District overview of travel time to ART facilities: Ntcheu

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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 Ntcheu, September 2020.

Total PLHIV (all ages)	31,600 (27,947–35,279)
HIV prevalence, age 15-49 years	6.7% (6.0%–7.5%)
Total patients receiving ART	58,127
Average walking time to nearest ART (minutes)	47 (45–49)
Number PLHIV > 60 minutes walking time	9,690 (8,354–11,228)
Percentage PLHIV > 60 minutes walking time	30.3% (28.3%–32.4%)

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 Champiti: 1,207 (881–1,561)	TA Goodson Ganya: 6,486 (5,223–8,034)
15-49 Prevalence	TA Mpando: 5.3% (4.1%–6.8%)	STA Tsikulamowa: 8.5% (6.8%–10.7%)
Average Walking Time	Ntcheu Boma: 5 min (5–5 min)	TA Goodson Ganya: 66 min (63–69 min)

Travel time to existing ART facilities

In Ntcheu, there are 32 ART facilities that had at least 1 patient in September 2020. The median number of ART patients per facility was 615. 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 Ntcheu is 47 minutes (45-49 min).
- The shortest estimated average walking time to the closest ART facility is in Ntcheu Boma (5 minutes (5-5 min)).
- The longest estimated average walking time to the closest ART facility is in TA Goodson Ganya (66 minutes (63-69 min)).

An estimated 30.3% (28.3%–32.4%) of PLHIV reside more than 60 minutes walking time to their nearest ART facility, compared to 31.5% of the total population. This decreases to 10.1% (8.6%–11.6%) of PLHIV and 11.0% 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	345,217	49.5%	15,379 (13,407–17,459)	48.1% (46.2%–50.0%)
60	219,870	31.5%	9,690 (8,354–11,228)	30.3% (28.3%–32.4%)
90	76,473	11.0%	3,224 (2,635–3,903)	10.1% (8.6%–11.6%)
120	22,787	3.3%	927 (711–1,192)	2.9% (2.2%–3.6%)

Proposed facilities for new ART services

A list of 12 *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 Goodson Ganya (3678 PLHIV (2903-4605) with walking time > 60 minutes).
- The facility that can reach the most PLHIV residing outside 60 minutes travel time is **Solomon Village Clinic**, with 538 PLHIV (362-734) 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

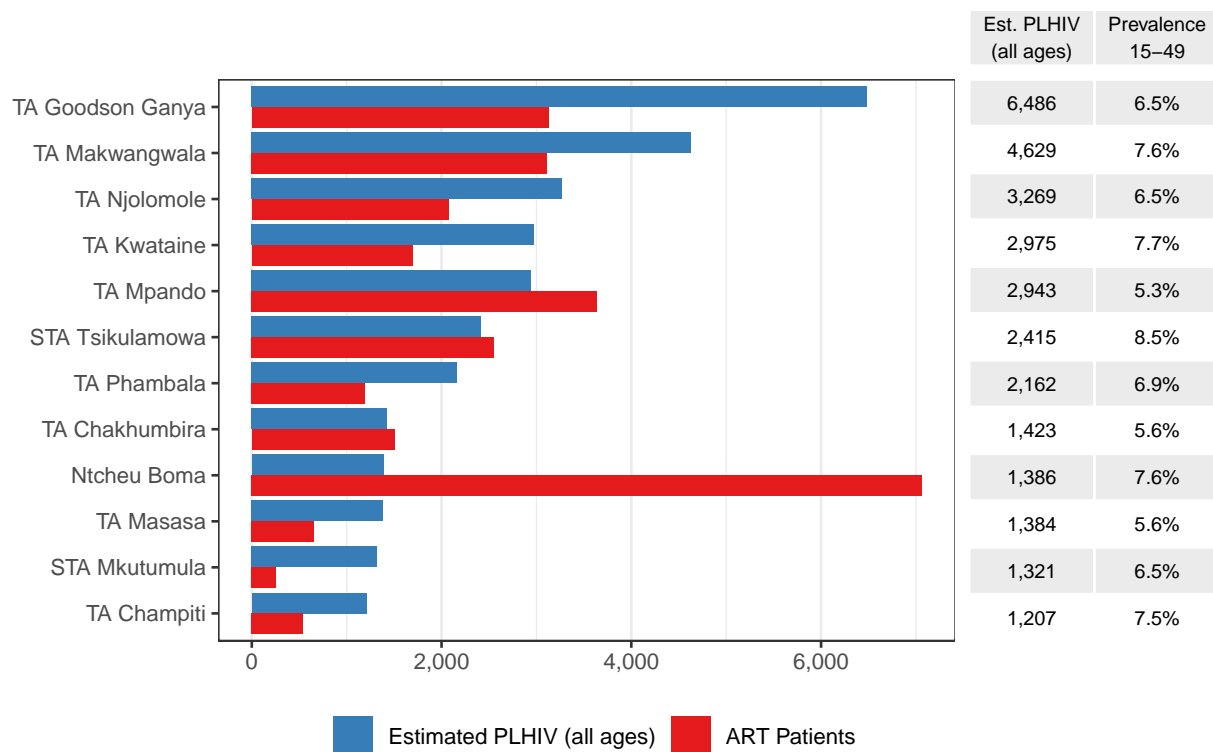|	Est. PLHIV (all ages)	Prevalence 15–49
TA Goodson Ganya	6,486	6.5%
TA Makwangwala	4,629	7.6%
TA Njolomole	3,269	6.5%
TA Kwataine	2,975	7.7%
TA Mpando	2,943	5.3%
STA Tsikulamowa	2,415	8.5%
TA Phambala	2,162	6.9%
TA Chakhumbira	1,423	5.6%
Ntcheu Boma	1,386	7.6%
TA Masasa	1,384	5.6%
STA Mkutumula	1,321	6.5%
TA Champiti	1,207	7.5%

