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Transport Connectivity and Health Care Access

Evidence from Liberia

Atsushi Iimi
Kulwinder Rao

World Bank Group
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Abstract

Health care access is an important policy concern, especially in rural areas. It is especially challenging in developing countries, where rural residents are poorer and less likely to be insured than those living in urban areas. Using the case of Liberia, this paper examines the effects of transport connectivity on health care access. The Ebola crisis in 2014 and 2015 clearly revealed the vulnerability of the country's transport and health systems to unexpected external shocks. Paying particular attention to the possible challenge of endogeneity associated with infrastructure investment, the study found that transport connectivity, especially greater road density, can increase access to health care, but there was no significant effect of road quality. This may be because of significantly skewed underlying data. The vast majority of roads in Liberia are in poor condition. The study also found that the statistical effect of road density varies depending on distance from a health facility. The effect is particularly significant within a 30- to 50-kilometer radius. Not only rural accessibility, but also broader transport connectivity needs to be developed to increase health care access.

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Transport Connectivity and Health Care Access:
Evidence from Liberia

Atsushi Iimi [¶], Kulwinder Rao

Transport & ICT Global Practice, The World Bank Group

Key words: rural roads; health care access; transport connectivity; instrumental variable estimation.

JEL classification: C25, C26, I15, Q42, R40.

[¶] Corresponding author.

I. Introduction

Health care access is an important challenge in rural areas, particularly in developing countries. It is generally difficult for people who live in remote areas to access good-quality health services (e.g., Gamm et al. 2003; Institute of Medicine 2005; Bourke et al. 2012). Even in the United States, rural residents of Washington State were less likely to visit the emergency department than their urban counterparts (Lishner et al. 2000). According to Laditka et al. (2009), rural residents are more likely to be hospitalized for ambulatory care–sensitive conditions in the United States. This could be prevented if people had better access to primary care, but because they do not, their condition tends to deteriorate.

Limited health care access in rural areas is attributed to demand and supply constraints. The demand for health services is weak in rural areas, holding everything else constant, because rural residents tend to be poor. Subscription to health insurance is generally lower in rural areas (e.g., Jovanovic et al. 2003). Without insurance, rural U.S. residents are less likely to use emergency medical services (Fan et al. 2011). Remoteness and unavailability of transport services increase costs further for rural residents (e.g., Klemick et al. 2009). Rural dwellers' travel distance to health facilities is much longer than that of urban dwellers (Gamm et al. 2003). In rural areas, other social and economic facilities also tend to be scattered or nonexistent, which also reduces demand for health care. Nemet and Bailey (2000) show that not only distance, but also people's activity space, including grocery shops and community centers, determines health care usage.

On the supply side, rural areas generally have fewer doctors and nurses. In the United States, approximately 20 percent of the total population lives in rural areas, but only 9 percent of physicians practice in rural areas (Rosenblatt and Hart 2000). The quality of health care services provided in rural areas may also be low. Rural physicians often see more patients than urban doctors do and therefore may have to compromise the level of services they provide. Bronstein et al. (1997) show that rural health services are cheaper but that fewer episodes include outpatient facility charges and that fewer ancillary services are provided.

Supply and demand constraints are complex in developing counties. Particularly in Sub-Saharan Africa, urban–rural inequality is significant in terms of health care access. In Liberia, for instance, the average distance to a functioning health facility is approximately 7 kilometers. Approximately 40 percent of rural residents must spend more than 2 hours to walk to the nearest health facility (Kruk et al. 2010). In Zambia, approximately 75 percent of urban residents, but only 30 percent of rural residents, live within 2 kilometers of the nearest health facility (Zambia Central Statistical Office 2012).

