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AIDS mortality and its effect on the labor market: Evidence from South Africa ☆

Luke Chicoine *

Department of Economics, University of Notre Dame, 434 Flanner Hall, Notre Dame, IN 46556, United States

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ABSTRACT

This paper investigates how HIV/AIDS has impacted the labor market in South Africa, focusing on its effect on wages and employment. This is done by matching individual level data with group specific cumulative AIDS mortality rates. Exploiting the panel nature of the data, I remove individuals whose productivity is most likely impacted by HIV/AIDS, and find evidence that cumulative AIDS mortality has led to reductions in wages of between 3 and 6% for the African population group (Black South Africans). Furthermore, I also find evidence that the epidemic has lowered employment in South Africa. This result is concentrated among those with the lowest levels of education and employment. Although not large in magnitude, these effects are widespread across a significant portion of the population, contributing to a substantial loss of income throughout the South African economy.

1. Introduction

In 2009, there were an estimated 33 million people living with HIV/AIDS, and 2 million people succumbed to the disease. Two-thirds of all HIV-positive individuals and three-fourths of all AIDS-related deaths are in sub-Saharan Africa. A unique characteristic of this epidemic is that over 90% of HIV-positive individuals are adults (Joint United Nations Programme on HIV/AIDS and World Health Organization, 2010). The substantial loss of adults has the potential for devastating consequences on the wellbeing of survivors. In 2009, there were over 16 million orphaned children living in sub-Saharan Africa due to the epidemic (Joint United Nations Programme on HIV/AIDS and World Health Organization, 2010).

The loss of so many prime-age workers is also thought to impact the aggregate economy as well. Theoretical work using over-lapping generations models predict that HIV/AIDS will adversely impact human capital formation leading to a reduction in long term economic growth (Bell et al., 2006; Corrigan et al., 2005). Using country-level panel data from Africa and exploiting the time-series and cross-sectional variation in the intensity of the disease, Fortson (2011) found that cohorts with high AIDS exposure rates complete fewer years of education. The HIV/AIDS epidemic should have an even greater impact on education in the future as millions of orphaned children are less likely to attend school (Evans and Miguel, 2007; Case and Ardington, 2006) and will complete fewer years of education (Case and Ardington, 2006).

The long term consequence of reduced human capital accumulation is slower economic growth, and the evidence suggests the impact of AIDS is already being felt. Surveying the literature between 1992 and 2001 Dixon et al. (2002) determined that HIV/AIDS had already led to reductions in African growth rates of between 2 and 4% annually. Recent work by McDonald and Roberts (2006) concludes that "poor economic performance of [the African] economies over the past 10 to 20 years can be attributable to the HIV epidemic." Lorentzen et al. (2008) came to a similar conclusion, although not specifically examining HIV/AIDS, they note that "adult mortality explains almost all of Africa's growth tragedy." However, after surveying the literature, Haacker (2010) concludes the impact of HIV/AIDS on growth appears to be small and lower than what is predicted by the work relating health and growth.

In contrast to the negative relationship between HIV/AIDS and growth found in much of the literature, a provocative article by Young (2005) finds some potential for enhanced economic growth from the AIDS epidemic. Drawing analogies to work on the wage consequences of the Black Plague, Young argued that the HIV/AIDS epidemic in sub-Saharan Africa will reduce cohort sizes due to increased mortality and reduced fertility, which will lead to increased wages and an increase in long run consumption for the surviving individuals. Acemoglu and

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* Tel.: +1 206 795 3151; fax: +1 574 631 4783.
E-mail address: lchicoin@nd.edu.

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Johnson (2007) also find that life expectancy and per capita income move in opposite directions; however, they acknowledge their results are driven by diseases that often target the youngest and most vulnerable in the population. They state that, “HIV/AIDS affects individuals at the peak of their labor productivity and could have a larger negative effect on economic growth.”

This paper uses individual level data from South Africa to examine the effect that HIV/AIDS has had on the labor market as a whole. Recent work by Levinsohn et al. (2009) finds evidence of considerable reductions in employment for HIV-positive individuals in South Africa. This work will expand on those conclusions by investigating the effect of the HIV/AIDS epidemic on both wages and employment for all adults in South Africa affected by the epidemic, not just those who are HIV-positive. Understanding the effect that HIV/AIDS has had on wages and employment is essential to being able to properly model and understand how the epidemic is affecting these outcomes. Theoretical predictions for the effect of HIV/AIDS on both wages and employment are ambiguous. Reduced life-expectancy due to the epidemic will lead to a reduction in human capital investment within the workforce by both individuals and firms alike. Alternatively, reduced availability of labor, due to increased mortality, may lead to an increase in the capital labor ratio and increased marginal labor productivity, applying upward pressure on wages. For employment, a reduction in total output due to the epidemic, as documented by the literature (Haacker, 2010), leads to decreased need for labor. This effect is counterbalanced by the fact that the reduced labor supply has inherently increased the likelihood of employment for the surviving individuals. In addition to these considerations, firms may be statistically discriminating against workers in high mortality groups. This would lead to lower levels of hiring and possibly reduced investment, and lower wages, for individuals who may not be directly affected by the epidemic, but who share demographic characteristics with high mortality segments of the population. Characteristics of the HIV/AIDS epidemic, such as those mentioned here, lead to ambiguous predictions on the direction of the epidemic's impact. This ambiguity necessitates an empirical study of the relationship between HIV/AIDS and these key labor market outcomes.

Since the first official case was reported in 1982, prevalence rates for prime-age adults in South Africa have risen to an estimated 17.8% in 2009, one of the highest rates of infection in the world. Since at least 2001, no other country witnessed more AIDS-caused deaths than South Africa (Joint United Nations Programme on HIV/AIDS and World Health Organization, 2010, 2008). In most societies, log mortality rates are linear in age, a result known as the Gompertz Law of Mortality. In contrast, the effects of AIDS-caused mortality in South Africa are so dramatic that the annual mortality rate of adult females younger than 60 peaks between the ages of 30 and 34. Not coincidently, the reported AIDS-caused mortality among females peaks in the same 30–34 year-old age bracket. The male AIDS mortality rate finds its highest point within the 30–44 year-old age range, a group for which the overall mortality rate doubled from 1997 to 2004 (Statisitcs South Africa, 2006).

Data for this project come from two different sources. Earnings and labor market data are obtained from South Africa's semi-annual Labor Force Survey (LFS) for the 2001 to 2007 period. The primary analysis examines whether a rise in within-group mortality rates alters wages and other labor market outcomes. Although death registration data from South Africa is publicly available, deaths caused by HIV/AIDS are often mistakenly attributed to alternative causes (Groenewald et al., 2005; Statisitcs South Africa., 2006; Birnbaum et al., 2011). I therefore employ estimates of AIDS-caused mortality from the Actuarial Society of South Africa's (ASSA) 2008 AIDS and Demographic Model. Section 2 demonstrates that this mathematical model successfully matches available HIV prevalence data and aggregate adult mortality rates. The ASSA2008 model is able to generate a cumulative mortality rate for each demographic group for all years of LFS data being utilized in this research. These cumulative AIDS mortality rates are based off migration adjusted, pre-epidemic, 1985 population data from the ASSA2008 model. In all, the model is able to generate nearly 2500 annual group-specific mortality rates. By 2007, the model estimates 10% of the adult cohorts' original 1985 population (ages 26–61 in 2007) had succumbed to the effects of AIDS. For the African population group that figure is roughly 20%. The sample also takes advantage of the longitudinal nature of the LFS data and the specifics of how quickly HIV infection transforms into AIDS to construct a sample of workers who are most likely affected by declines in cohort size but not afflicted by the virus at the time of the survey.

To estimate the effect of cumulative AIDS mortality on wages and employment, I match each individual observation from the LFS to the appropriate cumulative AIDS mortality rate, based on gender, province, birth cohort, and population group. Wages are reported in both exact amounts and within fixed categories. I construct a maximum likelihood estimation (MLE) model to measure the effect of AIDS mortality, exploiting data from both types of wage reports. To measure the effect on employment, I utilize a simple probit model to investigate if AIDS mortality affects the likelihood that an individual is employed. Both models include a detailed set of controls for age, province, time of survey, education, and various family characteristics.

Contrary to the predictions of Young (2005), this study finds no evidence that declining cohort size, caused by AIDS mortality, has increased wages in the South African economy. Furthermore, I find evidence that the HIV/AIDS epidemic has negatively affected both wages and employment of those from high mortality populations. This result is most consistent for the African population group, impacting both men and women. The baseline model estimates that cumulative AIDS mortality has led to a reduction in wages just over 3% for African males, and nearly 6% for African females. Alternative point estimates suggest that the effect could be even greater. Although this study is not able to directly address the mechanism through which this is occurring, reduced lifespan due to the widespread effect of the epidemic could lead to both firms and individuals investing less in their productivity, leading to falling wages. Additionally, over this time period, some firms operating in South Africa (e.g. DaimlerChrysler, Volkswagen, and Anglo American Mining) have taken the initiative to provide their work force with antiretroviral (ARV) treatment.[1] Habyarimana et al. (2010) find that the benefits of treatment for a typical manufacturing firm accounts for 8 to 22% of the cost of treatment. It is possible that some portion of the remaining cost is passed onto the workers in the form of lower wages.

This paper also finds evidence of reduced employment for African males and females in the presence of increasing cumulative AIDS mortality. I find that employment for these two groups has fallen by 1.5 to 3.5 percentage points. This reduction in employment is driven by the negative relationship between cumulative AIDS mortality and employment for those with less than a secondary school diploma. For about 90% of respondents, the highest level of education is less than a diploma. For men and women in both the African and Coloured population groups, there is evidence that education levels with high employment rates, generally those with at least a secondary school diploma, may actually have higher employment rates due to cumulative AIDS mortality. This may be the result of firms' desire to hire individuals with low HIV/AIDS risk when filling vacancies. Employment levels for Africans with less than a diploma range from 36 to 58%. That means that firms have a large population from which to select their hires for low skilled work, and possibly the ability to hire low risk individuals. Employment rates for African and Coloured individuals who have earned at least a diploma are between 70 and 89%, and these individuals make up less than 10% of the sample. As the labor supply is reduced due to the high levels of mortality, firms do not have the flexibility to discriminate against high risk workers. This

[1] http://www.gtz.de/en/themen/uebergreifende-themen/hiv-aids-bekaempfung/3283.htm. GTZ, works with firms to implement public private partnerships for ARV treatment programs.

