Socio-economic status, sexual behavior, and differential AIDS mortality

Evidence from Côte d'Ivoire

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Abstract

Lack of knowledge about differential AIDS mortality seriously hampers the study of the economic impact of AIDS in developing countries, at both the macro and micro-economic levels. In this paper, we derive, we think, reasonable assumptions on mortality differentials by age, education, and other micro-economic characteristics by exploiting variables from the Ivorian Demographic and Health Survey. Finally these differentials are calibrated on UN demographic projections to obtain disaggregated mortality tables. Our model is based on econometrically estimated equations using commonly available individual characteristics, therefore it can be used to forecast mortality differentials for other surveys as well. A main result of our model is that educated people have a higher risk of dying of AIDS, because they are more likely to have several sexual partners. This effect is however partly offset by a higher probability of condom use relative to less educated people. The identification of the socio-economic characteristics of low and high risk groups seems indispensable to set up adequate AIDS prevention and therapy policies in developing countries.

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Introduction

Not much is known about the distribution of the AIDS epidemic in African countries. For most countries in Africa, prevalence rates of the HIV and mortality attributable to AIDS illness are only roughly estimated at the national or regional level. UNAIDS produces, for each country and for the 1995-2050 period, estimates of AIDS-induced falls in life expectancy at birth for both sexes (United Nations 2001). Almost no information on AIDS mortality is available, apart from qualitative, sometimes anecdotal, sources, for specific groups defined by socio-economic characteristics such as localization, education or occupation. The only exception is South-Africa, where the first large and nation-wide representative survey with sero-prevalence tests was recently conducted (HSRC 2002). In the absence of such a representative survey, only partial evidence is available suggesting that urban, more educated people, teachers, and truck-drivers are more exposed to the risk of HIV/AIDS.[1] A number of factors like living standards, social status and spatial mobility may be invoked to explain differences in individual sexual behavior, which lead to risk differentials. A precise quantification of such risk differentials seems out of reach in the absence of micro-data providing information on both individual characteristics and HIV/AIDS infection (or related opportunistic illnesses).[2] Lack of such data seriously hampers the study of the economic impact of AIDS at both the macro and micro-economic level (in what follows we refer sometimes only to AIDS, when we mean HIV/AIDS).

Macro-economic studies of the impact of AIDS on growth and/or national welfare are forced to make rough assumptions concerning the distribution of the epidemic over the labor force. Using a computable general equilibrium model (CGEM), Kambou, Devarajan and Over (1994) consider in their study on the economic impact of AIDS in Cameroon an annual fall of 30,000 workers per year, which they dispatch equally over three categories of labor—rural, urban unskilled, and urban skilled—that is a fall of 10,000 workers in each category. They make thus the assumption that the infection is by far more pervasive among urban skilled workers. The shortage of skilled workers constitutes then of course the principal shock for the Cameroonian economy. Arndt and Lewis (2000), using also a CGEM, try to estimate the macro-economic implications of AIDS in the medium term for South-Africa. They adopt mortality rates for unskilled, skilled, and professional workers estimated by ING-Barings. These estimates are in contrast with the assumptions made by Kambou, Devarajan and Over (1994), as they imply that AIDS mortality decreases with education. Other studies do not consider any disaggregation of the labor force, making thus the assumption of uniform infection rates (see e.g., Haacker 2002, MacFarlan & Sgherri 2001, Cuddington & Hancok 1994, Cuddington, Hancok & Rogers 1994, Cuddington 1993, Becker 1990). Micro-economic studies are, with a few exceptions, restricted to a listing of potential effects on the welfare of households or the efficiency of enterprises or they are based on unrepresentative case studies (see e.g., Hargreaves, Morison, Chege *et al.* 2002, Booysen & Bachmann 2002, Gregson, Waddell & Chandiwana 2001, Aventin & Huard 2000, Menon, Wawer, Konde-Lule *et al.* 1998, Béchu 1998, Janjaroen 1998, Kamuzora & Gwalema 1998, Tibaijuka 1997, Philipson & Posner 1995, Barnett & Blackie 1989). Linkages between the macro and micro-economic level are rarely explored, while they are probably the main issue at stake. Indeed an unequal distribution of deaths has potentially huge macro and micro-economic consequences: labor force shortages will not only lead to growth constraints, but also to large relative wage changes and changes in the structure of households through reallocations of labor supply and school dropouts, and an appraisal of new categories of poor through unexpected transitions from the top to the bottom of the distribution of income. The study of these phenomena calls for applied dynamic microsimulation techniques as we argue and exemplify in another paper with an application to Côte d'Ivoire (Cogneau & Grimm 2003). It requires also the formulation of reasonable assumptions on mortality differentials by age, education, and other socio-economic characteristics.

This paper deals with this latter issue by analyzing a nationwide representative Demographic and Health Survey (DHS) undertaken in 1994 in Côte d'Ivoire, providing some clues on the distribution of mortality risks over some individual observable characteristics. In this survey, we find two variables which we may directly link to the risk of HIV infection: the number of sexual partners and the use of condoms during the two months preceding the survey. In addition this survey contains other variables which mainly reflect knowledge and attitudes regarding HIV/AIDS. We use multiple correspondence analysis to get a preliminary overview of the patterns of individual attitudes towards AIDS. We then construct a standard model for the risk of HIV infection, using information on sexual activity, protection behavior and partners' selection. We estimate this model with available variables using different empirical specifications. Finally, we derive various mortality tables disaggregated by individual characteristics by combining the estimated models with United Nations' (UN) life expectancy projections. Despite several methodological caveats, we believe that this analysis provides a better information basis than a "no-information" or "anecdotal" approach.

AIDS in Côte d'Ivoire and data sources

We use three different data sources: the Ivorian DHS of 1994, UN demographic projections for Côte d'Ivoire, and Ledermann model life tables. After a short description of some basic facts about the AIDS epidemic in Côte d'Ivoire, we present the DHS data and analyze them by a multiple correspondence analysis. The UN data and the used Ledermann life tables are presented, when we construct the mortality tables.

The AIDS epidemic in Côte d'Ivoire

The first two AIDS cases in Côte d'Ivoire were declared at the end of 1985 (Garenne, Madison, Tarantola *et al.* 1995). Afterwards the epidemic spread very rapidly over the whole country. Today Côte d'Ivoire is one of the 15 hardest hit countries in the world. End-2001 UNAIDS estimated the adult prevalence rate at 9.7%,[3] the number of adults and children who died in that year of AIDS at 75,000 and the number of currently living children who have lost their mother or both parents to AIDS since the beginning of the epidemic at 420,000 (UNAIDS/WHO 2002). The *Institut National de la Statistique* of Côte d'Ivoire calculated on the basis of the population census of 1998 a life expectancy at birth for men and women of 49.2 and 52.7 years respectively. Today, UNAIDS estimates that these indicators have fallen to 47.7 and 48.1 years. Whereas without AIDS the life expectancy for men and women would have been expected to increase to 61 and 65 years in 2015, they are now expected to be 15% and 18% below (United Nations 2001).

The results of a representative survey (rural and urban areas without Abidjan) carried out in 1989, showed that even in that early stage of the epidemic it was already distributed over all regions in Côte d'Ivoire. However, the intensity was very different. In the South (near Abidjan) 8.3% of the adult population were infected, whereas in the North the adult prevalence rate did not exceed 2.5% (Garenne *et al.* 1995). High prevalence rates around the main transport routes and borders suggest that spatial mobility is very important factor regarding the Ivorian AIDS epidemic. HIV prevalence among sex workers tested in Abidjan increased from 27% in 1986 to over 84% in 1992/93. In Odienne for instance, city in the North-West of Côte d'Ivoire, situated at one of the most important migration corridors, HIV prevalence among sex workers tested increased from 37% in 1987 to 53% in 1990 (UNAIDS/WHO 2000).

Since the late nineties, the AIDS epidemic seems more equally distributed across the different regions in Côte d'Ivoire. HIV1 sero-prevalence ranged from 8 to 13 percent among pregnant women in ten cities, while HIV2 infection remained low at 1 percent or below (U.S. Census Bureau 2000). These tests probably exclude pregnant women in remote rural areas. Nevertheless, according to the Ivorian DHS survey, more than 80 percent of pregnant women attend a prenatal examination.

To our knowledge, the most recent mortality study for Côte d'Ivoire is that of Garenne and Zanou (2000), which is based on census data of 1998, administrative data and the registered causes of deaths in the hospitals in Abidjan. The authors state a less or more stagnation of the excess mortality due to AIDS in Abidjan since 1992 suggesting a stabilization of the HIV prevalence rate. However, the study suffers from poor quality of the hospital registers. AIDS is only rarely declared and has therefore to be derived from other causes of death, as the tuberculosis, the meningitis and the toxoplasmosis, causes of death which increased in Côte d'Ivoire since the onset of the HIV/AIDS epidemic in 1985. These drawbacks justify to remain cautious concerning the hypothesis of a stabilization of the HIV prevalence rate in Abidjan.

Ivorian Demographic and Health Survey (DHS) 1994

The Ivorian DHS used for this study was carried out between June and November 1994 by the *Institut National de la Statistique* of Côte d'Ivoire with the technical assistance of the Demographic and Health Surveys Macro International Inc. (U.S.A.) (INS 1995). The weighted sample is representative at the national level. Each of the five sub-samples (Abidjan, Urban Forest, Rural Forest, Urban Savannah and Rural Savannah) is self-weighing.

This survey contains four types of questionnaires: one dedicated to households, one dedicated to women between 15 and 49 years old, one dedicated to men between 15 and 59 years old, and a community questionnaire collecting data about service facilities. The men questionnaire is a simplified version of the women questionnaire and was addressed only to a sub-sample of all men covered by the household questionnaire. The women and men questionnaires were filled out by 8,099 women and by 2,552 men respectively. These persons belong together to 5,935 households.

The household questionnaire provides information about the socio-demographic characteristics of household members, but no information about income or expenditure. The women questionnaire informs about reproductive behavior, contraception, pregnancy, vaccination and children's health, marriage, preferences regarding fertility, maternal mortality, height, and weight of mothers and their children. In addition, the survey aimed to evaluate the knowledge, attitudes and behavior with regard to AIDS. The corresponding section was integrated in the individual women and men questionnaire. It contains questions about the knowledge concerning the AIDS epidemic, about its transmission modes, and adequate strategies to avoid an infection with AIDS.

