The Globalization of Disease: Implications for Human Capital Consolidation and Endogenous Sustainable Development

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This paper provides an empirical analysis of the effects of public health on the educational status of a population, which forms the aggregate stock of endogenous human capital. Employing data from the entire population of nations during the late 1990s, we test the effect of health indicators on educational attainment levels. The data presented indicate that population health generates a significant long-term positive effect on the stock of education and skills within a given society. Our findings suggest that health has a significant and positive association with the development of human capital across the global spectrum of nations. Therefore, we argue that the international community should increasingly target funding towards the provision of basic needs such as health care, the construction of adequate public health infrastructure and nutrition in order to accelerate processes global economic development.

INTRODUCTION

The globalization of pathogenic agents is a hoary phenomenon, tracing its origins to the earliest intersections between diverse human societies. The first "globalized" disease appears in the emergence of the bubonic plague bacillus (*yersina pestis*) from its rodent reservoirs in Central Asia, and subsequent infection of the populations of both China and Europe via the Silk Road.[1] The arrival of smallpox in the Americas, courtesy of Iberian vectors in 1492, wrought profound demographic devastation among Amerindian populations as they lacked any acquired immunity to the contagion. Historian Alfred Crosby has argued that this "discovery" of the Americas by Columbus generated an exchange of pathogens, wherein European populations subsequently became afflicted with a previously unknown disease, a highly virulent and often lethal syphilis.[2] Subsequent waves of European imperial expansion accelerated the distribution of pathogens across the globe: with migration and trade spreading malaria through Africa and the Americas. The cargo holds of trade ships also carried Yellow Fever to the Americas, and Cholera spread via trade from the Sub-Continent to Europe, East Asia and the Americas as well. The penultimate example of pathogenic globalization appeared in 1918 in the form of a lethal influenza, which purportedly originated in the United States.[3] The "Spanish Flu" (so named because it was first reported in the Spanish media which were not under government restrictions) subsequently swept round the globe via the movement of military personnel and trade ships, which served as highly effective vectors of transmission. The horrific conditions of the trenches in the First World War (filth, malnutrition, and extreme population density) would seem to have

permitted the influenza to evolve traits of exceptional virulence and transmissibility, which resulted in the premature deaths of 40-50 million people in that year alone.[4]

ON GLOBALIZATION AND DISEASE

The revolutionary discoveries of germ theory[5] and anti-biotics[6] subsequently led to unprecedented victories against infectious disease throughout most of the 20th century, leading to the (premature) conclusion by U.S. Surgeon General William Stewart in 1967 that infectious diseases were mere relics of the past, and would no longer trouble human societies in the decades to come.[7] That comfortable illusion was effectively shattered by the emergence of HIV/AIDS in the early 1980s, and its subsequent metastasis into a global pandemic that has now killed over 30 million people, while circa 39.5 million are currently infected.[8] The rapacious spread of HIV has facilitated a global resurgence of tuberculosis, and malaria continues its expansion, debilitating and killing millions per year. Various clades of hepatitis are now rampant throughout Asia, and the once-contained polio virus has spread from reservoirs in northern Nigeria back into south Asia. Recent years have seen the emergence of the highly pathogenic SARS corona virus in China, which spread throughout East Asia to Canada, and the emergence of an H5N1 avian influenza in East Asia which possesses the genetic capacity to mutate into a virus similar to the one that devastated Europe in 1918.

The emergence and proliferation of infectious diseases (and their attendant vectors of transmission) is a pernicious side-effect of the modern era of globalization. In using the term globalization[9] we are referring to the increasing rapidity of flows of commodities and peoples around the globe, which serve as effective vectors of pathogenic dissemination. Moreover, the global scale of economic activity, particularly agriculture and resource extraction industries, may generate environmental change and damage to fragile ecosystems. Such ecosystem degradation is associated with the emergence of pathogenic agents inimical to both humans and other species.[10] In sum, over 33 novel pathogenic agents appear to have emerged since the mid-1970s, many of which appear to be associated with the processes of globalization delineated above.

Furthermore, a growing contingent of security analysts have argued that pathogenic proliferation, which results in the debilitation and mortality of populations, threatens to destabilize the economies and stable governance of seriously affected regions as prevalence rates increase.[11]

Our argument is predicated upon the following tenets. First, the spread of infectious disease decreases aggregate population health at the macro level, particularly in the indigent populations of developing nations. Second, infectious diseases such as HIV/AIDS, which strike at the heart of the adult workforce, are consequently rapidly destroying existing reservoirs of human capital, which require significant time and fiscal resources to reconstitute.