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could lead to increased employment opportunities for all highly educated individuals regardless of their HIV/AIDS risk.

The paper proceeds as follows. Section 2 describes the data and provides validation of the ASSA2008 model's accuracy in predicting various outcomes. Section 3 outlines the labor market divisions that exist in South Africa, also included in the section are means of relevant variables. Section 4 presents the empirical model used to estimate the effect of AIDS mortality on wages and employment. The results are presented in Section 5, and Section 6 concludes.

2. Data

2.1. Wage and mortality data

This study uses individual-level data from Statistic South Africa's (SSA) September 2001 to September 2007 semiannual Labor Force Survey (LFS). During the sample period, the LFS was conducted every March and September.[2] Each survey contains data for about 100,000 individuals from roughly 30,000 households. The LFS collects demographic information including age, gender, population group, province of residence, and highest level of educational attainment, among other characteristics.[3] The survey also collects detailed information regarding employment status, hours worked, earnings, and occupation.

The survey is a rotating panel replacing roughly one-fifth of the households each period, but the LFS was not designed to follow respondents across waves. The LFS provides household identifiers and roster numbers which can be combined to create unique individual IDs within each round of the survey. However, over half of all observations have an individual ID whose population group or gender variable is not consistent across survey waves, making it difficult to link individuals over time. In practice, each observation can be treated as an individual observation within the sample and the lack of consistency in the individual ID will not pose a problem. Nonetheless, exploiting the panel nature of the dataset is necessary to ensure that the results are not affected by a negative health bias. Therefore, in order to properly identify individuals across survey rounds, I create a new set of unique individual IDs that are assigned by matching characteristics across observations and survey rounds within each household. Relative to unmatched observations, individuals that I am able to match across survey rounds were born a year earlier, are six percentage points more likely to be female, have completed about eight-tenths of a year more schooling, are more likely to be married, and earn higher hourly wages.

For this work, only adults whose birth year is between 1946 and 1980 will be included in the sample. This restriction is made to focus on individuals who are most likely to actively participate in the labor market and identify groups most likely impacted by AIDS mortality. The LFS reports income from an individual's main occupation at the weekly, monthly, and annual levels. Respondents can either report their exact income or they can choose to report their income in one of 13 brackets. The monthly and annual income observations are converted to weekly values and divided by the number of reported hours worked in the last week to generate an hourly wage rate. The wage for individuals who reported their incomes categorically is a range between the lower and upper bounds of their income bracket, each divided by the number of hours worked in the last week. Real wages are constructed by adjusting wages using monthly Consumer Price Indices (SSA 2008); all values are reported in September 2007 Rand.[4]

The goal of the paper is to examine how rising mortality rates generated by the AIDS epidemic in South Africa have impacted the labor market. The key to this exercise is constructing an accurate measure of AIDS-caused mortality for the South African workforce. Unfortunately, South Africa's death registration data does not successfully record all deaths due to HIV/AIDS. HIV/AIDS weakens the host's immune system and the actual cause of death is often registered to other viruses or infections. An adult mortality report from SSA (2006) acknowledges that, “the age specific death rates we obtain in this [HIV/AIDS] section are too low,” and Birnbaum et al. (2011) found that more than 90% of AIDS deaths were misclassified between 1996 and 2006. Due to this underreporting of AIDS mortality, it is necessary to use an estimate of AIDS-caused mortality from a demographic model. Subsequently, AIDS mortality estimates from the ASSA2008 AIDS and Demographic Model are used. The model, which was released in March 2011, creates estimates of year-to-year mortality and HIV prevalence, as well as other outputs. The model is calibrated using data available through 2007, and includes updated assumptions on the impact of ARV treatment in South Africa.[5]

The model's output can be separated by age, population group, gender, province, and cause (AIDS or non-AIDS). From the model's estimates, a cumulative mortality rate is calculated for groups identified by a unique birth year, province, population group, and gender combination. A unique cumulative mortality rate is calculated for each group as a moving average around the group's birth year using the following equation:

$$\text{AIDS Mortality}_Y^A = \frac{1}{A}\left\{\sum_{i=1}^{\frac{A-1}{2}} \frac{\sum_{j=1985}^{Y}\text{DEATHS}_j^{b-i}}{\text{POP}_{1985}^{b-i}} + \frac{\sum_{j=1985}^{Y}\text{DEATHS}_j^{b}}{\text{POP}_{1985}^{b}} + \sum_{i=1}^{\frac{A-1}{2}} \frac{\sum_{j=1985}^{Y}\text{DEATHS}_j^{b+i}}{\text{POP}_{1985}^{b+i}}\right\}. \quad (1)$$

AIDS Mortality is the group specific cumulative mortality rate, ranging from 0 to 1. The number of birth years included in the moving average is represented by the variable A. The results in Section 5 use a seven year moving average ($A=7$), 3 years on either side of the group's birth year, b. Results using alternative moving averages are presented in the Appendix. The year of the cumulative mortality rate is denoted Y. DEATHS are the number of AIDS-caused deaths in each year, 1985 to Y; the cumulative mortality rate is calculated using the group's 1985 pre-epidemic population.[6] This is done for each group and then matched to the appropriate observations from the LFS data. This yields over 2500 different mortality estimates for each year, using the 1946–1980 birth cohorts.

2.2. Quality of the mortality data

Although there is no complete estimate of AIDS mortality at the level of aggregation needed for this paper, it is possible to compare the ASSA2008 model's predictions regarding HIV prevalence and overall adult mortality with estimates from other sources. I will compare HIV prevalence estimates from the model to measurements from the 2005 South African National HIV Prevalence, HIV Incidence,

[2] Data from the LFS closely match important characteristics from the 2007 South African Community Survey (SACS), which includes over 1 million observations. Data from SACS was obtained through IPUMS International. The sample means from the LFS and SACS for working adults aged 27 to 61, in 2007, for some key variables are: the mean level of education for the African population group in the SACS is 7.9 years of school, in the LFS it is 8.22, the difference in means is smaller for the other population groups. For the Coloured population group, the employment rate is 62.12% in the LFS, and 60.09% in the SACS, the difference in the employment rate across the two surveys is smaller for the Indian and White population groups. Employment is further apart for Africans, 55% in the LFS and 48.79% in the SACS, but when the sample is restricted to observations used in this paper the employment rate in the LFS is 51.2%. The fraction of the population made up of each population group is within 1%, for all four population groups, between the two surveys.

[3] Population group contains self reported information on whether the individual is African (Black), Coloured, Indian, or White. Coloured is an artificial group constructed by the Apartheid Era's 1950 Population Registration Act.

[4] Observations with wages that are outliers are restricted from the sample by removing outliers in the hours worked and income variables. Subsistence farmers, individuals who report income from begging, and self employed are not included in calculating the means of wages or wage regressions, but are included in all other calculations.

[5] More specific information regarding the ASSA2008 model can be found in the ASSA2008 AIDS and Demographic Models User Guide (ASSA, 2011).

[6] The 1985 population is adjusted for annual migration using group level estimates from the ASSA2008 model.

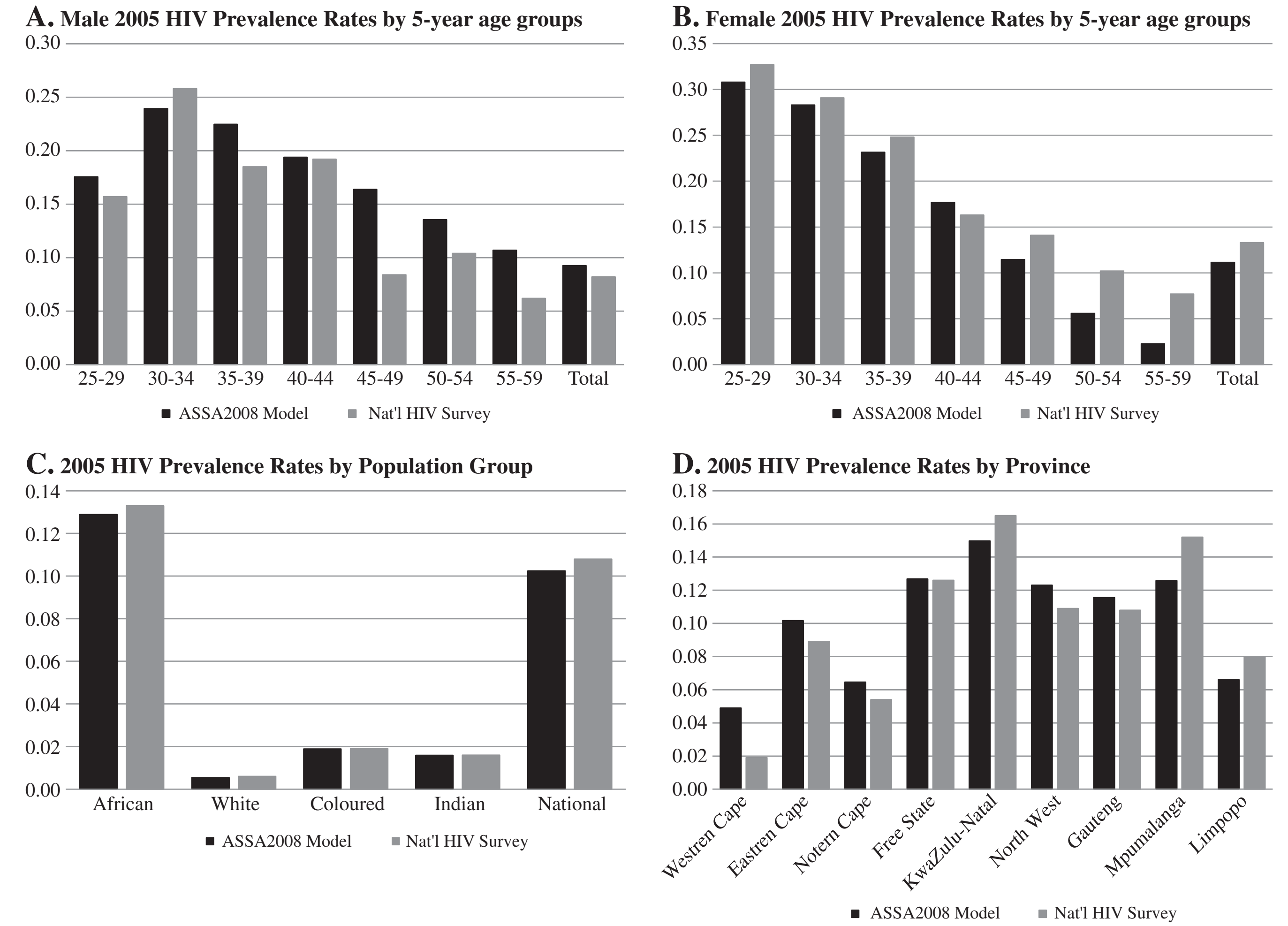

Fig. 1. 2005 HIV Prevalence Rates from ASSA2008 model and National Survey.

