State Capacity and HIV Incidence Reduction in the Developing World: Preliminary Empirical Evidence

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INTRODUCTION

As the scourge of the HIV/AIDS pandemic continues its inexorable spread throughout the developing world, it leaves in its wake a toll of enormous human suffering, economic decline, and increasing socio-political destabilization.[2] To date, the contagion has resulted in approximately twenty-seven million deaths. With forty million people currently infected, the virus represents a significant threat to the health and welfare of the entire human species. Over five million people became infected with HIV in 2003, and in that year, AIDS resulted in circa three million deaths, up from two million in 1999. Moreover, the infection is spreading rapidly from its current epicenter in Sub-Saharan Africa into other developing countries such as India, Russia, Ukraine, China, and the Caribbean, which has the highest levels of HIV seroprevalence outside of Africa.[3]

The public health and policy communities have struggled valiantly in their attempts to contain the spread of HIV, with moderate levels of success in highly industrialized nations such as Canada, Germany, France, the United Kingdom, and the United States. However, to date, there has been persistent failures to contain the spread of the epidemic throughout much of the developing world, particularly in Sub-Saharan African countries such as South Africa, Zambia, Namibia, Swaziland, Zimbabwe, and Botswana, where adult HIV seroprevalence levels range from approximately 20 percent to circa 39 percent, respectively.[4]

Drawing upon the axioms of classical dependency theory, certain scholars have argued that the international political economy is structured in such a fashion that

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developing societies are trapped in a cycle of perpetual poverty and marginalization.[5] Thus, the majority of the populace in developing countries will remain mired in destitution, lacking adequate nutrition, clean water, housing, sanitation, and the maintenance of adequate public health infrastructure. Poor nutrition and illness combine to impede the formation, accretion, and consolidation of human capital within impoverished societies, further constraining a given nation's ability to respond effectively to exogenous shocks such as the HIV/AIDS pandemic. Massive debt in developing countries result in low prices for exported commodities, poor infrastructure, marginal levels of human capital, and low levels of economic reserves to deal with crises; thus, these developing countries will typically lack the endogenous *capacity* to respond to the epidemic in an effective and proactive manner. Therefore, states with low endogenous levels of capacity, measured in terms of economic power, infrastructure, and human capital indicators, will theoretically experience far greater difficulty in generating effective adaptive countermeasures to the HIV/AIDS epidemic.

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However, there are several examples of nations—Uganda and Thailand—that exhibit low levels of capacity, but have mounted relatively successful campaigns to reduce HIV incidence within their respective populations. Conversely, countries with relatively higher levels of capacity—Botswana and South Africa—have not fared as well. The successful adaptor nations have utilized alternative strategies to offset their lack of endogenous capacity, such as the mobilization of political elites to induce behavioral change in the populace in order to reduce pathogen transmission rates. In cases of successful adaptation, political leaders worked with local community leaders and non-governmental organizations to mobilize communities, protect the rights of the infected, and distribute prophylaxis and therapeutic anti-microbials, which also served to limit transmission and improve the lives of those already infected.

Despite having a moderate level of endogenous capacity, Botswana is a classic example of maladaptation. It exhibits the highest levels of adult HIV seroprevalence in the world, 38.8 percent, and the epidemic shows no signs of abating.[6] On the other hand, Uganda, which has relatively lower levels of capacity, but higher levels of political commitment and social cohesion, has adopted relatively effective HIV/AIDS policies and successfully reduced the seroprevalence of HIV/AIDS in its populace to about 6 percent. Thailand also has relatively lower levels of state capacity than Botswana does. However, Thailand possesses a greater political commitment and social cohesion than Botswana, resulting in more effective policy implementation and thus, the incidence and prevalence of HIV has significantly declined over the

past decade. However, Thailand did recently decrease its prevention budget.[7] The conditions in these countries imply that some combination of the independent variable—state capacity—and the intervening variables—political will and social cohesion—is the prerequisite for the formulation and implementation of effective policy, resulting in successful HIV incidence reduction. Theoretically, we posit that when capacity is low, the effect of the intervening variables on the dependent variable— HIV incidence—may intensify. Therefore, this study constitutes a preliminary investigation of the empirical relationship between state capacity and HIV incidence reduction. Further, this study develops a novel empirical index by which to measure state capacity and articulates an empirically validated weighting system for that index.