Thus, disease-induced declines in aggregate population health compromise the educational stock of a given society, and further constrain the formation and consolidation of endogenous capital. Such erosion of endogenous human capital will seriously undermine the capability of developing countries in

their quest to attain sustainable trajectories of development. Consequently, the globalization of pathogens will result in both the destruction of accumulated human capital, and limit the formation of new human capital, perpetuating the poverty and marginalization of developing societies.

ON HEALTH AND ECONOMIC DEVELOPMENT

Britain's industrialization preceded that of its European rivals by many years, prompting a significant debate among economic historians over the reasons as to why Britain should have been first out of the gate. Robert Fogel argued that Britain's early industrial ascension was due to the mastery of high mortality and morbidity as a result of improved nutritional status, and the conquering of many infectious diseases from the late 18th century onward.[12] David Landes presents considerable evidence that advances in population health have spurred economic prosperity, while those societies that exhibited poor basal health tended to be laggards.[13] Indeed, the positive effects of improving population health on economic prosperity and governance are extensively documented by historians, notably William McNeill, Alfred Crosby, Michael Oldstone and Sheldon Watts.[14] In recent years, economists such as Jeffrey Sachs, John Gallup and Pia Malaney have also argued that population health is a key variable in the long-term economic success of countries, and that development is severely constrained by poor health generated by pathogenic infection to environmental toxicity.[15]

However, the effect of health on educational attainment, and the resulting formation and consolidation of human capital as a driver of long-term sustainable development, has only begun to receive significant attention. This paper examines the hypothesis that improvements in public health generate long term increases in the educational status of a population, resulting in the aggregate development of endogenous human capital and its consolidation. The paper then examines the potential for investments in health (as the core of human capital) to propel societies along a trajectory of sustainable economic development.

Distributionist arguments made by Paul Farmer,[16] and Nana Poku and Alan Whiteside,[17] posit that the proliferation of epidemic disease has historically resulted from poverty, and that pathogenic distribution on a global scale is largely a function of the inequitable distribution of resources (and power) between nations, between classes within nations, and between genders.[18] A dominant hypothesis within the Dependency/Marxist school holds that improvements in population health are typically the result of increasing economic prosperity.

While there is considerable merit in the distributionist position, it does not automatically follow that increasing wealth will *a priori* generate Pareto-optimal health outcomes for the aggregate population of a given society. For example, excessive concentration of wealth in a minority of the population will not manifest in improving the public health of the greater population. Moreover, macro-level gains in wealth are often not correlated with improving population health because increasing economic productivity is frequently associated with such factors as increasing population density, exposure to toxins resulting from pollution, declining urban public health conditions and limited or declining

sanitation capacity.[19] In an empirical study of these effects Bruce Moon and William Dixon found that

> (H)igher rates of growth did not lead to proportionately higher rates of basic needs improvement. Real product growth does seem to result in absolute gains in basic needs attainment, but the rates of change in basic needs provision do not suggest that growth is conducive to improving the provision of basic needs in developing countries. Indeed...higher rates of growth may have a negative impact upon subsequent basic needs improvements.[20]

Moreover, Loren King tested the findings of Moon and Dixon and concurred with their analysis, stating, "(economic) growth has no clear impact upon basic needs, and what effect is appears to have is negative....the longer – term impact of growth upon basic needs appears to be negligible."[21]

Macro-level estimates of wealth (e.g. GNP, and GDP per capita) do not indicate the concentration of wealth within a given society. If all economic gains are concentrated in the hands of socio-economic elites, there is little reason to argue that the basal health of the larger population will see significant improvement. Given that prosperity does not *necessarily* generate increased population health, health does appear to generate greater wealth over the longer-term. Preliminary empirical evidence suggests that increases in the basal health of populations will have a significant positive downstream effect on the prosperity of societies. Partha Dasgupta posits that improvements in public health, combined with education, are investments in human capital that promote trajectories of long-term economic productivity in a given society.[22] Furthermore, Amartya Sen argues that health should be seen as an end in itself, but he concurs that investments in human health and education are the essential paths to sustainable economic development.[23]

Extensive work has been undertaken on the relationship between human capital and the economic development of a given society. We argue that increases in population health will in turn augment the educational stack (i.e. intellectual capacity) of a given society, and that collectively such increases in the formation and consolidation of endogenous human capital will generate long-term sustainable growth trajectories.

