Appendix

1. Methods for cost surface creation

Road network data were downloaded in Spring 2017 from Geofabrik's free download server (https://www.geofabrik.de/), which is updated daily based on modifications to the OpenStreetMap project. The SRTM Digital Elevation Dataset, with a resolution of three arc seconds (approx. 90m), was used to generate slope angles. Lastly, GlobCover 2009 Land Cover data was used to estimate the travel cost to roads.

The walking surface was calculated using the slope coefficient (Table 1) and land cover coefficient (Table 2):

$$WT = baseT * slp * lc$$

where WT is the walking time cost in seconds per pixel; baseT is the baseline walking time cost (using 4km/hour); slp is the slope coefficient; lc is the land cover coefficient.

Table 1. Slope coefficients from Fogliati et al[1]

Slope %	Coefficient
0-20%	0.98
20-40%	1.00
40-60%	1.02
60-80%	1.04
80-100%	1.06
>100%	1.08

Table 2. Land cover coefficient used to estimate walking time. In column one this table lists the land cover types present in Haiti, Kenya, Malawi, Namibia, Nepal, and Tanzania as mapped by the GlobCover 2009 Land Cover dataset. The Dry Season column in the table are the author's conversions of the Land Cover Type into a classification of open, bushy, forest, or barrier. The Coefficient column is based on Fogliati, et. al., which lists coefficients of 0.95 for open areas, 1.00 for bushy areas, and 1.05 for forest areas. As the GlobCover 2009 land cover descriptions are much more detailed than "open", "bushy", or "forest", the authors made slight adjustments to the coefficients to better reflect how land cover type impacts travel. The coefficients were adjusted as follows:

- Any land cover types described as "closed", "water bodies", "waterlogged", or "permanent snow and ice" were considered barriers to travel, and given a coefficient of 0.
- Any land cover types described as "closed to open" were considered more difficult to travel through, and given an additional coefficient of 0.05.

Land Cover Type	Dry Season	Coefficient
Post-flooding or irrigated croplands	Bushy area	1
Rainfed croplands	Bushy area	1
Mosaic Cropland (50-70%) / Vegetation (grassland, shrubland, forest) (20-50%)	Bushy area	1

Mosaic Vegetation (grassland, shrubland, forest) (50-70%) / Cropland (20-50%)	Bushy area	1
Closed to open (>15%) broadleaved evergreen and/or semi-deciduous forest (>5m)	Forest area	1.1
Closed (>40%) broadleaved deciduous forest (>5m)	Barrier	0
Open (15-40%) broadleaved deciduous forest (>5m)	Forest area	1.05
Closed (>40%) needleleaved evergreen forest (>5m)	Barrier	0
Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	Forest area	1.05
Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)	Forest area	1.1
Mosaic Forest/Shrubland (50-70%) / Grassland (20-50%)	Forest area	1.05
Mosaic Grassland (50-70%) / Forest/Shrubland (20-50%)	Bushy area	1
Closed to open (>15%) shrubland (<5m)	Bushy area	1.05
Closed to open (>15%) grassland	Open area	1
Sparse (>15%) vegetation (woody vegetation, shrubs, grassland)	Open area	0.95
Closed (>40%) broadleaved forest regularly flooded - Fresh water	Barrier	0
Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water	Barrier	0
Closed to open (>15%) vegetation (grassland, shrubland, woody vegetation) on regularly flooded or waterlogged soil - Fresh, brackish or saline water	Barrier	0
Artificial surfaces and associated areas (urban areas >50%)	Open area	0.95
Bare areas	Open area	0.95
Water bodies	Barrier	0
Permanent snow and ice	Barrier	0

The cumulative travel time, including both driving and walking, towards to the nearest health facility was estimated using the Cost Distance Tool in ArcGIS. Due to the questionable accuracy of the health facility locations and the need for all facilities to be located on roads, all facilities less than 1,000 meters from the nearest road were re-located to the nearest road. We assumed that people would travel at the walking speed until encountering a road after which they would either take public transportation or drive at the normal driving speed. We also assumed that slope and land cover scenarios would not affect the speed of travel on the roads. Facility catchment areas within 2 hours was generated with the Zonal Statistics tool in ArcGIS for each country to calculate the total population within the catchment area. The same tool was used again to calculate the total population in the country, and then percentage of population with access to the health facilities with 2 hours was computed.