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At present, there are currently no comprehensive multi-national empirical studies that examine why some countries have adapted effectively to the epidemic while others have foundered and seen massive infection of their populations. Theoretically, it is important to develop models that explain the role of state capacity in a sovereign nation's adaptive response to crises such as the HIV/AIDS pandemic. For the purposes of this study, we conceptualize national incidence reduction as the dependent variable, influenced primarily by state capacity. In the context of the HIV/AIDS epidemic, this is of utmost importance as it helps to explain differential outcomes in the ability of governments to respond to the epidemic.

The foremost explanation as to why some states adapt more effectively than others is based on the notion of *state capacity*, which reflects the endogenous resources that a state may mobilize in order to deal with emergencies, such as epidemic disease. Theda Skocpol initiated the discussion with the supposition that there are five central components of state capacity: sovereign integrity, financial resources, loyal and skilled officials, stable administrative-military control, and the authority and institutional mechanisms to employ its resources.[8] Joel Migdal argued strong states are capable of penetrating society, extracting and appropriating resources, and regulating social relationships.[9] Pierre Engelbert sought to restrict the definition of state capacity to the government's ability to maintain effective institutions and markets and foster economic development.[10] Daniel Esty et al. employed state capacity as an intervening variable that moderated the effects of myriad independent variables upon the dependent variable of state failure.[11] Thomas Homer-Dixon also used the concept in order to measure the impact of resource scarcity upon political stability with reference to state attributes such as instrumental rationality, resilience, and autonomy.[12] With a nod to Migdal, we have refined our definition of state capacity as one country's

ability to maximize its prosperity and stability, to exert *de facto* and *de jure* control over its territory, to protect its population from predation, to extract resources, to regulate social relationships, and to adapt to diverse crises. State capacity concerns a government's ability to satisfy its most important national needs, such as survival, protection of its citizens from physical harm, economic prosperity and stability, effective governance, and territorial integrity.

This implies that those countries that possess very high levels of capacity, i.e., the developed world, will be much more adaptive than countries with declining or low levels of endogenous capacity.

This study draws upon the recent finding that there is a strong positive correlation between population health and state capacity over the long term. In a randomized empirical study of twenty nations, utilizing forty years of data, Price-Smith demonstrated that state capacity exerts a significant effect on population health.[13] This implies that those countries that possess very high levels of capacity, i.e., the developed world, will be much more adaptive than countries with declining or low levels of endogenous capacity.

METHODOLOGY

We collected data on a random sample of 50[14] of the 191 member states of the UN in order to determine how well indicators of state capacity explain a given nation's ability to adapt to the AIDS crisis.

Data and Variables
The HIV/AIDS adaptation variable is measured as the percent change from the historical maximum of HIV incidence in each nation. For example, in nations that have witnessed successful adaptation to the pandemic, HIV incidence has declined from a historical apex. Such an apex is an inflection point after which HIV incidence declines. Such a decline is then measured as a percentage against the apex point and then converted to a score out of a maximum of 100 points. Ergo, a nation that had witnessed a 65 percent decline in incidence against the historical apex point would thereby exhibit a score of 65 on the adaptation continuum. Nations that have not seen any decline in HIV incidence and are therefore maladaptors receive a score of zero. For most of the nations, data exist through 2001. In cases that did not have the latest available information, we used the percent change figure for the most recent available year.

In order to empirically measure variations in state capacity, we employed a core set of cross-national indicators that are based on a revision of Price-Smith's original index.[15] The following seven indicators are logically valid measures of the resources, commitments, outcome, and performance of government functions.

