National AIDS Communication Programmes, HIV Prevention Behaviour, and HIV Infections Averted in South Africa, 2005

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Introduction

Southern African countries have the highest HIV prevalence levels in the world, with population prevalence estimates ranging from 16.1% for adults aged 15–49 in Mozambique to 33.4% in Swaziland, with the estimate for South Africa being 18.8% (UNAIDS, 2006).

In South Africa by 2006, HIV among pregnant females was 29.1% and there had been no significant downward trend. A decline was, however, observed among pregnant females under 20 from 16.1% in 2004 to 13.7% in 2006.

Using modelled estimates, new HIV infections have been declining since the late 1990s, and estimates for total new infections in 2005 were 531,935, with a total population incidence of 1.3% – in other words, the proportion of the population who are newly infected each year. Some 64,117 new infections were estimated to have occurred among babies (Rehle & Shisana, 2003; ASSA, 2005). Incidence analysis of blood samples drawn during the 2005 Human Sciences Research Council (HSRC)/Nelson Mandela Foundation (NMF) national prevalence survey, show that comparatively higher than average incidence was found among black Africans (1.8%), people living in informal settlements (5.1%), females who were pregnant (5.2%), people who were single (3.0%), and people who reported more than one sex partner in the past 12 months (3.1%) (Rehle et al., 2007).

There are many AIDS communication campaigns in South Africa, ranging from national level programmes employing mass media and interpersonal approaches to provincial, sub-provincial and local level interventions. These include institutional and corporate programmes, alongside the work of a wide range of non-governmental and community-based organisations.

The impact of prevention components of AIDS communication programmes are not readily measured, given that there are multiple factors influencing risk of HIV infection, including overall HIV prevalence and relative risk, relative power over risk behaviours, contextual factors that influence HIV risk, as well as a wide range of cognitive influences on an individual which extend beyond the specific influences of AIDS communication programmes.

HIV prevention communication often includes promoting resources and service uptake – for example, condom dissemination or Voluntary Counselling and Testing (VCT) service provision. Other orientations include foci on expanding knowledge and promoting particular approaches to risk reduction, often falling within the 'Abstain, Be faithful, Condomise' (ABC) framework.

A recent review of prevention programmes called for more rigorous evaluations, noting that "For very few interventions… do reliable data exist on prevention effectiveness at full scale. For most of the interventions, we made use of the limited data available with highly variable estimates of effectiveness – some of which include zero" (Stover et al., 2006, p. 1476).

Prevention programmes include a range of methodologies and many incorporate mass media delivery among other communication approaches. Bertrand, O'Reilly, Denison, Anhang, and Sweat (2006) conducted a systematic review of literature from 1990–2004 to assess the impacts of mass media in changing HIV and AIDS related knowledge, attitudes, and behaviour in developing countries. Among the 24 interventions reviewed, the most common outcome was condom use, followed by knowledge of HIV transmission, reduction in high-risk sexual behaviour, perceived risk, interpersonal communication about AIDS and condom use, and self-efficacy of condom use. The overall results were mixed, and where statistically significant effects were found the size was small to moderate. The most positive impact was on knowledge of HIV transmission and reduction of high-risk behaviour. The study concluded that more rigorous evaluations are required to get definitive estimates of the impact of mass media campaigns on HIV and AIDS related behaviour.

A comprehensive meta-analysis of mass media health campaigns in the United States on a range of behaviours found significant effect sizes for seat belt use (.15), alcohol reduction (.09), heart disease prevention and smoking cessation (.05), and some sexual behaviours (.04). The results suggested that mass media campaigns – if effective – should be expected to have a .05 effect size on the average (Snyder, Hamilton, Mitchell, Kiwanuka, & Proctor, 2004).

In South Africa, the 2005 HSRC/NMF survey found a relatively high level of exposure to HIV prevention programmes, but concluded that "with respect to HIV prevalence and behavioural response it is clear that, in spite of massive investment, there has been inadequate progress in addressing HIV prevention" (Shisana et al., 2005, p. 136). In the same survey, among respondents aged 15 years and older who perceived themselves to be at low risk of HIV infection, about one in eight were HIV positive. Of those who perceived themselves to be at high risk of infection, about one in four were HIV positive (Shisana et al., 2005, p. 74).

When respondents were asked whether or not they thought they might become infected with HIV, those who said that they would probably or definitely not become infected gave reasons including being faithful to their partner, abstaining from sex, or always using condoms. Reasons given among those who felt they would probably or definitely get infected with HIV included having an accident or cuts, a blood transfusion, not trusting their partners, not using condoms and having multiple partners (Shisana et al., 2005, p. 74–75).

The survey also measured awareness of national level AIDS communication programmes with mass media components. These included Khomanani, loveLife, Soul City, Soul Buddyz, provincial government campaigns, Gazlam, Tsha Tsha, and Takalani Sesame. The former five programmes include mass media and other communication approaches, while latter three utilise only television for delivery.

This paper explores the 2005 survey dataset to estimate the number of HIV infections that may have been averted by means of HIV prevention practices, and the degree to which exposure to national level mass media AIDS communication programmes have affected HIV prevention behaviours.

Two research questions are addressed:

- Do national level mass media AIDS communication programmes increase the practice of HIV prevention behaviours?
- Do HIV prevention behaviours increase the probability of being HIV negative?

Population-based HIV surveys allow for an understanding of relationships between HIV status and various social, demographic, and other factors. While bivariate analysis of HIV positive status and demographic factors usefully informs understanding of the distribution of HIV prevalence, analysis of HIV positive status against current behavioural measures is problematic, given that HIV infection may not be recent. For example, individuals who perceive themselves to be at high risk of HIV infection may adopt HIV prevention behaviours, but may already be HIV positive. Additionally, individuals who know or believe they are HIV positive may adopt prevention behaviours that prevent HIV infection to others, for example, condom use.

To overcome this temporal problem, the first part of the analysis focuses on the relationship between HIV prevention behaviours and HIV *negative* status in 2005. From this perspective, HIV prevention behaviours do not cause something to happen but rather cause something not to happen (in other words, getting infected and losing one's HIV negative status). So, the emphasis is on maintaining one's health and HIV negative status, which is what prevention behaviour is intended to do. This analysis is followed by an analysis of the relationship between awareness of communication programmes and HIV prevention behaviours.

The conceptual framework for the analysis is represented by the path diagram shown in Figure 1(overleaf). It corresponds to the following two hypotheses:

- Hypothesis 1. Sexually active adults who practice HIV prevention behaviours have a significantly higher level of HIV negative status than those who do not practice these behaviours.
- Hypothesis 2. Awareness of national mass media AIDS communication programs has a direct, positive effect on HIV prevention behaviours. Corollary: AIDS communication programmes have an indirect effect on HIV status through their effect on HIV prevention behaviors.

The direction of causality shown in Figure 1 is indicated by the direction of the arrows from left to right. The socio-demographic variables on the left are exogenous variables in the analysis, thus not determined by any other variables in the model. The three main variables of interest are endogenous, meaning that they are determined by the exogenous variables and by another endogenous variable.

There are three justifications for causal inferences in this analysis.

First, the data were collected *after* two types of actions in the population occurred that were intended to have specific effects: (1) communication about ways to reduce risk of HIV infection and (2) behaviours reducing HIV risk.

Stating that one believes oneself to be at low risk of HIV infection in this context has two causal pathways – (1) that the communication programme influenced HIV prevention behaviours, and (2) that the communication programme influenced understanding that some of one's existing behaviours happen to be ones that reduce risk for HIV infection. Thus, a communication programme influenced knowledge of HIV prevention behaviours as well as inducing the behaviours themselves. There is likely to be a stronger causal relationship between exposure to communication programmes and behaviours that have been intensively promoted for HIV prevention – notably condoms – than behaviours that may have parallel causal pathways, for example, faithfulness to one's sexual partner, which may be underpinned by religious or moral beliefs and other socio-cultural factors and influences.

Second, there is a sound theoretical basis for assuming that HIV prevention behaviours can reduce the risk of HIV infection and that exposure to communication can influence such behaviours.

