

Walking access to health facilities and clinic siting: Kajiado County

Executive summary

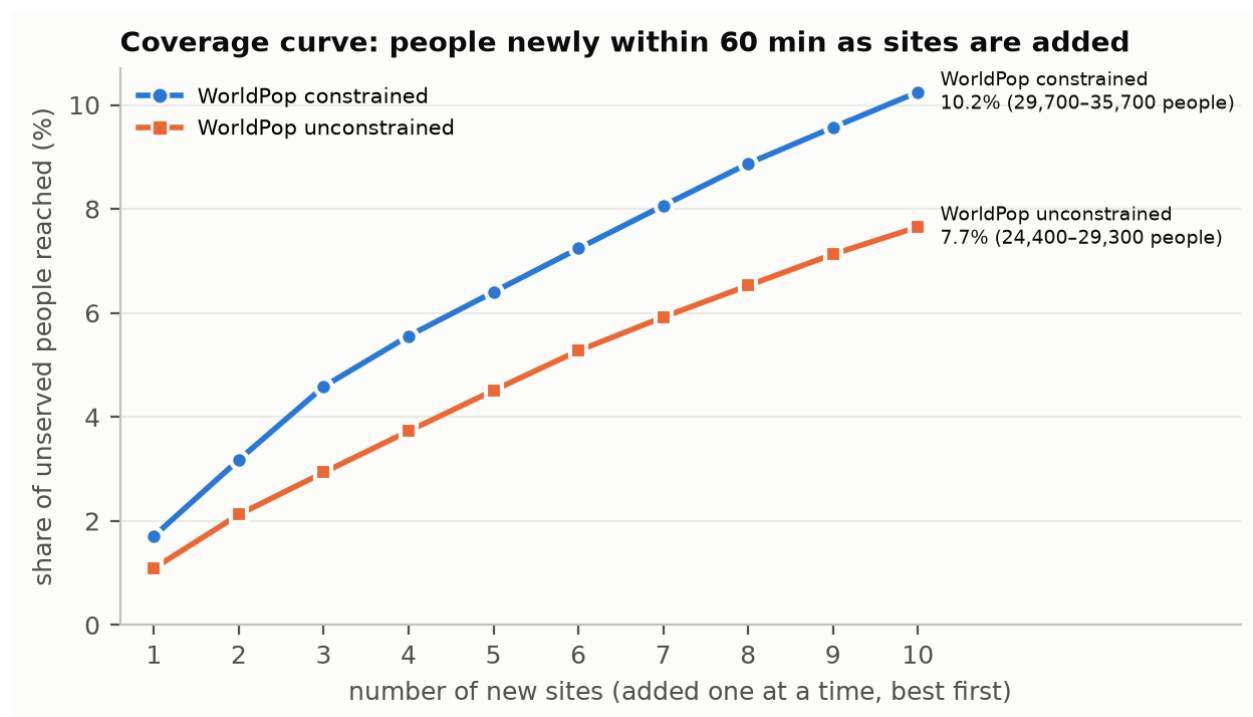
About 30–33% of Kajiado's population lives more than 1 hour's walk from a health facility (range across WorldPop constrained and unconstrained).

That is 290,100–382,800 people. Counts are ranges: the WorldPop share times the lowest (975,718, worldpop_unconstrained) and highest (1,172,614, census_projected_2020) Kajiado total. The share and the candidate ranking do not depend on the total.

No single best site is claimed. The robustness gate G2b failed: the two WorldPop products give shares 2.92 percentage points apart (limit 2.0) and their top candidate sites are 186 km apart. The coverage curve and the consensus sites below are the robust findings.

