WPS 2874

POLICY RESEARCH WORKING PAPER 2874

The Risks and Macroeconomic Impact of HIV/AIDS in the Middle East and North Africa

Why Waiting to Intervene Can Be Costly

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August 2002

Abstract

Robalino, Jenkins, and El Maroufi develop a model of optimal growth to assess the risks of an HIV/AIDS epidemic and the expected economic impact in nine countries in the Middle East and North Africa region—Algeria, Djibouti, Egypt, Iran, Jordan, Lebanon, Morocco, Tunisia, and Yemen. The model incorporates an HIV/AIDS diffusion component based on two transmission factors—sexual intercourse and exchange of infected needles among intravenous drug users. Given high levels of uncertainty on the model parameters that determine the dynamics of the epidemic and its economic impact, the authors explore large regions of the parameter space. The prevalence rates in year 2015 would be below 1 percent in 16 percent of the cases, while they would be above 3 percent in 50 percent of the cases. On average, GDP losses across countries for 2000–2025 could approximate 35 percent of today's GDP. In all countries it is possible to observe scenarios where losses surpass today's GDP. The authors quantify the impact of expanding condom use and access to clean needles for intravenous drug users. They show that these interventions act as an insurance policy that increases social welfare. They also show that delaying action for five years can cost, on average, the equivalent of six percentage points of today's GDP.

This paper—a product of the Human Development Group, Middle East and North Africa Region—is part of a larger effort in the region to raise awareness about the social and economic cost of HIV/AIDS. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Cheikh Fall, room H8-118, telephone 202-473-0632, fax 202-477-0036, email address cfall1@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. David Robalino may be contacted at drobalino@worldbank.org. August 2002. (34 pages)

Risks and Macro-Economic Impacts of HIV/AIDS in the Middle East and North Africa:

Why waiting to intervene can be costly

by

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Introduction

In 1991, with the evidence available at the time, experts estimated that by the year 2000, 15-20 million adults and 5-10 million children cumulatively would become infected with HIV. By the end of 2001, The World Health Organization (WHO) reported 40 million people were living with HIV/AIDS and 5 million new infections had occurred during the year. The great difference between earlier projections and current estimates reflects both the unexpected spread of the virus and the inadequacy of statistics used to track the epidemic. HIV does not always spread rapidly, though it certainly can if conditions permit. Rapid social and economic changes underlie the virus's spread in most of Africa, Russia, Central Asia, Eastern Europe, China, and elsewhere. HIV epidemics have been particularly sensitive to large migrations of people, wars, economic downturns, and other drastic alterations in social stability. WHO estimates that 1.2% of all adults on earth are presently infected with HIV and all experts agree that the worst effects of the pandemic are yet to come.

This paper is a first attempt to evaluate the risks of an epidemic in 9 Middle East and North Africa (MENA) countries[1] and its potential economic costs, while at the same time assessing the welfare implications of two preventive interventions: expanding condom use and access to clean needles for Injecting Drug Users (IDUs). WHO estimated that approximately 80,000 persons were newly infected with HIV in the MENA region in the year 2001, and that about 0.2% of adults in the region are currently infected. These figures are relatively low, compared to Africa, South and SE Asia and the Caribbean, but do not assure safety for the region. Inadequate methods of surveillance, universal in the region, can easily miss outbreaks in hidden populations. Further, even in low prevalence nations, the situation can change rapidly, as has occurred in Indonesia and Nepal.

Unfortunately, in MENA countries, continued low levels of case detection through mostly mandatory screening, the lack of appropriate behavioral data, and over-confidence in the protective effects of social and cultural conservatism have dictated low priority for HIV/AIDS Yet, there is evidence that the necessary risk factors to the spread of the epidemic are present. The first group is comprised of those with known risky behaviors, such as prostitutes, their clients, IDUs, Men who have Sex with Men (MSM), and those who acquire Sexually Transmitted Diseases (STDs). These persons are immediately at-risk. While it is likely that they represent a minority in any country, our analysis shows that any such group can become the core of spread into the rest of the population, depending upon the extent and nature of social linkages and networks. The next groups are those who may be considered vulnerable (i.e., could be at-risk if and when their life situation changes). For example, migrants going to work abroad, refugees, tourists traveling for fun and recreation, non-injecting drug users who may switch to injecting when the availability or price of the drug changes, and young people in general, in that some proportion will engage in non-marital sex under certain conditions. Further, structural factors, such as poor and dysfunctional health care systems, raising unemployment and poverty rates, and income and gender inequality create an environment that is suitable for the diffusion of the epidemic (see Over, 2000; and Jenkins and Robalino, 2002, Ch. 4, for econometric analysis of the socioeconomic determinants of HIV prevalence rates using cross-country data).

Clearly, there are methodological difficulties to predict the dynamics of the epidemic in different countries and to evaluate economic impacts. These difficulties are amplified by the lack of substantial HIV-related social or behavioral research in the region. Our analysis builds upon the large body of applied research on the economics of HIV/AIDS that has been conducted over the past 10 years. One tradition within this literature has focused on estimating econometrically, on the basis of

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[1] The countries included in the analysis are: Algeria, Djibouti, Egypt, Iran, Jordan, Lebanon, Morocco, Tunisia, and Yemen.

cross-country data, whether the HIV/AIDS incidence and prevalence rates impact economic growth. Given the difficulties in isolating the effects of HIV/AIDS from other factors, the evidence is mixed. Using an econometric model based on EPIMODEL (Chin, 1990), Bloom and Mahal (1997) find no significant correlation between the HIV/AIDS incidence rate and economic growth. On the other hand, using panel data on prevalence rates and GDP per capita, Bonnel (2000) finds that growth rates in Africa's most affected countries could have been higher by 1 percentage point in the absence of HIV/AIDS. A second tradition uses household surveys to study the impacts of the epidemic on household income. Bollinger et al. (1999), for example, find that rural household in Kenya could see their income fall by over 50% as a result of AIDS. In Kagar-Tanzania, Over et al. (1999) infer that household food expenditure per capita after the death of a household member is reduced by 32% and food consumption by 15%. A third tradition, to which our paper subscribes, uses simulation models to explore the impacts of HIV/AIDS on the economy through three main channels: premature deaths that affect the size and composition of the labor force, increases in morbidity and health expenditures that affect total factor productivity, and potentially lower saving rates that affect investments and growth. Micro-simulations by Soucat (2001) in the case of Chad and Ellis et al. (1997) in the case of India, for example, predict that health expenditures could increase by a factor of 2 to 3. Macro-simulation models, on the other hand, predict that in affected countries (countries where prevalence rates have surpassed 5% and continue on an upward trend) reductions in per capita GDP growth rates could be in the order of 0.5% to 1.5% per year (see, for instance, Over, 1992 for an application to Sub-Saharan Africa; Cuddington, 1993 for an application to Tanzania; Leighton, 1993 for an application to Thailand; Nalo and Aoko, 1994 for an application to Kenya; Lewis, 2000 and Quattek, 2000 for an application to South Africa; and MacFarlan and Sgherri, 2001 for a recent application to Botswana). The structure of these models has evolved over time from the one sector Solow-type model (Cuddington 1993), to models that allow to differentiate the effects that the epidemic has on skilled, unskilled, and unemployed workers (see MacFarlan and Sgherri, 2001), and where the savings rate of the economy is endogenous (see, Robalino et al., 2002 for an application to estimate optimal reduction targets for the HIV/AIDS incidence rate in Kenya). General Equilibrium Models have also been developed to evaluate the impact of the epidemic across sectors and relative prices (see, Kambou et al., 1992 for an application to Cameroon). While these models necessarily leave out important aspects of the interplay between the economy and the epidemic (e.g., the role of migration, multi-sectorial heterogeneity, social costs related to the increase in single parents households and the number of orphans, distortionary effects introduced when mobilizing resources to cure AIDS patients), they are useful to put boundaries on the magnitude of the potential economic impacts of the epidemic. The main limitation, however, is that model parameters rarely result from robust statistical inference and standard sensitivity analysis leave wide regions of the parameter space unexplored.

The model used in this paper has many of the features of other macro-models in the economics literature. The main addition is that it incorporates an HIV/AIDS diffusion component where the virus transmission occurs through sexual intercourse and the exchange of infect needles among IDUs. This allows us to simulate the impact of interventions such as improving access to condoms and clean needles for IDUs. Nonetheless, our efforts have not concentrated on model design, but rather on simulation design. Indeed, we recognize that the economy and the epidemic create a complex system that is structurally unpredictable. This unpredictability deepens when data to estimate model parameters is scant. The approach taken here has been to construct wide confidence intervals for model parameters, based on estimates from the literature and known economic constraints, and then conduct an extensive exploration of the parameter space to characterize the ensemble of plausible futures that the model can generate given countries' initial conditions (see Bankes, 1993; Lempert et al., 1996; and Robalino and Lempert, 2000, for other applications of exploratory modeling methods). Finally, we analyze the robustness of policy interventions against the wide range of futures.

The paper is organized in 4 sections. Section 1 develops the model used in the analysis. Section 2 applies the model to explore alternative diffusion scenarios and potential macroeconomic impacts in MENA countries. Section 3 evaluates the welfare gains that could be induced by two classic interventions: distributing condoms and improving access to clean needles for IDUs. Finally, Section 4 summarizes the major conclusions from the analysis and discusses some of its limitations.

1. The Model

Our model focuses on 4 channels through which the epidemic affects the economy: the size and composition of the labor force; productivity growth; health expenditures; and the savings rate of the economy. Other channels, such as reductions in human capital resulting from an increase in the number of orphans, who are less likely to fully develop their physical and intellectual capacities[2], are ignored for methodological reasons. Thus, it can be said that our model underestimates the economic cost of the HIV/AIDS epidemic.

The model has been modified from its original version (see Robalino et al., 2002) in two important ways. First, we introduce three types of labor than can be affected differently by the epidemic: skilled labor, unskilled labor, and unemployed labor. Second, we couple the macroeconomic model to an HIV/AIDS diffusion model that simultaneously takes into account sexual transmission and transmission through the sharing of infected needles among IDUs (the two major transmission mechanisms in the case of MENA countries). This is a convenient feature of the model as it allows us to simulate the welfare implications of specific interventions such as increasing condom use and access to clean needles for IDUs.

Another important feature of the model is that the savings rate of the economy is computed endogenously to maximize inter-temporal social welfare. This enables us to simulate the economic impacts of the epidemics under "ideal conditions" and to take a normative stance in terms of when and how governments should intervene[3]. In fact, the assumption introduced in most models that savings are reduced as a result of the epidemic is not supported by empirical data (see Robalino, 2002). In the absence of well functioning insurance markets, rational agents may actually increase savings to protect themselves against potentially high future health expenditures (see Appendix A for a technical discussion). The ultimate effect that HIV/AIDS has on the savings rate of the economy will depend on how it affects agents' preferences (risk aversion, discount rates) and the government fiscal balance. For simplicity, our simulations will keep preferences constant and assume that societies respond optimally to the shock resulting from the epidemic. This, again, would underestimate the welfare impacts of the epidemic.

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[2] Research has shown that beyond the psychological impacts, among low-income populations, the death of one parent is associated with a deterioration of nutritional status and lower school enrollment rates (see Ainsworth M. and Koda G., 1993).

[3] The implicit assumption is that the consumption of health services to treat AIDS patients is included in the consumption bundle.

Modeling the economy

The model is based on the assumption that the output of a given economy can be represented as a simple function of human and produced capital.

$$Y_t = L^{1-\theta} K_t^{\theta} A_t, \tag{1}$$

where Y is GDP, K is the stock of produced capital, L is quality adjusted labor, our proxy for human capital, and A is a scale factor. The growth rate of A captures changes in total factor productivity and its dynamic is determined exogenously, we have:

$$\log A_t = \log A_{t-1} + \gamma_a \exp(-\delta_a t), \tag{2}$$

where γ_a is the growth rate of aggregate labor productivity and δ_a is the yearly change in this growth rate (see Pfizer, 1998 for a similar formulation).

