

# District overview of travel time to ART facilities: Thyolo

Kevin Lam, Jeffrey W. Eaton, Stone Mbiriya, Brown Chiwandira, Tiwonge Chimpanzule, 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](mailto: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](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 Thyolo, September 2020.

Total PLHIV (all ages)	59,989 (53,682–66,401)
HIV prevalence, age 15–49 years	11.7% (10.5%–13.0%)
Total patients receiving ART	155,622
Average walking time to nearest ART (minutes)	37 (36–38)
Number PLHIV > 60 minutes walking time	7,291 (6,448–8,258)
Percentage PLHIV > 60 minutes walking time	12.1% (11.2%–12.9%)

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	Thyolo Boma: 1,019 (780–1,293)	TA Bvumbwe: 10,288 (8,630–12,212)
15-49 Prevalence	TA Thomas: 8.8% (6.9%–11.0%)	Thyolo Boma: 14.9% (11.4%–19.0%)
Average Walking Time	Thyolo Boma: 14 min (14–15 min)	STA Boyidi: 56 min (55–57 min)

## Travel time to existing ART facilities

In Thyolo, there are 26 ART facilities that had at least 1 patient in September 2020. The median number of ART patients per facility was 990. 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 Thyolo is 37 minutes (36-38 min).
- The shortest estimated average walking time to the closest ART facility is in Thyolo Boma (14 minutes (14-15 min)).
- The longest estimated average walking time to the closest ART facility is in STA Boyidi (56 minutes (55-57 min)).

An estimated 12.1% (11.2%–12.9%) of PLHIV reside more than 60 minutes walking time to their nearest ART facility, compared to 13.6% of the total population. This decreases to 1.6% (1.3%–1.9%) of PLHIV and 2.1% 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	254,658	34.1%	19,952 (17,826–22,317)	33.0% (31.9%–34.3%)
60	101,331	13.6%	7,291 (6,448–8,258)	12.1% (11.2%–12.9%)
90	15,832	2.1%	980 (792–1,195)	1.6% (1.3%–1.9%)
120	2,268	0.3%	144 (110–185)	0.2% (0.2%–0.3%)

## Proposed facilities for new ART services

A list of 24 *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 Mphuka (1282 PLHIV (975-1647) with walking time > 60 minutes).
- The facility that can reach the most PLHIV residing outside 60 minutes travel time is **BLM Bvumbwe**, with 1407 PLHIV (1106-1747) 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