Descriptive analysis of the pattern of individual attitudes towards AIDS

In this section we present the results of a multiple correspondence analysis (MCA) implemented on the men and women sub-samples of the DHS. In each analysis, the individuals are described by the vector of their answers to the "knowledge and attitude" variables.[4]

The MCA is the most suitable descriptive multivariate data analysis method for our purposes, since it deals directly with categorical variables without making linearity assumptions. MCA extracts information (inertia) from multivariate categorical data, providing an ordered set of orthogonal variables (axis). The first axis constitutes the best univariate summary of the cloud of answers in terms of inertia maximization (see e.g., Benzécri 1973, Volle 1981). The bi-dimensional map obtained by crossing the first and second axis thus gives an overview of the main contrasting patterns of the given answers.

First we look at the map giving the pattern of answers of men (see Figure A1 in Appendix A and Table A1 with the glossary of the variable names used). Unsurprisingly, the first axis opposes a global ignorance of the AIDS illness to a well-informed sensitivity to AIDS. On the one hand, we find men who do not even know how one gets AIDS, whether AIDS can be cured, whether an infected person may seem healthy, whether a mother may transmit AIDS to a child and where a test can be done. On the other hand, we find men who attended a conference on AIDS, knowing that an infected person may seem healthy, or that one may get AIDS by a sexual intercourse even with one's partner/spouse. Furthermore, the well-informed men know more often somebody who is infected and have had more often more than one sexual partner during the last two months.

The second axis puts at one end men who favor more often stopping sexual intercourse and/or avoiding occasional partners to avoid AIDS, although they declare more often that they had sexual intercourse with a woman who is not the spouse during the two months preceding the survey. At the other end of the axis, we find associated declared ignorance about the way to get AIDS or quotation of "other sexual behavior" as possible cause and individuals who favor the option of having only one sexual partner to avoid AIDS and who had a large number of partners the two months preceding the survey.

The map for women (see Figure A2 in Appendix A) closely resembles that for men, however it does not include the variable "number of sexual partners", which is not available in the women questionnaire. On the second axis, we find at the one end the beliefs that AIDS cannot be transmitted to children and that an ill person cannot seem healthy, characterizing women who are not fully aware of the dangerousness of AIDS. For a sub-sample of wives of whom the husband is comprised in the men sample, we find that the coordinates on each axis are correlated with the coordinates of the husband, reflecting the collective (intra-household) nature of knowledge about AIDS (map not presented).[5]

From these patterns of knowledge and attitudes, it is not straightforward to draw a definitive conclusion about who are those individuals who are the most susceptible to contract AIDS. For men, the number of partners is positively correlated with correct knowledge of the main features of the illness and awareness about the dangerousness of AIDS. Yet, it is far from certain that knowledge and awareness necessarily lead to safe practice.

Risk variables and their observable factors

We may argue that at the individual level, the probability of infection depends on the number of partners, the frequency of unprotected sexual intercourse with each partner, and the average level of infection of chosen partners. Drawing from the "susceptible-infected" (SI) model of

Anderson and May (1992), adopted by Kremer (1996), we write:

$$P = \rho\beta Y, \tag{1}$$

where P is the probability of infection over a given period, ρ is the number of partners during this period, β is the transmission rate, and Y is the average prevalence rate of partners. Thus, the variation of risk across individuals relies on a complex combination of factors. I.e. ρ is the number of partners, but β depends on the frequency of unprotected sexual activity with each partner, that is on both sexual activity and protection behavior,[6] and Y depends on partner selection behavior, that is avoiding of or matching with potentially infected people.

First, one may remember that if people maximize an utility function like the one hypothesized by Kremer (1996): $u(\beta, \rho) - P(\beta, \rho)$, they may choose a (β, ρ) combination with a low β (condom use and/or low frequency of intercourse) and a high ρ. Second, people may adopt a specific partner selection behavior which depends on utility derived from specific partners, however risky they are, and identification of partners' risk of infection. At least for men the survey gives us a proxy for ρ that is the declared number of sexual partners during the last two months. For β, we may analyze the frequency of condom use, assuming a constant frequency of sexual intercourse with each partner. The Y variable is the most difficult to measure with our data. "Knowing somebody with AIDS" may give a clue about the infection level of the social network surrounding the individual.[7] Descriptive statistics about the distribution of these three variables can be found in Appendix B.

Estimation procedure

First we describe the estimation procedure for the three variables entering the probability of infection for men aged between 15 and 59 years. We then adapt the procedure to the available information for women.

The case of men

We proxy ρ and β by the two following variables: "Number of sexual partners during the last two months" (NP) and "use of condoms" (C) (conditionally on the number of sexual partners).

$$P\left(NP_i = k\right) = P(r_k < X_i b_\rho + \nu_i < r_{k+1}) = \Phi\left(X_i b_\rho - r_{k+1}\right) - \Phi\left(X_i b_\rho - r_k\right) \tag{2}$$

$$\widehat{\rho}_i = \sum_{k=0}^{k=4} k \left[\Phi\left(X_i \widehat{b}_\rho - r_{k+1}\right) - \Phi\left(X_i \widehat{b}_\rho + r_k\right)\right] \tag{3}$$

$$\text{with } r_0 = -\infty, \quad \text{and} \quad r_5 = +\infty$$

$$P(C_i = 1) = P(X_i b_\beta + c\rho_i + \varepsilon_i < 0) = 1 - \Phi\left(X_i b_\beta + c\rho_i\right) \tag{4}$$

$$\widehat{\beta}_i = 1 - \Phi\left(X_i \widehat{b}_\beta\right) \tag{5}$$

X is a vector of observed variables for individual i containing age, educational attainment, localization, matrimonial status, household size, and being head of the household. We assume normality and independence for ν and ϵ.

As the available measure for ρ is a discrete variable, we choose an ordered probit specification to estimate the expected number of partners for each group. Three predictors of ρ might then be computed for each individual i. The first with the whole set of variables entering X, ρ_{i1}. The second without the matrimonial status in order to produce a maximum benchmark for the "unfaithful married men" effect, ρ_{i2}. However, this correction should be taken as maximum maximorum, because Y should be corrected as well for an arguable lower level of infection of wives, even if intra-marital sexual intercourse is usually unprotected. Fortunately, when looking at the estimation results, we will see that this correction turns out to be useless. The third predictor, ρ_{i3}, is computed through an estimated equation where for married men who declared having had only sexual intercourse with their wife, the number of sexual partners is coded as zero.

Note that we introduced the number of partners in equation (4), in order to control for the impact of sexual activity on the frequency of condom use. We then obtain a predictor for the probability of having had an unprotected intercourse for a given partner (holding fixed the number of partners). Under the additional assumption that the frequency of intercourse with a given partner does not vary with X, this equation provides an acceptable predictor for β.

For the third variable Y, we use two alternative assumptions. First, that Y is homogenous across observable groups, i.e. does not depend on X, denoted Y_1. Second, that Y varies with X like the probability of "knowing somebody with AIDS" (KN), once controlled for the number of sexual partners, denoted Y_2. We assume additionally that Y does not vary with ν or ε, that is the unobservable part of ρ and β. This assumption is needed for the econometric identification of the effect of ρ.[8] Note that ρ is eliminated in the predictor of Y_2 as for the predictor of β.

$$P(KN_i = 1) = P(X_i b_Y + d\rho_i + \eta_i \geq 0) = \Phi\left(X_i b_Y + d\rho_i\right) \tag{6}$$

$$\widehat{Y}_i = \Phi\left(X_i \widehat{b}_Y\right) \tag{7}$$

The case of women

For women, we would have implemented the same procedure, if information on the number of partners was available. To obtain a predictor for ρ, we may simply use the dichotomous information saying whether the woman had sexual intercourse the two months preceding the survey. However, such a choice may lead to biased coefficients, and automatically limit the variance of the infection risk. Alternatively, we may think of predicting an expected number of partners with the estimated coefficients for men. However, we have no reason to believe that the same parameters apply for women's sexual activity. In absence of a really convincing solution, we give our preference to the direct estimation of risk differentials based on the available dichotomous variable.

Estimation results

Sexual activity

For men, the number of sexual partners is only lower for ages between 15 and 19 years, the coefficients for all other age groups are not significantly different from each other (left part of Table 1). Household heads have a slightly higher expected number of sexual partners. Conversely, matrimonial status does not come out as significant. This means that we are not confronted with a high "married man" bias concerning the declared number of partners.[9] Most importantly, the declared number of partners grows in two steps with education. Possible reasons behind this relation may be that more educated persons have greater personal autonomy and spatial mobility, and are more often polygamous (partly due to higher income). Given the generally positive correlation of education with income, this may also reflect that more educated persons have more easily access to prostitutes. The declared number of partners is slightly lower in Abidjan relatively to the other areas, other things being equal.

[Table 1 about here]

For women, the probability of having had sexual intercourse the last two months preceding the survey is marked by a strong positive "married woman" effect (right part of Table 1), suggesting that the used dichotomous variable is not a perfect proxy for ρ. Nevertheless, it is interesting to observe that the results regarding education and localization obtained for men with the polytomic variable hold for women, i.e. sexual activity is growing in two steps with education and is slightly lower in Abidjan.

Condom use

The models explaining the probability of using condoms (conditionally on sexual activity) give very similar results for both sexes (Table 2). This similarity of results, which reflects "homogamy" in sexual matching, increases our confidence in our estimation procedure.

[Table 2 about here]

Condom use decreases with age and is lower for married persons, but increases with education.[10] For men, the number of sexual partners turns out to be significant, increasing condom use too. Remember that we do not introduce this latter variable in the prediction of β. Area of residence turns out as insignificant, as well as being head of a household in the case of men. For both sexes, the strong "marriage effect" on condom use may be a matter of worry. It partially corresponds to a higher confidence in the partner, which theoretically should be reflected in the Y rather than in the β variable. Again, unfortunately we cannot conclude satisfyingly on the respective weight of the "faithfulness" and "unprotected marital intercourse" factors. However, in our calibration procedure of the mortality rates, we cancel out this "marriage effect" on condom use, in order to obtain an—in our sense—average benchmark.