Third, advanced statistical methods can be applied to cross-sectional survey data to support a causal inference and create a valid counterfactual condition with which to estimate the net effect of prevention behaviours on HIV status.

Methods

Survey Design and Sampling

The hypotheses are addressed by means of analysis of the 2005 HSRC/NMF national, cross-sectional survey (Shisana et al., 2005). The survey sampled all persons over two years of age living in households in South Africa, and included a multi-stage disproportionate, stratified sampling approach. The sampling frame was based on a master sample consisting of 1,000 enumerator areas. These enumerator areas are a subsample of those used by Statistics South Africa for the 2001 census. The sample was stratified by province and locality type (formal urban areas, informal urban areas, informal rural areas and formal rural areas).[1] Within formal urban areas, the sample was also stratified by race. The ultimate sampling unit was the individual within selected households, with up to three members potentially sampled from three age groups (2–14 years, 15–24 years, and 25 years and older). To correct for disproportionate sampling, the data were adjusted for non-response and weighted by gender, age, race, locality type and province to produce a representative sample of the population.

Blood specimens were collected on absorbent paper and then tested for HIV infection using the Vironostika HIV-1 Uniform II Plus O assay (bioMerieux). All HIV-positive samples were retested with a second ELISA test (Vitros ECI, Ortho Clinical Diagnostics).

A subsample of 9,797 adults aged 15 years and older who had ever had sexual intercourse and who agreed to be tested for HIV in the survey were used for the present secondary analysis. This (weighted) subsample represents a population of 26,004,592 adults.

Data Analysis

The data were analysed by means of structural equation modelling (SEM), treatment effects analysis (biprobit regression) and propensity score matching (PSM). The application of all three methods together has been referred to as multivariate causal attribution analysis (MCA) (Kincaid & Do, 2006).

1 Informal rural areas include rural villages, while formal rural areas include commercial farms.

SEM examines three endogenous (dependent) variables in which two are treated as (independent) covariates in other equations. An endogenous variable is one that is explained by other variables in the system of equations. An exogenous variable is one that is explained by variables outside the system of interest. SEM helps resolve the problems of confounding variables and selection bias (the choice of being exposed to communication and practicing prevention behaviour).

A three-equation SEM is used to examine the impact of communication and HIV prevention behaviours on HIV status. The effects of mass media communication exposure and HIV prevention behaviours are estimated after adjusting for a set of potential confounding variables which are expected to affect them as well as well as the outcome of interest.

Three interrelated equations are used:

$y_{1it} = ß_0 + ß_1 y_{2it} + ß_3 \mathbf{X}_{it} + \varepsilon_{1it}$ HIV status (1)

$y_{2it} = \delta_0 + \delta_2 y_{3it} + \delta_3 \mathbf{Z}_{it} + \varepsilon_{2it}$ HIV prevention behaviours (2)

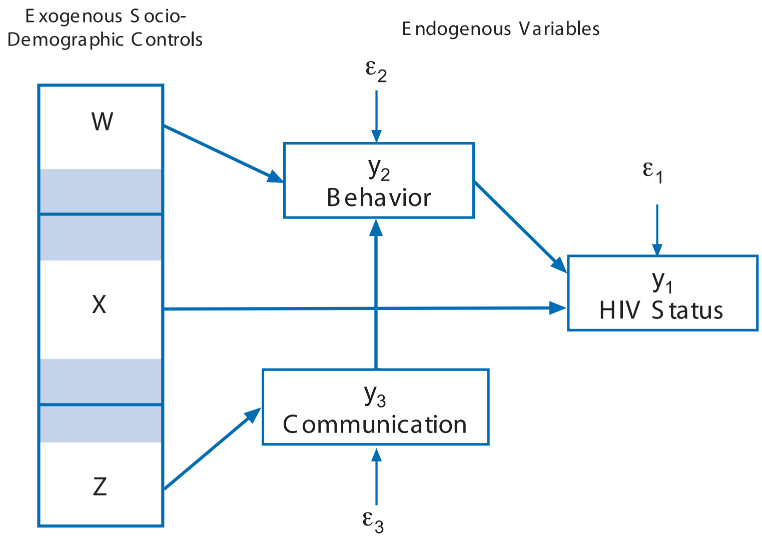
$y_{3it} = \Upsilon_0 + \Upsilon_1 \mathbf{W}_{it} + \varepsilon_{3it}$ communication (3)

where y_{1it} is HIV infection status, y_{2it} is HIV prevention behaviours, and y_{3it} is the level of exposure to AIDS communication programmes for subject i measured at time t. $\mathbf{X}_{it}$, $\mathbf{Z}_{it}$, and $\mathbf{W}_{it}$ are matrices of exogenous socio-economic and demographic control variables. Coefficients ß, δ, and ϒ are parameters to be estimated from the data with regression analysis, and ε_{1it}, ε_{2it}, and ε_{3it} are the disturbance terms (residuals from the fit of the model to the data).[2] HIV status and prevention behaviour are measured as binary variables, so logistic regression is used to estimate the parameters of those two equations.

Exposure to national level mass media AIDS communication programmes is measured as an interval variable, so ordinary least squares regression is used.

The causal pathways among the three endogenous variables and their exogenous determinants are represented as a path diagram in Figure 1.

Figure 1. Path Model of the Causal Relationship Among Communication Behaviour and HIV Status



Tests of exogeneity are used to determine if there are any unobserved variables responsible for the observed relationship among the three variables, and if any relationships are reciprocal (reverse causality). The threat of endogeneity can be ruled out if the disturbance term, ε_{3it}, is not statistically significant when added to the equations for prevention behaviour and HIV status respectively. If not significant, then ordinary regression rather than two-staged regression can be used (Bollen, Guilkey, & Mroz, 1995, p. 115).

2 The term "error" is also used interchangeably with the terms "disturbance" and "residual". "Residual" is the most accurate because it represents all of the variance in the dependent variable, either random or systematic but unobserved, that remains after fitting the model (with observed variables) to the data.

Because HIV prevention behaviours and HIV status are binary variables (0/1), treatment effect analysis with recursive biprobit regression is used to test for the exogeneity and the correlation of their error terms (Greene, 1993). If the correlation (rho) of the two residual terms, ε_{1it} and ε_{2it}, is zero, then random shocks to the first equation for prevention behaviour (ε_{2it}) have no effect on HIV status, y_3, and therefore y_2 can be considered as exogenous.

PSM is used to create a counter-factual condition with which to estimate the amount of HIV infections averted that can be attributed to HIV risk reduction behaviour. PSM uses all measured confounding variables to create a comparison group that is statistically equivalent, on the average, to subjects that are exposed in the 'treatment' group (those with HIV prevention behaviours) (Heckman, Ichimura, & Todd, 1998; Rosenbaum, 1989; Rosenbaum & Rubin, 1983, 1984; Rubin, 1974).

In our analysis, the propensity score is the probability of practicing HIV prevention behaviours (the 'treatment') given a set of observed covariates, **X**. With survey data, a single score for matching is created by statistically regressing HIV prevention behaviour on all of the variables that determine such behaviour and may also be related to the outcome variable – in this case, HIV status. The propensity score is calculated with a programme provided by Becker and Ichino (2002) using probit regression with the common support option.[3]

Technically, the propensity score is the "conditional probability of treatment given the observed covariates e(X)= pr(Z=1|X), which implies that Z and X are conditionally independent given e(X)" (D'Agostino, 1998, p. 2267). Propensity score matching balances the treatment and control units so that a direct comparison would lead to a valid conclusion (Rosenbaum & Rubin, 1983, p. 42):

> … if treatment assignment is *strongly ignorable* given x… then the difference between treatment and control means at each value of a balancing score is an unbiased estimate of the treatment effect at that value, and consequently pair matching, subclassification and covariance adjustment on a balancing score can produce unbiased estimates of the average treatment effect.

