District overview of travel time to ART facilities: Nsanje

Kevin Lam, Jeffrey W. Eaton, Stone Mbiriyanda, Brown Chiwandira, Tiwonge Chimpandule, Thokozani Kalua, Rose Nyirenda, Andreas Jahn. *Department of HIV and AIDS, Ministry of Health, Government of Malawi; MRC Centre for Global Infectious Disease Analysis, School of Public Health, Imperial College London*

Version: 05 March 2022; Correspondence to: Andreas Jahn (ajahn@hivmw.org)

Objectives

- Map the estimated prevalence and number of people living with HIV (PLHIV) by approximately 1 km grid cells.
- Estimate the travel time to the nearest ART facility for PLHIV in Malawi.
- Identify optimal locations for additional facilities with ART service to reach PLHIV with long travel times to existing ART facilities (>60, 90, or 120 minutes).

Interactive results are available at: https://mrc-ide.github.io/mwi-hiv/ART_facilities/index.html.

HIV prevalence and PLHIV estimates

Figure 2 illustrates estimates for spatial HIV prevalence for adults aged 15-49 years. Figure 3 shows the estimated number of PLHIV (all ages), and the locations of health facilities with ART services (labelled with **A**) and without current ART services (labelled with **F**).

Table 1: Summary estimates for Nsanje, September 2020.

Total PLHIV (all ages)	23,911 (20,112–28,392)
HIV prevalence, age 15-49 years	12.0% (10.1%–14.3%)
Total patients receiving ART	30,743
Average walking time to nearest ART (minutes)	47 (44–50)
Number PLHIV > 60 minutes walking time	5,944 (4,819–7,175)
Percentage PLHIV > 60 minutes walking time	25.5% (23.1%–28.0%)

Table 2: Traditional authorities with the lowest and highest estimated number of PLHIV, 15-49 Prevalence, and average walking time, respectively.

	Lowest TA	Largest TA
PLHIV	TA Nyachikadza: 319 (203–461)	TA Ngabu: 6,820 (4,902–8,978)
15-49 Prevalence	TA Makoko: 9.8% (6.2%–13.9%)	TA Mbenje: 15.5% (11.8%–19.8%)
Average Walking Time	Nsanje Boma: 14 min (14–14 min)	Mwabvi Game Reserve: 224 min (220–228 min)

Travel time to existing ART facilities

In Nsanje, there are 14 ART facilities that had at least 1 patient in September 2020. The median number of ART patients per facility was 1425. The list of *active ART facilities* is in Table 4. Private not-for-profit facilities have been excluded from the analysis. Figure 4 shows the modelled travel times to the nearest active ART facility. The average walking time to the nearest facility for residents in each traditional authority are in (Figure 5).

- The estimated average walking time for PLHIV to the closest ART facility across Nsanje is 47 minutes (44-50 min).
- The shortest estimated average walking time to the closest ART facility is in Nsanje Boma (14 minutes (14-14 min)).
- The longest estimated average walking time to the closest ART facility is in Mwabvi Game Reserve (224 minutes (220-228 min)).

An estimated 25.5% (23.1%–28.0%) of PLHIV reside more than 60 minutes walking time to their nearest ART facility, compared to 27.8% of the total population. This decreases to 16.5% (14.6%–18.3%) of PLHIV and 18.0% of the total population residing more than 90 minutes walking time to their nearest ART facility. More details are provided in Table 3.

Table 3: Estimated PLHIV and population not reached at different thresholds

Threshold (minutes)	Population not reached	As % of total population	PLHIV not reached	As % of total estimated PLHIV
45	109,082	35.1%	7,686 (6,348–9,145)	33.0% (30.6%–35.5%)
60	86,238	27.8%	5,944 (4,819–7,175)	25.5% (23.1%–28.0%)
90	56,019	18.0%	3,832 (3,058–4,665)	16.5% (14.6%–18.3%)
120	29,492	9.5%	1,997 (1,575–2,467)	8.6% (7.5%–9.7%)

Proposed facilities for new ART services

A list of 8 *non-ART facilities* were considered to identify existing health facility locations for expanding ART services, listed in Table 5. Figure 6 shows the number of PLHIV in grid cells where the estimated travel time is longer than 60 minutes and candidate new ART facilities.