ON HUMAN CAPITAL

There is considerable divergence in the conceptualization of human capital. For our purposes we argue that human capital is the endogenous basal health (which necessarily affects productivity), and the stock of education and skills, of a given population. Thus human capital serves as the basis of productivity in societies, and has a significant role in driving long-term economic development. While neo-classical economists typically focus on labor and capital (technology and machinery) inputs to the production process, recent models have emphasized the role of education and knowledge in economic growth. Angus Maddison has argued that education, the distribution of ingenuity, and refining of scientific

principles have been the central drivers of sustainable growth.[24] Hirofumi Uzawa and Robert Lucas developed models which hold that human capital (with an emphasis on education) is the principal driver of economic growth, collectively known as the Uzawa-Lucas Model (hereafter referred to as the U-L Model).[25] Having evolved out of Robert Solow's neoclassical growth models, the U-L model conceptualizes total output as dependent on the interaction of both human and physical capital.

Empirical work by Robert Barro and Xavier Sala-i-Martin provides evidence to support the hypotheses of the U-L model, and demonstrates the axiom that human capital drives the growth rate of real per capita GDP.[26] Regarding the influence of education, they found that the average years of secondary and post-secondary schooling is significantly correlated with the average growth rates of per capita GDP over their period of study. Interestingly, they found that primary education was not significantly correlated with economic growth. Additionally, Ross Lavine and David Renelt have found that secondary school enrollment is a robust variable and therefore appropriate for use in our model.[27]

However, the effect of schooling on development appears to be non-linear, and sensitive to the development level already reached by a given society. Alan Kruger and Mikael Lindahl demonstrated that levels of schooling exert a relatively greater impact upon developing nations than upon developed nations.[28] Further, Alfred Greiner, Willi Semmler and Gang Gong concur that the function of development curves is non-linear, "since educational efforts in advanced countries show less than proportional effects on growth rates."[29] They argue that "different forces of economic growth characterize each stage of development," and that education and knowledge have particularly significant influence on growth trajectories within the earlier stages of development, the effect being moderated in later stages.[30] Recent work by Robert Solow confirms such non-linear processes in development trajectories.[31] Theoretically then, investments in education should have relatively more powerful effects on the growth trajectories of developing economies, and provide diminishing returns in highly industrialized societies.

In addition, "new growth" theorists, led by Paul Romer, have developed an R and D model that emphasizes the accumulation of the endogenous stock of societal knowledge as the principal engine of long-term economic growth.[32] This preliminary evidence is supported by the work of Gene Grossman and Elhanen Helpman and Philippe Aghion and Peter Howitt.[33] In classic conceptualizations of human capital knowledge is seen as rivalrous, as it is embodied within an individual, whereas in the Romer model the emphasis is on the disembodied societal stock of knowledge which is non-rivalrous (at least within a given society). Greiner, Semmler and Gong provide empirical evidence, using time-series data, that the growth of human capital generates positive long-term effects on the economic growth trajectories of nations.[34] As a definitional issue, they admit that there is no generally accepted manner in which to empirically construct the stock of human capital. Robert Barro and Jong-Wha Lee[35] and George Psacharopoulos and Ana Arriagada[36] have defined a proxy for human capital as years of schooling. Alternatively, Vikram Nehru, Eric Swanson, and

Dubey Ashutosh have defined the stock of human capital as the sum of person-school years.[37]

EFFECTS OF HEALTH ON EDUCATIONAL STOCK

So how might poor health compromise educational attainment? Let us examine the role of infectious disease (e.g. HIV/AIDS) as it operates at the household level. We define a household as one or more individuals who represent both a consumption unit and a production unit. Household wealth is typically derived from their land, savings, and the time of their members. "At the micro level, increased disease incidence and lethality exert a significant negative effect on the household by killing and debilitating productive members, which in turn generates shifts in saving and consumption and results in supply-induced and demand-induced shocks that destabilize the household as an economic (and social) unit".[38] Therefore, morbidity and mortality can reduce the number of breadwinners in a household, the productivity of those breadwinners, decrease household income, and alter savings and consumption patterns. The direct and indirect costs of mortality and morbidity may push households into ever deeper poverty, and as a result generate various effects to undermine the educational stock of that household over time. For example, as breadwinners are debilitated and eventually die as the result of exposure to various agents ranging from carcinogens to pathogens, children are orphaned. Through processes of labor substitution, children of ailing or deceased breadwinners will often be forced to forego educational opportunities in order to generate income for the impoverished household. Other effects may include the infection of children via parasites (e.g. intestinal helminths) which impedes their absorption of nutrients, thereby impeding cognitive capacity over the longer-term and diminishing their ability to learn.

