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Development of a composite indicator of maternal and child health performance among districts in South Africa

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Development of a composite indicator of maternal and child health performance among districts in South Africa

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A research report submitted to the School of Public Health, University of the Witwatersrand, Johannesburg in partial fulfilment of the requirements for the degree of Master of Public Health.

DATE: 14 November 2016

Declaration

I, Jacqueline Roseleur, declare that this research report is my original work. It is submitted in partial fulfilment of the requirements for the degree of Master of Public Health, in the field of Health Systems and Policy, in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to this or any other university.



14 November 2016

Abstract

Introduction: South Africa has performed poorly in maternal and child health, even though it has greater resources available for health care than many other developing countries. A functioning district health system is essential if South Africa is to improve maternal and child health and to achieve its goal of "A Long and Healthy Life for All South Africans". Currently district health performance data are presented by the District Health Barometer (DHB) on 46 individual health related indicators. Because district performance varies for different indicators it is difficult in this analysis to assess overall district performance and to clearly distinguish better-functioning districts from those that are under-performing. This study explored the development of a composite index from the DHB indicators to compare district performance in maternal and child health. The association of this composite measure of performance with district level financing and deprivation was also explored.

Materials and methods: This was a secondary data analysis study using 18 maternal and child indicators from the DHB for all 52 districts of South Africa for the three year period from 2011/12 to 2013/14. Variation was explored across districts, across time and across provinces for the district indicators using summary statistics and graphs. Principal component analysis (PCA) was then used to develop a composite index of performance and the districts were ranked according to this index. Finally, linear regression was used to evaluate the relationship between the composite performance index, and indicators of district deprivation and public health financing.

Results: We found significant variation between districts, between provinces and over time. The variation however was inconsistent, with districts performing well on some indicators and poorly on others. The PCA identified five components with eigenvalues greater than one, explaining 72% of the total variation. The factor loadings of the first component were used to create the composite index. Districts were ranked according to the composite principal component (PC) score. The regression analysis found a significant relationship with the PC score and the deprivation and DHS per capita expenditure indicators.

Discussion: This study found that multivariate statistical methods may be useful in summarising and evaluating health system performance across a range of maternal and child health

indicators. The PCA analysis reduced the number of variables from 18 indicators to one PC score, and allowed us to rank districts by performance. However, the principal component extracted did not identify clear constructs related to maternal and child health performance. Limitations of this study include the uncertain quality of the primary data, and the limited variables available in the DHB to assess performance.

Conclusion: Methods for creating composite indices to summarise performance across a range of health indicators require more attention. Future research could explore alternative methods using the DHB dataset. Frontier analyses, such as data envelopment analysis, which evaluate performance relative to the inputs used, may be more appropriate if relevant inputs can be identified and measured.

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Abbreviations

ANC	Antenatal care
ART	Antiretroviral therapy
BCG	Bacille Calmette Guerin
DEA	Data envelopment analysis
DHB	District Health Barometer
DHIS	District Health Information System
DTaP	Diphtheria, tetanus and pertussis vaccine
FDH	Free Disposal Hull method
GDP	Gross Domestic Product
KMO	Kaiser-Meyer-Olkin
MDGs	Millennium Development Goals
NCCEMD	National Committee on Confidential Enquiries into Maternal Deaths
NGOs	Non-governmental organisations
NHLS	National Health Laboratory Service
OPV	Oral polio vaccine
PMTCT	Prevention of mother-to-child transmission
PCA	Principal component analysis
PCR	Polymerase chain reaction
PCV	Pneumococcal conjugated vaccine
SAIMD	South African Index of Multiple Deprivation
UHC	Universal Health Coverage

Chapter 1: Introduction

1.1 Background

South Africa's health system is uniquely challenged as the country faces a quadruple burden of disease; the largest HIV and TB burden globally (1), high maternal and child mortality, high levels of violence and injury, and an increasing burden of non-communicable diseases (2). Despite the fact that South Africa spends 8.7% of its Gross Domestic Product (GDP) on health care, large health inequities exist (3). The South African government has committed to implementing universal health coverage that aims to address these health inequities and improve the lives of its citizens (3, 4). Improvements in access to health care and the upgrading of the quality of public sector health services are primary focus areas of the first phase of universal coverage (4). In order for these goals to be achieved, measurement of performance to monitor progress in improving access and quality of health service provision is essential.

South Africa has performed poorly in achieving its Millennium Development Goals (MDGs), especially MDG 4 (reduce child mortality by two-thirds) and MDG 5 (reduce maternal mortality ratio by three quarters) (5, 6). South Africa's performance is particularly disappointing as it is classified as a middle-income country with a reasonably well-funded health system and a relatively good infrastructure. In addition to the HIV epidemic, poor implementation of existing essential care packages such as reproductive health care and antenatal care packages has been identified as the primary reason for worsening health outcomes (5). Other factors include shortcomings in administration, a lack of local accountability for provision of services and poor quality care (3, 5). A strategic output of the South African Government's vision of "A Long and Healthy Life for All South Africans" is to decrease maternal and child mortality (3). For this reason, it is vital that useful monitoring tools exist to understand the overall performance of South Africa's districts in relation to maternal and child health indicators.

The goal of the health system is to improve the health of a population in an equitable manner (7). In order to monitor whether the health system is meeting this goal, measurement of performance is considered essential, especially in countries that aim to achieve universal health coverage (UHC) (8, 9). Some may argue that the health system is a much too complex system to

easily measure performance (10). Health outcomes are not only attributable to health service provision, but also to other factors such as lifestyle choices. Furthermore, the social determinants of health such as poverty, unemployment, poor education and the living environment also impact substantially on health outcomes. It is now widely accepted that poorer people have poorer health outcomes (11), those with limited education have shorter life expectancy (12-14), and environmental conditions such as poor sanitation and lack of access to clean water affect health negatively (15-18). However, even with these complexities, progress cannot be assessed if performance is not measured and performance monitoring is now considered a necessary part of health system strengthening (7, 19-21).

Monitoring health system performance is reliant on health information systems. Timely and quality data are essential to enable informed planning (22). The District Health Information System (DHIS) software package is currently used in over 30 countries and was developed to collect routine aggregated information to allow for meaningful decision making at the district level in order to improve the functioning of the health system (23, 24). It was introduced in South Africa in 1996, and extended to the entire country by 2001 (25). Information is collected at the facility level using a combination of paper-based forms such as tally sheets and registers which are then sent to the sub-district for collation and entry in the DHIS software on a computer (25).

Measuring performance at the district level is currently being done in South Africa by considering the performance of individual indicators using different approaches. One approach used in facilities involves a dashboard system which uses traffic light style colour coding to monitor progress, or lack thereof, on key indictors related to priority programmes, such as prevention of mother-to-child transmission (PMTCT). Green is used when targets have been met, amber when progress has been made, but the set targets have not been met, and red for lack of progress or deterioration in performance. Dashboards can be used as a simple visual monitoring tool showing performance in key areas and can be effective in improving performance at facility level (26). Measuring performance only on key programme indicators such as HIV or immunisation rates may not promote broad-based primary care provision though, and could result in health workers focusing only on indicators that will be measured by the dashboard (27). This phenomenon has been referred to as tunnel vision (28).

Another approach is the District Health Barometer (DHB), which involves the ranking of districts based on performance on 46 individual health related indicators. The information collected through the DHIS, along with supplementary information from other sources such as Statistics SA (Stats SA), the National Health Laboratory Service (NHLS), and the National Treasury (BAS data), is used annually to create the DHB by the Health Systems Trust. Districts are ranked on their performance for each indicator (29). When reviewing this information it is difficult to identify clear patterns or trends regarding overall district performance as some districts are ranked in the top 10 for some indicators, and in the bottom group for other indicators (29).

The DHB aims to create information that is functional and easy to understand and to facilitate identification of poor performance requiring remedial measures (30). It also aims to highlight inequities in health outcomes, health resource allocation and outputs and to monitor the efficiency of districts (31). This is an important step towards achieving health goals and data needs to be presented in such a way that policy makers and managers can use the information to support change. Presentation of individual indicators makes comparison by overall performance challenging. It would be helpful to explore the development of a composite measure of district performance to address this challenge (20).

1.2 Statement of the problem

Existing analyses of district performance for maternal and child health are based primarily on single indicators (29). This makes it difficult to compare overall district performance. A composite measure could help differentiate well performing from poor performing districts and thereby support improvements in health system performance in maternal and child health.

1.3 Justification for the study

Monitoring performance is essential to health system functioning as it allows for identification of problems, improvement and accountability (20, 21). Progress at the national level is not always indicative of progress in reaching the most vulnerable groups in a country (21). In order to increase access to health service delivery for the poorest and most vulnerable in society, measurement of performance at lower levels of organisation in the health care system is necessary. In South Africa, this can currently be done at the facility level and the district level

through the DHIS. As the district has been identified as the primary point of implementation of primary health care, this study will focus on the district level (32). Measuring performance at this level could assist with strengthening health system performance and reducing inequities in health service delivery (31).

The aim of developing the DHIS was to generate indicators that are able to monitor health service delivery in a coordinated manner (33). The DHIS in South Africa is currently being used to monitor progress on individual health indicators (26, 29). Individual measures are important for monitoring specific processes or priority delivery areas, but do not provide an easy overview of performance since districts do not perform equally well on all indicators (34). An important first step would be to evaluate the variation in indicators between districts, across time, and across indicators. It would also be useful to explore whether the list of indicators can be reduced to a smaller set of composite indicators of performance that are easier to interpret, and better able to categorise districts by overall performance. This would also provide a starting point to understand why some districts perform well while others do worse, and to develop models of best practice (34).

Because district performance for maternal and child health indicators may be related to differences in socio-economic development or the resources provided for these services, it would also be helpful to evaluate if a composite performance index is associated with the indicators of district deprivation and public health care financing included in the DHB dataset.

