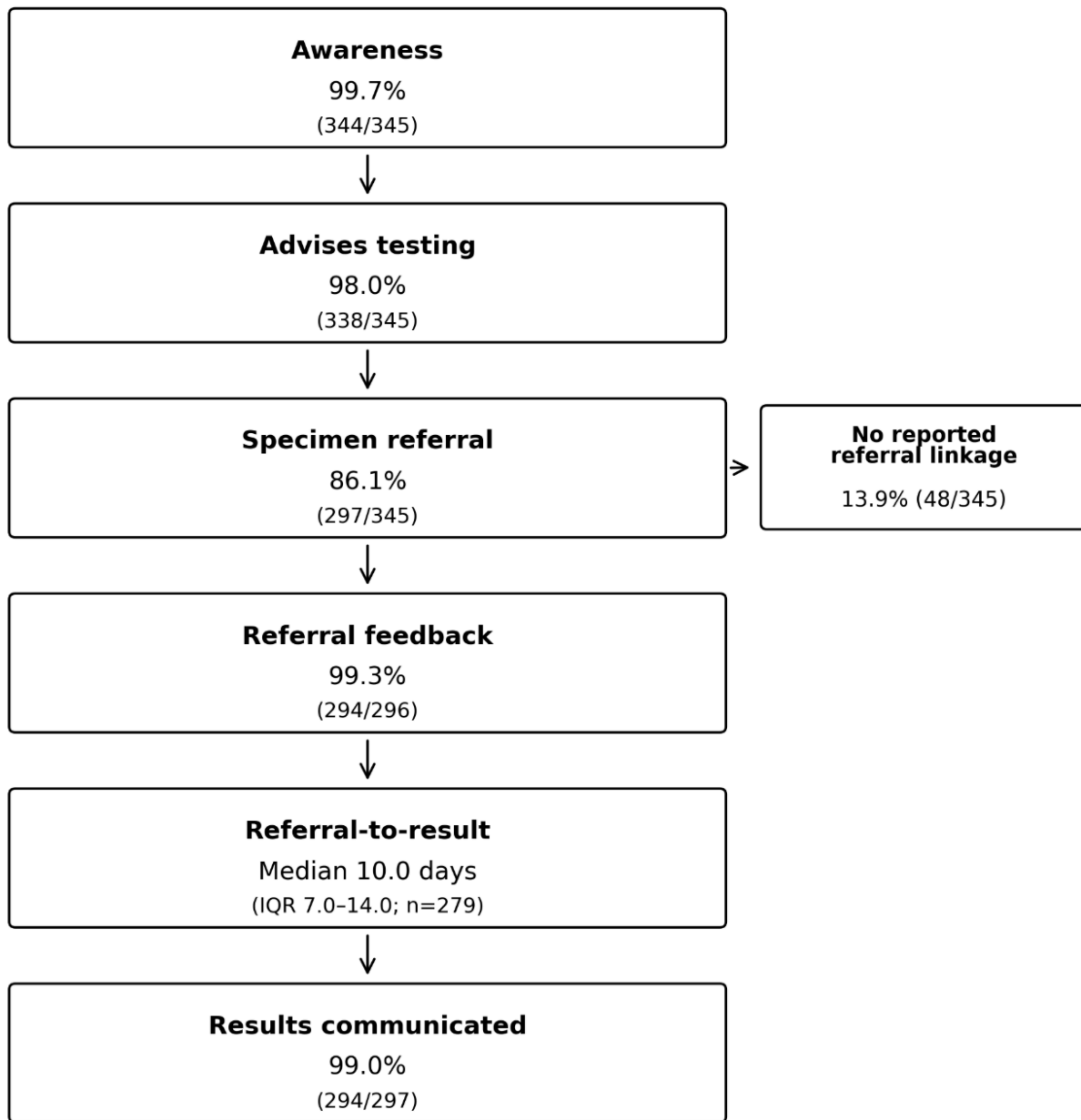
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Figures



Conceptual pathway; denominators differ across indicators.

Figure 1

Frontline recognition and referral-readiness pathway. Arrows depict the conceptual pathway rather than longitudinal attrition; denominators differ by indicator. Referral-to-result time is the health-worker-reported interval to receipt of results and should not be interpreted as analytic laboratory turnaround time.