Declining health can also prevent children from attending school or doing well if they do attend. Partha Dasgupta has observed that youth who have been prone to illness (and malnutrition) tend to exhibit learning disabilities and reduced cognitive function which is directly related to their poor health status.[39] Additionally, a World Bank study found that healthier and well-fed children do better in school, and enroll with greater frequency, than their deprived counterparts.[40] In this study Jamaican children infected with whipworm showed that those debilitated by the nematode infection scored 15 percent lower on average than healthy children in the same school. Following treatment, the previously ill children achieved scores markedly closer to those in the healthier control group.

Martha Ainsworth and Mead Over argue that the proliferation of HIV/AIDS will reduce the demand for education resulting from declining size of the cohort entering school and declining enrollment rates (as a result of onerous fees or due to labor substitution).[41] Supply-side shocks (due to HIV/AIDS) include depletion of the number of teachers available (due to increasing morbidity and mortality), increased teacher training and turnover costs, and reductions in the efficiency of the education system. Moreover, at the sectoral level it is logical to assume that decreasing population health may also result in a

shift of endogenous fiscal resources away from the educational sector in order to shore up the health sector.

METHODS

Human Capital is often conceptualized as an aggregate function including both health and education. For the purposes of this study we disaggregate these two components in order to test the effect of health (the independent variable) upon educational attainment (the dependent variable). We gleaned our data from the World Development Indicators provided by the World Bank. Overall, the WDI provides data on the entire population of 208 nations with separate results for each; however, we eliminated nations that are not independent, which lowered our N to 190. Because data on our variables were not reported consistently for each year, we measured our variables by averaging the values over the years 1998, 1999, and 2000. We employed SPSS to analyze our data.

The dependent variable in our study is the percentage of a given population currently enrolled in secondary school. This variable measures the percentage of the total population of possible secondary school attendees actually receiving secondary education on an annual basis. Secondary school enrollment (SSE) is an excellent proxy for measuring the general educational levels of a given society, particularly since Barro and Sala-i-Martin found that educational attainment at this level has the most significant effect upon downstream economic development.[42] The work of Levine and Renelt,[43] and Kruger and Rendahl,[44] also suggests that SSE is the most appropriate proxy for the dependent variable. Education is a core state function, and it is expensive to provide. Higher secondary school enrollment represents the greater educational capacity of that society.

In addition, we included primary school enrollment (as a percentage of the potentially enrolled population) as a second dependent variable as well. While SSE is quite powerful at measuring educational attainment outcomes within the middle and upper tier of countries, it is PSE that acts as a more accurate proxy for measuring the effect of health upon educational attainment for the poorest countries of the globe. Given the dearth of state capacity and resources within the LDCs, it therefore makes logical sense to explore the impact of health on primary school enrollment as well.

We included two variables as the principal metrics for population health: under-five mortality rate and life expectancy respectively. Under-five mortality is an excellent metric for gauging the general health of a given society, particularly youth cohorts. Further, we selected under-five mortality because it involves not only natal health but early childhood health as well. Therefore, it reflects a much broader cohort of the population, and is therefore theoretically logical. Life expectancy measures the basal health of the entire population and is therefore a comprehensive metric for establishing a panoramic snapshot of a given population's overall health outlook.[45] Life expectancy is measured as the average life expectancy at birth, and because it is a general measure of basal population health, we hypothesize that it will be positively related to secondary school enrollment. The under-five mortality rate variable is measured per 1,000 people,

and given that increases in the rate indicate declining population health (particularly in younger cohorts), we hypothesize that it will be negatively related to secondary school enrollment. Although we initially considered an infant mortality variable (measured per 1,000 live births) as well, there was a problem with multicollinearity between infant mortality and under-five mortality (the Pearson's correlation coefficient between the two variables is 0.989). Consequently, we could not include both variables in the model.

