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On the Mechanics of the Diseases Reduction in Poorest Developing Countries

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Abstract

This article is an endogenous growth model which deals with health, in order to evaluate policy recommendations' impact on sustainability in Sub-Saharan Africa. We show that, the existing vaccines as well as Medical insurance, may define thresholds able to limit health alteration due to HIV negative impact on human organism. We also examine how to induce the organism converge to a locus where there is no more HIV. This may be achieved by Medical R&D as long as a critical bound is not reached. Once the critical health alteration bound is reached, the system increases its velocity convergence to death locus. Then, none mechanics is able to prevent health alteration dynamics to reach its long run growth. Therefore, HIV is a dynamic process with several stages. Meaning that, HIV tools control must include prevention (information), protection (behaviours adaptation) and treatment (medical assistance).

Keywords

Medical assistance; Medical insurance, Medical R&D, Sustainability

1 INTRODUCTION

This paper examines the Kremer-Glennerster (2004) health economic policy recommendations for the developing countries i.e *In developing countries, Millions of people die from diseases like malaria, tuberculosis, schistosomiasis and AIDS. Vaccines offer the best hope for controlling these diseases and could dramatically improve health in poor countries.* Therefore, the model applied Kremer-Glennerster (2004) recommendations to developing

countries in order to understand health movements through the focus on HIV. We investigate health when Medical research is undertaken in order to understand and establish the mechanics of the HIV reduction in Africa.

The analysis follows the endogenous growth literature where the government intervention regulates the society. The originality of this analysis holds on health and precisely, HIV disease in developing countries.

The endogenous growth literature has almost covered all the fields except health which still in its infancy [Goel (2006)]. . Zon-Muysken (2001) is the first paper which suggests the integration of growth supporting heath variable. Most of the existing literature is empirical, inquiring into the causes of the observed rise in obesity over time [Cutler et *al* (2003), Chou et *al* (2004), Lakdawalla et *al* (2005), Rashad et *al* (2006)]. Philipson-Posner (1999) suggest a rational-choice model of food consumption and physical activity to examine the effect on weight of technological change that lowers both the price of food and the amount of physical exertion required at work. Levy (2002) developed a dynamic model of rational life-risking overeating to determine the individual's optimal "overweightedness". Then Gideon and *al* (2009), addresses a tax fat and thin subsidy within a food-intake rational choice model. But all the models quoted are not a theory of economic development like this article.

In this analysis, the government finances medical research on HIV through fiscal policy on the wage rate incomes of the agents and provides vaccines received from international funds to the population to prevent it from tropical diseases. The results highlighted by the analysis are: *first*: food absence accelerates HIV action whereas food availability is unable to slow HIV intensity in the organism. Similarly, basic vaccines are not enough to protect the organism from HIV action. *Second,* a development economy where exist massive HIV create growth oscillation because economic development requires a strong working-age population for agriculture, education, industrial work and other sectors of economic activity. Therefore, the scale of HIV/AIDS infection in sub-Saharan Africa has also economic implications at the levels of households such when able to purchase medical assistance and the capability to create the wealth of the nation. Medical care is not able to fight high HIV in Africa. *Third,* Medical R&D is the necessary condition for HIV eradication though an appropriate vaccine in Africa but it is not a sufficient HIV eradication tool.

The literature of infections in developing countries agrees with Kremer and Glennerster (2004) recommendations i.e the vaccines necessity in developing countries. This necessity includes the works of Hamed (2011) for Schistosomias, Chawla et a.l (2012) for tuberculosis, Urbano et a.l (2010) for Malaria and Agabi et a.l (2010) for HSV. The last infection analysis is the one which deserves the most attention in this study. Agabi et a.l (2010) find that infected agents are mostly men than female and that HSV infection is the concern of all groups of the population. Meaning that, it can be found in the concerns agents' sample, all the ages, all the marital status and all the types of jobs in Nigeria. The results of this study converge to those of Agabi et a.l (2010). Meaning that, no precise HIV control criteria than that already given in medicine is defined yet. More other, education only plays role in the concern of information for children protection like hygiene [Temu et a.l (2012)] and neonatal risk transmission as well as attendant complications at birth [Agabi et a.l (2010)]. The relation of this study with the last findings holds on prevention step control of HIV virus.

