Explaining Mortality Outcomes at the District Level in Ghana, Malawi, and Tanzania

Ann Meier
Department of Sociology • University of Minnesota • Twin Cities

Rachel Sullivan Robinson
School of International Service • American University • Washington, DC

Jenny Trinitapoli
Department of Sociology • Pennsylvania State University • State College

Abstract There is more variation in health outcomes within countries than between them, yet major studies of life expectancy, maternal mortality, and infant mortality persistently analyze outcomes at the national level. At the same time, research conducted at the individual level of analysis often fails to take into account the characteristics of populations and places that influence the spread of communicable and parasitic diseases. In order to address both these shortcomings, this paper uses unique data measured at the *district* level along with geographically weighted regression and exploratory spatial data analysis techniques to model the social, physical, and built environmental determinants of mortality outcomes in Ghana, Malawi, and Tanzania. Such a strategy makes it possible to identify the drivers of good, as well as poor, health at the level of analysis most conducive to programmatic interventions.

Introduction & Background

Sub-Saharan Africa suffers the highest disease burden in the world, much of it due to HIV/AIDS, maternal causes, and diseases afflicting infant and children (World Health Organization 2008). There are, however, healthy and unhealthy localities: places that can offer important insights for researchers and policy makers. Our approach adapts a distinguished tradition within the fertility literature to the study of population health—that understanding differences within, not just between, countries will substantially improve understanding of the processes that produce good or poor health as well as the influences of local contexts on these processes.

As a pilot for a larger project looking at health outcomes across 42 sub-Saharan African countries, this paper will analyze data at the district level from Ghana, Malawi, and Tanzania. We integrate a variety of measures to create a rich data set capturing mortality outcomes—life expectancy, maternal mortality, and infant mortality—and key indicators of the social, physical, and built environment, such as breastfeeding norms, rainfall, and health infrastructure.

A wealth of cross-national research on health inequalities focuses on nation states, asking why some have better population health than others (Caldwell 1986; Edwards 2011; Firebaugh and Goesling 2004; Kuhn 2010; Lopez et al. 2006; Murray and Lopez 1999). These studies find that with the exception of sub-Saharan Africa (Firebaugh and Goesling 2004; Wilson 2001), life expectancy is rising and health inequality declining, leading to a demographic convergence. Life expectancy in sub-Saharan Africa actually worsened in the 1990s (Timaeus and Jasseh 2004): this, coupled with the continent's faster-than-average rate of population growth, arrested an otherwise positive global trend toward lower levels of health inequality. Despite these troubling trends, Kuhn (2010) showed that four of 11 countries with the best infant mortality trajectories over the past 25 years were in sub-Saharan Africa. Thus while the world's poor health is concentrated on the sub-continent, healthy pockets exist, warranting a thorough investigation of mortality outcomes just in sub-Saharan Africa.

Scholars increasingly recognize that within-country variation in health accounts for most of world health inequality—substantially more than the oft discussed national differences (Pradhan, Sahn and Younger 2003). The literature on health inequality has followed the scholarship on income inequality, but with some very different conclusions: two-thirds of global health inequality exists within countries, while only one-quarter of global income inequality exists within countries (Firebaugh 2000; Milanovic 1999). Notably, Pradhan and colleagues (2003) report that four of the six countries with the greatest intra-country health inequality are in sub-Saharan Africa—Chad, Zimbabwe, Nigeria, and Mali—but they neither discuss the spatial dimensions of within-country variation nor specify the contexts that produce it.

For those who study health outcomes within countries, the primary strategies have either been to use individual-level data, or to situate individual-level data within particular contexts and build multi-level models. While our approach most closely resembles the latter, it takes the view that health is an attribute of place, and one that is not necessarily mediated by individual behavior, an approach that echoes recent findings from the literature. In a study of the influence of context on HIV outcomes, Feldacker et al. (2011) found that characteristics of

place, such as income inequality and distance from a health clinic within a census enumeration area, substantially and significantly affected an individual's likelihood of being HIV-positive. Notably, vulnerability to HIV infection was independent of individual indicators of risk behavior such as multiple partnerships and condom use, especially for women. Similarly, scholars have noted that features of the physical environment like temperature (Patz et al. 2005) and rainfall (Maccini and Yang 2009) are important health determinants. These and similar micro-level studies represent an important shift towards understanding the role of place in determining health. This perspective offers more general insights into how to conceptualize and analyze population health – not as characteristics of individuals, but of places.