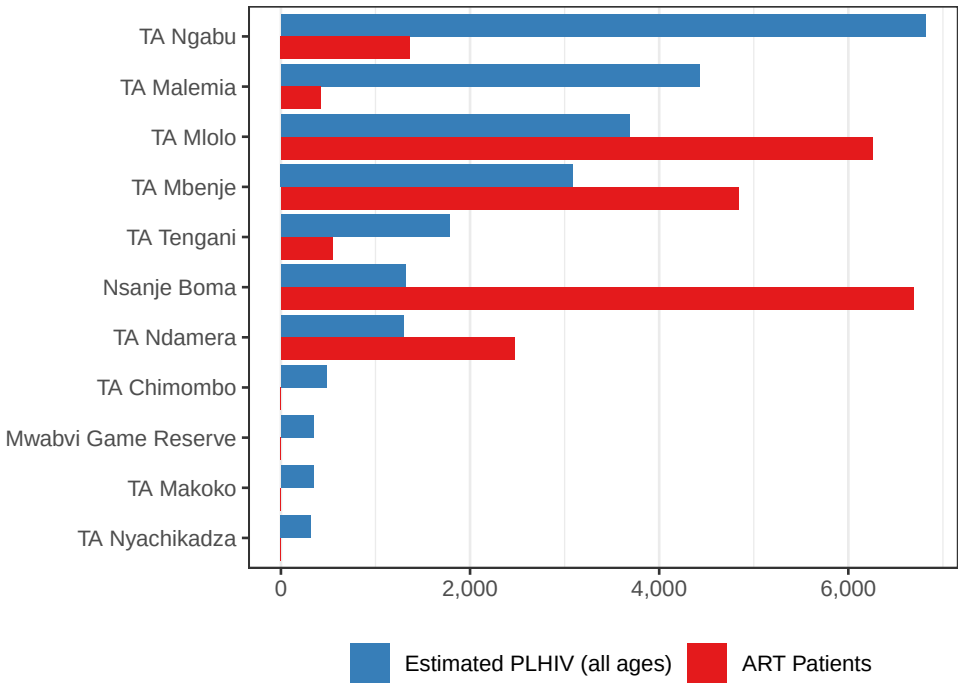
- The TA with the largest number of PLHIV residing more than 60 minutes from their closest ART facility is TA Ngabu (2088 PLHIV (1532-2739) with walking time > 60 minutes).
- The facility that can reach the most PLHIV residing outside 60 minutes travel time is **Mkango HP**, with 510 PLHIV (326-734) reached.

Limitations

There are several important limitations to this analysis:

- Travel time surfaces and catchments may not optimally reflect typical routine travel or movement patterns, for example for work or other activities.
- Results do not represent uncertainty in the 1km gridded maps of PLHIV arising from uncertainty about the gridded populations.
- There are discrepancies in the gridded HIV prevalence estimates from the Bayesian geostatistical model and the Naomi estimates for some districts which should be further reviewed, especially neighbouring urban and rural districts.
- Geographic locations of some health facilities are discrepant between multiple data sources and need to be confirmed.
- The physical infrastructure and suitability of candidate health facilities for supporting an ART service is unknown.
- Optimisation analysis for locations for new facilities has not considered overcrowding, wait times, or other barriers to access at existing facilities. It could be more optimal to expand services in some geographically dense locations to address barriers to access.

Summary figures and maps



Est. PLHIV (all ages)	Prevalence 15−49
6,820	10.8%
4,428	11.0%
3,690	14.8%
3,089	15.5%
1,786	12.3%
1,316	12.1%
1,293	10.9%
483	11.2%
345	11.4%
345	9.8%
319	12.2%

Figure 1: Number registered ART clients within each TA and estimated number of PLHIV within the TA. The right table indicates the estimated 15-49 HIV prevalence.

