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**The Shortage of Medical Workers in  
Sub-Saharan Africa and Substitution Policy**

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# The Shortage of Medical Workers in Sub-Saharan Africa and Substitution Policy

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## Abstract

Substitution policies are strategies sometimes chosen in Sub-Saharan Africa for cur-tailing the shortage of health professionals especially caused by the outflow of medical personnel. The aim of our contribution is to propose a way to assess the merits and drawbacks of substitution policies by developing a simple growth model of healthcare productivity with medical brain drain. Within this framework, we use a medical care production function of the CES type which aggregates low and high specialized health workers. We then run simulations which compare scenarios with and without substitution strategies by using data from the Ghana's medical sector.

Keywords: Medical shortage, healthcare policy, substitution policy.

JEL Classification: I18, F220.

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# 1 Introduction

The wide importance of health professionals shortage in developing countries<sup>1</sup>, which is aggravated by a dramatic emigration flow, is well documented. The medical brain drain in particular from Sub-Saharan Africa, has been addressed in several recent studies (by international organizations like WHO (2006), Awases et al.( 2004), OECD ( 2004), and public health policy publications, in general). The number of physicians trained in Sub-Saharan Africa (SSA) who work in OECD countries allow to calculate a rate of outflow which is alarming for some countries<sup>2</sup>: 27% for South Africa, 22% for Ghana and 14% for Uganda (WHO, 2006). For all SSA countries, these figures are indicative of an increase of what is referred to as medical brain drain (9% in 1991, and 12% in 2003) (Bhargava, Docquier, 2006), which particularly affects the Anglophone and Portuguese-speaking countries. Clemens and Petterson (2008) have expanded the definition of medical brain drain to cover medical personnel born in Africa, no matter where they were trained. In this case, the percentage of doctors born in Africa who are practicing in nine different host countries was, on average, 24% for the SSA countries in 2000. Moreover, a recent study which involved doctors located in six different SSA countries also revealed that they had very pronounced intentions of emigrating, from 26% in Uganda, up to 68% in Zimbabwe<sup>3</sup> (Awases, et al., 2004). This human capital outflows<sup>4</sup> do not constitute the only difficulty found with African health care systems, but it is certainly a considerable handicap for countries with limited resources, which are confronted with the challenges associated with big pandemic (Chen, Boufford, 2005).

Among the strategies which are proposed and sometimes undertaken to curtail the shortage of health professionals especially caused by the medical brain drain, some are strongly

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<sup>1</sup>According OMS (2006, p. 12), the 57 countries that fall below a minimal threshold and which fail to attain the 80% coverage level are defined as having a critical shortage. 36 of them are in Sub-Saharan Africa. The average ratio of physicians per 100,000 people in SSA is 15.5 compared to an average of 311 in nine selected industrialized countries.

<sup>2</sup>Report: doctors practicing abroad/(doctors practicing abroad + doctors remaining in their country of origin)

<sup>3</sup>Percentage of doctors indicating an intention to emigrate in 2002: Zimbabwe: 68%; Ghana: 62%; South Africa: 58%; Cameroon: 49%; Senegal: 38%; Uganda:26% (Awases et al., 2004)

<sup>4</sup>The reasons for this kind of brain drain are well documented in public health literature. In order of decreasing importance, these are: low remuneration, insecurity, lack of medical equipment, lack of promotions, and a search for training which is more advanced.... As far as host countries are concerned, the attraction factors are well-known: the aging of the medical corps (doctors and nurses), a quantitative insufficiency in training efforts as opposed to an increased demand for care, selective immigration policies, and active recruitment, targeted by specialized agencies (Awases, et al. 2004, WHO, 2006, Saravia, Miranda, 2004).

dependent on budgetary resources like: increasing qualified medical personnel's health worker's remuneration, providing bonuses to emigrated doctors if they return, improving medical personnel's living and working conditions, and directing aid towards development in the area of medical personnel training. On the other hand, some policies are more structural or regulatory in nature. Coercive measures have been decided like the obligation to reimburse educational expenses in the event that one's emigration proves to be ineffective (Mensah, et al., 2005) and recently, certain host countries introduced codes of good practice (Martineau, et al., 2004, Scott, et al., 2004, Pagett, C., Padarath, A., 2007).