Finally, this study is a complementary analysis to the infection models results presented above. Because it establishes a scale evolution of HIV in the organism of the human body and assimilates its behaviour over time to a dynamic process with three stages which are prevention, protection and treatment. HIV vaccine is unable to eradicate fully the infection because it is only preventive. Treatment alone is unable to provide protection too.

Section 2 presents the analysis of HIV and highlights the results which are discussed after and finally, we conclude in Section 3.

2 THE MODEL

Consider a developing country's economy where exist constants labour force stock L and a stock of specialized labour H at each time period which is infinite. There exist consumers, a social planner and firms over time. The social planner finances medical research through fiscal policy on wage rate incomes. He is given vaccines to international organizations that he gives to the population. Population size is constant at each period of time. The economy admits two kinds of firms and agents. There are medical and final good production firms. The agents are skilled or not skilled. The both kinds of labours work in the both production sectors at each time.

2.1 The labour market constraints are:

$H_G+H_M=H$ (1)

$L_G+L_M=L$ (2)

The skilled labour works in Medical R&D i.e H_M or in final good production i.e H_G . In parallel, the unskilled labour stock works in research i.e L_M or in final good production sector i.e L_G. Total skilled labour of the economy equals H and total labour force of the economy equals L.

2.2 The medical firm production function is expressed such as

$$Y_M(t) = \delta_M A(t)^{\alpha} H_M(t)^{\gamma} L_M(t)^{1-\alpha-\gamma} \quad (3)$$

δ_M>0 is the productivity of the medical research sector, α and γ are the respective elasticity of the research funds and of the skilled labour. Y_M is the medical firm production function, A are funds for research on HIV vaccine provided by fiscal policy, H_M is the stock of researchers of the medical firm, L_M is the stock of unskilled labour of the research sector.

The two previous production functions can be written in intensive term where $y_M(t)=Y_M(t)/L_M(t)$, $h_M(t)=H_M(t)/L_M(t)$ and $k_M(t)=A(t)/L_M$ i.e

$$y_M(t) = \delta_M k_M(t)^{\alpha} h_M(t)^{\gamma} \quad (4)$$

2.3 The final consumption good production function in intensive form is expressed such as equation (5) i.e

$$y_G(t) = \delta_G h_G(t)^{\beta} \quad (5)$$

Where $y_G(t)=Y_G(t)/L_G(t)$ and $h_G(t)=H_G(t)/L_G(t)$.

The final good production function doesn't contain research aid. The productivity of the consumption good sector is δ_G>0 and β is the elasticity of the skilled labor of good production sector.

2.4 Labors are remunerated at their marginal productivity for the respective two sectors of production. The factor market prices requires both the marginal productivity of the labor force and of the skilled labor to be the same in the both sectors of medical research and final good production i.e $w^{HM}(t)=w^{HG}(t)=w^{H}(t)$ and $w^{LM}(t)=w^{LG}(t)=w^{L}(t)$. Therefore, solving the two above respective expressions lead to a unique wage rate income for each category i.e

$$w^{H}(t)=\Delta^{H}h_{M}{}^{\beta-1} \qquad (6)$$

$$w^{L}(t)=\Delta^{L}h_{M}{}^{\beta} \qquad (7)$$

2.5 The Government budget constraint

There exist fiscal policies on wage rate incomes to finance HIV vaccine research, at amount A and the tax rate τ. Therefore, the social planner budget constraint is such as

$\tau w^{H}(t)H+\tau w^{L}(t)L=A$.

Indeed, the tax rate is expressed such as equation (8) i.e

$$\tau=\left[\Delta^{H}h_{M}{}^{\beta-1}k_{H}+\Delta^{L}h_{M}{}^{\beta}k_{L}\right]^{-1} \qquad (8)$$

Where

$k_H=H/A$ and $k_L=L/A$

are the labors intensive on research funds i.e per-*capita* skilled and unskilled labors existence due to research.

