

# District overview of travel time to ART facilities: Karonga

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 Karonga, September 2020.

Total PLHIV (all ages)	20,755 (17,109–24,786)
HIV prevalence, age 15–49 years	8.1% (6.7%–9.7%)
Total patients receiving ART	16,132
Average walking time to nearest ART (minutes)	45 (42–48)
Number PLHIV > 60 minutes walking time	5,120 (4,206–6,158)
Percentage PLHIV > 60 minutes walking time	26.0% (22.8%–29.1%)

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	Nyika National Park-Karonga: 0 (0–0)	TA Kilupula: 4,769 (3,562–6,141)
15-49 Prevalence	TA Wasambo: 6.6% (5.0%–8.6%)	Karonga Town: 9.4% (6.6%–13.1%)
Average Walking Time	Karonga Town: 15 min (15–16 min)	TA Mwakaboko: 62 min (60–63 min)

## Travel time to existing ART facilities

In Karonga, there are 17 ART facilities that had at least 1 patient in September 2020. The median number of ART patients per facility was 419. 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 Karonga is 45 minutes (42–48 min).
- The shortest estimated average walking time to the closest ART facility is in Karonga Town (15 minutes (15–16 min)).
- The longest estimated average walking time to the closest ART facility is in TA Mwakaboko (62 minutes (60–63 min)).

An estimated 26.0% (22.8%–29.1%) of PLHIV reside more than 60 minutes walking time to their nearest ART facility, compared to 29.3% of the total population. This decreases to 8.9% (7.4%–10.9%) of PLHIV and 10.9% 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	177,366	46.6%	8,493 (7,050–9,986)	43.0% (39.6%–46.3%)
60	111,679	29.3%	5,120 (4,206–6,158)	26.0% (22.8%–29.1%)
90	41,344	10.9%	1,761 (1,351–2,245)	8.9% (7.4%–10.9%)
120	18,193	4.8%	739 (529–1,014)	3.7% (2.8%–4.9%)

## Proposed facilities for new ART services

A list of 18 *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 Kyungu (1324 PLHIV (947-1801) with walking time > 60 minutes).
- The facility that can reach the most PLHIV residing outside 60 minutes travel time is **Mlare HP**, with 485 PLHIV (271-778) 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