1.4 Aims and Objectives

The overall aim of this study was to explore the use of a composite index to evaluate differences in performance in maternal and child health between all 52 districts in South Africa over a three year period.

The specific study objectives were:

1. To compare variation between districts for selected routine maternal and child health indicators in the DHB dataset for the period 2011/12 to 2013/14.

2. To explore the development of a composite index using principal component analysis (PCA) from the selected routine maternal and child indicators for the period 2011/12 to 2013/14.
3. To rank districts on maternal and child health performance using the composite index developed.
4. To evaluate associations of the composite index of district performance with health financing indicators and district deprivation levels for the period 2011/12 to 2013/14.

1.5 Research Questions

- Is principal component analysis a useful method for creating a composite index of maternal and child health performance from the DHB indicators?
- Is there a correlation between performance and financing provided to the district and the level of deprivation of the district?

1.6 Literature review

Measurement of health sector performance at the national level has been done for some time. However, aggregated national data hides many variations at lower levels, such as in provinces and districts. In order to ensure that the health system performs equitably, as is the underlying goal of UHC, it is critical to analyse performance at lower levels of the health system (21, 35-38).

As health systems are multi-dimensional, complex entities, it is almost impossible to reflect health system performance with an individual indicator. Yet, too many individual indicators can be overwhelming for readers and users (20). Infant mortality rates have been proposed as a proxy for population health in resource-constrained countries that do not have sufficient data available to create more complete performance indicators, however additional data are always advantageous (39).

Composite indicators aim to aggregate a set of indictors (40) and thereby are able to provide a more summarised overview of health system performance (41). Composite indicators have become widely used in other health analyses, such as the use of wealth indices to compare health outcomes by household socio-economic status, promoted by the World Bank (42).

Principal component analysis (PCA) and factor analysis are the most commonly used data reduction methods for creating composite indicators (41). Efficiency frontier methods and cluster analysis are related multivariate analysis techniques that could be used to analyse variation in performance (41, 43). Composite measures can allow for the identification of patterns in performance across a number of different indicators, enabling the identification of low and high performers, and supporting further study of the characteristics that influence performance levels (34).

Composite measures have been used elsewhere to evaluate performance in the health care sector. For example, a number of studies from the United States have used composite measures to compare hospital performance (44-48). Quality of neonatal intensive care units (NICU) (48, 49), quality measures for treatment of heart conditions and pneumonia (44), bariatric surgical quality (45) and childbirth morbidity (47) are a few examples of the other diverse uses of composite measures within healthcare. The Baby-MONITOR study used an expert panel to identify nine quality measures which were standardised, equally weighted and averaged to create a composite indicator of quality of NICU care for very low birth weight infants. The study found significant variation between NICUs on the quality of their care (48). The childbirth morbidity study aimed to create a composite measure to assess the quality of childbirth services by combining both maternal and infant morbidity data to reflect the system-related causes of childbirth outcomes (47).

Another use for composite indicators has been to determine effective coverage of interventions. For example, a composite coverage study undertaken in Mexico sought to benchmark the performance of states in the effective coverage of 14 priority health interventions (50). It also identified inequalities by socioeconomic status and determined the relationship between health care expenditure and coverage. The study found wide variation of coverage by state and that a strong link exists between coverage and per capita public spending.

Composite measures have also been used in African countries. For instance, composite measures of performance were used in Rwanda to implement performance-based financing (51), and in Kenya, a composite index was developed using exploratory factor analysis to assess the quality of routine services related to voluntary male circumcision (52). In Uganda, composite indicators have been used for many years in their league table rankings to rank districts by

performance from best to worst. Input, process and output measures are all used to rank the Ugandan districts on performance (53).

Composite measures have been used in a variety of ways in Africa to measure MCH performance. This has especially been the case in Uganda where a number of studies have been done. These include using a composite measure to assess the performance of community health workers in managing malaria, diarrhoea and pneumonia in children (54), creating a composite risk score to inform triage decisions in hospitals to reduce child mortality (55), and evaluating coverage and performance of MCH at the sub-region level to benchmark performance (37). The last study sought to compare district performance, but found it difficult to consistently allocate information to the district level as district boundaries have changed many times since 1990. In Ghana, the quality of intrapartum and postnatal care in health facilities has been assessed using composite measures created from 31 indicators that covered four broad dimensions of quality (56), and Mozambique classified performance in PMTCT measures through the creation of a composite through multiple measurement strategies (57). This study was able to classify facilities into low and high performers and found that lower performing clinics were consistently identified, irrespective of the measurement strategy used.

A number of studies on MCH performance have focused on coverage data for maternal and child health interventions and health service provision (9, 36, 37, 58). Three of these studies (9, 37, 58) developed the composite measure by summing the individual indicators using equal weights. The Tanzanian study (36) opted to use specific weights derived from a number of criteria such as public health relevance, data quality and consistency and plausibility of estimates. However, the authors were not clear in the exact reasons for each weighting allocation.

Colson et al. (9) investigated levels and trends in maternal and child indicators to assess performance across districts in Zambia. The researchers created a composite measure by averaging 10 indicators with equal weighting to determine coverage levels that reflected the priorities of the Zambian health system. Composite coverage was also compared with a composite measure of socio-economic status to explore any possible relationship. A very low correlation was found to exist between these two measures, which was in contrast to the Mexican study on effective coverage which found poorer coverage in poorer states (50). In

addition to coverage, studies in Uganda and Nigeria have created composite indicators using health outcomes (37, 58). The use of health outcomes in addition to coverage may allow for better assessment of health system performance as coverage alone may not indicate whether an intervention has been effective.

A review of the literature on measuring district performance using composite indicators in South Africa indicates limited work on this issue. A concept paper has been written proposing that data on acute appendicitis and other common surgical disorders be used as a way of benchmarking quality within district surgical services in South Africa (59), but no study has been undertaken thus far. Another study developed a model to evaluate the impact of poor service delivery on mortality rates, using a composite measure of service delivery derived from indicators of public water supply, refuse removal, education levels, and the availability of sanitation and electricity (60). As the indicators are measured on different scales, the components were normalised and then summed to create the aggregated composite score. Positive correlations were found between increased mortality and poor service delivery, even after adjusting for other factors such as HIV/AIDs rates, population density, income inequality and geographic location (60).

The most recent DHB report presents two approaches for creating a composite index of overall district performance which was then used to rank districts (29). The first method looked at change in performance, scoring districts on 20 indicators selected to reflect different dimensions of care, including quality of care, access to care, and costs and productivity. The scoring was done according to three categories: improvement, deterioration and no change. If performance on an indicator improved by more than 5%, a score of +1 was allocated, if performance decreased by more than 5%, a score of -1 was allocated, and 0 was allocated if the change was between these limits. The overall score for each district was then calculated by summing the scores of the individual indicators using equal weighting. Scores ranged from -5 to 12. Overall, seven districts deteriorated in performance (sum<0), three had no change (sum=0), and the remaining 42 districts improved performance levels (sum>0). The second method used a more sophisticated statistical technique, a type of non-parametric efficiency frontier method known as free disposal hull (FDH) analysis. This method used the same indicators as the first

method. In addition, the method also used input indicators and adjusted for context by using HIV prevalence and deprivation indicators (29).

We were unable to find previous studies that developed composite measures of performance related specifically to maternal and child health in South Africa.

Chapter 2: Methodology

2.1 Study Design

The basic study design for this research project was an analysis of secondary data, using the District Health Barometer (DHB) information that is available on their website for download. The primary DHB study was based on routinely collected cross-sectional data from a number of sources.

2.2 Study Sites

The study focused on the 52 districts of South Africa. South Africa is a middle-income country with a population of 53 million (61). It is divided into 9 provinces, which are further divided into 52 districts. Districts are classified as either metropolitan or district municipalities. District municipalities are made up of a number of smaller local municipalities. Metropolitan districts govern large urban areas with no local municipalities. Administratively, districts fall below provinces and above local municipalities, where these exist (62).

2.3 Study Population and Sampling

The study population for the primary study consisted of all 52 districts within South Africa. This study used data for the three year period from 2011/12 to 2013/14 for all 52 districts.

2.4 Data Measurement and Extraction

The DHB (primary study) was developed using data from sources such as the District Health Information Software (DHIS), Statistics SA (Stats SA), the National HIV and Syphilis Antenatal Sero-prevalence Survey, the National Health Laboratory Service (NHLS), the National Treasury (BAS data) and the national Electronic Tuberculosis (TB) Register (ETR.Net) (29).

Most of the maternal and child health indicators that are found in the DHB were updated from the DHIS data files at facility level. The indicator data were exported into a single MySQL database which facilitated uniform coding of districts and trend analysis from 2000/1 to 2013/14.

The PMTCT indicators for PCR tests of infants used two different methods, one (Infant 1st PCR test positive around 6 weeks rate) from the DHIS data and another (Percentage of PCR tests positive under 2 months) from the National Health Laboratory Service because the completeness of the DHIS may affect the reliability of the first indicator (29).

The district health financing indicators were extracted from the National Treasury Basic Accounting System database by the Health Systems Trust in the development of the DHB. Expenditure allocated to facilities was coded to the appropriate district level, and non-specific health expenditure was allocated to districts according to population proportions (29).

The deprivation index ranking is based on the South African Index of Multiple Deprivation (SAIMD) which was calculated using four domains of deprivation: employment deprivation, education deprivation, living environment deprivation and income and material deprivation. The basic unit used for this index was the ward, which was then weighted by population to determine the district ranking (29, 63).

The primary study had almost 100 indicators, comprising a number of categories including finance, management, maternal and child health, TB, HIV, burden of disease and socio-demographic information.

For this study, data was extracted for the period 2011/12 to 2013/14 from the most recent data available, namely the 2014/15 DHB dataset as the DHB is updated on an annual basis (64). A number of indicators had been dropped in the 2014/15 dataset. These were available in the 2013/14 dataset and therefore added to the information from the 2014/15 dataset. As Cacadu district had been renamed to Sarah Baartman district, the information from 2013/14 had to be recoded to reflect the correct district name. Labelling was changed for a number of indicators to reflect that the indicators are proportions, and not rates.