Finally, the wage rate net incomes are $W^{H}=(1-\tau)w^{H}$ *and* $W^{L}=(1-\tau)w^{L}$ equations *(9)* and *(10) i.e*

$$W^{H}=\mu^{H}\left[1-\left(\mu^{H}k_{H}+\mu^{L}k_{L}\right)^{-1}\right] \qquad (9)$$

$$W^{L}=\mu^{LH}\left[1-\left(\mu^{H}k_{H}+\mu^{L}k_{L}\right)^{-1}\right] \qquad (10)$$

$$\mu^{H}=\Delta^{H}h_{M}{}^{\beta-1}$$

$$\mu^{L}=\Delta^{L}h_{M}{}^{\beta}$$

2.6 The Utility Function

The agent may be hurt by HIV expressed by *b* if he suffers of it. Therefore, the utility function depends on his health state factors such as food consumption, *c* and vaccines, *a* provided by international organizations as well as HIV sickness, *b* and is expressed such as equation (9) i.e

$$U(c(t),a(t),b(t)) = \frac{\left[c(t)^{\pi} a(t)^{1-\pi}\right]^{1-\sigma} - 1}{1-\sigma} - B\frac{b(t)^{\varsigma}}{\varsigma} \qquad (11)$$

If *a*=0, there is no more vaccines left to treat the agent against diseases, therefore food alone is not able to keep the agent alive because his utility is negative.

If *a*≥1 means that, the agent has been given vaccines to protect him from basic diseases of tropical areas. Coupled to food, the agent who doesn't suffer from HIV has a positive utility function. Otherwise, the parameter *B* expresses HIV intensity on the agent's health state is positive. Thus, affect the utility function of the agent. We'll explain more this aspect below.

2.7 The optimal program can be written such as φ i.e

$$L(c(t),a(t),b(t)) = \int_0^{\infty} e^{-\rho t}\left[\frac{\left[c(t)^{\pi} a(t)^{1-\pi}\right]^{1-\sigma} - 1}{1-\sigma} - B\frac{b(t)^{\varsigma}}{\varsigma}\right]dt \quad +$$

$$\lambda_H\left[W^H - c(t) - b(t)\right] \quad + \quad \lambda_L\left[W^L - c(t) - b(t)\right] \qquad \varphi$$

The first order conditions of the optimal problem lead to the following relationships

$$b = \left[-\frac{\pi a^{(1-\pi)(1-\sigma)}}{B}\right]^{1/\zeta - 1} c^{\pi(1-\sigma)-1/\zeta - 1} \qquad (11)$$

$$c + b = W^i \qquad (12)$$

i=H,L

Indeed, using equation (12), the optimal consumption solutions become respectively for the skilled and the unskilled such as

$$c(t)+\left[-\frac{\pi a^{(1-\pi)(1-\sigma)}}{B}\right]^{1/\zeta-1} c(t)^{\pi(1-\sigma)-1/\zeta-1} = W^{i}$$

We solve the problem for the particular case where $(\pi(1-\sigma)-1)/\zeta\ 1=1$ i.e $\pi(1-\sigma)=\zeta$ because we are looking for the mechanics which may ensure HIV stability as we'll discuss it.

Therefore, the optimal consumptions solutions are

$$c^{*}{}_{j} = \frac{1}{1+\left[-\frac{\pi a^{(1-\pi)(1-\sigma)}}{B}\right]^{1/\zeta-1}} W^{j} \qquad (12)$$

Where $j=H,L.$

The HIV thresholds of the skilled and the unskilled labours are expressed such as

$$b^{*}{}_{j} = \left[-\frac{\pi a^{(1-\pi)(1-\sigma)}}{B}\right]^{1/\zeta-1} \left[\frac{W^{j}}{1+\left[-\frac{\pi a^{(1-\pi)(1-\sigma)}}{B}\right]^{1/\zeta-1}}\right]^{\pi(1-\sigma)-1/\zeta-1} \qquad (13)$$

$j=H,L$

The skilled labor is more hurt by HIV virus than the unskilled labor. Because he has more opportunity to access the sex market than the unskilled has. Therefore, the inequality access to the sex market is due to the workers income differentials.

3 RESULTS AND DISCUSSIONS

3.1 First results series:

$$a(t)^{(1-\sigma)(1-\pi)}\pi c(t)^{\pi(1-\sigma)-1} = -Bb(t)^{\zeta-1} \qquad \text{(D)}$$

It can be seen that, the balanced among the state variables *a* and *c* in regard to *b* are made when *c/a=b*, $a^{(1-\sigma)(1-\pi)}\pi(1-\sigma) = -B$ and π(1-σ)=ζ<1.