Gate	Status	Value	Rule
G1_completeness	pass	0.9641	≥ 0.95
G2_population	info	0.1543	abs diff ≤ 0.05
G2b_robustness	FAIL	2.918	share diff (pp) $\leq$ and same top site 2.0
G3_travel_time_sanity	pass	0	all checks zero 0
G4_reproducibility	pass	identical	identical rerun identical

Coverage curve



k	Constrained: cumulative people (share of unserved)	Unconstrained: cumulative people (share)
1	5,000–6,000 (1.7%) – Oloosirkon/Sholinke	3,500–4,200 (1.1%) – Kuku
2	9,200–11,100 (3.2%) – Keekonyokie	6,800–8,100 (2.1%) – Matapato South
3	13,300–16,000 (4.6%) – Kuku	9,300–11,200 (2.9%) – Kuku
4	16,100–19,400 (5.6%) – Kimana	11,900–14,300 (3.7%) – Keekonyokie
5	18,600–22,300 (6.4%) – Matapato South	14,400–17,300 (4.5%) – Rombo
6	21,000–25,200 (7.2%) – Kimana	16,800–20,200 (5.3%) – Rombo
7	23,400–28,100 (8.1%) – Oloosirkon/Sholinke	18,900–22,700 (5.9%) – Kimana
8	25,700–30,900 (8.9%) – Kaputiei North	20,800–25,000 (6.5%) – Oloosirkon/Sholinke

k	Constrained: cumulative people (share of unserved)	Unconstrained: cumulative people (share)
9	27,800–33,400 (9.6%) – Dalalekutuk	22,700–27,300 (7.1%) – Kimana
10	29,700–35,700 (10.2%) – Kuku	24,400–29,300 (7.7%) – Oloosirkon/Sholinke

Consensus sites

Pairs of top-50 sites, one per product, within 5 km of each other, ranked by the smaller of the two people-reached counts (shown as a range). Each pair is a location both population models agree on.

#	Constrained site (ward)	Unconstrained site (ward)	Apart	People reached (smaller)
1	-2.9346, 37.6553 (Kuku)	-2.9273, 37.6526 (Kuku)	0.9 km	3,480–4,180
2	-2.9346, 37.6553 (Kuku)	-2.9708, 37.6661 (Rombo)	4.2 km	3,090–3,710
3	-2.9635, 37.6913 (Kuku)	-2.9708, 37.6661 (Rombo)	2.9 km	2,570–3,090
4	-1.5047, 36.7419 (Keekonyokie)	-1.4975, 36.7509 (Keekonyokie)	1.3 km	2,530–3,040
5	-1.4912, 36.7850 (Oloosirkon/Sholinke)	-1.4975, 36.7509 (Keekonyokie)	3.9 km	2,530–3,040

51 pairs in total (results/consensus_sites.csv). Sites to check on the ground, with the nearest facilities and walking times, are in results/site_check.csv.

Bounds: if facilities are missing from the source, the headline overstates the gap; this is an upper bound. If closed facilities remain listed, the headline understates the gap; this is a lower bound. The file has no status field, so every facility is treated as operating.

Methods

Facilities. Only the geocode file (sheet with _geocodes, 12,375 rows) is used. Facilities are selected spatially: every point with valid WGS84 coordinates inside Kajiado or within 20 km of its boundary (geoBoundaries ADM1). all_health excludes 'other' and 'Stand-Alone service'; clinical keeps Hospital, Health Center, Medical Center, Medical Clinic and Dispensary; Nursing Home is all_health only. Exact duplicates are removed; points within 50 m of each other are flagged and kept.

Grid. 2560 x 2761 cells, county + 20 km at 100 m in EPSG:32737. Elevation from Copernicus GLO-30 (averaged to 100 m); slope from the 100 m DEM. Both WorldPop 2020 100 m products are sum-resampled onto the grid (county totals within 0.3% of the source).

Walking speed. Tobler's hiking function on slope with a 5 km/h flat-ground speed and Tobler's 0.6 off-path factor, averaged over walking up and down the slope. On a road the road speed is used if faster (by OSM highway tag; unlisted tags 4 km/h; motorways not walkable). Water polygons are barriers unless a road crosses them. Cost-distance (8-connected) from every facility in a set gives minutes to the nearest facility.

Candidates. 250 m lattice cells in the county that are passable, more than 60 min from a facility, and at least 2 km from every clinical facility. A shortlist of 200 is picked greedily by unserved people within 5 km, each at least 5 km from earlier picks; each is then evaluated exactly (people newly within 60 min, limited-radius cost-distance). The top 50 per product are kept. Coverage curve: sites added one at a time, each reaching the most people still unserved.

Gates. G1 completeness (hard); G2 population (information only); G2b robustness across products (hard, recorded as FAIL; by decision the results are reported side by side); G3 travel-time sanity (hard); G4 reproducibility (hard).