2.4.1 Indicators

Maternal and Child Health Indicators

For this study, 22 maternal and child health indicators were used for the 52 districts within South Africa to compare variation and to develop the composite index of performance (objectives 1 and 2). All the maternal and child health indictors were included except for

caesarean section rates as there are no guidelines on what constitutes the ideal rate (65). For some of the indicators, for example mortality and incidence rates, low values indicate good performance, and for indicators such as immunisation and Vitamin A coverage high values indicate good performance. The included variables grouped according to the DHB categories are shown in Table 1 below.

Table 1: Maternal and child health indicators

Indicator	Definition	Direction for Good Performance
Delivery Indicators		
Delivery in facility under 18 years prop	The proportion of pregnant women under 18 years at delivery	Low
Inpatient early neonatal death rate	Inpatient deaths within the first 7 days of life per 1 000 live births	Low
Maternal mortality ratio institutional	Women who die as a result of childbearing, during pregnancy or within 42 days of delivery or termination of pregnancy, per 100 000 live births, and where the death occurs in a health facility	Low
Maternal mortality in facility ratio	Women who die as a result of childbearing, during pregnancy or within 42 days of delivery or termination of pregnancy, per 100 000 live births, and where the death occurs in a health facility	Low
Stillbirth prop in facility	Stillbirths in facility as a proportion of total births in a facility	Low
PMTCT Indicators		
Antenatal 1st visit before 20 weeks prop	Women who have a booking visit (first visit) before they are 20 weeks (about half way) into their pregnancy as a proportion of all antenatal 1st visits	High
Antenatal client initiated on ART prop	Antenatal clients on antiretroviral treatment (ART) as a proportion of the total number of antenatal clients who are HIV positive and not previously on ART	High
Percentage of PCR tests positive under 2 months	The proportion of PCR tests that are positive for HIV (in infants under 2 months)	Low
Early infant HIV diagnosis coverage	The proportion of infants born to HIV-positive mothers who receive a PCR test before 2 months of age	High
HIV prevalence among antenatal clients (survey)	The proportion of antenatal clients surveyed who tested positive for HIV	Low

Indicator	Definition	Direction for Good Performance
Infant 1st PCR test around 6 weeks uptake prop	Babies PCR tested 6 weeks after birth as the proportion of live births to HIV positive women.	High
Infant 1st PCR test positive around 6 weeks prop	Infants tested PCR positive for the first time around 6 weeks after birth as proportion of infants PCR tested around 6 weeks	Low
Immunisation Indicators		
Immunisation coverage under 1 year	The proportion of all children in the target area under one year who complete their primary course of immunisation. A Primary Course includes BCG, OPV 1,2 & 3, DTP-Hib 1,2 & 3, HepB 1,2 & 3, and 1st measles (usually at 9 months).	High
DTaP-IPV/Hib 3 - Measles 1st dose drop-out rate	The percentage of children who dropped out of the immunisation schedule between DTaP-IPV/IPV Hib 3rd dose, normally at 14 weeks and measles 1st dose, normally at 9 months.	Low
Measles 2nd dose coverage (annualised)	The proportion of children who received their 2nd measles dose (around 18 months) - annualised	High
Child Health Indicators		
Child under 5 years diarrhoea with dehydration incidence	Children under 5 years newly diagnosed with diarrhoea with dehydration per 1 000 children under 5 years in the population	Low
Child under 5 years pneumonia incidence	Children under 5 years newly diagnosed with pneumonia per 1 000 children under 5 years in the population	Low
Child under 5 years severe acute malnutrition incidence	Children under 5 years newly diagnosed with severe acute malnutrition per 1 000 children under 5 years in the population	Low
Vitamin A coverage 12 to 59 months	Proportion of children 12-59 months who received vitamin A 200 000 units, preferably every six months. The denominator is therefore the target population 1-4 years multiplied by 2	High
Child Mortality Indicators		
Child under 5 years diarrhoea fatality prop	Proportion of children under 5 years admitted with diarrhoea who died	Low
Child under 5 years pneumonia fatality prop	Proportion of children under 5 years admitted with pneumonia who died	Low
Child under 5 years severe acute malnutrition fatality prop	Proportion of children under 5 years admitted with severe acute malnutrition who died	Low

There exist two measures each for the PCR uptake percentage indicator and the percentage of positive tests indicator. The measures have been calculated using different data sources, namely the DHIS and the National Health Laboratory Service (NHLS) (66), and give different results**.** When using Pearson's correlation coefficient, the indicators are poorly correlated (early infant HIV diagnosis coverage: infant 1st PCR test around 6 weeks uptake rate – 0.47 in 2013 and percentage of PCR tests positive under 2 months: infant 1st PCR test positive around 6 weeks rate – 0.37 in 2013). As the most recent DHB (2014/2015) has dropped the early infant HIV diagnosis coverage indicator and the percentage of PCR tests positive under 2 months indicator (67), for the purposes of this research project, they were also dropped and the 6 week indicators were used for further analysis.

There are also two measures of maternal mortality, one from the DHIS and the other from the National Committee on Confidential Enquiries into Maternal Deaths (NCCEMD). The information from the NCCEMD is only released every 3 years, whereas the DHIS information is available monthly (29). According to the DHB (29), the two systems are now providing approximately the same values. The values for 2013 are plotted in Figure 1. The Pearson's correlation coefficient for the two indicators increased from 0.74 in 2011 to 0.88 in 2013 supporting the assertion that the two indicators are getting closer to each other. For further analysis, only one of the indicators was used to avoid double counting and errors caused by their high correlation (68). The DHIS maternal mortality indicator was used as it is more readily available.

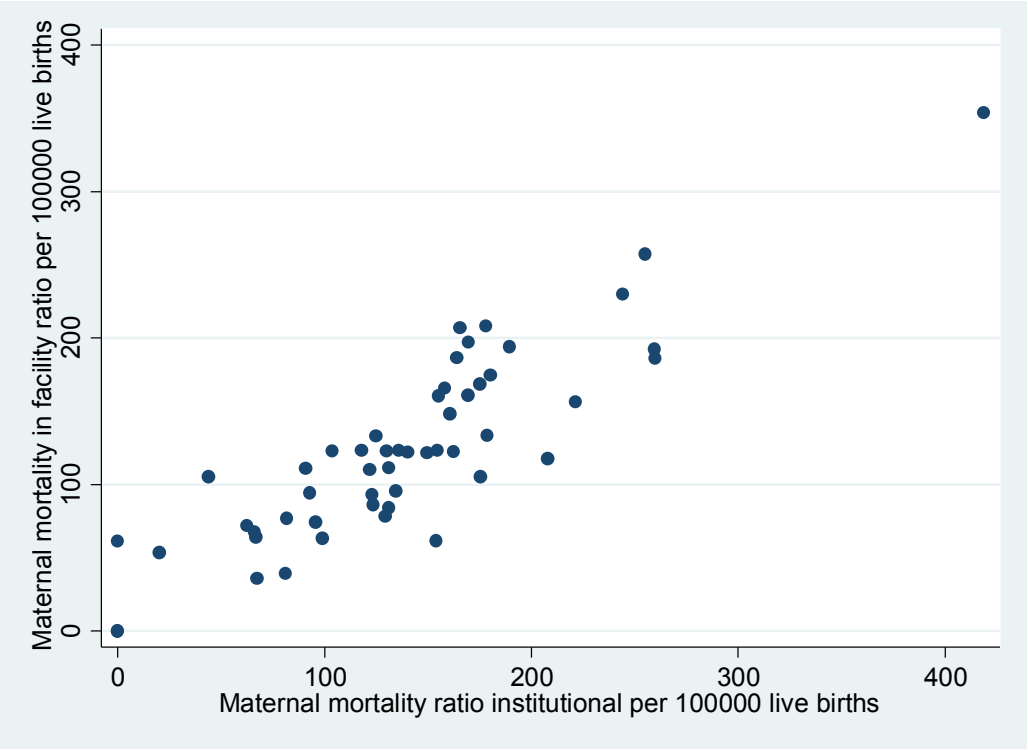


Figure 1: Scatter plot maternal mortality per 100,000 in 2013 by DHIS and NCCEMD data

The DTaP-Measles 1st dose drop-out rate indicator measures the percentage of children who dropped out of the immunisation schedule between DTaP-IPV/IPV Hib 3rd dose, normally at 14 weeks, and the measles 1st dose, usually at 9 months. The results for this indicator varied from -36% to 30%. The negative values mean that more children received the measles vaccination at nine months compared to those who received the DTaP-IPV/IPV Hib at 14 weeks. This could indicate poor data quality or a large in- or out migration of children from one district to another. In addition, the DTaP-Measles 1st dose drop-out rate data for the Western Cape districts are missing for 2012. As the indicator was only introduced in 2013/14 and then removed again in 2014/15 it was decided to drop the indicator from further analysis.

Financing Indicators

For objective 4, the following three health financing indicators from the DHB were used:

- Provincial and Local Government expenditure on District Health Services per capita (uninsured)

- Percentage of DHS expenditure on District Management
- Percentage of DHS expenditure on Primary Health Care

Deprivation Indicators

For objective 4, the South African Index of Multiple Deprivation Rank (SAIMD) score for districts was used. This deprivation index was developed by Noble et al. (63) and is presented as a score, as well as a ranking of the districts from most deprived to least deprived (rank 1 to 52). It was constructed from four different measures, namely income deprivation, employment deprivation, education deprivation and living environment deprivation.

2.5 Data Extraction

The information for this analysis was downloaded in Excel format from the Health Systems Trust website. As the information is provided in the form of Excel pivot tables, the underlying data was extracted to form a raw data file. The raw data file was imported into Stata version 14.1 for analysis. No imputation was done for missing data.