AIDS infection among relatives

In the case of men, the probability of knowing somebody who is infected with HIV/AIDS is lower for the youngest (inexperienced) persons (15-19 years old) and higher for household heads (see Table 3). As already mentioned when performing the MCA, the probability of knowing somebody with AIDS increases with the declared number of partners. It also increases with educational attainment. Of course, this latter effect may reflect an increasing social network rather than a higher probability of matching with infected people. Therefore, we assume that the use of this variable tends to overestimate the "true" Y for educated people. Conversely, living in Abidjan reduces significantly the probability of knowing an infected person. The interpretation may be that secrets are better preserved in large towns than in other areas where social links are more intimate and less anonymous.

[Table 3 about here]

In the case of women, age effects are almost insignificant, except for the 30-34 years old group. The positive effect of education holds. Other things being equal, married women know more often somebody who is infected. In contrast with men, the effect of living in Abidjan disappears. These two latter results may reflect gender differences in social networks—more extended and intimate knowledge of relatives for married women, whatever their localization.

Table 4 presents some statistics concerning the distribution of the four different risk factors, denoted, $P1$ to $P4$, which are obtained by using the described alternative predictions for ρ and Y. Figure 1 presents the corresponding Kernel density curves.

[Table 4 about here]

[Figure 1 about here]

Derivation of AIDS mortality probabilities for population subgroups

Now we have to derive mortality tables by introducing the risk factors, estimated in the former section, in more aggregated mortality tables, in a way that the overall mortality remains constant.

The most recent mortality tables for Côte d'Ivoire are those estimated by the INS using census data of 1988 and 1998 (INS 2001, 1992). However, the INS provides no specific estimations concerning mortality due to the AIDS epidemic. Another source are the UN demographic projections in the long term for Côte d'Ivoire. These projections incorporate infant ($_1q(1)$) and juvenile mortality ($_5q(0)$) for both sexes together as well as the life expectancy at birth (e_0) for each sex separately. These indicators are estimated for five-year periods until 2050 under two scenarios: the first taking into account the impact of AIDS, and the second under the hypothesis of an absence of AIDS (see Table 5).[11]

Comparing the UN projections with the estimations of the INS (Table

5), one notes that both show a rise in mortality since 1985. However, the UN projections are more optimistic concerning infant mortality, but more pessimistic concerning adult mortality. In any case, both institutions consider their estimations as relatively uncertain. We calibrate our model on the UN projections, allowing to isolate (at least approximatively) mortality due to AIDS, and to work with coherent projections into the future. Using these projections and the concept of model life tables, we construct mortality tables for both sexes and for five-year periods starting in 1990.

[Table 5 about here]

More precisely, a set of mortality tables is calculated for both sexes separately and for five year age intervals for the periods 1990-95, 1995-2000, ..., 2010-15 by introducing in a Ledermann (1969) model life table (*pattern 100*)[12] the UN life-expectancy projections under the hypothesis "No AIDS".[12] Then the mortality rates are proportionally adjusted such that they produce exactly the life-expectancy entered, given that in this type of Ledermann model life table the entered life-expectancy is slightly different from that finally produced by the constructed table. The mortality rates ${}_1q(0)$ and ${}_4q(1)$ are directly restricted to the UN projections. Then a second set of mortality tables is constructed, taking into account the impact of AIDS. Now, we use as entry for the model life-tables the UN "with AIDS" life-expectancies at birth. As before, the mortality rates are adjusted such that they produce exactly the life-expectancy entered. But, to ensure that the mortality rates are in line with those of a population affected by the AIDS epidemic, the adjustment concerns now only the age intervals between 20 and 59 years. For ${}_1q(0)$ and ${}_4q(1)$, the "with AIDS" mortality rates estimated by the UN are directly used. For the mortality rates ${}_5q(5)$, ${}_5q(10)$, ${}_5q(15)$, ${}_5q(60)$ $\ldots$ ${}_5q(80)$ those of the "without AIDS" scenario are retained, i.e. we suppose no impact of AIDS for these age groups. Children who get AIDS by her mother do normally not survive until they are five years old. In consequence, the adjustment increases strongly mortality in the intermediate adult age, and this the more the heavier the epidemic. For both types of tables—with AIDS and without AIDS—we set the mortality rate beyond 87 years to one, such that there is no survivor at 88 years.

To derive now mortality tables for deaths due to AIDS taking into account the heterogeneity in the risk of infection, we proceed as follows. In a first step we transform the mortality rates in the mortality tables, with and without AIDS, for age groups and five year periods in mortality rates for single ages a and years t. This is done by interpolating linearly the mortality rates for the five-year age groups between the tables of two neighboring periods and then by interpolating, likewise linearly, between two neighboring age groups.[13] Then we normalize the individual risk factors P_i calculated for all men (15 to 59 years) and all women (15 to 49 years) present in the DHS of 1994 for each age a to one by multiplying them with the ratio of the number of individuals of the same age n_a and the sum of the risk factors at this age:

$$\tilde{P_{ia}} = P_{ia} \frac{n_a}{\sum_{i=1}^{n_a} P_{ia}} \tag{8}$$

This normalization assures that the introduction of the individual risk factors in the mortality tables does not modify the overall mortality level given by the UN projections. However, it is clear that this normalization modifies the risk age pattern, in the sense that now the individual risk factor depends on the risk level and dispersion among his/her age-class mates. That means, an individual with a high risk who is surrounded by many other high risk individuals can finally have a risk factor lower than an individual with an initial very moderate risk factor, but who is surrounded by many low risk individuals. However, this bias is partly redressed by the calibration of the AIDS mortality rates on the mortality age pattern derived above. In a next step, we multiply for each man and woman in the DHS the normalized risk factor $\tilde{P_{ia}}$ with the difference between the interpolated mortality rate with and without AIDS, such that we obtain for each person a probability of dying of AIDS, given the period and its individual socio-economic characteristics.

HIV infection and the death of AIDS are separated by the incubation period, which is the duration between the infection and the onset of clinical AIDS, and by the duration between the onset and death. The length of the incubation period is thought to depend upon at least four determinants: (i) the mode of HIV transmission, (ii) the age of the person, (iii) the exposure to other disease, and (iv) other individual characteristics, including genetic make-up. Estimates of the mean incubation period range from 5.1 years to 10.6 years,[15] and those of the period between the AIDS onset and death around 1.5 years, but the uncertainty associated with these estimates is substantial (Palloni & Glicklich 1991). The way our risk factors are constructed imply that they measure rather the risk of infection than mortality. The infection might already have occurred or might occur in the future. In other words, the observed behavior concerns infected and uninfected individuals. We only know that they are still alive in 1994. In our model we suppose implicitly that the risk differentials among infected and uninfected people are distributed as the mortality differentials.

Discussion of the mortality tables

In the following tables figure the averages of the derived individual annual AIDS mortality probabilities for men (15 to 59 years old) and women (15 to 49 years old) disaggregated by educational attainment and area of residence. Of course, these tables could be derived for all other individual characteristics considered in our model as well. They are each time confronted with the mortality probabilities of dying by a cause other than AIDS (first column). The sum of this latter probability with the probability of dying of AIDS is equal to the overall death probability.

The results are presented for two of our four risk factors: $P1$ and $P4$. Furthermore, we used different mortality levels, that of 1994, year of the used DHS, and that of 2002, which would present the actual situation if the model is valid. All these computations are done using the female and male population covered by the Ivorian DHS women and men questionnaire. As already mentioned, the mortality probabilities for population subgroups are not independent of the population structure. The tables allow the following interpretations.

[Tables 6 to 9 about here]

1. The way our Ledermann life tables are adjusted to the life-expectancy given by the UN projections makes age groups with a higher risk of dying by a cause other than AIDS also more likely to die of AIDS (the age effects in the risk multipliers are canceled out by the calibration procedure). This pattern seems plausible, given that we consider here only age groups from 15 to 59 years (15 to 49 years for women). Furthermore, this increase is coherent with our estimation results showing that for men the number of sexual partners is, *ceteris paribus*, maximum for intermediate age groups (see Table 1). Second, condom use decreases with age for men and women (see Table 2). Third, the probability of knowing somebody with AIDS rises with age, likewise for men and women (see Table 3).

2. Given the UN projections (compare with Table 5) on which our

mortality probabilities are calibrated, the risk of dying of AIDS is in 2002 significantly higher than in 1994 for all stratifications chosen in Tables 6 to 9. For the male age groups 20 to 45 years old and the female age groups 20 to 49 years old the risk of dying of AIDS is equal or sometimes even higher, especially for women, than by dying of another cause than AIDS. Thus, AIDS becomes for these age groups the major cause of death.

3. The urban-rural mortality differential shows the following pattern. The AIDS death probabilities for men are higher in rural areas for the age groups 15 to 39, whereas they are lower for the age groups 40 to 54 (the last age group is rather small in rural areas and should thus considered with caution). For women, they are in 1994 always higher in rural areas. In contrast, in 2002, they are for all age groups older than 25 slightly higher in urban areas. It might seem surprising that the AIDS death probabilities are not significantly lower in rural areas than in urban areas, but it should be noted that (i) as mentioned earlier the epidemic reached very rapidly all regions in Côte d'Ivoire; (ii) the number of sexual partners for men, and sexual activity in general for women, is in rural areas significantly higher than in urban areas (see Table 1), which can for men be explained among other things by more polygamy in rural areas; and (iii) condom use seems in rural areas less frequent

than in urban areas (see Table 2). Furthermore, even if the used demographic projections are not disaggregated by area of residence, other data sources (INS 1992) indicate that the general mortality level in rural areas is higher than in urban areas, and thus the risk for an infected person of dying by opportunistic illnesses may be too.