Gross National Income (per capita)

This variable measures the total value of goods and services produced by the state on an annual basis. The sum is divided into a per capita measure and then standardized into current valuations. This indicator is a logically valid measure of state capacity because high per capita gross national income (GNI) values require an effective regulatory apparatus. GNI measures such aspects of state capacity as fiscal resources, autonomy, reach and responsiveness, resilience, human capital, and legitimacy. Data are available from the World Bank World Development Indicators.

Government Expenditure ($US 1,000)

This variable measures the total fiscal outlay of the state on the provision of services, such as education and health care, to its population on an annual basis. Government expenditure is a valid measure of state capacity because variation in state spending is an indicator of the ability of government to fund programs and to generate revenue. Data are available from the World Bank World Development Indicators.

School Enrollment Ratio (secondary)

This variable measures the percentage of the total population of possible school attendees receiving secondary education on an annual basis. It is a measure of state capacity because education is a core state function, and it is expensive. Of course in many states, families pay for education, yet education remains a public good that is subsidized by the state. This indicator also provides a proxy measure for the endogenous levels of human capital formation and consolidation within a state. Data are available from the World Bank World Development Indicators.

Military Spending (per soldier, per capita)

This variable measures the government's annual fiscal outlay for defense. The aggregate amount is divided by the number of soldiers, and then the value is adjusted to reflect a per capita ratio. This ratio allows a relative ranking of the amount spent on the training of soldiers and expenditures on weapons systems. High spending per soldier per capita is an indication of high-tech, capital- and training-intensive armed forces that can only be created and maintained by states that possess high state capacity. This is a valid measure of state capacity because it is one indication of the state's ability to provide a national defense system for the territory it governs. Data are available from the Stockholm Peace Research Institute.

Physicians (per 100,000/rate)

The ratio of health care providers to the general population is an excellent measure of the state's capacity to respond to various and diverse crises, such as exogenous shocks. It is also an excellent measure of the state's ability to train and employ health care providers, which is time-consuming and expensive. Moreover, this is a viable indicator of the level of endogenous health care infrastructure, which is expensive to develop and to maintain. Data are available from the World Health Organization and World Bank and national archival sources.

Telephones (per 100,000/rate)

Societies that have a high level of capacity will also possess a relatively sophisticated means of communication, which is particularly important when responding to crisis situations. This measure includes both landlines and cell phone usage and is a good proxy indicator of the technological sophistication of a given society. Moreover, communications infrastructure is a relatively expensive undertaking that is typically carried out by the state, particularly in the case of landlines. Data are available from the World Bank World Development Indicators.

Paved Roads

This variable is operationalized as the percent of roads in the state that are paved. This is another logical measure of a state's infrastructural capacity. Most states, except small island states, require a terrestrial transportation network in order to ensure the flow of goods and services throughout their sovereign territory. Such transportation networks also facilitate the flow of human capital throughout the state and permit rapid response to national emergencies should they arise. Moreover, paved roads are almost exclusively paid for and maintained by the state and are expensive to build and maintain. Data are available from the World Bank, IMF, and national archives.

FINDINGS

To determine the extent that each indicator of state capacity impacts HIV/AIDS adaptation, we first correlated each of the above independent variables on the adaptation dependent variable. Five of the seven individual indicators are statistically significant (at the .1 level) when correlated with AIDS adaptation: (1) schools (r=.349, p=.015, N=48); (2) roads (r=.391, p=.007, N=47); (3) phones (r=.434, p=.002, N=48); (4) physicians (r=.266, p=.062, N=50); and (5) GNI per capita (r=.400, p=.004, N=49). Military expenditures and government expenditures are not statistically significant.

