Wharton School

Wharton Research Scholars Journal

University of Pennsylvania *Year* 2005

HIV/AIDS in South Africa: Identification of Provinces in Most Need of Intervention at the Firm/Industry Level

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I. BACKGROUND AND INTRODUCTION

I. *a) Clinical Etiology of HIV/AIDS*

HIV (human immunodeficiency virus) is the virus that causes AIDS. The virus is transmitted when infected blood, semen, or vaginal secretions come in contact with broken skin or mucous membranes of an uninfected person. Pregnant women who are infected can pass HIV to their baby during pregnancy or delivery, as well as through breast-feeding (Centers for Disease Control [CDC], 2005).

Acquired **I**mmuno**d**eficiency **S**yndrome (AIDS) is characterized by a weakening of the immune system and refers to a group of symptoms that collectively indicate or characterize a disease. In the case of AIDS, this can include the development of certain infections and/or cancers as well as a decrease in the number of certain cells in a person's immune system (CDC, 2005).

I. *b) Effect of HIV/AIDS in Sub-Saharan Africa*

Sub-Saharan Africa comprises only 10% of the world's population but is home to over 60% of all people living with HIV. The region has a staggering adult HIV prevalence rate that is estimated at about 7.4% (UNAIDS, 2005). This is contrasted to the HIV prevalence rate in the United States of about 0.3%. There are an estimated 11.4 million people living with HIV/AIDS in Southern Africa which is about 30% of all global AIDS cases. This is in a region that accounts for only 2% of the world population (UNAIDS, 2005). Due to this large number of cases and the lack of infrastructure to manage the disease, Africa has suffered immeasurable losses due to HIV/AIDS.

The interrelation between poverty and AIDS has also made the epidemic more difficult to manage and has led to its socio-economic impact being amplified. There have been two key relationships between poverty and HIV/AIDS in Africa.

On the one hand, already existing poverty has made it more difficult for the populations affected to cope with the illness – this has resulted in more losses than would have resulted were poverty already not present in the equation. The other way in which poverty and HIV/AIDS have interacted has been in the productivity losses that have resulted due to the epidemic. Productivity losses have resulted because HIV/AIDS is concentrated within the most socially productive groups – those between the ages of 15-45 (UNDP, 2005).

HIV/AIDS has had an astounding negative impact on the economies of affected countries. Arndt and Lewis (2000) group the effects of HIV/AIDS on economies into four categories: effect on firms, households, government, households and the macro-economy.

Firm effects: costs increase and profits and savings decrease due to rising insurance premiums; overall productivity drops due to absenteeism; and labor productivity is diminished due to a diminished worker experience as a result of HIV infection.

Government effects: increased governmental AIDS spending detracts from spending in other areas; production structure shifts result in reduced revenues from value added tax (VAT) and trade taxes; and spending shift in household incomes affects income receipts.

Household effects: morbidity/mortality losses resulting in loss of income and creation of orphans that leads to vulnerable households; and increasing number of home caregivers leading to changed expenditure patterns, reduced savings, asset sales.

Macroeconomic effects: lower physical and human investment leading to reduced growth trajectory; and, class-biased impacts leading to uneven welfare effects.

Arndt and Lewis (2000) constructed a model comparing 2 scenarios. A "no-AIDS" scenario in which economic performance continued as normal without the effect of AIDS and an "AIDS" scenario in which AIDS related-factors had an impact on the economy. It was found that GDP at the end of the simulation period was 17% lower in "AIDS" scenario compared with the "no-AIDS" scenario. GDP per capita was found to be 8% lower in the "AIDS" scenario.

In a review article by Dixon et al. (2002), startling statistics are raised in the discussion of the economic effect of HIV/AIDS. Annual costs associated with sickness and reduced productivity range from $17 per employee in a Kenyan manufacturing firm, to $300 in the Ugandan Railway Association.

I. *c) Description of Prof MacMillan's Overall Project*

In response to the aforementioned need for HIV/AIDS intervention, Prof Ian MacMillan (Faculty – Management Dept, and my research mentor) is undertaking a project to develop a workforce health management system that will allow companies to optimally determine drug/nutrition regimens for a population of workers in firms located in countries with high HIV positive workforces. Professor MacMillan's project will include the development of a software system that will take limited input data about individual workers and infer the most cost effective method for distributing limited nutrition and drug supplies to maintain the vitality of infected workers. In order for this project to be successful however, specific regions will have to be identified where resources can be allocated.

I. *d) Description of Research*

The purpose of my research and this paper is to identify provinces in South Africa that are in most need of HIV/AIDS intervention at the firm/industry level. Through my research, I have developed provincial indices that aggregate demographic and public health indicators (Population Density, HIV prevalence & TB Prevalence) and macroeconomic indicators (Industry Density, Replacement Pools of Workers & Skill Level of Workers). I will use the aggregate data to pinpoint provinces that will a) have the highest public health need for this kind of intervention and b) would be most economically receptive. I will also use the aggregates I derive to come up with suggestions for allocation of resources across provinces to combat HIV/AIDS at the firm/industry level.

II. DEFINITION AND PRESENTATION OF PARAMETERS

II. *a) HIV Prevalence (AVERT[1], 2005)*

Given that the intervention in question is one of HIV/AIDS management, measuring HIV prevalence is crucial when coming up with a final aggregate that will be used to identify provinces in most need of intervention at the firm level. There are 2 main HIV prevalence studies that are referred to in South Africa. One study is the South African Department of Health Study (2003) and the other is the Nelson Mandela Study (2002).

The South African Department of Health Study is based on interviews of over 16,000 women attending antenatal clinics in all nine provinces of South Africa. The Nelson Mandela Study on the other hand, was based on a "household" survey. This involved sampling a proportional cross-section of society, including a large number of people from each geographical, racial and social group. The surveyors tried to adjust for

likely over- or under-representation of individual groups (according to census data). In the Nelson Mandela Study, 14,450 people were selected to take part, and surveyors managed to visit 13,518 of them.