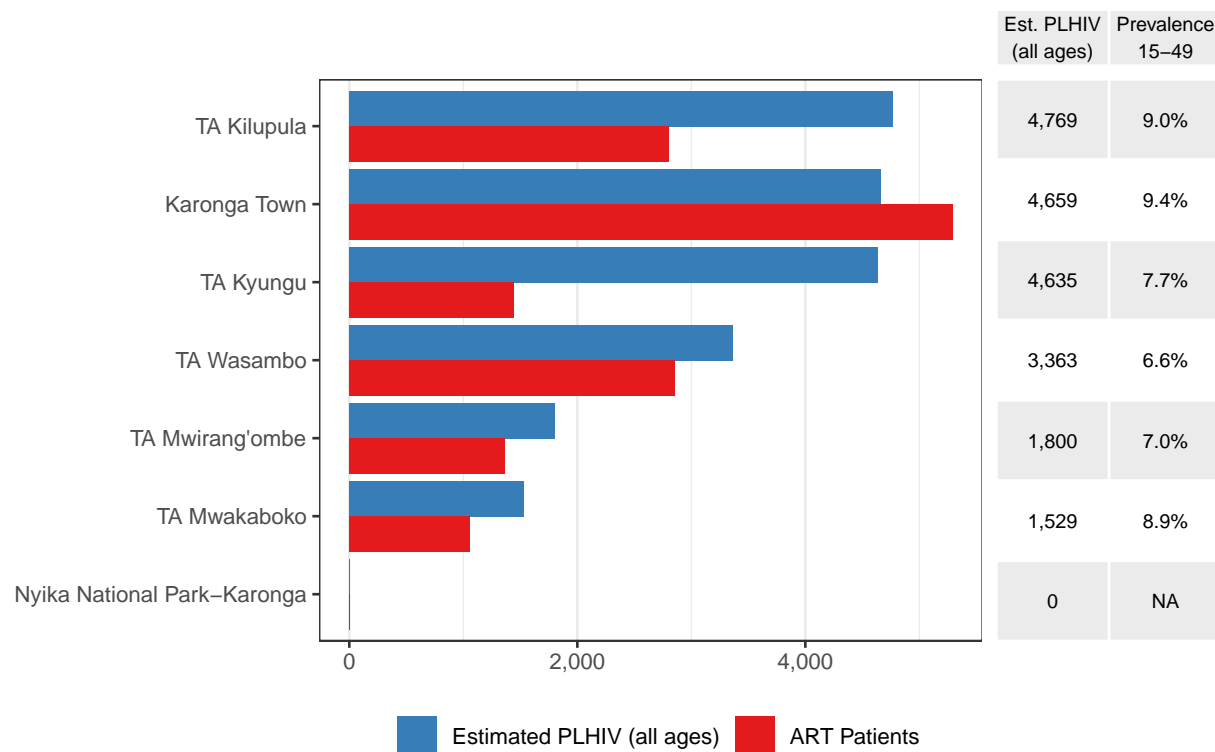


Figure 1: Number registered ART clients within each TA and estimated number of PLHIV within the TA. The right table indicates the estimated 15-49 HIV prevalence.