Legend: ■ Estimated PLHIV (all ages)   ■ ART Patients

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.
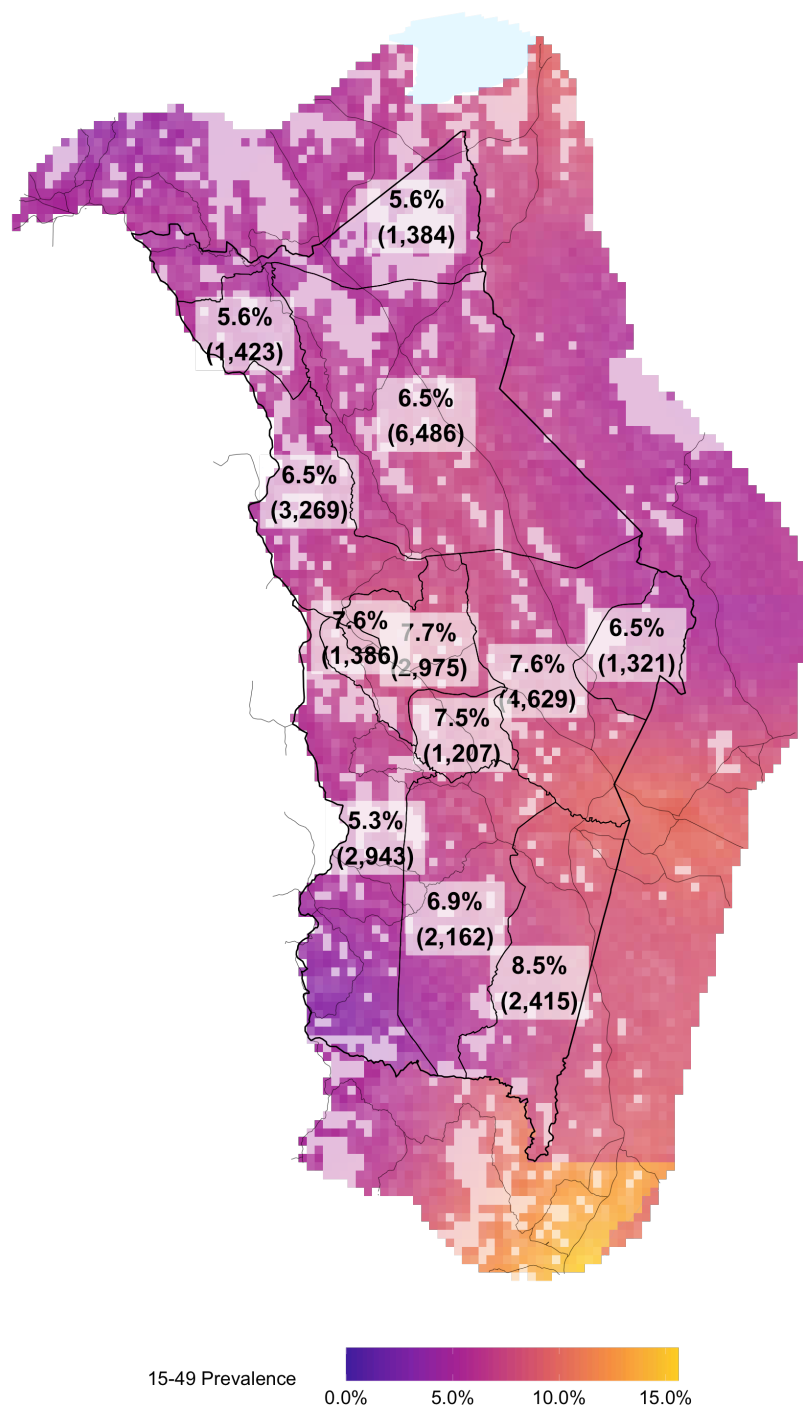
HIV prevalence in ages 15-49