Another analytical goal was to calculate the average time for pregnant women to travel to the nearest health facilities for each country. This process was performed separately for hospital and delivery facilities. The cost distance model was used again to calculate the cumulative travel time from each pixel to the nearest facility. The pregnancies population was first converted into points, which represent the number of pregnant population within each grid cell. The Extract Values to Points tool in ArcGIS was then used to extract the time per each population grid cell. The average time to travel to the nearest health facility was summarized based on the above statistics using the following equation:

$$\text{AvgT} = \frac{\sum_1^{Np} Pop * T}{\sum_1^{Np} Pop}$$

where AvgT is the average travel time to the nearest health facilities. Np is the number of points generated from the population raster data, one point corresponding to one pixel in the original raster data. Pop is the number of pregnant population per pixel. T is the travel time to its nearest facility from the pixel.

2. Quality of care indexes

Table 1. Maternal and newborn technical quality index components

	Haiti (N=395)		Kenya (N=403)		Malawi (N=540)		Namibia (N=256)		Nepal (N=623)		Tanzania (N=951)	
	N	%	N	%	N	%	N	%	N	%	N	%
Skilled staff available 24 hr a day	134	34%	108	63%	284	54%	92	52%	107	23%	256	28%
Referral capacity	168	42%	124	60%	449	85%	226	89%	134	29%	262	29%
Electricity and light	119	30%	49	24%	80	15%	77	30%	107	23%	59	6%
Safe water	160	40%	100	48%	313	59%	144	56%	300	65%	256	28%
Infection control resources	292	75%	172	83%	465	88%	217	85%	372	81%	720	80%
Partograph availability and use	93	24%	118	57%	457	87%	98	38%	341	74%	468	52%
Removal of retained products past 3 months	188	48%	72	35%	205	39%	15	6%	152	33%	320	35%
Parenteral oxytocin for haemorrhage past 3 months	266	68%	169	82%	517	98%	61	24%	394	86%	756	84%
Parenteral magnesium sulfate for (pre-)eclampsia past 3 months	120	31%	41	20%	261	49%	24	9%	46	10%	121	13%
Manual removal of placenta past 3 months	197	51%	69	33%	228	43%	29	11%	197	43%	307	34%
Antibiotics for infection past 3 months	217	56%	109	52%	431	82%	43	17%	187	41%	308	34%
Neonatal resuscitation past 3 months	163	42%	86	42%	464	88%	.	.	169	37%	472	52%
Regular KMC for low birthweight babies	96	25%	103	50%	297	56%	.	.	419	91%	194	21%
Maternal and newborn technical quality (mean, sd)	0.43	0.25	0.49	0.24	0.65	0.18	0.37	0.20	0.49	0.20	0.38	0.20

Referral capacity is functional ambulance with fuel or capacity to call another facility with ambulance; Infection control resources is soap and water, gloves, sharps disposal, and surface disinfectant in the delivery room; Partograph availability and use is blank partographs available and at least one provider who has used a partograph in the past month; KMC: Kangaroo mother care

Table 2. Relational quality index in Kenya and Malawi

	Kenya		Malawi	
	N	%	N	%
Respectfully greeted woman	32	81%	193	94%
Encouraged woman to have support person present	15	39%	84	40%
Asked woman if she has any questions	13	35%	82	39%
Explained procedures before proceeding	33	84%	191	91%
Informed woman of findings	33	83%	186	89%
Told woman what will happen during labor	24	60%	162	75%
Encouraged food and fluid consumption during labor	27	65%	150	70%
Encouraged woman to ambulate or change labor positions	31	73%	157	73%
Supported client in friendly way during labor	36	87%	.	.
Draped client before delivery	7	17%	78	36%
Relational quality (mean, sd)	0.62	0.21	0.67	0.19