2.6 Data Analysis

The unit of analysis was the district for a total of 52 districts. The analysis methods for each of the objectives are listed below:

Objective 1: To compare variation between districts for selected routine maternal and child health indicators in the DHB dataset for the period 2011/12 to 2013/14.

Methods:

The variation in maternal and child health indicators listed in section 2.4.1 for the last three years (2011/12 to 2013/14) was explored by calculating the mean, range, standard deviation, minimum, maximum and the coefficient of variation for each indicator. The coefficient of variation is a measure of spread that describes the amount of variability relative to the mean. The higher the value, the greater the spread around the mean. The mean for each indicator was calculated by averaging values for all districts for each year. Variation was explored across districts, across time and across provinces. Information is displayed using tables and various

graphs created in Stata, namely box plots and bar charts to show the variation in the data for selected indicators by district and province.

Objective 2: To explore the development of a composite index using principal component analysis (PCA) from the selected routine maternal and child indicators for the period 2011/12 to 2013/14.

Methods:

An average for each of the 18 maternal and child health indicators was calculated using data for the last 3 years (2011/12 to 2013/14). Calculation of an average reduced the impact of annual variations. Thereafter, Cronbach's alpha was used on the indicators for each broad category used by the DHB, namely delivery, immunisation, PMTCT, child health and child mortality to test the internal consistency. Cronbach's alpha was also performed on all the indicators together. A value of 0.80 or higher indicates that the internal consistency is reliable (41).

PCA with no rotation was performed in Stata (version 14.1) on the average variables created for each of the maternal and child health indicators. The eigenvalues were calculated to decide on the number of components that should be retained (69). A Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was performed.

Objective 3: To rank districts on maternal and child health performance using the composite index developed.

Methods:

The principal component (PC) score was generated without rotation for the first extracted component. This score represents a composite indicator for performance identified by PCA. Districts were then ranked by these scores.

Objective 4: To evaluate associations of the composite index of district performance with health financing indicators and district deprivation levels for the period 2011/12 to 2013/14.

Methods:

A multiple linear regression was used to examine the relationship between the created composite district performance measure, district deprivation scores and district public health financing indicators, using data for 2011/12 as deprivation scores are only available for that

year. The maternal and child health composite indicator is the outcome variable while the financing indicators and the deprivation score are the explanatory variables in this analysis. The regression coefficient was used to evaluate the strength of the association between the variables. A t-test was performed to test if the coefficient was significantly different from zero.

2.7 Ethics

The DHB data are available in the public domain and may be utilised without further permissions. The DHB states the following: “The information contained in this publication may be freely distributed and reproduced, as long as the source is acknowledged, and it is used for non-commercial purposes” (29). The dataset provided is not anonymised - data was analysed and results are reported using the names of the districts. As the DHB already names districts in its annual reports this should not be a concern. As there are no personal identifiers other than district names, data security is not required.

Ethics clearance was received from the Human Research Ethics Committee (Medical) from the University of the Witwatersrand (clearance number M160258, see Appendix 2)

Chapter 3: Results

The aim of this research project was to categorise districts by performance, using a range of maternal and child health (MCH) indicators. In this chapter the results of each of the study objectives are presented in turn. Objective one describes the variation in the indicators between districts, between provinces as well as over time. Objective two first evaluates the internal validity of the MCH categories using Cronbach's alpha, and then explores the use of PCA to create a composite indicator of performance. Objective three ranked the districts based on the principal component score generated and objective four tests the association of district performance with health financing indicators and district deprivation levels.

3.1 Objective 1: Variation of district maternal and child health indicators

Table 2 presents a set of summary measures for each indicator for years 2011, 2012 and 2013[1]. The summary measures include the mean (unweighted) of all districts, range, standard deviation, minimum, maximum, and coefficient of variation for each indicator by year. As shown, the variation for the indicators in 2011 across the districts ranged from a coefficient of variation of 12 and 19 for the immunisation indicators to 68 for the child mortality indicators. This means that the variation is more dispersed for the child mortality indicators than for immunisation indicators. The mean for pneumonia incidence was 79 cases per 1,000 with a standard deviation of 44.4 in 2011. This has decreased to 58 cases per 1,000 with a standard deviation of 39 in 2013. In contrast, the mean for diarrhoea incidence increased from 12 to 16 cases per 1,000 from 2011 to 2013.

Comparison of the child health incidence and mortality indicators show that while the incidence of malnutrition was less than that of diarrhoea and pneumonia (4.5 per 1,000 compared to 12.3 and 79 per 1,000 respectively), the proportion of fatalities from malnutrition was substantially higher (14% vs 5.6% and 4.4% respectively).

[1] For ease of reading, the 2011/12 period is hereafter referred to as 2011, the 2012/13 period is referred to as 2012 and the 2013/2014 period is referred to as 2014.

Table 3 shows summary measures for the variation by indicator over time from 2011 to 2013. Firstly, the mean for each indicator was calculated as the unweighted average of the 52 district values for each year. Then, the mean, range, standard deviation, minimum, maximum, coefficient of variation, and the mean annual percentage change were calculated across the three years using this indicator. In contrast to the variation illustrated in Table 2, the coefficients of variation indicate that there was less variation across time for most indicators, except for the infant 1st PCR test positive around 6 weeks. The standard deviation for the indicators was much lower across time than across districts with the highest standard deviation being maternal mortality at 8.8. The mean annual percentage changes reflect the direction and size of the changes from 2011 to 2013. Most of the indicators showed an improvement from 2011 to 2013 with the largest improvement occurring in the PCR positive rate which decreased an average of 22% per year over the two year period. The poorest performance was found in the incidence of diarrhoea with an annual increase of 14% from 2011 to 2013.

Table 2 and Table 3 illustrate that variation existed between indicators, districts and across time. The variation within each variable across districts, between provinces as well as over time will now be explored further within the five categories used by the DHB, namely: delivery, immunisation, PMTCT, child health, and child mortality.

Table 2: Summary table of variation across districts by year (2011 to 2013)[2]

			2011						2012						2013					
Category	Indicator	Measure	Mean	Range	Standard Deviation	Min	Max	Coeff. of Variation	Mean	Range	Standard Deviation	Min	Max	Coeff. of Variation	Mean	Range	Standard Deviation	Min	Max	Coeff. of Variation
Delivery	Delivery in facility under 18 years	Proportion	8.9	10.8	2.2	5.5	16.3	25	8.6	9.4	2.1	4.0	13.4	24	8.5	8.0	2.1	4.9	12.9	25
	Inpatient early neonatal death rate	Per 1,000	10.4	16.4	3.8	4.4	20.8	37	9.9	24.8	4.2	2.9	27.7	42	10.4	22.4	4.0	3.3	25.7	38
	Maternal mortality rate	Per 100,000	135.1	354.2	77.5	1.0	354.2	57	123.5	292.2	80.1	1.0	292.2	65	124.1	353.7	64.9	1.0	353.7	52
	Stillbirth rate in facility	Per 1,000	22.3	21.7	4.7	11.6	33.3	21	22	20.3	4.5	13.2	33.5	20	21.7	20.5	4.5	11.9	32.4	21
PMTCT	Antenatal 1st visit before 20 weeks	Proportion	44.9	46.3	10.9	25.5	71.8	24	48.6	42.1	10.2	31.5	73.6	21	53.9	40.9	9.5	34.4	75.3	18
	Antenatal client initiated on ART	Proportion	78.3	59.8	16.0	45.5	105.3	20	81.6	46.0	10.1	54.0	100.0	12	79.7	57.7	10.9	45.2	102.9	14
	HIV prevalence among antenatal clients	Proportion	28	39.9	9.0	6.2	46.1	32	27.8	39.2	8.7	1.5	40.7	31	.	.	.	.	.	
	Infant 1st PCR test around 6 weeks uptake	Proportion	94.7	203.7	31.7	35.2	238.9	33	98.3	181.3	27.5	52.6	233.8	28	105.1	226.0	30.5	67.0	293.0	29
	Infant 1st PCR test positive around 6 weeks	Proportion	3.8	6.9	1.5	1.3	8.2	39	2.6	7.8	1.1	1.0	7.8	42	2.3	7.8	1.2	0.9	8.7	52
Immunisation	Immunisation coverage under 1 year	Proportion	81.9	66.1	15.9	53.3	119.4	19	81.3	61.8	14.7	58.3	120.1	18	80.9	62.5	14.1	54.0	116.5	17
	Measles 2nd dose coverage	Proportion	84.1	44.2	10.1	63.2	107.4	12	73.9	55.2	12.2	53.5	108.7	17	74.0	48.3	10.9	51.1	99.4	15
Child Health	Child under 5 years diarrhoea with dehydration incidence	Per 1,000	12.3	28.7	6.0	4.8	33.5	49	11.4	26.1	4.8	4.4	30.6	42	15.9	25.9	6.6	4.2	30.2	42
	Child under 5 years pneumonia incidence	Per 1,000	79	166.5	44.4	19.9	186.4	56	66.9	137.0	37.4	20.1	157.1	56	57.7	141.3	32.9	15.0	156.3	57
	Child under 5 years severe acute malnutrition incidence	Per 1,000	4.5	17.0	2.8	1.5	18.5	62	4.7	16.5	2.9	0.9	17.4	62	5.4	18.1	3.5	1.3	19.5	65
	Vitamin A coverage 12 to 59 months	Proportion	43.8	75.9	14.2	21.4	97.3	32	42.6	58.9	13.7	20.0	78.9	32	46.4	50.4	13.1	27.1	77.5	28
Child Mortality	Child under 5 years diarrhoea fatality	Proportion	5.6	18.0	3.8	1.0	18.0	68	4.6	15.1	3.6	1.0	15.1	78	3.9	14.7	2.8	1.0	14.7	72
	Child under 5 years pneumonia fatality	Proportion	4.4	11.6	3.0	1.0	11.6	68	4.4	15.1	2.9	0.5	15.6	66	3.7	10.5	2.5	1.0	10.5	68
	Child under 5 years severe acute malnutrition fatality	Proportion	14	35.0	8.0	1.0	35.0	57	13.1	29.4	6.4	1.2	30.5	49	10.8	26.9	6.2	1.0	26.9	57