For the purpose of my analysis, I decided to use the Nelson Mandela Study which I found to be most representative of the South African population. That said though, this study still failed to include certain groups such as homeless people, soldiers, prisoners, and students living in boarding schools. Another limitation of the study is that it failed to document groups that may be of special interest in understanding the epidemic such as men who have sex with men, injecting drug users and sex workers. Below is a graph showing the provincial HIV prevalence data according to the Nelson Mandela Study:

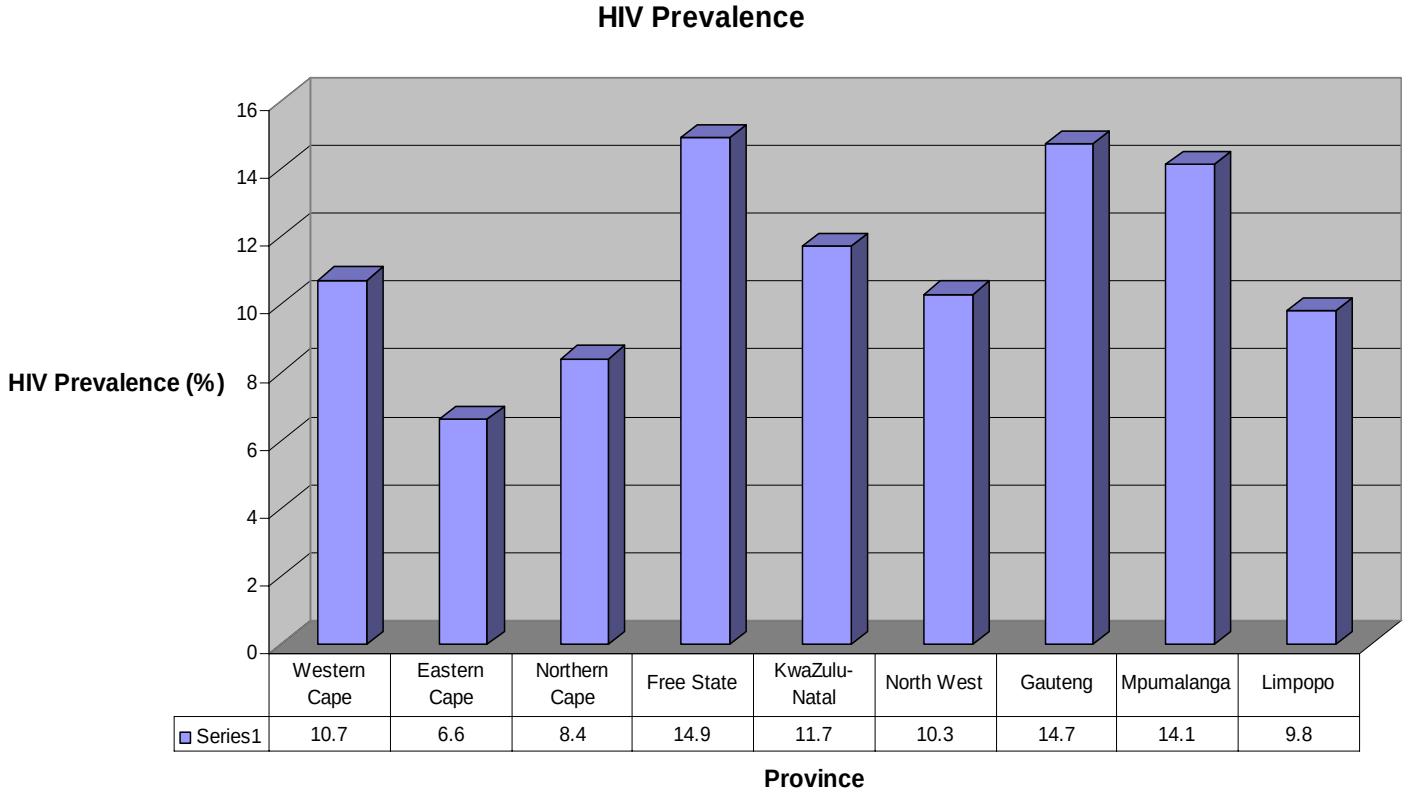

Figure 1: HIV Prevalence in South Africa (AVERT[1], 2005)

II. *b) Tuberculosis Incidence*

Tuberculosis (TB) is a contagious disease that kills approximately 2 million people each year. TB is the leading cause of death among those infected with HIV. It has been estimated that the disease accounts for 13% of AIDS deaths worldwide (AVERT², 2005). The presence of TB and HIV together necessitates greater resource allocation because of the following reasons (AVERT², 2005): TB is harder to diagnose in HIV-positive people, TB progresses faster in HIV-infected people, TB in HIV-positive people is more likely to be fatal if undiagnosed or left untreated, TB occurs earlier in the course of HIV infection than other opportunistic infections, and TB is the only major AIDS-related opportunistic infection that poses a risk to HIV-negative people.

Due to the importance of containing TB in the fight against AIDS, tuberculosis incidence was seen as a crucial parameter to be included when looking at areas that will be most suited to HIV/AIDS intervention. Areas with high TB incidence in the presence of HIV would need more resources allocated to them to combat HIV/AIDS. The South African TB data that was incorporated into the final analysis was obtained from the Health Systems Trust and is shown in Figure 2 on the following page.

II. *c) Population Density*

Population density was an important parameter to look at because it directly reflects accessibility to an intervention. Areas that have high population densities will be better candidates for a disease intervention because more people will be able to access the site where the intervention will take place. Also, information about the existence of HIV/AIDS intervention will be more easily disseminated in an area which is densely populated.