Human capital is defined by:

$$L_t = \sum_i a_i N_{it}; \ i \in I, \tag{3}$$

where N_i is the number of workers of type i, a_i is the productivity of labor type i, and **I** is the set of labor types. It is convenient to rewrite equation (3) as:

$$L_t = q_t N_t, \tag{4}$$

where q_t is the average quality of labor at time t, given by:

$$q_t = \frac{1}{N_t} \sum_i a_i N_{it}; \ i \in \mathbf{I}, \tag{5}$$

For simplicity in this application we use three types of labor: skilled (a=1), unskilled (a=0.5), and unemployed (a=0). Given little knowledge about the workings of the labor markets in the MENA region, we have avoided modeling explicitly its dynamics (i.e., by formalizing labor supply and demand decisions). Instead, we make assumptions about transition probabilities between different types of labor and treat the growth rate of the aggregate labor force exogenously. This treatment is sufficient to achieve our objective of been able to simulate the impact of alternative distributions of the burden of HIV/AIDS across the labor force. Thus, we postulate:

$$\mathbf{N}_t = \boldsymbol{\eta}_1 [\mathbf{N}_{t-1} - \mathbf{D}_{t-1}] + \boldsymbol{\eta}_2' \Delta N_t, \tag{6}$$

where N is a (3 ,1) vector giving the number of workers in each labor class, η_1 is a (3 ,3) matrix of transition probabilities, D is a (3 ,1) vector giving the number of deaths due AIDS in each labor class, η_1 is a (1 ,3) vector giving the share of new workers going to each labor class, and ΔN is the number of new workers. The dynamics of the total number of workers is characterized as follows:

$$\begin{cases} N_t = \exp[\log(N_{t-1}) + \gamma_n \exp(-\delta_n t)] - \Delta H_{t-10} \\ H_t = \beta_t N_t \end{cases}, \qquad (7)$$

where H is the total number of HIV/AIDS infected individuals and β is the aggregate HIV/AIDS prevalence rate. The prevalence rate is determined by the HIV/AIDS diffusion model described in the next section.

To derive the optimal savings rate, and therefore the dynamics of the stock of produced capital, we assume that the economy operates along a path that maximizes social utility, assumed to be a function of aggregate consumption. More specifically, we solve the following optimization problem:

$$\text{Max}_C : V(C_t) = \sum_t \rho^t \left\{ N_t \frac{(C_t / N_t)^{\tau}}{1-\tau} \right\}$$

$$\text{s.t.:} \quad K_t = K_{t-1}(1-\delta_k) + (Y_t - C_t), \qquad (8)$$
$$(1), (2), (4), \text{ and } (5).$$

where δ_k is the depreciation rate for produced capital, ρ is a discount factor, and τ is the coefficient of risk aversion. We use a standard constant elasticity of substitution utility function that is population weighted. By aggregating across the population we are able to capture part of the welfare losses due to the reduction of the labor force resulting from AIDS related deaths[4].

It can be shown that under optimality conditions the dynamics of the stock of produced capital can be approximated by:

$$\Delta \ln(K_{t+1}/N_{t+1}) = \alpha_1 + \alpha_2 (\ln(K_{t+1}/N_{t+1}) - \ln(T_t)), \qquad (9)$$

where $T_t = q_t A_t^{1/(1-\theta)}$, and α1 and α2 are functions of the sequence $\{q_t\}$, the growth rate of the labor force, and of the parameters γ_a, δ_k, θ, τ, and ρ (see Appendix B).

Up to here, the HIV/AIDS epidemic affects the size of the labor force and its composition, thus perturbing the quality of the labor force (through equation 5) and the savings rate of the economy (through equation 9). In addition, we consider the possibility that the HIV/AIDS prevalence rate affects the aggregate level of productivity (see for instance Haccker, 2001). This may occur as labor turnover and absenteeism increase and as firms divert resources to preventive activities. This can also occur if economic efficiency decreases as resources are allocated to treat HIV/AIDS patients, or as social capital is eroded. To formalize this idea we simply postulate that the realized level of productivity is given by:

$$A_t^* = A_t(1 - d_1 \beta_t - d_2 c_{ht}), \qquad (10)$$

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[4] Notice that as long as τ<1 $\partial U/\partial N = (1+\tau)N^{\tau}C^{\tau} + N^{1+\tau}\tau C^{\tau-1}\partial C/\partial N > 0$, so that a reduction in N, as a result of HIV/AIDS, results in a welfare loss.

where d_1 and d_2 are the parameters determining productivity losses, and c_h is the share of HIV/AIDS health related expenditures in GDP. In the presence of HIV/AIDS, A* replaces A in equations (1) and (3) to (9). We notice that the implicit assumption behind this formulation is that HIV/AIDS does not have *permanent* effects on total factor productivity. In other words, if the prevalence rate drops to zero at time t, total factor productivity will return to its steady-state level (A*=A). This again is a conservative assumption (for a case where the impacts are permanent see MacFarlan and Sgherri, 2001).

Health expenditures are simply modeled by keeping track of an average expenditure per patient (which depends on the level of GDP per capita) and a given level of access to health services. We have:

$$c_{h,t} = \left(\lambda_0 (y_t)^{\lambda_1} \lambda_2 H_t\right) / Y_t, \tag{11}$$

where λ_0 and λ_1 are the parameters determining the average cost of treating a patient as a function of GDP per capita (y), and λ_2 gives the share of the stock H of infected individuals who have access to curative services.

Modeling the diffusion of HIV/AIDS

As with any other infectious disease, the diffusion of HIV/AIDS depends on its *reproduction rate*. This is the average number of people who are infected by a person carrying the virus during his/her life span. The higher the reproduction rate, the faster the diffusion of the disease. Diseases that have a reproduction rate lower than 1 gradually disappear. In the case of HIV/AIDS, the reproduction rate is determined by the types of contagion mechanisms (e.g., sexual intercourse, sharing of infected needles among drug users, mother to child, blood transfusion, or repeated use of needles in hospitals and health centers), and three elements associated with each of them: the *duration of the period during which an individual can transmit the disease* through the given mechanism; the *risk of transmission* per contact; and the *frequency and heterogeneity of contacts*.

In this study we simulate the diffusion of the HIV epidemic trough two channels: sharing of infected needles among IDUs and sexual intercourse. The former is based on Law (2001), while the latter is based on the model AVERT developed in Rehle et al. (1998). AVERT was modified to consider additional population groups (the original model has only two population groups) and to introduce time (the original model is static)[5].

Our model divides a country's population aged 15-49 into 5 groups: sex workers, IDUs female, IDUs male, low-risk female, and low-risk male. In terms of infections related to needle sharing, the model assumes that needles are shared at random (this assumption is introduced for tractability). Hence, the probability that an uninfected IDU would become infected between time t-1 and t, is given by:

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[5] An alternative to the current model would have been a more complex agent-based model. Nonetheless, the time needed for calibration, simulation, and analysis of agent-based models tends to increase considerably. The current model is considered an adequate compromise. Moreover, AVERT, despite its simple formulation, has shown to produce reasonable forecasts of infections averted as a result of interventions such as increasing condom use or reducing the prevalence of STDs. For other non-agent models of the epidemic see Stover and Way, (1995) and Stover (1997).

$$\Pr_{it} = 1 - \left\{ \sum_{d} \phi_d \left[\beta_{dt} (1 - r_{idu}) + (1 - \beta_d) \right] \right\}^{n(1-u-dU)} \quad i \in D \;\; \forall \;\; d \in D, \tag{12}$$

where D is the vector of IDUs population groups (in this case D has two elements: male and female), ϕ_d is the share of the population of group d in the total population of IDUs, β_{dt} is the HIV/AIDS prevalence in the population group d, r_{idu} is the probability of infection after an injection with an infected needle, n is the total number of injections between time t-1 and time t, u is the share of these injections which use safe needles, and dU is a policy variable introduced to simulate reductions in sharing practices. In equation (10) the expression between {} is the probability of remaining uninfected after an injection with a shared needle. The probability that the needle will come from group d is given by ϕ_d. Within this group, the probability that the needle is infected is given by β_d, the HIV/AIDS prevalence rate in group d. Finally, if the needle is infected, the probability that the individual will not acquire HIV is given by $1-r_{idu}$. To obtain the joint probability of remaining uninfected after n injections, taking into account that a share 1-u-dU of these injections takes place through shared needles, we simply raise the expression in brackets to the n(1-u-dU) power.

In the simulations, before considering infections due to sexual intercourse, the prevalence rate for the IDUs population groups is updated on the basis of equation (10). We get:

$$\beta_{dt} = (H_{dt} + N_{dt}(1 - \beta_{dt})\Pr_{dt}) / N_{dt}, \tag{13}$$

where H_{dt} is the stock of HIV/AIDS infected individuals at time t in group d. At this stage deaths are not yet taken into account.

In terms of infections sexually transmitted we follow the same mechanics than the model AVERT. The probability that an HIV negative individual would become infected at time t is given by:

$$\Pr_{it} = 1 - \prod_{j} \left\{ \left[\beta_{jt} \left(\sum_{s} w_s (1 - r_s (1 - (f + dF)e))^{n_{ij}} \right) + (1 - \beta_{jt}) \right]^{m_{ij}} \right\} \quad i \in J; j \in J_{-i}; s \in S, \tag{14}$$

where J is the vector of population groups (5 in this case), β_{jt} is the HIV/AIDS prevalence observed in group j at time t, S is a vector containing different STDs status (four cases are considered: non-STDs, ulcerative STDs, non-ulcerative STDs, and both ulcerative and non-ulcerative), w_s is the probability of observing state s, r_s is the probability of HID/AIDS transmission after intercourse in status s, f is the probability of using condoms, e is the effectiveness of the condoms, m_{ij} is the average number of sexual partners that individuals of group i have in group j, and n_{ij} is the average number of intercourses with each partner between time t and t+1. Similar to the case of equation (12), the expression between {} gives the probability that an uninfected individual in group i would remain uninfected after sexual intercourse with m_{ij} partners in group j. The product over the J groups gives the joint probability of remaining uninfected after sexual intercourses with the partners in all groups. Inside the brackets, the probability that the partner will be infected with HIV is approximated by the prevalence rate β_j. If the partner is infected, the probability of remaining uninfected after n_{ij} intercourses is given by the expression in parenthesis. The probability of infection is given by r_s, which depends on whether the partner suffers from an STD. As previously mentioned, the probability of having different types of STDs is given by w_s. Therefore, the sum gives the expected probability of remaining uninfected after one intercourse with a partner, taking into account the prevalence of STDs.

Under these assumptions, the dynamics of the HIV/AIDS prevalence rate is given by:

$$\beta_{t+1} = \left(\sum_j H_{jt} + N_{jt}(1-\beta_{jt})\Pr_{jt} - \Delta H_{jt-10} \right) / N_{t+1} \,, \tag{15}$$

Calibrating models parameters

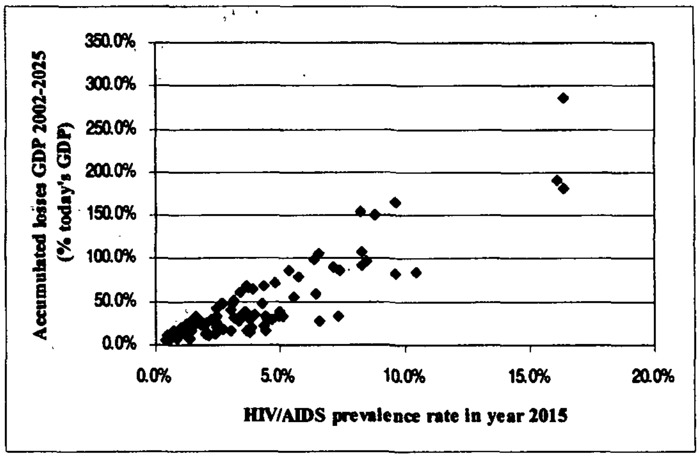
The model parameters can be grouped into three categories: economic parameters (those influencing growth and the dynamics of labor markets); parameters determining the economic impact of the epidemic for a given prevalence rate; and parameters affecting the diffusion of the epidemic (see Appendix C for a summary of parameter values and a description of calibration methods). Key economic parameters were estimated in order to replicate targets in terms of economic growth and savings rates, on the basis of the World Bank Country Assistance Strategies for each of the countries included in the analysis (World Bank 1997, 1999b, 1999c, 2000, 2001a, 2001b, 2001c, 2001d, 2002a). For the parameters determining the diffusion of the epidemic and potential economic impacts (for instance the distribution of deaths among skilled and unskilled workers), given the lack of data, we defined uniform probability distributions. The supports of these distributions were calibrated on the basis of results from the literature, in particular the works of Haacker (2001), MacFarlan and Sgherri (2001), Bonnel (2000), and Ainsworth and Over (1994), for economic impacts; Floyd and Gilks (2001), United Nations (2001), and Cavallini et al. (2000), for estimates about health expenditures; Jenkins et al. (2002) and Rehle et al. (1998), for sexual and drug use behavior; and UNAIDS and Jenkins and Robalino (2002), for initial prevalence rates.