Assignment is said to be "strongly ignorable" when, conditional on the observed covariates, there are no systematic, unobserved, pre-treatment differences between exposed and unexposed subjects that are related to the outcome response being studied (Joffe & Rosenbaum, 1999). Bias from self-selection and confounding variables can be ignored if all of the relevant covariates related to exposure and the outcome variable are observed and included in the construction of the propensity score. If there are no unobserved or omitted covariates, then the results are expected to be equivalent to the randomized experimental design. Using case-wise propensity score matching, Dehejia and Wahba (2002) were able to obtain results that came as close as 90–95% of the result found in the original randomised experiment. The results can be reported by means of a simple bar graph that shows the difference in group means or proportions, which are much more "understandable and persuasive to an audience with limited statistical training" than complex multivariate statistics such as SEM (Rosenbaum & Rubin, 1983, p. 52).

Results

Survey respondents were asked which of eight HIV and AIDS communication programmes they knew about. No specific time period of exposure was given, so the response can be considered as the cumulative level of exposure since each programme was initiated. The following levels of awareness were reported for each programme: Khomanani (38%), loveLife (52%), Soul City (64%), Soul Buddyz (46%), provincial government campaigns (23%), Gazlam (49%), Tsha Tsha (45%), and Takalani Sesame (55%). The internal reliability (alpha coefficient) of the summed total score (0–8) was 0.88, indicating a common underlying factor, exposure to AIDS communication programmes by 2005.

3 A computer programme has been written for the STATA statistical program by Sascha O. Becker (Center for Economic Studies, University of Munich) and Andrea Ichino (Department of Economics, European University Institute, Florence) that will compute the propensity score, create the subgroups, and conduct a statistical test of all the variables within each subgroup.

HIV prevention behaviour was measured by follow-up questions about perceived risk. It must be noted that no behaviour for prevention of sexual transmission of HIV is perfectly reliable nor provides 100% protection from HIV infection with the exception of total abstinence. Prevention behaviours can only reduce the *risk* or probability of becoming infected. We will continue to use "HIV prevention behaviour" in this report, however, to be consistent with common usage rather than introducing the more accurate term, "HIV risk reduction behaviour."

Among the 64% of respondents who believe they are not at risk, almost *two thirds* also gave a rational justification. The answers were unaided, hence they were not a response to a direct question about a specific behaviour: 36% said they were faithful and/or trusted their partner, 14% said that they always used a condom, 14% said that they were abstaining from sex, 4% said they avoided sex with sex workers, and 3% said that they did not share needles. In response to a separate question, 18% said that they used a condom the first time that they had sex. The six responses were combined into a single dichotomous variable referred to below as HIV prevention behaviour.

The 2005 HSRC/NMF survey noted that among those who perceived themselves to be at low risk, HIV prevalence was 12.8%. Among those who felt they were at high risk, HIV prevalence was 23.1% (Shisana et al., 2005, p. 74). In other words, about one in eight people who believed themselves to be at low risk of HIV infection were found to be HIV positive in the survey, while about a quarter of those who believed themselves to be at high risk of HIV infection were HIV positive. This reported 10.3 percentage point difference (23.1%–12.8%) in infection between the self-perceived high and low risk groups suggests that the reported risk prevention behaviour of the latter group might be responsible for the difference. This difference was the main stimulus for the secondary[4] analysis of the data reported here.

Table 1 presents the distribution of HIV prevention behaviour by sex, age group, and race. The four main HIV prevention methods – abstaining, condom use always, being faithful to a partner one can trust and using a condom at first sex – are shown separately. The differences in behaviour by sex, age, and race are quite illuminating and to a great extent reflect the same differences found in HIV prevalence. Overall prevention behaviour is significantly higher among males than females (69%>60%), but this difference is entirely due to Africans. Among Africans this finding is repeated in the youth (15–24 years) and middle adult (25–43 years) groups and then disappears in the older adult (44+ years) group. There is no sex difference in the other three groups combined (whites, coloured, and Indians).

Table 1. Percentage of HIV and AIDS Prevention Behaviours by Sex, Age, and Race

Age Groups	Race	Number of Cases**	Any of Six Prevention Behaviours		Now Abstaining From Sex		Used Condom at First Sex		Always Use a Condom		Faithful or Trust my Partner	
			% Male	% Fem	% Male	% Fem	% Male	% Fem	% Male	% Fem	% Male	% Fem
Total sample	All	9797	69	60*	10	17*	22	15*	18	10*	42	31*
	African	6171	66	60*	09	17*	20	14*	21	12*	36	26*
	Others	3626	78	76	12	18*	28	21*	09	04*	57	52
15–24 years	All	2317	82	71*	11	08	49	43	40	26*	31	32
	African	1669	81	69*	10	07*	45	41	41	27*	29	29
	Others	648	88	86	14	16	66	54	34	19*	42	50
25–43 years	All	3774	66	53*	05	08*	20	12*	17	09*	45	35*
	African	2439	61	48*	04	08*	16	10*	20	11*	38	29*
	Others	1335	82	75	07	10	33	22*	08	02*	66	58
44–96 years	All	3706	65	64	15	37*	06	04	04	02*	45	25*
	African	2063	61	60	16	41*	03	01*	06	02*	40	17*
	Others	1643	72	75	15	27*	11	12	02	01	55	46

Notes:
* Statistically significantly difference between male and female: $p<0.05$
** Respondents who have had sexual relation and who were tested for HIV (weighted)

4 There is a large discrepancy in HIV prevalence between Africans and the other three races studied in the survey, so for this analysis the latter groups have been combined.

For abstaining from sex, the gender gap reverses: females are more likely report this as a reason for low risk than males (17%>10%) for all racial groups. Abstinence levels are similar and relatively low (roughly 10%) for the youth and middle age groups, increasing dramatically for the older age group among all racial groups. The gender gap remains about double even in this group: African males to females (16%<41%) and other males to females (15%>27%).

For all age groups, males report higher rates of using condoms the first time they had sex than females (22%>15%). The levels are about the same among African males and females (20%>14%) and slightly higher for males and females in other racial groups (28%>21%). The most interesting finding in Table 1(overleaf) is the large difference in condom use at first sex in the youth group compared to the other two age groups, for both males and females and for all racial groups. Condom use at first sex is over twice as high among youth compared to older cohorts and there is no statistically significant gender gap. This is a sign of substantial cultural change in response to the epidemic and to over a decade of HIV prevention programmes in South Africa – in particular campaign emphases on condom promotion alongside intensive public sector, social marketing and commercial distribution. Overall, in the youth age group 49% of males compared to 43% of females reported using condoms the first time they had sex. The level is higher for the other three racial groups (66% and 54 respectively), but quite substantial among Africans males and females (45% and 41% respectively).

For the middle age group, the level is about half of the younger age cohort and the gender gap in condom at first sex is almost 2:1 (20%>12%). Among Africans in the middle age group the gender gap favours males 16% to 10%; among others it is 33% to 22%. In the middle age group, the higher level of condom use at first sex for the other three ethnic groups is higher than for Africans, suggesting that the former started this practice earlier in time. Compared to the two younger age groups, condom use at first sex in the older age group is quite low (6% and 4%).

The same generational jump exists for always using a condom, but with significant gender differences across all age groups and all racial groups. Overall, 18% of males and 10% of females report always using a condom as a reason for not believing they are at risk for HIV infection. The level of condom use among the youth is double than that reported by the middle age group. Among African youth, between males and females, the gender gap in always using a condom is substantial (41%>27%), and almost as great among the other three racial groups (34%>19%). The same gap exists for the middle age group, but at a substantially lower level (17%>9%, for males and females respectively). The gender gap exists in the older age group, but at a negligible level (4%>2%).

The gender difference in being faithful with a trusted partner is substantial and once again favours males over females (42%>31%). This is entirely due to the difference reported by Africans (36%>26%) rather than the other three racial groups, which report a much higher level than Africans (57%>52%). The youth age group has the lowest levels of faithfulness or trusted partner than the others. Males and females in the youth group have about the same moderate levels of faithfulness to a trusted partner (31% and 32% respectively), with substantially higher levels reported among other racial groups compared to Africans (42% and 50% respectively). The level is higher for both older age cohorts. The gender gap persists but only due to the difference found among Africans. In the middle age group, 38% of African males and 29% of African females say that faithfulness and a trusted partner is the reason they do not feel at risk for HIV. For the older age group, the gap is even greater among Africans (40%>17%, for males and females respectively).