Behaviour and Communication Survey (HSRC, 2005). This is a nationally representative survey that measures HIV prevalence by actually testing willing respondents. It is important to note that 30% of respondents who agreed to be interviewed for the survey refused HIV testing. This may bias the HIV prevalence reported in the survey, although the direction of the bias is not known. HIV prevalence rates taken from antenatal clinics are often higher than the rates found in the national survey. All results reported from the survey are weighted to correct for over sampling and non-response for HIV-testing (HSRC, 2005). In Fig. 1A and B the predicted HIV prevalence rates from the ASSA2008 model are compared with those from the 2005 South African National HIV Prevalence, HIV Incidence, Behaviour and Communication Survey (HSRC, 2005) for males and females, respectively, broken into five-year age groups. Further comparisons of HIV prevalence, across population groups and provinces are shown in Fig. 1C and D. In general, the model does a good job matching the survey for young males and females, but tends to overestimate the prevalence for older men and underestimate the prevalence of older women. The model also successfully matches HIV infection rates across population groups, and other than Western Cape, the model matches prevalence rates well across the other eight provinces.

The estimates from the ASSA2008 model also successfully replicate the rates of overall mortality from SSA's death registration data from the years 1997, and 2007 (SSA, 2009).[7] The data are first available for 1997, and the period of this study runs through 2007. It is important that the model successfully estimates early years of mortality because the variable of interest for this study is the cumulative mortality rate dating back to 1985, before the onset of HIV/AIDS. The mortality rates calculated from registered deaths are shown in Fig. 2A and B, separately for males and females, and compared to the model's predictions. As seen in Fig. 2, male mortality rates are higher than those for females. The model underestimates 2007 mortality for older females, but overall the model successfully matches the mortality rate patterns in both 1997 and 2007.

The model seems to better match available data for younger cohorts. There is some degree of error for the model's estimates of HIV prevalence rates for older cohorts of both men and women, and mortality rates for older women. In Section 5.2, I will investigate how this may be affecting the estimated effect of cumulative AIDS mortality on wages by focusing only on the age groups for which the model best performs.

3. Labor market characteristics and description of sample

3.1. South Africa 2001–2007: an overview

Information for the wage variable used in this paper is presented in Table 1. Individuals reported wages in exact amounts, and within one of 13 income brackets. Sample means for each of these categories are reported in the top panel of Table 1. Categorically reported wages are presented using the mean value of each individual's income bracket. The two are then combined to generate the mean for the

[7] Within the model itself, comparisons of mortality data and the model's estimates are shown for the years between 1997 and 2007. The model does well throughout this time period.

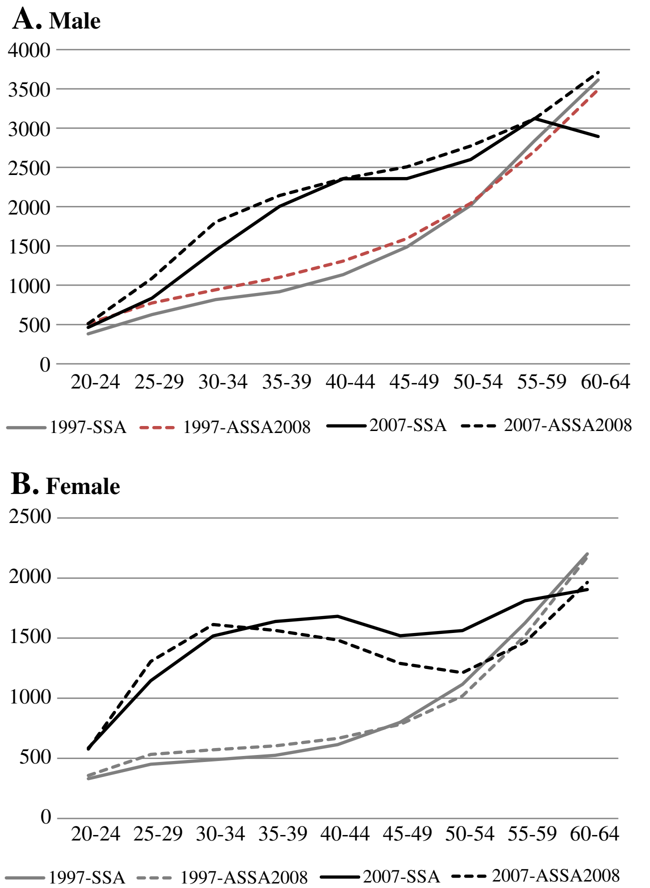

Fig. 2. Mortality rates (per 100,000) from ASSA2008 model and SSA death registration data, by 5-year age groups, in 1997 and 2004.

Table 1
Means of wage variable, by population group and gender.

A. Overall sample means	African		Coloured		White	
	Male	Female	Male	Female	Male	Female
Only exact wage reports						
Wage	15.22	13.09	17.64	15.16	53.83	37.08
	(0.148)	(0.135)	(0.300)	(0.315)	(1.506)	(0.650)
Income reported in brackets — using midpoint of brackets						
Wage	31.34	30.33	35.71	28.23	73.80	53.78
	(1.003)	(0.958)	(0.918)	(0.755)	(1.624)	(5.354)
Combining all wage reports — using midpoint of brackets						
Wage	18.62	16.55	23.44	19.51	65.32	46.82
	(0.255)	(0.236)	(0.381)	(0.350)	(1.124)	(3.234)

B. Change throughout sample	African		Coloured		White	
	Male	Female	Male	Female	Male	Female
Combining all wage reports — using midpoint of brackets						
9.2001 Wage	16.49	14.30	21.05	17.08	62.65	39.53
	(0.472)	(0.476)	(1.018)	(0.746)	(4.008)	(1.647)
9.2007 Wage	22.57	18.37	26.03	25.39	79.15	90.97
	(1.515)	(0.666)	(2.305)	(2.859)	(7.716)	(37.72)

Standard errors in parenthesis. Wages are reported in September 2007 Rand. All income and hours worked outliers are excluded. Also excluded from wage calculations are self-employed, observations with income reported from begging, and subsistence farmers.

overall sample in the bottom row of the top panel. Males consistently receive higher wages than females, across all population groups, and wages for White workers are considerably higher than African and Coloured wages. In the bottom panel of Table 1, I present the means of wages for the first (September 2001) and last (September 2007) round of the LFS used in this study. All groups see growth in wages over this time period. The reported wages for both White males and females in the September 2007 round of the survey are outliers from the trend established by the prior rounds of the survey.[8]

Reported in the top panel of Table 2 are 2007 population statistics and the sample means for key non-wage variables. About 80% of South Africa's 2007 population is African. The two largest minority population groups are Coloured and White, each make up about 9% of the country's population. Statistics for the Indian population group, which is approximately one-fourth the size of the other two minority populations and located mainly in KwaZulu-Natal province, are not reported. Changes over the period of this sample are again presented in the bottom panel. As can be seen in Table 2, employment and education are much higher for the White population group. Both African males and females completed less education and had lower employment rates than their Coloured and White counterparts; however, the level of education is not greatly lagging behind the means for Coloured males and females.[9] Employment rates for African males and females, as well as Coloured females, are exceedingly low. More than 40% of all of these groups are unemployed, just over 60% of African females included in this sample are without work. From the bottom panel in Table 2, the data show that employment increased for most groups over this time period, and the increase was greatest for African men and women.

Despite the positive economic growth over this period, the estimated annual AIDS mortality rate in South Africa more than doubled. The cumulative AIDS mortality rates from 1985 to 2001 and 1985 to 2007 are displayed in the bottom panel of Table 2. These mortality rates show that roughly 80% of all AIDS mortality in South Africa between 1985 and 2007 occurred after 2001. Between 1985 and 2007, the 1946 to 1980 birth cohorts lost an estimated 10% of their pre-HIV/AIDS population due to the epidemic. The mean for this variable, for each population group and gender category, is shown in the top panel of the table. Although HIV prevalence is greater for women in general, cumulative mortality rate for African men is slightly higher than for African women. This is due to greater effectiveness of interventions, such as HIV/AIDS awareness education, affecting the behavior of females within the model. A further example of why this may be occurring is the slow take up of ARV treatment by African males; as late as 2006, African men remained less likely to take up the life saving treatment.[10]

In Fig. 3A, I report the male cumulative AIDS mortality rates from 1985 to 2007 for each birth cohort. The same information is reported for women in Fig. 3B. In each graph, the average cumulative AIDS mortality rate for each birth cohort is presented for three population groups: African, Coloured, and White. The peak cumulative AIDS mortality rates are for African males born in 1964 and African females born in 1968. These birth cohorts have lost more than three out of every ten people from their pre-HIV/AIDS population due to AIDS mortality. The Coloured and White population groups had substantially lower AIDS mortality rates, peaking at levels less than one-sixth of the African's peak. The cumulative AIDS mortality rates for both White males and females over this time period are below one-half of a percent.

[8] Both White males and females did see small wage growth over this time period, but exact reports for White males and categorical reports for White females in the last survey round fall far above the trend established by the previous surveys. These wage figures where generated by larger weights given to the higher earning respondents in the last round of the survey. This pattern is consistent for respondents not included in the sample. In the March 2007 round of the survey, the mean wage for White males included in the sample was 68 rand per hour; for White females the mean wage was 47 rand per hour.

[9] Education data after the 12th grade is limited to diploma and degree acquisition, not years of schooling.

[10] http://www.plusnews.org/IndepthMain.aspx?InDepthID=40&ReportID=70991. PlusNews is the global online HIV and AIDS news service of the United Nations Integrated Regional Information Networks (IRIN).

Table 2
Means of selected variables, by population and gender.

