The impact of health workers on health outcome across sub-national units in South Africa

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ABSTRACT

The achievement of internationally agreed health development targets such as those in the Millennium Declaration depend very much on health system performance, specially on the size, skills, and commitment of health workers. A number of cross-national studies have demonstrated this positive association between health worker densities and maternal and child heath service coverage and outcome. However, the evidence-base at sub-national level remains still limited, despite the uneven distribution of health workers within national boundaries. Using data from the South African 2001 Population and Housing Census and a *stochastic production frontie*r model, we show the extent to which sub-national variations in population health are correlated with health workers availability across sub-national units. The analysis also highlights how socio-economic conditions of the population moderate the ability of health workers to perform their tasks efficiently.

Introduction

The publication of the *World Health Report 2006: Working Together for Health (WHR)* has brought renewed attention to the importance of health system performance, particularly of health workers, for the achievement of national and international health targets (WHO 2006). The report estimated that 57 countries, 37 of which are in sub-Saharan Africa, have an absolute shortage of 2.3 million physicians, nurses and midwives. These shortages suggest that many countries do not have sufficient health professionals to deliver essential health interventions, such as skilled attendance at birth and immunization programmes that are critical for the achievement of internationally agreed health development targets such as those in the Millennium Declaration.

The findings of the 2006 WHR are consistent with earlier studies that showed strong statistical association between health worker density, defined as number of health workers per 1000 population, and health status and intervention coverage Chen et al. (2004) and Anand & Bärninghausen (2004, 2006). These studies are, however, based on cross-national data, and, thus, are not specific enough to guide policy makers in low-income and middle-income countries who are constantly challenged by the double burden of absolute shortages and uneven distribution of health workers within their national boundaries (Gupta et al., 2003a; Gupta et al., 2003b). In this paper, using sub-national data from routine health information system and a national census, I show the extent to which variations in child mortality across districts are correlated with health workers densities in South Africa. The analysis also highlights how socio-economic conditions of the population moderate the ability of health workers to perform their tasks efficiently.

The health care system in South Africa

Prior to the political transition in 1994, there was hardly an integrated national health system in South Africa. However, after the transition, a 3-tiered health system, consisting of national, provincial and district level administration of health care services, begun to be implemented. In this approach, emphasis is placed on primary health care, with the district health system serving as the primary unit of management of district hospital services and delivery of comprehensive primary health care.

Currently, there are 54 specialized hospitals, 9 national central hospitals, 6 provinicial hospitals, about 70 regional hospitals, over 250 district hospitals in the country (Barron et al., 2006: 206-207). District hospitals provide a wide range of curative and emergency services, including surgical and obstetrical care, as well as primary health care. There are also some 3000 community health centers and clinics in South Africa. These clinics provide routine obstetric care as well as a range of primary health care services. All emergencies or any other conditions that are beyond the capacity of the clinics are referred to the district hospital, although the clinics are visited regularly by doctors from the hospital. In parts of districts that are not serviced by fixed clinics, about 1000 mobile health units operating the country provide care to the population at defined visiting points on a 2-4 weekly basis. The level and range of services offered by the mobile units are similar to those offered at the fixed clinics, though they do not offer obstetric delivery services or any other forms of treatment or care that require short-term stay or admission. In addition, community health workers (CHW) are also present in the area.

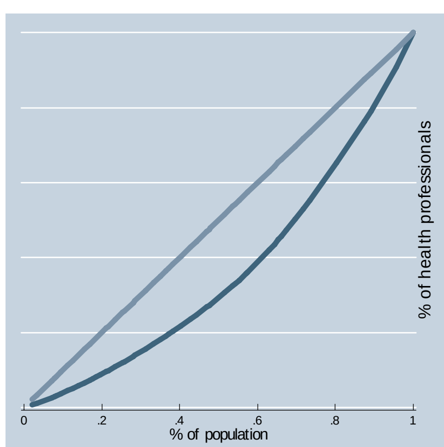

Figure 1: Uneven distribution of health workers: Lorenz Curve, South Africa: 2001

According to the latest census of the country conducted in 2001, over 42 thousand health professionals, about 26 thousand Nursing and Midwifery professionals, and close to 150 thousand associate health professionals are currently active in South Africa. Geographical inequalities in the distribution of health workers is often reflected in urban concentration and rural deficits. South Africa is no exception. The distance between the Lorenz curve and the equality line in Figure 1, clearly demonstrates the uneven distribution of health workers across districts in South Africa. Some districts Sekhukhune Cross Boundary, Alfred Nzo and OR. Tambo have fewer than 20 health workers per 10000 inhabitants, compared to Tshwane Metropolitan Municipality which has a density of over 102 health workers per 10000. These inequalities in availability of health workers are anticipated to have direct impact on health outcome.