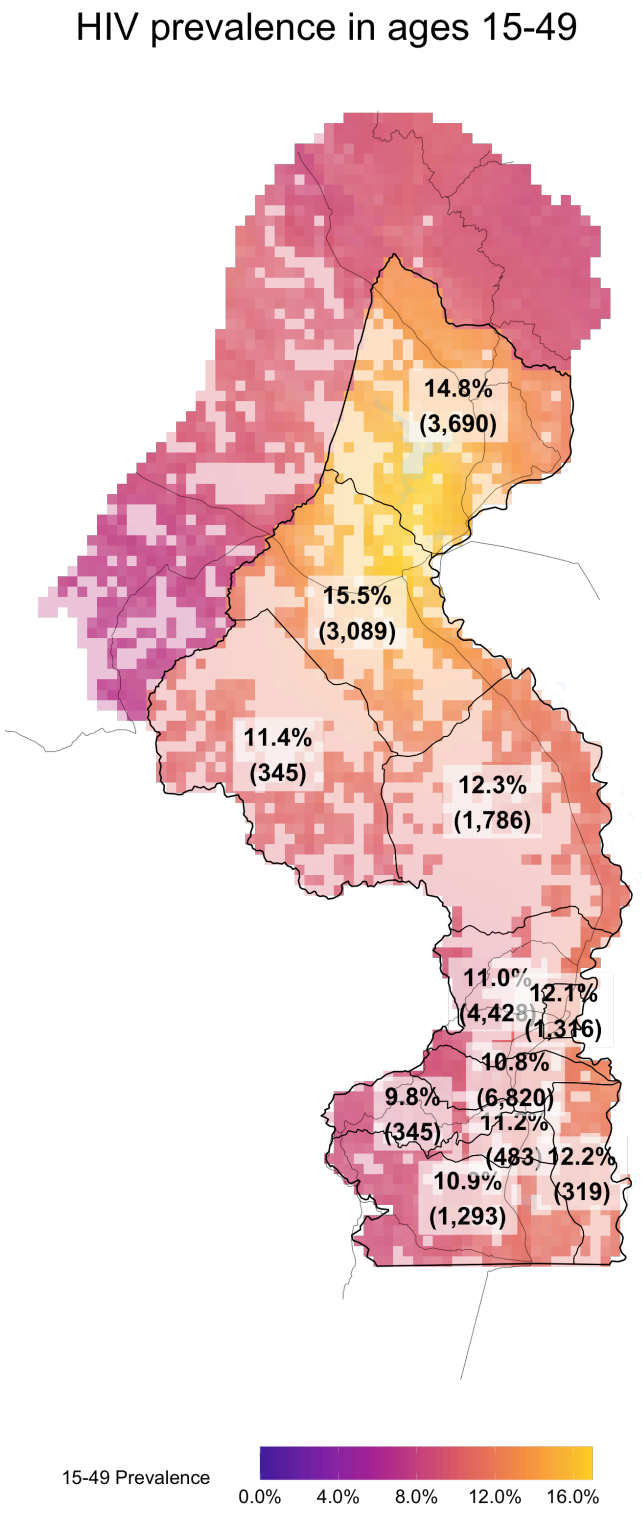


Figure 2: Estimated spatial HIV prevalence. Percentages correspond to TA level 15-49 HIV prevalence and numbers in brackets indicate the estimated number of PLHIV overall.