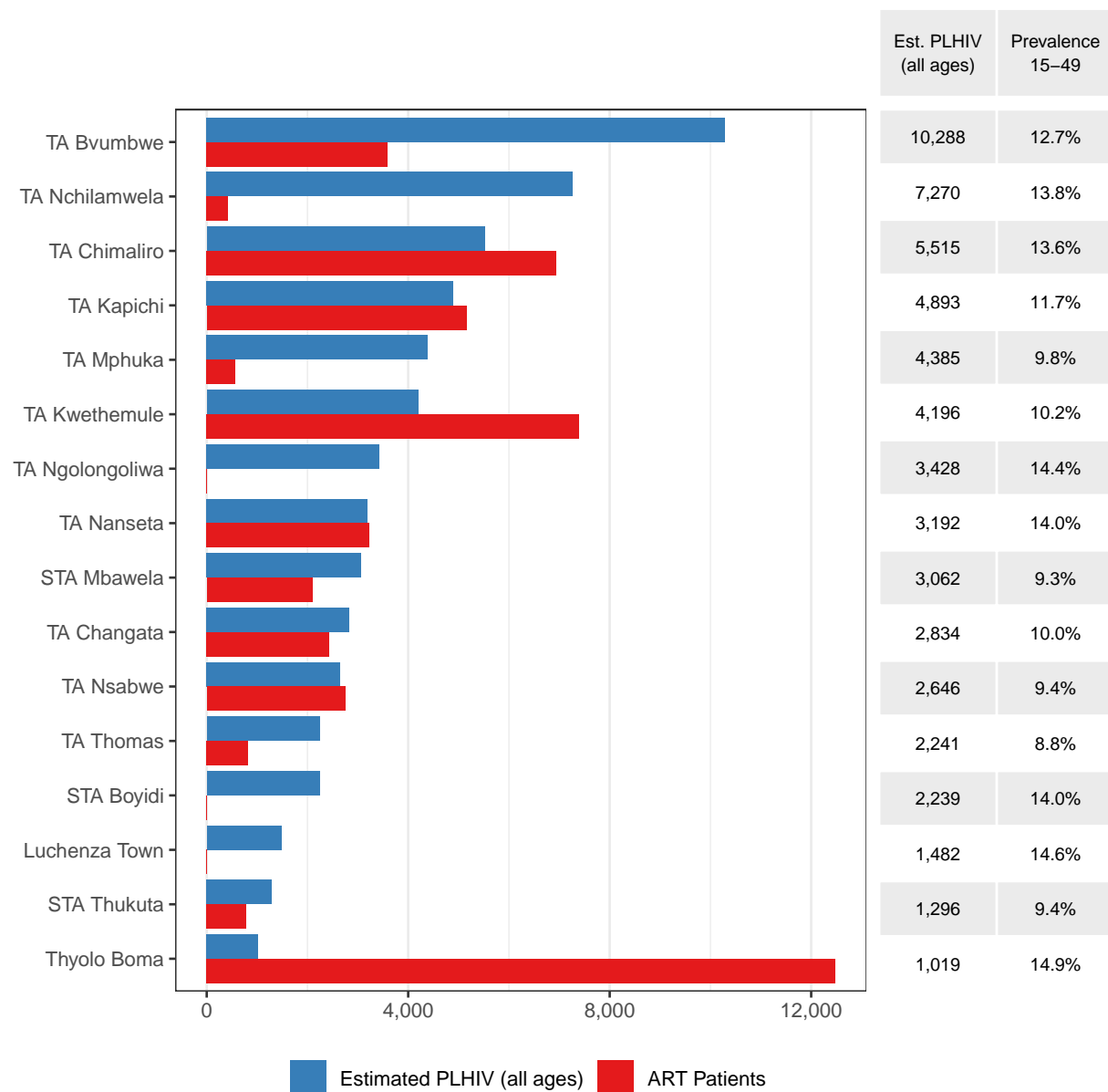


Figure 1: Number registered ART clients within each TA and estimated number of PLHIV within the TA. The right table indicates the estimated 15-49 HIV prevalence.

## HIV prevalence in ages 15-49

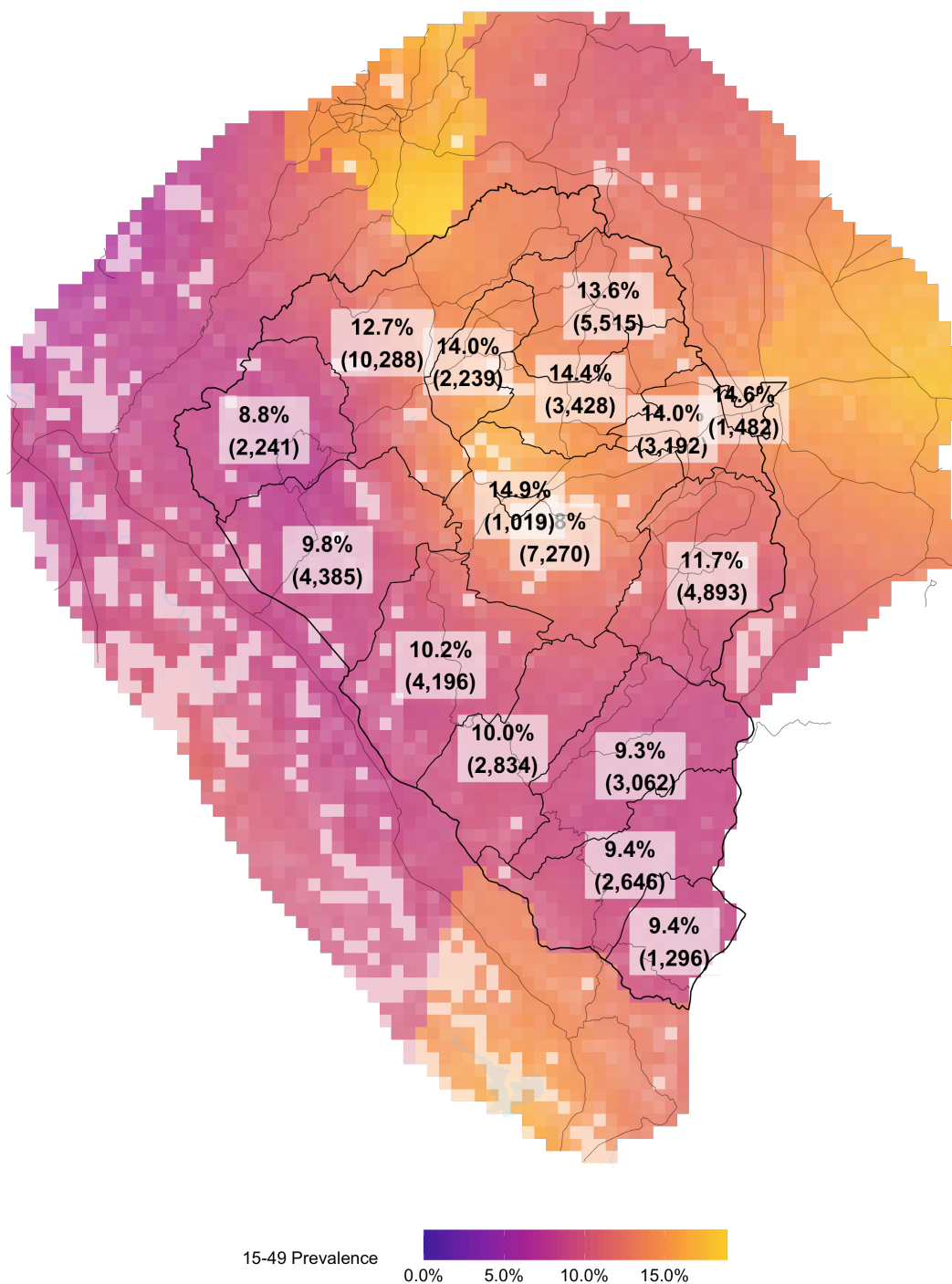


Figure 2: Estimated spatial HIV prevalence. Percentages correspond to TA level 15-49 HIV prevalence and numbers in brackets indicate the estimated number of PLHIV overall.