[2] N = 52 districts;

Table 3: Summary table of variation by indicator across time (2011 to 2013)[3]

Category	Indicator	Measure	2011	2012	2013	Mean	Range	Standard Deviation	Min	Max	Coeff. of Variation	Mean Annual Change
Delivery	Delivery in facility under 18 years	Proportion	8.9	8.6	8.5	8.7	0.4	0.1	8.5	8.9	1.1	-2.04%
	Inpatient early neonatal death rate	Per 1,000	10.4	9.9	10.4	10.2	0.6	0.2	9.9	10.4	2.0	0.43%
	Maternal mortality rate	Per 100,000	135.1	123.5	124.1	127.6	11.6	5.3	123.5	135.1	4.2	-4.15%
	Stillbirth rate in facility	Per 1,000	22.3	22.0	21.7	22	0.6	0.2	21.7	22.3	0.9	-1.30%
PMTCT	Antenatal 1st visit before 20 weeks	Proportion	44.9	48.6	53.9	49.1	9	3.7	44.9	53.9	7.5	9.60%
	Antenatal client initiated on ART	Proportion	78.3	81.6	79.7	79.9	3.3	1.4	78.3	81.6	1.8	0.94%
	HIV prevalence among antenatal clients	Proportion	28.0	27.8	.	27.9	0.3	0.1	27.8	28	0.4	-0.99%
	Infant 1st PCR test around 6 weeks uptake	Proportion	94.7	98.3	105.1	99.4	10.4	4.3	94.7	105.1	4.3	5.34%
	Infant 1st PCR test positive around 6 weeks	Proportion	3.8	2.6	2.3	2.9	1.5	0.7	2.3	3.8	24.1	-22.48%
Immunisation	Immunisation coverage under 1 year	Proportion	81.9	81.3	80.9	81.4	1	0.4	80.9	81.9	0.5	-0.60%
	Measles 2nd dose coverage	Proportion	84.1	73.9	74.0	77.3	10.2	4.8	73.9	84.1	6.2	-6.22%
Child Health	Child under 5 years diarrhoea with dehydration incidence	Per 1,000	12.3	11.4	15.9	13.2	4.6	2	11.4	15.9	15.2	14.04%
	Child under 5 years pneumonia incidence	Per 1,000	79.0	66.9	57.7	67.9	21.3	8.7	57.7	79	12.8	-14.51%
	Child under 5 years severe acute malnutrition incidence	Per 1,000	4.5	4.7	5.4	4.9	0.9	0.4	4.5	5.4	8.2	9.65%
	Vitamin A coverage 12 to 59 months	Proportion	43.8	42.6	46.4	44.3	3.7	1.6	42.6	46.4	3.6	2.88%
Child Mortality	Child under 5 years diarrhoea fatality	Proportion	5.6	4.6	3.9	4.7	1.7	0.7	3.9	5.6	14.9	-16.29%
	Child under 5 years pneumonia fatality	Proportion	4.4	4.4	3.7	4.2	0.7	0.3	3.7	4.4	7.1	-8.12%
	Child under 5 years severe acute malnutrition fatality	Proportion	14.0	13.1	10.8	12.6	3.2	1.4	10.8	14	11.1	-12.22%

3.1.1 Delivery

Delivery indicators include the proportion of deliveries in a facility by women under 18 years of age, the inpatient early neonatal death rate, the proportion of stillbirths, and maternal mortality.

Figure 2 shows the maternal mortality ratio by district for 2013. The worst performing district was Capricorn with 354 deaths per 100,000 live births. It performed substantially worse than the next poorest performing district, Dr K Kaunda, with a rate of 257 deaths per 100,000 live births. Two districts reported no maternal deaths (Xhariep and Central Karoo). This is likely to be due to a combination of low births in the district and referral of their complicated births to other districts with hospitals (29). The mean maternal mortality ratio in 2013 was 124 deaths per 100,000 live births, with a minimum of zero deaths and a maximum of 353 deaths per 100,000 live births (Table 2). The mean stayed roughly the same

[3] N = 52 districts

from 2012 to 2013, however the maximum increased from 292 to 354, indicating that some districts performed much worse.

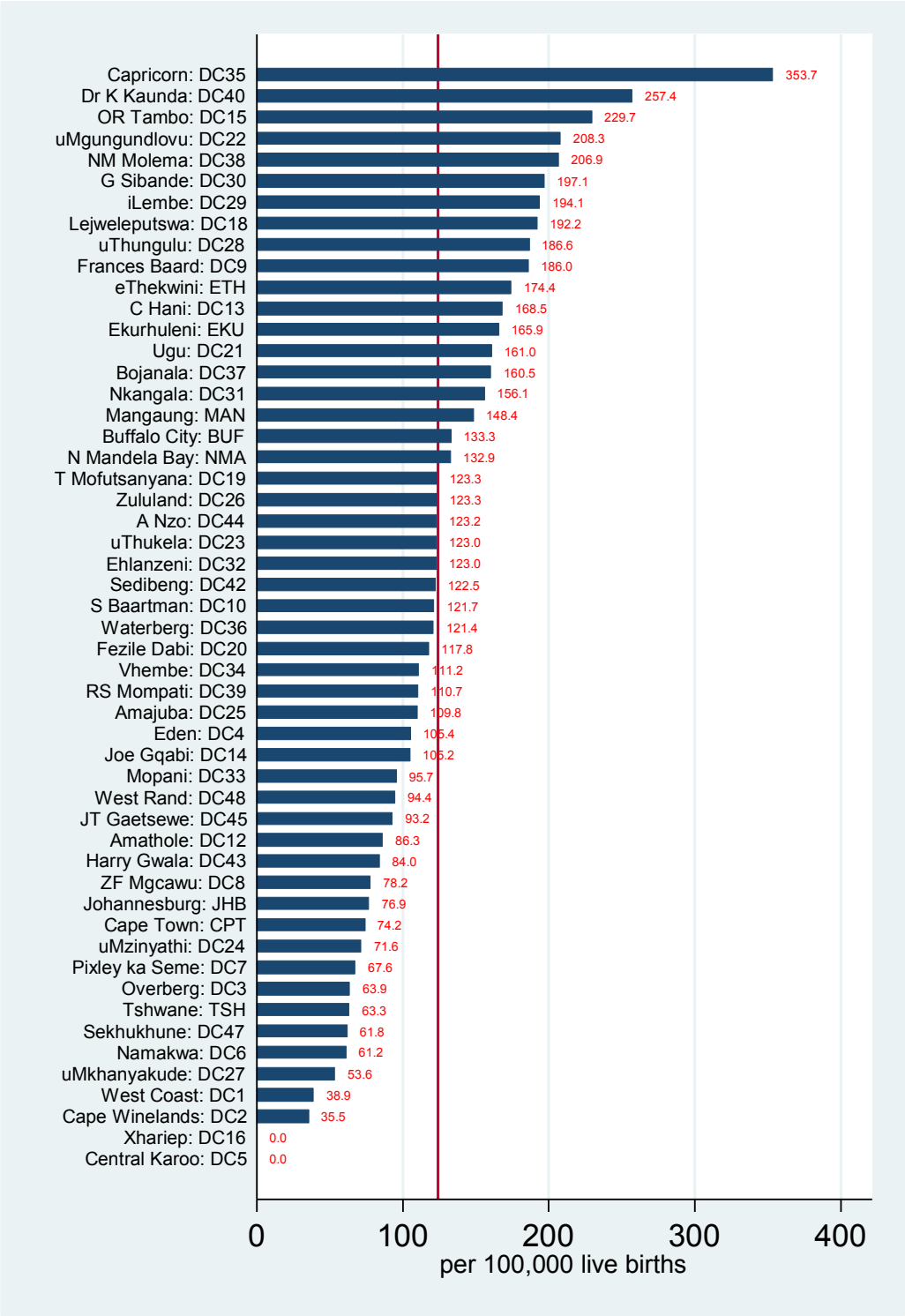


Figure 2: Maternal mortality per 100,000 live births by district in 2013[4]

[4] Vertical red line indicates mean maternal mortality of 124 deaths per 100,000 live births

In addition to maternal mortality, neonatal death rates are also used as a measure of delivery performance. The early neonatal death rate is defined as the number of deaths within the first 7 days of life per 1,000 live births. As can be seen in Figure 3, this death rate was highest in the Eastern Cape in 2012, at 15.6 deaths per 1,000 live births, and lowest in the Western Cape in 2013 at 4.9 deaths per 1,000 live births. There is no consistent trend across the provinces, with the neonatal death rate increasing from 2011 to 2013 in Limpopo, decreasing in Mpumalanga and the Northern Cape, and fluctuating in the other provinces. The mean for South Africa for the 3 year period was 10.23 deaths per 1,000 live births.