2. Simulating the costs of inaction

Given high levels of uncertainty in terms of model parameters traditional simulation methods, where outcome variables are analyzed for a handful of scenarios, are not appropriate. Here we adopt an exploratory modeling approach (see Bankes, 1995). Hence, for each country, we sample a large number of points in the parameters space from the uniform probability distributions described in the previous section (our priors). At each of these points we compute the value of five variables of interest: the present value of total GDP and its average growth rate during the period 2000-2025; the size of the population in year 2025; and the HIV/AIDS prevalence rate and HIV/AIDS related health expenditures in year 2015.

As an illustration, Figure 1 graphs losses in the present value of total GDP and the HIV/AIDS prevalence rate for 100 sampled points in the case of Tunisia. We observe that there is a wide range of plausible futures (see Appendix D for a sample of diffusion profiles). The HIV/AIDS in year 2015 could fluctuate anywhere between 0.18% and 15%, while losses in the present value of GDP for the period 2000-2025 could be equivalent to 2% to 300% of today's GDP. Clearly, not all the futures have the same likelihood. For instance, in 35% of the cases explored the HIV/AIDS prevalence rate in year 2015 would be below 2%. That being said, only in 16% of the cases the HIV/AIDS prevalence would be below 1%. In fifty percent of the cases, the prevalence rate would be above 3%.

Figure 1: Tunisia: plausible futures for the HIV/AIDS prevalence rate and losses in GDP (2000-2015)



The same type of analysis was conducted for the 9 countries included in the study. For each country we summarize the distribution of the output variables of interest by reporting the mean, standard deviation, and the minimum and maximum values (see Table 1). Graphics of the full distributions are provided in Appendix E. All distributions deviate from the normal distribution, and therefore one needs to be careful when interpreting the means.

Table 1: Descriptive statistics for Selected Output Variables (Status-quo)

Country	Statistic	pvGDP[2000-2025] loss (% today's GDP)	Average GDP growth rate (2000-2025)	Population change in 2025 (%)	HIV prevalence 2015 (%)	Health expenditures 2015 (% GDP)
Algeria	Mean	36.2%	-0.32%	-3.5%	3.9%	1.3%
	std	36.7%	0.37%	2.8%	3.5%	1.2%
	min	4.5%	-2.39%	-13.7%	0.4%	0.1%
	max	222.2%	-0.03%	-0.6%	17.1%	5.8%
Djibouti	mean	227.1%	-1.64%	-22.2%	18.3%	6.4%
	std	121.5%	1.24%	10.6%	12.4%	4.4%
	min	85.2%	-7.19%	-53.6%	2.5%	0.9%
	max	698.2%	-0.36%	-8.2%	55.3%	19.9%
Egypt	mean	44.3%	-0.33%	-3.2%	3.8%	1.3%
	std	47.6%	0.40%	2.6%	3.3%	1.1%
	min	4.4%	-2.61%	-12.7%	0.4%	0.1%
	max	285.4%	-0.03%	-0.5%	16.1%	5.5%
Iran	mean	33.6%	-0.33%	-3.3%	3.7%	1.3%
	std	36.0%	0.41%	2.6%	3.3%	1.1%
	min	3.3%	-2.67%	-12.8%	0.4%	0.1%
	max	215.8%	-0.03%	-0.5%	15.9%	5.4%
Jordan	mean	27.9%	-0.27%	-2.6%	3.2%	1.1%
	std	31.0%	0.34%	2.1%	2.8%	1.0%
	min	2.3%	-2.18%	-10.5%	0.3%	0.1%
	max	187.8%	-0.02%	-0.3%	14.0%	4.8%
Lebanon	mean	26.3%	-0.36%	-3.8%	4.1%	1.3%
	std	26.9%	0.43%	3.0%	3.6%	1.2%
	min	3.1%	-2.77%	-14.8%	0.4%	0.1%
	max	161.8%	-0.03%	-0.6%	17.5%	5.7%
Morocco	mean	33.2%	-0.33%	-3.3%	3.7%	1.3%
	std	35.3%	0.40%	2.6%	3.3%	1.1%
	min	3.5%	-2.55%	-13.1%	0.4%	0.1%
	max	211.5%	-0.03%	-0.5%	16.0%	5.4%
Tunisia	mean	45.5%	-0.34%	-3.5%	3.8%	1.2%
	std	47.7%	0.41%	2.8%	3.3%	1.1%
	min	5.2%	-2.62%	-13.7%	0.4%	0.1%
	max	286.1%	-0.03%	-0.5%	16.4%	5.3%
Yemen	mean	31.4%	-0.27%	-2.5%	3.3%	1.2%
	std	34.8%	0.33%	2.0%	2.9%	1.1%
	min	2.6%	-2.17%	-9.8%	0.3%	0.1%
	max	211.7%	-0.02%	-0.3%	14.1%	5.2%

The level of uncertainty surrounding the dynamics of HIV/AIDS is considerable. Given that all countries start from similarly low baselines, the range of variation of the prevalence in year 2015 is similar (between 0.3% and 17% excluding Djibouti). Across countries, losses in the present value of GDP per capita could range between close to 2.3% of today's GDP to over 100% (in Djibouti maximum impacts could be equivalent to 7 times current GDP). Average real GDP growth rates for the period could be reduced by 0.02% to 2.7% per year. The size of the population in year 2025 could be reduced by 0.3% to 15%, and HIV/AIDS related expenditures could increase by 0.1% to 6% of GDP in year 2015.

On average, impacts are likely to be considerable. Excluding Djibouti, the average HIV/AIDS prevalence rate in year 2015 across scenarios approximates 4%. The GDP growth rate for the period 2000-2025 could be reduced, on average, by 0.27% per year in Yemen and Jordan, to 0.36% in Lebanon, and over 1.6% in Djibouti. Lower economic growth would result in output losses for the period 2002-2025 equivalent to 31.4% of today's GDP in Yemen, 36% in Algeria, 44.3% in Egypt, and 227% in Djibouti. In year 2015, HIV/AIDS related health expenditures could average 1.2% of GDP. By year 2025, the labor force could have been reduced by 2.5% in Yemen to 4% in Algeria and 22% in Djibouti. Thus, regardless of the distribution of factors that affect the vulnerability of different countries (differences in unemployment rates, the share of labor in total inputs, the growth rate of labor productivity), HIV/AIDS poses a considerable treat.

The HIV/AIDS epidemic presents a typical problem of decision making under conditions of deep uncertainty. Prevalence rates could remain at low levels, but there is also a risk that the epidemic reaches alarming levels and causes not only economic damage, but also grieve as individuals in their most productive ages die. The next section discusses the type of policy interventions that could be implemented to insure societies against these risks.

3. Social gains from preventive interventions

It has been extensively discussed in the policy arena that governments have a key role in developing and financing the implementation of policies to confront HIV/AIDS. Indeed, individuals alone could not devise appropriate mechanisms to contain the epidemic. First, individuals do not take into account the social costs of the risks they take, or the social benefits of the preventive measure they adopt. In an unregulated market we would observe an excess of risky behavior and too little prevention from a social point of view. A second reason is given by information problems. Individuals may not have enough information about the risks of HIV and may lack knowledge about preventive behaviors. Finally, cultural/religious values may constraint individuals' actions in ways that render them, and society, more vulnerable to HIV/AIDS. The role of Governments in providing information and subsidizing interventions to reduce risky behaviors is therefore critical.

Governments can only intervene, however, if there are cost-effective interventions at their disposable. Fortunately, international experience has demonstrated that this is the case with HIV/AIDS. Recent studies show that interventions which focus on reducing risks (through information and preventive behaviors and services) in those population groups most likely to contract and spread HIV can be highly cost-effective (see Kahn, 1996). Interventions such as reproductive health and HIV/AIDS education in schools, targeted STD treatment for highly vulnerable groups, and harm reduction for IDUs have also proved to be cost-effective (see Jenkins, 2002). In general early interventions bring higher benefits and lower costs.

The question of interest for policymakers in MENA countries, where prevalence rates remain low and future dynamics are highly uncertain, is whether there are still interventions that government could/should implement. We focus on two classical interventions: condoms' distribution and expanding access to safe needles for IDUs. As previously discussed, heterosexual transmission and transmission through the sharing of infected needles among IDUs are the two major mechanisms that could sustain the development of the epidemic.

To implement these policies we affect the parameters dU (equation 12) and dF (equation 14), which are respectively the reduction in the probability of sharing a needle and the increase in the probability of using a condom. The total costs of these interventions is given by:

$$\cos t(dF, dU, s) = \sum_{t=s}^{T} \rho\left[sex(t).dF.p_c + drugs(t).dU.p_n\right], \tag{16}$$

where s is the time when the policy is in effect, sex(.) is a function giving the total number of sexual contacts, drug(.) is a function given the total number of needles consumed (both defined on the basis of equations 12 and 14), and p_c and p_n are respectively the average costs of distributing a condom and a needle.

We simulate two policies that are summarized in Table 2. In both cases, dU is set equal to 0.20 (that is the probability of sharing a needle is reduced by 20 percentage points) and dF is set equal to 0.30 (the probability of using a condom increases by 30 percentage points). The first case sets s=1 (i.e., the policy is implemented immediately), while the second case sets s=5 (the policy is implemented after 5 years). Since we prefer to underestimate benefits and overestimate costs, we work with high-end estimates from the literature. Thus, we assume that the average cost of distributing a condom is equal to USD 0.5 while the average cost of distributing a needle is equal to USD 1.5 (see Table 3).

Table 2: Two interventions: expanding condom use and access to safe needles for IDUs

	Policy A	Policy B
Increase in condom use (dF)	30%	30%
Reduction in needle sharing (dU)	20%	20%
Year when the policy is implemented (s)	1	5
Average cost condom in USD (Pc)	0.5	0.5
Average cost needle in USD (Pn)	1.5	1.5

Table 3: Unit costs for a needle distribution intervention

Input	Cost	Unit
Cost needle and syringe	0.1	per unit
Rent drop-in center	165	month
Electricity drop-in center	35	month
Supervisor drop-in center	3,000	year
Cost distributor	2	day

We assume that all costs are directly subtracted from GDP[6]. For each sampled point in the parameter space we then re-compute the same five output variables than in the non-intervention case.

[6] At the macro level this is not necessarily the case, since the production and distribution of condoms and needles can also contribute to GDP. A more realistic approach, but less conservative, would have been to look at the distortionary effects of reallocating resources to the production and/or importation and distribution of needles and condoms.