## Estimated number of PLHIV at 1km square

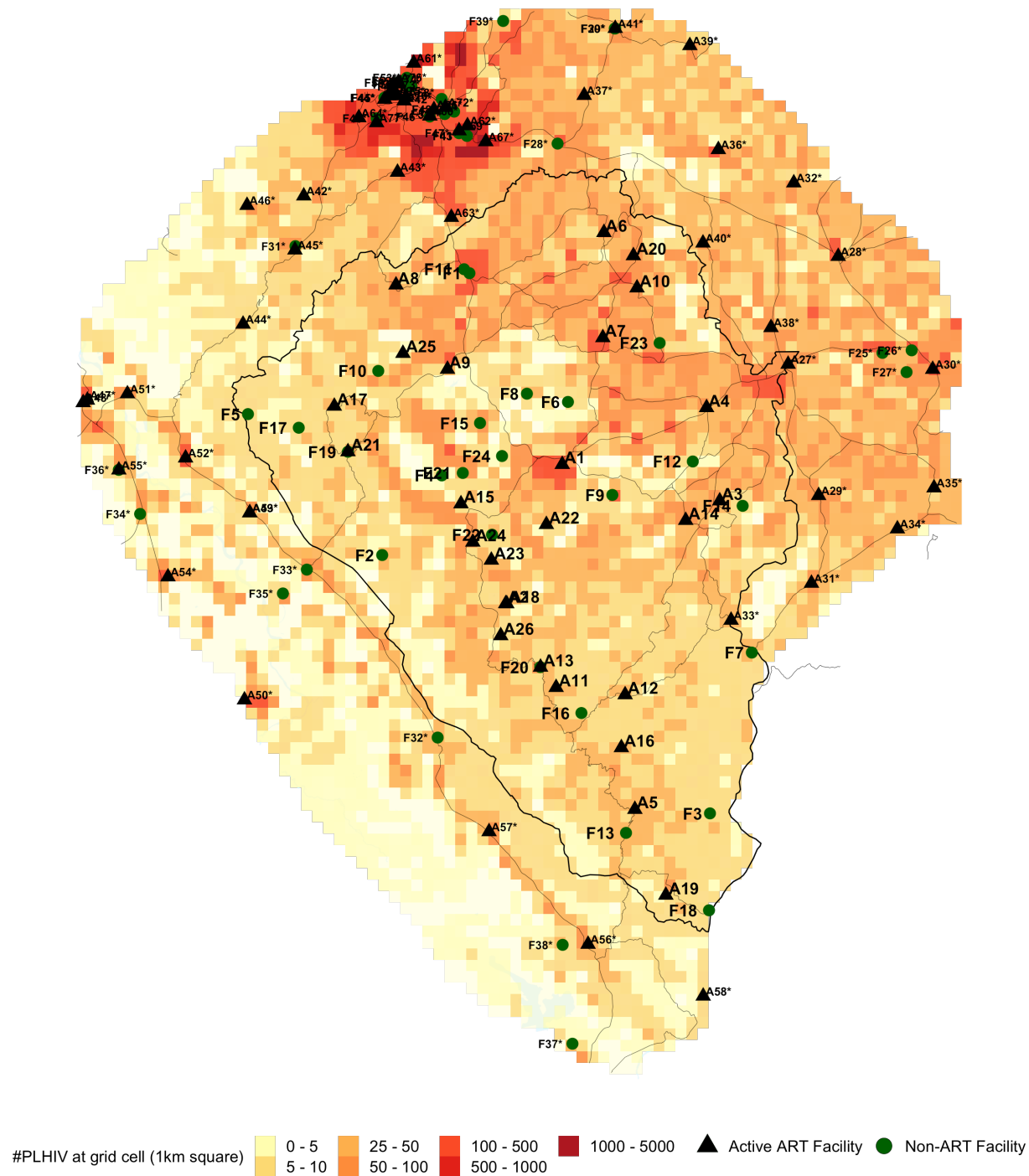


Figure 3: Estimated number of PLHIV on a 1km square.