The current paper examines the effect of transport connectivity on health care access in Liberia. Before the Ebola crisis, Liberia was experiencing robust economic growth, at more than 7 percent on average, mainly driven by strong natural resource exports such as iron ore and rubber. The majority of people engage in subsistence farming, with limited market access, and live below the poverty line. The national poverty rate was estimated at 63.8 percent in 2007. The Ebola crisis in 2014 and 2015 revealed vulnerability of the country's transport and health care systems to unexpected external shocks. The transport network does not seem to have been adequate to manage a rapid pandemic of disease in rural and remote areas. Economic activity is highly concentrated in Monrovia, but more than 2.2 million people, or approximately half of the total population, live in rural areas.

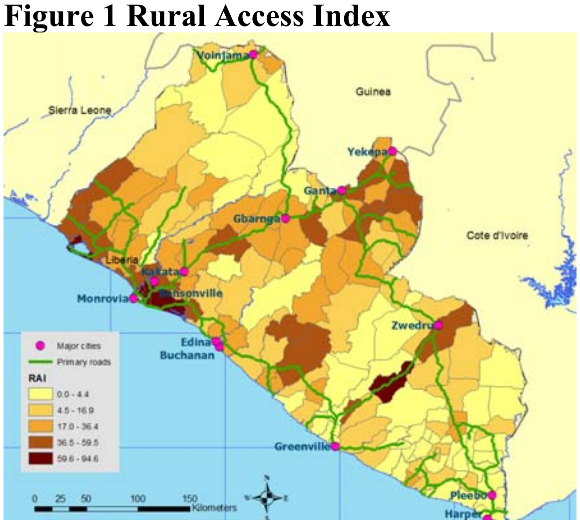
To examine the effect of transport connectivity on health care access, this paper uses newly collected spatial data at the facility level with the potential endogeneity issue associated with infrastructure placement taken into account. Although attribution is weak, the paper shows that road infrastructure is important to meet health care demand in rural Liberia. The following sections are organized as follows: Section II provides an overview of the road network and health facilities in Liberia. Section III describes data and methodologies. Section IV presents main estimation results and discusses policy implications. Section V concludes.

II. Transport connectivity in Liberia

Liberia is one of the poorest countries in the world. Gross domestic product per capita was US$457 in 2014.[1] More than half of Liberians live below the poverty line. According to the national census, the national poverty rate was estimated to be 54.1 percent in 2008 (LISGIS 2009). There is significant urban–rural inequality. Monrovia has a poverty rate of 31.6 percent, but poverty is generally more prevalent in the inland north central region (72 percent), such as Lofa County, which was most severely affected by the initial Ebola outbreak, and the southeastern region (79 percent), such as Maryland and Grand Gedeh.

The manufacturing sector is limited, with agriculture being an important sector, employing approximately half of the labor force. Productivity is low. Many farmers engage in subsistence farming, with limited market access, especially in rural and remote areas. The Rural Access Index, which measures the share of rural population that lives within 2 kilometers of a road in good condition, is estimated at 41.9 percent (figure 1). Although Liberia has a relatively high urbanization rate (approximately 50 percent), some 2.3 million residents are not connected to a reliable road network (World Bank 2016).

Figure 1 Rural Access Index

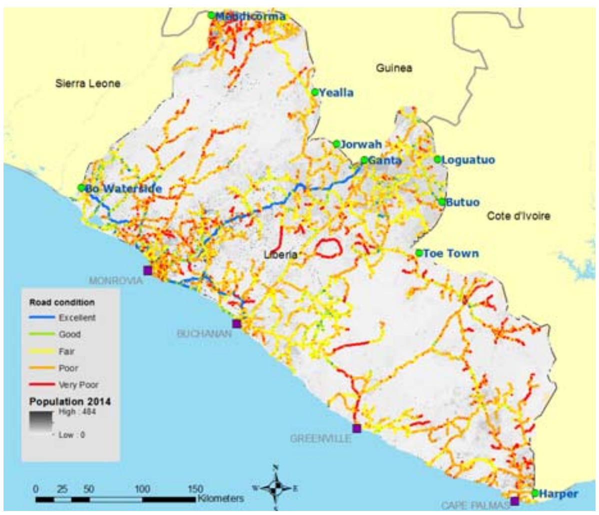


Source: Authors' calculation.