The remaining analysis examines the extent to which prevention behaviours are actually protective: that is, increase the probability of being HIV negative. Results of the structural equation model are shown in Table 2 (opposite). Only respondents who already had previously had sexual intercourse and who were tested for HIV during the survey are included in the analysis. The second column presents the descriptive statistics for each variable used in the models. The third column presents the results of a single regression analysis for HIV negative status without taking communication and prevention behaviour into account (Model 1). The last four columns present the regression results for the three interlinked, endogenous variables (Model 2a–c). Results are reported in the form of standardised beta coefficients (Model 2a) and adjusted odds ratios (Model 1 and Model 2b–c), which indicate the observed effect of each variable independent of, and controlled for, all of the other variables included in the regression.

Table 2. Results of the Structural Equation Model for HIV Negative Status, HIV Prevention Behaviour and Awareness of AIDS Communication Programmes in South Africa in 2005

Variables		HIV Negative Status Model 1	AIDS Communication Exposure Model 2a	HIV Prevention Behaviour Model 2b	HIV Negative Status Model 2c	
	Description: Weighted % or Mean (Range)	Adjusted Logistic Odds Ratio.	Standardised Beta Coef.	Adjusted Logistic Odds Ratio	Adjusted Logistic Odds Ratio	95% CI
HIV Negative Status	84.6 %					
AIDS Communication Programme Awareness	3.6 (0–8)			1.03***	—-	
Any One of 6 HIV Prevention Behaviours*	64.2%				1.52***	1.33–1.74
No. of Current Sex Partners						
None (ref.)	28.4%	1.00	ref.	1.00	1.00	
One Only	66.2%	0.91	.027**	0.87*	0.93	0.79–1.10
Two or More	5.3%	0.70*	.018*	0.37***	0.78	0.57–1.08
Frequency of Having More Than 4–5 alcoholic drinks	0.31 (1–4).	0.91*	—-	0.91**	0.91*	0.83–1.00
Ever Used Injectable Drugs	4.8%	0.76*	—-	—-	0.76	0.58–1.01
Ever Forced to Have Sex	2.6 %	1.00	.022**	0.69**	1.04	0.72–1.50
Away From Home One Month or More in the Last Year	11.5 %	0.85	—-	—-	0.84	0.69–1.03
HIV Prevalence in One's Sampling Cluster	12.6 %	0.34***	—-	0.40***	0.36**	0.19–0.68
Television Viewing Frequency	3.0 (1–4)	1.05	.355***	—-	—-	—-
Radio Listening Frequency	3.4 (1–4)	1.02	.068***	—-	—-	—-
Newspaper Reading Frequency	2.1 (1–4)	0.99	.125***	—-	—-	—-
Community HIV and AIDS Meeting	17.4%	1.09	.121***	—-	—-	—-
Female Gender	54.9 %	0.69***	—-	0.77***	0.69***	0.59–0.81
Single Marital Status	51.2 %	0.60***	—-	—-	0.61***	0.53–0.71
No Children	24.7 %	1.18	—-	1.54***	—-	—-
Age in Years	39.3 (15-96)					
44–96 years (ref.)	32.8 %	1.00	ref.	1.00	1.00	
25–43 years	45.8 %	0.36***	.106***	0.77***	0.37***	0.31–0.45
15–24 years	21.4 %	0.56***	.159***	1.29***	0.56***	0.44–0.70
Education						
No School (ref)	11.3%	1.00	ref.	1.00	1.00	
Primary	22.6 %	0.95	.073***	0.94	0.96	0.75–1.23
Secondary	33.8 %	0.91	.179***	1.00	0.91	0.71–1.17
Matric	21.5 %	1.14	.188***	1.46***	1.13	0.85–1.49
Tertiary	10.8 %	1.89**	.150***	1.30*	1.89***	1.30–2.77
Employment Status					1.00	1.00
Unemployed (ref.)	48.8%	1.00				
Employed	34.1%	1.16	.004	1.17**	1.14	0.97–1.33
Pensioner	9.0 %	3.62***	–.049***	1.65***	3.42***	2.20–5.29
Student	8.1%	2.61***	.034**	1.55***	2.65***	1.95–3.62
Any Level of Poverty	57.0 %	0.81**	—-	—-	0.79**	0.68–0.92
Type of Residence						
Urban formal (ref.)	48.1%	1.00	ref.	1.00	1.00	—-
Urban Informal	8.9%	0.89	–.019*	0.94	0.87	0.72–1.05
Tribal	34.1%	1.12	–.094***	1.05	1.08	0.89–1.31
Rural Formal	8.9%	1.23	–.060***	1.08	1.16	0.91–1.48
Racial Group						
African (ref.)	77.2%	1.00	ref.	1.00	1.00	
White	12.3%	7.79***	–.311***	2.05***	7.19***	3.97–13.02
Coloured	7.7%	3.44***	–.115***	1.48***	3.36***	2.55–4.44
Indian	2.6%	16.16***	–.124***	4.08***	13.98***	7.26–26.92

Variables			HIV Negative Status Model 1	AIDS Communication Exposure Model 2a	HIV Prevention Behaviour Model 2b	HIV Negative Status Model 2c	
		Description: Weighted % or Mean (Range)	Adjusted Logistic Odds Ratio.	Standardised Beta Coef.	Adjusted Logistic Odds Ratio	Adjusted Logistic Odds Ratio	95% CI
Province:	Western Cape (ref)	9.6%	1.00		1.00	1.00	
	Eastern Cape	13.1%	0.63*	.044***	1.03	0.63*	0.44–0.92
	Northern Cape	1.9%	0.54**	.000	1.06	0.53**	0.35–0.81
	Free State	6.6%	0.35***	.006	0.81	0.36***	0.24–0.53
	Kwazulu-Natal	23.1%	0.28***	.011	0.63***	0.30***	0.21–0.42
	North West	8.4%	.0.55**	.024*	1.04	0.55**	0.37–0.82
	Gauteng	20.3%	0.41***	.032**	0.95	0.40***	0.28–0.57
	Mpumalanga	6.8%	0.30***	.006	1.31*	0.29***	0.20–0.43
	Limpopo	10.2%	0.66*	–.013	1.00	0.66*	0.44–0.99
Number of Cases[1]		9,797	9,797	9,797	9,797	9,797	
Variance Explained (R^2)			0.18	0.44	0.07	0.18	
Goodness of Fit[2]							
Hosmer-Lemeshow Chi[2] (df)			16.40 (8)		9.45 (8)	13.29(8)	
Probabilit			p> 0.04		p>0.31	P>0.10	
Test for Exogeneity[3]							
AIDS Communication Programmes: Probability				p>0.17			
Test for Exogeneity							
Biprobit rho (-0.33): Probability					p>0.16		

Statistical significance: * p<.05, ** p<.01, *** p<.001;
- indicates exclusion of non-significant variables for model identification.
1 Sample of respondents who have had sexual intercourse and who were tested for HIV during the survey.
2 Hosmer-Lemeshow Chi2 with 10 groups. A probability greater than .05 indicates no significant difference between the model and the data.
3 The Bollen-Guilkey-Mroz test was used to test the exogeneity of AIDS communication recall in the risk prevention behaviour equation; biprobit analysis was used to test the exogeneity of risk prevention behaviour in the equation for HIV negative status. A probability that is greater than 0.05 indicates that the variable is exogenous.
* Prevention by any one of the 6 following methods: used a condom at first sex, always use a condom, faithful or trust my partner, sexual abstinence, no sex with sex workers, or not sharing needles Intravenous (IV) drug use.

Model 1: HIV Negative Status Without HIV Prevention Behaviour

The first set of independent variables shown in Table 2 reflects behavioural choices or AIDS-related "lifestyle" characteristics of the population. These are followed by general patterns of mass media use and then basic socio-demographic characteristics. Exposure to AIDS communication programmes and HIV prevention behaviour were purposely excluded from the first analysis (Model 1). The second model (Model 2a–c) shows what happens when AIDS communication and prevention behaviour are added to this picture.