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.

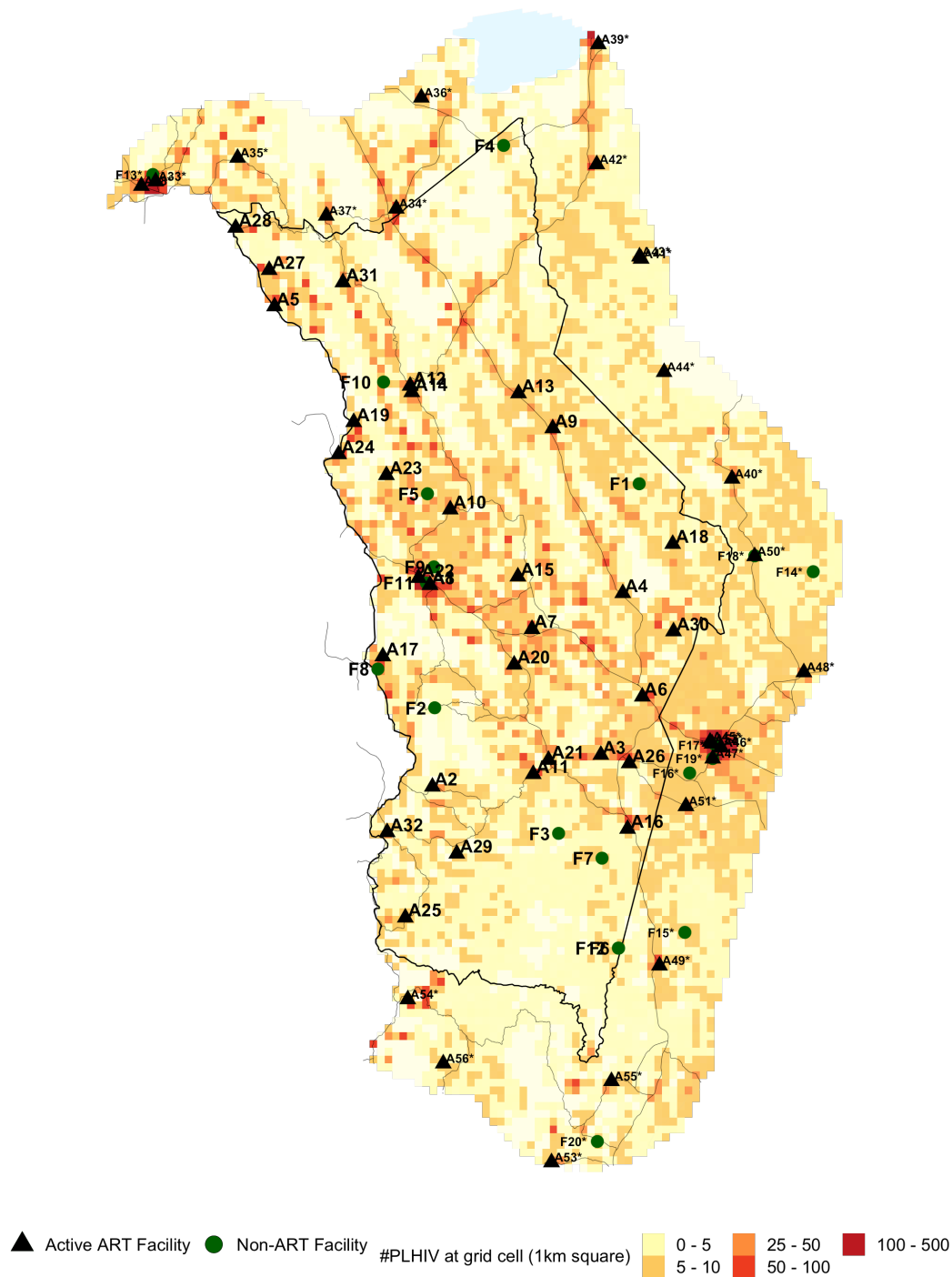# Estimated number of PLHIV at 1km square