[1] According to *World Development Indicators*.

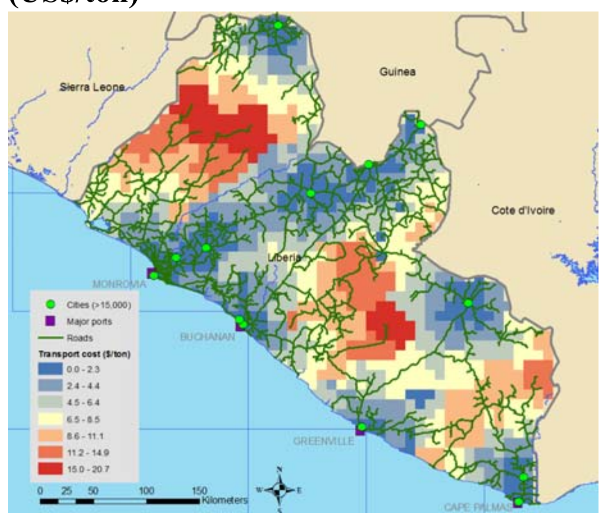
The poor condition of the road network limits residents' mobility, especially in rural and remote areas (figure 2). Using georeferenced road condition data, transport costs to bring one unit of goods to a major market were calculated using spatial software. In principle, if road conditions are bad, road user costs tend to be high and travel speed low, which increases time costs. From each location, the optimal route was selected to minimize the total transport cost to reach a city with more than 15,000 residents. Transport costs are relatively low along the Monrovia-Ganta Corridor, which has recently been rehabilitated, but significantly higher in some remote inland areas (figure 3).

Figure 2 Road Network Condition



Source: World Bank survey.

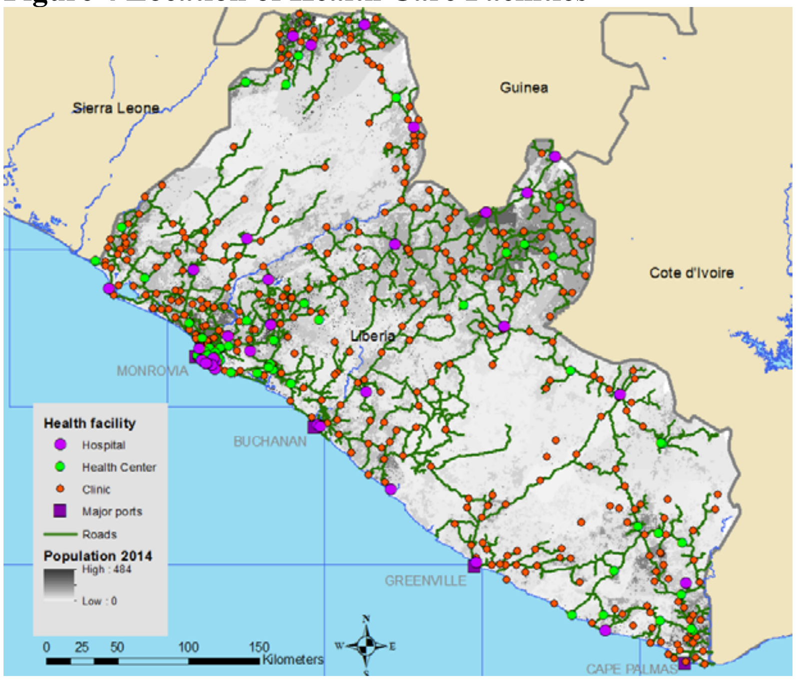
Figure 3 Transport Costs to Market (US$/ton)



Source: World Bank estimate.