In Table 4 we summarize the new set of descriptive statistics when the policy is implemented today, as well as changes in the means with respect to the non-intervention cases and the standard error of the estimate of this change (in italics). We measure the efficiency of the policy intervention by its impact on total GDP. We observe that, averaging across scenarios, GDP losses during the period 2000-2025 are significantly reduced, by an equivalent of 15.5% of today's GDP in the case of Jordan, to 27% in the case of Egypt, and 71% in the case of Djibouti. This is after taking into account the costs of distributing condoms and needles. Lower losses result from a significant reduction in the average HIV/AIDS prevalence rate in year 2015 (minus 2.8 percentage points). We observe that the minimum and maximum loss (that is the extremes of the support of the distribution) are reduced as well. The latter in particular is reduced by an equivalent of 100% of today's GDP in the case of Yemen, to 200% in the case of Egypt. This is a clear illustration of how to mitigate the risks associated with HIV/AIDS. In other words, even if the likelihood of each scenario remains de same, the loss in each case would be considerably reduced. Implementing the policy can then be considered as a form of insurance against the risks of the epidemic.

The policy intervention also produces statistically significant reductions in population losses and health expenditures. In most countries the total population in year 2025 could be 2.4% higher than in the case of the status-quo. In Djibouti, the total population would be, on average, 9% higher. Health expenditures related to the treatment of HIV/AIDS, on the other hand, would be reduced by close to one percentage point of GDP.

A clear message from these results is that, in the face of an uncertain future regarding the dynamics of the HIV/AIDS epidemic and its economic impacts, countries in the MENA region will be better-off if interventions such as the ones simulated here are adopted.

Table 4: Descriptive statistics for Selected Output Variables (Policy A)

Country	Statistic	pvGDP[2000-2025] loss (% today's GDP)	Average GDP growth rate (2000-2025)	Population change in 2025 (%)	HIV prevalence year 2015 (%)	Health expenditures 2015 (% GDP)	Loss pvGDP	Loss GDP growth rate	Pop	HIV	Health
Algeria	mean	15.8%	-0.1%	-1.2%	1.2%	0.4%	-20.4%	0.2%	2.3%	-2.8%	-0.9%
	std. dev.	12.7%	0.1%	1.0%	1.2%	0.4%	*0.1%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
	min	2.9%	-0.6%	-5.9%	0.0%	0.0%	-1.6%	1.8%	7.8%	-0.4%	-0.1%
	max	70.5%	0.0%	-0.1%	6.9%	2.3%	-151.6%	0.0%	0.5%	-10.1%	-3.4%
Djibouti	mean	155.8%	-0.8%	-13.5%	8.2%	2.9%	-71.2%	0.8%	8.7%	-10.1%	-3.5%
	std. dev.	69.5%	0.6%	5.8%	6.6%	2.3%	*1.6%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
	min	76.7%	-4.0%	-33.7%	0.8%	0.3%	-8.5%	3.2%	19.9%	-1.7%	-0.6%
	max	485.1%	-0.3%	-6.3%	31.9%	11.3%	-213.0%	0.1%	1.9%	-23.4%	-8.6%
Egypt	mean	16.8%	-0.1%	-0.9%	1.0%	0.3%	-27.5%	0.2%	2.4%	-2.8%	-0.9%
	std. dev.	14.9%	0.1%	0.9%	1.1%	0.4%	*0.2%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
	min	2.4%	-0.6%	-5.5%	0.0%	0.0%	-1.9%	2.0%	7.3%	-0.4%	-0.1%
	max	82.0%	0.0%	0.0%	6.6%	2.2%	-203.4%	0.0%	0.5%	-9.5%	-3.2%
Iran	mean	13.0%	-0.1%	-0.9%	0.9%	0.3%	-20.6%	0.2%	2.4%	-2.8%	-0.9%
	std. dev.	11.3%	0.1%	0.9%	1.1%	0.4%	*0.1%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
	min	2.0%	-0.6%	-5.5%	0.0%	0.0%	-1.3%	2.1%	7.3%	-0.4%	-0.1%
	max	62.1%	0.0%	0.0%	6.5%	2.2%	-153.7%	0.0%	0.5%	-9.4%	-3.2%
Jordan	mean	12.4%	-0.1%	-0.7%	0.9%	0.3%	-15.5%	0.2%	1.9%	-2.4%	-0.8%
	std. dev.	10.1%	0.1%	0.7%	0.9%	0.3%	*0.1%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
	min	2.3%	-0.5%	-4.5%	0.0%	0.0%	0.0%	1.7%	6.0%	-0.3%	-0.1%
	max	55.4%	0.0%	0.0%	5.8%	2.0%	-132.3%	0.0%	0.3%	-8.2%	-2.8%
Lebanon	mean	9.5%	-0.1%	-1.1%	1.1%	0.4%	-16.8%	0.3%	2.7%	-3.0%	-1.0%
	std. dev.	8.4%	0.1%	1.0%	1.2%	0.4%	*0.1%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
	min	1.5%	-0.6%	-6.3%	0.0%	0.0%	-1.6%	2.1%	8.4%	-0.4%	-0.1%
	max	45.6%	0.0%	-0.1%	7.1%	2.3%	-116.3%	0.0%	0.5%	-10.4%	-3.4%
Morocco	mean	13.1%	-0.1%	-0.9%	0.9%	0.3%	-20.2%	0.2%	2.4%	-2.8%	-0.9%
	std. dev.	11.2%	0.1%	0.9%	1.1%	0.4%	*0.1%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
	min	2.2%	-0.6%	-5.6%	0.0%	0.0%	-1.4%	2.0%	7.5%	-0.4%	-0.1%
	max	62.6%	0.0%	0.0%	6.6%	2.2%	-148.9%	0.0%	0.4%	-9.4%	-3.2%
Tunisia	mean	15.1%	-0.1%	-1.0%	1.0%	0.3%	-30.4%	0.3%	2.5%	-2.8%	-0.9%
	std. dev.	14.4%	0.1%	1.0%	1.1%	0.4%	*0.2%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
	min	2.0%	-0.6%	-5.9%	0.0%	0.0%	-3.2%	2.0%	7.8%	-0.4%	-0.1%
	max	80.8%	0.0%	-0.1%	6.7%	2.2%	-205.3%	0.0%	0.5%	-9.6%	-3.1%
Yemen	mean	29.2%	-0.1%	-0.8%	1.0%	0.4%	-22.2%	0.1%	1.7%	-2.3%	-0.8%
	std. dev.	16.7%	0.1%	0.7%	1.0%	0.4%	*0.1%*	*0.0%*	*0.0%*	*0.0%*	*0.0%*
	min	8.7%	-0.6%	-4.2%	0.0%	0.0%	6.0%	1.5%	5.6%	-0.3%	-0.1%
	max	94.8%	0.0%	0.0%	5.7%	2.1%	-116.9%	0.0%	0.3%	-8.4%	-3.1%

What are the social costs of delaying action? This a second question that policymakers would like to have answered. Here we have simulated the impact of a relatively small delay in the policy intervention: 5 years. The new descriptive statistics are summarized in Table 5. The results suggest that delaying the intervention for 5 years could cost an equivalent of 4% of today's GDP in the case of Yemen and Jordan, to 8% in the case of Egypt and Tunisia, and 20% in the case of Djibouti. Five years of inaction would increase the average HIV/AIDS prevalence rate in year 2015 by 0.4 to 0.6 percentage points. This represents more than 60,000 additional infections in the case of Algeria, more than 100,000 in Egypt, and over 400,000 adding across the 9 countries included in this analysis. Thus, the costs of delaying action are considerable. Governments ought to intervene today when HIV/AIDS prevalence rates are still low.

Table 5: Descriptive statistics for Selected Output Variables (Policy B)

Country	Statistic	pvGDP[2000-2025] loss (% today's GDP)	Average GDP growth rate (2000-2025)	Population change in 2025 (%)	HIV prevalence year 2015 (%)	Health expenditures 2015 (% GDP)	Loss pvGDP	Loss GDP growth rate	Pop	HIV	Health
Algeria	mean	21.5%	-0.1%	-1.8%	1.7%	0.6%	5.641%	-0.035%	-0.596%	0.501%	0.169%
	std. dev.	17.5%	0.1%	1.4%	1.6%	0.5%	*0.035%*	*0.000%*	*0.000%*	*0.000%*	*0.000%*
	min	4.0%	-1.0%	-7.2%	0.1%	0.0%	-2.401%	-0.332%	-1.284%	0.074%	0.025%
	max	115.3%	0.0%	-0.2%	8.1%	2.7%	-0.013%	-0.005%	-0.123%	1.200%	0.405%
Djibouti	mean	176.0%	-1.0%	-15.5%	9.4%	3.3%	20.191%	-0.115%	-2.053%	1.173%	0.412%
	std. dev.	81.3%	0.7%	6.8%	7.4%	2.6%	*0.827%*	*0.000%*	*0.006%*	*0.007%*	*0.001%*
	min	81.3%	-4.4%	-38.5%	0.9%	0.3%	-7.907%	-0.422%	-4.722%	0.109%	0.038%
	max	544.4%	-0.3%	-6.9%	35.4%	12.5%	-0.342%	-0.023%	-0.562%	3.443%	1.247%
Egypt	mean	25.1%	-0.1%	-1.6%	1.6%	0.5%	8.238%	-0.045%	-0.698%	0.641%	0.217%
	std. dev.	21.8%	0.1%	1.3%	1.5%	0.5%	*0.053%*	*0.000%*	*0.000%*	*0.000%*	*0.000%*
	min	4.1%	-1.0%	-6.7%	0.1%	0.0%	-2.594%	-0.416%	-1.264%	0.097%	0.033%
	max	143.7%	0.0%	-0.2%	7.8%	2.6%	-0.011%	-0.007%	-0.149%	1.202%	0.407%
Iran	mean	19.2%	-0.1%	-1.6%	1.6%	0.5%	6.257%	-0.044%	-0.692%	0.631%	0.213%
	std. dev.	16.6%	0.1%	1.3%	1.5%	0.5%	*0.031%*	*0.000%*	*0.000%*	*0.000%*	*0.000%*
	min	3.3%	-1.0%	-6.8%	0.1%	0.0%	-2.657%	-0.427%	-1.245%	0.095%	0.032%
	max	109.5%	0.0%	-0.2%	7.7%	2.6%	-0.011%	-0.006%	-0.146%	1.171%	0.397%
Jordan	mean	16.7%	-0.1%	-1.2%	1.3%	0.4%	4.260%	-0.029%	-0.454%	0.457%	0.157%
	std. dev.	14.3%	0.1%	1.0%	1.3%	0.4%	*0.023%*	*0.000%*	*0.000%*	*0.000%*	*0.000%*
	min	2.5%	-0.8%	-5.5%	0.0%	0.0%	-2.182%	-0.328%	-1.005%	0.021%	0.007%
	max	93.9%	0.0%	0.0%	6.8%	2.3%	-0.007%	-0.001%	-0.024%	1.003%	0.344%
Lebanon	mean	14.5%	-0.1%	-1.9%	1.8%	0.6%	5.054%	-0.048%	-0.792%	0.684%	0.223%
	std. dev.	12.5%	0.2%	1.5%	1.6%	0.5%	*0.017%*	*0.000%*	*0.000%*	*0.000%*	*0.000%*
	min	3.0%	-1.1%	-7.7%	0.1%	0.0%	-2.766%	-0.456%	-1.400%	0.122%	0.040%
	max	82.9%	0.0%	-0.3%	8.4%	2.7%	-0.015%	-0.010%	-0.226%	1.270%	0.415%
Morocco	mean	19.2%	-0.1%	-1.6%	1.5%	0.5%	6.086%	-0.044%	-0.666%	0.609%	0.206%
	std. dev.	16.4%	0.1%	1.3%	1.5%	0.5%	*0.030%*	*0.000%*	*0.000%*	*0.000%*	*0.000%*
	min	2.9%	-1.0%	-6.9%	0.1%	0.0%	-2.554%	-0.397%	-1.300%	0.057%	0.019%
	max	107.3%	0.0%	-0.1%	7.8%	2.6%	-0.010%	-0.004%	-0.086%	1.225%	0.416%
Tunisia	mean	23.2%	-0.1%	-1.7%	1.6%	0.5%	8.114%	-0.046%	-0.690%	0.618%	0.201%
	std. dev.	21.3%	0.1%	1.3%	1.5%	0.5%	*0.050%*	*0.000%*	*0.000%*	*0.000%*	*0.000%*
	min	3.0%	-1.0%	-7.3%	0.1%	0.0%	-2.617%	-0.408%	-1.357%	0.059%	0.019%
	max	139.8%	0.0%	-0.2%	8.0%	2.6%	-0.010%	-0.004%	-0.090%	1.255%	0.409%
Yemen	mean	33.2%	-0.1%	-1.2%	1.4%	0.5%	4.072%	-0.022%	-0.389%	0.373%	0.137%
	std. dev.	20.5%	0.1%	1.0%	1.3%	0.5%	*0.051%*	*0.000%*	*0.000%*	*0.000%*	*0.000%*
	min	9.2%	-0.9%	-5.1%	0.1%	0.0%	-2.249%	-0.241%	-0.893%	0.048%	0.017%
	max	132.1%	0.0%	-0.1%	6.6%	2.4%	-0.020%	-0.003%	-0.066%	0.919%	0.338%