## HIV prevalence in ages 15-49

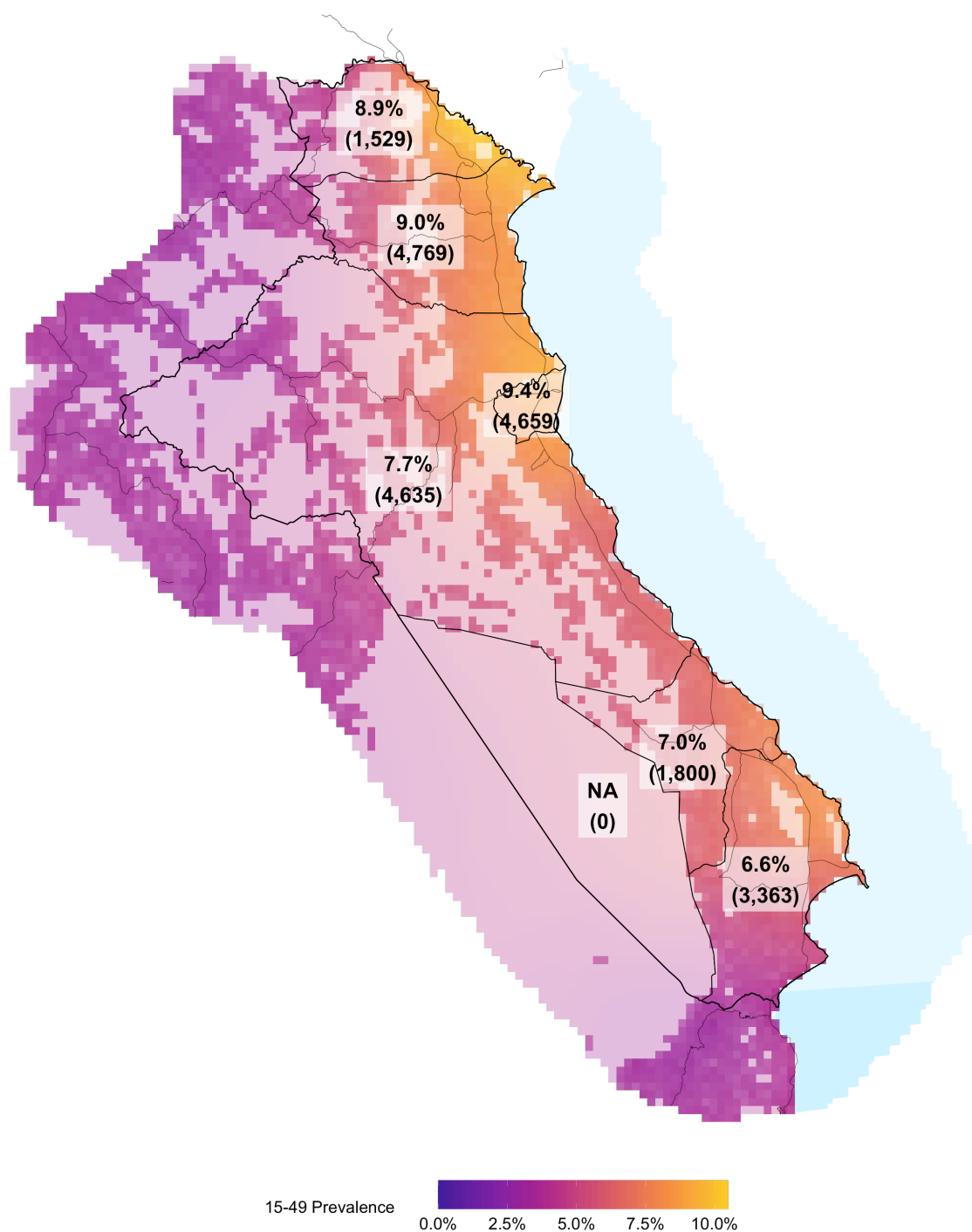


Figure 2: Estimated spatial HIV prevalence. Percentages correspond to TA level 15-49 HIV prevalence and numbers in brackets indicate the estimated number of PLHIV overall.