We also included five variables within our model to control for other factors that might impact the extent of secondary school enrollment in each nation. A nation's economic capacity could logically impact secondary school enrollment. Government expenditures per capita indicates the extent to which governments can provide essential services, of which education is a core basic need, and expensive to provide.[46] We hypothesize that government expenditures per capita are both positively related to secondary school enrollment. Further, we control for urbanization, i.e., the percent of a nation's population living in an urban area. Because secondary education is difficult to provide in rural areas, inefficient, and often costly, we expect to see a positive relationship between urbanization and secondary school enrollment. Two variables control for the extent that a nation is developed. Internet usage (per 1,000 people) measures technological development, and the percent of roads that are paved measures infrastructure development. We hypothesize that both variables will be positively related to the dependent variables. Finally, we include a measure of foreign aid, which incorporates the official developmental assistance and official aid (in current U.S. Dollars). We expect lower educational progress in countries that receive more foreign aid. Table 1 reports each variable's operationalization and mean value.

Table 1: Variables, Their Measurements, and Mean Values

Variables	Measurement	Mean value
DEPENDENTS		
Primary School Enrollment	% eligible age enrolled in primary school: average for years 1998, 1999, and 2000	92.97%
Secondary School Enrollment	Average % eligible age enrolled in secondary School: average for years 1998, 1999, and 2000	65.76%
INDEPENDENT – HEALTH VARIABLES		
Under-5 Mortality	Average deaths for children under 5 per 1000 People: average for years 1998, 1999, and 2000	65.19 deaths
Life Expectancy	Average life expectancy: average for years 1998, 1999, and 2000	65.59 years
INDEPENDENT – CONTROLS		
Urbanicty	% of people living in urban area: average for years 1998, 1999, and 2000	54.75%
Government Expenditures	Dollar value (1995) of government expenditures per capita: average for years 1998, 1999, and 2000	$1,209.75

Internet Usage people/1000	Number of internet users per 1,000 people: average for years 1998, 1999, 2000	61.77
Paved Roads	Percent of roads that are paved: average for years 1998, 1999, 2000	49.63%
Foreign Aid	Official development assistance and official aid (current US$): average for 1998, 1999, 2000	$229,618.80

Before proceeding further it is important to ascertain whether the missing data we encountered will be a problem. Unfortunately, the World Development Indicators data were somewhat incomplete for all of our variables, and although we averaged scores over a three year period, there were cases that lacked data on different variables. Missing data reflects the uneven availability of data on a global scale. This becomes a greater problem when dealing with developing nations where the necessary infrastructure (to collect such data on a yearly basis) is often weak. If the pattern of missing values for the dependent variable is related to the values of any of the independent variables, then our results will be biased. To test whether the missing data in the two dependent variables are related to any of the independent variables, we created two variables that merely register whether the case is missing for the secondary school enrollment variable and the primary school enrollment variable, and then we measured the Pearson's-r correlation coefficient with that variable and each of the independent variables. None of the independent variables is statistically associated with missing data in the dependent variable. Therefore, we are confident that missing data in the dependent variable will not bias our results, and we instructed SPSS to exclude missing data listwise.

For the purposes of this study Ordinary Least Squares (OLS) Regression is not appropriate for testing the effect of the independent variables on secondary school enrollment. Although we hypothesize that our health variables influence education, it is also likely that education influences the health variables, and this feedback means that the health variables are correlated with the error terms, which violates an assumption of OLS Regression. The Two-Stage Least Squares (2SLS) technique controls for this bias. The two-stage least squares uses instrumental variables, which are not influenced by education, to predict the health variables. Those predicted health variables, which are influenced by the instrumental variables and not the dependent variable, are then substituted for the observed health variables, which eliminates the bias. For the purposes of this analysis, the instrumental variables used to predict the health variables are: urbanicity, number of physicians per 1,000 people; government expenditures per capita; internet usage; paved roads; foreign aid; lagged life expectancy; and lagged under-five mortality. We lagged the life expectancy and under-5 mortality rate variables by taking the average values for each country during the years 1995, 1996, and 1997.