A. Overall sample means	African		Coloured		White	
	Male	Female	Male	Female	Male	Female
2007 Population	18,775,600	19,304,300	2,081,500	2,163,500	2,130,600	2,221,500
Cumulative group-specific AIDS mortality rate	0.127	0.120	0.012	0.015	0.002	0.004
	(5.5e-4)	(3.7e-4)	(1.4e-4)	(1.5e-4)	(2.7e-5)	(6.7e-5)
Employment	58.0	39.1	74.2	52.8	89.4	66.2
	(0.23)	(0.19)	(0.47)	(0.49)	(0.41)	(0.62)
Age	37.48	37.99	38.84	38.95	40.96	40.82
	(0.044)	(0.038)	(0.107)	(0.097)	(0.133)	(0.131)
Highest grade level	8.768	8.405	9.095	8.959	12.75	12.55
	(0.018)	(0.016)	(0.035)	(0.032)	(0.030)	(0.029)

B. Change throughout sample	African		Coloured		White	
	Male	Female	Male	Female	Male	Female
2001 Cumulative group-specific AIDS mortality rate	0.043	0.044	0.003	0.004	0.001	0.001
	(5.7e-4)	(3.9e-4)	(1.3e-4)	(1.3e-4)	(2.6e-5)	(3.2e-5)
2007 Cumulative group-specific AIDS mortality rate	0.220	0.196	0.025	0.029	0.004	0.007
	(1.9e-3)	(1.3e-3)	(5.9e-4)	(6.1e-4)	(1.3e-4)	(2.8e-4)
9.2001 Employment	51.0	35.2	70.0	50.5	89.3	63.9
	(0.81)	(0.66)	(1.69)	(1.79)	(1.41)	(2.19)
9.2007 Employment	63.7	42.3	73.5	51.9	87.7	72.4
	(0.96)	(0.80)	(1.88)	(2.06)	(3.11)	(4.27)

Standard errors in parenthesis. All income and hours worked outliers are excluded. Sample includes self-employed, observations with income reported from begging, and subsistence farmers. Cumulative group-specific AIDS Mortality corresponds to the cumulative AIDS mortality rate from 1985 to the year of observation, using a seven year moving average. AIDS mortality in the following tables refers to the same cumulative AIDS mortality rate. Population statistics are from Statistics South Africa's "Mid-year population estimates: 2007."

As a result, the analysis in this paper will focus on the effect that AIDS mortality has had on the African and Coloured population groups.

3.2. Labor Market Divisions

To better understand the labor market substitutability between the population groups that will be used in the main analysis, I compare occupations and wages of African and Coloured respondents. An initial examination of the distribution of the two groups across broad occupation categories reveals that men and women in the two population groups work in similar types of occupations. However, working in the same broad occupation category does not necessarily mean the two population groups are labor market substitutes, or are even paid the same wage.

Using LFS data it is possible to determine whether or not individuals from different population groups are earning similar wages. To compare wage rates, the natural log of wages is regressed on a dummy for race as well as fixed effects for education level, province, age, marriage status, number of children, and the time of the survey. The regression results reveal that the non-white groups earn significantly lower wages than Whites. Furthermore, an F-test of the null assumption that the coefficients are the same for the African and Coloured population groups can be rejected at the ninety-five percent confidence level, for both males and females.

Even though each group is being paid different wage rates, it is possible that this could be due to differing levels of education. This comparison can be made by including an interaction of population group and education in the above regression. The null hypothesis that the coefficients of the interaction terms for the African and Coloured groups are the same can again be rejected, at the ninety-five percent confidence level for females and the ninety-five percent confidence level for males. This is additional evidence that the individuals participating in the labor force are not substitutable across population groups and this paper will proceed using the assumption that African and Coloured individuals are operating in distinct labor markets.

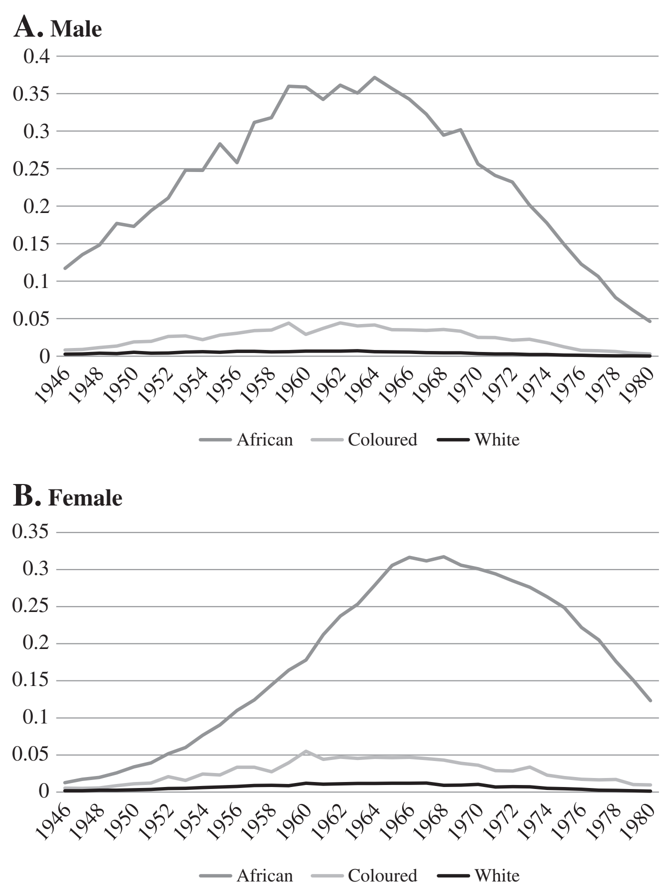

Fig. 3. Cumulative AIDS mortality rate (1985–2007), by birth cohort, as a portion of the birth cohort's migration adjusted 1985 population, using 7 year moving averages.

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4. Estimation strategy

This paper investigates the effect of cumulative AIDS mortality on the labor market in South Africa. I focus on the effect of AIDS mortality on both wages and employment from 2001 to 2007. To investigate the impact of the cumulative AIDS mortality on these outcomes, I utilize data on synthetic cohorts over time, using a within-group model. The empirical model will be estimated for four different groups representing distinct labor markets: two population groups (African and Coloured) by gender. First, I investigate the impact on wages. The dependant variable of interest is the natural log of hourly wages defined as y_{icpt} where the subscripts identify individual (i) from cohort (c) living in province (p) observed in time period (t). The basic relationship between log wages and observed characteristics is given by the equation:

$$y_{icpt} = \alpha + AIDSmort_{cpt}\pi + k_{icpt}\gamma + \theta_p + \mu_t + \varepsilon_{icpt}. \tag{2}$$

The covariate of interest is the cumulative AIDS mortality rate (defined as $AIDSmort_{cpt}$) and this variable ranges in value from 0 to 1. A coefficient on π of 0.1 would represent a one-tenth of a percent increase in wages for each percentage point increase in cumulative AIDS mortality. Included in all estimates are fixed effects for province and year, represented as $\theta_p$and $\mu_t$respectively. The vector k_{icpt} includes characteristics about the individual, such as, indicator variables for marital status, the number of children living in a household, the language spoken at home, month of the survey, and highest level of education completed. To capture the time series pattern in wages for workers a third-order age polynomial is also included. The results do not depend on the order of the polynomial. Finally, although there is variation across workers in birth cohorts, birth year is a linear combination of age and year, only two of these three variables can be included.

If hourly wages were reported for all workers, Eq. (2) could easily be estimated using ordinary least squares (OLS). However, the incomes used to construct the measure of hourly wages are not reported in exact amounts for all respondents. Respondents unwilling or unable to report incomes in exact rand are then shown a series of categorical options used to define income. For respondents that reported income categorically, I divide the range in incomes by the hours worked to generate a range in hourly wages. Assuming the underlying log wages and the ranges in wages are generated by the same equation, we can employ a maximum likelihood estimation strategy to estimate the components of the wage equation.

For simplicity, let the i subscript represent data across individuals and let $x_i\beta$ represent all the covariates on the right hand side of Eq. (2) and re-write the equation as,

$$y_i = x_i\beta + \varepsilon_i \text{ where } \varepsilon_i \sim N\left[0, \sigma^2\right]. \tag{3}$$

Within the sample, there are two types of respondents: those who reported an exact income ($D_i = 1$) and those who reported income categorically ($D_i = 0$). For individuals that reported income as a single number, their hourly wage can be constructed and the PDF for ε_i, for individual i, is given by the equation,

$$f(\varepsilon_i) = \frac{1}{\sigma_\varepsilon}\phi\left(\frac{\varepsilon_i}{\sigma_\varepsilon}\right) = \frac{1}{\sigma_\varepsilon}\phi\left(\frac{y_i - x_i\beta}{\sigma_\varepsilon}\right), \tag{4}$$

where $\phi(\bullet)$ is the standard normal PDF. For individuals who categorically report their income, the natural log of their wage is between an upper and lower bound, denoted as y_i^u and y_i^l, respectively. The probability that a wage is between these two values is given by the equation,

$$Pr\left(y_i^l \le y_i \le y_i^u\right) = Pr\left(y_i \le y_i^u\right) - Pr\left(y_i \le y_i^l\right), \tag{5}$$

which, given the assumption that the errors are normally distributed, can be written as:

$$Pr\left(y_i^l \le y_i \le y_i^u\right) = \Phi\left(\frac{y_i^u - x_i\beta}{\sigma_\varepsilon}\right) - \Phi\left(\frac{y_i^l - x_i\beta}{\sigma_\varepsilon}\right). \tag{6}$$

Where $\Phi(\bullet)$is the standard normal CDF. Combining data for these two groups of people, the parameters for Eq. (2) can be estimated by a single log-likelihood function:

$$ln\, L(\beta|y,X) = \sum_{i=1}^{N} ln\left[D_i\left(\frac{1}{\sigma_\varepsilon}\phi\left(\frac{y_i - x_i\beta}{\sigma_\varepsilon}\right)\right) + (1-D_i)\left(\Phi\left(\frac{y_i^u - x_i\beta}{\sigma_\varepsilon}\right) - \Phi\left(\frac{y_i^l - x_i\beta}{\sigma_\varepsilon}\right)\right)\right]. \tag{7}$$

The model is estimated by a quasi-Newton search algorithm and the Hessian is estimated by a procedure suggested by Berndt et al. (1974). To allow for within group correlation in observations, a Huber–White type procedure for maximum likelihood outlined by Liang and Zeger (1986) is used to calculate the covariance matrix. In this case, correlation is allowed within a specific cohort/province cell, which is the dimension over which the covariate of interest varies.