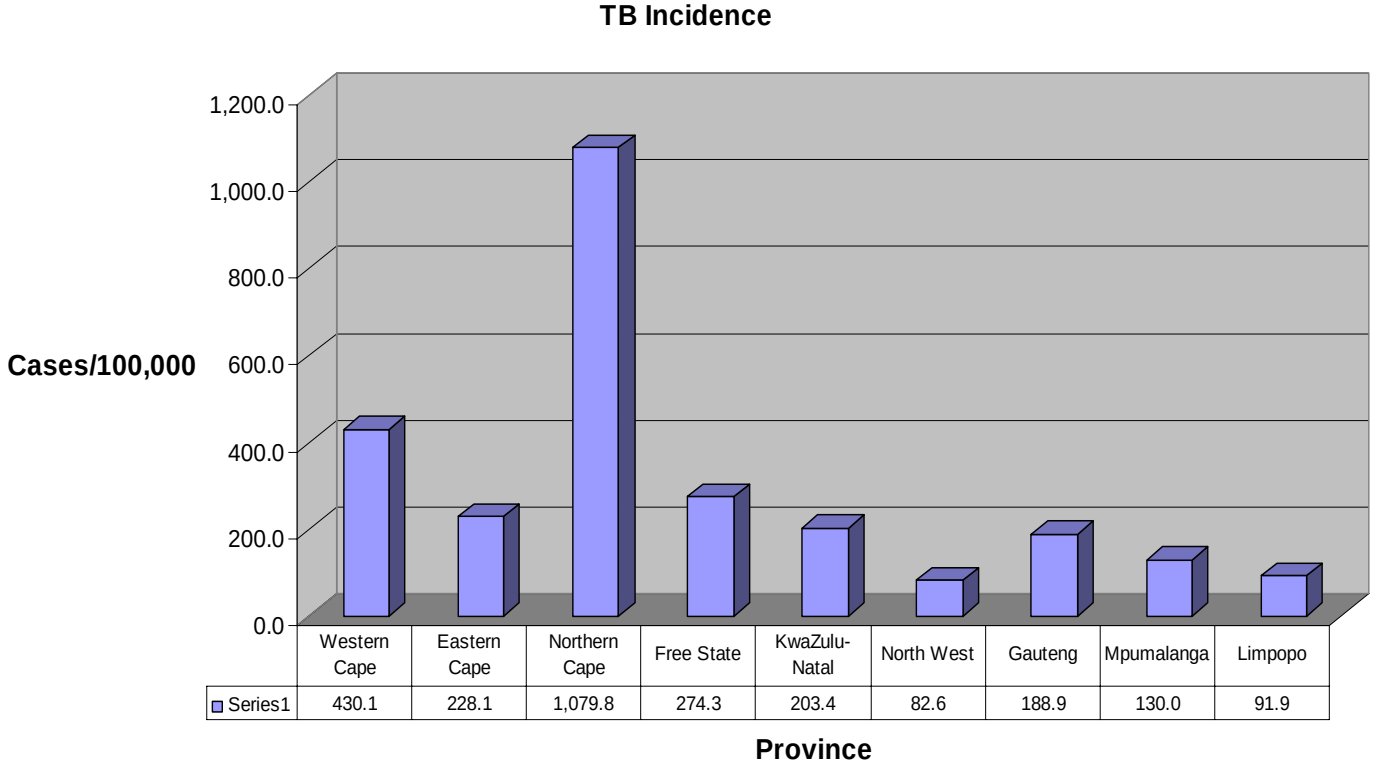

Figure 2: TB Incidence in South Africa (Health Systems Trust[1], 2005)

Population density is also a key variable to look at because it has direct repercussions for the spread of diseases in general and HIV/AIDS in particular. Human interaction is increased in areas that are densely populated and consequently, spread of HIV/AIDS is likely higher in these provinces. Population density data for South Africa was obtained from the Health Systems Trust and can be viewed on the following page.

II. *d) Industry Density*

Industry density is another parameter that we found to be crucial to look at in order to identify provinces in most need of intervention. Areas with a high industry density in the presence of HIV/AIDS have probably already encountered productivity losses due to the malady and will likely be good targets for an intervention at the firm level.

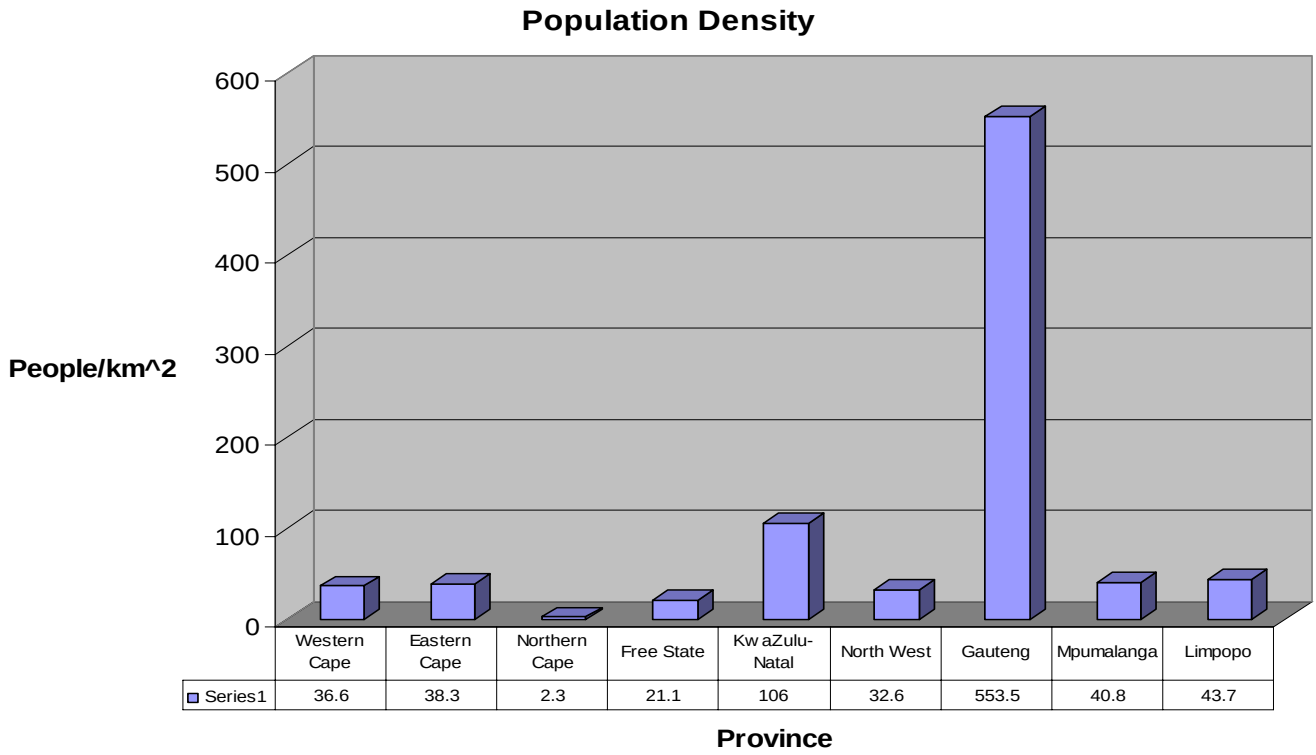

Figure 3: Population Density in South Africa (Health Systems Trust[2], 2005)

In addition to firms having more incentive to engage in HIV/AIDS intervention at the firm level, areas with high industry densities will also enable dissemination of information at a more rapid pace. HIV/AIDS consultants will therefore have to travel shorter distances when visiting firms on site and similarly, patients will not have to travel far when visiting a voluntary, counseling and testing center.

However, given that industry density data per se is not available, a proxy needed to be developed to approximate this. A possible way of calculating industry density may include obtaining the number of firms in a given province, multiplying this with a factor to estimate size of each firm and then dividing this quantity by the area of the province. That said, this kind of approach would be tedious to implement. Instead, an industry density proxy was obtained by dividing GDP (South African Dept. of Trade and

Industry [SADTI][1], 2005) by the area (Wikipedia, 2005) of each province. This was a good proxy as it gives data across many different industries in a province. The proxy does not however account for undocumented economic activities. Below is the graph showing GDP/km^2 for each province.