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	Thyolo	Thyolo Boma	Thyolo District Hosp.	District hospital	Government	35.15	-16.07	12480
A2	Thyolo	TA Kwethemule	Malamulo Mission Hosp.	District hospital	CHAM	35.11	-16.17	5006
A3	Thyolo	TA Kapichi	Khonjeni HC	Health centre	Government	35.27	-16.10	4188
A4	Thyolo	TA Nanseta	Mangunda HC	Health centre	Government	35.26	-16.03	3225
A5	Thyolo	TA Nsabwe	Thekerani HC	Rural/Community	Government	35.21	-16.32	2746
A6	Thyolo	TA Chimaliro	Mikolongwe HC	Health centre	Government	35.18	-15.90	2393
A7	Thyolo	TA Chimaliro	Chimaliro HC	Health centre	Government	35.18	-15.98	2386
A8	Thyolo	TA Bvumbwe	Makungwa HC	Health centre	Government	35.03	-15.94	1811
A9	Thyolo	TA Bvumbwe	Thunga HC	Health centre	Private	35.07	-16.00	1636
A10	Thyolo	TA Chimaliro	Chisoka HC	Health centre	Government	35.21	-15.94	1512
A11	Thyolo	TA Changata	Changata HC	Health centre	Government	35.15	-16.23	1421
A12	Thyolo	STA Mbawela	Zoa HC	Health centre	Government	35.20	-16.24	1219
A13	Thyolo	TA Changata	St Martins Molere HC	Health centre	CHAM	35.14	-16.22	1011
A14	Thyolo	TA Kapichi	Mitengo HC St Joseph	Health centre	CHAM	35.25	-16.11	970
A15	Thyolo	TA Kwethemule	Mianga HC	Health centre	Private	35.08	-16.10	949
A16	Thyolo	STA Mbawela	Mapanga Mat.	Special	CHAM	35.20	-16.28	875
A17	Thyolo	TA Thomas	Thomasi HC	Health centre	CHAM	34.98	-16.03	821
A18	Thyolo	TA Kwethemule	Chipho HC	Health centre	CHAM	35.11	-16.17	801
A19	Thyolo	STA Thukuta	Gombe HC	Health post	Government	35.23	-16.38	784
A20	Thyolo	TA Chimaliro	Chingazi HC	Health centre	CHAM	35.21	-15.92	648
A21	Thyolo	TA Mphuka	Didi HC	Health centre	Government	34.99	-16.06	569
A22	Thyolo	TA Nchilamwela	Mchima Clinic	Health centre	Private	35.14	-16.11	423
A23	Thyolo	TA Kwethemule	Sambankhanga HC	Health centre	Private	35.10	-16.14	298
A24	Thyolo	TA Kwethemule	Hallena Oakley Ntambanyama HC	Health centre	CHAM	35.08	-16.13	241
A25	Thyolo	TA Bvumbwe	Amalika HC	Health post	Government	35.03	-15.99	138
A26	Thyolo	TA Kwethemule	Makwasa Estate Clinic	Health centre	Private	35.11	-16.19	100
A27*	Mulanje	TA Nthiramanja	Chonde HC	Health centre	Government	35.32	-16.00	4064
A28*	Mulanje	TA Juma	Thuchila HC	Health centre	Government	35.36	-15.92	3940
A29*	Mulanje	TA Chikumbu	Mbiza HC	Health centre	Government	35.35	-16.09	2476
A30*	Mulanje	TA Chikumbu	Chisitu HC	Health centre	Government	35.43	-16.00	2229
A31*	Mulanje	STA Tombondiya	Chinyama HC	Health centre	Government	35.34	-16.16	1510
A32*	Mulanje	TA Juma	Namulenga HC	Health centre	CHAM	35.33	-15.87	1155
A33*	Mulanje	STA Tombondiya	Makapwa HC	Health centre	CHAM	35.28	-16.18	782
A34*	Mulanje	TA Mabuka	Dzenje Mat.	Special	Government	35.41	-16.12	738
A35*	Mulanje	TA Mabuka	Thembe HC	Dispensary	CHAM	35.43	-16.09	496
A36*	Chiradzulu	STA Mpunga	Namitambo HC	Health centre	Government	35.27	-15.84	5334
A37*	Chiradzulu	TA Likoswe	St Joseph Mission Hospital Nguludi	District hospital	CHAM	35.17	-15.80	4204
A38*	Chiradzulu	TA Nkalo	Nkalo HC	Health centre	Government	35.31	-15.97	3277
A39*	Chiradzulu	TA Kadewere	Thumbwe HC	Health centre	Government	35.25	-15.77	2338
A40*	Chiradzulu	TA Nkalo	Chimwawa HC	Health centre	Government	35.26	-15.91	481
A41*	Chiradzulu	STA Onga	PIM HC	Health centre	CHAM	35.19	-15.75	236
A42*	Blantyre	TA Somba	Mpemba HC	Health centre	Government	34.96	-15.87	1910
A43*	Blantyre	TA Somba	Soche Mat.	Special	Government	35.03	-15.86	789
A44*	Blantyre	TA Somba	Madziabango HC	Health centre	Government	34.91	-15.97	761
A45*	Blantyre	TA Somba	St Vincent HC Chadzunda	Health post	CHAM	34.95	-15.91	738
A46*	Blantyre	TA Somba	Mpingo Mat.	Health centre	Government	34.91	-15.88	104
A47*	Chikwawa	Chikwawa Boma	Chikwawa District Hosp.	District hospital	Government	34.79	-16.02	6504