For the second part of the study, I will use a probit model to estimate the effect of cumulative AIDS mortality on employment. The same set of covariates that were used to estimate the log-likelihood function will be used here. The outcome of interest is the variable EMP_{icpt}, which is an indicator variable that equals one if the individual is employed, and zero otherwise. The subscripts are defined as above and the probit equation estimates the probability of employment which is defined as the equation:

$$Pr\left(EMP_{icpt} = 1\right) = \Phi\left[\alpha + AIDSmort_{cpt}\pi + k_{icpt}\gamma + \theta_p + \mu_t\right]. \tag{8}$$

Where $\Phi[\bullet]$ is the standard normal CDF and all variables are defined as above in Eq. (2). As with the model outlined in Eq. (7), the model is estimated allowing for arbitrary correlation in outcomes within a cohort/province cell and marginal effects from the probit model are reported for the covariate of interest.

5. Results

5.1. The effect of AIDS mortality on wages: full matched sample

The effect of cumulative AIDS mortality on wages, as estimated by Eq. (7), is presented in Table 3; each value represents estimates from a separate model. All results presented in this paper are estimated using an AIDS mortality rate constructed with a 7-year moving average. In Table 3, standard errors are reported in parentheses and calculated allowing for within-group correlation in outcomes (e.g., clustered) with groups defined by birth cohort, province, gender, and population groups. The results are robust to changing the size of the moving average, the variable A in Eq. (1).

The baseline estimates are displayed in Panel A of Table 3. The estimates in Panel A are calculated with the sample of observations that are matched on observable characteristics across survey rounds. This sample has two major assets, matching individuals across survey rounds increases the likelihood that the sample is comprised of healthy individuals who remained well enough to be included in the survey over multiple rounds. This sample is also comprised of observations whose data were recorded accurately enough to be matched across survey rounds. Every individual included in Panel A was active in the sample for at least two rounds. The drawback of this sample is that its characteristics differ from individuals who are not matched across survey rounds. Matched individuals earn higher wages, are slightly older, and have about eight-tenths of a year more schooling. There is no consistent difference between the matched and unmatched individuals in terms of employment rates.

Table 3
Effect of AIDS mortality on wages.

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
A. Matched observations — all birth cohorts				
AIDS mortality	−0.243**	−3.728**	−0.491**	−0.171
	(0.120)	(1.629)	(0.199)	(1.082)
Observations	35,189	11,243	31,439	10,111
B. Matched observations — only birth cohorts after 1960				
AIDS mortality	−0.890***	−3.467	−0.840***	1.505
	(0.154)	(2.413)	(0.193)	(1.235)
Observations	24,674	7,876	21,034	7,487

***p<0.01, **p<0.05, *p<0.1. Estimates generated using the log-likelihood function described in Eq. (7). Standard errors are reported in parenthesis, and calculated allowing for arbitrary within-group correlation in outcomes (e.g., clustered) using the procedure suggested by Liang and Zeger (1986). The dependent variable is the natural log of wages adjusted for inflation to September 2007 Rand. AIDS mortality is a cohort specific cumulative AIDS mortality rate from 1985 to the time of the observation, based on the cohort's migration adjusted 1985 population. Includes indicator variables for each level of education, marital status, number of children in the household, language spoken at home, a third order age polynomial, and fixed effects for province, month, and year. Income and hours worked outliers, self-employed, observations with income reported from begging, and subsistence farmers are not included in the sample. Weighted using sampling weights from LFS, adjusted to sum to number of observations each survey round.

The results in Panel A of Table 3 demonstrate there is no positive impact of AIDS mortality on wages, and suggest that the epidemic has actually led to lower wages for laborers in South Africa. Estimates for African males and females, as well as Coloured males, are statistically significant and negative. Evaluated at the sample mean of cumulative AIDS mortality, the estimate for African males suggests there has been a 3.09% reduction in wages. The same analysis suggests a reduction in wages of 5.89% for African females and 4.47% for Coloured males. The point estimate for Coloured females is statistically insignificant and small in magnitude.

Although the sample used in Panel A is comprised only of individuals who are observed across multiple waves, there may continue to be downward pressure on wages from the inclusion of workers whose productivity is reduced due to illness. Thirumurthy et al. (2008) and Habyarimana et al. (2010) both found evidence of a rapid reduction in worker productivity as health deteriorates due to HIV/AIDS. Focusing on data from Bostwana, Habyarimana et al. (2010) found that worker absenteeism increases in the final months before receiving ARV treatment. Data from Western Kenya in Thirumurthy et al. (2008) showed there is a rapid decrease in hours worked and labor force participation during the 8 weeks immediately prior to receiving ARV treatment. The ARV treatment in clinics examined by Thirumurthy et al. (2008) is administered when patients are clinically considered to have developed AIDS. However, an individual lives in the asymptomatic stage of HIV for an average of ten years.[11] The evidence presented by both of these studies suggests that an individual's ability to actively participate in the labor market does not slowly decline, but rather, rapidly deteriorates.

Unfortunately, most waves of the LFS do not include information on worker health. As an alternative strategy, the characteristics of the HIV/AIDS virus and the panel design of the data are exploited to remove potentially weakened workers. Specifically, whether or not an individual remains in the dataset for multiple periods can be observed using the previously explained technique to match individuals across surveys. Using the information from Thirumurthy et al. (2008) and Habyarimana et al. (2010), the assumption can be made that if a person was participating in the labor force and is located in the dataset again at least 6 months in the future (i.e. the next survey round) they were healthy in the previous observation(s). While this is far from a perfect way to control for the health of the work force, it will likely reduce the sample to a fundamentally healthier group.

To remove potentially contaminated observations, I include only the first observation of individuals who are observed up to two and a half years later. Although well over half of the observations are lost, this technique guarantees that every respondent was alive at least 6 months after the interview was conducted. The estimation is then redone using this subsample of first observations. If the results are consistently more positive than the baseline estimates in Panel A, this would indicate the results in Panel A are possibly contaminated by including workers whose productivity has been reduced due to AIDS-caused mortality. However, the results using the first observation subsample are not systematically higher than the baseline results in Panel A. In fact, the results are very similar to those from the baseline estimates and slightly more negative. This is suggestive that bias from the health of the worker should not be a concern in the baseline model.

A second potential concern is that the results may be biased due to the selection of the matched sample. There are two main concerns with using the unmatched sample. First, I may not be able to follow the unmatched observations across survey waves due to data recording errors. For many observations within a single household, key demographic characteristics (e.g. age, gender, population group, etc.) do not match across survey waves. It is not possible to separate which instances are caused by poor data recording and which observations are new to the sample. For this reason, unmatched observations have been removed from the main sample. Second, unmatched individuals could be leaving the sample, which would make them inherently different from the individuals that I am able to match across survey waves. To allay the first concern to the greatest degree possible, I assume that the first time an enumerator interviews the household all the information recorded is likely to be correct, and in following rounds of the survey the likelihood that an individual's characteristics may be misreported increases. With this assumption, I re-estimate the model including only the first time an unmatched observation's household was interviewed. Using this sample of unmatched observations the estimates for Coloured males and females differ from Panel A, but continue to show no evidence of AIDS mortality leading to increased wages. More importantly, the estimates for African men and women are similar to the results in the top panel and statistically significant. This suggests the results for the African population group found in Panel A are not a construct of the matched sample, and thus providing additional evidence of a negative relationship between AIDS mortality and wages in South Africa.

As Figs. 1 and 2 demonstrate, the ASSA2008 model does a good job matching overall HIV prevalence rates and adult mortality. However, for older individuals the model has a much higher degree of error. Estimates of HIV prevalence for both men and women over 45 years old are at least 23% different than the 2005 national survey. The same pattern is true with the ASSA2008 model's estimates in relation to death registration data for women of the same age group. It is not possible to verify whether the model is wrong, because both the national survey and the death registration data have their drawbacks, but there is a noticeable change in the ASSA2008's estimations relative to the available data for both men and women over 45 years old.

To investigate whether data for these older cohorts alters the basic estimates, I rerun the log-likelihood model using only cohorts born after 1960. Results for the matched sample of post-1960 cohorts are presented in Panel B of Table 3. These results again show evidence that cumulative AIDS mortality has led to lower wages in South Africa. The point estimate for Coloured females is positive but statistically insignificant. The point estimate for Coloured males remains negative and similar to the point estimate in Panel A, but is not statistically significant. The estimates for African males and females are larger than those from the full matched sample, and are again negative and statistically significant. The estimates evaluated at the sample mean of cumulative AIDS mortality imply wages of African males have been reduced by 11.3%, and African females have seen a 10% reduction in their wages.

[11] http://www.avert.org/stages-hiv-aids.htm.

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Table 4
Population and employment by education level.

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
A. Percent of group population at each level				
Education level 1	31.6	27.1	33.6	29.1
Education level 2	16.4	20.7	16.6	22.8
Education level 3	42.5	43.8	39.9	39.2
Education level 4	9.4	8.4	9.9	8.8
B. Employment rate				
Education level 1	54.1	67.9	36.4	40.9
Education level 2	55.4	68.6	37.3	44.5
Education level 3	58.1	80.0	36.1	60.8
Education level 4	83.1	88.3	75.4	87.6

Income, hours worked outliers, and respondents unable to work due to “illness, invalid, disabled, or being unable to work” are excluded.

I also repeat the previously explained checks for the full matched sample. When restricting the sample to the individual's first observation, the estimates show no signs of a negative health bias. Estimates for unmatched observations using only observations from the first time an individual's household is included in the sample yield a pattern similar to when the restriction was used with the full matched sample. Estimates for Coloured males and females differ from the results in Panel B, and neither coefficient provides evidence of a statistically significant or qualitatively important positive relationship between cumulative AIDS mortality and wages. The coefficients for the unmatched African males and females are again similar to the estimates from the matched sample, and remain statistically significant and negative. Restricting the model to the ages for which it best performs yields increasingly robust evidence that cumulative AIDS mortality has led to reduced wages for African men and women in South Africa.

5.2. The effect of AIDS mortality on wages: by education level

To further investigate the effect of cumulative AIDS mortality on wages, I examine the effect across different levels of education. To do this, I create indicator variables for four education levels and add AIDS mortality/education level interactions to the model. I use information from UNESCO's 1961 International Yearbook of Education and 1981 Statistical Yearbook to construct the education groups. Education level one refers to the completion of primary school. Level two refers to students who entered secondary school and completed mandatory schooling which was 9 years of education for those living in areas with compulsory schooling laws. The third level of education refers to students who completed more than the mandatory time in school, but failed to earn a diploma or certificate. As seen in the top panel of Table 4, over 90% of the sample fits into one of these three categories, this is true for every population group, gender category. Education level 4 is comprised of those who earned at least a secondary school diploma or certificate; this group makes up between 8.5 and 10% of the sample. With the inclusion of the education and AIDS mortality interactions described above, I again use Eq. (7), the log-likelihood function, to estimate the effect of AIDS mortality on wages. The results are presented in Table 5. The estimates show evidence of a negative relationship between cumulative AIDS mortality and wages across all four columns. The results are similar for African males and females, with the estimates for African females being slightly more negative.[12]

When the sample is restricted to only observations born after 1960, not shown, the results for African males and females become increasingly negative. In this sample, estimates on the AIDS mortality interactions are negative and statistically significant for all four education levels for African men and again for the highest three levels for African women. The results for Coloured males are similar to those shown in Table 5, but the interaction term for the third education level is no longer significant, while the result for the interaction on the second education level becomes statistically significant. For Coloured females there remains no effect across most education levels, the only statistically significant interaction is a positive effect for diploma earners.