There is an extensive network of health facilities comprising hospitals, health centers, and clinics in Liberia. Although not complete, 618 facilities were mapped in our data (figure 4). It is estimated that approximately 90 percent of the population has access at least to a clinic within 10 kilometers, but access to the higher level of health services provided at hospitals is more limited; less than 40 percent of the population lives within 10 kilometers of a hospital. Some of the facilities are located in remote and disconnected areas, which not only limits access to health care, but also increases the country's vulnerability to unexpected external shocks, such as the Ebola pandemic. This study investigated the relationship between transport connectivity and people's access to health care.

Figure 4 Location of Health Care Facilities



III. Methodology and data

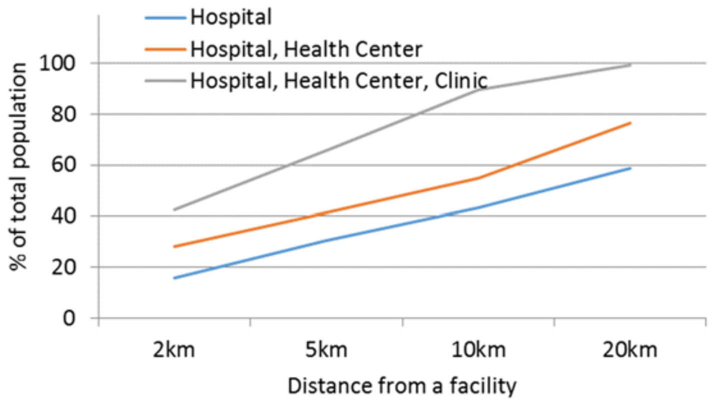
The following simple, reduced-form equation was used to examine the possible effect of transport connectivity on health care access.

$$y_i = \beta_{TR} TR_i + X_i ' \beta + \varepsilon_i \qquad (1)$$

Health care access (y) at facility i is determined according to transport connectivity (TR) and other characteristics of the facility (X). Three outcome variables are used to measure health care access: number of patients receiving a medical consultation at the outpatient department of each health facility (*OPD*), number of malaria cases treated (*MAL*), and number of babies delivered at each facility (*DEL*).

Two traditional transport indicators are used to indicate transport connectivity (TR): road density (*RDDEN*), which is focused on an area within a 10-kilometer radius of each health facility, and share of roads in good condition within the same area (*GDRD*). This allows examining whether the quantity or the quality of roads is more important in facilitating access to health care. The threshold of 10 kilometers was selected because approximately half of the total population lives within 10 kilometers of a hospital or health center in Liberia (figure 5).[2] Other thresholds were examined to check the robustness of the estimation results.

Figure 5 Share of Population with Health Care Access



Our sample data comprised 69 health facilities in Liberia—39 hospitals and 30 health centers. Their locations were georeferenced, and detailed information on their medical operations is available in the Health Management Information System that the Ministry of Health has developed. No detailed information or location data is available for other health facilities, including health clinics.[3] Cross-sectional data from 2015 were used, which may not be ideal because the end of the Ebola crisis was not officially declared until January 2016, but data for 2016 were not fully available at the time of the survey.

The summary statistics are shown in table 1. Each health care facility provided medical consultation to an average of 8,700 people, and approximately 1,300 malaria cases were treated. An average of 390 babies were born per medical institution under the overall

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[2] This was estimated using the location data for health facilities and spatial population distribution data developed by WorldPop.
[3] There are more than 520 health clinics in Liberia, but there are no detailed operational data.

supervision of trained health personnel. To control for differences between facilities, the number of beds (*BED*) was used as a proxy for each institution's capacity. A dummy variable for health centers (*CENTR*), as opposed to hospitals, is also included in *X*. Health centers generally have less capacity than hospitals. In addition, to control for the size effect, population density within a 10-kilometer radius of each facility, calculated using the global population data set, WorldPop (*POPDEN*), was included. In populated areas, it is expected that more people will visit a health facility regardless of transport connectivity.