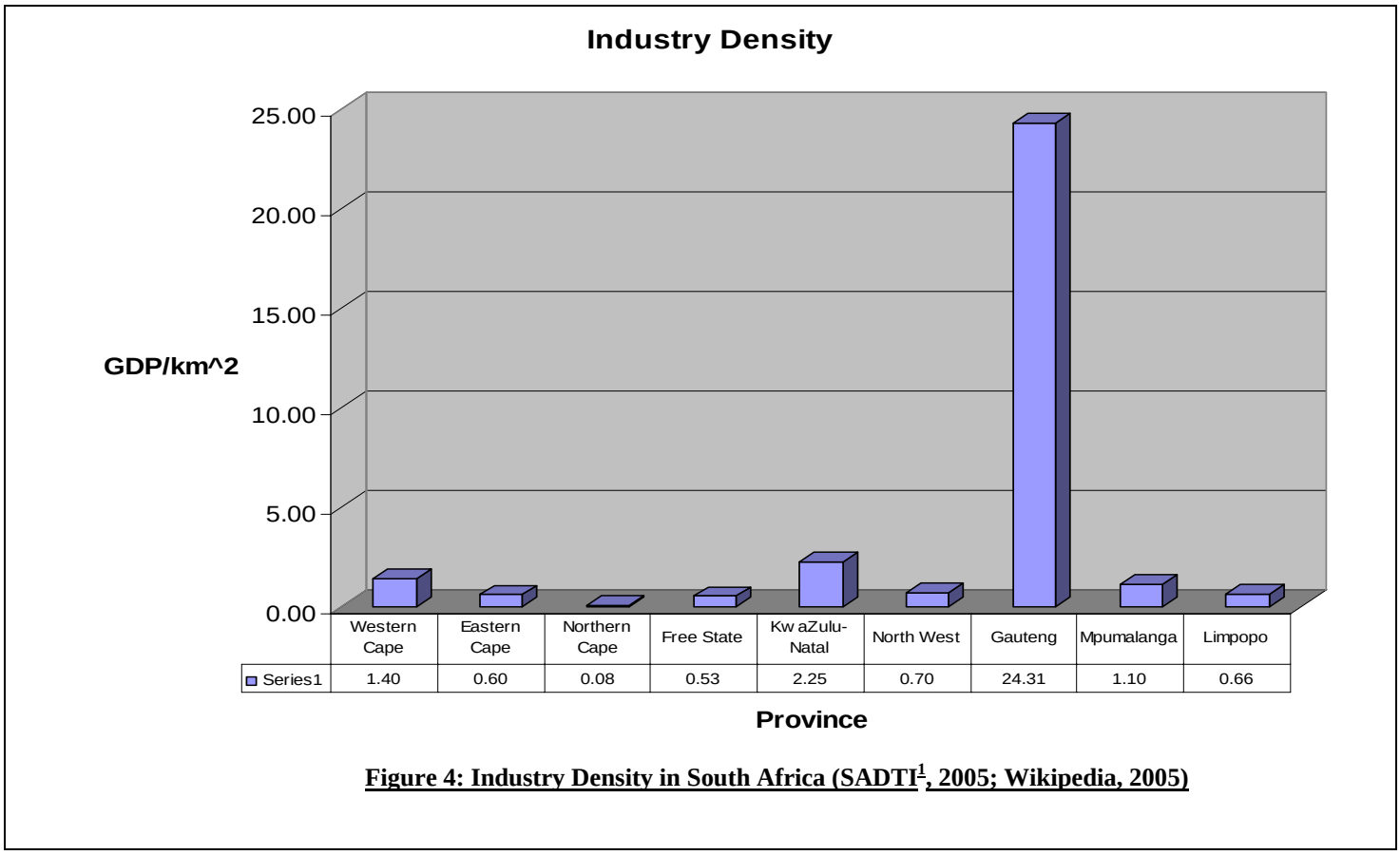

Figure 4: Industry Density in South Africa (SADTI[1], 2005; Wikipedia, 2005)

II. *e) Level of Worker Skill*

Provinces that have industries in which firms have higher worker skill levels will be more receptive to HIV/AIDS intervention at the firm level. The reason for this is because firms will be less inclined to spend more money in training new personnel while they can spend significantly less money on treatment and counseling programs. However, the question becomes how best to evaluate worker skill level.

There are several ways that worker skill level can be evaluated: standardized tests and education qualifications can be used to assess intellect and skill, evaluation of the sophistication of technologies that workers are using can also be used to evaluate skill level and lastly, skill can be evaluated by looking at the level of compensation of workers – workers earning more will be assumed to be more skilled.

In this study, given the data available, worker skill level was evaluated using worker compensation. To do so, total remuneration per province were divided by the number of employed persons in the province. Remuneration is defined as salaries; wages; services and other bonuses; allowances (including car allowances); overtime payments; retirement benefits; contributions to medical, pension and provident funds; unemployment insurance and accident funds; remuneration in kind; and housing subsidies (SADTI[2], 2005).

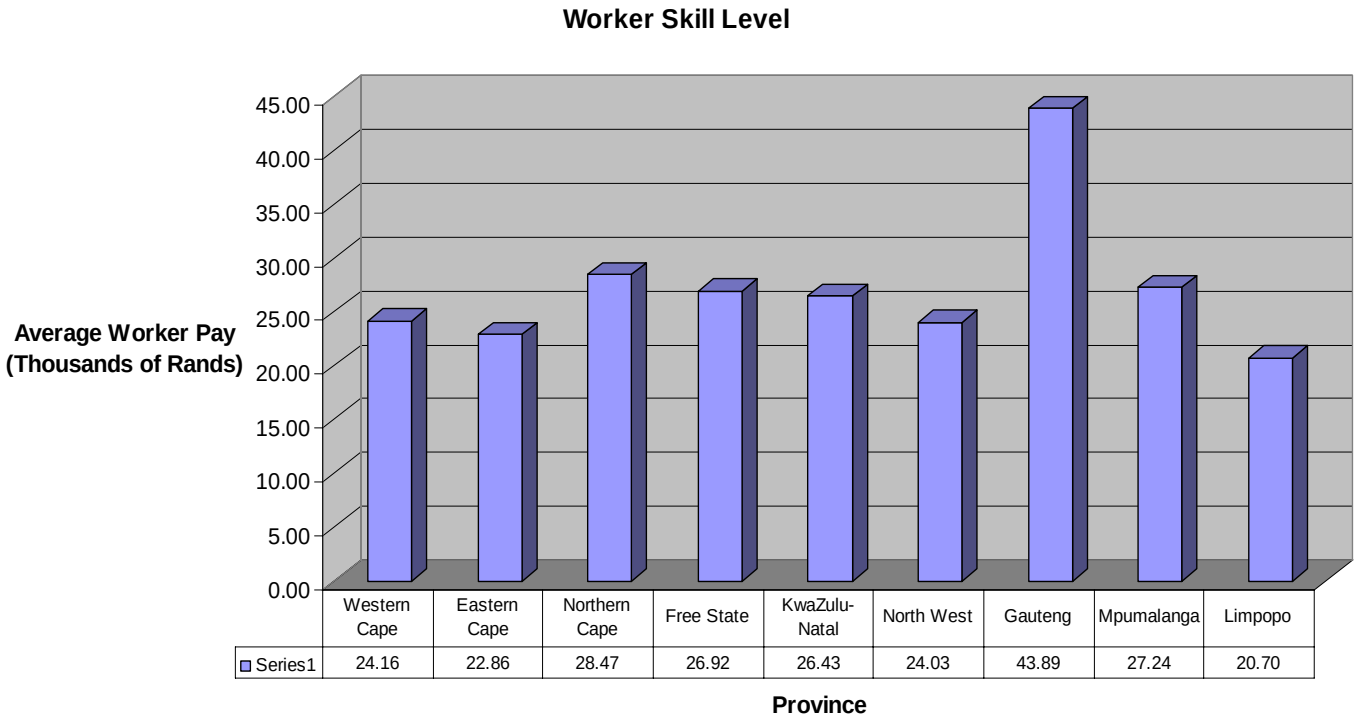

Figure 5: Worker Skill Level in South Africa (SADTI[2], 2005)