4. The AIDS mortality probabilities increase for each age group with educational attainment, especially for men, but a little less for women in urban areas (see Table 6 to 9). This effect is larger the older the individuals and maximum for the age groups 40 to 44 for men and 44 to 49 for women. For instance, in urban areas the probability of dying of AIDS in the year 2002 is for the male age group 25 to 29, using P1, 25% higher for individuals with at least secondary high school than for those who know neither reading nor writing. In contrast, this increase is more than 35% for the age group 40 to 44. If we use the risk factor $P4$ instead of $P1$, the risk heterogeneity becomes, as expected, even higher, because then the probability of "knowing somebody with AIDS" determines the prevalence level of the individual's environment, and this probability increases strongly with education (see Table 3). For instance, in urban areas in the year 2002 the probability for individuals having a higher secondary schooling level is 2.3 to 4 times

higher than that of individuals having no schooling at all. These results are consistent with the literature survey by Hargreaves and Glynn (2002), and with the results of the first general population survey with HIV testing undertaken in South-Africa. In this latter survey, prevalence of HIV significantly and monotonically increases with education among African adults, going from 8.7 percent for those with no schooling to 21.1 percent for those who have matriculated (HSCR 2002). Some argue that these excess infection levels seen among more educated groups may disappear as the epidemic progresses, because educated people may adopt new, less risky lifestyles quicker than other groups (see e.g., Hargreaves & Glynn 2002, Walque 2002, Gregson, Waddell & Chandiwana 2001, Ainsworth & Semali 1998). We checked this hypothesis by running the same regression on the Ivorian DHS of 1998/99.[16] We found very similar regression coefficients to 1994, especially the measured associations between risk and education hold. Of course, the expected changes in behavior may be more visible in the longer run. But again, in 2002 in South-Africa for instance, according to the HSCR survey, the association between education and HIV infection was still strong among Africans (HSCR 2002).

Conclusion

The aim of this paper was to model and estimate individual heterogeneity regarding AIDS mortality. Knowledge in this field seems indispensable to quantify the economic impact of AIDS and to set up adequate AIDS prevention and therapy policies in developing countries.

A main result of our study is that the risk of infection and therefore the risk of dying of AIDS increases with educational attainment. The driving force behind this relation is that educated people are more likely to have several sexual partners. However, this effect is partly offset by a higher probability of condom use. If we account for heterogeneity in the individual risk environment, we find again a positive association between risk and education. Some argue that this excess infection levels observed among more educated groups may disappear as the epidemic progresses because educated people may adopt, quicker than other groups, new, less risky lifestyles. Walque (2002), for instance shows, using surveillance data of the HIV/AIDS epidemic among pregnant women attending prenatal care clinics collected in the city of Fort Portal in Western Uganda between 1991 and 2000, that the increased exposure to HIV/AIDS of the most educated disappears at the end of the survey period when their HIV prevalence reduces to 18% at a level similar to the prevalence in other education categories. In addition Walque (2002) analyses the correlation between education and the number of sexual partners using DHS (as we did) for 17 African countries. He finds no or negative correlation only for the few countries where the HIV prevalence is very high (above or around 15%). For all other countries (including Côte d'Ivoire), he finds a positive correlation, suggesting that the excess infection levels among more educated groups may only disappear when the epidemic reaches a very high level.

The economic consequences of a positive correlation between education and risk of infection are potentially important. From a macro-economic point of view this could imply a massive destruction of human capital. From a micro-economic point of view, one could expect an appraisal of new categories of poor through transitions from the top to the bottom of the income distribution. These issues can be studied with our model, given that it is based on econometrically estimated equations using commonly available individual and household characteristics. It can therefore be used to forecast mortality differentials for other data sources as well, household living standard surveys for example, allowing to analyze the impact of AIDS on household incomes and the resulting distributional and poverty effects (as done in another paper by the authors).

However, we are conscious of the simplicity of our model specification. Dynamics, which are generally important in epidemiology, are only added to our model through the calibration of our risk factors on UN demographic projections, but they do not directly affect individual behavior. Furthermore, the used variables are only imperfect proxies of sexual behavior. However, in spite of its methodological caveats, we think that this study is a first step in modelling the distribution of AIDS over socio-economic groups. A more detailed model for the case of Côte d'Ivoire will be feasible when better data, especially a representative survey about HIV infection, becomes available.

Appendix A: Graphical output of the multiple correspondence analysis

[Figure A1]

[Figure A2]

[Table A1]

Appendix B: Descriptive statistics of the three risk variables

[Table A2]

[Table A3]

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Notes

1. See e.g. Gregson, Waddell and Chandiwana (2001), Ainsworth and Semali (1998), Becker (1990), Miller and Rockwell (1988) and for empirical studies showing a positive relation between socio-economic status and HIV infection in Sub-saharan Africa. See also Hargreaves and Glynn (2002) for a literature survey on this issue. Philipson and Posner (1995) try to rationalize a positive correlation between income and HIV infection, although they acknowledge it could be spurious.

2. The most representative surveys available in developing countries are those based on tests in prenatal care centers. But, first not all women consult prenatal clinics, even if the proportion is in some developing countries relatively high. Second, not all women have the same probability to be pregnant, this is especially true for women infected by HIV (see e.g., Desgrées du Loû, Mselatti, Yao *et al.* 1999). Third, these data say not much about infection levels among men.

3. Against 10.8% end-1999, suggesting a stabilization of the epidemic (UNAIDS/WHO 2002, 2000) in the late nineties. These estimations include all adults (15 to 49 years) alive, with HIV infection, whether or not they have developed symptoms of AIDS.

4. For a statistical description of the answers given in the DHS AIDS module for several other countries see, for instance, United Nations (2002), Gersowitz (2001) or Filmer (1998).

5. This correlation means two things: (i) the topological similarities between the two independently constructed bi-dimensional spaces, and (ii) the correlation between individual answers of husbands and their wives.

6. Brouard (1994) quotes epidemiological studies which tend to show that the risk of infection depends only weakly on the frequency of sexual intercourse with each partner. In developed countries, β would be around 0.1 for the transmission from women to men, and 0.2 for the transmission from men to women, whatever the level of sexual activity.

7. "Ignoring that an infected person may seem healthy", "not considering that occasional partners may be risky", "not quoting avoidance of prostitutes" may reflect a "preferred matching" with partners of higher incidence rates, either by ignorance or by conscious

choice. However, because of their ambiguous nature, these variables are not used.

8. Alternatively, we could estimate equations (2), (4), and (6) simultaneously, but then an identifying variable for each equation is necessary which our survey does not provide. A third possibility would be to impose correlation coefficients between the residual terms, but in lack of any information regarding their size, we prefer the independence hypothesis.

9. Normally the interviews in the DHS are undertaken separately for men and women. Each man is interviewed by one man and each woman by one woman.

10. Similar results were found by Filmer (1998) and Deheneffe, Caraël and Noumbissi (1998).

11. All these indicators are estimated within the World Population Prospects 2000, version February 2001 (United Nations 2001). The estimation method is explained in United Nations (1999).

12. This model has as equation: $\log_{10} \hat{q}_j = \hat{a}_{j0} + \hat{a}_{j1} \log_{10}(100 - e_0)$, with $\hat{q}_j$ the mortality rate predicted for the age group j, e_0 the life-expectancy at birth, and $\hat{a}_{j0}$ and $\hat{a}_{j1}$ the estimated parameters using mortality tables of a large number of countries.

13. Ledermanns model life tables are preferable to the standard OECD

tables (Clairin, Condé, Fleury-Brousse *et al.* 1980) which are despite the fact that they are only based on data of developing countries judged as of poor quality (see e.g., Duchêne 1999). They are also more suitable than the "new" tables of the United Nations (1982) which do not even include Sub-saharan Africa. The only represented African country is Tunisia.

14. In the demographic literature one can find more adequate interpolation methods—parametric and non-parametric ones (see e.g., Kostaki & Panousis 2001)–but given that the introduction of risk multipliers in the mortality tables will in any case modify the mortality age pattern within age groups, the use of these methods does not seem necessary.

15. The UN uses a median adult progression time of eight years for African countries (United Nations 1999). Mulder (1996), for instance, assumes a shorter interval of five to six years.

16. We used however the DHS 1994 in our analysis, because the DHS 1998/99 has a much smaller sample size (8,099 women and 2,552 men vs. 3,040 and 886 respectively) (see Macro International Inc. 1999).

References

Ainsworth, M., & Semali, I. (1998). Who is most likely to die of AIDS? Socioeconomic correlates of adult deaths in Kagera Region, Tanzania, pp. 95-109, in: M. Ainsworth, L. Fransen, & M. Over (eds.), *Confronting AIDS: Evidence from the Developing World*, European Commission, Brussels and World Bank, Washington, D.C.

Anderson, R.M. & May, R.M. (1992). *Infectious diseases of humans: dynamics and control*, Oxford: Oxford University Press.

Arndt, C. & Lewis, J.D. (2000). The macro implications of HIV/AIDS in South Africa: A preliminary assessment, *South African Journal of Economics* 68(5):1-32.

Aventin, L. & Huard, P. (2000). Le coût du SIDA dans trois entreprises manufacturières en Côte d'Ivoire, *Revue d'économie du développement* 3:55-82.

Barnett, T. & Blackie, P. (1989). AIDS and food production in East and Central Africa: A research outline, *Food Policy* 14(1):2-6.

Béchu, N. (1998). The impact of AIDS on the economy of families in Côte d'Ivoire: Changes in consumption among AIDS-affected households, pp. 340-348, in: M. Ainsworth, L. Fransen & M. Over (eds.), *Confronting AIDS: Evidence from the Developing World*, European Commission, Brussels and World Bank, Washington, D.C.

Becker, C. M. (1990). The demo-economic impact of the AIDS pandemic in Sub-saharan Africa, *World Development* 18(12):1599-1619.

Benzécri, J.-P. (1973). *L'analyse de données*, Vol. 2., Paris: Dunod.

Booysen, F. & Bachmann, M. (2002). HIV/AIDS, poverty and growth: Evidence from a household impact study conducted in the Free State Province, South Africa, Paper presented at the Annual Conference of the Centre for the Study of African Economies (CSAE), 18-19 March, Oxford.

Brouard, N. (1994). Aspects démographiques et conséquences de l'épidémie de SIDA en Afrique, pp. 119-178, in: B. Auvert, N. Brouard, F. Chièze, J.-P. Dozon & A. Guillaume (eds.), *Populations africaines et sida*, Paris: Editions La Découverte.

Clairin, R., Condé, J., Fleury-Brousse, M., Waltisperger, D. & Wunsch, G. (1980). *La mortalité dans les pays en développement, Vol. 3: Nouvelles tables types de mortalité à l'usage des pays en développement.* OECD, Development Center, Paris.