Results

Share of each area's population more than 60 min from a health facility (geoBoundaries ADM2 units; the census uses six different sub-counties, so no census figure is matched to these).

Area	Constrained: over 60 min	Unconstrained: over 60 min	People over 60 min (range)
Kajiado County	29.7%	32.6%	290,700–383,700
Kajiado Central	55.1%	51.8%	78,800–100,800
Kajiado East	31.7%	30.7%	55,800–69,200
Kajiado North	0.0%	0.0%	0–100
Kajiado South	29.5%	44.2%	58,600–105,500
Kajiado West	53.5%	56.1%	90,700–114,300

People ranges per area use that area's share of the constrained county population, times the lowest and highest county totals.

Rural and urban split: each county cell takes the Q2 class of its nearest facility (straight line).

Q2 of nearest facility	Constrained	Unconstrained
Rural	45.5%	51.6%
Urban	4.0%	4.9%

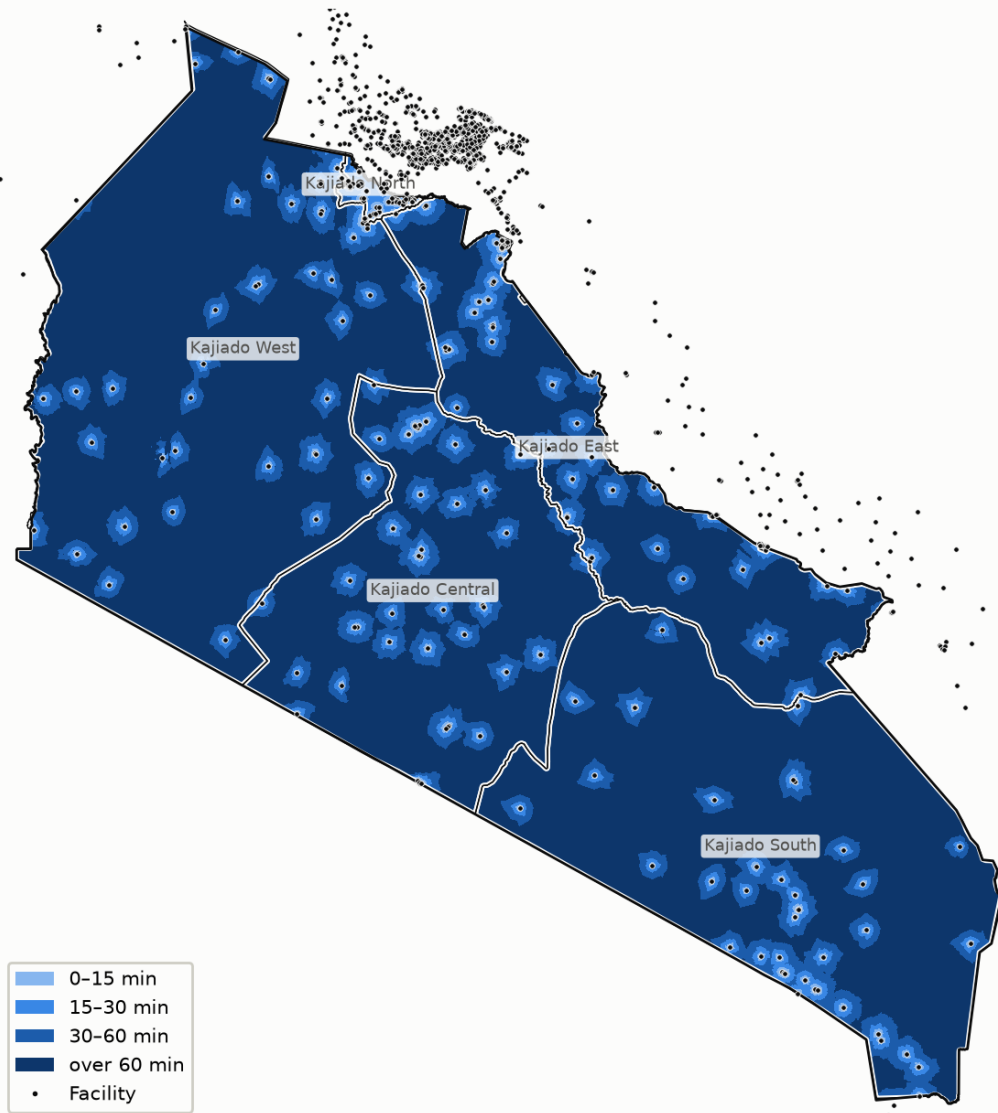
Facilities inside the county by the facility file's sub_county field; blank fields are assigned by point-in-polygon on ADM2. The file's five sub-counties are not the census's six (no Isinya or Mashuuru); no mapping is assumed.