Table 1 Summary Statistics

Variable	Abb.	Obs.	Mean	Std. Dev.	Min	Max
Number of patients in outpatient department (1,000)	OPD	69	8.76	7.20	0	44.78
Number of malaria cases treated (1,000)	MAL	69	1.29	1.14	0	5.15
Number of babies delivered (1,000)	DEL	69	0.39	0.45	0	2.61
Population density in a 10-km radius of each facility (1,000 per km^2)	POPDEN	69	0.74	1.19	0.01	3.63
Poverty rate (percent)	POV	69	56.15	18.28	31.60	78.90
Number of beds (1,000)	BED	69	0.38	1.01	0	8.02
Road density within a 10-km radius of each facility (km/100 km^2)	RDDEN	69	34.66	24.31	5.68	94.75
Share of good roads within a 10-km radius (%)	GDRD	69	14.39	13.26	0	63.86
Dummy for health center	CENTR	69	0.57	0.50	0	1
Instrumental variables						
Slope of land where facility is located (degrees)	SLOP	66	0.4	0.5	0.0	3.6
Elevation of land where facility is located (m)	ELEV	66	143.3	162.2	5.0	547.0
Distance to nearest historic port (km)	DIST	69	76.7	67.2	0.4	222.7

An empirical challenge to estimating Equation (1) is that transport connectivity may be endogenous. For instance, more people may visit a particular hospital because it is better connected, but transport connectivity may be better because the government invests in roads where more people live. The risk of this self-selection bias is generally high when the effect of infrastructure investment is examined (e.g., Donaldson 2010; Mu and van de Walle 2011). Several techniques to address the problem have been discussed in the literature. Panel analysis can eliminate selection bias, as long as unobserved characteristics are time-invariant (Dercon et al. 2008; Khandker et al. 2009; Khandker and Koolwal 2011). Unfortunately, the current data from Liberia do not allow this, because time-series data on transport connectivity are not available.

The current paper used the instrumental variable technique. Two types of instruments are considered. First, following Dinkelman (2011), geographic conditions are used. Land gradient (*SLOP*) and elevation (*ELEV*) at each location may affect the technical feasibility of developing road infrastructure. Roads are difficult to build in mountainous areas or on steep terrain.

Second, historical events related to infrastructure development are used (e.g., Jedwab and Moradi 2012). In Africa, much current transport infrastructure, such as railways and trunk roads, date back to the colonial era. In Liberia, several seaports had been developed by the mid-19th century. It is likely that proximity to these ports, namely, Monrovia, Edina, Bassa Cove (Buchanan), Mississippi Colony (Greenville), and Cape Palmas (Harper), affects development of the road network but is not necessarily directly related to residents' access to health care. The straight-line distance to the nearest historic port is calculated (*DIST*), and these three variables in logarithm are used as instruments for *RDDEN* or *GDRD*. Exogeneity and validity will be examined empirically.

IV. Main estimation results

Ordinary least squares estimation performed for each of the health care access outcomes (*OPD*, *MAL*, and *DEL*) shows that road density has a significant effect on all these health care outcomes; with more roads, more people can take advantage of health care services (table 1). The coefficients vary depending of outcome measurements. The number of visiting patients has the largest coefficient. This reflects all types of medical demand.

Contrary to prior expectations, the quality of roads does not seem to influence people's health care access. This may mean that road development should be given higher priority than road improvement, given the level of road development in Liberia. From an empirical point of view, it may also be true that the effect of road quality was not detected because the share of roads in good condition is too small, at 14 percent on average.

In addition to transport connectivity, population density affects health care access, with demand for health care access higher where population density is lower, holding everything else constant. There are two possible reasons for this. First, health service demand may be higher in rural or remote areas, although this is unlikely, because our poverty variable was found to be insignificant. In rural areas in Liberia where population density is low, poverty is high. Thus, the negative coefficient of population density is less likely to capture the effect of remoteness, and the demand for health care services does not differ regardless of poverty. The effect is insignificant.