Another proposed solution concerns policies designed to increase substitutability between high qualified professionals with lower qualified personnel (Dovlo, D., 2004). These strategies are aimed at making high and/or low skilled workers more polyvalent and thus contribute to reducing the skill gap between different types of health professionals. Dolvo (2004) distinguishes between two types of substitution.

*Direct substitution* consists of creating new qualified medical personnel who are less specialized than doctors but who deliver many services usually reserved for physicians. These new qualifications need in general two to three years of training rather than five years in medical school. (Buchan, Dal Poz, 2002). This policy is not new in Africa and in the case of certain countries dates back to the elaboration of post-colonial health policies (Martineau, et al., 2004). The organization of direct substitution has been documented by Ghana and several eastern and southern African countries (Dolvo, 2004). The designation differs from one country to another: clinical officer in Tanzania, Kenya and Zambia; medical assistant in Malawi, Mozambique and Ghana. But the principle is based upon a general, shorter kind of medical training, accompanied by a specialty, for example, anesthesia, ophthalmology, orthopedics, reproductive medicine, general medicine, etc.

*Indirect substitution* (or delegation) doesn't necessarily generate a specific training policy. The principle consists of the authorization of workers with weaker qualifications, or who are less specialized in terms of carrying out duties or tasks which normally would not be attributed to them. The most common instance is that of nurses taking over tasks which have traditionally been the responsibility of doctors, in the developing countries, as well as in the northern countries. The recent reforms by the British National Health System (NHS) introduced two extensions (in 2002 and 2003) of the scope of nursing duties in relation to medical prescriptions<sup>5</sup> (Courtenay, Maynard, 2005). The nurses involved must have under-

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<sup>5</sup>Independent extended prescribing in 2002; Supplementary prescribing in 2003 (Department of health, Lon-

gone a short training (3-6 months) and be experienced. Along these lines, a substitution of nurses for carrying out doctors' tasks has been arranged in a certain number of southern African countries: Botswana, Tanzania, Zambia, Malawi (Padarath, et al., 2003). Dolvo (2004) mentions training in Ghana which has been created for nurses who work in a rural environment and who are required to carry out the same tasks which a doctor would. Still, in Ghana, a second form of delegating is at work, in this case between specialist and general physicians. The West Africa Post-Graduate College offers 18-month specialised courses for generalist doctors so that substitution may be allowed.

Substitution policies might also reduce the emigration of high qualified medical professionals since more substitutable health workers will have more locally specific qualifications, which are less valuable in the international medical jobs market<sup>6</sup> (Martineau, 2004, Dolvo, 2004). The negative relationship between substitution and the outflow of medical personnel (doctors) might also be deduced by the general observation of a lower emigration rate (between two and four times lower) for SSA nurses than for physicians (WHO, 2006).

Substitution policies have raised questions about their effectiveness in terms of healthcare productivity. Evaluation studies which have been undertaken to justify the implementation of substitution policies are poorly conclusive. Chopra et al.(2008) carried out a systematic review of experiences realized over the past ten years which are concerned with the improvement in human resource management in relation to health policy among which substitution measures appear high on the list. The authors did not find studies about substitution experiences which resulted in an increase in neonatal infections, complications or mortality. However, they do insist on the fact that these analysis are almost not concerned with developing countries. Health economists (Richardson, et al., 1998, Maynard, 2006) have been very critical regarding available evaluations of substitution experiments, since these studies are based on simple case studies and the use of very small samples. Concerning Sub-Saharan Africa, Awases (2004, p. 58) notices however that “ Cameroon and Senegal reported (...) reasons for the decline in quality of health care, including that of non-qualified personnel performing duties that are normally beyond their scope of practice, such as a nurse functioning as a medical doctor.”