Data and method

The goal of the present study is to examine the extent to which sub-national variations in mortality and diarrhoea incidence among under five children are related to variations in availability of health workers across districts in the country. To do so, a dataset of health inputs and outputs at district level were complied for the year 2001 from two separate sources. The first source was the 2001 National Population Census, which, among others, collected detailed data on household social and economic characteristics and child survival in the population. From these, three input indicators—namely: average household income, female literacy status, and number of health workers, and one of the output indicator—child mortality—were extracted.

The Census identifies five groups or categories of health workers matching with the International Standard Classification of Occupations (ISCO) at three-digit code level and the four categories of industry related to the health sector (as per the International Standard Industry Classification, ISIC). These include health professionals (excluding Nursing and Midwifery), nursing and midwifery professionals, modern associate health professionals, nursing and midwifery professionals and traditional healers. For the purpose of analysis only the first four groups were retained. To this, we added three more health input variables—number of ambulatory units (i.e. health facilities for outpatient care), per capita public health expenditure, and access to pipe water— and information on diarrhoea incidence obtained from routine health system information database (Barron et al., 2006: 206-207).

Using a stochastic production frontier model, the output variable, q_i, is, then, modeled as a function of a vector of inputs x_i for the i^{th} district $q_i=f(x_i)$ (Aigner, Lovell and Schmidt, 1977: 21-37; Meeusen and van den Broeck, 1977: 435-444; Coelli, Rao and Battese, 1998; Kumbhakar and Lovell's 2000; Jacobs, Smith and Street, 2006). The x_i vector of inputs is composed of health professional density (HP_i), Nursing and Midwifery Professionals

(NMP_i), public health expenditure per capita HE_i, and ambulatory units AU_i. Following Kumbhakar and Lovell's (2000) the model can be expressed as:

$$q_i = f\left(HW_i, HE_i, AU_i; \beta\right) \cdot \exp\{v_i\} \cdot TE_i \quad (1)$$

where [f(HWi, HEi, AUi; β)*exp(vi)] is the stochastic production frontier. The stochastic production frontier consists of two parts: a deterministic part, common to all producers f (HPi, NMP_i, HEi, AUi; β); and a producer-specific part exp(vi), which captures the effect of random shocks on each producer. The ratio of the observed output for the i-th district, qi , relative to the potential out put, defined by the frontier function, given the input vector, xi , provides the technical efficiency (TE) measure (Coelli, Rao and Battese, 1998: 184). Algebraically, this is given by:

$$TE_I = \frac{q_i}{f(HP, NMP, HE, AU,; \beta).\exp\{v_i\}}$$

As an out-put oriented Farrell measure the TE takes a value between zero and one. The maximum out put is that produced by a fully efficient district using the same input vector. A technical efficiency estimate that is below unity, TEi<1, provides a measure of shortfall of observed output from maximum feasible output in an environment characterized by exp(vi), which is allowed to vary across producers. Note that districts are in our case producers, and under five mortality represents their output.

Assuming a log-linear Cobb–Douglas function, which is the most common functional form in efficiency analysis, our stochastic production frontier model reduces to the following:

$$\ln q_i = \beta_0 + \beta_1 \ln THW + \beta_2 \ln AU + \beta_3 \ln HE + v_i - u_i \quad (3)$$

The coffeicent $\beta_1$represents the average relationship between health professionals and the two outcome variables, q_i . In the model, the noise component v_i – random shocks – is assumed to follow a normal distribution $N\left(0, \sigma_u^2\right)$,where as u_i , the nonnegative technical inefficiency component of the error term, is assumed to follow a truncated normal distribution $N^+\left(\mu, \sigma_u^2\right)$. The error term is defined as $\varepsilon_i = v_i - u_i$, and V_i is distributed independently of u_i. The results of these analyses are presented in the following section.

Results

Two production function models were run. In the first, diarrhoea incidence under 5 years was modeled as a function of density of health professionals, density of nursing and midwifery professional, number of ambulatory units and per capita public health expenditure. In the second, the same explanatory variables were regressed against under five mortality. In both models, the efficiency of these health system inputs was assumed to be moderated by female literacy, per capita annual income, and availability of piped water. Table 1 and Table 2 presents these results, respectively.