If (*1/* ζ-1) is pair and ζ<1, then $\left[-\frac{\pi a^{(1-\pi)(1-\sigma)}}{B}\right]^{1/\zeta-1}$ >0 therefore vaccines, *a* and food elasticity π increase the optimal consumption but *b* decrease it.

Otherwise, if (*1/* ζ-1) is impair and ζ>0, then $\left[-\frac{\pi a^{(1-\pi)(1-\sigma)}}{B}\right]^{1/\zeta-1}$ <0, the results are: vaccines and food elasticity are unable to maintain health because the organism dynamics has reached the HIV threshold highlights by the transition dynamics $\frac{\overset{\circ}{b}(t)}{b(t)}$ which begins to move to different locus of the second stage. Then, HIV vaccine is not efficient to make virus treatment to hold i.e to make $\frac{\overset{\circ}{b}(t)}{b(t)}$ converge to 0. Because ζ and *B* are the mechanics which make $\frac{\overset{\circ}{b}(t)}{b(t)}$ keep moving along its path over time. Indeed, the transition dynamics of the system, $\frac{\overset{\circ}{b}(t)}{b(t)}$ leaves the second stage and converge to the third stage toward b^{max} where it will remain indefinitely because, this locus is its long run growth i.e $\frac{\overset{\circ}{b}(t)}{b(t)} \to b^{max}$ means that, death locus is achieved. Analytically, this achievement is effective through the establishment of the inequality among food and medicine expressed by: $a^{(1-\sigma)(1-\pi)}\pi(1-\sigma) < -B$ where $B\to\infty$ and $\zeta\to\infty$

The summary of the first results series is:

First, equation (12) links positively consumption to vaccines and negatively consumption to HIV effect on the utility function of the agent as long as (*1/* ζ-1) is pair and ζ<1 as well as HIV intensity quite low i.e 0<ζ≈*B<1*. Then, standard vaccines are negatively linked to HIV presence in the organism i.e vaccines positive effects are quite good. Since (*1/* ζ-1) is impair and ζ>0 then, both consumption and vaccines are unable to eradicate HIV inside the agent organism. Consumption elasticity expressed by π has almost no effect against HIV action expressed by *ζ*.

Second, a given agent is not infected by HIV if *ζ=B=0* thus, the utility function depends on both consumption goods and vaccines only. Indeed, medical care cost is able to maintain health. The organism dynamics is located below the HIV thresholds and $\frac{\overset{\circ}{b}(t)}{b(t)}=0$.

Third, once the health state dynamics leaves the thresholds, then $\frac{\overset{\circ}{b}(t)}{b(t)}>0$ i.e HIV dynamics is introduced in the organism and its transition dynamics, $\frac{\overset{\circ}{b}(t)}{b(t)}$ moves in different locus of the organism to try to converge to its long run growth, b^{max}. Because vaccines are no more efficient at that state, the system crosses the second stage and its velocity highly increases such that $B\rightarrow\infty$ and $\zeta\rightarrow\infty$. Whatever medical insurance can do, there exist no mechanism which may ensure $\frac{\overset{\circ}{b}(t)}{b(t)}\rightarrow 0$ since the system has crossed the second stage it converges to its long run in HIV growth towards the AIDS point, b^{max}. HIV vaccine is not able to make the agent's system converge back to its healthy locus. Once the system left the healthy locus and keeps moving along its long run growth path, HIV vaccine is unable to break the long run growth convergence rule. Health system acts in the opposite way of traditional growth models where the system may converge to its initial level in the long run when economic policy positive shocks are not efficient enough to lift the economy from poverty trap for example. In contrast, when medical assistance is not strong enough to help the organism fight against HIV virus, the system doesn't converge to its initial state like traditional systems, but convergence to higher negative locus. Because after the cross of the thresholds i.e when $\zeta\geq 1$ and $b>c/a$, no force is able to make the organism fight more, therefore the system converges fast to death locus.