## Estimated number of PLHIV at 1km square

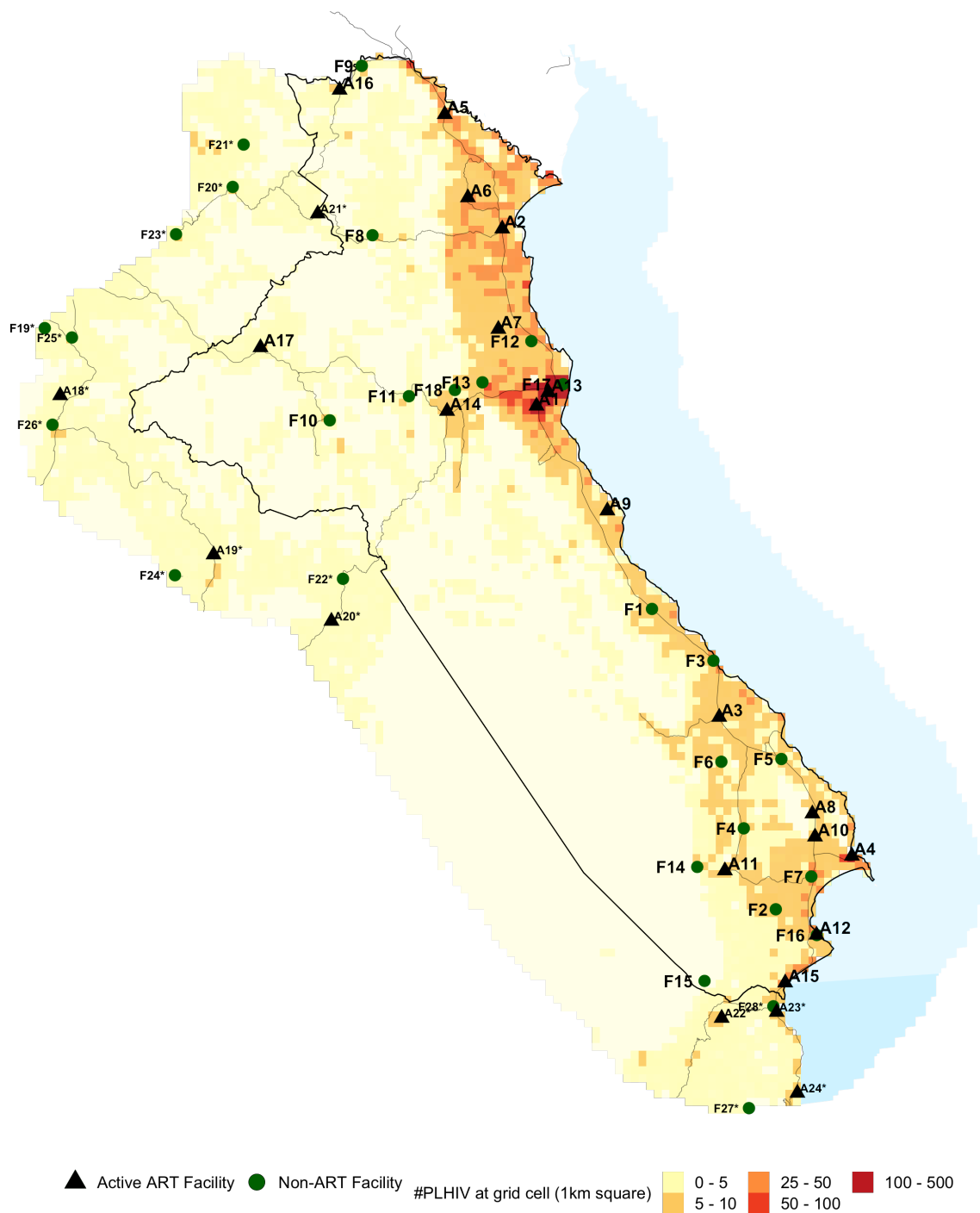


Figure 3: Estimated number of PLHIV on a 1km square.

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	Karonga	Karonga Town	Karonga District Hosp.	District hospital	Government	33.91	-9.95	5059
A2	Karonga	TA Kilupula	Kaporo Rural Hosp.	Rural/Community	Government	33.87	-9.77	1994
A3	Karonga	TA Mwirang'ombe	Nyungwe HC	Health centre	Government	34.11	-10.28	1366
A4	Karonga	TA Wasambo	Chilumba Rural Hosp.	Rural/Community	Government	34.25	-10.43	1325
A5	Karonga	TA Mwakaboko	Iponga HC	Health centre	Government	33.81	-9.65	935
A6	Karonga	TA Kilupula	Atupele HC	Health centre	CHAM	33.84	-9.73	808
A7	Karonga	TA Kyungu	Kasoba HC	Health post	Government	33.87	-9.87	746
A8	Karonga	TA Wasambo	Chilumba Barracks Clinic	Special	Other	34.21	-10.39	570
A9	Karonga	TA Kyungu	Lupembe HC	Health centre	Government	33.99	-10.07	419
A10	Karonga	TA Wasambo	St Anne's HC	Health centre	CHAM	34.21	-10.41	309
A11	Karonga	TA Wasambo	Fulirwa HC	Health centre	Government	34.11	-10.45	249
A12	Karonga	TA Wasambo	Sangilo HC	Health centre	CHAM	34.21	-10.52	241
A13	Karonga	Karonga Town	BLM Karonga	Special	NGO	33.92	-9.94	232
A14	Karonga	TA Kyungu	Mpata HC	Health centre	Government	33.81	-9.96	191
A15	Karonga	TA Wasambo	Lwezga HC	Health centre	Government	34.18	-10.57	157
A16	Karonga	TA Mwakaboko	Ngana HC	Health centre	Government	33.70	-9.62	122
A17	Karonga	TA Kyungu	Wiliro HC	Health centre	Government	33.61	-9.89	87
A18*	Chitipa	TA Mwenewenya	Chambo HC	Health centre	CHAM	33.40	-9.94	226
A19*	Chitipa	TA Mwenewenya	Wenya HC	Health centre	Government	33.56	-10.11	193
A20*	Chitipa	STA Nthengatenga	Mahowe HC	Health centre	Government	33.69	-10.18	75
A21*	Chitipa	STA Lwangwa	Msumbe HC	Health centre	CHAM	33.68	-9.75	11
A22*	Rumphi	TA Mwalweni	Livingstonia Mission Hosp.	District hospital	CHAM	34.11	-10.60	313
A23*	Rumphi	TA Mwalweni	Chitimba HC	Health centre	Government	34.17	-10.60	279
A24*	Rumphi	TA Mwalweni	Luwuchi HC	Health centre	CHAM	34.19	-10.68	225