No statistically significant relationship was found between HIV status and ever being forced to have sex or being away from home for a month or more during the last year. Three lifestyle behaviours stand out at the top of Model 1. The odds of being HIV negative was found to be significantly related to number of current sexual partners (odds ratio, OR=0.70), the frequency of having five or more alcoholic drinks at a time (OR=0.91), and ever use of injectable drugs (OR=0.76). Each of these lifestyle behaviours significantly lowers the probability of being HIV negative.

HIV status is also strongly related to living in an area (sampling cluster) with high HIV prevalence. One is 66% less likely to be HIV negative if living in an area characterised by high HIV prevalence (OR=0.34).[5] This is the estimated effect of HIV prevalence in one's near surroundings *after* controlling for province, type of residence, and all other variables in the model.

The logistic regression analysis indicates each variable's effect independent of all other variables. Two of these lifestyle variables are also closely related to one another: heavy drinking and having concurrent sexual partners. Only 7.6% of

5 Odds ratios of less than 1.00 indicate a lower probability of being HIV negative compared to the reference group (for example, not using drugs). It may be interpreted as a percent (probability) by subtracting it from 1.00 (1.00–0.34=0.66, or 66%).

respondents with no current sexual partner report heavy drinking, similar to the 9.9% of those with just one current sexual partner. In contrast, 26.8% of those with more than one current sexual partner report heavy drinking. The unadjusted logistic regression of heavy drinking on having more than one partner versus one or none is 3.6. In other words, the odds of heavy drinking are 3.6 times greater for those with multiple concurrent partners compared to those with only one or no sexual partner. It is also quite likely that heavy drinking also lowers the likelihood correct and consistent condom use.

None of the general measures of communication – television, radio, newspapers, and community meetings – have a direct, statistically significant relationship with HIV status, it only has indirect effects through exposure to the eight AIDS communication programmes and HIV prevention behaviour. The results do confirm, however, the important role played by socio-demographic characteristics. Females are less likely to be HIV negative than males (OR=0.69), as are those who are single (OR=0.60). Both younger age groups are less likely to be HIV negative than the older age group (44 years and older). The odds of being HIV negative are 0.36 for those 25–43 years of age and 0.56 for those 15–24 years of age. Number of children is not related to HIV status. No significant difference in HIV status was found between those with no schooling at all and those of any other educational level except those who are tertiary institution graduates. The odds of being HIV negative are 1.89 times greater among those with a tertiary education compared to those without any schooling. Employment per se is unrelated to HIV status, but the odds of being HIV negative are 3.62 times greater for those with pensions and 2.61 times greater for students than for those who are currently unemployed. HIV negative status is also significantly lower among those who have experienced any level of poverty during the last 12 months (OR=0.81).

Type of residence is unrelated to HIV status. The likelihood of being HIV negative is no greater or less for those living in informal urban, formal rural or tribal areas compared to those living in formal urban areas. This unexpected finding is due to the inclusion of other variables in the regression, especially HIV prevalence in one's sampling cluster. The average HIV prevalence in urban informal areas, for example, is 20%, twice the average level of the other three types of residence. When HIV prevalence in one's cluster is omitted from the regression analysis, those living urban informal areas are significantly less likely to be HIV negative (OR=.81, $p<0.024$).

Province, however, does make a difference. Compared to those living in the Western Cape (the reference province), the odds of being HIV negative are significantly less for every other province in South Africa. Odds ratios range from lows of 0.28 and 0.30 in Kwazulu-Natal and Mpumalanga respectively, to a high of 0.66 in Limpopo Province. One's racial group makes a difference as well. The African population of South Africa has the lowest HIV negative prevalence; hence, the highest level of HIV infection. All other racial groups are significantly more likely to be HIV negative than Africans. The odds of whites being HIV negative are 7.79 times greater than for Africans. Odds are also 3.44 times greater for coloureds, and 16.16 times greater for Indians.

The pattern of HIV status in South Africa is characterised by where one lives (province) and the prevalence of the disease among those with whom one lives (residential cluster). One's social and demographic characteristics increase or decrease the likelihood of staying HIV negative. HIV negative status is lower among females, single people, those under 44 years of age, and those who have experienced any type of poverty. HIV negative status is higher among students and pensioners, and those with tertiary education. It is unrelated to general mass media exposure and participating in community meetings about HIV and AIDS. Finally, the model identifies a cluster of "lifestyle" behaviours that are related to HIV status: having more than one current sexual partner, heavy alcoholic drinking, use of injectable drugs, and living in a local area with high rates of HIV infection. The following model shows what happens when HIV prevention behaviour is added to this picture.

Model 2a: AIDS Communication Exposure

The mean number of AIDS communication programmes known was 3.6. 78% in the adult sample that have had sex and were tested for HIV were aware of one or more communication programme. The linear regression analysis (Model 2a) shows that the strongest determinant of awareness of these programmes was frequency of watching television (beta coefficient, b=.35), along with frequency of listening to the radio, reading newspapers, participation in community meetings, and any level of formal education. Awareness was significantly lower in urban informal, tribal, and rural formal areas compared to urban formal areas of residence. Whites, coloureds, and Indians had significantly lower levels of awareness of these programmes compared to Africans. Compared to the Western Cape, only residents of the Eastern Cape, North West, and Gauteng were significantly more likely to be exposed to more AIDS communication programmes. The model as a whole fit the data quite well, explaining 44% of the variance in awareness of the eight AIDS related communication programmes.

Model 2b: HIV Prevention Behaviour

The logistic regression analysis of risk prevention behaviour (Model 2b) shows a positive statistically significant effect of the awareness of AIDS communication programmes on HIV prevention behaviour. The odds ratio is 1.03, indicating that for every increase of one additional communication programme, the likelihood of practicing one or more of the reported HIV prevention behaviours increases by 3%. When the residual term from the equation for communication awareness (Model 2a) is included in the equation for HIV prevention behaviour (Model 2b) it is not statistically significant ($p<0.17$), indicating that AIDS communication programmes can be treated as an exogenous predictor of HIV prevention behaviour. Frequency of mass media use is not statistically significantly for prevention behaviour when awareness of communication programmes is included in the regression. This indicates that the mass media influence prevention behaviour *indirectly* through their effects on exposure to the eight communication programmes that were measured.[6]

The estimate of the effect of communication programmes on prevention has been adjusted (controlled) statistically for all of the other variables included in Model 3. The results show that those with one sex partner were somewhat less likely to practice HIV prevention behaviour (OR=0.87). Respondents with two or more current sex partners were substantially less likely to practice HIV prevention behaviour than those who currently have no sex partner. The data show that 65% of those with no current partner or one current partner are practicing some form of prevention behaviour, compared to 53% among those with concurrent partners. As might be expected, 46% of those with no current sex partner report that they are abstaining from sex to prevent HIV infection.

Heavy drinking is also negatively related to HIV prevention behaviour. Those who frequently drink 4–5 alcoholic drinks at a time are significantly less likely to practice HIV prevention behaviours (OR=0.91). Those who were ever forced to have sex against their will are also significantly less likely to practice prevention behaviours (OR=0.69). Intravenous (IV) drug use is not related to prevention behaviour.

To obtain a rough estimate of disease prevalence as a contextual factor affecting HIV risk, we calculated the percentage of respondents in each person's own sampling cluster who tested positive for HIV during the survey (excluding the respondent's own HIV status from the calculation). The mean percentage of one's sample cluster members who are HIV positive is 12.6%. Some 3,738 respondents live in sample clusters whose HIV prevalence is above this mean. 19.8 % of respondents who live in these "high" HIV positive clusters are themselves HIV positive. Conversely, 2,046 respondents live in sample clusters with zero HIV positive members. Only 7.5 % of these respondents are themselves HIV positive. Hence, living in an area where HIV prevalence is higher increases one's risk of infection. The regression results for Model 3 show that those who live in a local environment (sample cluster) with a higher proportion of HIV positive people are significantly *less likely* to practice any of the HIV prevention behaviours (OR=0.40).

HIV prevention behaviour is significantly *less* likely among females than males (OR=0.77) and more likely among those who have no children. Marital status is unrelated to prevention behaviour. HIV prevention behaviour was found to be more likely among young adults 15–24 years of age than among older adults 44 years and above (OR=1.29), and significantly *less* likely among adults in the middle age group, 25–43 years (OR=0.77). Education is also positively related to HIV prevention behaviour, but only at higher levels. Prevention is more likely to occur among those with matriculation (OR=1.46) and tertiary levels of education (OR=1.30) than those with no schooling at all. Those with primary and secondary education are not significantly different from those with no schooling.