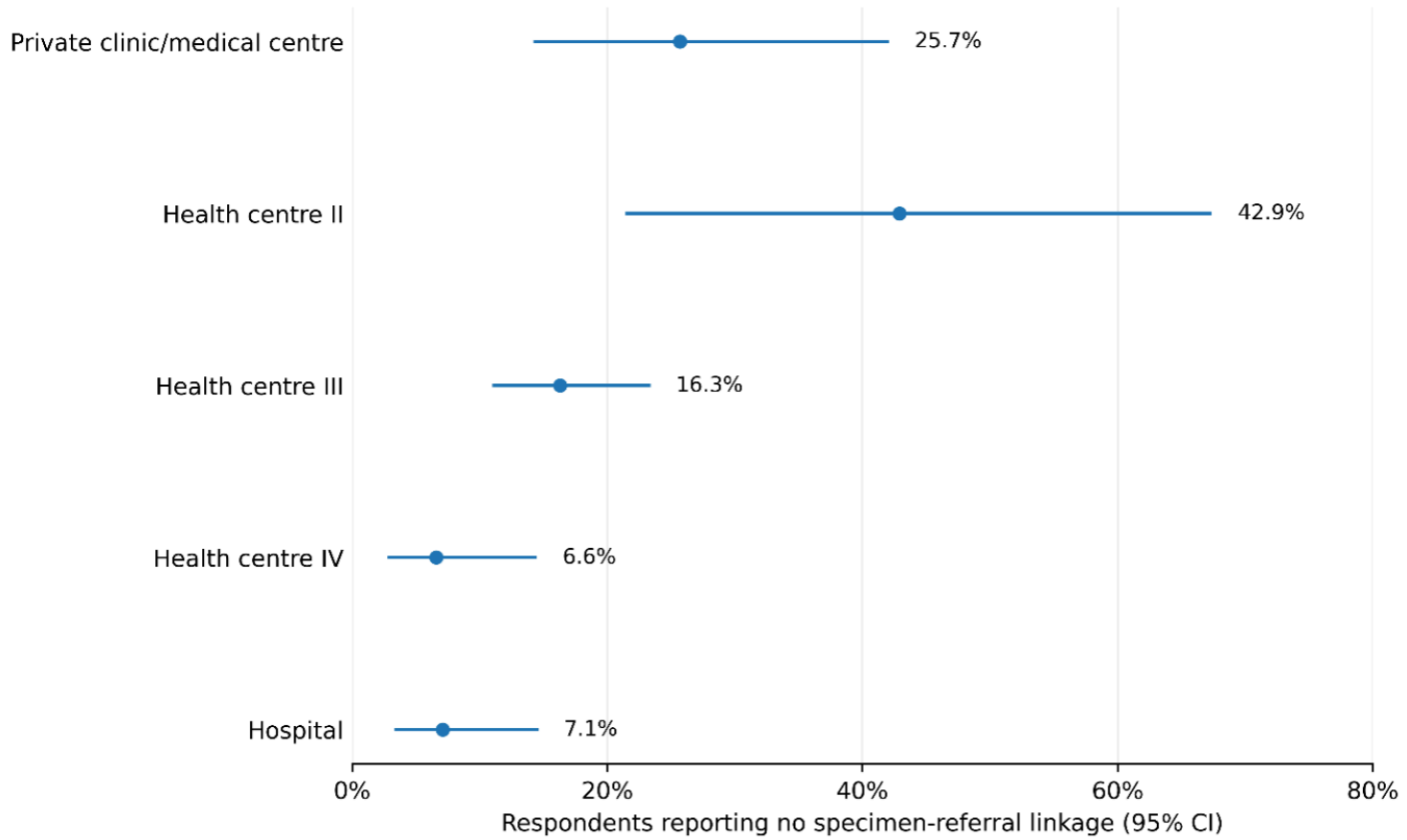


Figure 2

Reported referral-linkage gap by health-facility level. Points show crude respondent-level prevalences with Wilson 95% confidence intervals. The measure represents health-worker-reported referral linkage and not an audited facility attribute.

Supplementary Files

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