II. *f) Availability of Replacement Pools of Workers*

This parameter refers to the presence of unemployed workers who can take the place of those who are employed and have to leave work due to external reasons such as disease. Availability of worker pools does not distinguish between skill levels. Provinces with very low replacement pools will be in greater need for HIV/AIDS intervention due to the lack of replacement for workers who fall ill.

A proxy for the presence of replacement pools of workers was obtained by computing the ratio of employed to unemployed persons in each province. "The *unemployed* are those people within the *economically active* population who: (a) did not work during the seven days prior to the [labor survey], (b) want to work and are available to start work within two weeks2 of the [labor survey]." (SADTI3, 2005). Below is the calculated proxy for replacement pools of workers.

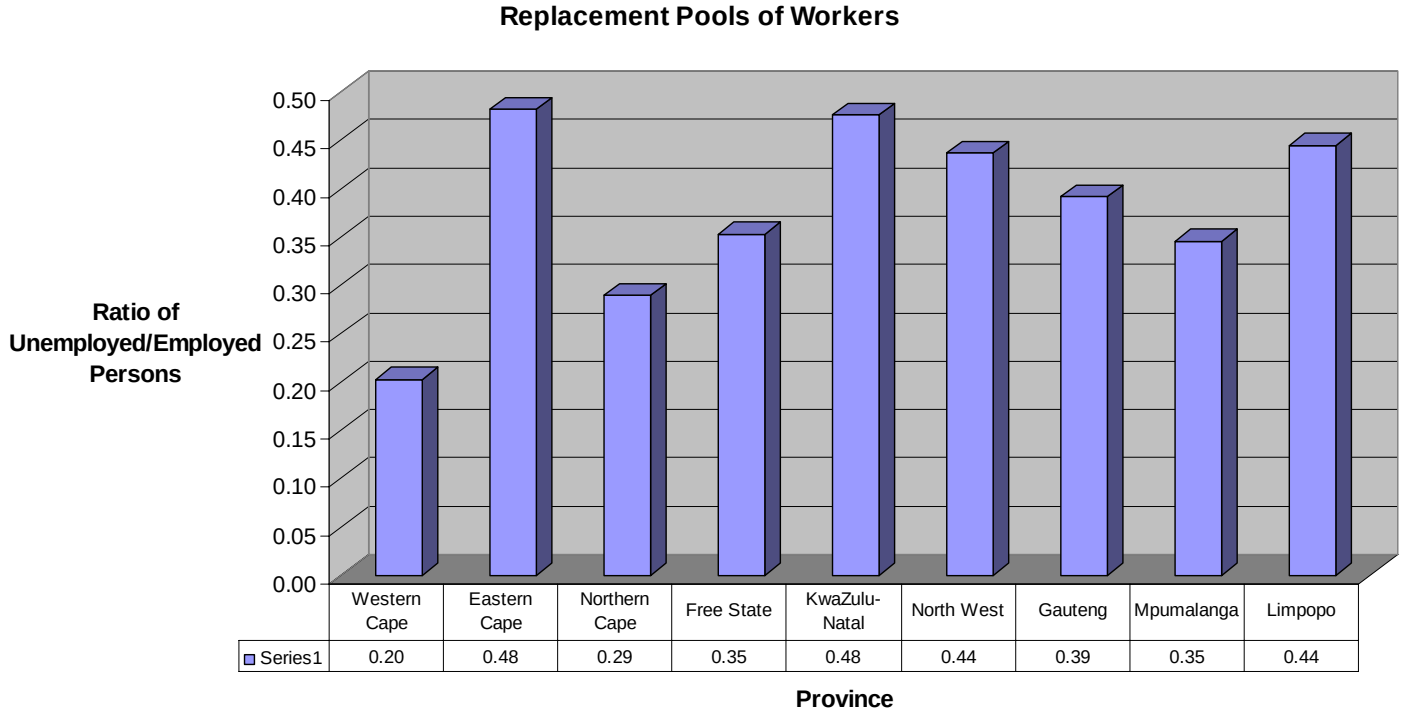

Figure 6: Replacement Pools of Workers in South Africa (SADTI[3], 2005)

III. AGGREGATION OF PARAMETERS

III. *a) Data Conversion to a Common Scale*

After obtaining all the data pertaining to the different parameters to be analyzed, the next task was to get a way to combine them. The different data would have to be combined into a single provincial aggregate that gave an indication of how receptive the province would be to HIV/AIDS intervention at the firm level. In order to convert the data obtained into a common scale, the following permutation formula was devised:

$$\left\{ \frac{X_{VARIABLE} - X_{MIN}}{X_{MAX} - X_{MIN}} \right\} * 10$$

Where:

$X_{VARIABLE}$ = Data point to be converted in a given parameter set

X_{MIN} = Lowest data point in any parameter data set

X_{MAX} = Highest data point in any parameter data set

A sample of the above permutation applied to the population density data is shown below. As expected, the lowest value in the data range will get a zero while the highest value will get a value of 10.

Population Density		
	People/km^2	Aggregate Score
Western Cape	36.6	**0.62**
Eastern Cape	38.3	**0.65**
Northern Cape	2.3	**0.00**
Free State	21.1	**0.34**
KwaZulu-Natal	106	**1.88**
North West	32.6	**0.55**
Gauteng	553.5	**10.00**
Mpumalanga	40.8	**0.70**
Limpopo	43.7	**0.75**

Table 1: Sample of Population Density Indices

III. *b) Derivation of Overall Provincial Aggregates*

In order to identify the provinces that would be in most need of intervention, all the readjusted parameter values were added up per province. The sums obtained would range from 0 to 60, and would be used to predict the provinces in which intervention would be most needed – both from an economic and a public health perspective.