Compared to the unemployed, those currently employed are slightly more likely to practice prevention behaviours (OR=1.17), as are students (OR=1.55) and those on pensions (OR=1.65). Marital status is not related, but respondents without any children

6 Likelihood ratio tests were performed to justify the exclusion of all non-significant variables.

are more likely to report practicing prevention behaviours (OR=1.54). Living away from home was not found to be related. Type of residence is not related to HIV prevention behaviour, but race is significantly related. The odds of practicing HIV prevention behaviour is 48% greater among coloureds than Africans (OR=1.48), twice as great among whites (OR=2.05), and four times greater among Indians (OR=4.08).

Most provinces are not significantly different from the Western Cape (the reference province), except for Kwazulu Natal where respondents are less likely to practice HIV prevention behaviour (OR=0.63) and Mpumalanga Province where respondents are somewhat more likely to practice HIV prevention behaviour (OR=1.31).

Model 2c: HIV Negative Status with Prevention Behaviour

The results of the logistic regression analysis for HIV negative status is presented in Model 2c. It is important to point out that nothing "causes" a person to become HIV negative. Everyone is born HIV negative and remains negative unless infected by one's mother or by other events known to transmit the virus (in other words, risky sexual behaviour, blood transfusion, and other forms of blood exposure). The statistical analysis attempts to determine to what extent self-reported HIV prevention behaviour increases the likelihood of *remaining HIV negative*. This is rather awkward logic if one is used to thinking about what causes someone to become infected with HIV. Prevention behaviour does not cause anything to happen, but rather "causes something *not* to happen" by reducing the probability (risk) of becoming infected with HIV. In other words, prevention behaviour helps one maintain a healthy status. In theory, it protects. Only evidence from research can determine if prevention behaviour offers any protection in practice, that is, actually increases the probability of remaining HIV negative.

This approach is consistent with HIV prevention programmes that strive to keep people from becoming HIV positive. It also helps eliminate the potential problem with time-order and reciprocal causality that modelling HIV positive status creates. Someone may begin initiate prevention behaviour *after* they have already become infected, or perhaps begin practicing to protect others *after* getting an HIV test that shows they are already HIV positive. Thinking that you are still HIV negative may convince you to begin practicing before it is too late, but it remains to be seen over time if the behaviour actually helps anyone maintain that healthy status.

With regression analysis, these problems can be handled statistically by including "knowledge of one's HIV status" as a control variable in the regression analysis or by excluding respondents from the analysis who say that they were tested before the survey was conducted, whether they know the results or not. Both types of analyses were conducted with the regression reported for Model 2c. When knowledge of one's HIV status is included in that regression, it does show that this group is indeed less likely to be HIV negative (OR=0.83). However, after controlling for this variable the magnitude and significance of the effect of prevention behaviour is unaltered (OR=1.51 compared to 1.52). When those people who know their HIV status are removed from the regression, the effect of prevention behaviour on HIV status is still statistically significant, but the effect is not as large (OR=1.29 compared to 1.52). Furthermore, when knowledge of one's HIV status is added to the equation for prevention behaviour (Model 2b), it has no statistically significant effect on practicing prevention behaviour. This means that knowledge of one's HIV status does not confound the observed relationship between prevention behaviour and HIV status in Model 2c.

As Table 2 shows, the practice of one or more of the six HIV prevention behaviours has a positive, statistically significant effect on HIV negative status (OR=1.52; confidence interval, 1.33 to 1.74). The odds of remaining HIV negative among those who practice one or more prevention behaviours is 50% greater than among those who do not. This result does not indicate that all of those who practice have remained HIV negative. Some who say they practice prevention behaviour are no longer HIV negative. These regression results merely indicate that HIV negative prevalence is higher among those who practice prevention behaviour, controlling for all other variables. The propensity score analysis (see Figure 2) is used to estimate exactly how many people would *not* have remained HIV negative, in other words, would have become HIV positive if they had *not* practiced any HIV prevention behaviour.

Exposure to AIDS communication programmes is excluded from the analysis because it is hypothesised to have only indirect effects through its effect on prevention behaviour. This hypothesis was confirmed: when communication exposure is included in the regression for Model 2c, its relationship to HIV negative status is not statistically significant. The biprobit statistical analysis of the equation for prevention and HIV status shows that the correlation (rho) of the residuals, e_{1it}, e_{2it}, from the prevention and HIV equations is not statistically significant (rho=−0.33; prob.<0.16). This means that ordinary probit and logistic regression is appropriate, and that prevention behaviour can be considered as an exogenous predictor in the equation for HIV negative behaviour (Model 2c).

After controlling for prevention behaviour and all other variables, the relationship between number of current sexual partners and HIV status is not statistically significant. As the results for Model 2b show, those with multiple partners are substantially less likely to practice prevention behaviour (OR=0.37). About half of them, however, do report practicing some type of prevention. The simple bivariate analysis confirms that the level of prevention behaviour is higher for those with no or one sexual partner compared to those with multiple partners (65% versus 53%). The method most frequently reported by those with no current partners is abstaining from sex (45.6%). For those with one current partner, the most frequently reported method is faithfulness and trust of one's partner (48.9%). For those with multiple partners, the most frequently reported method is condom use (31.8%).

The results show that those who frequently drink more than 4–5 alcoholic drinks at a time are significantly less likely to remain HIV negative (OR=0.91). Those who live in an area (sample cluster) with higher HIV prevalence are also significantly *less* likely to be HIV negative (OR=0.36). IV drug use, ever being forced to have sex, and being away from home for a month or more are not significantly related to HIV negative status after controlling for all other variables in the model. None of the mass media exposure measures are directly related to HIV status. Their effects are indirect: general media exposure increases the likelihood of exposure to AIDS communication programmes, which increases the likelihood of practicing prevention behaviour which is directly related to HIV negative status.

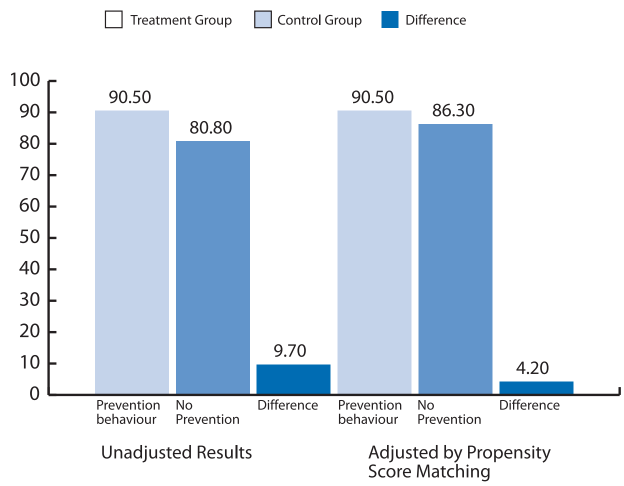
Several socio-economic control variables are related to HIV status. The probability of being HIV negative is significantly greater among those with tertiary education (OR=1.89), but no other level of education, compared to those with no schooling at all. There is no statistically significant difference between those employed and unemployed, but those currently on pensions (OR=3.42) or students (OR=2.65) are significantly more likely to be HIV negative. It has been widely reported that Africans in South Africa have higher rates of HIV infection. The regression analysis confirms this finding. After taking into account prevention behaviour and other variables, all other racial groups are substantially more likely to be HIV negative than Africans: coloureds (OR=3.36), whites (OR=7.19), and Indians (OR=13.98).

Poverty was measured as ever experiencing one or more of the following conditions in the last 12 months: not enough fuel to heat or cook, not enough clean water to drink and cook with, not enough food to eat, not enough cash income, and lack of medicine or medical treatment. 57% report having experienced one or more of those conditions in the last 12 months. Those who experienced any one or more of these are significantly *less* likely to be HIV negative (OR=0.79).