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	Ntcheu	Ntcheu Boma	Ntcheu District Hosp.	District hospital	Government	34.64	-14.82	5627
A2	Ntcheu	TA Mpando	Katuli HC	Health centre	Government	34.64	-15.03	2202
A3	Ntcheu	STA Tsikulamowa	Sister Theresa Community Hospital Mikoke	Rural/Community	CHAM	34.83	-15.00	1597
A4	Ntcheu	TA Makwangwala	Bilira HC	Health centre	Government	34.85	-14.83	1442
A5	Ntcheu	TA Chakhumbira	Lizulu HC	Health centre	Government	34.47	-14.52	1289
A6	Ntcheu	TA Makwangwala	Nsiyaludzu HC	Health centre	Government	34.87	-14.94	1129
A7	Ntcheu	TA Kwataine	Nsipe HC	Health centre	CHAM	34.75	-14.86	1059
A8	Ntcheu	Ntcheu Boma	Biriwiri HC	Health centre	Government	34.64	-14.82	1039
A9	Ntcheu	TA Goodson Ganya	Bwanje HC	Health centre	Government	34.77	-14.65	1034
A10	Ntcheu	TA Njolomole	Mphepozinai Disp.	Dispensary	Government	34.66	-14.74	782
A11	Ntcheu	TA Phambala	Mtonda HC	Health centre	CHAM	34.75	-15.02	722
A12	Ntcheu	TA Goodson Ganya	Kandeu HC	Health centre	Government	34.62	-14.60	713
A13	Ntcheu	TA Goodson Ganya	Sharpe Valley HC	Special	CHAM	34.74	-14.61	709
A14	Ntcheu	TA Goodson Ganya	Ganya HC	Health centre	CHAM	34.62	-14.61	671
A15	Ntcheu	TA Kwataine	Dzunje Disp.	Dispensary	Government	34.74	-14.81	637
A16	Ntcheu	STA Tsikulamowa	Senzani HC	Health centre	CHAM	34.86	-15.08	618
A17	Ntcheu	TA Mpando	Nzama HC	Health centre	CHAM	34.59	-14.89	612
A18	Ntcheu	TA Makwangwala	Chikande HC	Health centre	Government	34.91	-14.77	541
A19	Ntcheu	TA Njolomole	Lakeview HC	Health centre	CHAM	34.55	-14.64	540
A20	Ntcheu	TA Champiti	Champiti HC	Health centre	Government	34.73	-14.90	539
A21	Ntcheu	TA Phambala	Kapeni HC	Health centre	Government	34.77	-15.00	473
A22	Ntcheu	Ntcheu Boma	FPAM Clinic Ntcheu	Health centre	NGO	34.63	-14.81	399
A23	Ntcheu	TA Njolomole	Gowa Heath Centre	Health centre	CHAM	34.59	-14.70	389
A24	Ntcheu	TA Njolomole	Mlangeni HC	Health centre	Government	34.54	-14.68	360
A25	Ntcheu	TA Mpando	Tsangano HC	Health centre	CHAM	34.61	-15.17	350
A26	Ntcheu	STA Tsikulamowa	Manjawira Mat.	Special	Government	34.86	-15.01	336
A27	Ntcheu	TA Masasa	Mlanda HC	Health centre	CHAM	34.46	-14.48	334
A28	Ntcheu	TA Masasa	Masasa HC	Health centre	Government	34.42	-14.43	321
A29	Ntcheu	TA Mpando	Matanda HC	Dispensary	CHAM	34.67	-15.11	314
A30	Ntcheu	STA Mkutumula	Kalimanjira HC	Health centre	Government	34.91	-14.87	257
A31	Ntcheu	TA Chakhumbira	Chigodi HC	Health centre	CHAM	34.54	-14.49	213
A32	Ntcheu	TA Mpando	Doviko Disp.	Health centre	Government	34.59	-15.08	160
A33*	Dedza	Dedza Boma	Dedza District Hosp.	District hospital	Government	34.33	-14.38	5282
A34*	Dedza	TA Kachindamoto	Golomoti HC	Health centre	Government	34.60	-14.41	785
A35*	Dedza	TA Kamenya Gwaza	Bembeke HC	Health centre	CHAM	34.42	-14.36	782
A36*	Dedza	TA Kachindamoto	Kavuzi HC	Health centre	Private	34.63	-14.29	371
A37*	Dedza	TA Kachindamoto	Mganja HC	Health centre	Government	34.52	-14.42	189
A38*	Dedza	Dedza Boma	FPAM Clinic Dedza	Health centre	NGO	34.32	-14.39	171
A39*	Mangochi	TA Nankumba	Malembo HC Mangochi	Health centre	Government	34.83	-14.24	1459
A40*	Mangochi	TA Chilipa	Chilipa HC Mangochi	Health centre	Government	34.97	-14.70	1198
A41*	Mangochi	TA Nankumba	Chipwaila HC	Health centre	Government	34.87	-14.47	1174
A42*	Mangochi	TA Nankumba	Nankumba HC	Health centre	Government	34.82	-14.37	1097
A43*	Mangochi	TA Nankumba	Chilonga HC	Health centre	Government	34.87	-14.46	571
A44*	Mangochi	STA Ntonda	Phirilongwe HC	Health centre	Government	34.90	-14.59	515
A45*	Balaka	Balaka Town	Balaka District Hosp.	District hospital	Government	34.95	-14.99	4272