Table 1: Sub-national stochastic frontier model: Impact of health system inputs on diarrohea incidence

	Coef.	Std. Err.	z	P>|z|	95% Conf.	
Diarrhoea incidence under 5 years						
HW (Health professionals per 10000)	-2.155	0.738	-2.920	0.003	-3.601	-0.709
HW (Nursing & midwifery professionals per 10000)	0.958	0.742	1.290	0.197	-0.497	2.414
Ambulatory units (per 10000)	-2.141	0.464	-4.620	0.000	-3.050	-1.232
Puplic health expenditure	2.361	0.743	3.180	0.001	0.905	3.816
Constant	-37.615	7.615	-4.940	0.000	-52.540	-22.690
lnsig2v						
Constant	0.365	0.235	1.550	0.120	-0.096	0.826
lnsig2u						
Percapita annual income	3.6784	2.5937	1.4200	0.1560	-1.4053	8.7620
Female literacy	23.9271	21.4765	1.1100	0.2650	-18.1661	66.0203
Access to pipe water	13.1919	9.5877	-1.3800	0.1690	-31.9834	5.5996
Constant	82.7893	73.9303	-1.1200	0.2630	-227.6901	62.1114
sigma_v	1.2003	0.1411			0.9533	1.5112
Log likelihoo	-89.074314			Prob	> chi2 =	0

Table 2: Sub-national stochastic frontier model: Impact of health system inputs on under 5 mortality

	Coef.	Std. Err.	z	P>|z|	95% Conf.	
Under five mortality						
HW (Health professionals per 10000)	-0.0181	0.0067	-2.6800	0.0070	-0.0313	-0.0049
HW (Nursing & midwifery professionals per 10000)	-0.0087	0.0067	-1.3100	0.1920	-0.0218	0.0044
Ambulatory units (per 10000)	-0.0111	0.0031	-3.6000	0.0000	-0.0171	-0.0050
Puplic health expenditure	0.0052	0.0058	0.9000	0.3670	-0.0061	0.0165
Constant	-0.2897	0.0619	-4.6800	0.0000	-0.4110	-0.1684
lnsig2v						
Constant	-9.2887	0.2133	-43.5500	0.0000	-9.7067	-8.8707
lnsig2u						
Percapita annual income	9.1531	6.3515	-1.4400	0.1500	-21.6019	3.2957
Female literacy	6.8417	10.5132	-0.6500	0.5150	-27.4472	13.7638
Access to pipe water	6.2858	3.5822	1.7500	0.0790	-0.7353	13.3068
Constant	70.4762	42.2273	1.6700	0.0950	-12.2878	153.2401
sigma_v	0.0096	0.0010			0.0078	0.0119
Log likelihoo	167.60477			Prob	> chi2 =	0

Source: Authors` calculation.

Table 1 shows the relationship between diarrhoea incidence among under 5 children and health system variables at sub-national level, controlling for female education, percapita annual income and waetr supply. The coefficients in the model represent elasticities. The result shows that health professional density and ambulatory units are significant related to low incidence of diarrhoea. A 1% increase in total health worker density is associated with a 2.2 per cent decline in diarrhoea incidence among under 5 children. A similar magnitude of effect is also evident for presence of ambulatory units. Interesting, the relationship between public health expenditure and coverage is positive, which may suggest that government health expenditure is more directed to districts with significant health risks. All the coefficients of the covariates of inefficiency—female education, income ad access to piped water—had the expected signs, but were all insignificant.

The results for under five mortality presented in Table 2 mirror a similar relationship. Health professional density and ambulatory units contain to maintain significant impact on the outcome variable.

Concluding remark

There are great inequalities in the distribution of health workers across districts in South Africa. Applying a stochastic frontier model on sub-national data, we have, for the first time, sought to examine the impact that such variations have on two sets of child health outcome: mortality and diarrhoea incidence among under five children. The stochastic frontier model chosen for the analysis separates inputs to the production process from the determinants of efficiency. Two primary inputs were examined: labour – represented by total number of health workers available per 1000 population – and capital – represented by the number of ambulatory units. Health expenditure per capita was also incorporated as an input on the assumption that it incorporates other types of inputs to the production process.

The density of health professionals and number of ambulatory units have a statistically significant, positive correlation with both mortality and diarrhoea incidence among under five children. But we found no relationship between nurse and midwifery professionals and the outcome of interest. This was contrary to our expectations, because this category of health worker is composed largely of primary health workers, specifically trained to deliver basic care interventions such as many of those undertaken for antenatal care visits. All the coefficients of the covariates of inefficiency—female education, income ad access to piped water—had the expected signs, but were all insignificant.

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