Sub-county (facility file)	All health	Clinical	Assigned by
ADM2: Kajiado Central	10	9	point-in-polygon (blank field)
ADM2: Kajiado East	35	35	point-in-polygon (blank field)
ADM2: Kajiado North	18	18	point-in-polygon (blank field)
ADM2: Kajiado South	3	3	point-in-polygon (blank field)
ADM2: Kajiado West	5	5	point-in-polygon (blank field)
Kajiado Central	37	36	facility file sub_county
Kajiado East	54	53	facility file sub_county
Kajiado North	47	44	facility file sub_county
Kajiado West	48	46	facility file sub_county
Kibwezi West	3	3	facility file sub_county

Sub-county (facility file)	All health	Clinical	Assigned by
Loitokitok	42	42	facility file sub_county

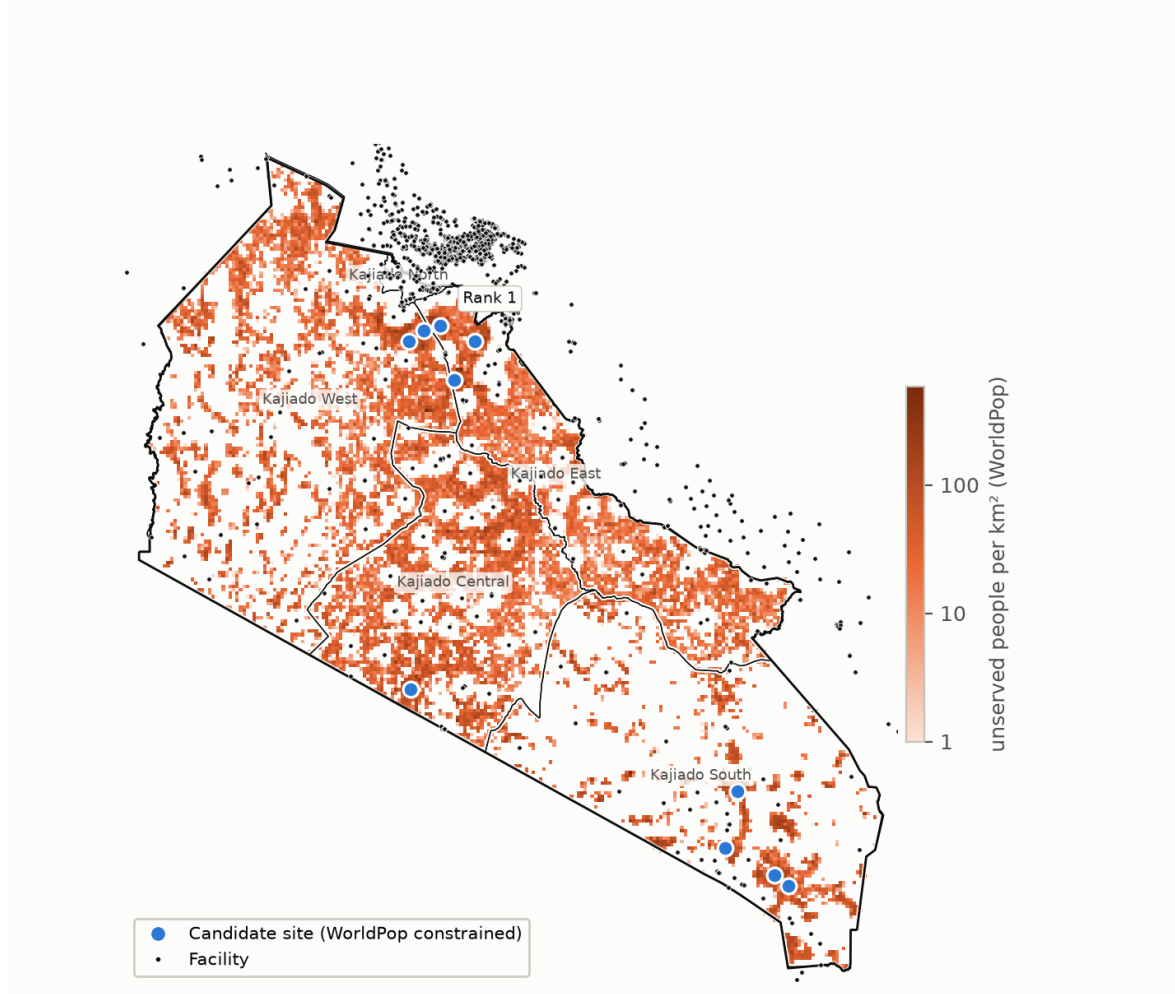
Walking time to the nearest facility: all health facilities