Below is a graph showing the computed provincial aggregates for South Africa. The next section will seek to discuss these results in more detail:

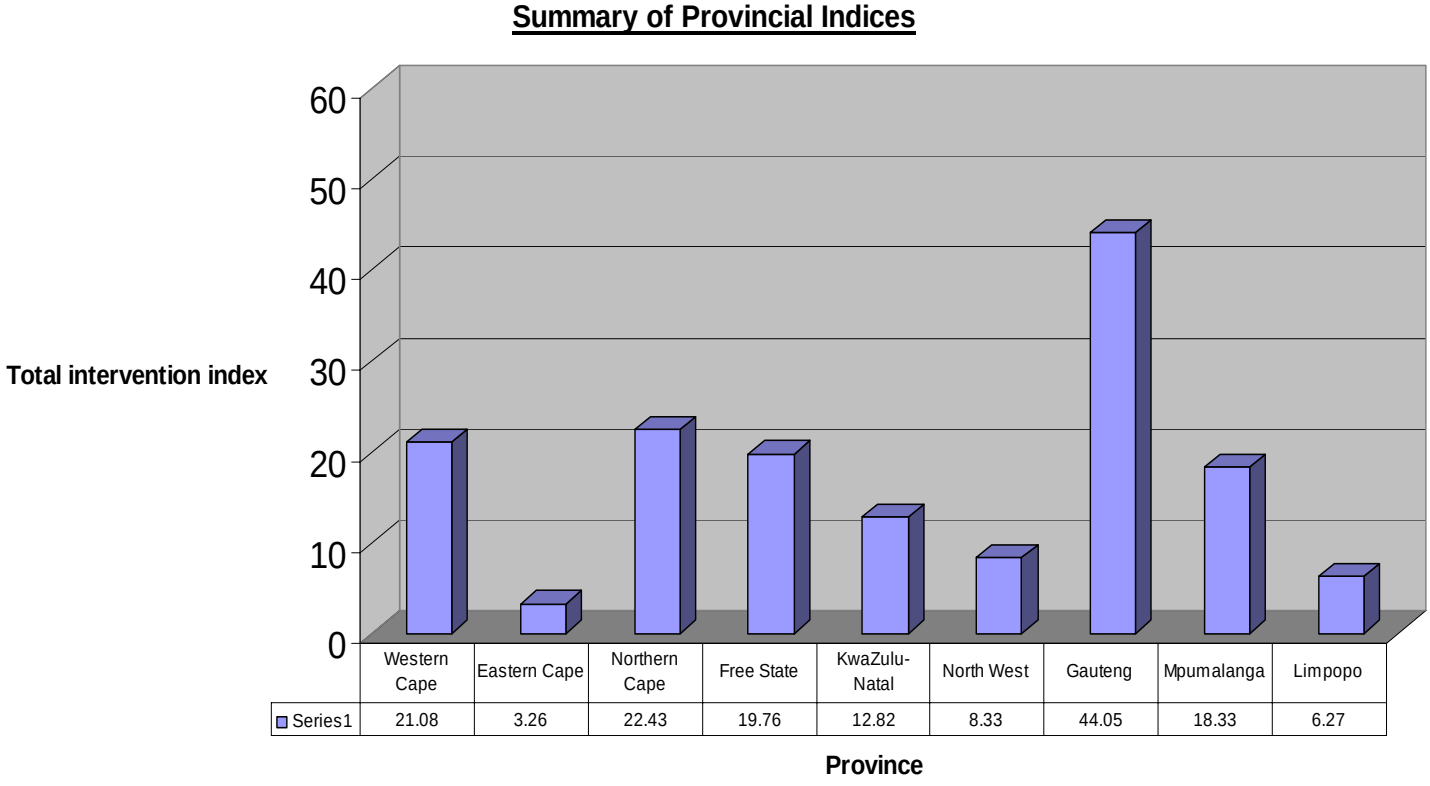

Figure 7: Derived HIV/AIDS Intervention Indices for South Africa

III. *c) Discussion of Aggregate Provincial Indices*

From the data above, it is clear that Gauteng has the highest overall intervention index at 44.05, which is 2.19 standard deviations above the mean (see appendix). The mean for the obtained data was 17.37 units and the standard deviation for the data was

12.16 units. Other than Gauteng, there were really no other provinces that extraordinarily stood out as being areas that should be focused on for HIV/AIDS intervention at the firm level. However, on the opposite end of the spectrum, the Eastern Cape stood out as a province that would **not** be suited for HIV/AIDS intervention at the firm level. The Eastern Cape had an aggregate value of 3.26 which is 1.16 standard deviations below the mean of 17.37.

Although the above data is clearly an indication of which provinces should get priority if an HIV/AIDS intervention is implemented in South Africa, contrarians may argue that a native South African could have given a good guess for some of the trends that have just been demonstrated. An example is with Gauteng which is known to be home to the largest city in South Africa – Johannesburg. One may argue at it is obvious that Gauteng would be a prime candidate for HIV/AIDS intervention.

That said though, what an ordinary passerby would not be able to predict is percent of resource allocation across provinces in South Africa. With the obtained data, it is possible to come up with accurate resource allocation percentages that will be able to guide the resource allocation process across provinces. The next section discusses two ways the data can be used for resource allocation.

III. *d) Use of Derived Indices to Guide Resource Allocation*

As mentioned in the previous section, one of the primary goals of conducting this research was to come up with a very clear research allocation framework. With these derived aggregates, it is possible to come up with unambiguous resource allocation guidelines that are solely based on need for the intervention. One way that the data can be used for resource allocation involves simply allocating based on a

province's fraction of the total nationwide aggregate figure. An example of this form of resource allocation is shown below. This form of resource allocation is more nationalistic in approach and ensures that all provinces are covered. This first means of resource allocation is shown in the table below:

	Total intervention index-general	***Percent resource allocation***
Western Cape	21.08	**13.49%**
Eastern Cape	3.26	**2.08%**
Northern Cape	22.43	**14.35%**
Free State	19.76	**12.64%**
KwaZulu-Natal	12.82	**8.20%**
North West	8.33	**5.33%**
Gauteng	44.05	**28.18%**
Mpumalanga	18.33	**11.73%**
Limpopo	6.27	**4.01%**

Table 2: Resource Allocation Guide Across all Provinces

The second method of resource allocation that will be discussed involves completely disregarding provinces that have relatively low aggregate scores. The goal of doing this would be to focus resources in the provinces that need them most. If this was to be done and all provinces that had aggregate scores below the mean were disregarded, the following resource allocation framework would ensue:

	Total intervention index-general	***Percent resource allocation***
Gauteng	44.05	**35.06%**
Northern Cape	22.43	**17.85%**
Western Cape	21.08	**16.78%**
Free State	19.76	**15.72%**
Mpumalanga	18.33	**14.59%**

Table 3: Resource Allocation Guide only for Provinces with Indices above the National Mean

III. *e) Re-Weighting of Parameters Based on Importance*

So far, all the different parameters have been treated equally. However, depending on one's perception of the HIV/AIDS pandemic, the weighting may be different and some parameters could be assigned more weight than others. This section attempts to come up with 2 different sets of aggregate values based on a re-weighting of parameters.