Another possible reason is that the demand for health care services per health facility is lower where population density is high and many health facilities coexist. This is more likely to be the case in Liberia. Hospitals and health centers are concentrated around Monrovia, and as a result, population density has a negative effect on health care access per facility.

The capacity of hospitals affects the number of babies born there. The coefficients of *BED* are always positive and significant; health facilities with more capacity, measured according to number of beds in our analysis, can attract or absorb more needs for delivery. Not surprisingly, development of the physical capacity of health facilities is important in improving access to health care.

Table 2 Ordinary Least Squares Results without County Fixed Effects

	OPD		*MAL*		*DEL*		*OPD*		*MAL*		*DEL*	
RDDEN	0.348	***	0.042	**	0.013	**						
	(0.103)		(0.017)		(0.006)							
GDRD							0.002		-0.007		0.001	
							(0.052)		(0.010)		(0.002)	
POPDEN	-7.669	***	-0.888	**	-0.210	*	-1.607	*	-0.143		0.010	
	(2.095)		(0.359)		(0.121)		(0.868)		(0.160)		(0.043)	
POV	-0.041		0.010		0.000		-0.100		0.000		-0.002	
	(0.057)		(0.012)		(0.003)		(0.067)		(0.013)		(0.003)	
BED	1.225		-0.053		0.232	***	1.690		0.023		0.247	***
	(1.229)		(0.140)		(0.053)		(1.488)		(0.171)		(0.062)	
CENTR	-2.201		-0.275		-0.142		-1.174		-0.122		-0.107	
	(1.793)		(0.325)		(0.097)		(1.870)		(0.332)		(0.096)	
Constant	5.408		0.114		0.125		15.560	***	1.561	*	0.471	**
	(4.090)		(0.875)		(0.222)		(4.784)		(0.901)		(0.216)	
Observations	69		69		69		69		69		69	
R-squared	0.248		0.121		0.415		0.108		0.043		0.368	
F-statistic	3.07		1.40		5.49		1.36		0.63		4.27	
Number of county dummies	0		0		0		0		0		0	

Note: Robust standard errors are shown in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

County-specific fixed effects are incorporated into the model to take into account potential differences between facilities. Because some counties have only one hospital or health center in our data, only eight county-specific dummy variables are used. The poverty variable was omitted because it is a county-specific variable in our data.

The results are not different from the above (table 3). Although road density has an important effect on health care access, road quality measured according to the share of good roads does not seem to matter much. The needs for health services are relatively high where population density is low, because there are fewer hospitals and health centers in such areas. Hospital capacity is an important determinant of the number of babies delivered. With more capacity, more patients can be treated.

Table 3 Ordinary Least Squares Results with County Fixed Effects

	OPD		*MAL*		*DEL*		*OPD*		*MAL*		*DEL*	
RDDEN	0.332	**	0.036	**	0.013	*						
	(0.127)		(0.017)		(0.007)							
GDRD							0.022		-0.006		0.006	*
							(0.071)		(0.015)		(0.003)	
POPDEN	-7.207	**	-0.723	**	-0.279		-1.438		-0.066		-0.069	
	(3.132)		(0.325)		(0.202)		(1.399)		(0.190)		(0.099)	
BED	1.286		-0.059		0.235	***	1.598		-0.008		0.237	***
	(1.350)		(0.136)		(0.061)		(1.569)		(0.160)		(0.070)	
CENTR	-2.163		-0.181		-0.124		-1.153		-0.057		-0.093	
	(1.926)		(0.295)		(0.104)		(1.878)		(0.304)		(0.099)	
Constant	3.158		1.353	***	0.061		9.321	***	2.079	***	0.271	**
	(2.758)		(0.435)		(0.147)		(1.999)		(0.389)		(0.104)	
Observations	69		69		69		69		69		69	
R-squared	0.257		0.278		0.453		0.146		0.229		0.419	
F-statistic	2.55		1.55		5.03		2.25		1.81		4.18	
Number of county dummies	8		8		8		8		8		8	

Note: Robust standard errors are shown in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

The above results may be biased if the transport variables are endogenous. To examine this, the instrumental variable technique is used. The analysis is focused on the model with road density, which was found to be statistically significant. The results are broadly consistent with the above (table 4). Higher road density results in greater health care access in terms of total visiting patients and babies delivered.