The probability of being HIV negative is significantly *lower* for young adults ages 15–24 years (OR=0.56) and ages 25–43 years (OR=0.37) compared to older adults 44 years of age and above. Females are less likely to be HIV negative than males (OR=0.69), as are those who are single rather than married (OR=0.61). Compared to urban formal residents, there is no statistically significant relationship between HIV status and living in any other type of residence. The likelihood of being HIV negative is significantly lower in every province compared to the Western Cape. Odds ratios range from 0.29 to 0.66. The odds of being HIV negative are the lowest in Mpumalanga and Kwazulu Natal (OR=0.29 and 0.30 respectively).

All three models (2a–c) fit the data quite well. The variance explained by the equation for AIDS communication exposure is 0.44. The post-estimation Chi^2 goodness of fit test indicated that there was no statistically significant difference between the model and the data for prevention behaviour (Chi^2=9.45, p>0.31) nor the model for HIV negative status (Chi^2=13.29, p>0.10). The HIV prevention behaviour of 70.0% of cases was correctly classified (predicted) by Model 2b, and the negative HIV status of 87.3 % of cases was correctly classified (predicted) by Model 2c. The correct classification of HIV status by Model 2c was due to negative rather than positive HIV status. Correct classification of HIV negative status was 87.8% compared to 48.6% for HIV positive status.

Figure 2. Percent Who are HIV Negative by HIV Prevention Behaviour: Before and After Propensity Score Matching



N = 9,764 (weighted); HIV test administered

Propensity Score Estimate of HIV Infections Averted

Probit regression with the same variables used in Model 2b was used to conduct propensity score analysis of the degree of impact of prevention behaviour on HIV negative status. Propensity score matching allows us to estimate the net difference in HIV negative status that can be attributed to HIV prevention behaviour.

The region of common support (overlap of propensity scores) included 9,793 cases (four cases fell outside the range of comparability and were therefore excluded). The propensity score is the probability of practicing HIV prevention behaviour based on the weighted sum of all of the variables used in the probit regression (Model 2). This probability ranged from a low of 0.22 to a high of 0.98. The balancing property was satisfied with nine blocks (strata) with the common support option and probability level set at 0.001. This means that there were no statistically significant differences in the mean propensity scores of those who practice prevention behaviour and those who do not within each of the nine blocks, nor in any of the variables used in the regression. Using this propensity score to create a matched, statistically balanced, control group approximates what would be found with a randomised control group to the extent that no confounding variables have been left out of the regression (the assumption of strong ignorability). Support for this assumption is provided by the fit of Model 2b to the data (Chi^2=13.29; p<0.10) and the biprobit test for the exogeneity of prevention behaviour in the equation for HIV negative status (Model 2c) (rho=–0.33; p>.16).

The estimated mean level of HIV negative status for those who practiced prevention behaviour (treatment group) was 90.5% compared to 86.3% in the statistically equivalent, matched control group (see Figure 2). Thus, the average treatment effect on the treated (those who practiced HIV prevention behaviour) was 0.042, or a 4.2 percentage point difference (SE=0.007, Z=6.26, p<0.001). The unadjusted difference in HIV negative status estimated without propensity score matching was 9.7 percentage points, suggesting that the bias due to self-selectivity that was removed by means of propensity score matching was 5.5 percentage points (9.7 minus 4.2).

The percent of sexually active adults who practiced some form of HIV prevention behaviour was 64.2%, which corresponds to 16,702,263 people in the population (weighted). Without practicing prevention behaviour we would expect that their HIV negative prevalence *would have been* the same as the matched control group (the counter-factual condition), or 4.2 percent lower (86.3 % rather than 90.5%). This translates into a reduction in HIV negative status of 701,495 cases (0.042 x 16,702,263). In other words, according to the propensity score analysis, 701,495 people *would have been* HIV positive in 2005 if they had not practiced some form of HIV prevention behaviour.

Using a conservative estimate of the annual cost of ARV treatment for AIDS (Kahn, Marseille, & Auvert, 2006, p. 2353), the 20-year lifetime savings of this reduction in HIV infections would amount to US 5.6 billion dollars (US $400 x 20 years x 701,495 people). This cost estimate only applies to the number of HIV infections averted by 2005. The cost of ARVs for those already infected will require many billions of dollars more than this. A 20-year projection is not very realistic, only because many in this group would probably die before ever getting ARV treatment. Also, over a 20-year period, less expensive drugs are expected to become available. However, a related factor is the possibility of earlier death as a product of inconsistent drug use, and need for more expensive treatment regimes as HIV illness progresses.

In the final instance however, it is highly unlikely that this much money would ever become available for treatment.

An estimate of the first year of ARV treatment is much more meaningful. To treat this many people for one year would cost US $ 280,600,000 ($400 x 701,495). Recognising the cost savings of HIV infections in this manner dramatises what is already well known in the public health community: that the expected growth in the cost of ARV treatment cannot be sustained, so the effort to conduct effective HIV prevention programmes must be substantially increased. The one-year estimate of $ 280,600,000 savings in medical costs by preventing as many as 701,495 infections makes it very clear that every dollar allocated to effective HIV prevention programmes is highly cost-effective.

It is also important to point out that just because many people have purposely maintained their negative HIV status at 2005 does not mean that they will continue to do so in the future. Many of those who say they are abstaining will become sexually active and place themselves at risk. Some trusted partners may eventually have other partners. Condoms may not always be used correctly and consistently. Given the unreliability of the prevention methods, some HIV negative people in 2005 will eventually become HIV positive. At the same time, however, many people in the *non-prevention group* in 2005 undoubtedly began practicing HIV prevention behaviour *after* the 2005 survey was conducted while they were still HIV negative. In the next national HIV survey planned for 2009, this group, along with a whole new cohort of young people who were 12–14 years of age in 2005 will be included in the next estimate of HIV prevalence. HIV negative prevalence in 2009, as we have seen in 2005, is a function of the social/cultural context of each person's risk for infection, many related socio-demographic factors, the capacity of AIDS communication programmes to induce and reinforce HIV prevention behaviour, and population's commitment and capacity to sustain HIV prevention behaviours.

Conclusions

The secondary analysis – with SEM and propensity score analysis – confirmed that:

- The practice of HIV prevention behaviour increases the probability of staying HIV negative.
- Awareness of national level mass media AIDS communication programmes has an indirect effect on HIV status through its effect on several HIV prevention behaviours.
- By 2005, a substantial number of HIV infections were averted because of the practice of HIV prevention behaviour.

The SEM was successful to a great extent due to the fit of the model to the data. The relatively high level of fit means that the residual terms of the equations are more likely to represent random variance than the systematic variance of potential variables that were omitted from the analysis (in other words, unobserved confounding variables). The tests for exogeneity made use of these residual terms. The results showed that they functioned like random variables with respect to one another and to the endogenous (dependent) variables in the models. This outcome supports the assumption of 'strong ignorability' in the propensity score analysis – that there were no variables omitted from the analysis that would have affected the observed outcome. Of course, many potentially confounding variables were not measured in the survey and thus were omitted. To threaten the internal validity of the results, however, they would each have to have an effect that is sufficiently independent of variables already included in the model and large enough to be statistically significant. Otherwise, they would make no difference in the results presented here.

Identification of the AIDS communication equation was also helped by the fact that mass media use in general is strongly related to exposure to national level AIDS communication programmes, and in fact works through those programmes to influence prevention behaviour and HIV negative status. Theoretically, this is how mass media are expected to work, and the data confirm this general proposition. Identification of the HIV status equation was helped by including risky lifestyle variables and an estimate of the prevalence of HIV infection in each respondent's near surround.

It is important to emphasise that empirical findings from one study should only be accepted tentatively until corroborated by another study. That is, nothing should be accepted as valid until it has been observed at least twice. This analysis can be replicated in upcoming surveys using the same questions.[7] It is imperative that the same HIV risk question and unaided prevention behaviour question be included in future studies so that the hypotheses tested in this study can be adequately replicated. The prediction, however, is that in 2009 the percentage and number of HIV infections averted should be substantially greater than what was observed in 2005. This prediction assumes, of course, that the population of South Africa will have correctly and consistently practiced HIV preventative behaviour and in even greater numbers than in 2005. In other words, the AIDS communication programmes and other prevention interventions will have continued to have had a positive impact on prevention behaviour.