The aim of our contribution is to propose a way to assess the merits and drawbacks of  
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<sup>6</sup>According to Hongoro and McPake (2004, p. 1451) “Auxiliary cadres are often less employable abroad, especially if the qualifications involved do not easily translate into those used in the developed world, such as medical assistant or clinical officer.”

substitution policies by developing a simple growth model of healthcare productivity with medical brain drain. Within this framework, we use a medical care production function of the CES type which aggregates different kinds of skills (low and high specialized health workers). In the present paper, we treat the choice of the substitution degree (which may vary from strict complementarity to perfect substitution) between both skills as a policy issue. Accordingly, we examine two opposite scenarios. One in with a substitution policy is designed to narrow the skills gap between different healthcare specialities and another without public intervention. The first scenario will reduce skills specialization (and increase skills substitution) and may also decrease the emigration rate of high skilled personnel. To study the differential impact of both strategies on the dynamics of healthcare productivity, we calibrate our model to available data from a Sub-Saharan African country like Ghana.

It appears that in the case of Ghana emigration of health professionals accentuates the relative scarcity of the higher qualified. The absence of a substitution strategy will eventually lead to a productivity collapse in healthcare services. On the other hand a substitution policy weakens complementarity between both types of health workers and thus reduces in the short run productivity gains from skills specialization. Since there is no strategy that uniformly dominates the other, substitution policy assessments can hardly be achieved without having some idea about the time preference of policy makers. Finally, this problem of intertemporal choice persists, though at a lower extent, even if a substitution strategy could completely eliminate the emigration of physicians.

## 2 The Model

We introduce a health care production function which integrates two types of skilled medical workers: higher qualified health personnel ( $R$ ) and lower skilled personnel ( $U$ ). The first category may be represented by physicians and the second by graduated nurses. We consider that both types of professionals are prone to emigrate.

Denote the emigration flow of higher and lower skilled personnel respectively by  $E_R$  and  $E_N$ . Accordingly, we assume that the proportion of emigrants of each type are respectively  $\xi_R$  ( $\xi_R = E_R/R$ ) and  $\xi_N$  ( $\xi_N = E_N/N$ ). The growth rates of higher and lower skilled professionals who are trained by the domestic education system are exogenously given by  $g$  and  $n$ . The law of motion of higher and lower skilled workers who remain in their country

of origin are successively

$$\begin{aligned}\dot{R} &= gR - E, \\ \dot{U} &= nU - E.\end{aligned}$$

It follows that the growth rates of medical professionals who do not emigrate are

$$r = \frac{\dot{R}}{R} = g - \xi_R, \quad (1)$$

$$u = \frac{\dot{U}}{U} = n - \xi_N. \quad (2)$$

Assume that the (medical) labor input is a synthetic measure of higher and lower skilled personnel given by following CES function:

$$L = [bR^{-\beta} + (1-b)U^{-\beta}]^{-\frac{1}{\beta}}, \quad -1 < \beta < \infty. \quad (3)$$

Following de la Grandville (1989), we normalize the parameter  $b$  for given initial values of  $R_0$  and  $U_0$  and assume that  $R_0 < U_0$ . We obtain following value:

$$b = \frac{\rho_0^{1+\beta}}{\rho_0^{1+\beta} + \mu_0}, \quad (4)$$

where  $\rho_0 = \frac{R_0}{U_0}$  and  $\mu_0 = \frac{w_{U(0)}}{w_{R(0)}}$  the initial wage ratio of both skill types.

Denote the elasticity of substitution between high skilled and less skilled by  $\sigma = \frac{1}{1+\beta}$ . The labor force index  $L$  that combines  $R$  and  $U$  is able to grasp the full range of substitution degrees starting from strict complementarity ( $\sigma = 0$  or  $\beta \rightarrow \infty$ ) to perfect substitution ( $\sigma \rightarrow \infty$  or  $\beta = -1$ ). Notice that in the second case both labor-types are additive since they are perfectly interchangeable.

Since we are also interested in the impact of complementarity on the emigration rate of the higher skilled we will assume that the emigration rate  $\xi$  decreases with the degree of labour substitution. So we write that  $\xi_R(\sigma)$  with  $\xi'_R(\sigma) < 0$  or  $\xi'_R(\beta) > 0$ .