29.7% (constrained) to 32.6% (unconstrained) of the population is more than 60 min away.
Colour shows area; most people live near facilities. Facilities up to 20 km outside the county are used.



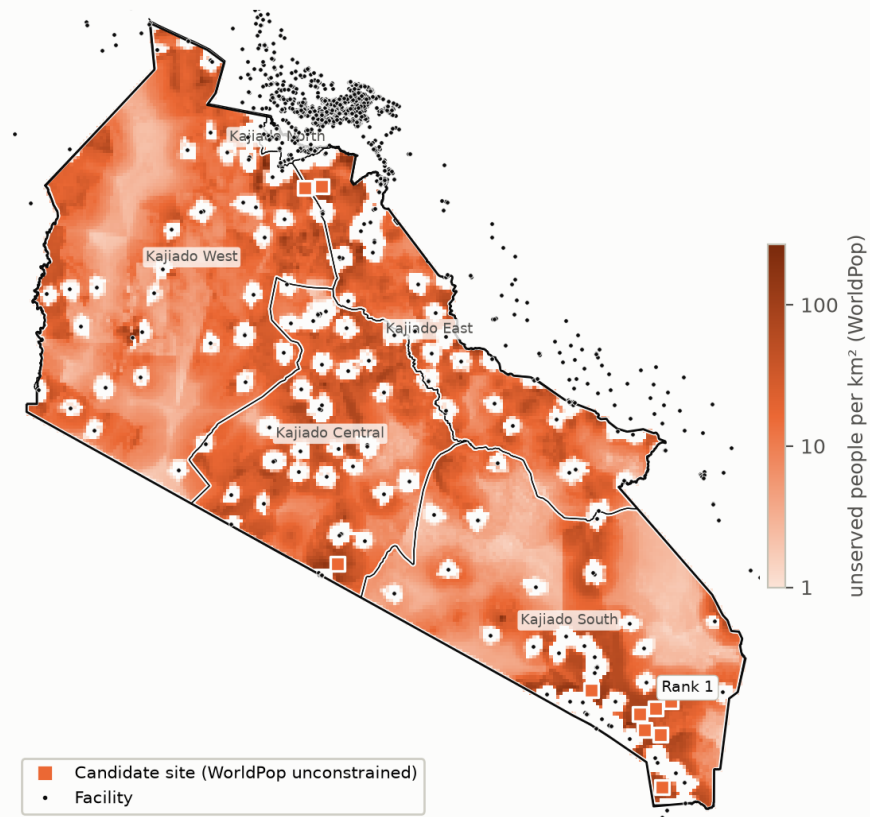
People more than 60 min from a health facility: WorldPop constrained

29.7% of the population; per km². Markers: this product's 10 best candidate sites (at least 5 km apart).



