Health Professionals, Population Density, and Adequate Antenatal Care in Nine Sub-Saharan African Countries

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1. Introduction and Background

While sustainable development goals call for at least 4.45 skilled health professionals per 1,000 population (WHO 2016), many sub-Saharan African regions fall below this standard (Physicians for Human Rights 2004). Health professional shortages are a barrier to achieving health goals, such as adequate antenatal care (ANC). A common perception is that health shortages have the greatest impact in rural areas, but data limitations are a barrier to empirical testing, and WHO's per capita measure does not consider population density. More health professionals per capita may be needed in rural areas, due to distance between people and communities. We hypothesize that 1) more health professionals per capita will be associated with a greater likelihood of women receiving adequate ANC, and 2) this effect will be significantly smaller in low-density, compared to high-density, areas within African countries.

We used nationally representative health survey data on ANC for children under five, taken from IPUMS DHS (www.idhsdata.org; Boyle et al. 2017), coupled with corresponding close-in-time census data on health professionals per capita (using census microdata samples from IPUMS International) and Gridded Population of the World (GPW) data on population density. Adequate antenatal care was defined as: 1) having first antenatal care visit in the first trimester and 2) having at least four visits in total. Children who had experienced this level of antenatal attention were coded as one; all others, including children receiving no ANC were coded as zero. The DHS data were linked to the other sources using GIS information on the location of sample clusters, providing estimates of health professional availability at the second administrative level and population density within a 10-kilometer radius. The analysis includes Cameroon, Ghana, Malawi, Mali, Mozambique, Nigeria, Rwanda, Uganda, and Zambia (N= 63,787).

2. Our Measures for Social Contexts

Health Professionals per Capita at a Sub-national Level

This paper considers evidence to evaluate whether higher health professional availability in a given social context is linked to better ANC health outcomes. Further, we seek to move the analysis to consider sub-national units, as national statistics might mask heterogeneities and large inequities in healthcare availability within a country.

Towards that goal, we use the census' detailed occupation variable and the occupation type variable in IPUMS International to identify health professionals. A person is counted as a "health professional" when two conditions are met. First, their occupation must be in the medicine or health areas.[4] Second, their occupation must be classified as "professional," to distinguish them from other health workers that are less specialized, such as *mbusas*. We then calculate the (weighted) number of health professional per 1,000 population at the second administrative level. This indicator is broader than medical doctors, as it includes professional nurses, midwives, and other health professionals who can make a positive impact on women's health.

As a simple validation, we compare our aggregations at the national level with data from a different source, namely the Global Health Workforce Statistics (GHO), a database

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[4] When possible, we do not include "veterinarian" in our definition of health professionals.

developed and maintained by the World Health Organization (WHO). Note that the two sources of data are not directly comparable, as GHO uses a slightly different definition of the health workforce that is based on different aspects the healthcare systems rather than on professional skills.[5] Nevertheless, as shown in Figure 1, our aggregation method shows similar patterns to GHO data at the national level. For instance, among the nine countries, Ghana has the highest number in both GHO health care workforce per 1,000 and in IPUMS-International aggregated health professionals per 1,000. The correlation between the two measures is 0.73.

---FIGURE 1 ABOUT HERE---

A major advantage of our aggregation method is that it is possible to go into sub-national unit. We are able to get to level-2 geographic units in most countries, which give some approximation to the actual lived context of pregnant women and small children. While national level of health professionals per 1,000 in nine Sub-Saharan African countries are well below the SDG suggested levels (4.45 health workers per 1,000), Figure 2 shows that there are some outliers among the level-2 geographic units.

---FIGURE 2 ABOUT HERE---

Two Measures for Urbanization

Existing research on maternal health in developing countries general suggest that women residing in urban areas tend to have better access to health care services and better health outcomes (e.g., see Kyei et al 2012). This difference is due to the disproportionate distribution of health facilities in urban areas, compared to rural areas (Chama-Chiliba and Koch 2013). Recent outreach efforts to provide mobile maternity services, however, have been more active in rural areas, which are helping to erase the rural-urban disparity in maternal health (Banda et al. 2012).

In this paper, we seek to provide more nuance to the rural-urban disparity in healthcare access by examining potential variations among urban and rural areas. We start with the observation that, at least among the nine Sub-Saharan African countries in question, urban areas tend to be defined around administrative units (such as cities or townships). Table 1 provide a detail list of urban definitions across nine countries.

---TABLE 1 ABOUT HERE---

A potential pitfall of this definition of "urban" is that it does not capture exactly the social context that pregnant women and their children reside in. For instance, one can live at the fringe of a city, with little or no connection to the city's center where healthcare providers are concentrated. Thus, an urban residence might not correlate with potentially better access to healthcare.

To consider the impact of this pitfall, we use an alternative definition of urbanization that is based on population density. Our data measures the population density (persons per square kilometer) within a 5-kilometer circular buffer around each DHS cluster location, in the survey year. In our models, we consider whether those living in more urban location (higher population density) experience better ANC outcomes.