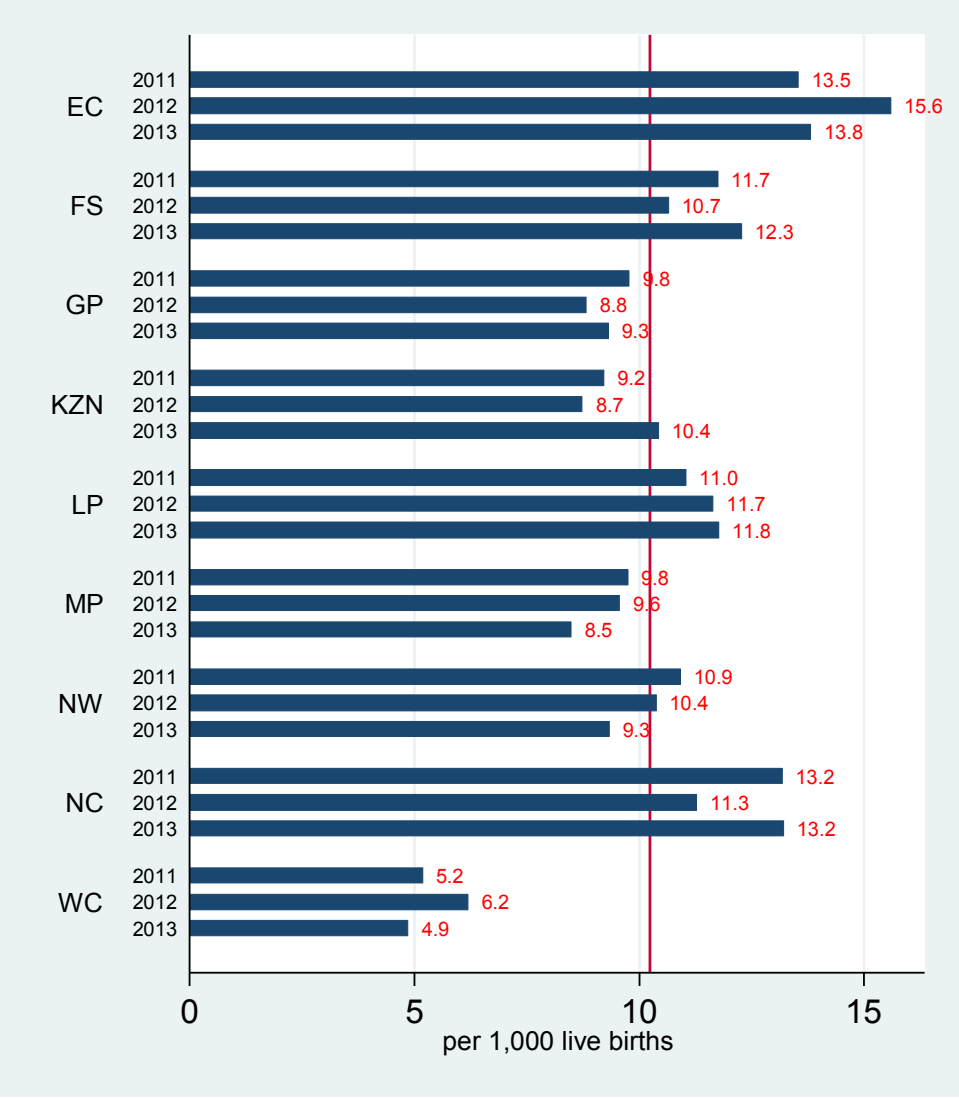


Figure 3: Early neonatal death rate per 1,000 live births by province for years 2011, 2012 and 2013 (weighted by population)[5]

[5] Vertical red line indicates mean neonatal death rate of 10.2 per 100,000 live births over 3 year period

Another measure of delivery performance is the stillbirth rate. The stillbirth rate measures the number of babies who are born dead per 1,000 live births. It is considered a good indicator of care during the final trimester of pregnancy and of care during labour and delivery (29). The average stillbirth rate over the period from 2011 to 2013 per district ranged from 13.4% in Overberg to 30.1% in Lejweleputswa. The national average was 22 deaths per 1,000 live births for this period (Figure 4).

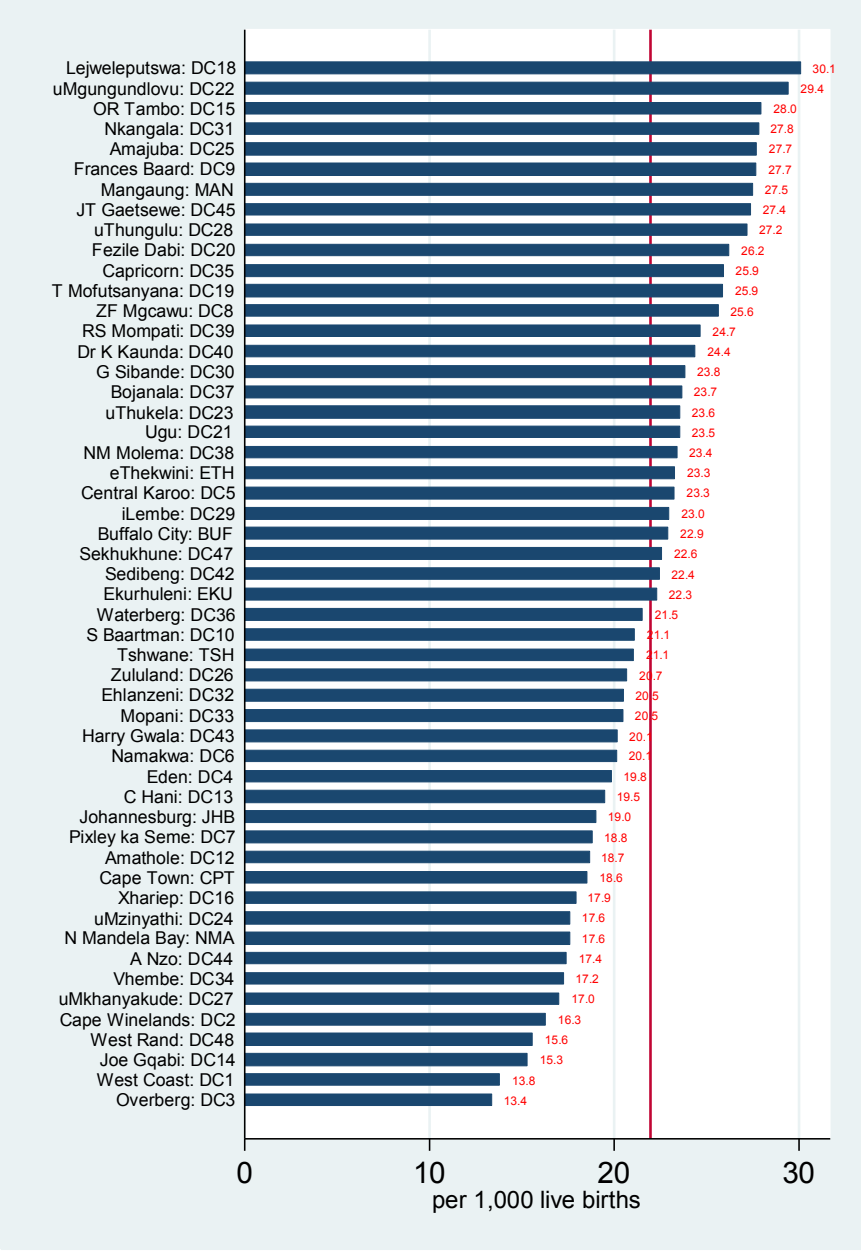


Figure 4: Average stillbirth rate in facilities by district between 2011 and 2013.[6]

[6] Vertical red line indicates mean stillbirth rate of 22 per 100,000 live births over 3 year period

3.1.2 Immunisation

Different immunisation indicators are collected by the DHIS. These include the proportion of all children in a target area that have completed their primary course of immunisation (immunisation coverage under 1) and the measles 2nd dose coverage.

The primary course of immunisation includes the following (66)[7]:

At birth	OPV (0), BCG
6 weeks	OPV (1), DTaP-IPV/ Hib (1), Hep B (1), RV (1), PCV (1)
10 weeks	DTaP-IPV/ Hib (2), Hep B (2)
14 weeks	DTaP-IPV/ Hib (3), Hep B (3), RV (2), PCV (2)
9 months	Measles (1), PCV (3)

Figure 5 shows the variation in these indicators by province in 2013. The immunisation coverage in Gauteng exceeds 100%, whereas rates in Limpopo, Mpumalanga and Eastern Cape are much lower. In general, the measles 2nd dose coverage is lower than the immunisation coverage for children under one. As the measles 2nd dose is given at around 18 months, this indicates poorer coverage in the older age group. Limpopo province performed poorly on both indicators.

[7] OPV is oral polio vaccine, BCG is Bacille Calmette Guerin, DTaP-IPV/ Hib is diphtheria, tetanus, acellular pertussis, inactivated polio vaccine and Haemophilus influenzae type b combined, Hep B is hepatitis B vaccine, RV is rotavirus vaccine and PCV is pneumococcal conjugated vaccine.

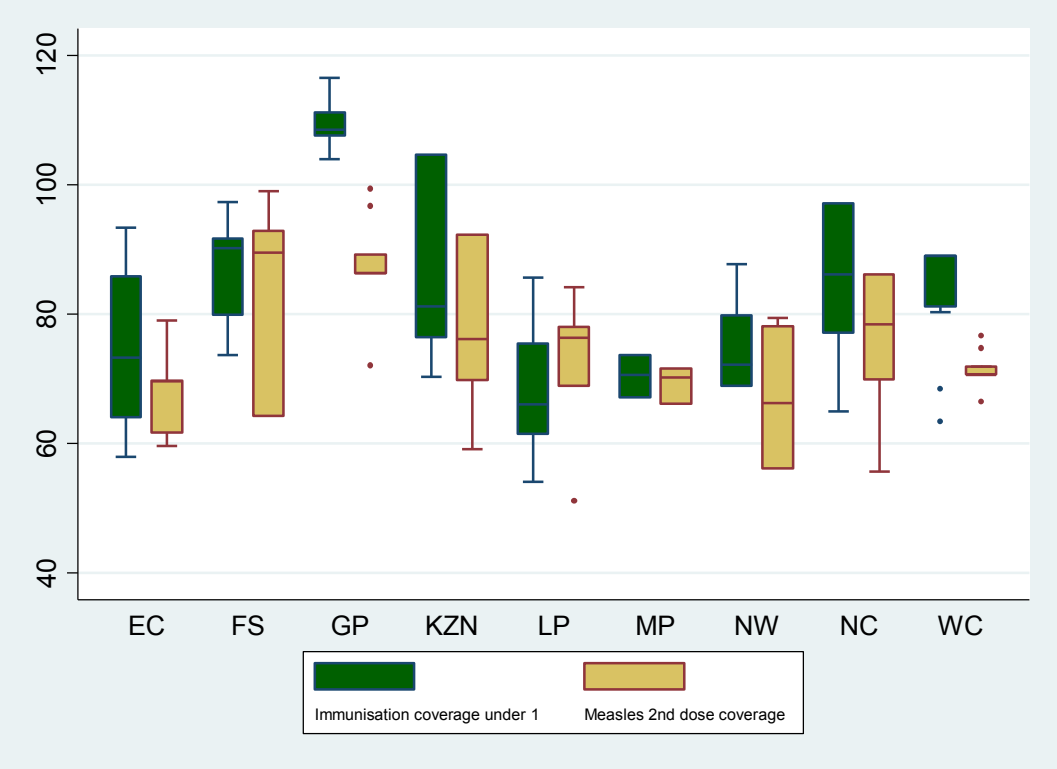


Figure 5: Immunisation indicators (immunisation coverage under 1 and measles 2nd dose coverage) by province in 2013