A46*	Balaka	Balaka Town	Balaka OPD HC	Health centre	Government	34.96	-14.99	2912
A47*	Balaka	TA Msamala	Balaka Dream Clinic	Special	NGO	34.95	-15.00	2799
A48*	Balaka	STA Kachenga	Mbera HC	Health centre	Government	35.05	-14.91	1693
A49*	Balaka	STA Phalula	Phalula HC	Health centre	CHAM	34.89	-15.23	1516
A50*	Balaka	STA Kachenga	Kapire Dream Centre	Health centre	NGO	35.00	-14.79	1025
A51*	Balaka	TA Chanthunya	Kankao HC	Health centre	CHAM	34.92	-15.05	613
A52*	Balaka	Balaka Town	Chimatilo HC	Health centre	Government	34.95	-14.99	119
A53*	Neno	TA Symon Likongwe	Lisungwi Community Hosp.	Health centre	Government	34.77	-15.44	852
A54*	Neno	TA Dambe	Msambe HC	Health centre	Government	34.61	-15.26	488
A55*	Neno	TA Symon Likongwe	Midzemba HC	Health centre	Government	34.84	-15.35	424
A56*	Neno	TA Chekucheku	Matandani HC	Health centre	Government	34.65	-15.33	412

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	Ntcheu	TA Goodson Ganya	Solomon Village Clinic	Clinic	CHAM	34.87	-14.71	538	(362-734)
F2	Ntcheu	TA Mpando	Dzonzi-Mvai HC	Health Centre	Government	34.64	-14.95	327	(225-456)
F3	Ntcheu	TA Phambala	Namisu Disp.	Dispensary	CHAM	34.78	-15.08	232	(165-321)
F4	Ntcheu	TA Masasa	Phanga Disp.	Dispensary	Government	34.72	-14.34	211	(139-316)
F5	Ntcheu	TA Njolomole	Muluma HC	Health Centre	CHAM	34.64	-14.72	165	(118-226)
F6	Ntcheu	STA Tsikulamowa	Machereza HP	Health Post	Government	34.85	-15.21	161	(102-233)
F7	Ntcheu	STA Tsikulamowa	Likudzi U5 Clinic HP	Health Post	Government	34.83	-15.11	207	(150-283)
F8	Ntcheu	TA Mpando	Kaloga Maternity	Maternity	Government	34.58	-14.91	143	(93-210)
F9	Ntcheu	TA Kwataine	Chiole Clinic	Clinic	CHAM	34.64	-14.80	41	(30-56)
F10	Ntcheu	TA Njolomole	Kampanje Maternity	Special	Government	34.59	-14.60	35	(24-48)
F11	Ntcheu	Ntcheu Boma	BLM Ntcheu	Special	Private	34.63	-14.81	4	(3-5)
F12	Ntcheu	STA Tsikulamowa	Matchereza HP	Health Post	Government	34.85	-15.21	161	(102-233)
F13*	Dedza	Dedza Boma	BLM Dedza	Special	NGO	34.33	-14.38	2	(1-3)
F14*	Balaka	STA Kachenga	Nambira HP	Health Post	Government	35.06	-14.80	368	(244-512)
F15*	Balaka	TA Chanthunya	NYANYALA	Health Post	CHAM	34.92	-15.19	186	(136-248)
F16*	Balaka	TA Msamala	BULEYA	Health Post	CHAM	34.93	-15.02	19	(15-24)
F17*	Balaka	Balaka Town	BLM Balaka	Special	NGO	34.96	-14.99	0	(0-0)
F18*	Balaka	STA Kachenga	Kapire HC	Health Centre	CHAM	35.00	-14.79	0	(0-0)
F19*	Balaka	TA Msamala	Comfort Clinic	Health Centre	CHAM	34.95	-15.00	0	(0-0)
F20*	Neno	TA Symon Likongwe	Mota-Engil Clinic - Mkwinda Ca	Clinic	Company	34.82	-15.41	628	(448-827)