Across both sets of estimates, using the full matched sample and the sample restricted to younger birth cohorts, there is a consistent negative relationship between AIDS mortality and wages. Of the 40 point estimates produced by the two sets of regressions most show a negative relationship between AIDS mortality and education, and there is evidence of this effect across all levels of schooling. The results are strongest for African males and females.

[12] Using a likelihood ratio test, the null hypothesis that the four AIDS mortality/education group interactions are equal to zero can be rejected for all four columns.

Table 5
Effect of AIDS mortality on wages — by education level.

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
AIDS mortality				
*Education level 1	0.053	−5.785**	0.094	−1.208
	(0.170)	(2.932)	(0.251)	(2.141)
* Education level 2	−0.103	−5.090	−0.477*	−3.903**
	(0.175)	(3.278)	(0.257)	(1.605)
* Education level 3	−0.464***	−3.953**	−0.722***	−0.492
	(0.133)	(1.714)	(0.208)	(1.153)
* Education level 4	−0.398**	2.761	−0.598**	1.921
	(0.166)	(2.565)	(0.268)	(1.829)
Joint significance:				
Test statistic (χ^2)	44.14	31.76	65.92	15.50
P-value	0.000	0.000	0.000	0.004
Education level 2	0.336***	0.417***	0.374***	0.319***
	(0.030)	(0.041)	(0.032)	(0.041)
Education level 3	0.761***	0.879***	0.879***	0.817***
	(0.028)	(0.042)	(0.031)	(0.034)
Education level 4	1.875***	1.551***	2.205***	1.495***
	(0.036)	(0.056)	(0.040)	(0.055)
Observations	35,189	11,243	31,439	10,111

***$p<0.01$, **$p<0.05$, *$p<0.1$. Estimates generated using the log-likelihood function described in Eq. (7). Standard errors are reported in parenthesis, and calculated allowing for arbitrary within-group correlation in outcomes (e.g., clustered) using the procedure suggested by Liang and Zeger (1986). The dependent variable is the natural log of wages adjusted for inflation to September 2007 Rand. AIDS mortality is a cohort specific cumulative AIDS mortality rate from 1985 to the time of the observation, based on the cohort's migration adjusted 1985 population. Includes indicator variables for marital status, number of children in the household, language spoken at home, a third order age polynomial, and fixed effects for province, month, and year. Income and hours worked outliers, self-employed, observations with income reported from begging, and subsistence farmers are not included in the sample. Education level 1, individuals not completing more than primary school, is used as the reference group for the education level dummy variables. Weighted using sampling weights from LFS, adjusted to sum to number of observations each survey round.

5.3. The effect of AIDS mortality on employment

The previously discussed estimates show evidence of a negative relationship between wages and cumulative AIDS mortality in South Africa. Another fundamental way that the HIV/AIDS epidemic may be affecting the labor market is by impacting individual's ability to find employment. To investigate the effect of AIDS mortality on employment, I construct a dichotomous variable and set the variable equal to one if the individual reports being employed, and zero otherwise. I then estimate the probit model represented by Eq. (8), while controlling for the same set of covariates used in the previous estimates. In addition, the LFS asks the unemployed respondents for the reason they are not working, to ensure the employment estimates are not the result of individuals being unable to work, I also remove observations which report not working due to “illness, invalid, disabled, or being unable to work.” The standard errors reported allow for within-group correlation in

Table 6
Effect of AIDS mortality on employment.

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
A. Matched observations — all birth cohorts				
AIDS mortality	−0.120*	1.630	−0.121	−1.494
	(0.068)	(1.156)	(0.086)	(1.037)
Observations	76,581	17,673	105,647	22,261
B. Matched observations — only birth cohorts after 1960				
AIDS mortality	−0.148	1.843	−0.259**	−1.326
	(0.104)	(1.264)	(0.102)	(1.411)
Observations	54,073	11,797	74,771	15,070

***p<0.01, **p<0.05, *p<0.1. Estimates generated using the probit model described in Eq. (8), marginal results reported. Clustered standard errors are reported in parenthesis. The dependent variable is a binomial variable equal to 1 if employed. AIDS mortality is a cohort specific cumulative AIDS mortality rate from 1985 to the time of the observation, based on the cohort's migration adjusted 1985 population. Includes indicator variables for each level of education, marital status, number of children in the household, language spoken at home, a third order age polynomial, and fixed effects for province, month, and year. Income and hours worked outliers and respondents unable to work due to "illness, invalid, disabled, or being unable to work" are excluded. Weighted using sampling weights from LFS.

outcomes (e.g., clustered) with groups again defined by birth cohort, province, gender, and population group. The marginal effect of the probit model is reported in Table 6.

The results for all cohorts from the matched sample are reported in Panel A. The estimate for African males suggests a reduction in employment due to AIDS mortality, and is significant at the ninety percent confidence level. When restricting the sample to the first observation of the matched sample, to check for a health bias, and when using the subsample of unmatched observations from the first time a household is interviewed, the results for both African males and females are negative and statistically significant. The results for the sample restricted to cohorts born after 1960 are shown in Panel B. The result for African males is no longer statistically significant at the ninety percent confidence level, but the point estimate remains similar to that from Panel A. The estimate for African females is negative and statistically significant in Panel B.[13] Evaluated at the sample mean, the statistically significant point estimates for African men range from a reduction in employment of 1.52 to 3.44 percentage points, for African females the range is from 1.96 to 3.11 percentage points. The estimates for the Coloured population group are often statistically insignificant. However, the estimates for Coloured females more closely resemble the estimates for the African males and females. The results in the following tables will present a potential explanation for the negative impact that AIDS mortality is having on employment for African males, African females, and possibly Coloured females, and why the point estimates for Coloured males tend to be positive.

As shown in the lower panel of Table 4, African males and females, as well as Coloured females, have a similar pattern of employment. Individuals in the first three education groups, those without a diploma, have extremely low rates of employment. African males in the three lowest education groups are employed at a rate between 54 and 58%, African females at a rate of 36 or 37%. Only between 40 and 44% of Coloured females who did not complete more than the required amount of school are employed, and about six in ten of those who completed more than the compulsory level of schooling without a diploma are employed. For all three of these groups employment dramatically jumps for individuals who have obtained at least a diploma. The top education level has an employment rate above 75% across all columns in Table 4, some being as high as 88%. In contrast to the pattern of employment experienced by the other

[13] For the sample of cohorts born after 1960 the first observation estimates, both matched and unmatched, remain negative and similar in magnitude for African males and females. Both estimates are statistically significant for African females, only the first observations of the matched sample are statistically significant for African males.

Table 7
Effect of AIDS mortality on employment — by education level.

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
AIDS mortality*				
*Education level 1	−0.227**	−0.163	−0.095	−3.638***
	(0.089)	(1.445)	(0.085)	(1.216)
* Education level 2	−0.107	0.984	−0.289***	−3.055**
	(0.088)	(1.311)	(0.104)	(1.365)
* Education level 3	−0.059	2.448*	−0.168*	−0.598
	(0.076)	(1.409)	(0.099)	(1.221)
* Education level 4	0.112	3.457*	0.470***	5.715**
	(0.137)	(1.991)	(0.121)	(2.884)
Joint significance:				
Test statistic (χ^2)	7.80	9.75	35.70	21.63
P-value	0.099	0.045	0.000	0.000
Education level 2	0.004	−0.016	0.072***	0.008
	(0.015)	(0.025)	(0.011)	(0.029)
Education level 3	0.061***	0.055**	0.104***	0.110***
	(0.014)	(0.021)	(0.013)	(0.024)
Education level 4	0.244***	0.105**	0.383***	0.318***
	(0.016)	(0.035)	(0.019)	(0.043)
Observations	76,581	17,673	105,647	22,261

***p<0.01, **p<0.05, *p<0.1. Estimates generated using probit model described in Eq. (8), marginal results reported. Clustered standard errors are reported in parenthesis. The dependent variable is a binomial variable equal to 1 if employed. AIDS mortality is a cohort specific cumulative AIDS mortality rate from 1985 to the time of the observation, based on the cohort's migration adjusted 1985 population. Includes indicator variables for marital status, number of children in the household, language spoken at home, a third order age polynomial, and fixed effects for province, month, and year. Income and hours worked outliers and respondents unable to work due to "illness, invalid, disabled, or being unable to work" are excluded. Education level 1, individuals not completing more than primary school, is used as the reference group for the education level dummy variables. Weighted using sampling weights from LFS.

groups, employment is high across all levels of education for Coloured males, never falling below 68%.

To investigate the effect of cumulative AIDS mortality on employment for each level of education I employ the same set of covariates used to estimate the effect on wages, and estimate a probit model. I report the marginal probit results in Table 7. Across all four columns a pattern emerges when the estimated effect is compared to the corresponding employment rate shown in Table 4. For most education levels with employment around 60% or below, the effect of AIDS mortality on employment is negative. However, the effect of AIDS mortality on employment, for most levels of education with employment around 70% or above, is positive. This pattern is maintained for every statistically significant coefficient, and holds for all but one point estimates with very low significance, education level one for Coloured males.

This pattern is again present when the sample is restricted to the cohorts for which the model better matches the data, those born after 1960. For African females the results are statistically significant for all four education levels, and the interactions on the first and fourth education levels are statistically significant for African males. For both African men and women the point estimates for the first three education levels are negative, and then become positive for the highest, and most employed, education level. The pattern is similar to the estimates in column (4), for Coloured females. For Coloured males, the null hypothesis that all AIDS mortality interactions are equal to zero can no longer be rejected.