4. Conclusions and discussion

This paper develops a model of optimal growth coupled to a diffusion model of the HIV/AIDS epidemic based on two transmission factors: sexual intercourse and exchange of infected needles among IDUs. The model is used to assess the risks of a major HIV/AIDS epidemic and expected economic impacts. The paper argues that the necessary conditions to support the diffusion of HIV/AIDS are present in MENA countries. Clearly, high levels of uncertainty pervade any projection of prevalence rates. Thus, in the simulations we explore large regions of the parameter space and derive distributions for the dynamics of 5 variables of interest: the HIV/AIDS prevalence rate, total GDP, the growth rate of GDP, total labor force, and HIV/AIDS related health expenditures. The results show that in only 16% of the cases analyzed would prevalence rates in year 2015 be below 1%. On average, GDP losses across countries for the period 2000-2025 could approximate 35% of today's GDP. However, in all countries it is possible to observe scenarios where losses surpass today's GDP. So while HIV/AIDS prevalence rates could remain low, there are also risks that they continue to increase and in this case economic costs can be considerable.

The analysis shows, however, that there are policies that governments could put in place to insure against these risks. The two policies considered in this study (expanding condom use by 30% and expanding access to clean needles for IDUs by 20%), could reduce GDP losses across the 9 countries by an average of 19% of today's GDP. The analysis also shows that delaying action can be considerably costly. For instance, waiting for 5 years before intervening could cost an equivalent of 6% of today's GDP.

It is important to note that in this paper we have only looked at two types of interventions that are not tailored to specific countries. Clearly, the total amount of resources that societies ought to invest to fight HIV/AIDS and the allocation across alternative interventions depend on countries' characteristics. Indeed, the costs and effectiveness of the different interventions are given by factors such as the level of development of the epidemic, social and economic constraints on safe behavior, underlying patterns of sexual and drug-injecting behavior, local costs, and implementation capacity. Several methodologies are available to guide these allocations (see Kaplan and Pollack, 2000). These methodologies, however, require baseline data. Therefore, one of the priorities among MENA countries is to strengthen surveillance and information systems. Strategies would then need to be designed with strong involvement from civil society. Programs that are implemented should be carefully monitored to evaluate costs and impacts, thus allowing adjustments/corrections when necessary.

Another limitation of our analysis is that it doesn't shade light on the question of how the epidemic affects different population groups, in particular the poor. This is important when designing policy interventions. There is some evidence that the economic impact of the epidemic is likely to be higher among the poor, because their main or only source of revenue is their labor force (the non-poor can hedge with other assets losses in wage-income related to AIDS). Furthermore, coping mechanisms for the poor are more limited and usually involve changes in consumption patterns (e.g., reducing education, food, and health expenditures) or sending children to work. These mechanisms produce human capital losses as a result, among others, of high child malnutrition or lower school enrollment rates. While in MENA countries informal coping mechanisms to manage risks are diverse – ranging from family support and kinship ties to religious charitable organizations – research has shown that they are usually insufficient to hedge against adverse shocks (see World Bank, 2002b). Studies show that reductions in consumption in low-income households following the death of an adult household member would reduce food expenditures by 32% and food consumption by 15% (see Over et al., 2001). This occurs not only as household income is lost and funeral expenditures need to be financed (on average households spend 50% more, $800-$900, on funerals than they do for medical care), but also because households that experience a death cut back on the number of hours they work for wages (Beegle, 1996). In most MENA countries, the poor already face problems of access to health services As health systems become financially constrained, these problems can be exacerbated. At the same time, the poor are more exposed to infectious diseases and complicated with malnutrition, and thus are more vulnerable to the deterioration of their immune system.

With all its limitations, four important conclusions can be derived from the analysis developed in this paper: i) the risk of an increase in the HIV/AIDS prevalence rate in MENA countries is real; ii) expected costs over the next 25 years could be considerable; iii) there are actions that can be implemented to prevent the spread of the epidemic and the costs of these actions would be more than compensated by the savings they generate; and iv) the time to act is today when prevalence rates are still low.

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Appendix A: A caveat about savings and current international evidence

In the current version of the model, HIV/AIDS does not have any impact on the parameters of the utility function; the coefficient of risk aversion and the discount rate are fixed. Nonetheless, from a micro-economic perspective there are reasons to believe that this is not necessarily true, and that in fact the epidemic could increase aggregate savings. To see this consider the following problem faced by a representative consumer trying to allocate consumption over two periods.

$$\begin{aligned} &Max_{c_0} : U(c_0) + \rho U(c_1) \\ &s.t. \\ &c_1(c_0) = w_1 - h + (w_0 - c_0)(1+r) \end{aligned} , \qquad \text{(A1)}$$

where U(.) is a utility function with decreasing marginal returns to consumption, c is consumption, ρ is the discount factor, w stands for wage related income, h are health expenditures during the second period (the assumption is that the individual is healthy during the first period), r is the interest rate received on savings, and the indexes identify the period.

The first order condition of the maximization problem is given by:

$$\frac{\partial U}{\partial c_0} = -\rho \frac{\partial U}{\partial c_1} \frac{\partial c_1}{\partial c_0}, \qquad \text{(A2)}$$

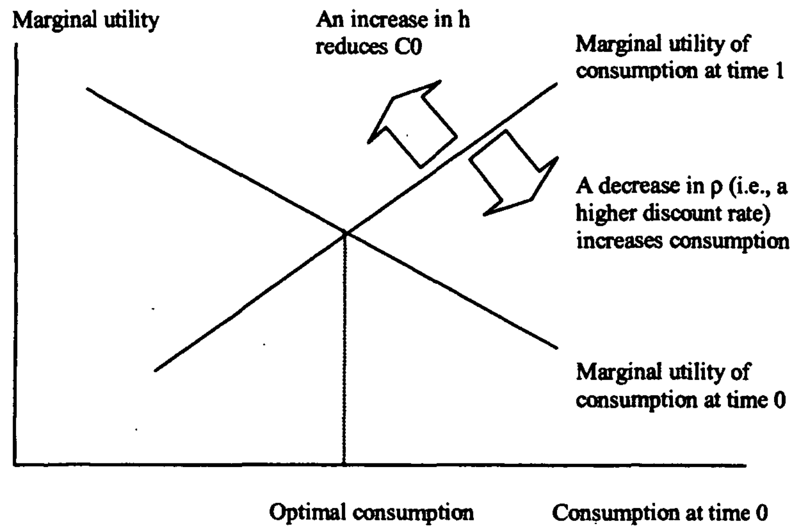
which states that optimality implies equating the discounted marginal utility of consumption between the two periods.

From the assumption of decreasing marginal returns we get the following results:

$$\frac{\partial^2 U}{\partial c_0 \partial c_0} < 0; \quad \frac{\partial\left(-\rho \frac{\partial U \partial c_1}{\partial c_1 \partial c_0}\right)}{\partial c_0} > 0; \quad \frac{\partial\left(-\rho \frac{\partial U \partial c_1}{\partial c_1 \partial c_0}\right)}{\partial h} > 0; \quad \frac{\partial\left(-\rho \frac{\partial U \partial c_1}{\partial c_1 \partial c_0}\right)}{\partial \rho} > 0$$

The graphical representations of these partial derivatives is given in Figure A1. The implication for our study is that HIV infected individuals expecting higher health expenditures at time 2 (as a result of HIV/AIDS), would experience an increase in the expected marginal utility of consumption (the right hand side of equation A2), and therefore reduce consumption today. Intuitively, these individuals will save for bad times. Similarly, an increase in the discount rate as a result of shorter life expectancy (i.e., a reduction in the right hand side of equation A2) would increase consumption today and therefore reduce savings. These ideas are summarized in the Figure A1. Given uncertainty about the effect that HIV/AIDS has on the parameters of the utility function, we have opted for keeping them constant.

Figure A1: Changes in savings rates resulting from the HIV/AIDS epidemic



Appendix B: Solving the optimization problem

To solve the problem we re-write equation (1) as:

$$Y_t = (TN)^{1-\theta} K_t^{\theta}, \tag{B1}$$

We recognize that the growth rate of T and N decreases over time. We approximate the dynamics of these growth rates by:

$$\dot{T}_t = \gamma_T \exp(-\delta_T t), \tag{B2}$$

$$\dot{N}_t = \gamma_{N'} \exp(-\delta_{N'} t), \tag{B3}$$

where the parameters γ_T, $\gamma_{N'}$, δ_T, and $\delta_{N'}$ are estimated by OLS for each scenario regarding the diffusion of the HIV/AIDS epidemic, which affects the composition and size of the labor force and therefore the dynamics of q, A, T, and N. There are no scenarios where the growth rate of N is negative (this is consistent with international evidence, see World Bank, 1999).

The optimization problem to be solved then has t the same formulation than Pfizer (2000) and Robalino et al. (2002). At the optimum the parameters $\alpha1$ and $\alpha2$ in equation (9) are given by:

$$\alpha_1 = \gamma_T - \alpha_2 \ln \widetilde{k}$$
$$\alpha_2 = (f_1 - f_2)/ f_3 - 1$$

where:

$$f_1 = \exp(\gamma_T + \gamma_{n'}) + \kappa_{kk} + \kappa_{kc}(\kappa_{ck} / \tau)$$
$$f_2 = \sqrt{\exp(\gamma_T + \gamma_{n'}) + \kappa_{kk} + \kappa_{kc}(\kappa_{ck} / \tau)^2 - 4\exp(\gamma_T + \gamma_{n'})\kappa_{kk}}$$
$$f_3 = 2\exp(\gamma_T + \gamma_{n'})$$
$$\kappa_{kc} = -\widetilde{c} / \widetilde{k}$$
$$\kappa_{ck} = (1+\rho)^{-1}(\theta - 1)\theta \widetilde{k}^{\theta-1} \exp(-\gamma_T \tau)$$
$$\kappa_{kk} = (1+\rho)\exp(\gamma_T \tau)$$
$$\widetilde{c} = \widetilde{k}^{\theta} + (1 - \delta_k - \exp(\gamma_T + \gamma_{n'}))\widetilde{k}$$
$$\widetilde{\kappa} = [((1+\rho)\exp(\gamma_T \tau) - (1-\delta_k))/\theta]^{\frac{1}{\theta-1}}$$

Appendix C: Calibrating model parameters

The different model parameters are summarized in Tables C1 to C3. Table C1 is divided in three sections. The first section defines economic parameters (those determining growth and the dynamics of labor markets). The second section defines parameters determining the economic impact of the epidemic for a given prevalence rate. Finally, the third section concerns the parameters affecting the diffusion of the epidemic. Tables C2 and C3 present additional parameters affecting this diffusion. We discuss each of these in turn.