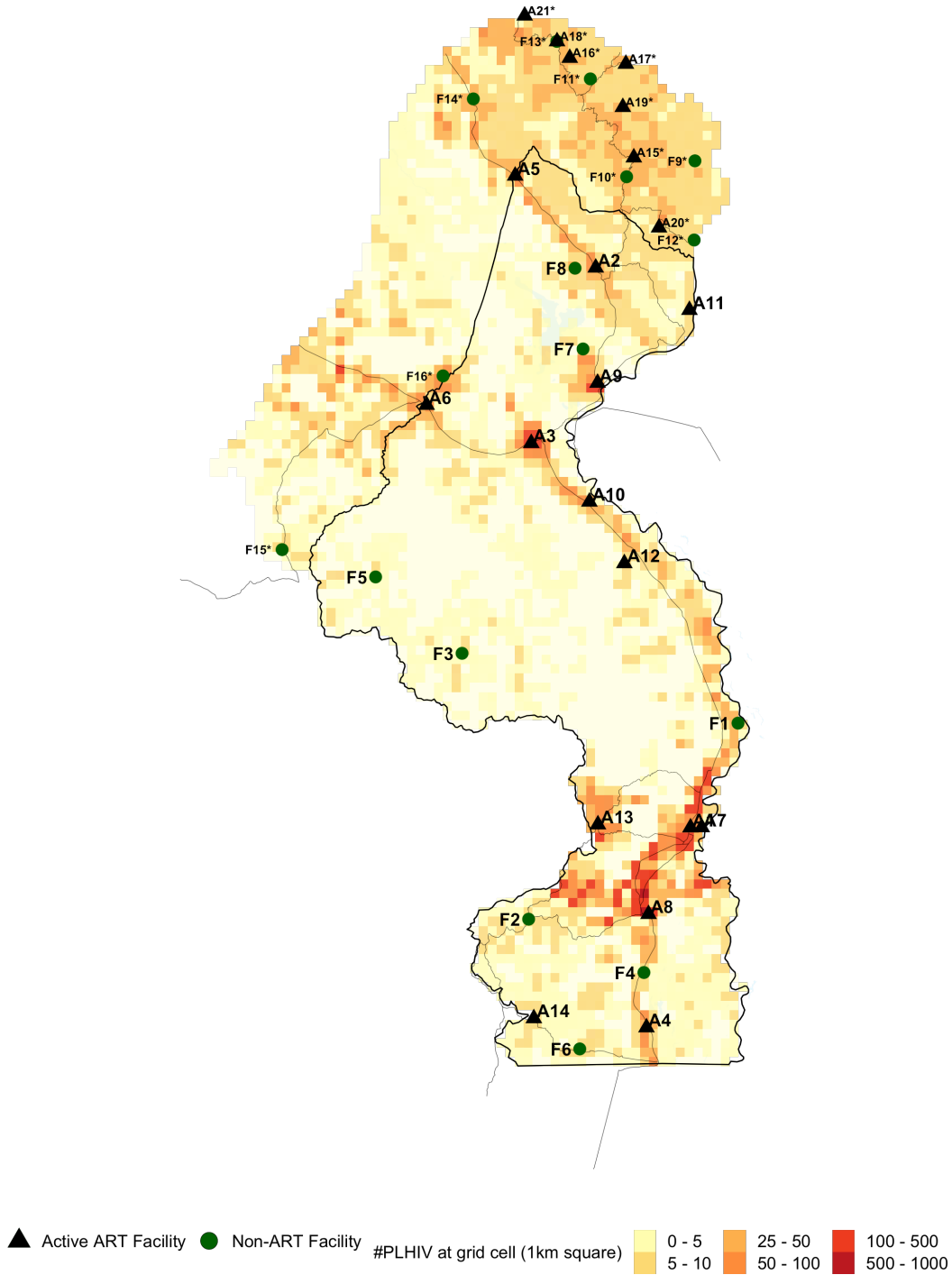


Figure 3: Estimated number of PLHIV on a 1km square.

Table 4: List of active ART facilities that had at least 1 registered ART patient in September 2020. The column ”ART” indicates how many ART patients are registered at the ART facility. Facilities outside the district boundaries that may be accessible to residents within the district are marked with ”*”.