To analyze the extent that state capacity explains AIDS adaptation, we constructed a composite measure of state capacity. However, we cannot assume that each variable within the index is likely to contribute equally to state capacity; therefore, it is necessary to develop a scheme for weighting those variables. To date, there has been no prior empirical research on which to base the weighting of these various indicators. Thus, we have established a preliminary theoretical justification for the weighting of such an index, which is reinforced by empirical tests below. We accord prominence to the infrastructural variables because these variables speak directly to the state's ability to respond to a wide range of different problems and crises with which the state must contend. On the other hand, we assign a lesser weight to military spending and macro level government expenditure. While military spending is an indicator of the state's power within and beyond its borders, some states do not have standing armies and/or they may not see a need to project power beyond their

borders. Government expenditure is given a lesser weight since it includes the various infrastructural variables. Based on this logic, we assign the following weights to the variables:

GNI	0.2
Phones	0.2
Roads	0.2
Schools	0.14
Physicians	0.14
Government Expenditures	0.06
Military Expenditures	0.06
Total	1.0

Additionally, the units for the different components of the state capacity measures fluctuate wildly. The schools and paved roads variables are percentages; the telephones and physicians variables are measured per 100,000 people; the government expenditure variable is measured in $1,000; the GNI variable is measured per capita; and the military expenditure variable is measured per capita, per soldier. If one were to use these unstandardized outcomes in constructing the composite measure, then the differing units would contaminate the weighting process. The composite measure would reflect the difference of units far more than the weighting scheme outlined above. Consequently, we standardized the variables by converting each value for each variable into its z–score. Specifically, we subtracted the variable's mean from
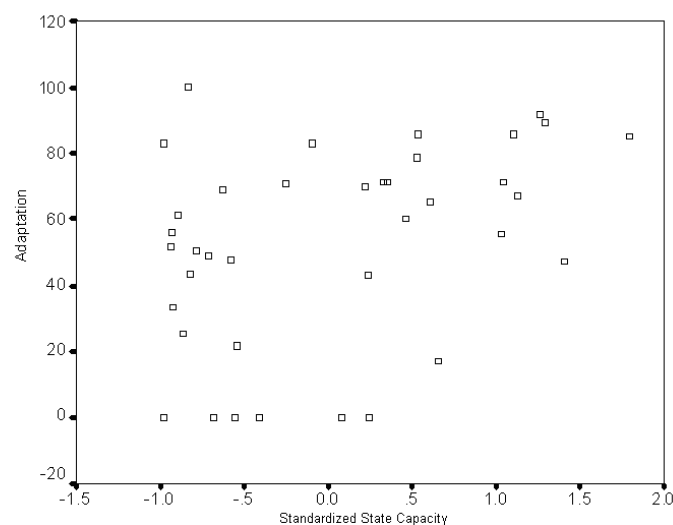

Figure 1. State Capacity and AIDS Adaptation

each value for that variable and then divided the difference by the variable's standard deviation.[16] This procedure for standardizing the variables did not change their relative influence and will not affect how they behave in subsequent analysis.

This composite state capacity variable is statistically associated with AIDS adaptation. Figure 1 shows the scatterplot of the two variables, with the dependent variable AIDS adaptation plotted on the y-axis and the independent variable state capacity plotted on the x-axis. The scatter plot suggests that the two variables are positively associated. As state capacity increases, so does AIDS adaptation. However, there are clearly some outliers.

OLS Regression further establishes that state capacity is statistically associated with AIDS adaptation. Table 1 reports the results for this regression. The state capacity variable is statically significant (p=.018). Additionally, the positive beta coefficient of .381 means that the correlation coefficient between state capacity and AIDS adaptation is 0.381. Although this result demonstrates that state capacity is an important influence on AIDS adaptation, it is worth noting that state capacity only explains 38 percent of the variation in AIDS adaptation. Consequently, factors that we have not yet specified explain 62 percent of the variation in AIDS adaptation. The statistically significant and strong error term (constant) further demonstrates that much is left unexplained. Accordingly, future research should develop a more fully specified model that includes variables reflecting political will and community mobilization. Nevertheless, at this point, we can confidently conclude that there is preliminary evidence that state capacity is statistically associated with AIDS adaptation.