Economic parameters

Economic parameters are grouped in two categories: *growth parameters* and *labor market* parameters. Among the 10 growth parameters, three were defined exogenously and are fixed across countries: the depreciation rate of capital (δ_k), the discount rate (ρ), and the coefficient of risk aversion in the utility function (τ). The other parameters (in bold and italics) along with one of the labor market parameters (the share of unemployed workers who find a job) were estimated in order to achieve targets in terms of medium and long-term economic growth, investment targets, and demographic projections. We proceed as follows. The growth rate of the labor force (γ_N) and the change in the growth rate of the labor force (δ_N) were estimated basis of the World Bank official country projections (World Bank, 2002). The remaining parameters, the labor productivity growth (λ_A), the change in the growth rate of labor productivity growth (δ_A), the coefficient of the labor factor in the production function (θ), and the share of unemployed workers who find a job (η_{13}), were estimated by solving the following optimization problem:

$$Min_{\gamma_a,\delta_a,\theta,\eta_{13}}:\left[g(1-5)-(Y_5/Y_1)^{1/4}\right]^2+\left[g(5-15)-(Y_{15}/Y_5)^{1/10}\right]^2+\left[g(15-25)-(Y_{25}/Y_{15})^{1/20}\right]^2+\left[I(1-25)-\frac{1}{25}\sum_{t=1}^{t=25}s_t\right]^2$$

where g(t-z) gives targets for the average growth rate during year t and year z, and I(t-z) gives targets for the average saving rate during the period t-z. These targets were set for each country of the basis of the Country Assistance Strategies (World Bank 1997, and World Bank 1999b to World Bank 2002 a). Medium term growth targets are based on the Country Assistance Strategies. Long-term growth rates increase the medium term targets by 1%. Investment rates are based on the last 10 years average. When this average is below 20%, 20% is used instead.

In terms of *labor market* parameters, initial unemployment rates come from World Bank Country Assistance Strategies (World Bank 1997-2002). For simplicity, the initial share of skilled workers is arbitrarily set equal to 50% and kept fixed across countries. The share of unskilled labors is then computed by difference. We take an optimistic stance assuming that new entrants in the labor force are not unemployed and that a majority, 70%, are skilled. We do not allow mobility across labor types (except from the unemployed group to the skilled).

The *initial conditions* for the output variables are set on the basis of the World Bank SIMA (World Bank, 2002) and in the case of the capital output ratio (COR), using the World Bank TFP tool kit (see Mahajan, 2001).

Parameters affecting the impact of the epidemic

There are three sets of parameters determining the economic impact of the epidemic. First the parameters affecting the distribution of HIV/AIDS related deaths among labor types. Second, the parameters determining HIV/AIDS related health expenditures and the impact on productivity, finally the parameter determining the direct impact of the HIV/AIDS prevalence on labor productivity.

In terms of the distribution of AIDS related deaths, given little or no data in that respect, we allow the share of skilled workers to vary between 20% and 50%. The higher this share, the larger the economic impact. By constraining the upward bound to 50% we are taking a conservative stance. The remaining deaths are equally distributed among low-skilled and unemployed workers.

The calculation of potential changes in health expenditures is based on estimates from the literature. In terms of the average cost of treatment, estimates from cross-country studies suggest a range of 2-3 times GDP per capita (see Floyd and Gilks, 2001; United Nations 2001; Cavallini et al, 2000). In this analysis we assume that the average yearly cost of treating an HIV/AIDS patient is equal to 1,400 USD in a country with a GDP per capita of $1,000 and that it increases by 0.95% for each 1% increase in GDP per capita. Access to treatment, on the other hand, varies widely across countries. For our calculations we assume that only a modest 30% of those affected by AIDS would obtain treatment. For simplicity we neglect the costs that health has on productivity.

Finally, the parameter defining the direct impact of HIV/AIDS on labor productivity is allowed to vary between 0 and 0.5. This implies that a 1% prevalence rate can reduce the growth rate of labor productivity by up to 0.5 percentage points. This is the low range from estimates in the literature (see Haccker, 2001; and MacFarlan and Sgherri, 2001).

Table C1: Model parameters

	Algeria	Djibouti	Egypt	Iran	Jordan	Lebanon	Morocco	Tunisia	Yemen
ECONOMIC PARAMETERS									
Growth parameters									
deltaK	0.04000	0.04000	0.04000	0.04000	0.04000	0.04000	0.04000	0.04000	0.04000
deltaA	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.00500	0.01000
deltaN	0.05200	0.01416	0.03627	0.07246	0.04181	0.11327	0.05036	0.08827	0.01323
lambdaA	0.03690	0.00386	0.04017	0.01937	0.01360	0.02734	0.02617	0.05357	0.00100
lambdaN	0.03162	0.02396	0.02350	0.03538	0.03951	0.03575	0.02220	0.02705	0.03868
rho	0.06000	0.06000	0.06000	0.06000	0.06000	0.06000	0.06000	0.06000	0.06000
thau	0.90000	0.90000	0.90000	0.90000	0.90000	0.90000	0.90000	0.90000	0.90000
theta	0.48337	0.24010	0.33260	0.27609	0.32662	0.34267	0.36577	0.42584	0.20954
alfa1	0.31056	0.23486	0.18673	0.15346	0.16536	0.26148	0.23544	0.47009	0.43993
alfa2	-0.14861	-0.11626	-0.07217	-0.08636	-0.06166	-0.16948	-0.08978	-0.28734	-0.40277
Labor markets									
Share unemployed	21%	40%	11%	15%	10%	15%	20%	15%	30%
Share skilled labor	50%	50%	50%	50%	50%	50%	50%	50%	50%
Share unemployed in new labor	0%	0%	0%	0%	0%	0%	0%	0%	0%
Share skilled in new labor	70%	70%	70%	70%	70%	70%	70%	70%	70%
Share unemployed who find a job	1.27%	0.13%	1.46%	0.38%	0.40%	0.53%	0.58%	0.99%	0.01%
Constraints									
s(2001-2010)	0.27827	0.20000	0.24458	0.20000	0.25000	0.20500	0.25000	0.27849	0.20000
g(2000-2005)	0.04525	0.03475	0.05500	0.03767	0.04000	0.03600	0.04000	0.05700	0.04000
g(2005-2015)	0.05025	0.03975	0.06000	0.04267	0.04500	0.04100	0.04500	0.06200	0.04500
Initial conditions (million GDP 1995)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
COR*	5.03310	2.00000	2.69900	2.67200	3.20300	3.50000	3.16900	3.62600	2.00000
Y	47,085.0	486.0	74,610.0	99,920.4	7,604.0	12,358.6	38,387.0	22,600.0	4,880.0
C	34,123.4	440.3	57,607.4	81,708.9	6,023.6	9,639.7	29,110.6	16,583.6	3,972.6
I/Y	0.3	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2
K	175,019.6	2,173.4	249,224.6	318,825.9	36,482.8	37,075.8	168,344.7	69,667.7	11,256.4
A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N	16.0	0.3	34.3	34.4	3.1	1.7	15.1	5.2	7.6
IMPACTS OF THE EPIDEMIC									
Share AIDS related deads among skilled	[20%-50%]	[20%-50%]	[20%-50%]	[20%-50%]	[20%-50%]	[20%-50%]	[20%-50%]	[20%-50%]	[20%-50%]
Impact labor productivity (d1)	[0-0.5]	[0-0.5]	[0-0.5]	[0-0.5]	[0-0.5]	[0-0.5]	[0-0.5]	[0-0.5]	[0-0.5]
Impact health spending (d2)	0	0	0	0	0	0	0	0	0
Initial cost of AIDS treatment/GDP	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Marginal increase in the cost	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Access to treatment	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
HIV/AIDS DIFFUSION									
Epidemiology									
Share sex workers	[0.01%-0.5%]	1.00%	[0.01%-0.5%]	[0.01%-0.5%]	[0.01%-0.5%]	[0.01%-0.5%]	[0.01%-0.5%]	[0.01%-0.5%]	[0.01%-0.5%]
Share IDUS1	[0.01%-0.1%]	0.00%	[0.01%-0.1%]	[0.01%-0.1%]	0.00%	[0.01%-0.1%]	[0.01%-0.1%]	[0.01%-0.1%]	0.00%
Share IDUs2	[0.01%-0.1%]	0.00%	[0.01%-0.1%]	[0.01%-0.1%]	0.00%	[0.01%-0.1%]	[0.01%-0.1%]	[0.01%-0.1%]	0.00%
Share infected sex workers	10.00%	50.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	7.00%
Share infected IDUs1	0.30%	0.00%	1.00%	1.00%	0.00%	2.20%	0.34%	0.34%	0.00%
Share infected IDUs2	0.30%	0.00%	1.00%	1.00%	0.00%	2.20%	0.34%	0.34%	0.00%
Aggregate prevalence rate	0.07%	6.00%	0.02%	0.03%	0.02%	0.09%	0.03%	0.06%	0.02%
Preventive/Health Behavior									
Condom use	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]
Condom effectiveness	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%	98.00%
Needle sharing	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]	[10%-50%]
Average number of injections per year	730		730	730		730	730	730	
STDs prevalence	[0%-5%]	[0%-5%]	[0%-5%]	[0%-5%]	[0%-5%]	[0%-5%]	[0%-5%]	[0%-5%]	[0%-5%]

Parameters determining the diffusion of the epidemic

Given the lack of epidemiological and behavioral data, we allow the different parameters to vary uniformly along wide intervals. We start by defining the approximate HIV/AIDS prevalence rates in the general population and prevalence rates among high-risk groups (sex workers and IDUs). For this we use UNAIDS country profiles and data collected for this study. In the case of Morocco where data on the prevalence rate of IDUs are not available, we assume levels equivalent to Tunisia. There are no reliable data regarding the population share of sex workers and IDUs in the different countries. Thus, we treat these shares as exogenous parameters that are allowed to change between simulations from a conservative baseline; changes range between 0 and 0.1%. Given the share of the different population groups, the aggregate prevalence rate, and the prevalence rates for the high-risk groups, we compute the implicit prevalence rates for the low-risk groups.

There are also scarce data regarding sex behaviors and drug use. The probability of using a condom is allowed to vary between 10% (close to Morocco) and 40% (close to Jordan). The probability of sharing a needle is allowed to vary between 10% and 50% while the average number of injections per year is set at 730 (on the basis of Jenkins et al., 2001). Finally, the STDs prevalence is allowed to vary between 0 and 5%. The total number of STDs cases is equally divided between non-ulcerative, ulcerative, and both.

The second important set of parameters that affects the dynamics of the HIV/AIDS epidemic is given by the level and heterogeneity of sexual activity. Table B2 presents the average number of partners across population groups and the average number of sexual intercourses. The numbers are based on Rehle et al. (1998). Given high uncertainty about the correct values across countries, we also allow these parameters to vary (all in the same proportion). The matrices are thus multiplied in different simulations by a scalar ranging between 1 and 2.

Table C2: Average number of partner and sexual intercourses per year

Partners	**Sex workers**	**IDUs males**	**IDUs females**	**Low-risk M**	**Low-risk F**
Sex workers	0	5	0	30	0
IDUs males	5	0	5	0	1
IDUs females	0	5	0	2	0
Low-risk M	0.8	0	0.016	0	2
Low-risk F	0	0.008	0	2	0
Contacts	**Sex workers**	**IDUs males**	**IDUs females**	**Low-risk M**	**Low-risk F**
Sex workers	0	10	0	10	0
IDUs males	10	0	40	0	10
IDUs females	0	40	0	10	0
Low-risk M	5	0	10	0	50
Low-risk F	0	10	0	50	0

Source: Based on Rehle et al. (1998)

The final set of model parameters relates to HIV/AIDS transmission probabilities. As previously discussed, we consider two mechanisms: sexual transmission and needle sharing. In the case of sexual transmission we allow the probability of infection to vary as a function of the presence of the 3 different types of STDs (ulcerative, non-ulcerative, and both). The different probabilities are summarized in Table 3. Diffusion profiles for selected scenarios are presented in Appendix D.