The health-care output function may be given as follows:

$$Y = F(K, AL) = K^\alpha (AL)^{1-\alpha}, \quad 0 < \alpha < 1. \quad (5)$$

The health care output ( $Y$ ) is produced with a Cobb-Douglas technology which embeds a synthetic measure of health labor  $L$  that is combined with a stock of capital ( $K$ ) used

in the health sector.  $A$  is a technology parameter. Technological change is described by  $A(t) = A(0)e^{g_A t}$ , where  $g_A \geq 0$  is an exogenous growth rate. In order to focus on the impact of available health labor forces we assume that  $A$  is given ( $g_A = 0$ ) and normalized to 1. Since  $0 < \alpha < 1$ , where  $\alpha$  is the share of capital in health care output, the health technologies exhibits constant returns. Let us consider the case where capital is perfectly mobile. We suppose that the international interest rate  $i$  is given and constant over time. Furthermore, we assume that the capital depreciation rate is zero for simplicity. It follows that the health system maximizes net profits for given (administered) health prices. For that sake it equates the marginal product of capital to the international interest rate. We thus get:

$$f' = i, \quad \text{with} \quad k = \frac{K}{L}. \quad (6)$$

Equation (6) is solved for the constant capital-labor ratio  $k = \bar{k} = \left(\frac{\alpha}{i}\right)^{\frac{1}{1-\alpha}}$  and the health care output becomes:

$$Y(t) = f(\bar{k})L(t). \quad (7)$$

The resulting growth rate of health care production becomes:

$$g_Y = g_L.$$

After having calculated the logarithmic derivative of equation (3), it follows

$$g_L = (u - r)(1 - a(t)) + r, \quad \text{with} \quad a(t) = b \left( \frac{R(t)}{L(t)} \right)^{-\beta}. \quad (8)$$

We thus can write following law of motion of labor ratio equation:

$$\dot{a} = -\beta a(t)(r - g_L) \quad (9)$$

which is a standard Bernoulli equation and its general solution is given by (see Pieretti, Zou 2007, 2008)

$$a(t) = \frac{1}{\frac{1-a(0)}{a(0)} e^{\beta(r-u)t} + 1}. \quad (10)$$

Combining equations (8) and (10), it yields the growth rate of aggregated medical labor:

$$g_L(t) = \frac{(1 - a(0)(u - r))e^{\beta(r-u)t}}{(1 - a(0))e^{\beta(r-u)t} + a(0)} + r. \quad (11)$$

Recalling equations (1), (2),(7) and (11), we can write as follows the average labor productivity in the health care sector:

$$\frac{Y(t)}{U(t) + R(t)} = \frac{f(\bar{k})L_0 e^{g_L t}}{U(0)e^{ut} + R(0)e^{rt}}. \quad (12)$$

### 3 Simulations

Equations (11) (12) are useful for studying the impact of a substitution policy on the time pattern of healthcare productivity. For running simulations we calibrate the model using data from the Sub-Saharan African medical sector. More specifically, we focus on the case of Ghana which appears as an important victim of medical brain drain<sup>7</sup> and which was one of the first countries to experience substitution policies.

By using data from various sources, may be extract following key-figures which help calibrating our model to the case of Ghana.

The number of active physicians (or medical officers) estimated by the year 2004 was 3240 according to the World Health Organization (2008) and this number existing by the year 1995 may evaluated at about<sup>8</sup> 2400 according to data from the Ministry of Health, Ghana (2005). Accordingly, the (constant) growth rate of doctors who did not emigrate equals<sup>9</sup>  $r = 0.035$ . Since about 740 (Ministry of Health, Ghana, 2005) doctors emigrated during the period 1995 -2004, the growth rate of annually educated doctors becomes<sup>10</sup>  $g = 0.058$ . It follows that the estimated emigration rate of doctors equals  $\xi_R = 0.023$ .

The situation of nurses for Ghana is grossly depicted by following data. In 1996 there were 12961 (source: World Bank 2004) nurses working in Ghana and in 2004 their number grew to 19707 (WHO, 2008). During the period 1996-2004 about 1700 (source : Ministry of Health, Ghana, 2005) nurses emigrated. As above, simple calculations provide following parameter values  $n = 0.065$ ,  $\xi_U = 0.011$  and  $u = 0.054$ . We further assume following parameter values. (a) The ratio of higher to less qualified personnel measured at an initial date equals  $\rho_0 = \frac{R_0}{N_0} = 0.3$ . This value approximately corresponds to the ratio we would observe by the middle of the seventies if we apply the growth rates calculated above. (b) The international rate of interest is assumed to equal  $i = 0.05$ . (c) The share of capital in general corresponds to  $\alpha = 0.3$  and the saving rate is supposed to be  $s = 0.10$ .

