



Effect of digital viral load requests on viral load turnaround time trends in Rwenzori Region, Uganda, 2024–2025: an interrupted time series analysis

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Summary

Background: Timely viral load (VL) results are essential for monitoring antiretroviral therapy and optimizing patient care. Paper-based VL request can delay sample processing because they require duplicate data entry and are prone to illegible information. On April 7, 2025, digital VL requests through Uganda EMR and extended Laboratory Information Management System (LIMS) were rolled out in Rwenzori Region but their effect was unknown. We assessed the effect of digital VL requests on Turnaround Time (TAT) between June 2024 and July 2025.

Methods: We abstracted VL data from the Central Public Health Laboratory (CPHL) dashboard for one hospital, six health centre (HC) IVs, and 18 HC IIIs in one city and four districts between June 2024 and July 2025. We defined TAT as duration in days from sample collection to facility results reception. We computed weekly median TAT by district. We defined the study period as pre-(June 1, 2024–April 6, 2025) and post-(April 7, 2025–July 15, 2025) digital VL request rollout. We conducted interrupted time series analysis using autoregressive integrated moving average models with the appropriate (p,d,q) specification determined separately for each district and the overall region to determine the effect of digital VL requests on TAT.

Results: Of the 5,168 VL records in the post-digital, 3,317 (64%) were digital VL requests of which 3,201 (97%) were through UgandaEMR. Median TAT for digital (35, IQR:25–45) and paper-based (36, IQR:25–49) VL requests was significantly different. Median TAT was 17 (IQR: 12–24) pre-digital, 36 (IQR: 25–47) post-digital and 20 (IQR=14–30) days overall. Median TAT increased significantly pre-digital period overall [slope=0.4 (p<0.01)]. Digital VL rollout increased TAT immediately overall [27.7 days (p<0.01)], then a significant decline in the post-digital trend overall [slope-change=-3.0 (p<0.01)] and across all districts. Reductions in TAT were highest in Kabarole [slope-change=-3.6 (p<0.01)] and lowest in Bunyangabu.

Conclusion: Digital VL requests were associated with an initial increase in TAT followed by a significant downward trend. However, TAT was comparable between digital and paper based requests which suggested that the improvement was not attributable to digital VL requests alone. We recommend rollout of digital VL request countrywide.



Introduction

The World Health Organization recommends viral load (VL) testing as the preferred method for monitoring antiretroviral therapy (ART) response among people living with HIV and confirming treatment failure (1). Timely return of VL results is important for clinical decision-making, including adherence counselling and regimen switching, with a commonly used turnaround-time target of 14 days from sample collection to receipt of results at the healthcare facility (1–3).

In Uganda, VL testing is largely centralized, requiring samples to move through multiple steps from healthcare facilities to testing laboratories and results back to facilities (4,5). Paper-based VL requests can contribute to delays through incomplete or illegible information, data-entry errors, and difficulties linking samples to patient records (6,7).

To strengthen VL sample tracking and reporting, the Ministry of Health introduced digital VL request systems linked to UgandaEMR and the Laboratory Information Management System, together with barcode-based sample identification. In April 2025, barcode-linked VL testing was rolled out in Fort Portal City and Bundibugyo, Bunyangabu, Kabarole, and Ntoroko districts in Rwenzori Region, where VL turnaround time exceeded the 14-day target (3) with an average of 17 days. We assessed the effect of digital VL requests on VL TAT at selected healthcare facilities in Rwenzori Region during June 2024–July 2025.

Methods

We conducted an interrupted time series study using routinely collected viral load (VL) programme data from 25 public ART-providing health facilities in Fort Portal City and Bundibugyo, Bunyangabu, Kabarole, and Ntoroko districts, Rwenzori Region, western Uganda, from 1 June 2024 to 15 July 2025. The facilities included one general hospital, six Health Centre IVs, and 18 Health Centre IIIs, all using UgandaEMR version 4.0.3 or higher with internet-enabled VL health information exchange.

In April 2025, facilities transitioned from paper-based VL request slips to digital VL requests using barcodes through UgandaEMR or extended LIMS. The barcode uniquely linked each specimen to the corresponding patient and request record and enabled electronic retrieval of requests and synchronization of results.

We extracted VL programme data from the national VL dashboard and triangulated these with UgandaEMR data. Variables included district, hub, request type, request platform, sample collection date, laboratory receipt date, test date, and result-printing date. VL turnaround time (TAT) was defined as the number of days from sample collection to receipt of results at the health facility, using the hub result-printing date as a proxy for result receipt.

Data were aggregated into 60 weekly observations and divided into pre-digital (1 June 2024–6 April 2025) and post-digital (7 April–15 July 2025) periods. We used

autoregressive integrated moving average (ARIMA) models to estimate the immediate level change and post-intervention trend change in weekly median VL TAT following rollout of digital VL requests. Models were selected using stationarity assessment, autocorrelation diagnostics, and Akaike information criterion. In the post-digital period, median TAT for paper-based and digital requests was compared using the Mann–Whitney U test.

Results

Characteristics of Viral Load Program Data by Digital Viral Load Request Period in Rwenzori Region, Uganda, 2024–2025

Between 1 June 2024 and 15 July 2025, 21,502 VL samples were collected from the 25 healthcare facilities. Of these, 5,793 (27%) were from Kabarole, 5,436 (25%) from Bunyangabu, 4,829 (22%) from Fort Portal City, 3,089 (14%) from Bundibugyo and 2,355 (11%) from Ntoroko. The majority of samples (21001, 98%) were referred to CPHL.