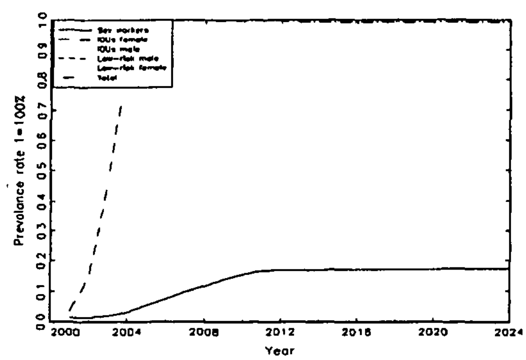
Table C3: HIV/AIDS transmission probabilities

	Sex workers	IDUs Males	IDUs females	Low-risk M	Low-risk F
Sex workers	0	10	0	10	0
IDUs males	10	0	40	0	10
IDUs females	0	40	0	10	0
Low-risk M	5	0	10	0	50
Low-risk F	0	10	0	50	0

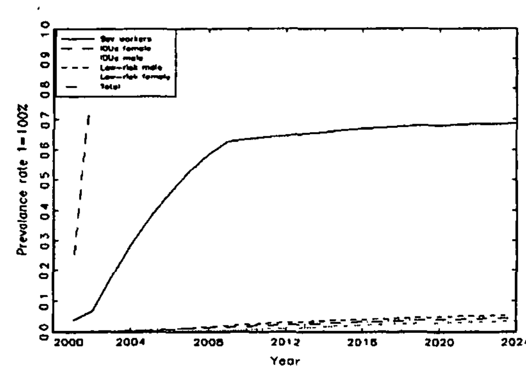
Source: Rehle et al. (1998)

Appendix D: Selected HIV/AIDS diffusion profiles

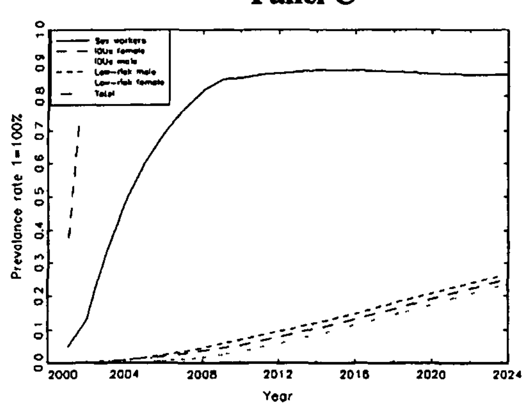
Panel A



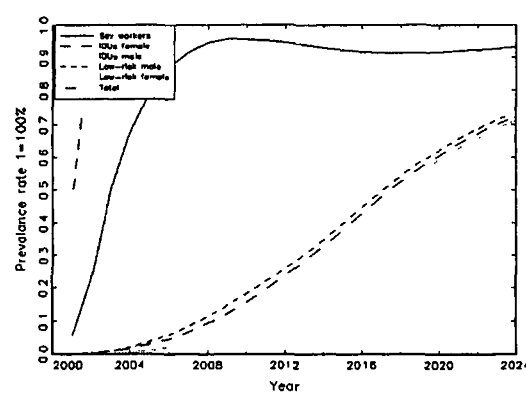
Panel B



Panel C



Panel D



Parameters:

	Probability of using a condom	Probability of sharing a needle	STDs prevalence	Share high risk population	Prevalence in high risk population	Average number of partners	Average number of contacts
Panel A	0.455556	0.855556	0.005556	0.000111	0.005556	1.222222	1.222222
Panel C	0.277778	0.677778	0.027778	0.000556	0.027778	2.111111	2.111111
Panel D	0.188889	0.588889	0.038889	0.000778	0.038889	2.555556	2.555556
Panel E	0.1	0.5	0.05	0.001	0.05	3	3

Appendix E: Distributions for selected outcome variables under the status-quo

Figure E1: Distribution of GDP losses (2000-2025) resulting from the HIV/AIDS epidemic

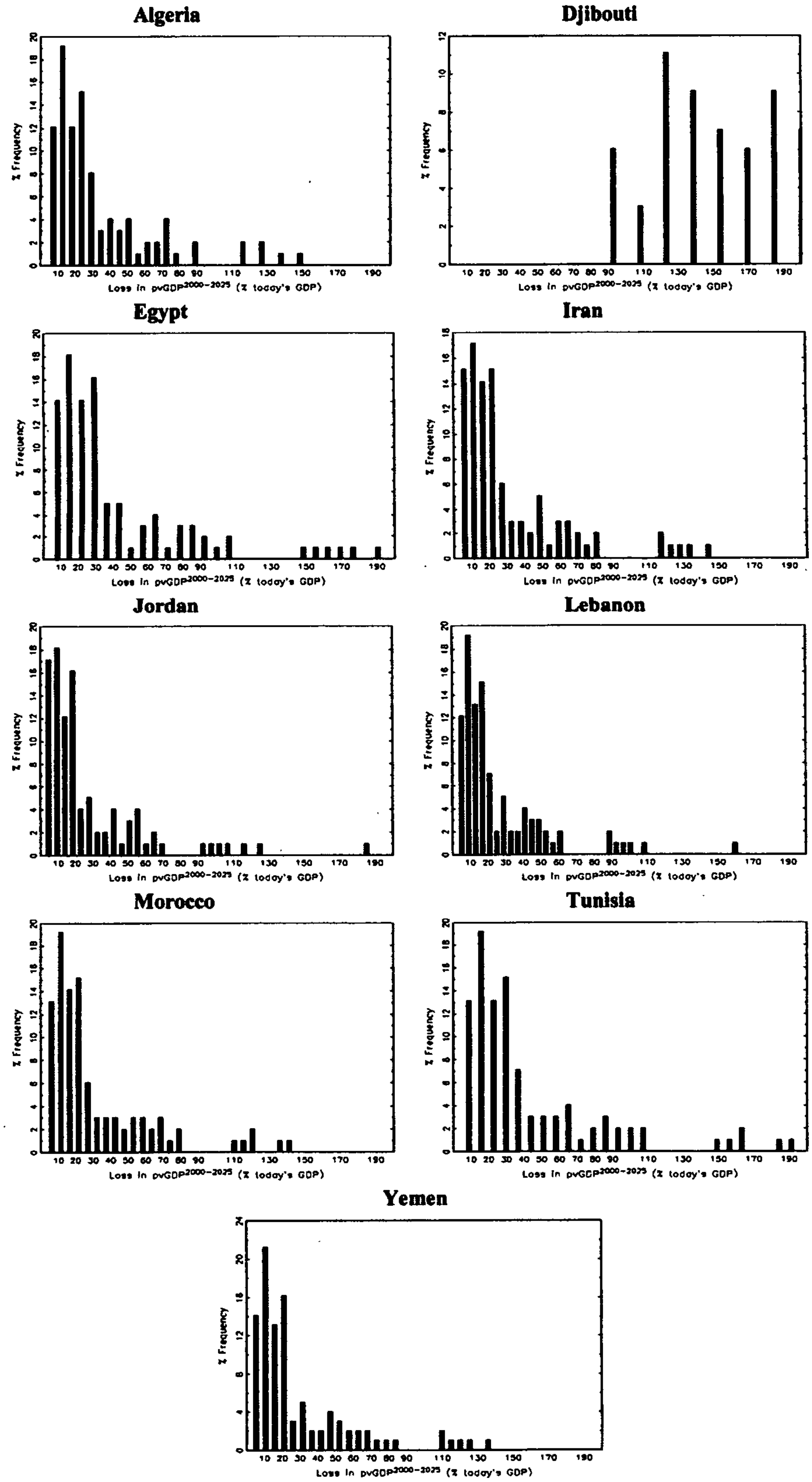


Figure E2: Distribution of reductions in the GDP growth rate (2000-2025) resulting from the HIV/AIDS epidemic