In order to study how a substitution policy may impact the time pattern of healthcare productivity, we consider two alternative situations. First, no substitution policy is assumed,

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<sup>7</sup>According to Dovlo and Nyongator (1999 ) some 60.9% of doctors produced in Ghana between 1985 and 1994 emigrated country, mainly to the United Kingdom and USA.

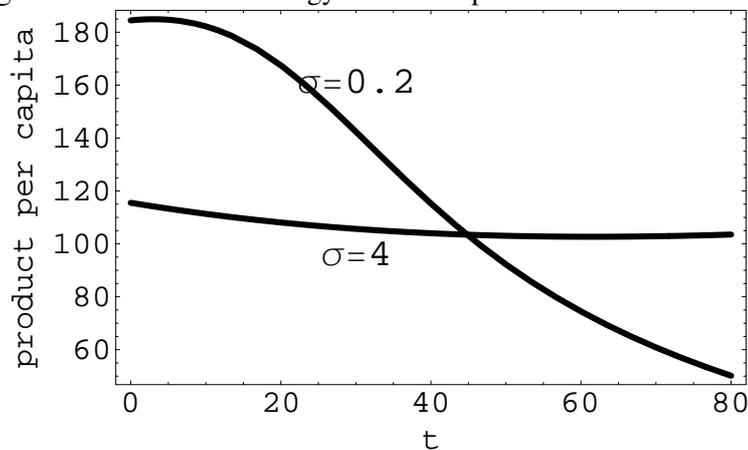
<sup>8</sup>This value is derived from data of the Health Ministry of Ghana (2005) about the annual numbers of trained physicians .

<sup>9</sup>More exactly,  $r = \left(\frac{3240}{2400}\right)^{\frac{1}{9}} - 1 = 0.035$

<sup>10</sup>More exactly,  $g = \left(\frac{3240+740}{2400}\right)^{\frac{1}{9}} = 0.058$ .

and accordingly, healthcare skills will be highly specialized or weakly substitutable (a low elasticity of skills substitution). Then, we assume that the elasticity of substitution between higher and lower skilled healthcare workers may be increased by adequate policy decisions. We already saw (see Introduction) that substitution policies may also be designed to reduce medical brain drain of the higher skilled professionals. Since we are not able to precisely assess the impact on this type of emigration, we consider extreme scenarios. At one extremity, we have perfect effectiveness (the optimistic case) and accordingly the emigration rate of the higher skilled decreases from  $\xi_R$  to 0. On the other hand, there could be no effect at all (the pessimistic case) by assuming that higher skilled personnel continue to emigrate. The consequence would be that the value of the emigration rate remains at  $\xi_R = 0.023$ . In so doing we consider that the reality lies somewhere in-between<sup>11</sup>. Notice that there is a declining trend in the ratio between higher and lower skilled health workers if we don't consider emigration ( $g < n$ ). This trend is emphasized if emigration of both qualified personnel takes place. The medical brain thus causes growing (relative) scarcity of physicians in Ghana. In the optimistic scenario where a substitution policy is able to completely suppress emigration of physicians the skills ratio would however remain almost constant or would increase very slightly ( $g$  slightly exceeds  $u$ ).

Figure 1: Substitution strategy without impact on medical brain drain

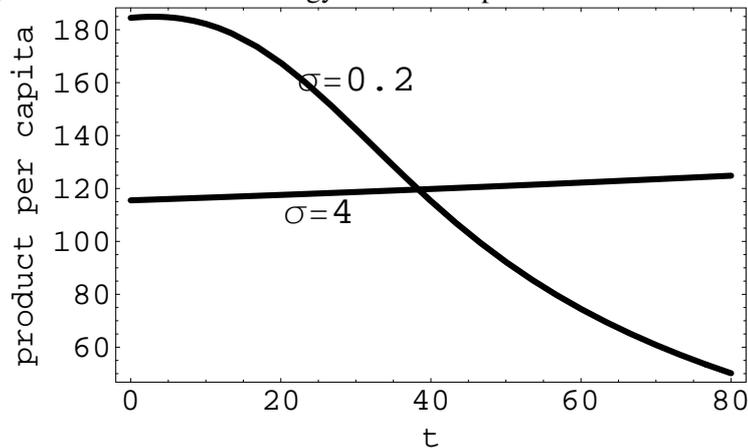


Simulation results are shown in Figures 1 and 2. Each figure compares two time patterns of healthcare productivity. One where a substitution policy is implemented and another one without such a policy. Figure 1 depicts the pessimistic case where the healthcare policy has no impact on the emigration rate of the higher skilled, whereas Figure 2 considers the opti-