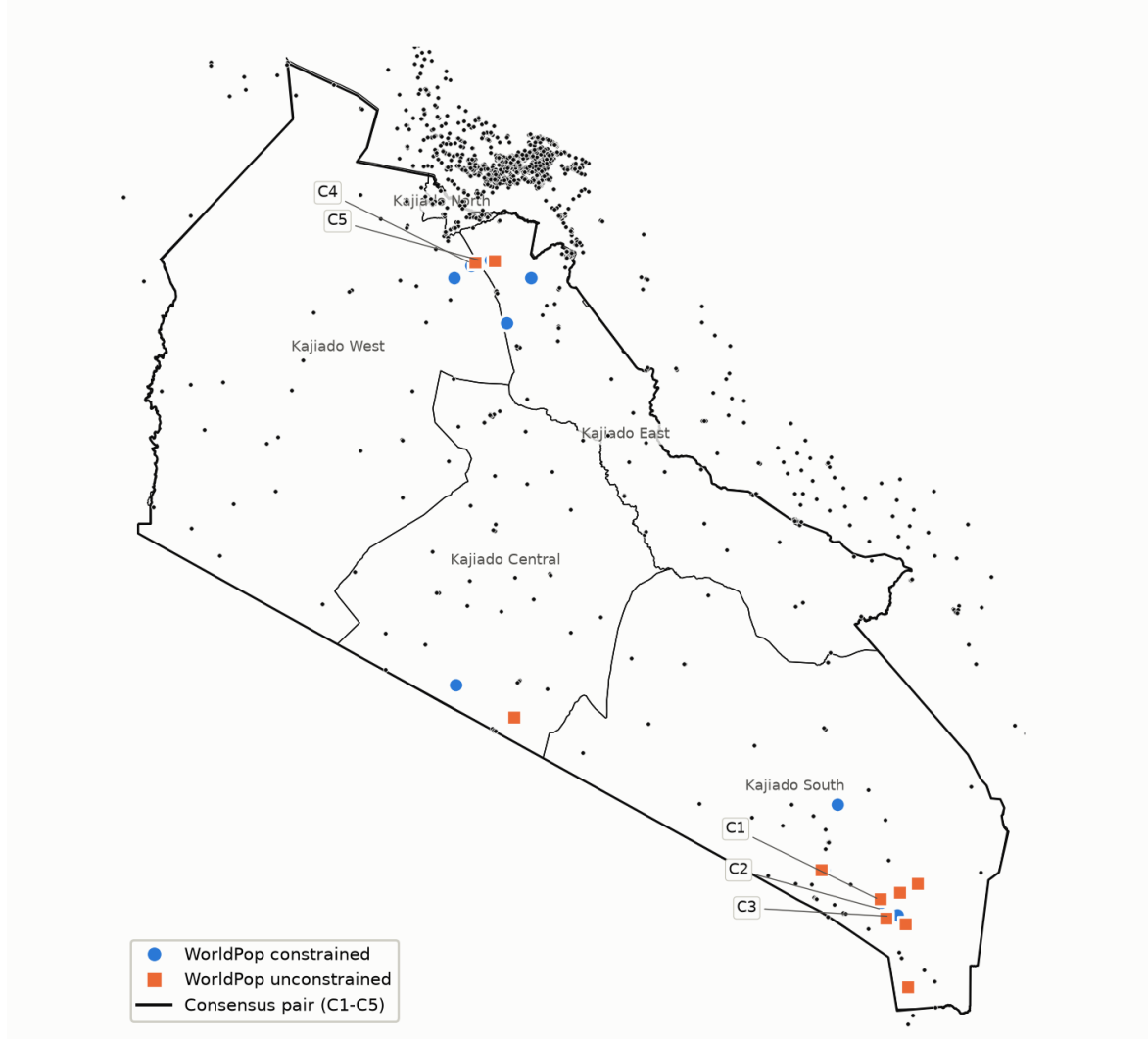
People more than 60 min from a health facility: WorldPop unconstrained

32.6% of the population; per km². Markers: this product's 10 best candidate sites (at least 5 km apart).