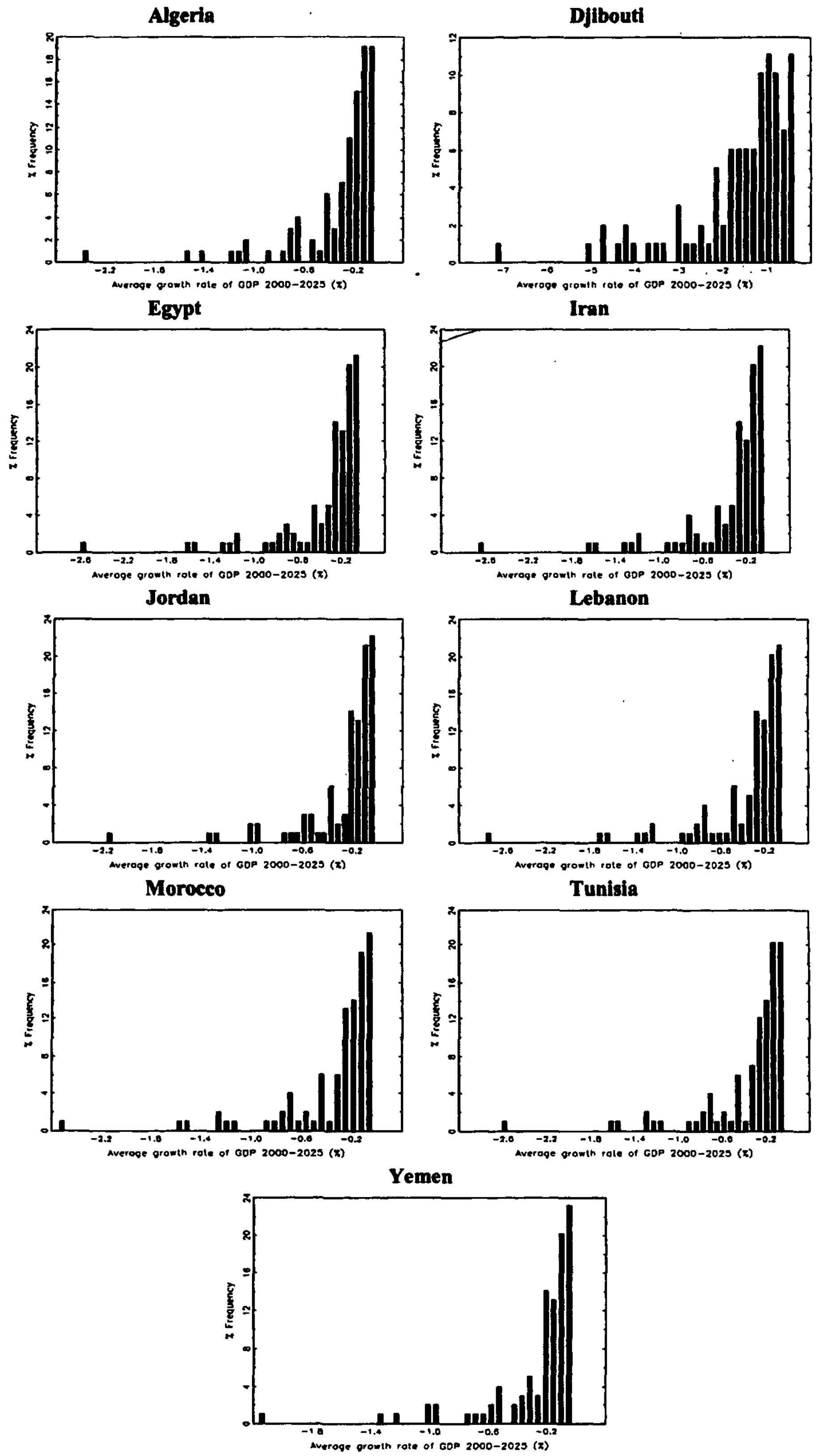


Figure E3: Distribution of reductions in the labor force in year 2025

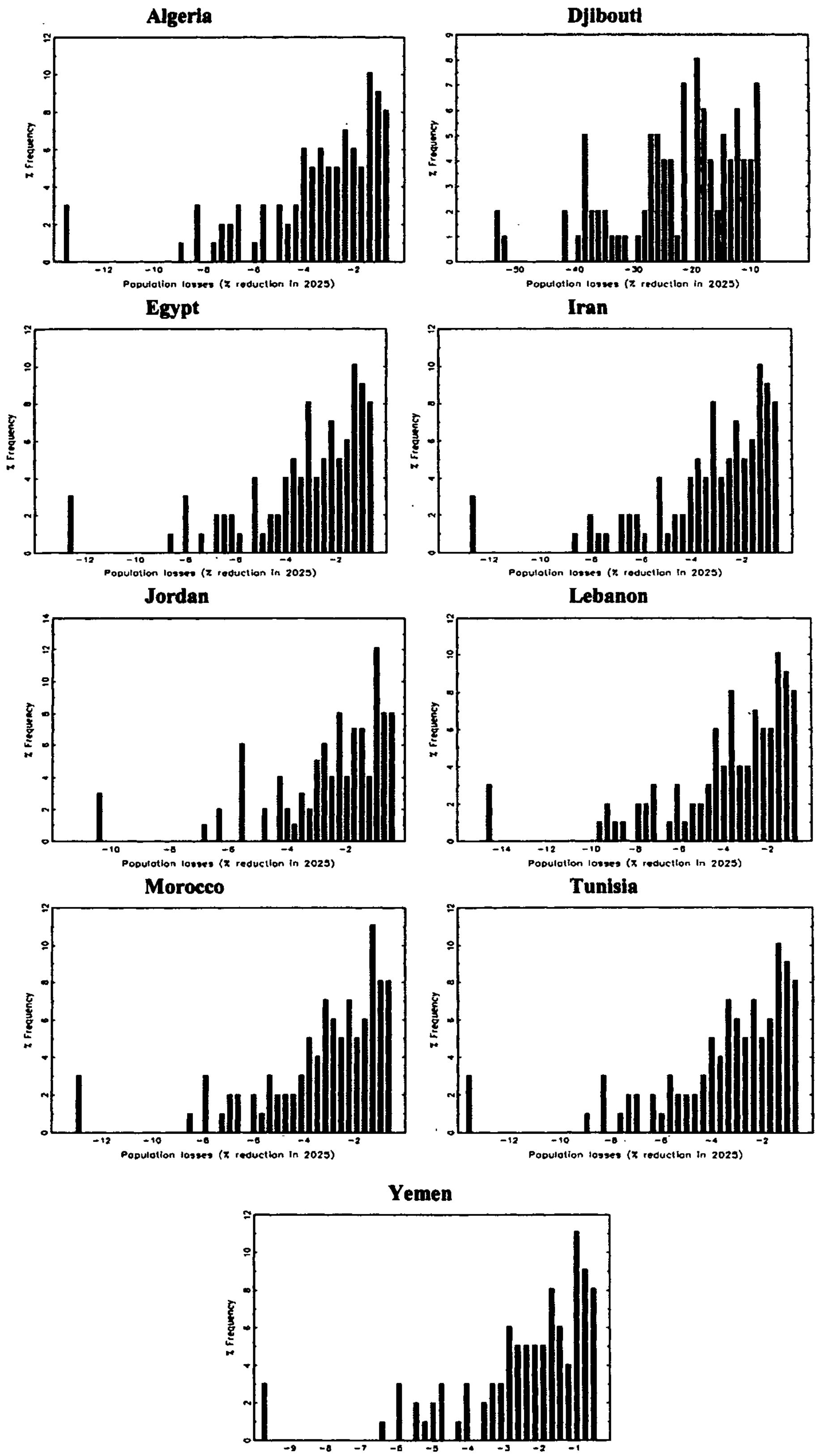
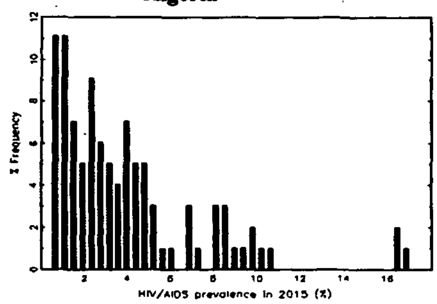
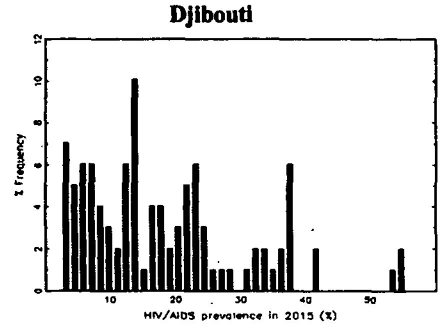


Figure E4: Distribution of the HIV/AIDS prevalence rate in 2015

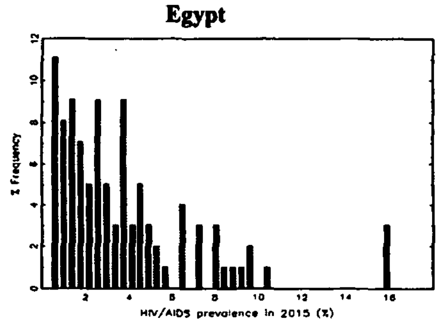
Algeria



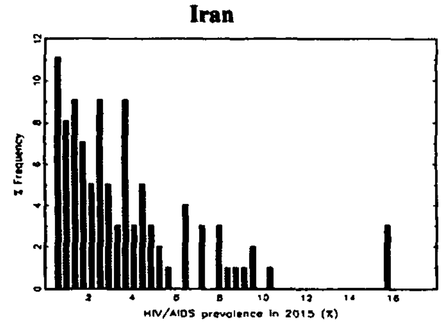
Djibouti



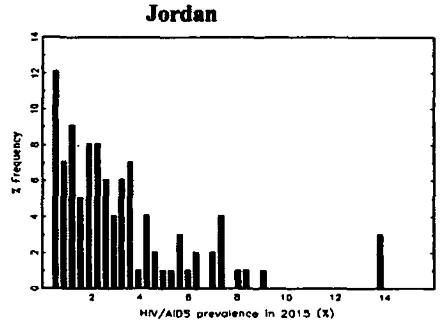
Egypt



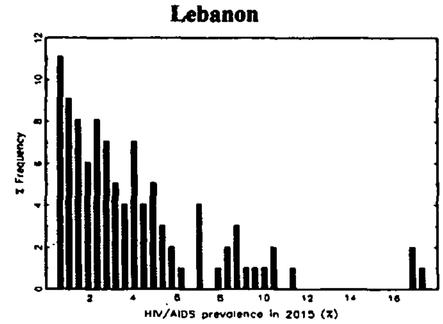
Iran



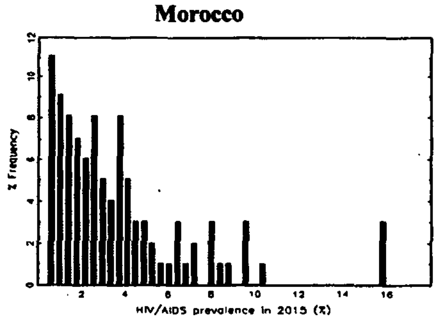
Jordan



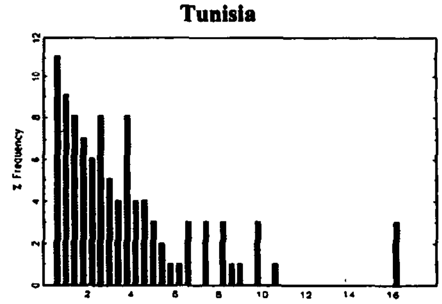
Lebanon



Morocco



Tunisia



Yemen

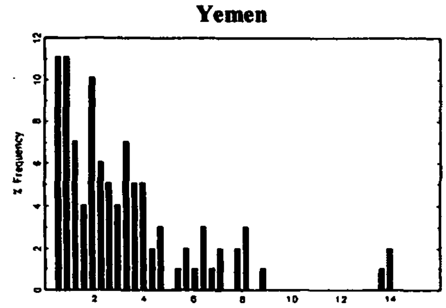
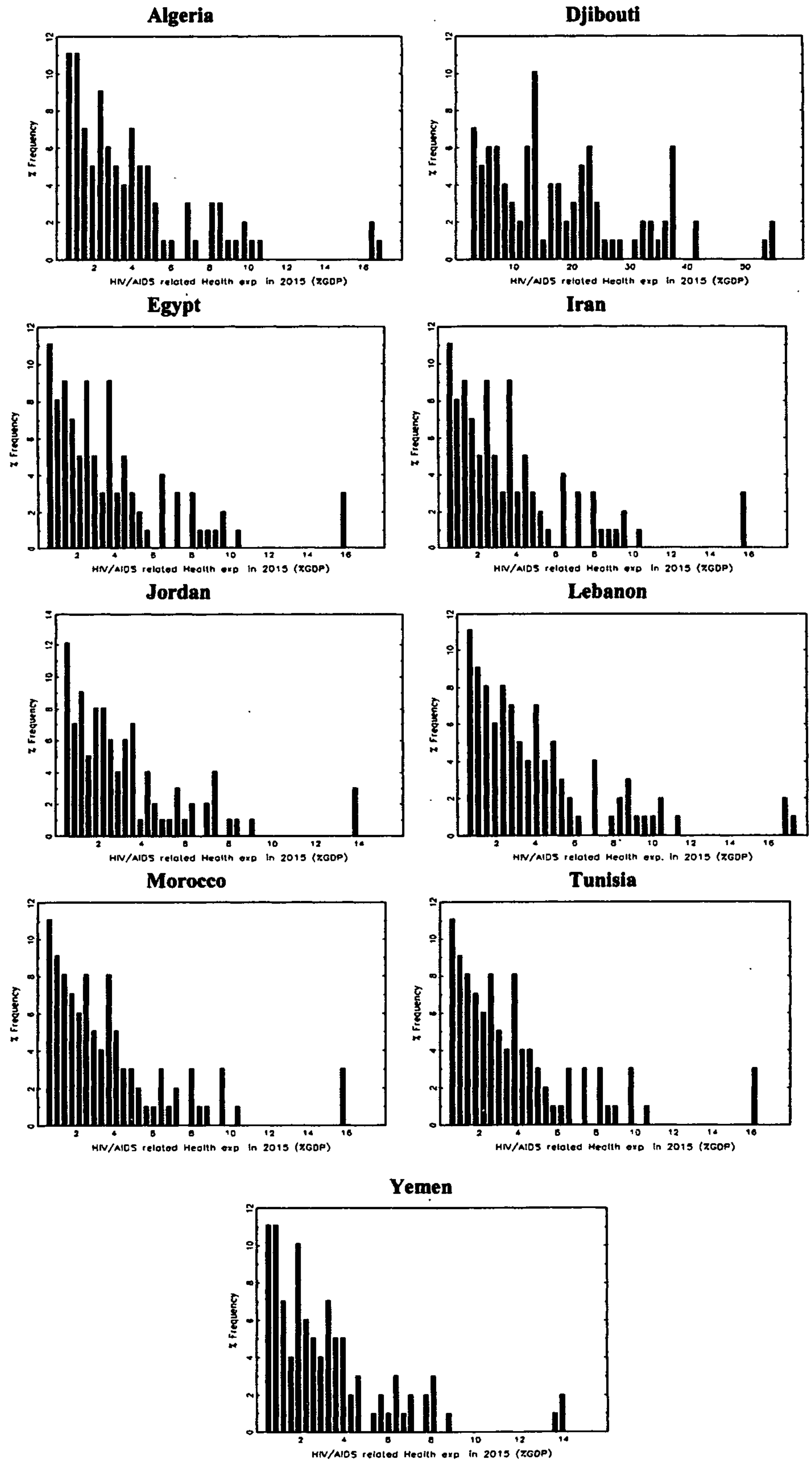


Figure E5: Distribution of HIV/AIDS related health expenditures in year 2015



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