ID	District	TA	Name	Type	Authority	Long.	Lat.	ART
A1	Nsanje	Nsanje Boma	Nsanje District Hosp.	District hospital	Government	35.26	-16.92	5208
A2	Nsanje	TA Mlolo	Trinity Mission Hosp.	District hospital	CHAM	35.17	-16.42	2798
A3	Nsanje	TA Mbenje	Kalemba Community Hosp.	Health centre	CHAM	35.11	-16.58	2476
A4	Nsanje	TA Ndamera	Ndamera HC	Health centre	Government	35.22	-17.10	2075
A5	Nsanje	TA Mlolo	Masenjere HC	Health centre	Government	35.10	-16.34	1532
A6	Nsanje	TA Mbenje	Sorgin HC	Health centre	Government	35.01	-16.54	1504
A7	Nsanje	Nsanje Boma	Tengani HC	Health centre	Government	35.27	-16.92	1485
A8	Nsanje	TA Ngabu	Mbenje HC	Health centre	Government	35.22	-16.99	1365
A9	Nsanje	TA Mlolo	Makhanga HC	Health centre	Government	35.17	-16.52	1222
A10	Nsanje	TA Mbenje	Phokera HC	Health centre	Government	35.17	-16.63	860
A11	Nsanje	TA Mlolo	Sankhulani HC	Health centre	Government	35.26	-16.46	700
A12	Nsanje	TA Tengani	Nyamithuthu HC	Health centre	Government	35.20	-16.68	547
A13	Nsanje	TA Malemia	Chididi HC Nsanje	Health centre	CHAM	35.17	-16.92	419
A14	Nsanje	TA Ndamera	Lulwe HC	Health centre	CHAM	35.11	-17.09	396
A15*	Thyolo	TA Nsabwe	Thekerani HC	Rural/Community	Government	35.21	-16.32	2746
A16*	Thyolo	TA Changata	Changata HC	Health centre	Government	35.15	-16.23	1421
A17*	Thyolo	STA Mbawela	Zoa HC	Health centre	Government	35.20	-16.24	1219
A18*	Thyolo	TA Changata	St Martins Molere HC	Health centre	CHAM	35.14	-16.22	1011
A19*	Thyolo	STA Mbawela	Mapanga Mat.	Special	CHAM	35.20	-16.28	875
A20*	Thyolo	STA Thukuta	Gombe HC	Health post	Government	35.23	-16.38	784
A21*	Thyolo	TA Kwethemule	Makwasa Estate Clinic	Health centre	Private	35.11	-16.19	100

Table 5: List of non-ART facilities considered in the analysis. The column ”PLHIV” indicates the number of PLHIV that currently need more than 60 minutes to walk to the closest ART facility but less than 60 minutes to the listed health facility in the table. Facilities outside the district boundaries that may be accessible to residents within the district are marked with ”*”.

ID	District	TA	Name	Type	Authority	Long.	Lat.	PLHIV	95% CI
F1	Nsanje	TA Tengani	Mkango HP	Health Post	Government	35.30	-16.82	510	(326-734)
F2	Nsanje	TA Makoko	Ching’oma HP	Health Post	Government	35.11	-17.00	503	(304-752)
F3	Nsanje	Mwabvi Game Reserve	Misamvu HP	Health Post	Government	35.05	-16.76	114	(57-197)
F4	Nsanje	TA Ndamera	Kamphata HP	Health Post	Government	35.22	-17.05	57	(39-79)
F5	Nsanje	Mwabvi Game Reserve	Kanyimbi HP	Health Post	Government	34.97	-16.69	66	(30-125)
F6	Nsanje	TA Ndamera	Nkhande HP	Health Post	Government	35.16	-17.11	43	(30-61)
F7	Nsanje	TA Mlolo	Mchacha HP	Health Post	Government	35.16	-16.49	37	(26-51)
F8	Nsanje	TA Mlolo	Mlolo HP	Health Post	Government	35.15	-16.42	19	(14-24)
F9*	Thyolo	TA Nsabwe	NKHATAOMBERE	Health Post	Government	35.26	-16.32	345	(234-487)
F10*	Thyolo	TA Nsabwe	Nsabwe HC	Dispensary	Government	35.20	-16.34	40	(31-51)
F11*	Thyolo	STA Mbawela	Mbalanguzi HC	Health Centre	CHAM	35.17	-16.25	15	(11-19)
F12*	Thyolo	STA Thukuta	THUKUTA	Health Post	Government	35.26	-16.39	9	(6-13)
F13*	Thyolo	TA Changata	Molere HC	Special	Government	35.14	-16.22	0	(0-0)
F14*	Chikwawa	TA Makhwira	Mitondo HP	Health Post	Government	35.06	-16.27	1118	(770-1570)
F15*	Chikwawa	STA Masache	THENDO	Health Post	Government	34.88	-16.67	161	(80-291)
F16*	Chikwawa	TA Ngowe	MWANAWANJOBVU	Health Post	Government	35.03	-16.52	59	(40-82)

