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Roads and the spread of HIV in Africa☆

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ABSTRACT

I here use GIS and HIV data from five African countries to estimate the effect of road proximity on HIV infection. I find a negative effect of the distance to the nearest paved road on the probability of being infected with HIV: a one standard-deviation fall in this distance (approximately 2.4 km) increases the probability of infection by 0.6–2.0 percentage points. Using slope as an instrument for road distance continues to produce a negative and significant estimated coefficient. However this relationship may also reflect selection and reverse causality in individual choice of location, and I extensively discuss the role of migration. While the number of lifetime sexual partners is significantly influenced by the presence of roads in some recent years, the effect of road distance on access to protection has disappeared.
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1. Introduction

While transport infrastructure is essential for development, as it facilitates the movement of people, goods and services, it can also bring negative health effects. Diseases are often geographically transmitted by trade and travel, so that the movement of people due to roads may contribute to the rapid propagation of communicable diseases. In the 1300s, trade between Asia and Europe along the Silk Road was at the origin of the introduction of the Black Death in Europe (Schmid et al., 2015) and major trade routes played a dominant role in spreading the plague in pre-industrial Europe (Yue et al., 2017). In the case of an infectious disease like HIV/AIDS, the relationship between road access and infection is ambiguous. Road proximity has two competing effects on HIV risk. On the one hand, roads may increase the risk of infection by bringing people who live in accessible areas into contact with more mobile populations who are at a greater risk of infection, and by facilitating the movement of people who live close to roads. On the other hand, roads may affect behavior and reduce risk by increasing access to condoms and knowledge about HIV/AIDS, both of which reduce the cost of protection.

In this paper I provide estimates of the net effect of road proximity on the individual risk of HIV infection in Sub-Saharan Africa, and explore a number of hypotheses regarding why roads matter for HIV. Evaluating the negative health effects of roads, if they exist, is crucially important in order to try to counterbalance them with appropriate policies. I examine the spread of the HIV epidemic in sub-Saharan Africa along existing paved roads and compare the risk of HIV infection of individuals living in areas located close to a road to that of those who live in remoter areas. This paper uses a unique dataset constructed by matching data from nationally-representative household surveys from the Demographic and Health Surveys to geographical data on road infrastructure in a sample of five African countries at three points in time, namely Cameroon, Ethiopia, Kenya, Malawi and Zimbabwe.

The main issues in the estimation of the effect of roads on HIV infection are that roads are not randomly located, and that individuals may decide to move to live close to a road. I deal with endogenous road placement by controlling for a large set of potential confounding factors at the community level (urbanization, population density, wealth, labor opportunities and population mix) and by estimating instrumental-variable models using geo-

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graphical characteristics as instruments: slope, the location of historical routes and location of hypothetical lines connecting old cities. The endogeneity of road distance may also work at the individual level. To attenuate the bias due to unobserved heterogeneity at the individual level, the estimations are carried out at the community level, which produces similar results. Second, the issue of non-random individual location is addressed by considering individual migration patterns. Road proximity may increase the probability of being HIV-infected as a disproportionate number of at-risk individuals migrate to live close to roads, leading to selection bias.

I find compelling evidence that people living closer to roads are more likely to be infected with HIV than people living in remoter areas. The effect is sizable: a one standard-deviation rise in the distance to the nearest road (about 2.4 km) reduces the risk of infection by between 0.6 and 2.0 percentage points. I show that the effect of distance to roads does not significantly differ by migration status. There are a number of channels via which road proximity could affect HIV risk, including changes in the demand for and supply of protection. I estimate the effect of road distance on HIV knowledge, condom availability, sexual behaviors and access to antiretroviral therapy between remote and accessible areas. Living close to a road increases HIV knowledge and condom access in the mid-2000 data waves, but not in the later waves collected in the early 2010s. The effect of road distance on the number of lifetime sexual partners is significant in recent years. Individuals aged 30–39 (at the time of the survey) are especially protected from HIV-risk when living far from a paved road.

A considerable literature has established the effect of infrastructure on various outcomes of interest, such as poverty, city growth, trade, and economic performance. The role of transport infrastructure in alleviating poverty has been examined in a number of countries: Papua New Guinea (Gibson and Rozelle, 2003), Ethiopia (Dercon et al., 2008), Bangladesh (Khandker et al., 2009), Cameroon (Gachassin et al., 2010) and Nepal (Dillon et al., 2011). In low-income countries, infrastructure encourages trade by reducing transport costs (Jacoby, 2000) and enhances non-farm earnings (Jacoby and Minten, 2009). Buys et al. (2010) estimate that a major investment in upgrading the road network and maintaining existing roads could increase trade flows in Sub-Saharan Africa by about USD 250 billion over 15 years. Research along these lines has examined the role of road and railway infrastructure in enhancing economic performance (e.g. Straub et al., 2008; Banerjee et al., 2012; Bird and Straub, 2014; Wang and Wu, 2015; Donaldson, 2018). A separate set of papers has analyzed the effect of transport infrastructure on city size in both developed (e.g. Duranton and Turner, 2012) and developing (e.g. Jedwab and Moradi, 2016; Jedwab and Storeygard, 2017) countries.