Table 4 Instrumental Variable Estimation

	OPD	*MAL*	*DEL*	*OPD*	*MAL*	*DEL*
RDDEN	0.564 *	-0.025	0.028 *	1.002 *	-0.053	-0.010
	(0.319)	(0.065)	(0.015)	(0.617)	(0.098)	(0.020)
POPDEN	-11.490 **	0.305	-0.481 *	-18.170 *	0.862	0.193
	(5.616)	(1.206)	(0.256)	(10.920)	(1.747)	(0.358)
POV	0.030	-0.002	0.004			
	(0.077)	(0.013)	(0.004)			
BED	0.534	-0.005	0.192 ***	0.204	-0.019	0.224 ***
	(0.680)	(0.168)	(0.024)	(0.678)	(0.176)	(0.040)
CENTR	-2.166	-0.156	-0.132	-3.345	0.008	-0.022
	(1.635)	(0.361)	(0.085)	(2.790)	(0.403)	(0.097)
Constant	-3.389	2.145	-0.492	-9.818	3.107 *	0.521
	(10.180)	(1.834)	(0.490)	(11.790)	(1.931)	(0.354)
Obs.	66	66	66	66	66	66
R-squared	0.091		0.328		0.007	0.378
Wald chi^2	11.92	2.28	195.89	20.36	23.43	107.99
Number of county dummies	0	0	0	8	8	8
Exogeneity test [1]						
Chi^2 test statistic	1.167	1.327	2.091	3.420 *	0.898	1.481
P-value	(0.280)	(0.249)	(0.148)	(0.064)	(0.343)	(0.224)
Overidentifying restriction test [1]						
Chi^2 test statistic	1.354	2.432	3.263	0.668	2.873	1.045
P-value	(0.508)	(0.297)	(0.196)	(0.716)	(0.238)	(0.593)

Note: Robust standard errors are shown in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

[1] The instrumental variable estimation is performed with *RDDEN* or *GDRD* instrumented with three variables in logarithm: *SLOP*, *ELEV*, and *DIST*.

The results indicate that transport connectivity is exogenous. The traditional exogeneity test is performed; the test statistics are found to be lower than the critical value, except in one case—the regression on *OPD* with county dummy variables. In this case, the exogeneity hypothesis can be rejected at the 10 percent significance level. The coefficient of *RDDEN* is still positive and significant, confirming the importance of road density. The overidentifying restriction test is always rejected at the conventional significance level, meaning that our instruments are less likely to be correlated with the dependent variables.

One may be concerned about the robustness of the results against our transport variables. Ordinary least squares regression is performed with different thresholds applied for road density (table 5), and the results are broadly consistent with the above, where a threshold of 10 kilometers was used; there is greater health care access where there are more roads and road density is high, although the statistical significance of the effect of road density decreases with the threshold of the distance from a health facility. The statistical significance in the model of the total number of patients disappears when road density is measured within a 50-kilometer radius. For institutional deliveries, road density has a significant effect only when it is measured within a 30-kilometer distance. The results indicate the importance of broad transport connectivity up to a 30- to 50-kilometer distance from a health facility. The policy implications for Liberia are straightforward—when transport infrastructure development increases health care access, particularly access to high-level health facilities, it is important to develop not only rural accessibility, but also broader transport connectivity. The supporting coverage depends on the type of health care services.