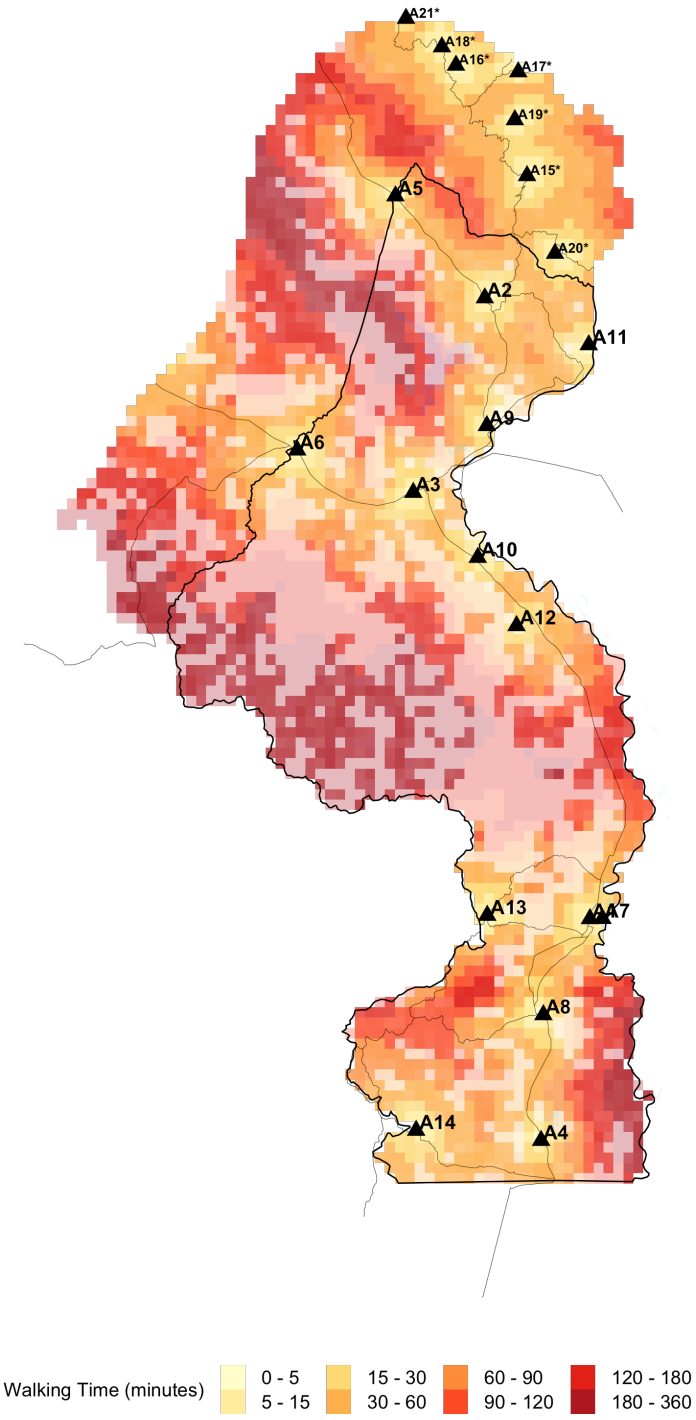
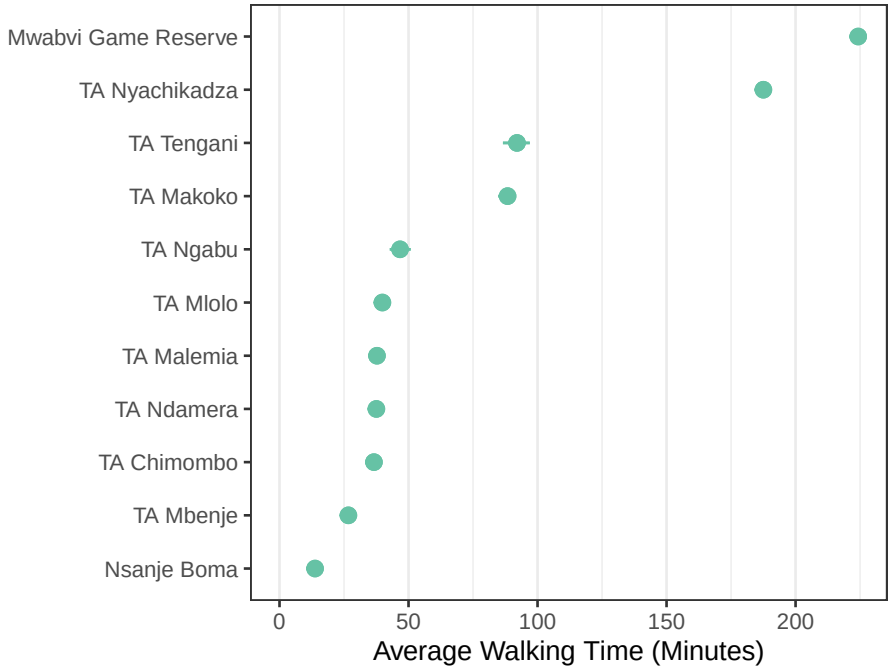