3.1.3 Prevention of Mother to Child Transmission (PMTCT)

PMTCT indicators include the following:

- Antenatal 1st visit before 20 weeks proportion
- HIV prevalence among antenatal clients (survey)
- Antenatal client initiated on ART proportion
- Infant 1st PCR test around 6 weeks uptake rate
- Infant 1st PCR test positive around 6 weeks rate

In order to provide appropriate antenatal care (ANC), especially care related to HIV treatment and PMTCT, it is important for pregnant women to present at the clinic as early as possible during pregnancy (70). A measure of this is the proportion of women who had their first antenatal visit before they were 20 weeks pregnant. The proportion of ANC visits before 20 weeks increased in all provinces over the three year period (Figure 6). The greatest increase was seen in KwaZulu-Natal which increased from 40.8% in 2011 to 56.1% in 2013. Only 43.6% of pregnant women who visited the clinic for ANC in Gauteng in 2013 did so before 20 weeks whereas the proportion was 61.3% in the Western Cape.

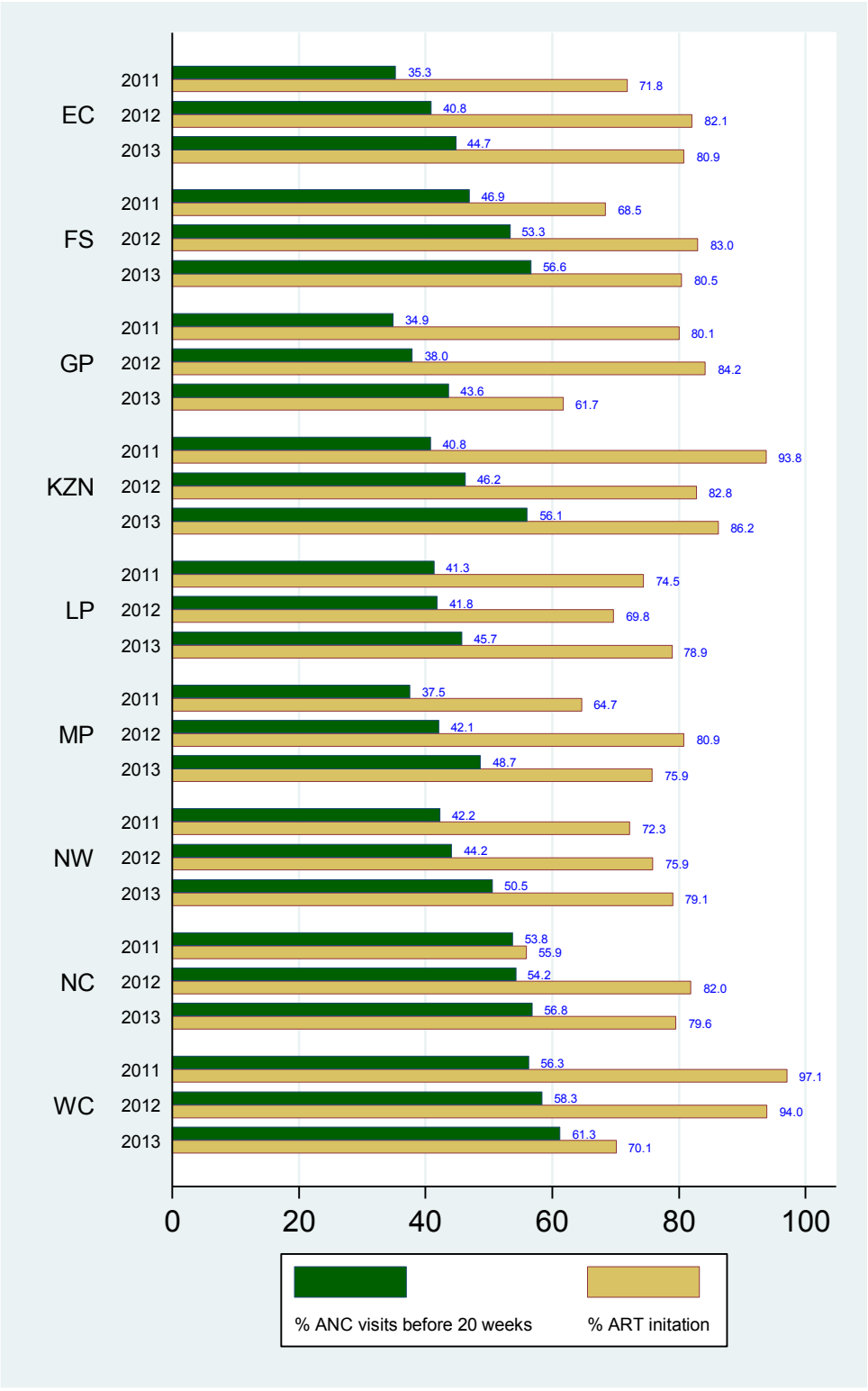


Figure 6: Proportion of ANC Visits before 20 weeks gestation and ART initiation rate by province in years 2011, 2012 and 2013 (weighted by population)

The National Antenatal Sero-Prevalence Survey provided data on HIV prevalence among antenatal clients in 2011 and 2012. Data for 2013 was unavailable. The results for each of the years were very similar with the mean for 2011 at 28.0% and the mean for 2012 at

27.8%. Figure 7 shows the district with the lowest prevalence was Namakwa at 1.5% followed by West Coast at 9.4%. The districts with the highest prevalence were uMgungundlovu at 40.7% and G. Sibande at 40.5%. Five of the six districts with the highest prevalence are located in Kwa-Zulu Natal.

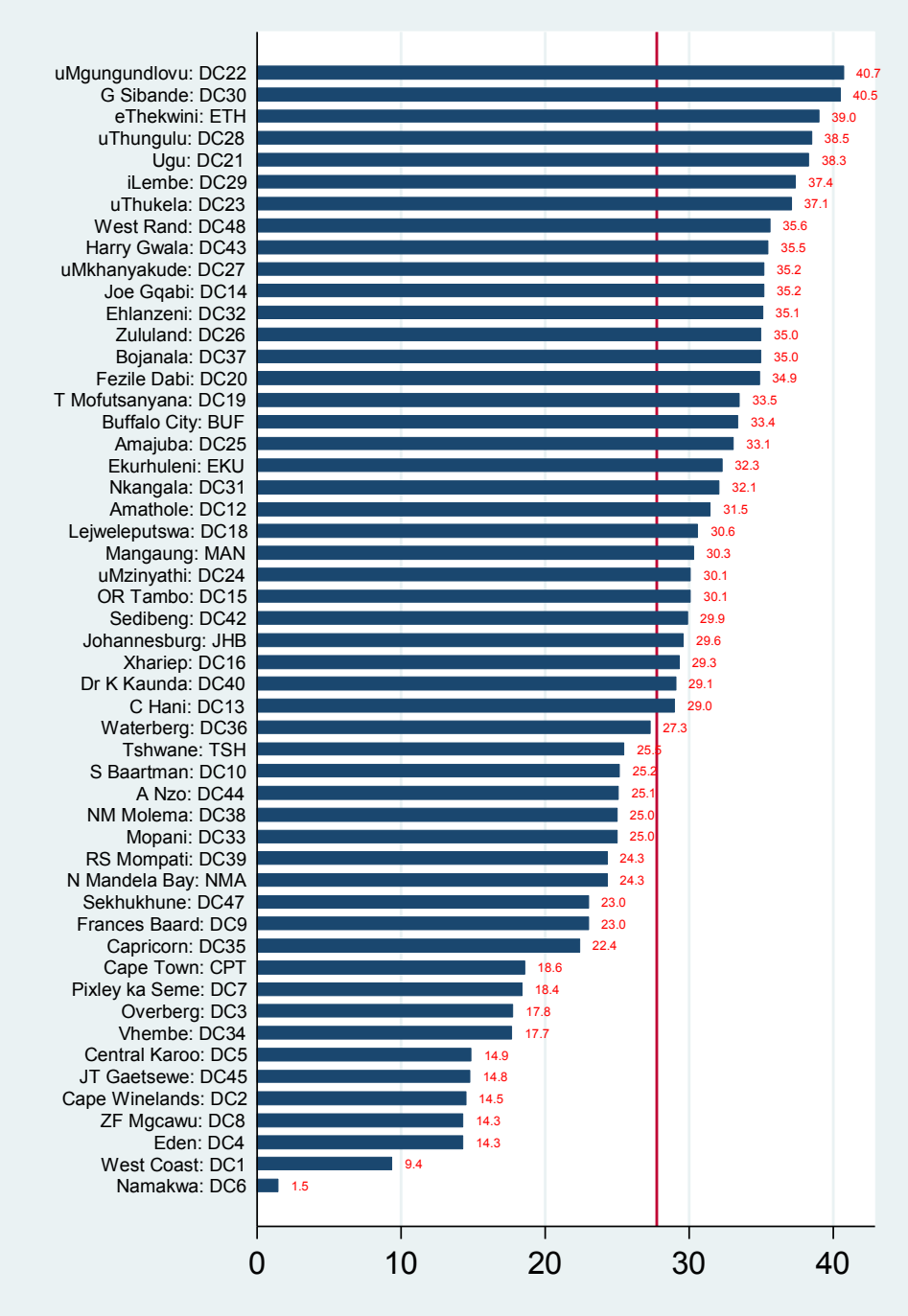


Figure 7: HIV prevalence among antenatal clients (survey) by district in 2012[8]

[8] Vertical red line indicates mean HIV prevalence of 27.8% in 2012

Another measure of PMTCT success is the proportion of antenatal clients eligible for ART treatment, who had initiated ART treatment. In contrast to the above indicator, the proportion of clients who initiated ART fluctuated over time across the provinces. The data for 2012 showed an increase from 2011 for most provinces, but then the proportion decreased again in 2013. Notably, the Western Cape dropped consistently from 97.1% in 2011 to 94% in 2012 and then to 70.1% in 2013 (Figure 6).