Cogneau D. & M. Grimm (2003). AIDS and income distribution in Africa. A micro-simulation study for Côte dIvoire, mimeo, DIAL, Paris.

Cuddington, J.T. (1993). Modelling the macroeconomic effects of AIDS with an application to Tanzania, *World Bank Economic Review* 7(2):172-189.

Cuddington, J.T. & Hancock, J.D. (1994). Assessing the impact of AIDS on the growth path of the Malawian economy, *Journal of Development Economics* 43:363-368.

Cuddington, J.T., Hancock, J.D. & Rogers, C.A. (1994). A dynamic aggregative model of the AIDS epidemic with possible policy interventions, *Journal of Policy Modeling* 16(5):473-496.

Deheneffe, J.-C., Caraël, M. & Noumbissi, A. (1998). Socioeconomic determinants of sexual behaviour and condom use, pp. 131-146, in: M. Ainsworth, L. Fransen & M. Over (eds.), *Confronting AIDS: Evidence from the Developing World*, European Commission, Brussels and World Bank, Washington, D.C.

Desgrées du Loû, A., Mselatti, P., Yao, A., Noba, V., Viho, I., Ramon, R., Welffens-Ekra, C. & Dabis, F. (1999). Impaired fertility in HIV-1-infected pregnant women: a clinic-based survey in Abidjan, Côte d'Ivoire, 1997, *AIDS* 13:517-521.

Duchêne, J. (1999). Les tables types de mortalité, Démographie: analyse et synthèse, pp. 155-169, Vol. 2 / Actes du Séminaire International de Roma-Napoli-Possuoli, 26-29 May.

Filmer, D. (1998). The socioeconomic correlates of sexual behaviour: A summary of the results from an analysis of DHS data, pp. 111-130, in: M. Ainsworth, L. Fransen & M. Over (eds.), *Confronting AIDS: Evidence from the Developing World.* European Commission, Brussels and World Bank, Washington, D.C.

Garenne, M., Madison, M., Tarantola, D., Zanou, B., Aka, J. & Doré, R. (1995). *Conséquences démographiques du SIDA en Abidjan, 1986-1992.* Les études du CEPED 10, CEPED, Paris.

Garenne, M. & Zanou, B.C. (2000). Treize ans de mortalité en Abidjan en présence du SIDA, Paper presented at the monthly CEPED research seminar, September 13, Paris.

Gersowitz, M. (2001). The African HIV epidemic as seen through the Demographic and Health Surveys, mimeo, Johns Hopkins University.

Gregson, S., Waddell, H. & Chandiwana, S. (2001). School education and HIV control in sub-saharan Africa: from discord to harmony? *Journal of International Development* 13:467-485.

Haacker, M. (2002). The Economic Consequences of HIV/AIDS in Southern Africa, IMF Working Paper 02/38, International Monetary Fund, Washington D.C.

Hargreaves, J.R. & Glynn, J. R. (2002). Educational attainment and

HIV-1 infection in developing countries: a systematic review, *Tropical Medicine and International Health* 7(6):489-498.

Hargreaves J.R., Morison, L.A., Chege, J., Rutenburg, N., Kahindo, M., Weiss, H.A., Hayes, R. & Buvé, A. (2002). Socioeconomic status and risk of HIV infection in an Urban Population in Kenya, *Tropical Medecine and International Health* 7(9):793-802.

HSRC (2002). HSRC Study of HIV/AIDS in South-Africa. Survey Report. Human Science Research Council, Cape Town, South-Africa.

Institut National de la Statistique, INS (1992). Recensement général de la population et de l'habitat 1988, Vol. 1: Structure, état matrimonial, fécondité et mortalité, Institut National de la Statistique, République de Côte d'Ivoire.

Institut National de la Statistique, INS (1995). Enquête Démographique et de Santé 1994. Institut National de la Statistique, République de Côte d'Ivoire.

Institut National de la Statistique, INS (2001). Récensement Général de la Population et de l'Habitation de 1998. Rapport d'analyse. Thème 4: La Mortalité. Institut National de la Statistique, République de Côte d'Ivoire.

Janjaroen, W.S. (1998). The impact of AIDS on household composition and consumption in Thailand, pp. 349-354, in: M. Ainsworth, L. Fransen & M. Over (eds.), *Confronting AIDS: Evidence from the Developing World*, European Commission, Brussels and World Bank, Washington, D.C.

Kambou, G., Devarajan, S., & Over, M., (1994). The economic impact of AIDS in an African country: Simulations with a Computable General Equilibrium Model of Cameroon, *Journal of African Economies* 1(1):109-130.

Kamuzora, C. & Gwalema, S. (1998). Labour constraints, population dynamics and the aids epidemic: the case of rural Bukoba district, Tanzania. Research Report No. 98.4, Research on Poverty Alleviation (REPOA), Dar es Salaam.

Kostaki, A. & Panousis, V. (2001). Expanding an abridged life table, *Demographic Research* 5(1):1-22 [online journal: www.demographic-research.org].

Kremer, M. (1996). Integrating behavioral choice into epidemiological models of the AIDS epidemic, *Quarterly Journal of Economics* 151(2):549-573.

Ledermann, S. (1969). *Nouvelles tables-types de mortalité.* Travaux et documents, Cahier n. 53, Paris: INED and PUF.

MacFarlan, M. & Sgherri, S. (2001). The macroeconomic impact of

HIV/AIDS in Botswana, IMF Working Paper 01/80, International Monetary Fund, Washington D.C.

Macro International Inc. (1999). Enquête Démographique et de Santé Côte d'Ivoire 1998/99. Rapport Préliminaire, Demographic and Health Surveys, Macro International Inc., Calverton, Maryland.

Menon, R., Wawer, M.J., Konde-Lule, J.K., Sewankambo, N.K. & Li, C. (1998). The economic impact of adult mortality on households in Rakai district, Uganda, pp. 325-339, in: M. Ainsworth, L. Fransen & M. Over (eds.), *Confronting AIDS: Evidence from the Developing World*, European Commission, Brussels and World Bank, Washington, D.C.

Miller, N. & Rockwell, R.C., eds. (1988). *AIDS in Africa*. Lewiston, NY: Edwin Mellen.

Mulder, D. (1996). Disease progression and mortality following HIV-1 infection, in: J. Mann & D. Tarantola (eds.), *Aids in the World II*, New York: Oxford University Press.

Palloni, A. & Glicklich, M. (1991). Review of approaches to modelling the demographic impact of the AIDS epidemic, pp. 20-50, in: *The AIDS epidemic and its demographic consequences*, Proceedings of the UN/WHO Workshop on Modelling the Demographic Impact of the AIDS Epidemic in Pattern II Countries: Progress to Date and

Policies for the Future, United Nations, New York.

Phlilipson, T. & Posner, R.A. (1995). The microeconomics of the AIDS epidemic in Africa, *Population and Development Review* 4(21):835-848.

Tibaijuka, A.K. (1997). AIDS and economic welfare in peasant agriculture: case studies from Kagabiro Village, Kagera Region, Tanzania, *World Development* 25(6):963-975.

UNAIDS/WHO (2000). Epidemiological fact sheets on HIV/AIDS and sexually transmitted infections, 2000 Update, UNAIDS/WHO, Geneva.

UNAIDS/WHO (2002). Epidemiological fact sheets on HIV/AIDS and sexually transmitted infections, 2002 Update, UNAIDS/WHO, Geneva.

United Nations (1982). *Model life tables for developing countries.* United Populations Studies, 77, United Nations, New York.

United Nations (1999). The demographic impact of HIV/AIDS. Report on the technical meeting, New York, 10 November 1998, Population Division, Department of Economic and Social Affairs, United Nations, New York.

United Nations (2001). World population prospects: The 2000 revision, version February 2001 (data files), Population Division, Department of Economic and Social Affairs, United Nations, New York.

United Nations (2002). Sensibilisation au VIH/SIDA et comportements, Report No. ST/ESA/SER.A/209, Department of Economic and Social Affairs, United Nations, New York.

U.S. Census Bureau (2000). HIV/AIDS Surveillance Data Base, June, International Program Center, Population Division, U.S. Census Bureau, http://www.census.gov/ipc/www.

Volle, M. (1985). *Analyse des données*. Paris: Economica.

Walque, D. de (2002). How does educational attainment affect the risk of being infected by HIV/AIDS? Evidence from Uganda and Zambia, mimeo, University of Chicago.

Table 1. Men 15 to 59 years old, Ordered Probit model
"Number of sexual partners the last two months" ($\rho_{1,2,3}$)
(0 = 0 partners, 1 = 1 p., 2 = 2 p., 3 = 3 p., 4 = 4 and more p.)

Women 15 to 49 years old, Probit model
"Had sexual relation the last two months" (ρ_1)
(1 = yes, 0 = no)

	Men		Women	
Variables	Coeff.	Std. err.	Coeff.	Std. err.
Age group				
15-19	Ref.		Ref.	
20-24	0.662 *	(0.081)	0.166 *	(0.048)
25-29	0.728 *	(0.089)	0.150 *	(0.054)
30-34	0.761 *	(0.102)	0.044	(0.057)
35-39	0.726 *	(0.114)	0.044	(0.064)
40-44	0.734 *	(0.123)	-0.028	(0.069)
45-49	0.516 *	(0.135)	-0.089	(0.075)
50-54	0.500 *	(0.147)		
55-59	0.756 *	(0.162)		
Ever married	0.093	(0.073)	0.490 *	(0.044)
Household head	0.192 *	(0.068)		
Educational level				
analphabetic	Ref.		Ref.	
reading/writing	0.216 *	(0.068)	0.235 *	(0.043)
Primary school	0.282 *	(0.063)	0.270 *	(0.043)
Lower secondary[a]	0.585 *	(0.080)	0.393 *	(0.076)
Higher secondary	0.522 *	(0.105)		
Household size	0.007 *	(0.004)	-0.005 *	(0.002)
Abidjan	-0.203 *	(0.067)	-0.121 *	(0.043)
Other Cities	0.036	(0.054)	0.018	(0.034)
Rural areas	Ref.		Ref.	
Intercept			-0.225 *	(0.047)
Number of observations	2446		7552	
log likelihood	-2627		-4965	
dl	17		13	

Source: DHS 1994; estimations by the authors.
* Coefficient significative at the 5% level.
[a] For women the levels "lower secondary" and "higher secondary" are aggregated.