The relationship between employment rates and cumulative AIDS mortality could yield substantial insight to how the labor market in South Africa is responding to the HIV/AIDS epidemic. A vast majority of the population fits into one of the lower three education groups, which also have elevated levels of unemployment for all groups except Coloured males. As firms make hiring decisions, or are in a situation where they must replace a worker affected by the epidemic, they may be consciously avoiding taking on additional costs associated with individuals who are part of high AIDS mortality segments of the population. In occupations that can be filled by low skilled individuals, the firms have an abundance of excess labor to select from and may have the ability to select individuals with lower risk to fill their vacancies. Firms with jobs requiring highly educated individuals likely do not have the same luxury. These populations are rather small to begin with, and some education levels have employment as high as 88%. For these highly employed groups there are only relatively few unemployed individuals to fill vacant positions. As the labor supply dwindles due to continued AIDS mortality, firms have fewer unemployed individuals to choose from, and the likelihood that a firm hires an individual from a high risk group only increases as the labor supply is further reduced.

To briefly test the plausibility of the above hypothesis, I constructed a new variable with three possible outcomes, unemployed, employed, and self-employed. This variable is then used to estimate a multinomial logit, with unemployed as the reference group. If the above description of statistical discrimination is correct, the pattern should not be prevalent for the self-employed results. For self-employment, the estimates across all four education levels were statistically insignificant for both African males and Coloured females. However, for African females, the pattern between self-employment and AIDS mortality is similar to the pattern in Table 7. The estimates are negative for the three lower education levels, with the coefficient on the interaction of the highest level becoming positive, although statistically insignificant. This evidence is admittedly inconclusive, suggesting the need for a more thorough investigation.

6. Conclusion

The paper provides a first look at the effect of the HIV/AIDS epidemic on the labor market of an entire population, not only those afflicted with the disease. This paper uses nationally representative data to examine the effect that AIDS-caused mortality has had on wages and employment in South Africa. To identify the effect, data from South Africa's Labor Force Survey are used to measure labor market outcomes and matched with estimates from the ASSA2008 AIDS and Demographic Model. The study finds no evidence that reduced labor supply, due to increased AIDS mortality, has led to higher wages. This finding is a sharp contrast to the predictions made by Young (2005). In fact, the evidence presented in this paper suggests that as AIDS mortality has increased, wages have actually declined.

Adding to the negative economic impact of reduced wages, rates of employment for both African genders have also declined in the face of mounting AIDS-caused mortality. The reduction in employment is concentrated among the lowest educated populations. Although the magnitude of the effect, reductions in wages of 3 to 6%, and in employment of 1.5 to 3.5 percentage points, is not insurmountable for the South African economy, it is clear that the effect of the epidemic expands beyond the HIV positive population. Furthermore, the evidence presented in this paper suggests that the effect of HIV/AIDS on wages and employment is decidedly unambiguous.

A quick back of the envelope calculation can be done using the effects estimated from the sample mean in earlier sections of this paper. Based on 2007 population estimates from SSA, and using a middle of the road two percentage point reduction in employment for African men and women, over 368,000 fewer people were employed in 2007 due to the epidemic. Assuming a 40 hour work week, and 50 working weeks per year, lost earnings for 2007 can be estimated. With reductions in wages of 3% for African males, and 6% for African females, added to the lost wages of the 368,000 unemployed, lost household earnings in 2007 total roughly US$4.6 billion. This equates to about 1.7% of South African GDP in 2007.[14] Although the size of the effect is modest, the breadth of the epidemic's impact reverberates throughout South Africa.

[14] Based on the September 1, 2007 exchange rate. Source: xe.com. GDP information is from the International Monetary Fund.

Appendix

Table A1
Effect of AIDS mortality on wages.

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
A. Three year moving average				
AIDS mortality	−0.231**	−3.620**	−0.473**	−0.091
	(0.114)	(1.573)	(0.188)	(1.045)
B. Five year moving average				
AIDS mortality	−0.236**	−3.668**	−0.482**	−0.127
	(0.117)	(1.596)	(0.193)	(1.060)
C. Second order age polynomial				
AIDS mortality	−0.225**	−3.704***	−0.397*	−0.863
	(0.112)	(1.416)	(0.208)	(0.996)
D. Fourth order age polynomial				
AIDS mortality	−0.320**	−2.751	−0.502**	0.054
	(0.126)	(1.756)	(0.202)	(1.137)
Observations	35,189	11,243	31,439	10,111

***p<0.01, **p<0.05, *p<0.1. Estimates generated using the log-likelihood function described in Eq. (7). Standard errors are reported in parenthesis, and calculated allowing for arbitrary within-group correlation in outcomes (e.g., clustered) using the procedure suggested by Liang and Zeger (1986). The dependent variable is the natural log of wages adjusted for inflation to September 2007 Rand. AIDS mortality is a cohort specific cumulative AIDS mortality rate from 1985 to the time of the observation, based on the cohort's migration adjusted 1985 population. Includes indicator variables for each level of education, marital status, number of children in the household, language spoken at home, a third order age polynomial, and fixed effects for province, month, and year. Income and hours worked outliers, self-employed, observations with income reported from begging, and subsistence farmers are not included in the sample. Weighted using sampling weights from LFS, adjusted to sum to number of observations each survey round.

Table A2
Effect of AIDS mortality on wages — only first observations.

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
A. Matched observations — first only				
AIDS mortality	−0.349**	−5.530***	−0.671***	−0.549
	(0.160)	(1.935)	(0.242)	(1.647)
Observations	13,276	4,104	11,495	3,601
B. Unmatched observations — first observation only				
AIDS mortality	−0.231**	0.214	−0.566***	−2.657*
	(0.102)	(2.017)	(0.182)	(1.461)
Observations	21,669	4,084	15,143	3,251
C. Matched observations — first only, birth cohorts after 1960				
AIDS mortality	−1.136***	−4.828	−1.261***	1.080
	(0.202)	(3.087)	(0.259)	(1.879)
Observations	9,265	2,866	7,686	2,666
D. Unmatched observations — first only, birth cohorts after 1960				
AIDS mortality	−0.920***	−0.348	−0.671***	−0.662
	(0.152)	(2.727)	(0.239)	(1.857)
Observations	15,474	2,913	10,658	2,412

***p<0.01, **p<0.05, *p<0.1. Estimates generated using the log-likelihood function described in Eq. (7). Standard errors are reported in parenthesis, and calculated allowing for arbitrary within-group correlation in outcomes (e.g., clustered) using the procedure suggested by Liang and Zeger (1986). The dependent variable is the natural log of wages adjusted for inflation to September 2007 Rand. AIDS mortality is a cohort specific cumulative AIDS mortality rate from 1985 to the time of the observation, based on the cohort's migration adjusted 1985 population. Includes indicator variables for each level of education, marital status, number of children in the household, language spoken at home, a third order age polynomial, and fixed effects for province, month, and year. Income and hours worked outliers, self-employed, observations with income reported from begging, and subsistence farmers are not included in the sample. Weighted using sampling weights from LFS, adjusted to sum to number of observations each survey round.

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Table A3
Effect of AIDS mortality on wages — by education level, birth year>1960.

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
AIDS Mortality*				
*Education Level 1	−0.778***	−5.837*	−0.380	1.149
	(0.210)	(3.419)	(0.269)	(2.562)
*Education Level 2	−0.857***	−8.613**	−0.607**	−0.214
	(0.216)	(4.194)	(0.296)	(1.936)
*Education Level 3	−1.028***	−3.549	−0.764***	0.640
	(0.176)	(2.346)	(0.211)	(1.385)
*Education Level 4	−0.916***	0.922	−1.185***	4.623**
	(0.204)	(2.878)	(0.304)	(1.973)
Joint significance:				
Test statistic (χ^2)	70.58	25.56	44.76	10.16
P-value	0.000	0.004	0.000	0.038
Education level 2	0.271***	0.413***	0.290***	0.304***
	(0.034)	(0.046)	(0.055)	(0.049)
Education level 3	0.689***	0.878***	0.767***	0.832***
	(0.034)	(0.050)	(0.051)	(0.037)
Education level 4	1.833***	1.574***	2.230***	1.455***
	(0.043)	(0.064)	(0.062)	(0.063)
Observations	24,674	7,876	21,034	7,487

***p<0.01, **p<0.05, *p<0.1. Estimates generated using the log-likelihood function described in Eq. (7). Standard errors are reported in parenthesis, and calculated allowing for arbitrary within-group correlation in outcomes (e.g., clustered) using the procedure suggested by Liang and Zeger (1986). The dependent variable is the natural log of wages adjusted for inflation to September 2007 Rand. AIDS mortality is a cohort specific cumulative AIDS mortality rate from 1985 to the time of the observation, based on the cohort's migration adjusted 1985 population. Includes indicator variables for marital status, number of children in the household, language spoken at home, a third order age polynomial, and fixed effects for province, month, and year. Income and hours worked outliers, self-employed, observations with income reported from begging, and subsistence farmers are not included in the sample. Education level 1, individuals not completing more than primary school, is used as the reference group for the education level dummy variables. Weighted using sampling weights from LFS, adjusted to sum to number of observations each survey round.

Table A4
Effect of AIDS mortality on employment — only first observations.

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
A. Matched observations — first only				
AIDS mortality	−0.267***	2.462*	−0.163*	−3.392**
	(0.089)	(1.302)	(0.094)	(1.406)
Observations	28,971	6,393	38,974	7,928
B. Unmatched observations — first only				
AIDS mortality	−0.271***	0.619	−0.203***	−0.119
	(0.066)	(1.164)	(0.073)	(1.383)
Observations	65,588	11,910	77,715	14,008
C. Matched observations — first only, birth cohorts after 1960				
AIDS mortality	−0.296**	2.436	−0.294***	−3.166
	(0.124)	(1.650)	(0.112)	(1.984)
Observations	20,557	4,300	27,617	5,399
D. Unmatched observations — first only, birth cohorts after 1960				
AIDS mortality	−0.156	2.111*	−0.309***	1.668
	(0.106)	(1.210)	(0.010)	(1.786)
Observations	47,912	8,177	56,937	9,762

***p<0.01, **p<0.05, *p<0.1. Estimates generated using probit model described in Eq. (8), marginal results reported. Clustered standard errors are reported in parenthesis. The dependent variable is a binomial variable equal to 1 if employed. AIDS mortality is a cohort specific cumulative AIDS mortality rate from 1985 to the time of the observation, based on the cohort's migration adjusted 1985 population. Includes indicator variables for each level of education, marital status, number of children in the household, language spoken at home, a third order age polynomial, and fixed effects for province, month, and year. Income and hours worked outliers and respondents unable to work due to "illness, invalid, disabled, or being unable to work" are excluded. Weighted using sampling weights from LFS.