A48*	Chikwawa	Chikwawa Boma	Makhwira HC	Health centre	Government	34.79	-16.03	2383
A49*	Chikwawa	TA Makhwira	Mapelera HC	Health centre	Government	34.92	-16.11	1051
A50*	Chikwawa	TA Lundu	Kalulu Health Centre, Chikwawa	Health centre	Private	34.91	-16.24	854
A51*	Chikwawa	TA Mlilima	Bereu HP	Health post	Government	34.82	-16.02	835
A52*	Chikwawa	TA Katunga	Mfera HC	Health centre	Government	34.87	-16.07	794
A53*	Chikwawa	TA Makhwira	Mangulenje HC	Health centre	Private	34.92	-16.11	560
A54*	Chikwawa	TA Maseya	Alumenda HC	Health centre	Private	34.85	-16.15	387
A55*	Chikwawa	TA Katunga	Kasitu HC	Health centre	Government	34.82	-16.07	363
A56*	Nsanje	TA Mlolo	Trinity Mission Hosp.	District hospital	CHAM	35.17	-16.42	2798
A57*	Nsanje	TA Mlolo	Masenjere HC	Health centre	Government	35.10	-16.34	1532
A58*	Nsanje	TA Mlolo	Sankhulani HC	Health centre	Government	35.26	-16.46	700
A59*	Blantyre City	Soche East Ward	Queen Elizabeth Central Hosp.	Central hospital	Government	35.02	-15.80	15053
A60*	Blantyre City	Limbe Central Ward	Limbe HC	Health centre	Government	35.05	-15.82	7758
A61*	Blantyre City	Ndirande Matope Ward	Ndirande HC	Health centre	Government	35.04	-15.78	6254
A62*	Blantyre City	Bangwe Mthandizi Ward	Bangwe HC	Health centre	Government	35.08	-15.82	6030
A63*	Blantyre City	Chigumula Ward	Bvumbwe Research HC	Health centre	Government	35.07	-15.89	5391
A64*	Blantyre City	Blantyre South Ward	Zingwangwa HC	Health centre	Government	35.00	-15.82	3524
A65*	Blantyre City	Soche East Ward	Gateway Clinic	Dispensary	Government	35.02	-15.80	1545
A66*	Blantyre City	Limbe Central Ward	MASM Medi Clinic Limbe	Special	Private	35.06	-15.81	1324
A67*	Blantyre City	Naminyango Ward	Umunthu Foundation Clinic	Special	NGO	35.09	-15.84	953
A68*	Blantyre City	Soche East Ward	Blantyre City Assembly Clinic	Special	Government	35.03	-15.80	855
A69*	Blantyre City	Bangwe Mthandizi Ward	Bangwe Madina HC	Health centre	CHAM	35.07	-15.83	593
A70*	Blantyre City	Soche East Ward	Chichiri Prison Clinic	Health centre	Government	35.03	-15.81	337
A71*	Blantyre City	Limbe Central Ward	Kanjedza Police Clinic	Dispensary	Other	35.06	-15.81	259
A72*	Blantyre City	Limbe Central Ward	Soche Adventist HC	Health centre	CHAM	35.06	-15.81	225
A73*	Blantyre City	Namalimwe Ward	Pace Clinic	Special	Private	35.02	-15.80	211
A74*	Blantyre City	Namalimwe Ward	Chichiri ESCOM Clinic	Special	Private	35.02	-15.79	172
A75*	Blantyre City	Soche East Ward	Polytechnic Blantyre	Special	Other	35.03	-15.80	90
A76*	Blantyre City	Namalimwe Ward	Lafarge Cement Clinic	Special	Private	35.03	-15.79	74
A77*	Blantyre City	Soche West Ward	Nancholi Youth Organisation Clinic	Special	NGO	35.01	-15.82	

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	Thyolo	TA Bvumbwe	BLM Bvumbwe	Special	NGO	35.08	-15.93	1407	(1106-1747)
F2	Thyolo	TA Mphuka	CHILENGO	Health Post	Government	35.02	-16.14	1073	(763-1406)
F3	Thyolo	TA Nsabwe	NKHATAOMBERE	Health Post	Government	35.26	-16.32	345	(234-487)
F4	Thyolo	TA Mphuka	CHAWANI	Dispensary	Company	35.06	-16.08	337	(259-425)
F5	Thyolo	TA Thomas	THABWANI	Health Post	Government	34.91	-16.03	276	(206-358)
F6	Thyolo	TA Ngolongoliwa	Nasonia	Clinic	Company	35.16	-16.02	275	(221-338)
F7	Thyolo	STA Mbawela	SANDAMA	Health Post	Government	35.30	-16.21	127	(88-178)