The evidence that national level AIDS communication programmes with mass media components can help change health behaviour is an important finding, as it runs counter to the belief that "HIV prevention campaigns aren't working" in South Africa. It is important to explicate what is meant by AIDS communication programmes, HIV prevention campaigns, and "working" versus "not working." AIDS communication programmes typically address a wider range of objectives than prevention, including general AIDS-related knowledge, stigma, counselling and HIV testing, clinical services for therapeutic approaches for HIV prevention during pregnancy, ARV treatment of HIV infection, and activities related to care and support for adults and children living with and/or affected by HIV and AIDS (Kincaid et al., 2007). The AIDS epidemic has created a very large, complex agenda for the public health system to address.

HIV prevention is a subset of that agenda. It needs to be examined within the hyperendemic context of HIV prevalence in southern Africa. The high expectations for prevention impacts have not unfolded as quickly as hoped. While it is easy to point to a complex of contextual factors that underpin HIV risk, there is clear emerging evidence that the foci of prevention communication has skirted a core epidemic driver in the regions – multiple and concurrent sexual partnerships (MCP) (See Table 2, Model 1 and Varghese, Haher, Peterman, Bernard, & Steketee 2002; Doherty, Padian, Marlow, & Aral, 2005; Halperin & Epstein, 2007). In South Africa, this risk factor is closely related to late marriage, mobility and unemployment, among other factors. While awareness of condoms as a means for HIV prevention is now high and reported condom use has increased over time, there is considerably lower awareness of the risks of MCP (Parker, Makhubele, Ntlabati, & Connolly, 2007). While it is acknowledged that condom use addresses incident infections in some contexts, it does not follow that this instrumental act alone is sufficient to address overall HIV risk and contain and reduce HIV prevalence (see Rehle et al., 2007). Future HIV prevention programmes need to respond to this growing body of evidence about MCP to be theoretically and scientifically sound.

While individuals may have some degree of agency and instrumentality in relation to MCP, such as ensuring that they do not have overlapping sexual partnerships, people have little control over the sexual behaviours of their partners. Risk of HIV infection is considerably increased if a partner has other concurrent partners, since this links an individual into a wider sexual network, irrespective of their own instrumental HIV prevention behaviour (in other words, faithfulness). While consistent condom use would be a related risk reduction strategy, it is recognised that consistent and ongoing condom use is not readily sustained in longer-term relationships. In this sense, HIV prevention communication needs shift its focus from individual behaviour to partner relationships and group norms, with particular emphasis on managing one's *sexual relationships* in a risk-averse manner. In the context of hyperendemic HIV epidemics, this requires urgent and intensified action by AIDS communication programmes that function at the global, national and sub-national level.

7 A follow-up survey by the HSRC and partners is planned for 2009.

References

Actuarial Society of South Africa. (2005). *ASSA2003 AIDS and demographic model*. Cape Town: ASSA.

Becker, S.O., & Ichino, A. (2002). Estimation of average treatment effects based on propensity scores. *The Stata Journal 2*(4), 358–377.

Bertrand, J.T., O'Reilly, K.O., Denison, J., Anhang, R., & Sweat, M. (2006). Systematic review of the effectiveness of mass communication programs to change HIV and AIDS-related behaviors in developing countries. *Health Education Research*, *21*(4), 567–597.

Bollen, K. A., Guilkey, D. K., & Mroz, T. A. (1995). Binary outcomes and endogenous explanatory variables: Tests and solutions with an application to the demand for contraceptive use in Tunisia. *Demography, 32*(1), 111–131.

D'Agostino, R. B., Jr. (1998). Propensity score methods for bias reduction in the comparison of a treatment to a non-randomized control group. *Statistics in Medicine*, *17*, 2265–2281.

Dehejia, R.H. & Wahba, S. (2002). Propensity score matching methods for non-experimental causal studies. *Review of Economics and Statistics*, *84*(1), 151–161.

Doherty, I., Padian, N.S., Marlow, C. & Aral, S. (2005). Determinants and consequences of sexual networks as they affect the spread of Sexually Transmitted Infections. *Journal of Infectious Diseases*, *191*, S42–S54.

Greene, W.H. (1993). *Econometric Analysis*. New York: MacMillan.

Halperin, D. & Epstein, H. (2007). Why is HIV prevalence so severe in Southern Africa? The role of multiple concurrent partnerships and lack of male circumcision: Implications for AIDS prevention. *Southern African Journal of HIV Medicine*, March, 19–27.

Heckman, J. J., Ichimura, H., & Todd, P. (1998). Matching as an econometric evaluation estimator. *Review of Economic Studies*, *65*, 261–294.

Joffe, M. M., & Rosenbaum, P. R. (1999). Invited commentary: Propensity scores. *American Journal of Epidemiology*, *150* (4), 327–333.

Kahn, J. G., Marseille, E., & Auvert, B. (2006). Cost-effectiveness of male circumcision for HIV prevention in a South African setting. *Public Library of Science Medicine* (*PLoS Med*), *3*(12), 2349–2358.

Kincaid, D. L., & Do, M. P. (2006). Multivariate causal attribution and cost-effectiveness of a national mass media campaign in the Philippines. *Journal of Health Communication*, *11* (Supplement 2), 1–21.

Kincaid, D. L., Parker, W., Johnson, S., Schierhout, G., Connolly, C., & Pham, V.T.H. (2007). AIDS communication programmes, HIV prevention, and living with HIV and AIDS in South Africa, 2006. Joint working paper of CADRE, HDA, and JHU-CCP, Johannesburg, South Africa.

Parker, W., Makhubele, B., Ntlabati, P., & Connolly, C. (2007). Concurrent sexual partnerships amongst young adults in South Africa: Challenges for HIV prevention communication. Johannesburg: CADRE.

Rehle, T., & Shisana, O. (2003). Epidemiological and demographic HIV and AIDS projections: South Africa. *African Journal of AIDS Research* 2(1), 1–8.

Rehle, T., Shisana, O., Pillay, V., Zuma, K., Puren, A., & Parker, W. (2007). National HIV incidence measures - new insights into the South African epidemic. *South African Medical Journal 97*(3), 194–199.

Rosenbaum, P.R. (1989). The role of known effects in observational studies. *Biometrics*, *45*, 557–569.

Rosenbaum, P., & Rubin, D.B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, *70*, 41–55.

Rosenbaum, P., & Rubin, D.B. (1984). Reducing bias in observational studies using subclassification on the propensity score. *Journal of the American Statistical Association*, *79*, 516–524.

Rubin, D. B. (1974). Estimating causal effects of treatments in randomized and nonrandomized studies. *Journal of Educational Psychology*, *66*, 688–701.

Shisana O., Rehle T., Simbayi L.C., Parker W., Zuma K., Bhana A., Connolly C., Jooste S., Pillay V., et al. (2005). *South African national HIV prevalence, HIV incidence, behaviour and communication survey, 2005*. Cape Town: HSRC Press.

Snyder, L.B., Hamilton, M.A., Mitchell, E.W., Kiwanuka, J., & Proctor, D. (2004). A meta-analysis of the effect of mediated health communication campaigns on behavior change in the United States. *Journal of Health Communication*, *9* (1), 71–96.

Statistics South Africa. (2005). Mid-year population estimates, South Africa 2005. Pretoria: Statistics South Africa.

Stover, J., Bertozzi, S., Gutierrez, J., Walker, N., Stanecki, K.A., Greener, R., Gouws, E., Hankins, C., Garnett, G.P., Salomon, J.A., Boerma, J.T., De Lay, P., & Ghys, P.D. (2006). The global impact of scaling up HIV and AIDS prevention programs in low- and middle-income countries. *Science*, *311*, 1474–1476.

UNAIDS. (2006). *Report on the global AIDS epidemic*. Geneva: UNAIDS.

Varghese, B., Haher, J.E., Peterman, T.A., Bernard, M. & Steketee, R.W. (2002). Reducing the risk of sexual HIV transmission: Quantifying the per-act risk for HIV on the basis of choice of partner, sex act, and condom use. *Sexually Transmitted Diseases, 29*(1), 38–43.

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