Most samples were from HC IIIs, 12,345 (57%), followed by HC IVs, 7,664 (36%), and the general hospital, 1,493 (7%). Overall, 18,117 (84%) VL requests were paper-based and 3,317 (16%) were digital requests. Among digital requests, 3,201 (97%) were made through UgandaEMR and 117 (3%) through extended LIMS (Table 1).

Table 1: Characteristics of Viral Load Program Data by Digital Viral Load Request Period in Rwenzori Region, Uganda, 2024–2025

Variable	Overall N=21,502 n(%)	Pre-digital VL requests N=16,334 n(%)	Post-digital VL requests N=5,168 n(%)
District			
Bundibugyo	3089 (14.4)	2354 (10.9)	735 (3.4)
Bunyangabu	5436 (25.3)	4144 (19.3)	1292 (6.0)
Fort Portal City	4829 (22.5)	3537 (16.4)	1292 (6.0)
Kabarole	5793 (26.9)	4393 (20.4)	1400 (6.5)
Ntoroko	2355 (10.9)	1906 (8.9)	449 (2.1)
Health facility level			
HC III	12345 (57.4)	9261 (43.1)	3084 (14.3)
HC IV	7664 (35.6)	5977 (27.8)	1687 (7.8)
General Hospital	1493 (6.9)	1096 (5.1)	397 (1.9)
Type of request			
Paper based	18117 (84.3)	16266 (75.7)	1851 (8.6)
Digital	3385 (15.7)	68 (0.3)	3317 (15.4)
Request option			
Not digital	18117 (84.3)	16266 (75.7)	1851 (8.6)
UgandaEMR	3268 (15.2)	67 (0.3)	3201 (14.9)
Extended LIMS	117 (0.5)	1 (0.0)	116 (4.6)
Reference laboratory			



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District	ARIMA (p,d,q)	Pre-intervention trend (Wk1–45: 01/06/2024– 06/04/2025)		Post-intervention: Immediate change (at Wk46: 07/04/2025)		Post-intervention: Trend (slope change) (Wk46–60: 07/04/2025– 20/07/2025)	
		Estimated change (95% CI)	P- valu e	Estimated change (95% CI)	P- value	Estimated change (95% CI)	P- value
Bundibugyo	ARIMA(2, 0, 2)	0.3 (0.2, 0.3)	<0.001	31.2 (21.1, 41.2)	<0.001	-2.5 (-3.7, -1.4)	<0.001
Bunyangu	ARIMA(0, 0, 2)	0.3 (0.1, 0.5)	0.002	16.6 (7.4, 25.8)	<0.001	-1.4 (-2.3, -0.4)	0.004
Fort Portal City	ARIMA(0, 0, 2)	0.2 (0.0, 0.5)	0.034	27.83 (17.0, 38.7)	<0.001	-2.6 (-3.7, -1.4)	<0.001
Kabarole	ARIMA(0, 0, 0)	0.3 (0.2, 0.45)	<0.001	38.4 (30.7, 46.1)	<0.001	-3.6 (-4.4, -2.9)	<0.001
Ntoroko	ARIMA(1, 0, 0)	0.6 (0.3, 1.0)	<0.001	23.7 (6.4, 41.1)	0.007	-3.4 (-5.1, -1.6)	<0.001
Overall	ARIMA(1, 0, 0)	0.4 (0.2, 0.7)	<0.001	27.7 (19.0, 36.4)	<0.001	-3.0 (-4.0, -2.0)	<0.001

Comparison of TAT for digital versus paper-based requests during the post-digital period

Of the 5,168 VL requests made in the post-digital period, 3,317 (64%) were digital requests. Median TAT between paper-based (36 days, IQR:25–49) and digital (35 days, IQR:25–45) VL requests were significantly ($p<0.001$) different but they were close to each other. This gap was not clinically meaningful but rather a gap due to the large sample size.

Discussion

Following rollout of digital VL requests, weekly median VL turnaround time (TAT) initially increased by about 28 days, but subsequently declined significantly, with an overall post-intervention slope change of -3.0 days per week. Significant declines were observed in all five districts, although the magnitude varied. This pattern suggests an initial implementation or workflow adjustment period followed by progressive improvement in TAT (2,8).

During the post-rollout period, median TAT was similar for digital and paper-based requests (35 versus 36 days). Although the difference was statistically significant, it was small and unlikely to be operationally meaningful. This suggests that the downward



trend cannot be attributed solely to whether an individual request was digital; broader workflow changes accompanying rollout may also have contributed.

The findings indicate that digital VL request implementation was associated with a favorable change in the trajectory of TAT rather than an immediate reduction. Continued monitoring is needed to determine whether these improvements are sustained and whether increasing uptake of digital requests further reduces TAT (2,8).

Study limitations: The date results were printed at the hub was used as a proxy for receipt at the health facility and may therefore underestimate actual TAT. The study had no concurrent control group because digital VL requests were introduced programmatically, limiting causal attribution. Other changes occurring during implementation may also have contributed to the observed improvement.

Conclusion: Rollout of digital VL requests was associated with an initial increase in VL TAT followed by a significant sustained downward trend across all five districts. However, similar TATs for digital and paper-based requests during the post-rollout period suggest that the improvement may reflect both digitalization and accompanying workflow changes. Continued monitoring and strengthening of the digital VL request process are needed to determine whether these gains translate into sustained reductions in TAT.

Conflict of interest: The authors declare no competing interests.

Author Contributions: TE came up with the study idea, led the data collection, analysis, and interpretation, and wrote the first draft of the manuscript. GW and KDA reviewed the draft and contributed important intellectual input through several rounds of revisions. JN, IL, EAP, PM, also reviewed the bulletin and provided feedback to strengthen its intellectual content and scientific integrity.

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