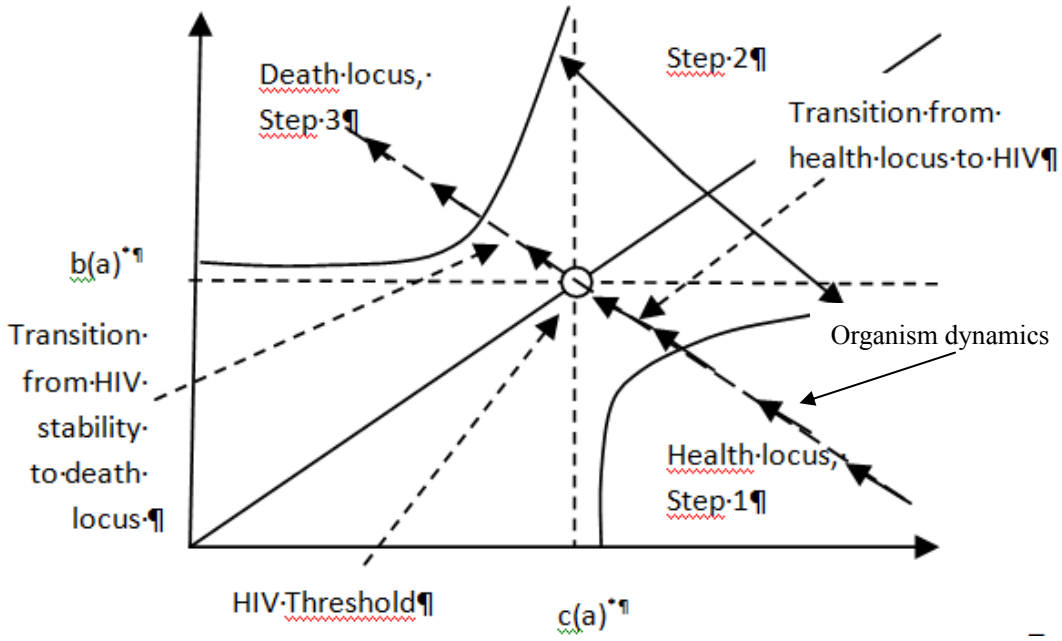
3.2 Second results series

Food is necessary to maintain health but not sufficient to fight against diseases. Consequently, World Development Organizations ought to take account of health and HIV more for development purpose.

Basic vaccines have no effect on health in presence of HIV highlighted by the parameter *B*. The increase of the amount of average food eaten i.e π and vaccines taken i.e $(1-\pi)$ by a given agent, are able to make a balance on health and ensure HIV absence through HIV vaccine.

The existence of a bound in regard to the HIV law of motion is highlighted by ζ and *B* such that: HIV is balanced if $0<\zeta<1$ and $B<1$. Otherwise, if $\zeta>1$, there exist a critical HIV level b^{max} through which the transitory HIV dynamics converge to the last stage. Otherwise, if $\zeta=B=0$, then the agent is not infected by the virus HIV as shows the utility function. In that case, the utility function is not hurt by HIV. Medical insurance fully play its role of health care and the organism dynamics is located in the healthy zone.

Representation of the health state dynamics over time



In the figure, $b(a)^*$ is the beginning of the infection, HIV and $c(a)^*$ is food consumed in function of vaccines undertaken

3.3 Third examination results:

Is HIV decreases growth as stipulated by recent WHO report? i.e "*HIV/AIDS has changed from a 'health issue to a development crisis' argues the Secretary-General of UNAIDS (the joint United Nations program on HIV/AIDS) The ability of Sub-Saharan African states to increase economic activity and social well-being is threatened*" *[UNAIDS 1999]*.

Proposition: the economic growth rate expressed by equation (15) decreases in the marginal productivity of the skilled labour i.e μ^H and increases in the marginal productivity of unskilled labour i.e μ^L

$$g = \rho - \frac{(1+\Delta)\mu^{H^2} - \mu^{L^2}}{\left(1+\Delta^{-1}\right)} \qquad (15)$$

The proposition result confirms the finding previously established such that, HIV infection touch more skilled labour than unskilled labour because of the opportunity differentials among them concerning the sex market access.

WHO[1] announces a crisis in development economics because HIV growth rates are the resulting effect of health degradation leading to productivity decrease in wealth creation activity over time.

3 CONCLUSION

What answer may we give to the HIV phenomenon in regard to the propositions of Kremer-Glennerster (2004)?