The first re-weighting assigns more value to the demographic and public health parameters (population density, HIV prevalence and TB incidence). In this analysis, these 3 aforementioned parameters will receive a weight that is double that of the macroeconomic indicators (industry density, worker skill level and replacement pools of workers). As is seen below, the derived "Health Indices" are not too different from the general un-weighted parameters.

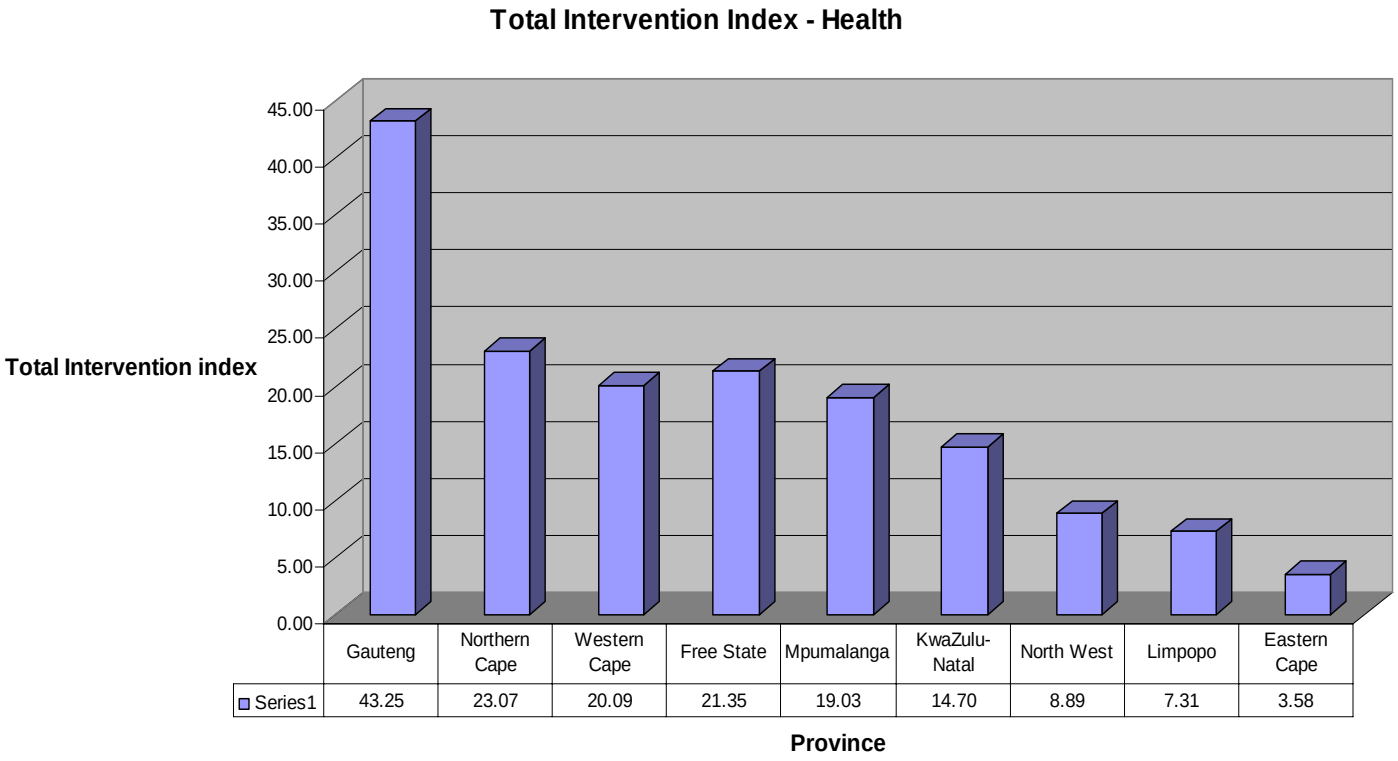

Figure 8: Total "Health" Intervention Index for South Africa

The second re-weighting that was implemented is the inverse of the one previously discussed. The macro economic indicators were assigned weights double those of the demographic and public health indicators. Like the derived "Health Indices" above, the "Business Indices" below did not show any significant variation from the unweighted indices.