Table 1. OLS Regression of State Capacity on HIV/AIDS Adaptation

Variable	Slope	Standard Error	Beta	Significance
Constant	52.36	4.58	N/A	.000
State Capacity	13.79	5.58	.381	.018

Because our weighting scheme for the state capacity variables is based on a preliminary understanding of the relative importance of the indicators, we need to explore the interrelationships among the seven indicators of state capacity before proceeding to further research. The correlation matrix in Table 2 shows the extent to which each indicator is correlated with one another. While this table demonstrates that many of the indicators are associated with one another, it also shows that some variables are not significantly correlated with other variables.

Although the correlation matrix provides some useful information about the indicators, there are seven variables and twenty-one separate correlations to consider. Therefore, it is difficult to learn much from the correlation matrix. Factor analysis is a useful technique for summarizing the relationships among a large group of variables. It identifies which variables are most closely related to individual factors that underlie the variables.   Since each of the variables related to a factor are similar

to one another, each factor can represent a group of similar variables. Therefore, factor analysis allows us to reduce and summarize the number of variables that constitute state capacity.

Table 2. Correlation Matrix Among State Capacity Indicators (Statistical Significance in Parentheses)

	Sch. Enroll (%)	Rds. Paved	Drs. per 100,000	Phones per 100,000	Mil. Exp.	Gov. Exp.	GNI
Sch. Enroll (%)	N/A	.816 (.000)****	.814 (.000)****	0.794 (.000)****	.150 (.185)	.248 (.066)*	.613 (.000)****
Rds. Paved	.816 (.000)****	N/A	.782 (.000)****	0.675 (.000)****	.261 (.057)*	.107 (.262)	.549 (.000)****
Drs. per 100,000	0.814 (.000)****	.782 (.000)****	N/A	0.610 (.000)****	.121 (.236)	.149 (.186)	.430 (.003)***
Phones per 100,000	0.794 (.000)****	.685 (.000)****	.610 (.000)****	N/A	.344 (.017)***	.383 (.006)****	.921 (.000)****
Mil. Exp.	0.150 (.185)	.261 (.057)*	.121 (.236)	.344 (.017)**	N/A	-.049 (0.385)	.568 (.000)****
Gov. Exp.	0.613 (.066)*	.107 (.262)	.129 (.186)	.383 (.009)****	-.049 (.385)	N/A	.403 (.006)***
GNI	0.248 (.000)****	.549 (.000)****	.430 (.003)***	.921 (.000)	.568 (.000)	.403 (.006)***	N/A

*p<0.1; **p<0.05; ***p<0.01; ****p<.001

Table 3 displays the results of a principal components factor analysis, which identifies as many factors as there are variables. The table shows the extent to which each factor explains the variance in the data. We also ranked the factors according to amount of variance explained; therefore, table 3 also reports the cumulative amount of variance explained. Factor 1 explains 57.9 percent of the variance; factor 2 explains 16.7 percent of the variance; and factor 3 explains 15.2 percent of the variance. Cumulatively, these three factors account for 89.9 percent of the variance in the data.

Table 3. Principal Component Factor Analysis

Factor	% Variance Explained	Cumulative % Variance Explained	Eigenvalue	Cumulative Eigenvalue
1	57.911	57.911	4.054	4.054
2	16.707	74.628	1.170	5.224
3	15.201	89.829	1.064	6.288
4	5.166	94.995	.362	6.650
5	2.548	97.849	.200	6.850
6	1.814	99.663	.127	6.977
7	0.337	100.00	.024	7.001*

*This figure is slightly over 7.0 because of rounding.

The Eigen values indicates the number of variables that each factor represents in terms of explaining the variance in the data. Thus, factor 1 explains as much of the variance as 4.05 variables would, and factors 2 and 3 each explain as much variance as slightly over 1 variable. Factors 4, 5, 6, and 7 each explain as much variance as a fraction of a variable. Since the goal of factor analysis is to reduce

variables, factors with Eigen values less than 1 are not useful and should be discarded. Consequently we retained the first three factors, which cumulatively explain 89.8 percent of the variance and yielded 6.29 Eigen values—close to the initial number of seven variables. In other words, using only the first three factors instead of the seven individual indicators does not cause us to lose much explanatory power, but it does reduce the number components comprising state capacity.