<sup>11</sup>This imprecision will however show of minor importance for the arguments we will develop.

mistic case ( $\xi_R = 0$ ). If no healthcare policy is decided, the elasticity of skills substitution is low ( $\sigma = 0.2$ ) and the medical professions are specialized. The implementation of a substitution policy narrows the skill gap between both healthcare professionals and the intra-labor elasticity of substitution is assumed to climb to  $\sigma = 4$ .

Figure 2: Substitution strategy with full impact on medical brain drain



The simulations show that the strategy (implementing a substitution policy or not) chosen by the health ministry impacts very significantly the intertemporal shape of average productivity in the domestic healthcare sector. In the complementarity scenario (no substitution policy) it appears that, compared to the case where there is high skills substitution, the productivity path is higher in a first time interval and it lowers drastically afterwards until it collapses. Since there is no path that strictly dominates the other, the choice of the right strategy depends on the perceived time preference of the policy makers who face brain drain. If they favor the short and middle term, they should prefer the complementarity case by not deciding to implement a substitution policy. Being more forward-looking, they should foster skills substitutability since this strategy smoothen the time pattern of average healthcare productivity<sup>12</sup>. In the medium and long run there will thus be no breakdown in healthcare services as a consequence of growing (relative) scarcity in higher qualified health professionals.

As a general conclusion, we can say that a substitution policy may smoothen the dynamic effects of (growing) high skills scarcity in the health sector but at a cost that could be high,

<sup>12</sup>In the case where a substitution strategy completely eliminates medical brain drain, we see in Figure 2 that average health productivity is weakly increasing. This results from the fact that the ratio between doctors and nurses increases slightly in this optimistic scenario.

in the medium run, in terms of reduced productivity of healthcare services. The simulations also show that a substitution strategy that is fully successful in decreasing the emigration rate of physicians does not eliminate its depressing impact on productivity but that this effect is slightly lowered.

## 4 Conclusion

In Sub-Saharan Africa, substitution policy regarding medical professionals is one of the strategies that have been chosen to make up for the lack of highly qualified people working in the health field. One rationale underlying this strategy is to reduce medical brain drain by lowering the degree of specialization of skilled medical professionals. Our contribution is an attempt to compare the effectiveness (in terms of average productivity in the health sector) of alternative scenarios characterized by different degrees of skills specialization. For that purpose we used a CES production function aggregating higher and lower skilled healthcare personnel. In that context the concept of elasticity of substitution was central to characterize the degree of specialization between different healthcare skills. So we assumed that the more different skills are specialized, the less they are substitutable.

In our model we did not take account of possible “brain gain” effects on the sending economy. In that context, we did not consider the impact of remittances from medical emigrants since these sums are not directly reinvested in human capital for the health system (Stilwell et al., 2003). In addition, we did not model the effect of emigration on the incentive to acquire healthcare education in the source country (Mountford 1997; Stark, Helmenstein and Prskawetz, 1997 and 1998). If this phenomenon would impact differently the growth rates of different types of healthcare professionals, the evolution in terms of relative skills scarcity would be altered. For example, if the growth rate of nurses was the most affected, the relative scarcity of doctors would worsen. There is however a lack of empirical evidence on the possible effect of emigration on the growth rates of different health skills and their possible impact on the workforce mix.

Rather than trying to reproduce reality, down to the slightest details, our intention was to lend theoretical support to the assessment of some aspects of health care policy in developing countries. Indeed, even if they are simplified, the scenarios we have discussed in this paper bring forces into play which induce interesting dynamics. Accordingly, our simulations show that during an initial phase, which may be rather long, the specialization of qualified medi-

cal personnel is more efficient than strategies implying high levels of substitution even if a substitution strategy would fully cease medical emigration.

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