The major issue in this comparison is the non-random location of infrastructure. A number of contributions have exploited exogenous variation in the location of physical infrastructure to identify the causal relationship between access to railways, roads, electricity or water and economic outcomes such as growth, employment and urbanization. Examples here include the location of historical routes,[1] straight lines connecting major cities in the 19th Century[2] and land characteristics.[3]

The impact of roads on health and HIV outcomes has attracted much less attention (exceptions are Barongo et al., 1992; Tatem et al., 2012). The most closely-related paper is Oster (2012), who considers the role of exports in fostering HIV incidence. In an ancillary analysis, she looks at the uninstrumented effect of road distance on HIV prevalence at the cluster level. The analysis presented here goes further by generating accurate GIS information on the distance to roads using recent geo-referenced data, explicitly considering the potential non-random location of both roads and individuals (i.e. through migration), proposing and testing a number of behavioral mechanisms via which roads may affect the spread of HIV in Africa, and exploring the impacts over time. The suggestive negative correlation between HIV and distance to road is confirmed in the careful casual analysis of this paper.

The remainder of the paper is organized as follows. Section 2 discusses the influence of road infrastructure on HIV/AIDS outcomes. Section 3 describes the data and Section 4 presents the empirical strategy and discusses identification and potential validity problems. Section 5 then presents the empirical results and Section 6 explores the mechanisms and examines the persistence of the main results over time and age cohorts. Last, Section 7 concludes.

2. Analytical framework

Consider a village with no HIV and no information about HIV. The individuals who live there will not adopt any HIV-protective behaviors as they know nothing about HIV transmission or the means of protection. HIV will enter the village if a visitor infected with HIV comes in, or an inhabitant leaves the village and comes back infected. This has a greater probability of occurring in communities closer to roads than in those further away. Roads facilitate physical contact and communication among individuals, which may increase the probability of HIV infection by increasing the pool of potential sexual partners, and the proportion of potential partners who are infected. Those living closer to roads are in particular more likely to be in contact with mobile groups – truck drivers, migrant workers, travelers, servicemen, traders – which groups are known to be more likely to engage in risky sexual behaviors (e.g. Rao et al., 1999) and to be HIV infected than the local population. For example, Orubuloye et al. (1993) found that long-distance truck drivers in Nigeria are more likely to engage in multiple sexual partnerships, including stable partnerships with women who are not commercial sex workers. Meekers (2000) reported similar findings for migratory mine workers in South Africa. In Nwokoji and Ajuwon (2004), naval servicemen posted abroad had more sexual partners, were more likely to have had sex with a female sex worker, and were less likely to have used condoms during their last sexual encounter with a sex worker than naval personnel stationed locally. Similar findings appear in Lippman et al. (2007) for truckers in Brazil. Other mobile population groups are also at greater risk of infection. Short-term mobility was associated with risky sexual behavior in Lagarde et al. (2003). In addition, road infrastructure may lead local residents to use the road to visit areas with higher HIV prevalence. On the contrary, HIV prevalence rates in remoter communities are more stable, as the rates of in- and out-migration are lower and the cost of mobility is higher. Isdory et al. (2015) use mobile-phone data to show that the most important consequence of movement is the transmission of the disease from high- to low-prevalence areas. As such, the improved mobility from roads will lead to the introduction and spread of HIV.

Regarding the spread of an infectious disease, transmission results from a susceptible agent coming into contact with an infected agent. Roads increase the likelihood of coming into contact with infected individuals, and in turn the number of secondary infections (the number of infections from one infected agent). Population density matters here as it increases the number of contacts. In this respect, part of the effect of roads is similar to that of pop-

[1] Duranton and Turner (2012), Baum-Snow et al. (2017) and Agrawal et al. (2017).

[2] Banerjee et al. (2012), Atack et al. (2009), Bird and Straub (2014), Donaldson (2018), Jedwab and Moradi (2016) and Agrawal et al. (2017).

[3] Duflo and Pande (2007), Batzilis et al. (2010), Dinkelman (2011) and Lipscomb et al. (2013).

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