To answer the above question, note that: the results given by the previous study stipulate that, food is necessary to live and vaccines are necessary to fight tropical diseases such as malaria, tuberculosis,.., . But the vaccines have no effect on health state in presence of HIV. Without infection i.e before the cross of the threshold, health state may be kept in

[1] World Health Organization

balanced through medical assistance, food and vaccines. Therefore, HIV vaccine is a HIV prevention tool. The infection may successfully be treated through adapted vaccine as long as the system is located under the HIV threshold.

In conclusion, vaccine is a necessary to act as a HIV prevention tool. But the virus is a transitional oscillatory dynamic such that it gets its power as the distance to its long run locus is becoming short over time. HIV vaccine may be established according to this aspect of the infection. The model evidences that, skilled labour is more exposed to the virus because he has an easier access to the sex market than the unskilled labour. In Africa, infected agents are not necessary poor people.

The economic policy needs to take account of the fact that, HIV eradication depends both on its stages of evolution and in its location over time. Each stage agrees with a specific tool control. The closer to the threshold the organism is, the lower its velocity is. Once the threshold is crossed, health degradation speeds in order to converge to its long run growth. People must be informed more about the consequences of the HIV virus both for the whole economy and for them self for HIV vaccine to be a successful tool control.

Once HIV vaccine consumed, protections must be followed to limit risks associated to this infection to prevent the system from the death zone convergence. Otherwise, depending on the state where the organism dynamics is located, vaccine may be not enough to eradicate this infection. Kremer-Glennerster (2004) remedy may hold for the last generation only, but those who have been already infected are not concerned.

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Appendice

The factor market prices requires both the marginal productivity of the labour force and of the skilled labour to be the same in the both sectors of medical research and final good production which yields,

$$k_M^{\alpha}=[\beta\delta^G/\gamma\delta_M](h_G^{\beta-1}/(h_M^{\gamma-1})$$

Introducing the previous expression in the research wage rate equation for example, yields to the exact expression of the homogenous skilled labour wage rate income, w^H

$$k_M^{\alpha}[(1-\beta)\delta_G/(1-\alpha-\gamma)\delta_M](h_G^{\beta}/h_M^{\gamma})$$

$$\Delta^H = \beta\delta_G\left[\frac{(1-\alpha-\gamma)\beta}{\gamma(1-\beta)}\right]^{\beta-1} \text{ and } \Delta^L = (1-\beta)\delta_G\left[\frac{(1-\alpha-\gamma)\beta}{\gamma(1-\beta)}\right]^{\beta-1}$$

$$\mu^H = \Delta^H h_M{}^{\beta-1}$$

$$\mu^L = \Delta^L h_M{}^{\beta}$$

To compute the growth rates, we need to write the second order conditions or the factor market prices of consumption and HIV are respectively expressed such as

$$\overset{\circ}{\lambda}_H = \rho\lambda_H - \frac{\partial L}{\partial k_H}$$

$$\overset{\circ}{\lambda}_L = \rho\lambda_L - \frac{\partial L}{\partial k_L}$$

We compute

$$\frac{\overset{\circ}{\lambda}_H}{\lambda_H} = \rho - \Delta\left[\mu^{H\,2} + \mu^L\mu^H\left(\frac{\lambda_L}{\lambda_H}\right)\right]$$

$$\frac{\overset{\circ}{\lambda}_L}{\lambda_L} = \rho - \Delta\left[\mu^{L\,2} + \mu^L\mu^H\left(\frac{\lambda_H}{\lambda_L}\right)\right]$$

Where

$$\Delta = \left[\mu^H k_H + \mu^L k_L\right]^{-2}$$

According to endogenous growth literature, the growth rate of the economy i.e g must move such as

$$g = \frac{\overset{\circ}{\lambda}_H}{\lambda_H} = \frac{\overset{\circ}{\lambda}_L}{\lambda_L}$$

Therefore, we find a relationship between factor prices and finally, we determinate the unique growth rate

$$g = \frac{\left(1+\Delta^{-1}\right)\rho + \left(\mu^L\right)^2 - \left(1+\Delta\right)\left(\mu^H\right)^2}{\left(1+\Delta^{-1}\right)}$$