Table A5
Effect of AIDS mortality on employment — by education level, birth year>1960.

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
AIDS mortality*				
*Education level 1	−0.422***	0.618	−0.343***	−4.114***
	(0.117)	(1.664)	(0.100)	(1.562)
* Education level 2	−0.154	0.959	−0.400***	−2.741*
	(0.130)	(1.664)	(0.124)	(1.501)
* Education level 3	−0.038	1.961	−0.215*	−0.499
	(0.111)	(1.468)	(0.118)	(1.629)
* Education level 4	0.454***	3.451	0.664***	5.042
	(0.168)	(2.424)	(0.147)	(3.310)
Joint significance:				
Test statistic (χ^2)	48.53	4.10	76.76	16.58
P-value	0.000	0.392	0.000	0.002
Education level 2	−0.016	−0.031	0.033**	−0.027
	(0.018)	(0.032)	(0.016)	(0.035)
Education level 3	0.039**	0.033	0.049***	0.104***
	(0.016)	(0.025)	(0.015)	(0.027)
Education level 4	0.210***	0.110***	0.278***	0.292***
	(0.018)	(0.031)	(0.016)	(0.040)
Observations	54,073	11,797	74,771	15,070

***p<0.01, **p<0.05, *p<0.1. Estimates generated using probit model described in Eq. (8), marginal results reported. Clustered standard errors are reported in parenthesis. The dependent variable is a binomial variable equal to 1 if employed. AIDS mortality is a cohort specific cumulative AIDS mortality rate from 1985 to the time of the observation, based on the cohort's migration adjusted 1985 population. Includes indicator variables for marital status, number of children in the household, language spoken at home, a third order age polynomial, and fixed effects for province, month, and year. Income and hours worked outliers and respondents unable to work due to "illness, invalid, disabled, or being unable to work" are excluded. Education level 1, individuals not completing more than primary school, is used as the reference group for the education level dummy variables. Weighted using sampling weights from LFS.

Table A6
Effect of AIDS mortality on wages — baseline model.

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
AIDS mortality	−0.243**	−3.728**	−0.491**	−0.171
	(0.120)	(1.629)	(0.199)	(1.082)
Age	0.092**	0.092	0.209***	0.180***
	(0.038)	(0.080)	(0.037)	(0.067)
Age^2	−0.001	−0.001	−0.004***	−0.003*
	(0.001)	(0.002)	(0.001)	(0.002)
Age^3	0.000	0.000	0.000022***	0.000
	(0.000)	(0.000)	(0.000008)	(0.000)
Reference year is 2001				
Year = 2002	−0.076***	−0.108***	−0.021	−0.097**
	(0.020)	(0.030)	(0.020)	(0.030)
Year = 2003	−0.035	−0.047	0.015	−0.054
	(0.023)	(0.033)	(0.023)	(0.035)
Year = 2004	0.038	0.023	0.115***	0.069*
	(0.025)	(0.039)	(0.026)	(0.042)
Year = 2005	−0.004	0.023	0.051*	0.021
	(0.027)	(0.045)	(0.030)	(0.045)
Year = 2006	0.066**	0.087**	0.168***	0.072
	(0.028)	(0.043)	(0.036)	(0.048)
Year = 2007	0.077**	0.100*	0.195***	0.148**
	(0.033)	(0.052)	(0.042)	(0.058)
Reference Province is Western Cape				
Eastern Cape	−0.214***	−0.114***	−0.406***	−0.252***
	(0.042)	(0.037)	(0.038)	(0.032)
Northern Cape	0.111	−0.194***	−0.302***	−0.296***
	(0.108)	(0.052)	(0.106)	(0.055)
Free State	−0.180***	0.187***	−0.395***	0.047
	(0.052)	(0.070)	(0.048)	(0.043)
KwaZulu-Natal	0.060	−0.205***	−0.282***	−0.456***
	(0.050)	(0.048)	(0.048)	(0.041)

Table A6 (*continued*)

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
Reference Province is Western Cape				
North West	0.020	−0.029	−0.303***	−0.100
	(0.050)	(0.063)	(0.046)	(0.070)
Gauteng	0.241***	0.213***	0.028	0.254***
	(0.046)	(0.046)	(0.042)	(0.038)
Mpumalanga	0.053	0.136	−0.299***	−0.051
	(0.052)	(0.193)	(0.051)	(0.176)
Limpopo	−0.189***	*[2 obs*	−0.558***	0.075
	(0.051)	*dropped]*	(0.049)	(0.333)
Reference highest level of education completed is no schooling				
Grade R	0.145	0.053	0.102	0.377
"Reception year"	(0.131)	(0.294)	(0.108)	(0.351)
Grade 1	0.049	−0.005	−0.022	0.085
	(0.073)	(0.145)	(0.079)	(0.153)
Grade 2	0.174***	0.240**	0.058	0.265
	(0.063)	(0.107)	(0.061)	(0.187)
Grade 3	0.303***	0.465***	0.108**	0.213
	(0.043)	(0.087)	(0.045)	(0.151)
Grade 4	0.361***	0.347***	0.129***	0.228**
	(0.040)	(0.081)	(0.041)	(0.098)
Grade 5	0.423***	0.392***	0.173***	0.402***
	(0.042)	(0.080)	(0.043)	(0.077)
Grade 6	0.448***	0.478***	0.257***	0.392***
	(0.041)	(0.064)	(0.040)	(0.081)
Grade 7	0.521***	0.612***	0.314***	0.565***
	(0.040)	(0.063)	(0.036)	(0.073)
Grade 8	0.634***	0.804***	0.470***	0.635***
	(0.041)	(0.059)	(0.034)	(0.074)
Grade 9	0.723***	0.918***	0.517***	0.757***
	(0.041)	(0.061)	(0.037)	(0.076)
Grade 10	0.830***	1.105***	0.674***	0.931***
	(0.038)	(0.055)	(0.036)	(0.078)
Grade 11	0.856***	1.128***	0.699***	1.074***
	(0.041)	(0.063)	(0.037)	(0.076)
Grade 12	1.224***	1.537***	1.209***	1.482***
No diploma	(0.039)	(0.058)	(0.034)	(0.076)
Certificate or diploma	1.800***	1.826***	2.069***	1.854***
<Grade 12	(0.049)	(0.084)	(0.042)	(0.091)
Certificate or diploma	2.060***	2.115***	2.219***	1.977***
With grade 12	(0.042)	(0.063)	(0.037)	(0.085)
Bachelors degree	2.495***	2.301***	2.624***	2.211***
	(0.045)	(0.079)	(0.040)	(0.095)
Graduate degree	2.577***	2.435***	2.550***	2.065***
	(0.066)	(0.173)	(0.053)	(0.193)
Reference month is March				
September	0.039***	0.021*	0.016**	0.044***
	(0.007)	(0.012)	(0.008)	(0.013)
Reference language is Afrikaans				
English	0.101*	0.387***	0.047	0.484***
	(0.085)	(0.026)	(0.100)	(0.025)
Ndebele	−0.084		−0.135	
	(0.084)		(0.089)	
Xhosa	−0.016	−0.143	−0.217***	−0.153
	(0.078)	(0.189)	(0.083)	(0.232)
Zulu	−0.081	−0.582***	−0.150*	−0.197
	(0.077)	(0.105)	(0.082)	(0.221)
Northern Sotho	−0.084		−0.145*	
	(0.076)		(0.081)	
Sotho	−0.139*	−0.673***	−0.289***	−0.509***
	(0.078)	(0.174)	(0.081)	(0.092)
Tswana	−0.068	−0.488***	−0.145*	−0.439
	(0.073)	(0.121)	(0.081)	(0.436)
Swazi	−0.155*		−0.231**	
	(0.087)		(0.093)	
Venda	−0.227***		−0.291***	
	(0.082)		(0.085)	
Tsonga	−0.089		−0.144*	
	(0.080)		(0.084)	
Other	−0.083	−0.470***	−0.175	0.330
	(0.088)	(0.107)	(0.126)	(0.473)

Table A6 (*continued*)

	Male		Female	
	African (1)	Coloured (2)	African (3)	Coloured (4)
Reference status is unmarried				
Married	0.165***	0.168***	0.083***	0.060**
	(0.014)	(0.030)	(0.014)	(0.026)
Reference is no children<15 living in the household				
1 Child	−0.042***	0.060**	0.047***	0.039
	(0.016)	(0.028)	(0.016)	(0.027)
2 Children	−0.059***	0.071**	0.044***	−0.057*
	(0.014)	(0.032)	(0.016)	(0.032)
3 Children	−0.051***	−0.009	0.030*	−0.011
	(0.018)	(0.035)	(0.018)	(0.036)
4 Children	−0.172***	0.008	−0.063***	−0.079**
	(0.024)	(0.046)	(0.022)	(0.038)
5 Children	−0.210***	0.095	−0.092***	−0.169**
	(0.035)	(0.075)	(0.034)	(0.067)
6 Children	−0.210***	−0.032	−0.143***	−0.650***
	(0.056)	(0.114)	(0.044)	(0.076)
7 Children	−0.204**	−0.201*	−0.109	−0.120
	(0.087)	(0.114)	(0.080)	(0.202)
8 Children	−0.420***	0.028	−0.048	−0.105
	(0.096)	(0.383)	(0.076)	(0.246)
9 (or more) children	0.102	0.649	−0.329**	0.328
	(0.240)	(1.057)	(0.142)	(0.892)
10 or more children	0.029	*[Included in 9*	−0.125	0.428
	(0.154)	*or more]*	(0.186)	(0.718)
Observations	35,189	11,243	31,439	10,111

***p<0.01, **p<0.05, *p<0.1. Estimates generated using the log-likelihood function described in Eq. (7). Standard errors are reported in parenthesis, and calculated allowing for arbitrary within-group correlation in outcomes (e.g., clustered) using the procedure suggested by Liang and Zeger (1986). The dependent variable is the natural log of wages adjusted for inflation to September 2007 Rand. AIDS mortality is a cohort specific cumulative AIDS mortality rate from 1985 to the time of the observation, based on the cohort's migration adjusted 1985 population. Includes indicator variables for each level of education, marital status, number of children in the household, language spoken at home, a third order age polynomial, and fixed effects for province, month, and year. Income and hours worked outliers, self-employed, observations with income reported from begging, and subsistence farmers are not included in the sample. Weighted using sampling weights from LFS, adjusted to sum to number of observations each survey round.

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