Table 2. "Used condom the last two months" (β)
Probit models, men 15 to 59, women 15 to 49 years old

	Men		Women	
Variables	Coeff.	Std. err.	Coeff.	Std. err.
Age group				
15-19	Ref.		Ref.	
20-24	0.068	(0.145)	-0.058	(0.086)
25-29	-0.128	(0.156)	-0.238 *	(0.107)
30-34	-0.219	(0.180)	-0.273 *	(0.123)
35-39	-0.354	(0.203)	-0.279	(0.144)
40-44	-0.616 *	(0.237)	-0.554 *	(0.215)
45-49	-0.595 *	(0.273)	-0.659 *	(0.281)
50-54	-0.591 *	(0.317)		
55-59	-0.925 *	(0.412)		
Ever married	-0.444 *	(0.123)	-0.693 *	(0.080)
Household head	-0.025	(0.121)		
Educational level				
analphabetic	Ref.		Ref.	
reading/writing	0.118	(0.129)	0.402 *	(0.084)
Primary school	0.396 *	(0.114)	0.460 *	(0.082)
Lower secondary[a]	0.788 *	(0.128)	0.960 *	(0.113)
Higher secondary	0.562 *	(0.162)		
Household size	-0.007	(0.007)	0.000	(0.004)
Abidjan	0.116	(0.118)	0.084	(0.090)
Other Cities	0.183	(0.096)	0.085	(0.072)
Rural areas	Ref.		Ref.	
Number of sex. partners				
1 partner	Ref.			
2 partners	0.553 *	(0.105)		
3 partners	0.766 *	(0.163)		
4 and more partners	0.941 *	(0.188)		
Intercept	-0.726 *	(0.165)	-1.194 *	(0.095)
Number of observations	1339		4436	
log likelihood	-606		-947	
dl	20		13	

Source: DHS 1994; estimations by the authors.
* Coefficient significative at the 5% level.
[a] For women the levels "lower secondary" and "higher secondary" are aggregated.

Table 3. "Knows somebody infected with HIV/AIDS" (Y_2)
Probit models, men 15 to 59, women 15 to 49 years old

	Men		Women	
Variables	Coeff.	Std. err.	Coeff.	Std. err.
Age group				
15-19	Ref.		Ref.	
20-24	0.284 *	(0.100)	-0.054	(0.054)
25-29	0.193	(0.112)	0.083	(0.059)
30-34	0.398 *	(0.129)	0.171 *	(0.062)
35-39	0.268	(0.144)	0.104	(0.070)
40-44	0.386 *	(0.155)	0.114	(0.077)
45-49	0.585 *	(0.166)	0.087	(0.085)
50-54	0.426 *	(0.183)		
55-59	0.353	(0.208)		
Ever married	-0.033	(0.093)	0.145 *	(0.049)
Household head	0.166 *	(0.085)		
Educational level				
analphabetic	Ref.		Ref.	
reading/writing	0.361 *	(0.086)	0.283 *	(0.047)
Primary school	0.560 *	(0.078)	0.332 *	(0.046)
Lower secondary[a]	0.630 *	(0.100)	0.527 *	(0.077)
Higher secondary	0.719 *	(0.129)		
Household size	0.011 *	(0.004)	0.000	(0.002)
Abidjan	-0.215 *	(0.084)	-0.031	(0.048)
Other Cities	-0.097	(0.068)	-0.018	(0.037)
Rural areas				
Number of sex. partners				
0 partner	Ref.			
1 partner	0.133	(0.068)		
2 partners	0.281 *	(0.103)		
3 partners	0.493 *	(0.166)		
4 and more partners	0.828 *	(0.177)		
Had sex last two months			0.105 *	(0.034)
Intercept	-1.527 *	(0.106)	-1.125 *	(0.055)
Number of observations	2422		7536	
log likelihood	-1253		-3883	
dl	21		14	

Source: DHS 1994; estimations by the authors.
* Coefficient significative at the 5% level.
[a] For women the levels "lower secondary" and "higher secondary" are aggregated.

Table 4. Summary statistics of the alternative risk factors

Risk factor	Obs.	Mean	Std. dev.	Min.	Max.
Men 15 to 59 years old					
$P1 = \rho_1 \beta Y_1$	2446	0,0041009	0,0015774	0,0009032	0,0083762
$P2 = \rho_2 \beta Y_1$	2446	0,0038631	0,0014032	0,0009032	0,0077560
$P3 = \rho_3 \beta Y_1$	2446	0,0025684	0,0009402	0,0005708	0,0058652
$P4 = \rho_1 \beta Y_2$	2446	0,0130047	0,0089671	0,0005516	0,0534365
Women 15 to 49 years old					
$P1 = \rho_1 \beta Y_1$	7552	0,0070848	0,0012960	0,0037269	0,0087682
$P4 = \rho_1 \beta Y_2$	7552	0,0205611	0,0070826	0,0066786	0,0418143

Source: DHS 1994; estimations and computations by the authors.

Table 5. Estimations and projections of mortality in Côte d'Ivoire with and without AIDS

Indicator	1985-90	1990-95	1995-00	2000-05	2005-10	2010-15
Infant mortality						
with AIDS	0.102	0.094	0.089	0.081	0.072	0.063
without AIDS	0.098	0.086	0.079	0.071	0.064	0.056
census 1988 and 1998	0.097		0.104			
Mortality under five						
with AIDS	0.167	0.159	0.152	0.138	0.121	0.104
without AIDS	0.160	0.142	0.128	0.113	0.099	0.085
Life expectancy at birth						
with AIDS/Men	49.8	48.6	47.4	47.7	49.5	52.0
without AIDS/Men	51.0	52.8	54.9	57.0	59.0	61.1
census 1988 and 1998	53.6		49.2			
with AIDS/Women	52.8	50.8	48.1	48.1	50.1	52.9
without AIDS/Women	54.5	56.7	58.4	60.5	62.5	64.6
census 1988 and 1998	57.2		52.7			

Source: World Population Prospects 2000, version February 2001 (United Nations 2001), Population census 1988 (INS 1992) and 1998 (INS 2001).

Table 6. AIDS mortality probabilities p.a. x100 by educational attainment, men, urban Côte d'Ivoire

Age group	other causes	mortality attributable to AIDS all	anlph.	read.	prim.	losec.	hisec.
risk factor: $\rho_1\beta Y_1$, using the mortality level of 1994							
15-19	0.376	0.014	0.008	0.013	0.002	0.049	0.136
20-24	0.540	0.258	0.268	0.279	0.230	0.255	0.266
25-29	0.562	0.398	0.368	0.429	0.401	0.388	0.457
30-34	0.608	0.434	0.397	0.483	0.442	0.439	0.494
35-39	0.713	0.471	0.424	0.514	0.469	0.485	0.537
40-44	0.900	0.522	0.441	0.564	0.602	0.585	0.605
45-49	1.183	0.547	0.487	0.562	0.602	0.737	0.518
50-54	1.609	0.606	0.615	0.558	0.542		0.647
55-59	2.237	0.601	0.576	0.601	0.667		0.894
risk factor: $\rho_1\beta Y_2$, using the mortality level of 1994							
15-19	0.376	0.013	0.000	0.007	0.004	0.058	0.180
20-24	0.540	0.238	0.122	0.231	0.255	0.323	0.339
25-29	0.562	0.387	0.176	0.380	0.474	0.474	0.721
30-34	0.608	0.418	0.218	0.455	0.510	0.543	0.658
35-39	0.713	0.442	0.213	0.455	0.526	0.619	0.726
40-44	0.900	0.534	0.249	0.571	0.771	0.859	0.910
45-49	1.183	0.554	0.325	0.640	0.807	1.064	0.819
50-54	1.609	0.611	0.483	0.671	0.786		1.110
55-59	2.237	0.572	0.443	0.740	1.202		1.325
risk factor: $\rho_1\beta Y_1$, using the mortality level of 2002							
15-19	0.312	0.052	0.043	0.052	0.037	0.099	0.231
20-24	0.446	0.508	0.518	0.550	0.465	0.502	0.522
25-29	0.463	0.727	0.670	0.782	0.732	0.705	0.838
30-34	0.503	0.791	0.724	0.874	0.806	0.799	0.897
35-39	0.596	0.860	0.777	0.937	0.852	0.905	0.973
40-44	0.767	0.961	0.824	1.033	1.069	1.098	1.112
45-49	1.036	1.004	0.897	1.023	1.106	1.316	1.050
50-54	1.440	1.099	1.093	1.062	1.042		1.207
55-59	2.036	1.087	1.040	1.222	1.278		1.368
risk factor: $\rho_1\beta Y_2$, using the mortality level of 2002							
15-19	0.312	0.050	0.011	0.039	0.042	0.119	0.316
20-24	0.446	0.472	0.251	0.462	0.511	0.627	0.657
25-29	0.463	0.707	0.322	0.694	0.865	0.861	1.317
30-34	0.503	0.761	0.400	0.822	0.931	0.989	1.195
35-39	0.596	0.807	0.392	0.830	0.956	1.148	1.315
40-44	0.767	0.983	0.478	1.045	1.372	1.594	1.663
45-49	1.036	1.015	0.607	1.162	1.474	1.901	1.591
50-54	1.440	1.107	0.857	1.263	1.478		2.032
55-59	2.036	1.036	0.804	1.470	2.231		2.152

Source: Estimations by the authors.
anlph.=analphabetic; read.=reading/writing; prim.=primary school; losec.=lower secondary; hisec.=higher secondary and +.