RESULTS

Table 2 reports the results of the primary school enrollment model. The Adjusted R-Squared of 0.68 indicates that the model as a whole explains a decent amount

of the variance in primary school enrollment across the global population of nations. Additionally, the model demonstrates that the under-five mortality variable is statistically significant at the 0.05 level. When controlling for other independent variables and for the reciprocal influence of the dependent variable, an increase of one death of a child under five years old (per 1,000) results in a 0. 209 percent decrease in primary school enrollment as a percentage of possible enrollment. The life expectancy variable and none of the control variables are statistically significant at the 0.05 level. This result suggests that early childhood heath policy influences early childhood education.

Table 2: Two-Stage Least Squares Regression on Percent Enrolled in Primary School

Variables	Slope	Standard Error	Beta	Significance
Constant	96.047	27.513	N/A	0.001**
HEALTH VARIABLES				
Life Expectancy (at birth)	0.171	0.376	0.117	0.651ns
Under 5 Mortality Rate	-0.209	0.050	-0.908	0.000***
CONTROL VARIABLES				
Government Expenditures	$-3.65e^{-5}$	0.001	-0.010	0.952ns
Urbanicity	-0.072	0.067	-0.137	0.286ns
Internet Usage	-0.004	0.013	-0.051	0.749ns
Paved Roads	-0.017	0.036	-0.048	0.640ns
Foreign Aid	$1.22e^{-6}$	0.000	0.048	0.588ns

Adjusted R-Squared = 0.68
* $p<0.05$; ** $p<.01$; *** $p<0.001$

Instrumental Variables: Physicians per 1,000; Urbanicity; Government Expenditures; Paved Roads; Foreign Aid; Internet Usage; Lagged Life Expectancy; and Lagged Under 5 Mortality

Table 3 reports the results of the secondary school enrollment model. The Adjusted R-Squared of 0.82 indicates that the model as a whole explains a considerable amount of the variance in secondary school enrollment across the global population of nations. Additionally, the model demonstrates that the under-five mortality variable is variable is significant at the 0.05 level. When controlling for other independent variables and for the influence of the dependent variable, an increase of one death of a child under five years old (per 1,000) results in a 0.212 percent decrease in secondary school enrollment. This result suggests that the influence of early childhood health even extends to secondary school enrollment. Again, the life expectancy variable is not significant, but some control variables are significant at the 0.05 level. With all other variables held constant an increase of one percent of people living in an urban area results in 0.265 percent increase in secondary school enrollment; an

increase of one internet user (per 1,000 people) results in a 0.059 percent increase in secondary school enrollment; and an increase in one percent of the roads that are paved results in a 0.288 percent increase in secondary school enrollment. Both health and economic/developmental variables explain secondary school enrollment. However, it is worth noting that the under-five mortality variable has the highest Beta score; consequently, it is the strongest of the significant variables.

Table 3: Two-Stage Least Squares Regression on Percent Enrolled in Secondary School

Variables	Slope	Standard Error	Beta	Significance
Constant	-44.047	46.684	N/A	0.350ns
HEALTH VARIABLES				
Life Expectancy (at birth)	0.080	0.635	0.025	0.900ns
Under 5 Mortality Rate	-0.212	0.086	-0.418	0.017*
CONTROL VARIABLES				
Government Expenditures	-0.002	0.001	-0.206	0.095ns
Urbanicity	0.265	0.114	0.230	0.025*
Internet Usage	0.059	0.022	0.322	0.011*
Paved Roads	0.288	0.061	0.362	0.000***
Foreign Aid	$-1.06e^{-6}$	0.000	-0.019	0.779ns
Adjusted R-Squared = 0.82				

* $p<0.05$; ** $p<.01$; *** $p<0.001$

Instrumental Variables: Physicians per 1,000; Urbanicity; Government Expenditures; Paved Roads; Foreign Aid; Internet Usage; Lagged Life Expectancy; and Lagged Under 5 Mortality.

RAMIFICATIONS FOR INTERNATIONAL DEVELOPMENT

As reported above, the model indicates that an increase of one death of a child under five years old (per 1,000) results in a 0.212 percent decrease in secondary school enrollment (of the viable population). Likewise, an increase of one death of a child under five per 1,000 people results in a 0.209 percent decrease in secondary school enrollment (as a percentage of possible enrollment). The data suggest that changes in population health have a powerful downstream effect on the educational stock of a given society. Thus, investment in health should intensify the level of endogenous education, skills and literacy within a given society. Collectively, investments in health thereby augment the stock of human

capital, which should in turn accelerate the growth rates of developing economies, and permit sustained economic development.