Figure 4: Estimated travel times to the closest ART facility. Travel times were calculated using data on road infrastructure, types of terrain and land elevation.



#PLHIV >60 mins	%PLHIV >60 mins
327	100.0%
312	100.0%
1,265	74.3%
280	84.9%
2,088	31.6%
600	16.4%
531	12.4%
182	14.7%
59	12.5%
301	10.0%
0	0.0%

Figure 5: Estimated average walking time to the closest ART facility, weighted by the estimated number of PLHIV within the traditional authority. The right table indicates estimated number and proportion of PLHIV that need more than 60 minutes to travel to the closest ART facility, respectively.

Areas outside 60 minutes travel

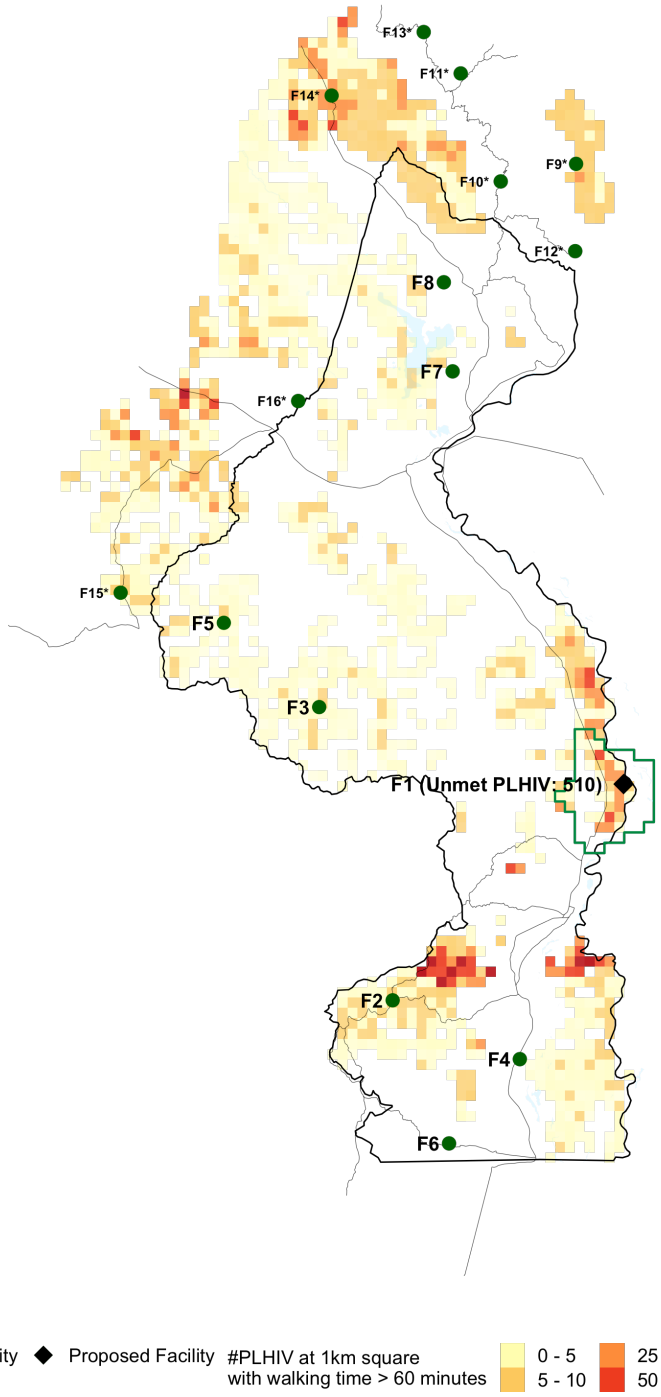


Figure 6: Proposed facility locations. Areas where the walking time to the closest ART facility is <60 minutes have been removed. Green lines indicate the 60-minutes catchment area of the proposed facility.

Appendix (Methods Summary)

The analysis involved several steps:

1. **Creating a map of spatial prevalence by approximately 1km grid cells.** We used cluster-level survey data from the 2015/16 MDHS and MPHIA household surveys and HIV prevalence amongst ANC clients from routine health facility data to obtain a gridded PLHIV prevalence map (1km grid cells).
2. **Calculate the estimated number of PLHIV in each 1km grid cell.**
   - Modelled estimates of total population by 1km grid cell were sourced from the WorldPop project (https://www.worldpop.org/geodata/summary?id=49698). Gridded populations are constrained to only grid cells containing built settlements based on satellite imagery.
   - Gridded populations were adjusted to match traditional authority (TA) population data from the 2018 household census, projected forward to 2020 based on district population projections.
   - Gridded HIV prevalence (step 1) was multiplied by population for estimates of the distribution of PLHIV by 1km grid cell.