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	Karonga	TA Kyungu	Malre HP	Health Post	Government	34.04	-10.17	485	(271-778)
F2	Karonga	TA Wasambo	Hara Disp.	Dispensary	Government	34.17	-10.49	405	(283-575)
F3	Karonga	TA Mwirang'ombe	NGARA	Health Post	Government	34.10	-10.23	366	(204-597)
F4	Karonga	TA Wasambo	GONTHAMINGA	Health Post	Government	34.13	-10.40	266	(184-381)
F5	Karonga	TA Wasambo	TILOLA	Health Post	Government	34.18	-10.33	229	(149-328)
F6	Karonga	TA Mwirang'ombe	CHIHEPUSHA	Health Post	Government	34.11	-10.33	211	(139-313)
F7	Karonga	TA Wasambo	ULIWA	Health Post	Government	34.21	-10.45	245	(171-342)
F8	Karonga	TA Kilupula	CHIKUTU	Health Post	Government	33.73	-9.77	72	(43-114)
F9	Karonga	TA Mwakaboko	NGISI	Health Post	Government	33.72	-9.59	63	(36-102)
F10	Karonga	TA Kyungu	KAYELEKELA	Health Post	Government	33.69	-9.97	60	(31-103)
F11	Karonga	TA Kyungu	VILAULE	Health Post	Government	33.77	-9.94	45	(28-69)
F12	Karonga	TA Kyungu	MALUNGO	Health Post	Government	33.91	-9.89	12	(8-17)
F13	Karonga	TA Kyungu	LUPASO	Health Post	Government	33.85	-9.93	8	(5-11)
F14	Karonga	TA Wasambo	Wovwe Escom Clinic	Clinic	Company	34.08	-10.44	2	(1-3)
F15	Karonga	Nyika National Park-Karonga	Wovwe HP	Health Post	Government	34.09	-10.56	0	(0-0)
F16	Karonga	TA Wasambo	Sangiro HC	Health Centre	CHAM	34.21	-10.52	0	(0-0)

F17	Karonga	Karonga Town	OLD Hosp.	Health Post	Government	33.94	-9.93	0	(0-0)
F18	Karonga	TA Kyungu	SILU	Health Post	Government	33.82	-9.94	5	(3-7)
F19*	Chitipa	TA Mwabulambya	NACHIPANGAPANG	Health Post	Government	33.38	-9.87	140	(82-221)
F20*	Chitipa	TA Mwenemisuku	SOKOLA	Health Post	Government	33.58	-9.72	61	(33-97)
F21*	Chitipa	STA Lwangwa	ITULO	Health Post	Government	33.60	-9.68	58	(33-94)
F22*	Chitipa	STA Nthengatenga	KOPAKOPA	Health Post	Government	33.70	-10.14	48	(24-85)
F23*	Chitipa	TA Mwenemisuku	CHIPWERA	Health Post	Government	33.52	-9.77	59	(33-96)
F24*	Chitipa	TA Mwenewenya	MPEMBA	Health Post	Government	33.52	-10.13	32	(18-54)
F25*	Chitipa	TA Mwabulambya	CHENDO	Health Post	Government	33.41	-9.88	138	(80-224)
F26*	Chitipa	TA Mwenewenya	Chisenga HP	Health Post	Government	33.39	-9.97	28	(16-47)
F27*	Rumphi	TA Mwalweni	Mchenga Clinic	Clinic	Company	34.14	-10.70	91	(59-134)
F28*	Rumphi	TA Mwalweni	Khondowe HC	Health Centre	Government	34.17	-10.59	4	(2-5)