Table 4 shows the extent to which each variable loads onto each of the three factors. Load values that are close to +1 or -1 indicate that the variable is closely related to that factor. Therefore, percent enrolled in secondary school, percent of roads that are paved, telephones per 100,000 people, physicians per 100,000 people, and GNI per capita are all related to factor 1. Since these variables all involve conditions necessary for economic development, we can call this factor the economic resilience factor. Military expenditure per capita, per soldier is the only variable that loads high on factor 2, therefore, we will call this factor the military expenditure factor. Government expenditure is the only variable that loads high on factor 3; consequently, this will be called the government expenditure factor. These factor loadings demonstrate that state capacity is best measured through variables that include economic development, military expenditure, and government expenditure.

Table 4. Factor Loadings

Variable	Factor 1	Factor 2	Factor 3
School Enrollment	.901	-.309	-.017
% Roads Paved	.850	-.282	-.233
Physicians per 100,000	.797	-.449	-.135
Telephones per 100,000	.929	.144	.120
Military Expenditure	.405	.734	-.457
Government Expenditure	.364	.166	.892
GNI Per Capita	.850	.454	0.91

Additionally, this factor analysis demonstrates that the economic resilience factor (factor 1) is clearly the most influential. Recall that, as table 3 demonstrates, this factor alone explains almost 60 percent of the total variance among the seven variables. These results confirm the earlier findings that the five economic development variables were the most important aspects of state capacity.

Furthermore, the correlation coefficient between factor 1 and AIDS adaptation is 0.374 (p=0.021), which is almost identical to the correlation between our weighted state capacity score and AIDS adaptation. In short, the five economic development variables constitute the most significant part of state capacity. These empirical findings provide preliminary justification for the weighting scheme of the state capacity variables as developed above.

Discussion

The results of our preliminary analysis confirm that there is a correlation between the multivariate empirical index of state capacity and national HIV/AIDS incidence. The data were standardized to a common unit scale and then analyzed using OLS Regression. The balance of evidence suggests that there is a significant positive association between state capacity and change in HIV/AIDS incidence. However, there is also considerable evidence that state capacity is primarily a function of economic resilience variables and not expenditure variables. Therefore, in future research, we will need to refine the index of state capacity.

This preliminary evidence reinforces earlier findings that state capacity has a significant positive association with population health.[17] Moreover, these recent findings suggest that countries with high levels of endogenous capacity will have an easier time of mounting effective responses to HIV/AIDS than countries with middling to low levels of endogenous capacity. This preliminary evidence also serves to reinforce the claims of the dependency school, that countries with lower levels of capacity are trapped in a cycle of decline as the epidemic increasingly erodes their economic power and socio-political stability, which in turn decreases their ability to respond effectively. Consequently, we still need to investigate further those moderating factors that permit states with low to middling capacity to reduce HIV incidence with their populations. We also need to determine the extent to which the intervening variables become more pronounced as state capacity declines.

Additionally, this analysis demonstrates that state capacity alone does not sufficiently explain a nation's ability to generate successful adaptive countermeasures to counter the HIV/AIDS pandemic. The fact that state capacity explains only 38 percent of the variance in adaptation suggests that other variables such as political commitment and community mobilization may be of equal or greater importance in determining whether a country adapts successfully. Certain constituencies in affected countries may prefer to blame their lack of effective response to the epidemic on imbalances in the international political economy, but this approach exonerates apathetic domestic political elites and absolves the populace of responsibility for behavioral change. The balance of evidence suggests that the international distribution of wealth disadvantages poorer nations; however, despite low levels of capacity, countries that exhibit good governance through strong political leadership and community involvement can in fact mount an effective response to reducing HIV incidence in their respective populations.