Our emphasis on place hearkens back to the European Fertility Project, which generated critical insights about how diffusion of knowledge, ideas, and values within a country, rather than across national boundaries, facilitated fertility declines in Europe during the 19th century (Coale and Watkins 1986). Important insights in fertility research, both classic and new, come from sub-national studies in India (Guilmoto and Rajan 2001), and Brazil and Mexico (Potter et al. 2010) that feature spatial perspectives, and we expect the same to be the case for insights into mortality. Thus, we utilize a spatial approach at the district level.

Data

The data for this analysis will be compiled from multiple secondary and primary sources as described in Table 1. The secondary sources include those from the World Health Organization (WHO), the Demographic and Health Surveys (DHS), and the Integrated Public Use Microdata Series (IPUMS) International, as well as environmental data from the Moderate Resolution Imaging Spectroradiometer (MODIS). The primary sources include directories of NGOs (the Worldwide Association of NGOs, WANGO), media outlets (the Cooperative Africana Microform Project, CAMP, and www.AllAfrica.com), and donor and government funding sources (e.g., www.AidData.org). There are approximately 300 districts across the three countries, allowing sufficient degrees of freedom to include a number of variables in the regression analyses.

Table 1. Indicators for District-Level Analysis of Mortality Outcomes

Indicator	Source	Indicator	Source
Outcomes		***Social Environment, Cont'd***	
Life expectancy	WHO	**Media coverage of health**	CAMP, AllAfrica.com
Maternal mortality	WHO	**Presence of NGOs**	WANGO
Infant mortality	DHS	**Donor/government funding**	Donors, govs
Social Environment		***Physical Environment***	
Ethnic/religious diversity	DHS	**Elevation**	MODIS, govs
Breast-feeding norms	DHS	**Temperature**	MODIS, govs
Contraceptive access/use	DHS	**Rainfall**	MODIS, govs
Access to antiretrovirals	DHS	***Built Environment***	
Polygamy	DHS	**Proximity to roads**	World Road Statistics
Population density	IPUMS	**Housing infrastructure**	DHS/IPUMS
Population age structure	IPUMS	**Health infrastructure**	DHS, govs
Literacy	IPUMS	**Clinic access**	DHS

Indicators that come from individual-level surveys are geo-coded and will be aggregated to the district level via a number of techniques, including small area estimation (Rao 2003) and geographically weighted descriptive statistics (Fotheringham, Brunsden and Charlton 2002).

Analysis

The analysis is based on exploratory spatial data analysis tools and two advanced spatial analysis techniques: (i) geographically weighted regression to assess and adjust for non-stationarity and (ii) spatial econometrics to address issues of spatial autocorrelation. There will ultimately be three regression-based multivariate analyses, one for each mortality outcome (life expectancy, maternal mortality, and infant mortality), and each will take into account the characteristics of the social, physical, and built environments described in Table 1. Those characteristics of place that are not modifiable (e.g., altitude) will be treated primarily as controls for estimating the true impact of the social (e.g., breast-feeding norms) and built (e.g., clinics, road proximity) environment on mortality outcomes.

The size, geographic complexity and economic structure of sub-national areas and countries in sub-Saharan Africa suggest the need to test for the presence of non-stationarity in the predictors of mortality outcomes. Specifically, when the same stimuli (sets of covariates) provoke a different response in different parts of a district, non-stationarity exists and indicates that there is a diversity of processes taking place in the districts. Geographically weighted regression is an exploratory technique designed to detect non-stationarity (Fotheringham, Brunsden and Charlton 2002) and will provide the basis for all of our subsequent analyses. We will also use Exploratory Spatial Data Analysis and spatial econometric techniques to describe and measure the autocorrelation structure of the spatial data. This information is central for improving model specification because it allows us to incorporate different forms of spatial dependency (both substantive and nuisance) in subsequent analyses.

Conclusions

The analysis in this paper will begin to identify the social, physical and economic circumstances of the healthiest and the least healthy places in sub-Saharan Africa. This will provide an evidentiary basis for interventions to promote the characteristics associated with the healthiest places and eliminate, where possible, factors that exacerbate disease and low life expectancy. In particular, the findings from this paper relate directly to Millennium Development Goals 4 and 5, which cover child and maternal health, respectively. While our findings may complicate policies by indicating place-specific strategies, such targeting can lead to greater efficiencies in utilizing limited public health resources to improve population health.

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