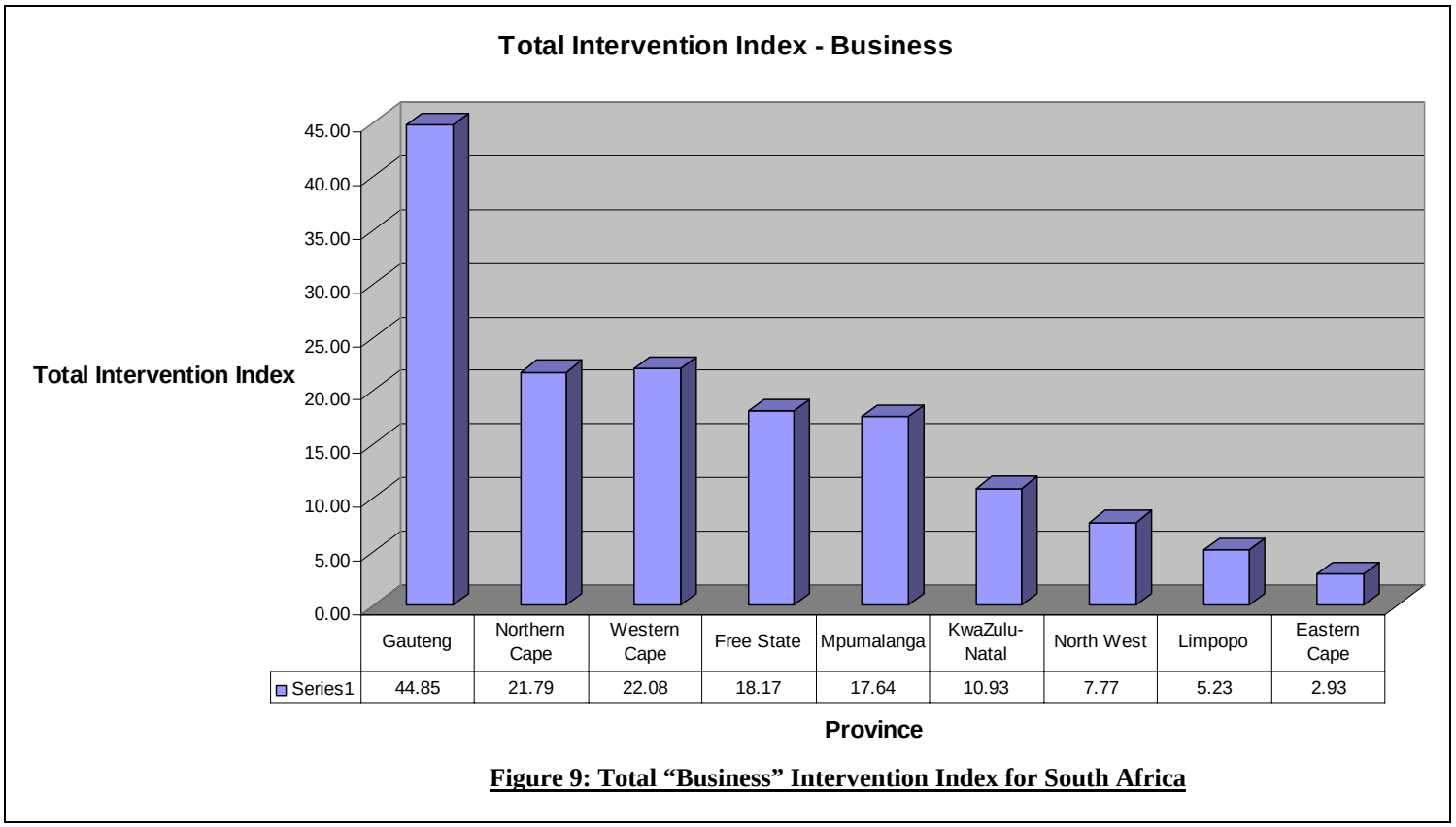

Figure 9: Total "Business" Intervention Index for South Africa

IV. CONCLUSION

HIV/AIDS is a disease process that has caused innumerable social and economic losses in the world and on the African continent in particular. Even with relative global awareness of the current pandemic, not enough is being done to rescue affected

societies. The information obtained from this research will be instrumental in coming up with practical solutions for combating HIV/AIDS.

The analysis in this paper may be replicated in other countries and also transnationally to compare different nations and their need for HIV/AIDS intervention at the firm level. Researchers may also assign weights differently depending on what parameters they deem most important and may come up with different recommendations for resource allocation in South Africa.

The guidelines obtained from this research provide a useable framework for all concerned with resource allocation in South Africa. Governmental and non-governmental organizations in South Africa confronted with the challenge of accurate allocation of resources may use this research as a guide to more concretely identify provinces in greatest need of HIV/AIDS intervention at the firm level.

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APPENDIX

Appendix 1: Map of South Africa

Appendix 2: Summary of Demographic and Public Health Parameters

	Population Density (2003)		HIV +ve Prevalence (2002)		TB Incidence (2002)	
	People/km^2	Aggregate Score	HIV prevalence (%)	Aggregate Score	cases/100,000	Aggregate Score
Western Cape	36.6	**0.62**	10.7	**4.94**	430.1	**3.48**
Eastern Cape	38.3	**0.65**	6.6	**0.00**	228.1	**1.46**
Northern Cape	2.3	**0.00**	8.4	**2.17**	1,079.8	**10.00**
Free State	21.1	**0.34**	14.9	**10.00**	274.3	**1.92**
KwaZulu-Natal	106	**1.88**	11.7	**6.14**	203.4	**1.21**
North West	32.6	**0.55**	10.3	**4.46**	82.6	**0.00**
Gauteng	553.5	**10.00**	14.7	**9.76**	188.9	**1.07**
Mpumalanga	40.8	**0.70**	14.1	**9.04**	130.0	**0.48**
Limpopo	43.7	**0.75**	9.8	**3.86**	91.9	**0.09**

Appendix 3: Industry Density

	Industry Density (2003)			
	GDP in Rand millions (2003)	Area (KM^2)	Industry density proxy (GDP/Km^2)	Aggregate Score
Western Cape	181,069	129,370	1.40	**0.54**
Eastern Cape	101,127	169,580	0.60	**0.21**
Northern Cape	29,659	361,830	0.08	**0.00**
Free State	69,094	129,480	0.53	**0.19**
KwaZulu-Natal	206,766	92,100	2.25	**0.89**
North West	81,442	116,320	0.70	**0.26**
Gauteng	413,554	17,010	24.31	**10.00**
Mpumalanga	87,461	79,490	1.10	**0.42**
Limpopo	81,295	123,910	0.66	**0.24**

Appendix 4: Worker Skill Level

	Level of Worker Skill (2002)			
	Remuneration of employees - Calendar year 2002 (Millions of Rands)	Number of Employed workers (Thousands)	Remuneration per worker (Thousands)	Aggregate Score
Western Cape	45,399.60	1879	24.16157531	**1.49**
Eastern Cape	24,666.80	1079	22.86079703	**0.93**
Northern Cape	6,205.50	218	28.46559633	**3.35**
Free State	21,214.30	788	26.92170051	**2.68**
KwaZulu-Natal	57,144.90	2162	26.43149861	**2.47**
North West	21,318.10	887	24.03393461	**1.44**
Gauteng	147,064.30	3351	43.88669054	**10.00**
Mpumalanga	22,226.20	816	27.2379902	**2.82**
Limpopo	16,664.20	805	20.70086957	**0.00**

Appendix 5: Replacement Pools of Workers

Replacement Pools of Workers (2003)				
	Employed workers	**Unemployed individuals**	**Ratio of Unemployed over employed**	**Aggregate Score**
Western Cape	1879	381	0.202767429	**10.00**
Eastern Cape	1079	520	0.481927711	**0.00**
Northern Cape	218	63	0.288990826	**6.91**
Free State	788	278	0.352791878	**4.63**
KwaZulu-Natal	2162	1029	0.475948196	**0.21**
North West	887	387	0.436302142	**1.63**
Gauteng	3351	1313	0.391823336	**3.23**
Mpumalanga	816	282	0.345588235	**4.88**
Limpopo	805	358	0.444720497	**1.33**

Appendix 6: Sum of Aggregates and Assignments of Weights

	Total intervention index-general	***number of SDs from the mean***	***Total intervention index-health***	***number of SDs from the mean***	***Total intervention index-business***	***number of SDs from the mean***
Gauteng	**44.05**	2.19	**43.25**	2.13	**44.85**	2.26
Northern Cape	**22.43**	0.42	**23.07**	0.47	**21.79**	0.36
Western Cape	**21.08**	0.31	**20.09**	0.22	**22.08**	0.39
Free State	**19.76**	0.20	**21.35**	0.33	**18.17**	0.07
Mpumalanga	**18.33**	0.08	**19.03**	0.14	**17.64**	0.02
KwaZulu-Natal	**12.82**	-0.37	**14.70**	-0.22	**10.93**	-0.53
North West	**8.33**	-0.74	**8.89**	-0.70	**7.77**	-0.79
Limpopo	**6.27**	-0.91	**7.31**	-0.83	**5.23**	-1.00
Eastern Cape	**3.26**	-1.16	**3.58**	-1.13	**2.93**	-1.19

Appendix 7: Formula for Assignment of Weights

Total "Business" Intervention index =

4/3 * [Macroeconomic Indicators] + 2/3 * [Demographic and Public Heath Indicators]