Table 5 Ordinary Least Squares Estimation with Different Road Density Thresholds

	OPD	*OPD*	*OPD*	*OPD*	*OPD*	*DEL*	*DEL*	*DEL*	*DEL*	*DEL*
RDDEN_10km	0.348 ***					0.013 ***				
	(0.103)					(0.006)				
RDDEN_20km		0.406 **					0.022 **			
		(0.168)					(0.010)			
RDDEN_30km			0.325 **					0.014 *		
			(0.138)					(0.007)		
RDDEN_40km				0.305 **					0.006	
				(0.135)					(0.008)	
RDDEN_50km					0.325 *					0.002
					(0.170)					(0.010)
POPDEN	-7.669 ***	-4.131 ***	-1.960 **	-1.475 *	-1.288	-0.210 **	-0.128	-0.004	0.014	0.012
	(2.095)	(1.446)	(0.940)	(0.908)	(0.891)	(0.121)	(0.084)	(0.047)	(0.044)	(0.045)
POV	-0.041	-0.023	-0.024	-0.028	-0.025	0.000	0.002	0.001	-0.001	-0.002
	(0.057)	(0.064)	(0.071)	(0.074)	(0.082)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
BED	1.225	1.527	1.575	1.474	1.445	0.232 ***	0.240 ***	0.244 ***	0.245 ***	0.248 ***
	(1.229)	(1.300)	(1.395)	(1.424)	(1.447)	(0.053)	(0.052)	(0.059)	(0.062)	(0.063)
CENTR	-2.201	-1.576	-1.439	-1.630	-1.706	-0.142	-0.127	-0.116	-0.113	-0.106
	(1.793)	(1.776)	(1.792)	(1.795)	(1.810)	(0.097)	(0.092)	(0.093)	(0.093)	(0.092)
Constant	5.408	4.746	6.458	7.510	7.473	0.125	-0.101	0.107	0.335	0.459
	(4.090)	(5.322)	(5.707)	(5.798)	(6.551)	(0.222)	(0.223)	(0.252)	(0.323)	(0.378)
Observations	69	69	69	69	69	69	69	69	69	69
R-squared	0.248	0.211	0.152	0.138	0.133	0.415	0.447	0.388	0.371	0.368
F-statistic	3.07	2.01	2.25	2.28	2.14	6.61	5.78	4.97	4.58	4.38
Number of county dummies	0	0	0	0	0	0	0	0	0	0

Note: Robust standard errors are shown in parentheses. *, **, and *** indicate statistical significance at 10%, 5% and 1%, respectively.

V. Conclusion

Health care access is an important policy concern, especially in rural areas. This is especially challenging in developing countries, where residents are poorer and less likely to be insured than those in urban areas. In addition, doctors are less available in rural areas. Supporting infrastructure services, such as electricity and transport connectivity, are less favorably compared in rural areas. The international donor community has been making significant efforts to increase rural health care access in many countries.

Using the case of Liberia, this study examined the effect of transport connectivity on health care access. In Liberia, rural health care access is an important challenge. The Ebola crisis in 2014 and 2015 clearly revealed the vulnerability of the country's transport and health systems to unexpected external shocks. Although most urban residents have good access to health care services, many rural people do not have any hospital or health center within 10 kilometers.

With particular attention paid to the possible problem with endogeneity associated with infrastructure investment, this study also found that transport connectivity, especially greater road density, can increase access to health care, but no significant effect of road quality was found. This may be because of significantly skewed underlying data; the vast majority of roads are in poor condition in Liberia. The study also found that the statistical effect of road density varies depending on distance from a health facility. The effect is particularly significant within a 30- to 50-kilometer radius. This confirms that, to improve health care access, it is important to develop not only rural accessibility, but also transport connectivity over a broader area. The optimal coverage depends on the type of health care services. A 30- to 50-kilometer distance is recommended given the current road network and locations of health facilities.

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