F8	Thyolo	TA Nchilamwela	MIKUNDI	Dispensary	Company	35.13	-16.02	317	(247-404)
F9	Thyolo	TA Nchilamwela	Gotha Disp.	Dispensary	Company	35.19	-16.09	92	(67-119)
F10	Thyolo	TA Thomas	Chithebe HC	Health Centre	Government	35.01	-16.00	87	(64-117)
F11	Thyolo	TA Bvumbwe	Bvumbwe HC	Health Centre	Government	35.08	-15.93	1320	(1036-1635)
F12	Thyolo	TA Kapichi	Mafisi HC	Clinic	Company	35.25	-16.07	144	(110-183)
F13	Thyolo	TA Nsabwe	Nsabwe HC	Dispensary	Government	35.20	-16.34	40	(31-51)
F14	Thyolo	TA Kapichi	Kumadzi Disp.	Dispensary	Company	35.29	-16.10	29	(23-37)
F15	Thyolo	TA Bvumbwe	Naming'omba HC	Health Centre	Private	35.09	-16.04	261	(205-328)
F16	Thyolo	STA Mbawela	Mbalanguzi HC	Health Centre	CHAM	35.17	-16.25	15	(11-19)
F17	Thyolo	TA Thomas	PUTENI	Health Post	Government	34.95	-16.04	85	(63-111)
F18	Thyolo	STA Thukuta	THUKUTA	Health Post	Government	35.26	-16.39	9	(6-13)
F19	Thyolo	TA Mphuka	Dzimhiri HP	Health Post	Government	34.99	-16.06	0	(0-0)
F20	Thyolo	TA Changata	Molere HC	Special	Government	35.14	-16.22	0	(0-0)
F21	Thyolo	TA Mphuka	Satemwa Clinic	Health Centre	Company	35.08	-16.08	144	(113-180)
F22	Thyolo	TA Kwethemule	Kasembeleka	Dispensary	Company	35.10	-16.12	0	(0-0)
F23	Thyolo	TA Ngolongoliwa	SAMU	Health Post	Government	35.23	-15.98	0	(0-0)
F24	Thyolo	TA Nchilamwela	MWALANTHUNZI	Dispensary	Company	35.11	-16.06	87	(68-111)
F25*	Mulanje	TA Chikumbu	KHAYA	Health Post	CHAM	35.39	-15.99	595	(461-752)
F26*	Mulanje	TA Chikumbu	LUWANJE	Health Post	CHAM	35.42	-15.99	552	(438-677)
F27*	Mulanje	TA Chikumbu	MSITHE	Health Post	CHAM	35.41	-16.00	336	(261-424)
F28*	Chiradzulu	TA Likoswe	Malavi Disp.	Dispensary	Government	35.15	-15.84	3	(2-4)
F29*	Chiradzulu	STA Onga	Providence Industrial Mission HC	Health Centre	CHAM	35.19	-15.75	0	(0-0)
F30*	Chiradzulu	STA Onga	P.I.M HC	Special	Government	35.19	-15.75	0	(0-0)
F31*	Blantyre	TA Somba	St Vincent HC	Health Centre	CHAM	34.95	-15.91	0	(0-0)
F32*	Chikwawa	TA Makhwira	Mitondo HP	Health Post	Government	35.06	-16.27	1118	(770-1570)
F33*	Chikwawa	TA Makhwira	Nkhate HP	Health Post	Government	34.96	-16.15	1050	(735-1413)
F34*	Chikwawa	TA Maseya	HOPE VILLAGE	Dispensary	NGO	34.83	-16.11	119	(76-168)
F35*	Chikwawa	TA Makhwira	MWANAYAYA	Health Post	Government	34.94	-16.16	289	(200-398)
F36*	Chikwawa	TA Katunga	Kasinthula Disp.	Dispensary	Government	34.82	-16.07	0	(0-0)
F37*	Nsanje	TA Mlolo	Mchacha HP	Health Post	Government	35.16	-16.49	37	(26-51)
F38*	Nsanje	TA Mlolo	Mlolo HP	Health Post	Government	35.15	-16.42	19	(14-24)
F39*	Blantyre City	Mapanga Ward	Amitofo Care Centre	Clinic	NGO	35.11	-15.75	1852	(1483-2287)
F40*	Blantyre City	Soche West Ward	BLM Zingwangwa	Special	NGO	35.01	-15.82	0	(0-0)
F41*	Blantyre City	Bangwe Mthandizi Ward	BLM Midima	Special	NGO	35.08	-15.83	0	(0-0)
F42*	Blantyre City	Limbe Central Ward	Unilever South East Company Clinic	Special	Private	35.06	-15.80	0	(0-0)
F43*	Blantyre City	Bangwe Mthandizi Ward	BLM Bangwe	Special	NGO	35.08	-15.83	0	(0-0)
F44*	Blantyre City	Soche East Ward	Beit trust Cure International	Other Hospital	CHAM	35.02	-15.80	0	(0-0)
F45*	Blantyre City	Soche East Ward	Kachere Rehabilitation Centre	Other Hospital	NGO	35.02	-15.80	0	(0-0)
F46*	Blantyre City	Limbe Central Ward	Limbe Home Based Care Centre	Clinic	NGO	35.05	-15.82	0	(0-0)
F47*	Blantyre City	Bangwe Mthandizi Ward	Madinah Social Services Clinic	Clinic	NGO	35.07	-15.83	0	(0-0)
F48*	Blantyre City	Bangwe Mthandizi Ward	Auction Holdings Clinic	Clinic	Company	35.06	-15.81	0	(0-0)
F49*	Blantyre City	Ndirande Matope Ward	Blantyre Water Board - Mudi	Clinic	Company	35.04	-15.80	0	(0-0)
F50*	Blantyre City	Namalimwe Ward	Carlsberg Brewery Malawi Ltd.	Clinic	Company	35.03	-15.79	0	(0-0)
F51*	Blantyre City	Bangwe Mthandizi Ward	Central East African Railways	Clinic	Company	35.06	-15.82	0	(0-0)

F52*	Blantyre City	Namalimwe Ward	David Whitehead	Clinic	Company	35.03	-15.79	0	(0-0)
F53*	Blantyre City	Namalimwe Ward	Henred Fruehauf Clinic	Clinic	Company	35.03	-15.79	0	(0-0)
F54*	Blantyre City	Bangwe Mthandizi Ward	Limbe Leaf Tobacco Clinic Limb	Clinic	Company	35.07	-15.81	0	(0-0)
F55*	Blantyre City	Namalimwe Ward	Portland	Clinic	Company	35.03	-15.79	0	(0-0)