   - The gridded PLHIV in each district were scaled to align to total PLHIV in each district from the from 2020 Naomi model estimates.
3. **Calculate walking travel time for PLHIV to existing ART services.** We used data on land cover terrain type (Global Land Cover 2000), roads (OpenStreetMap), elevation (GMTED2010), and water bodies (NASA Shuttle Radar Topography Mission) to model walking time from each grid cell to 757 public or not-for-profit health facilities providing ART services using the AccessMod software. Walking speed was assumed to be 6-7km/h on roads and 2-3 km/h on non-road surfaces.
4. **Analyse the number and locations of PLHIV residing greater than 60, 90, or 120 minutes walking time from existing ART facilities.** Grid cells were classified by the travel time to the nearest public or not-for-profit ART facility using the travel time model. Maps were filtered for PLHIV residing greater than 60, 90, or 120 minutes, thresholds of interest defined based on discussions with the Department of HIV and AIDS (DHA).
5. **Identify optimal locations to reach the most PLHIV who currently reside greater than 60 or 90 minutes from ART services.** An optimisation algorithm was implemented to systematically select the best facilities and locations where ART service delivery can be introduced to reach the most PLHIV residing outside travel time thresholds.

The list of 757 active facilities currently providing ART services was sourced from DHA-MIS database. Facilities that were private-for-profit were excluded from the analysis of travel time catchments. Health facilities which do not currently provide an ART service, which are candidate locations for expanding ART services, were sourced from facilities visited during the 2018/19 Service Availability and Readiness Assessment (SARA). Candidate facilities included existing health posts which are not staffed full time.