3. Preliminary Results

We display preliminary results in Table 2. The results are generated using logistic regression models with DHS weights. Variables of interests are urban status, population density, and health professionals per 1,000. Our control variables include mother's age, marital status, education level, household wealth quintile, whether child is the first-born, and fixed country-

[5] For more details on GHO's definition of the health workforce, please see http://www.who.int/hrh/statistics/TechnicalNotes.pdf?ua=1

year effect. As evidenced in all four models, more health professionals per 1,000 is associated with better ANC outcomes, such that one additional professionals per 1,000 will lead to a 3.6% increases in the odds of adequate ANC. Variables for urban status and population density do not have a statistically significant relationship with adequate ANC, as shown in Model 1-3.

In Model 4, we interact the two measures and observe an interesting relationship, such that the interaction between urban and population density is positive, while the coefficient for urban residence becomes negative. This means women residing in urban places with extremely low population density have lower probability of adequate ANC care; and that an increase in population density is only beneficial for adequate ANC care of the location is urban (versus rural).

4. Discussions and Next Steps

The preliminary results suggest that there are complexity between the urban classification of a location and its population density. In the coming months, we plan to perform additional analysis and potentially apply thresholds to help understanding the relationship between urbanization and adequate ANC. Further, we will also implement three-way interactions to examine whether and how the presence of health professionals per 1,000 has varying impact in each type of social contexts. The results from our analysis will be crucial in updating current knowledge on health inequities in Sub-Saharan Africa. At the same time, our attention to the sub-national units could help envisioning more locally-relevant efforts to develop local healthcare facilities and workforces in these countries.

Key References[6]

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TABLE 1. Definitions of "Urban" across nine DHS samples of Sub-Saharan African countries

Country	Definition of "Urban"
Cameroon	An entity that either has an administrative function (i.e., headquarters of a district, sub-division, division, or province), or has a population of at least 5,000 inhabitants and the following socioeconomic and administrative facilities: a complete primary school, a developed health center, water supply and electricity facilities, and a daily market.
Ghana	Localities with 5,000 or more inhabitants
Malawi	All townships, town planning areas, and district centers
Mali	Localities with 40,000 or more inhabitants
Mozambique	23 cities and 68 towns/vilas
Nigeria	Towns with 20,000 or more inhabitants whose main occupations are primarily non-agricultural
Rwanda	All districts/townships in Kigali Ville (capital); Administrative centers of prefectures and their important agglomerations with their surroundings
Uganda	Gazetted cities, municipalities and towns with 2,000 or more inhabitants
Zambia	Localities of 5,000 or more inhabitants with a majority of the labor force engaged in non-agricultural activities

[6] A complete bibliography can be made available by the authors upon request

TABLE 2. Logistic regressions predicting the odds of adequate antenatal care, all 9 DHS samples

	Model 1	Model 2	Model 3	Model 4
Urban (Yes/No)	0.990		0.985	0.753*
	(0.041)		(0.044)	(0.088)
Population density (logged)		1.002	1.003	0.972
		(0.011)	(0.012)	(0.017)
Urban x Pop. Density				1.052*
				(0.022)
Health professionals per 1,000	1.036**	1.035*	1.035*	1.030*
	(0.014)	(0.015)	(0.015)	(0.015)
Observations	63,705	63,705	63,705	63,705

Notes: Models controlled for mother's age, marital status, education level, household wealth quintile, whether child is the first-born, and fixed country-year effect; Coefficients are exponentiated; Robust SE in parentheses; * p<0.05 **p<0.01 ***p<0.001

FIGURE 1. Comparing national estimates of health professionals per 1,000 using IPUMS-I and using the Global Health Workforce Statistics (GHO)

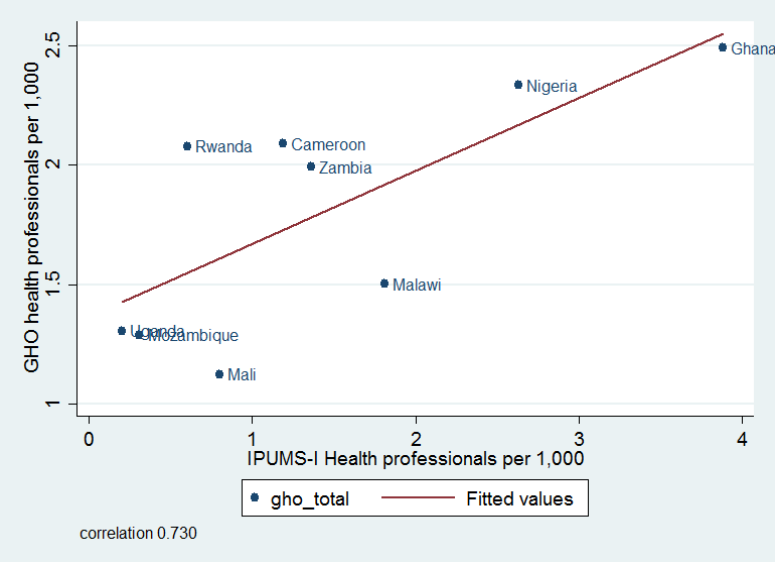

FIGURE 2. Health professionals per 1,000 across level-2 geographic units in nine Sub-Saharan African countries