## Travel Times to Closest ART Facilities

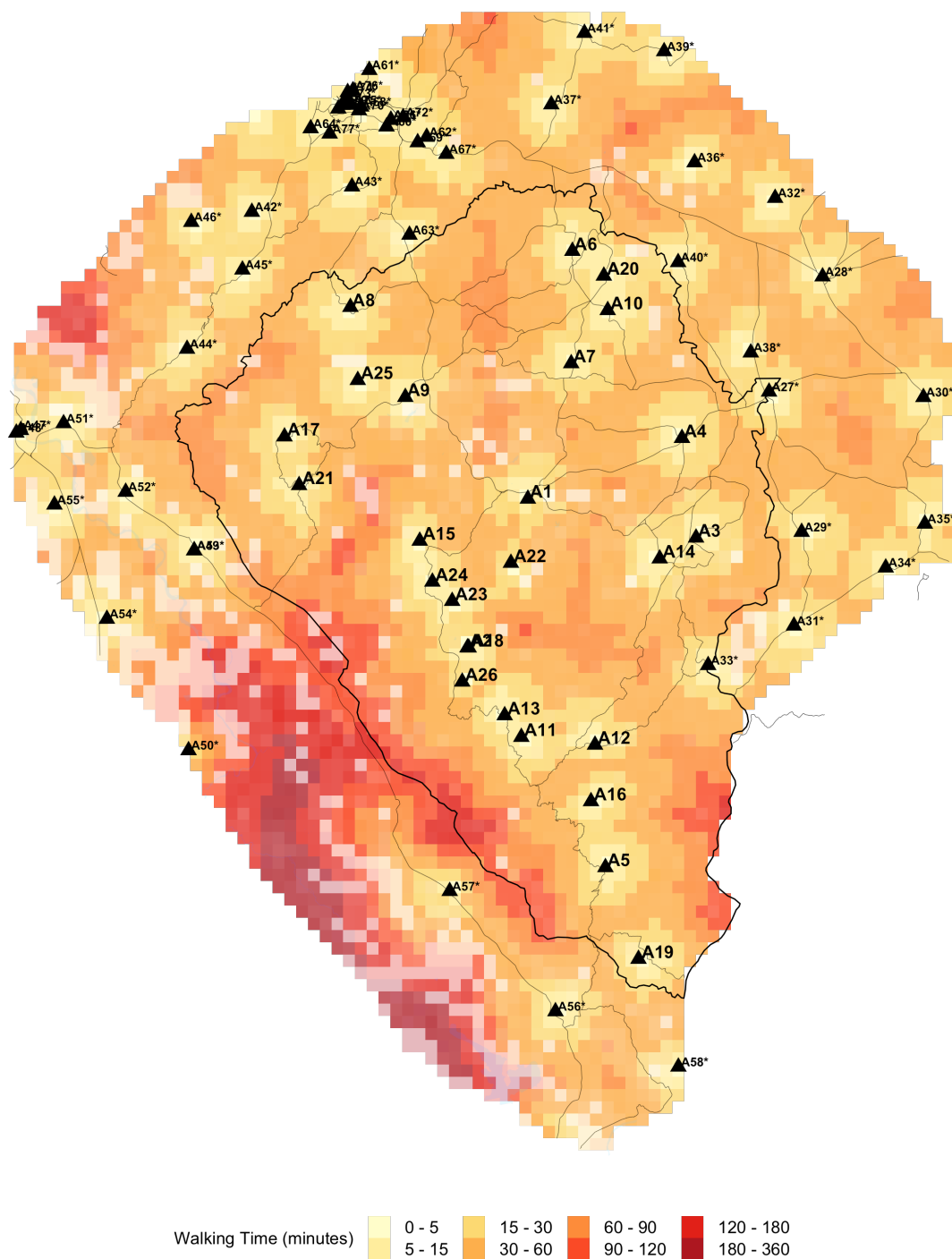


Figure 4: Estimated travel times to the closest ART facility. Travel times were calculated using data on road infrastructure, types of terrain and land elevation.