## Travel Times to Closest ART Facilities

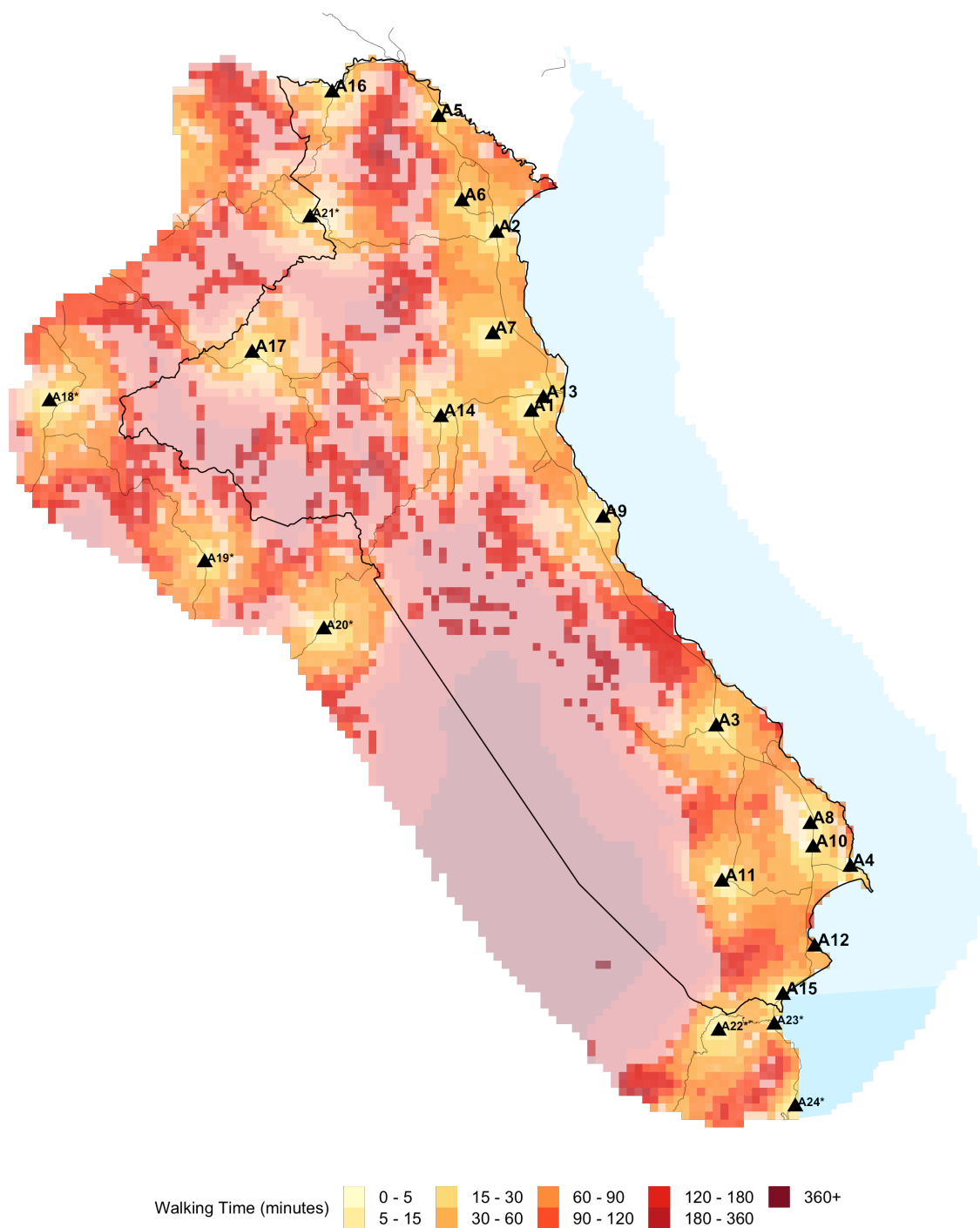


Figure 4: Estimated travel times to the closest ART facility. Travel times were calculated using data on road infrastructure, types of terrain and land elevation.

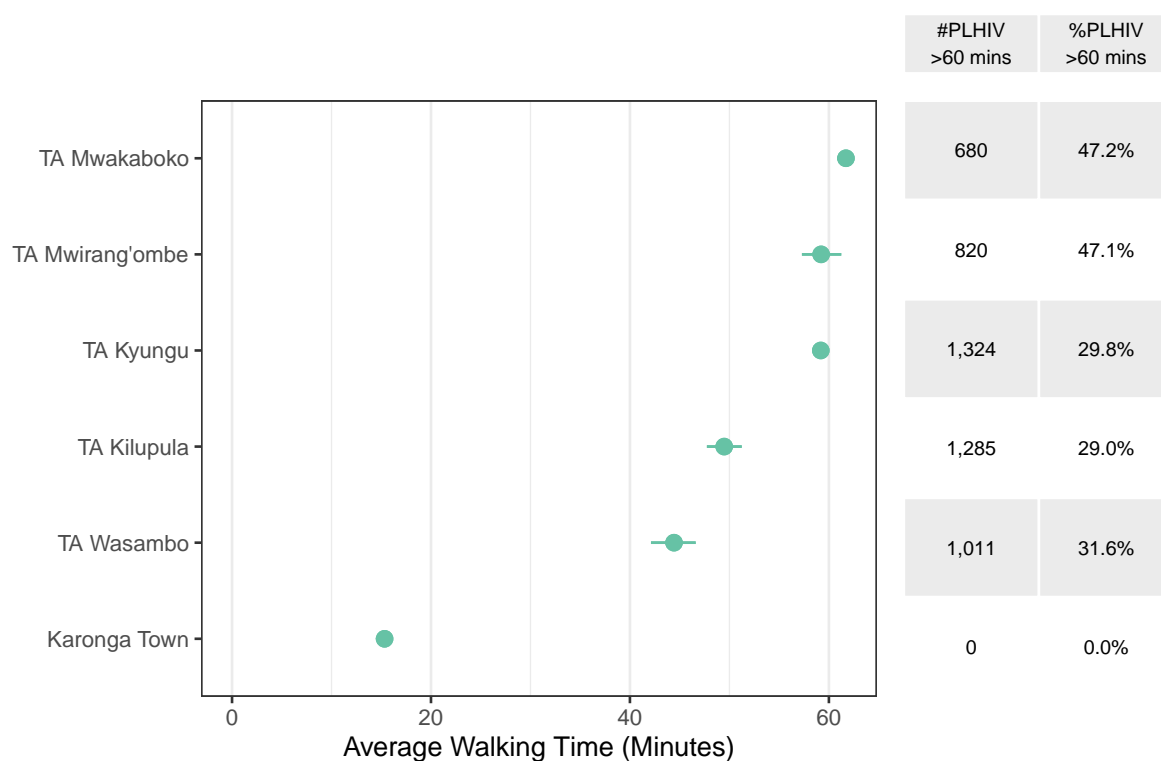


Figure 5: Estimated average walking time to the closest ART facility, weighted by the estimated number of PLHIV within the traditional authority. The right table indicates estimated number and proportion of PLHIV that need more than 60 minutes to travel to the closest ART facility, respectively.

## 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.