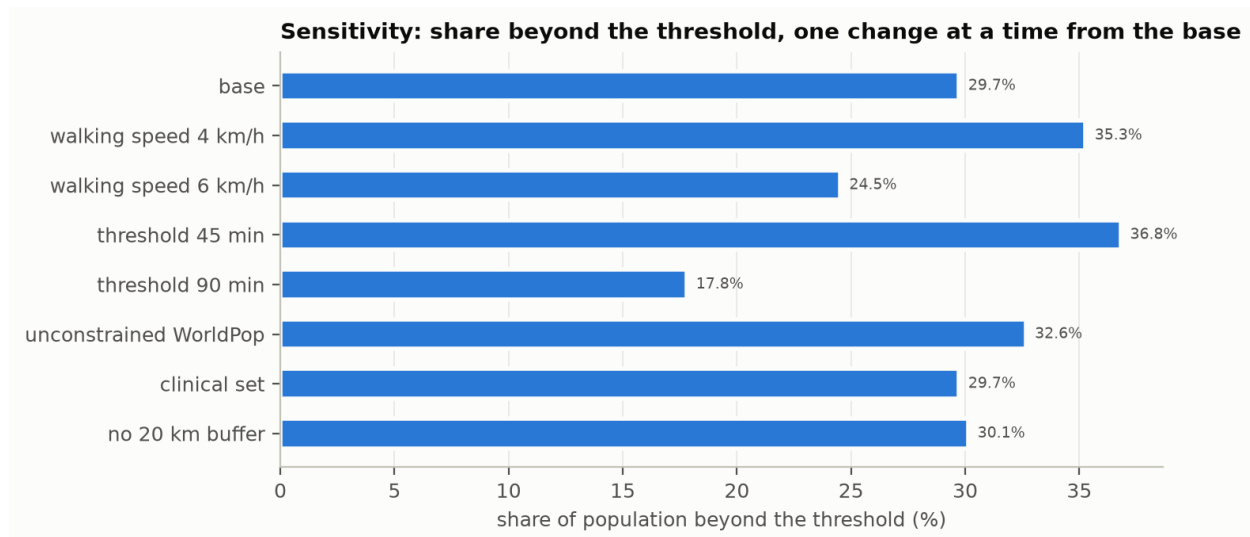


Candidate sites under both WorldPop products

Top 10 per product (at least 5 km apart). Lines join the 5 best consensus pairs (one site per product, within 5 km).



Sensitivity



Scenario	Share over	People over (range)	Top site (ward)	Reached (range)	From base
base	29.7%	290,100–348,600	Oloosirkon/Sholinke	5,000–6,000	0.0 km
walking speed 4 km/h	35.3%	344,100–413,600	Oloosirkon/Sholinke	3,500–4,200	0.0 km
walking speed 6 km/h	24.5%	239,200–287,500	Keekonyokie	6,200–7,400	4.1 km
threshold 45 min	36.8%	359,300–431,800	Oloosirkon/Sholinke	3,100–3,700	0.0 km
threshold 90 min	17.8%	173,800–208,900	Keekonyokie	6,600–8,000	3.9 km
unconstrained WorldPop	32.6%	318,500–382,800	Kuku	3,500–4,200	185.8 km
clinical set	29.7%	290,100–348,600	Oloosirkon/Sholinke	5,000–6,000	0.0 km
no 20 km buffer	30.1%	294,100–353,400	Oloosirkon/Sholinke	5,000–6,000	0.0 km

Each row changes one thing from the base (all health facilities, 5 km/h, 60 min, WorldPop constrained, 20 km buffer). The threshold rows use their own threshold for the share and the site.

Limitations

- The facility file has no operating-status column.
- Kajiado facilities with no coordinates are excluded.
- WorldPop is a modelled product. Constrained and unconstrained versions differ, and both are reported.
- Road coverage in rural Kajiado is incomplete, so travel times on unmapped tracks are overestimated.
- Walking speed is a model, not a measurement.
- Facilities in Tanzania are not in the source, so distances near the southern border are overstated.
- Results measure travel-time access, not utilisation or quality of care.
- Population level (G2, information only): WorldPop 2020 gives 991,700 (constrained) and 975,718 (unconstrained) for Kajiado, against 1,117,840 in the 2019 census and 1,172,614 projected to 2020 (-15.4% and -16.8%). People counts are given as ranges for this reason.
- The two WorldPop products place people differently, so the best single site depends on the product (G2b failed). The coverage curve and consensus sites are reported instead.
- Candidate cells near ADM2/ADM3 edges can show a sub-county and a ward that do not nest: geoBoundaries ADM2 and ADM3 come from different sources.

Bounds

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