Travel Times to Closest ART Facilities
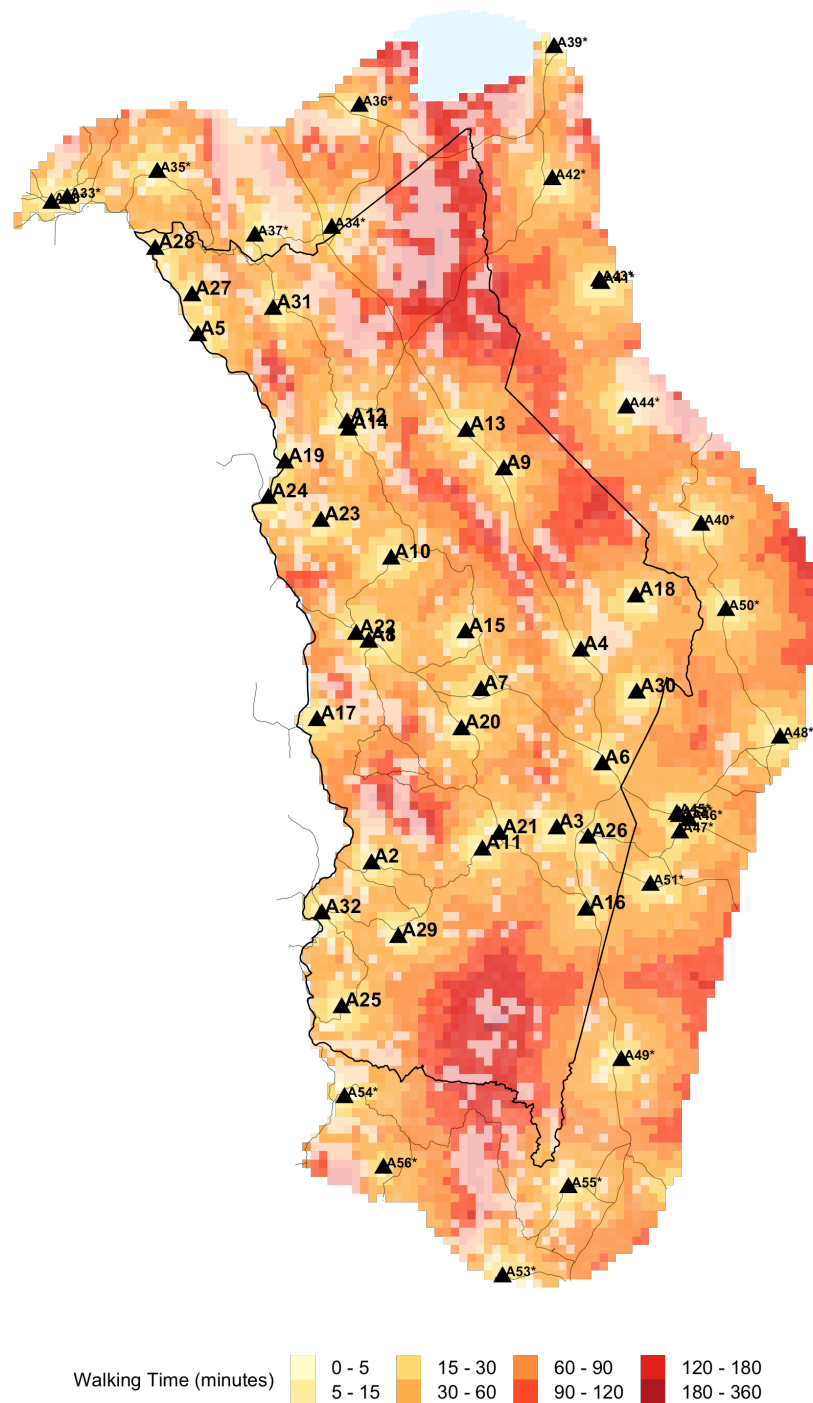
Figure 4: Estimated travel times to the closest ART facility. Travel times were calculated using data on road infrastructure, types of terrain and land elevation.
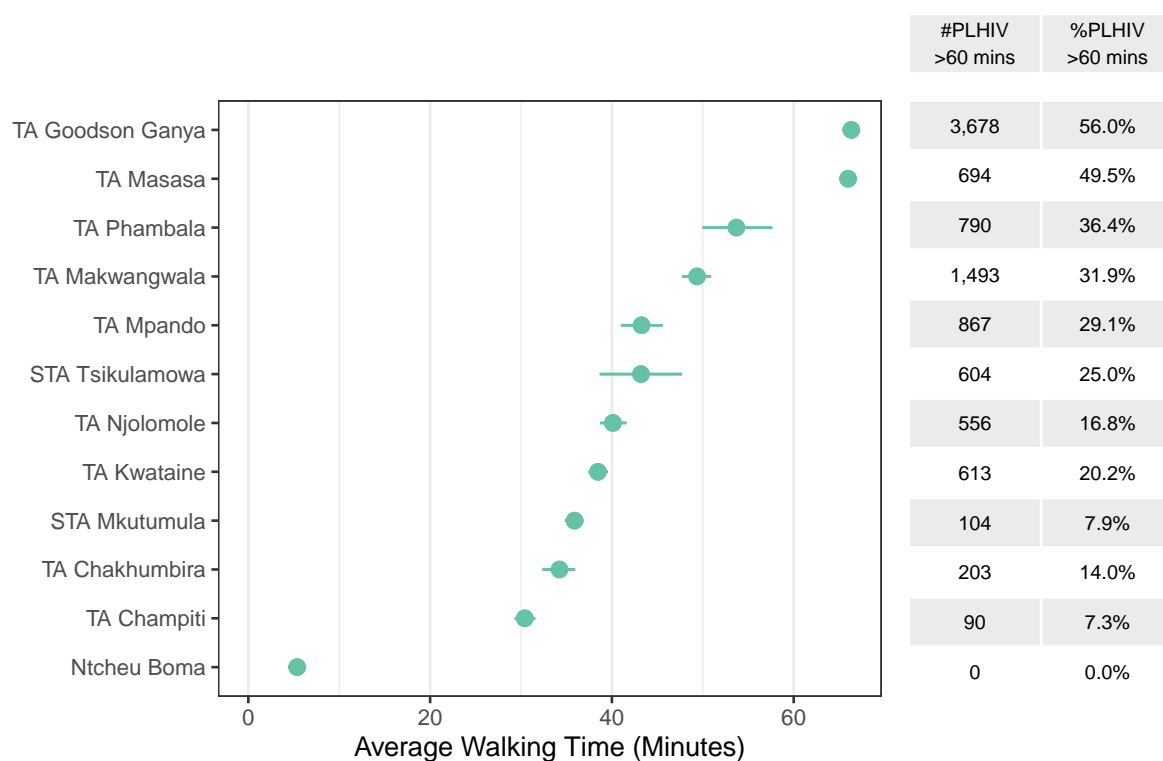
	#PLHIV >60 mins	%PLHIV >60 mins
TA Goodson Ganya	3,678	56.0%
TA Masasa	694	49.5%
TA Phambala	790	36.4%
TA Makwangwala	1,493	31.9%
TA Mpando	867	29.1%
STA Tsikulamowa	604	25.0%
TA Njolomole	556	16.8%
TA Kwataine	613	20.2%
STA Mkutumula	104	7.9%
TA Chakhumbira	203	14.0%
TA Champiti	90	7.3%
Ntcheu Boma	0	0.0%