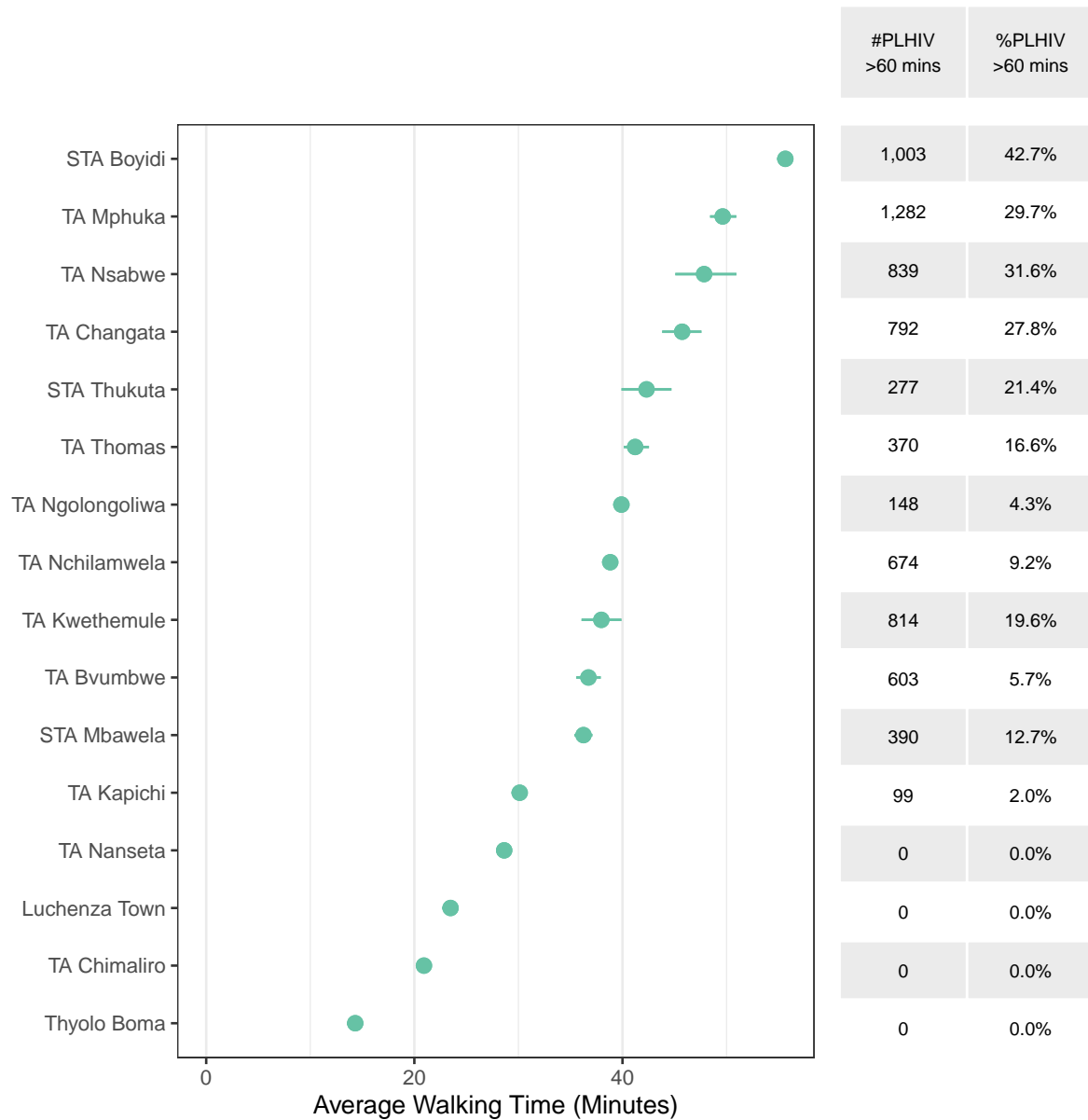


Figure 5: Estimated average walking time to the closest ART facility, weighted by the estimated number of PLHIV within the traditional authority. The right table indicates estimated number and proportion of PLHIV that need more than 60 minutes to travel to the closest ART facility, respectively.

## Areas outside 60 minutes travel

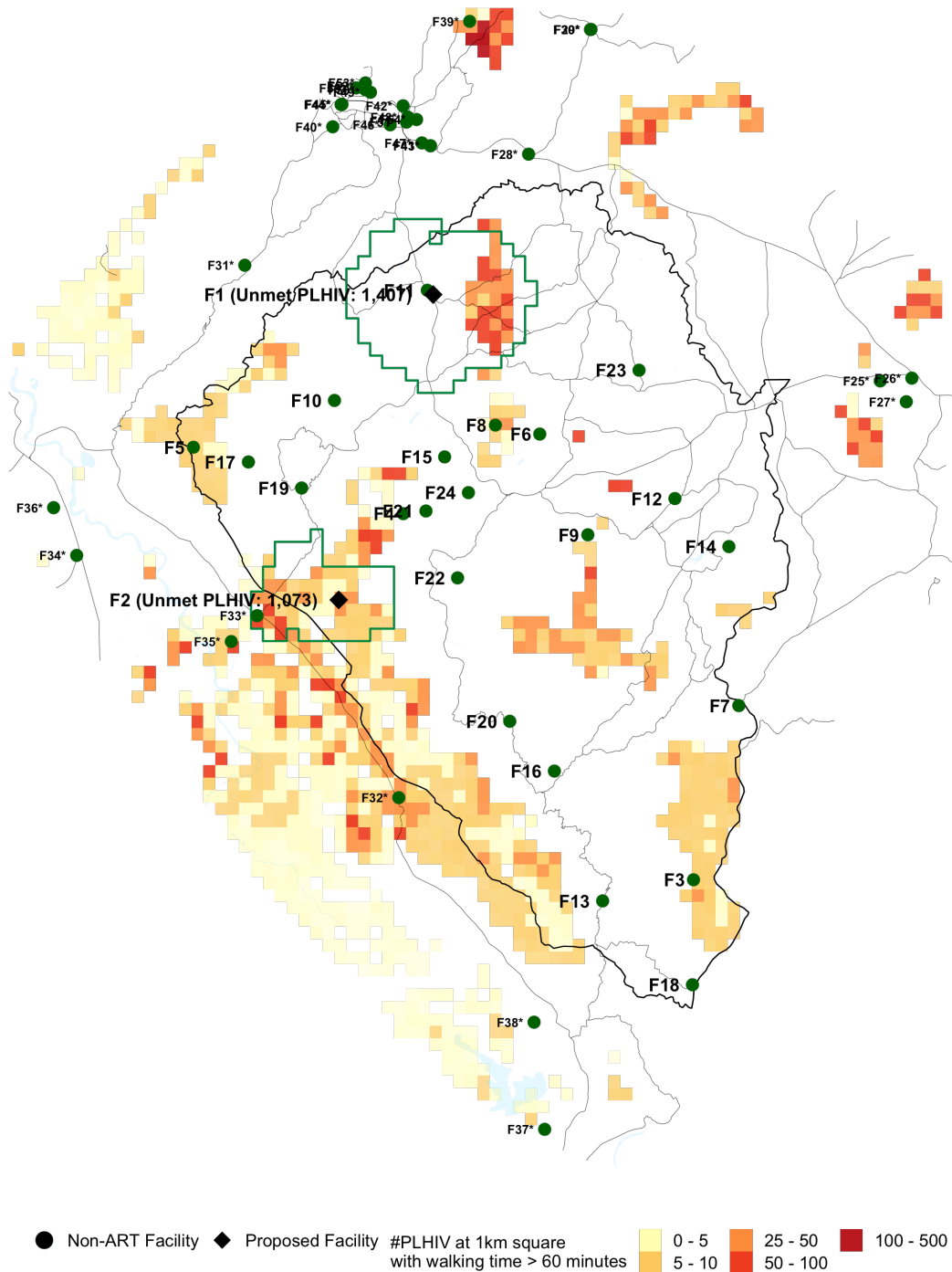


Figure 6: Proposed facility locations. Areas where the walking time to the closest ART facility is <60 minutes have been removed. Green lines indicate the 60-minutes catchment area of the proposed facility.

## 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 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.