Table 7. AIDS mortality probabilities p.a. x100 by educational attainment, men, rural Côte d'Ivoire

Age	other	mortality attributable to AIDS					
group	causes	all	anlph.	read.	prim.	losec.	hisec.
risk factor: $\rho_1 \beta Y_1$, using the mortality level of 1994							
15-19	0.376	0.021	0.020	0.029	0.000	0.081	
20-24	0.540	0.325	0.293	0.333	0.362	0.343	
25-29	0.562	0.455	0.419	0.491	0.467	0.514	
30-34	0.608	0.473	0.428	0.522	0.485	0.539	
35-39	0.713	0.512	0.449	0.551	0.524	0.598	
40-44	0.900	0.525	0.488	0.609	0.574	0.692	
45-49	1.183	0.552	0.522	0.614	0.619	0.702	
50-54	1.609	0.588	0.562	0.726	0.679		
55-59	2.237	0.622	0.609	0.709	0.869		
risk factor: $\rho_1 \beta Y_2$, using the mortality level of 1994							
15-19	0.376	0.021	0.000	0.027	0.005	0.108	
20-24	0.540	0.344	0.170	0.362	0.513	0.521	
25-29	0.562	0.462	0.267	0.524	0.648	0.813	
30-34	0.608	0.487	0.282	0.561	0.648	0.800	
35-39	0.713	0.545	0.279	0.572	0.719	0.934	
40-44	0.900	0.513	0.355	0.734	0.811	1.181	
45-49	1.183	0.546	0.416	0.702	0.890	1.156	
50-54	1.609	0.585	0.490	0.998	1.232		
55-59	2.237	0.633	0.578	1.064	1.237		
risk factor: $\rho_1 \beta Y_1$, using the mortality level of 2002							
15-19	0.312	0.067	0.059	0.081	0.038	0.149	
20-24	0.446	0.629	0.570	0.650	0.690	0.657	
25-29	0.463	0.830	0.765	0.895	0.852	0.935	
30-34	0.503	0.864	0.783	0.951	0.888	0.986	
35-39	0.596	0.943	0.833	0.996	0.971	1.103	
40-44	0.767	0.966	0.904	1.107	1.045	1.268	
45-49	1.036	1.008	0.953	1.133	1.132	1.278	
50-54	1.440	1.080	1.037	1.304	1.264		
55-59	2.036	1.135	1.114	1.313	1.322		
risk factor: $\rho_1 \beta Y_2$, using the mortality level of 2002							
15-19	0.312	0.069	0.028	0.077	0.060	0.207	
20-24	0.446	0.663	0.344	0.703	0.967	0.983	
25-29	0.463	0.843	0.488	0.955	1.182	1.479	
30-34	0.503	0.890	0.517	1.022	1.185	1.461	
35-39	0.596	1.004	0.524	1.033	1.325	1.712	
40-44	0.767	0.944	0.664	1.333	1.472	2.151	
45-49	1.036	0.996	0.763	1.290	1.618	2.090	
50-54	1.440	1.076	0.908	1.787	2.248		
55-59	2.036	1.154	1.059	1.948	1.991		

Source: Estimations by the authors.
anlph.=analphabetic; read.=reading/writing; prim.=primary school; losec.=lower secondary; hisec.=higher secondary and +.

Table 8. AIDS mortality probabilities p.a. x100 by educational attainment, women, urban Côte d'Ivoire

Age group	other causes	mortality attributable to AIDS all	anlph.	read.	prim.
risk factor: $\rho_1 \beta Y_1$, using the mortality level of 1994					
15-19	0.285	0.020	0.019	0.032	0.012
20-24	0.383	0.473	0.501	0.482	0.430
25-29	0.429	0.630	0.644	0.642	0.601
30-34	0.471	0.660	0.661	0.689	0.645
35-39	0.539	0.657	0.658	0.668	0.647
40-44	0.632	0.643	0.632	0.678	0.668
45-49	0.789	0.605	0.597	0.634	0.645
risk factor: $\rho_1 \beta Y_2$, using the mortality level of 1994					
15-19	0.285	0.020	0.000	0.038	0.019
20-24	0.383	0.486	0.391	0.564	0.561
25-29	0.429	0.651	0.533	0.770	0.796
30-34	0.471	0.681	0.560	0.839	0.886
35-39	0.539	0.682	0.558	0.824	0.902
40-44	0.632	0.671	0.565	0.884	0.989
45-49	0.789	0.632	0.550	0.895	1.034
risk factor: $\rho_1 \beta Y_1$, using the mortality level of 2002					
15-19	0.237	0.060	0.060	0.080	0.048
20-24	0.321	0.887	0.937	0.904	0.809
25-29	0.361	1.157	1.182	1.179	1.105
30-34	0.399	1.203	1.205	1.255	1.176
35-39	0.463	1.184	1.185	1.207	1.168
40-44	0.554	1.142	1.120	1.206	1.195
45-49	0.710	1.052	1.036	1.125	1.125
risk factor: $\rho_1 \beta Y_2$, using the mortality level of 2002					
15-19	0.237	0.062	0.045	0.091	0.064
20-24	0.321	0.911	0.734	1.056	1.050
25-29	0.361	1.195	0.980	1.414	1.460
30-34	0.399	1.241	1.022	1.526	1.613
35-39	0.463	1.229	1.005	1.486	1.625
40-44	0.554	1.192	1.003	1.568	1.762
45-49	0.710	1.099	0.956	1.576	1.796

Source: Estimations by the authors.
anlph.=analphabetic; read.=reading/writing;
prim.=primary school and +.

Table 9. AIDS mortality probabilities p.a. x100 by educational attainment, women, rural Côte d'Ivoire

Age group	other causes	mortality attributable to AIDS all	anlph.	read.	prim.
risk factor: $\rho_1 \beta Y_1$, using the mortality level of 1994					
15-19	0.285	0.027	0.030	0.021	0.020
20-24	0.383	0.506	0.523	0.494	0.450
25-29	0.429	0.666	0.663	0.684	0.667
30-34	0.471	0.683	0.677	0.702	0.701
35-39	0.539	0.682	0.676	0.706	0.701
40-44	0.632	0.654	0.649	0.718	0.693
45-49	0.789	0.613	0.613	0.636	0.621
risk factor: $\rho_1 \beta Y_2$, using the mortality level of 1994					
15-19	0.285	0.026	0.000	0.029	0.028
20-24	0.383	0.491	0.433	0.599	0.597
25-29	0.429	0.648	0.569	0.849	0.905
30-34	0.471	0.663	0.589	0.870	0.946
35-39	0.539	0.662	0.588	0.895	0.970
40-44	0.632	0.630	0.595	0.939	0.984
45-49	0.789	0.598	0.582	0.918	0.982
risk factor: $\rho_1 \beta Y_1$, using the mortality level of 2002					
15-19	0.237	0.074	0.079	0.066	0.062
20-24	0.321	0.950	0.980	0.928	0.850
25-29	0.361	1.223	1.217	1.257	1.225
30-34	0.399	1.244	1.234	1.279	1.278
35-39	0.463	1.229	1.219	1.271	1.264
40-44	0.554	1.159	1.149	1.273	1.232
45-49	0.710	1.066	1.064	1.120	1.108
risk factor: $\rho_1 \beta Y_2$, using the mortality level of 2002					
15-19	0.237	0.072	0.065	0.083	0.081
20-24	0.321	0.922	0.814	1.122	1.120
25-29	0.361	1.190	1.046	1.558	1.660
30-34	0.399	1.209	1.074	1.584	1.724
35-39	0.463	1.193	1.061	1.610	1.745
40-44	0.554	1.116	1.054	1.662	1.745
45-49	0.710	1.040	1.010	1.607	1.731

Source: Estimations by the authors.
anlph.=analphabetic; read.=reading/writing; prim.=primary school and +.

Table A1. Glossary of the variable names used in the MCA analysis

AVH1P	= Avoid AIDS by having only one partner (1=cited)
AVSTE	= Avoid AIDS by using sterilized needles for medical injections (1=cited)
AVNOP	= Avoid AIDS by avoiding prostitutes (1=cited)
AVNOS	= Avoid AIDS by stopping sexual intercourse (1=cited)
GASWP	= Getting AIDS by sexual intercourse with partner/spouse (1=yes)
GASWC	= Getting AIDS by sexual intercourse with occasional partners (1=yes)
GASWO	= Getting AIDS by other sexual behavior (1=yes)
GASWD	= Do not know how to get AIDS (1=do not know)
ILLSH	= Ill person can seem healthy (1=yes, 0=no, 8=do not know)
ILLGU	= AIDS can be cured (1=yes, 0=no, 8=do not know)
KNSWA	= Do/did you know somebody with AIDS (1=yes, 0=no, 8=do not know)
NOMSP	= Number of sexual partners during the two months prior to the survey (0=0, 1=1, 2=2, 3=3, 4=4 et +, 95= only spouse/partner)
HADSE	= Had sexual contact the two months preceding the survey (1=yes)
PCONF	= Participated at conference about AIDS (1=yes)
TRAB0	= Transmission mother-baby possible (1=yes, 0=no, 8=do not know)
TESTD	= Do not know where getting an AIDS test (1=do not know)

Table A2. Did you have a sexual relation during the last two months? If yes, did you use condoms? Do/did you know somebody with AIDS?

	Abidjan	Other cities	Rural areas
Had sexual relation last two months			
Men	50.4	56.6	56.6
Women	55.6	59.6	59.2
Used condom			
Men	29.9	28.7	19.6
Women	9.1	8.9	4.8
Knows/knew somebody with AIDS			
Men	22.2	23.8	23.7
Women	22.2	21.6	20.7

Source: DHS 1994; computations by the authors.

Table A3. With how many partners did you have sexual intercourse during the last two months? (only men)

	0	spouse only	1	2	3	4 and more
Abidjan	49.4	20.8	16.6	9.7	/	/
Other cities	43.3	28.0	13.4	9.2	(3.6)	(2.6)
Rural areas	44.6	28.5	13.2	8.6	3.0	(2.2)
All	45.1	27.0	13.8	9.0	2.9	2.3

Source: DHS 1994; computations by the authors.
( ) = group $\leq$ 30 obs.; / = group $\leq$ 10 obs.