Average Walking Time (Minutes)

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.
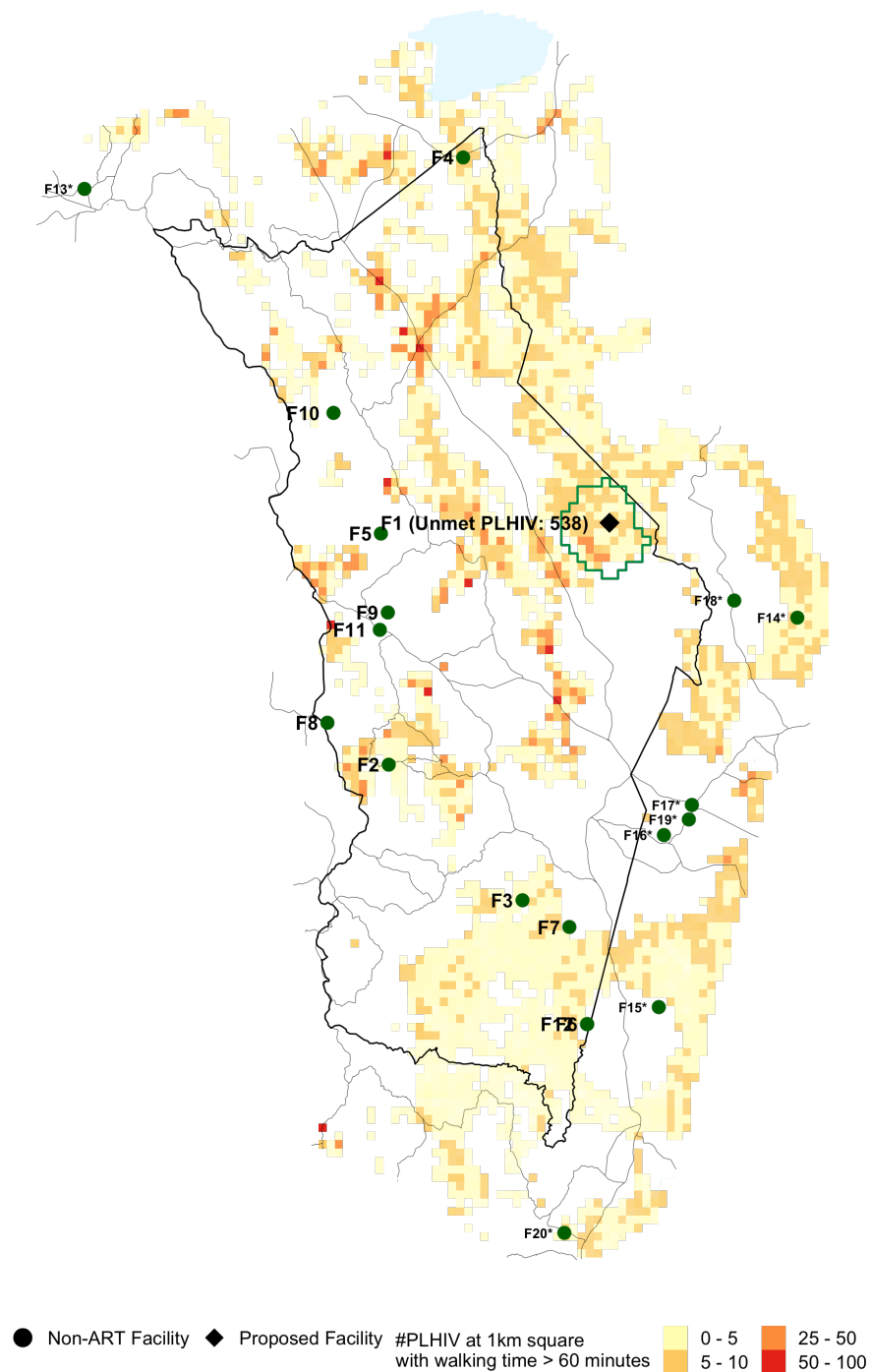
Areas outside 60 minutes travel

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.