According to the advocates of New Growth Theory (e.g. Paul Romer, Job Graca) increases in endogenous human capital in turn will result in higher levels of ingenuity,[47] and generally increase the long-term economic productivity of a given society. Graca argues that NGT promises a path to self-sustaining growth, and contradicts neoclassical economic growth theories of the 1960s, which had effectively ignored the role of human capital in the development equation, focusing exclusively upon physical capital.[48] Further, Graca posits that the inclusion of the human capital component within NGT "make possible a balanced growth equilibrium, where endogenous human capital accumulation, rather than exogenous technical change drive the process of growth."[49] Further, Edward Denison found that while physical capital played a major role in the initial growth phase of societies, human capital gradually came to exert a dominant effect on the growth trajectory of a given nation over the long-term.[50] In addition, Robert Barro found that rates of growth for a wide sample of countries, from 1960 to 1985, were positively associated with initial levels of human capital.[51] World Bank analysts have also argued that positive effects of schooling augmented physical capital inputs in their analysis of the growth trajectories of a sample of nations in East Asia.[52] George Pscharopoulos and others have also argued that one of the most important factors explaining variations in income distribution among workers was their educational attainment.[53] Based upon this preliminary evidence we argue that human capital combines with physical capital to drive long-term processes of economic development.

This growing body of evidence illustrates the positive effect of human capital formation and accumulation on endogenous technical change and growth trajectories. We suggest that basal population health has a significant positive association with the development and consolidation of human capital. We find that health has a significant and positive association with the downstream development of *intellectual capacity* across the global spectrum of nations. Collectively, health and education combine to form a nations stock of human capital. Human capital combines with physical capital to generate long-term endogenous growth. Based upon the empirical data collected and analyzed above, we argue that investment in population health should henceforth be recognized as a central component to the theory and practice of international development, generating significant future returns on investment. The results therefore cast doubt upon the claims of orthodox development economists who posit that population health and educational attainment are merely products of economic growth.

In conclusion, the data indicate that population health generates a significant long-term positive effect on the stock of education and skills within a given society. Given that educational achievement, including literacy, and other skills are associated with the development of endogenous long-term growth trajectories in affected nations, investment in health generates sustainable development trajectories. Therefore, the international community should increasingly target funding towards the provision of basic needs such as health care, the construction of adequate public health infrastructure, and improving

nutrition. The results of this analysis suggest that those societies that are consistently burdened by poor population health will have a relatively more difficult time in creating the endogenous stock of human capital necessary to generate trajectories of sustainable economic development. This evidence supports the findings of Fogel, and Landes, and it buttresses the work of Sachs who found that endemic malaria has generated a significant drag upon the economic trajectory of nations in the tropics. Furthermore, those countries experiencing significant pathogen-induced declines in population health (e.g. Russia, Zimbabwe) are likely to see a concurrent long-term decline in their educational stock, thereby diminishing their prospects for sustainable economic development in the long run. As the processes of globalization facilitate both the diffusion of existing pathogens, and contribute to the emergence of novel pathogens, this will compromise the consolidation of human capital and impede sustainable development in the LDCs. Therefore, globalization produces perverse externalities (pathogen emergence and diffusion) that function to impede economic development.

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[3] Carol Byerly, *Fever of War The Influenza Epidemic in the U.S. Army during World War I* (New York: NYU Press, 2005); and Alfred Crosby, *America's Forgotten Pandemic: The Influenza of 1918* , 2nd ed. (New York: Cambridge University Press, 2003).
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[6] Penicillin was discovered in 1928 by Alexander Fleming.
[7] Noted in Anthony S. Fauci, "Infectious Diseases: Considerations for the 21st Century," *Clinical Infectious Diseases* 32, no. 5 (March 2001): 675-685.
[8] http://data.unaids.org/pub/EpiReport/2006/02-Global_Summary_2006_EpiUpdate_eng.pdf

[9] Barry Gills has advocated a conceptual plurality regarding the definition of the term globalization, arguing against the "idea that there can ever be a single theory or interpretation of globalization." See Barry Gills, "The Turning of the Tide," *Globalizations* 1, no. 1 (September 2004): 1.
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