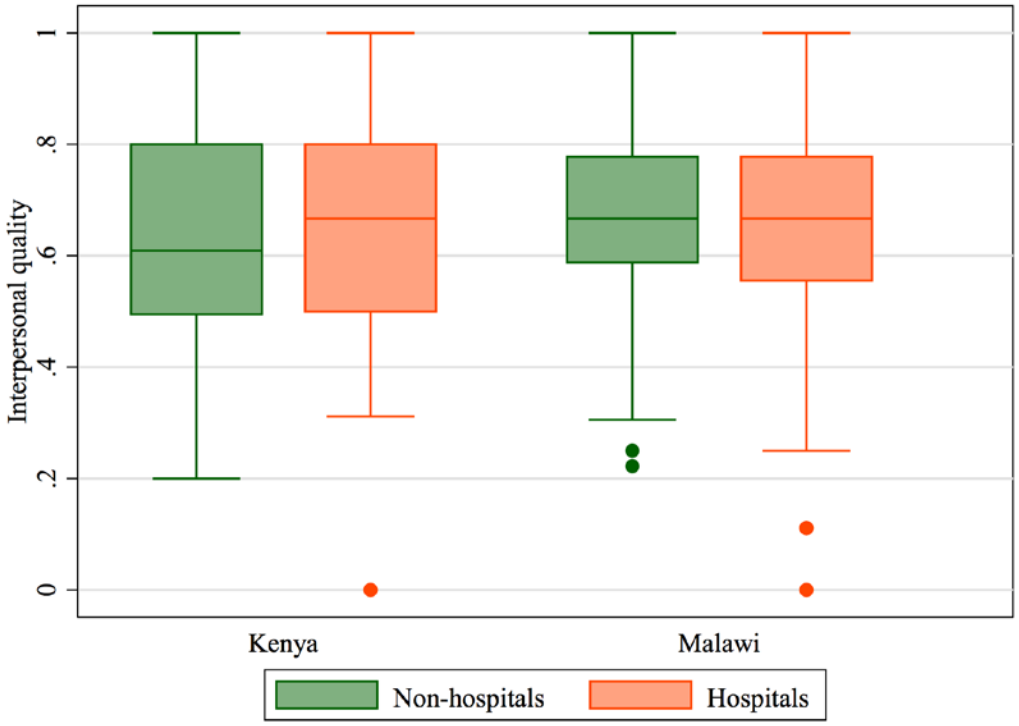
Observations of delivery were completed in 169 Kenyan facilities and 222 Malawian facilities. However, because observations were completed during different stages of labor, not all indicators were collected in each facility, therefore the sample size differs by indicator. The relational quality score is defined as the proportion of non-missing indicators for each facility with observations.

3. One hour access

Table 1. One-hour access to delivery facilities and hospitals

	N One-hour access		% One-hour access	
	All delivery facilities	Hospitals	All delivery facilities	Hospitals
Haiti	103,436	97,113	97.4%	91.5%
Kenya	2,036,135	1,935,997	85.3%	81.1%
Malawi	925,334	867,138	91.9%	86.1%
Namibia	73,021	62,089	84.8%	72.1%
Nepal	762,207	630,723	81.1%	67.1%
Tanzania	1,975,591	1,447,246	74.3%	54.5%

4. Interpersonal quality by facility type



References

- 1. Fogliati P, Straneo M, Brogi C, et al. How can childbirth care for the rural poor be improved? A contribution from spatial modelling in rural Tanzania. *PLoS One* 2015; **10**(9): e0139460.