Notes

[2] See David Gordon, *The Global Threat of Infectious Disease*, Washington, D.C.: National Intelligence Council, 2000; Andrew T. Price-Smith, "Ghosts of Kigali: Infectious Disease and Global Stability at the Turn of the Century," *International Journal* Summer 1999; Robert L. Ostergard Jr., "Politics in the Hot

Zone: AIDS and National Security in Africa," *Third World Quarterly*, vol. 23, no. 2, 2002, pp. 333–350.

[3] See UNAIDS and World Health Organization, *AIDS Epidemic Update 2003*. (Geneva: UNAIDS, 2003), available online at www.unaids.org.

[4] UNAIDS, World Health Organization, and UNICEF. 2002 Estimates of Adult HIV Seroprevalence by Country. Epidemiological Fact Sheets on HIV/AIDS and Sexually Transmitted Infections, available online at http://www.who.int/emc-hiv/fact_sheets/All_countries.html.

[5] See Paul Farmer, *Pathologies of Power: Health, Human Rights, and the New War on the Poor* (Berkeley, CA: University of California Press, 2003); Alan Whiteside, "Poverty and HIV/AIDS in Africa," *Third World Quarterly* 2002, pp. 313–332; Nana Poku, "Poverty, Debt and Africa's HIV/AIDS Crisis," *Journal of International Affairs* vol. 78, no. 3, July 2002.

[6] See UNAIDS, World Health Organization, and UNICEF. Epidemiological Fact Sheets on HIV/AIDS and Sexually Transmitted Infections. It bears noting, however, that in early 2004, Botswana instituted a policy requiring HIV tests to anyone entering a clinic or hospital, unless the patient refused. See Sharon LaFraniere, "Mandatory Tests Bolster Botswana's War on AIDS," *New York Times*, June 14, 2004, p. A8.

[7] For more on Thailand's efforts to reduce HIV/AIDS, see Ellen Nakashima, "Cracks Start to Show in Thailand's Model Anti-AIDS Program," *Washington Post*, July 10, 2004, p. A1.

[8] Theda Skocpol, "Bringing the State Back In: Strategies of Analysis in Current Research," in Peter B. Evans, Dietrich Rueschemeyer, Theda Skocpol, eds., *Bringing the State Back In* (Cambridge: Cambridge University Press, 1985), pp. 3–43.

[9] Joel S. Migdal, *Strong Societies and Weak States* (Princeton: Princeton University Press, 1988).

[10] Pierre Engelbert, *State Legitimacy and Development in Africa* (Boulder: Lynne Riennerm, 2000).

[11] Daniel Esty et al., *State Failure Task Force: Phase II Report* (Washington, D.C.: Science Applications International Corporation, 1997).

[12] Thomas Homer-Dixon, *Environment, Scarcity and Violence* (Princeton: Princeton University Press, 1999).

[13] Andrew T. Price-Smith, *The Health of Nations: Infectious Disease, Environmental Change, and Their Effects on National Security and Development* (Cambridge: MIT Press, 2002).

[14] The 50 countries are: Algeria, Austria, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Benin, Bolivia, Botswana, Burkina Faso, Congo, Costa Rica, Czech Republic, Eritrea, Equatorial Guinea, Ethiopia, Georgia, Ghana, Indonesia, Iraq, Israel, Kazakhstan, Latvia, Lebanon, Luxembourg, Madagascar, Moldova, Morocco, Netherlands, New Zealand, Niger, Norway, Paraguay, Peru, Portugal, Qatar, Romania, Rwanda, Sierra Leone, Slovenia, Sri Lanka, Suriname, Sweden, Switzerland, Ukraine, United Kingdom, United States of America, Yemen, and Zimbabwe.

[15] Price-Smith, *The Health of Nations*, pp. 32–39.

[16] $Z = (X_i - \text{mean-}X)/s$

[17] Price-Smith, *The Health of Nations*.