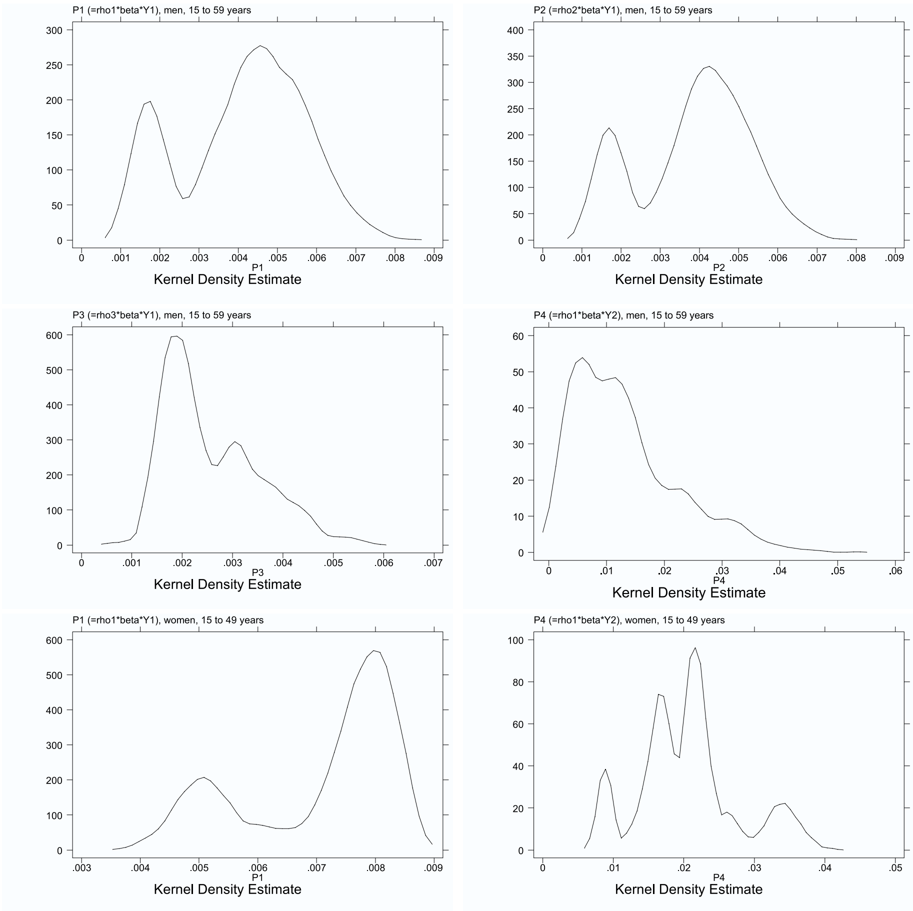

Figure 1. Kernel density curves for the distribution of the different risk factors (Men: P1, P2, P3, P4; Women P1, P4). Source: DHS 1994; estimations by the authors.

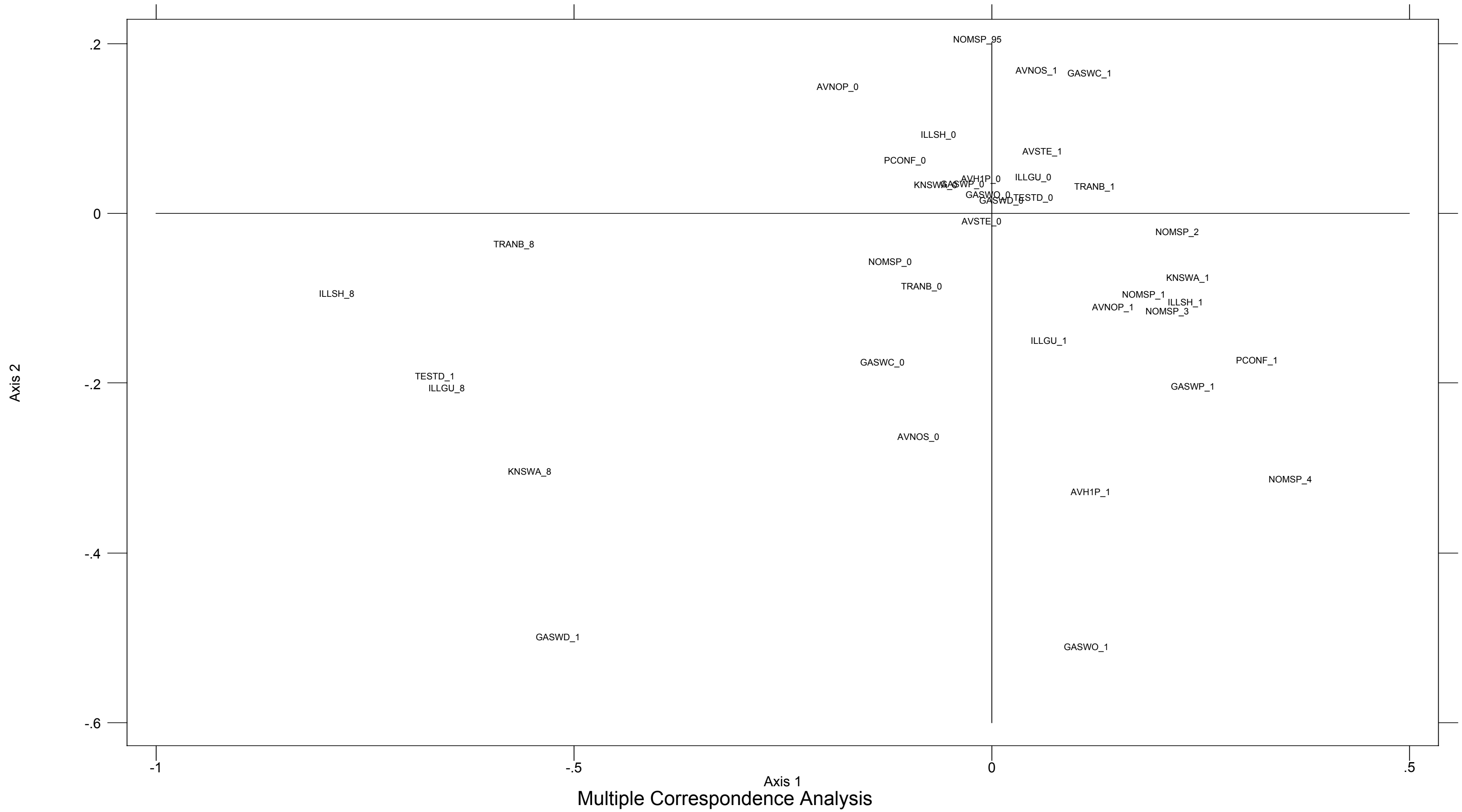

Figure A1. Coordinates of the first and second dimension given by the multiple correspondence analysis (men, 15 to 59 years). Source: DHS 1994; computations by the authors.

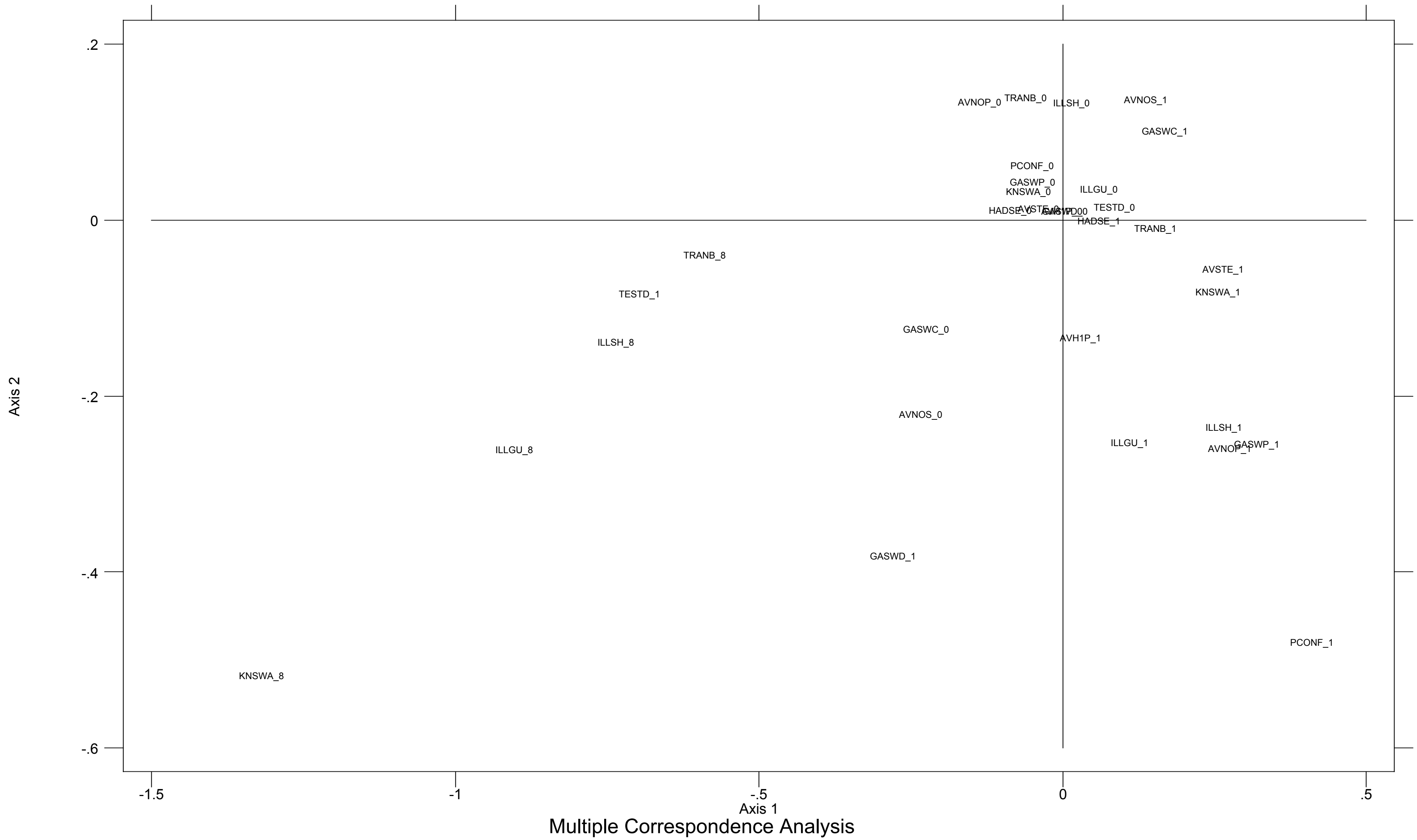

Figure A2. Coordinates of the first and second dimension given by the multiple correspondence analysis (women, 15 to 49 years). Source: DHS 1994; computations by the authors.