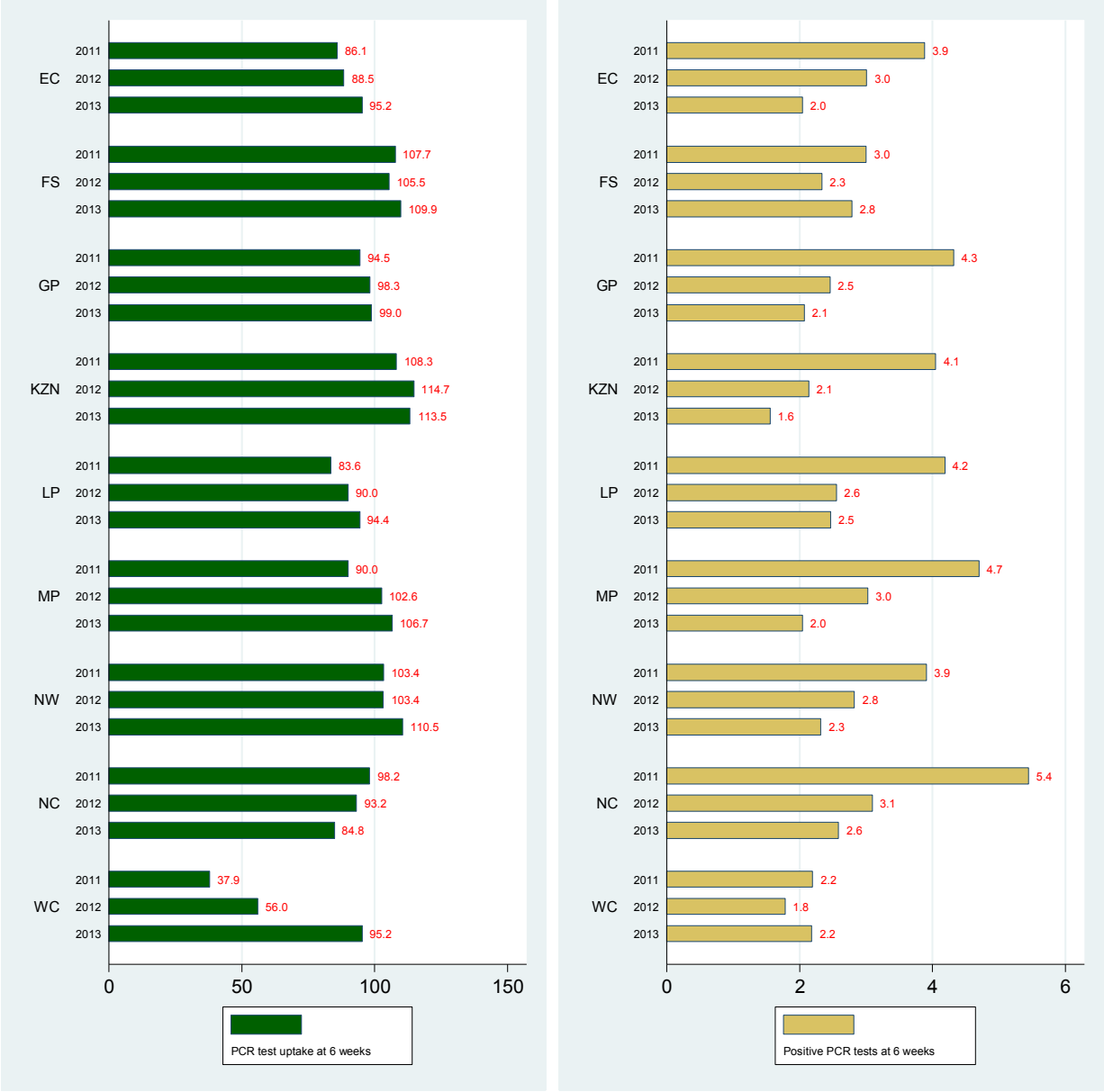


Figure 8: Infant HIV testing by province for years 2011, 2012 and 2013 (weighted by population)

The PMTCT programme includes testing of infants born to HIV mothers at around six weeks of age. The PCR uptake percentage had steadily increased for all provinces except for the Northern Cape which had decreased from 98% to 85% (

Figure 8). The Western Cape has had dramatic increases from 37.9% in 2011 to 95% in 2013. Four of the provinces had rates exceeding 100% which could indicate issues related to the choice of denominator. The proportion of PCR tests that tested positive in 2013 range from 1.6% in KwaZulu-Natal to 2.8% in the Free State. When examining the positive PCR tests by district in 2013 (Figure 9), the variation was much greater, ranging from 0.9% in Joe Gqabi district to 8.7% in the West Coast district. The West Coast had a substantially higher proportion testing positive than the next district, namely Namakwe at 4.2%. The mean (unweighted) of all 52 districts for 2013 was 2.3%, which was a reduction from the mean of 3.8% in 2011.

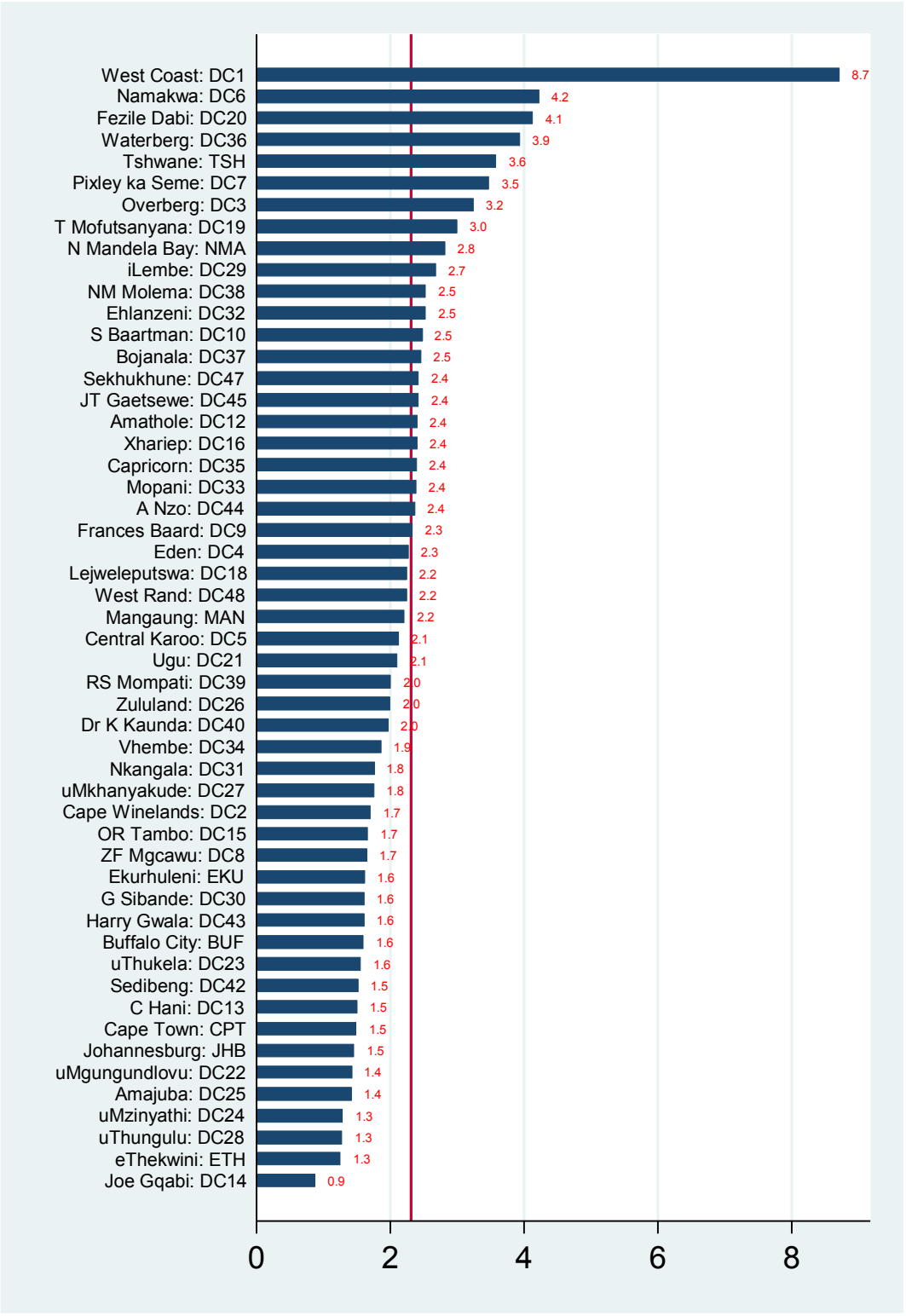


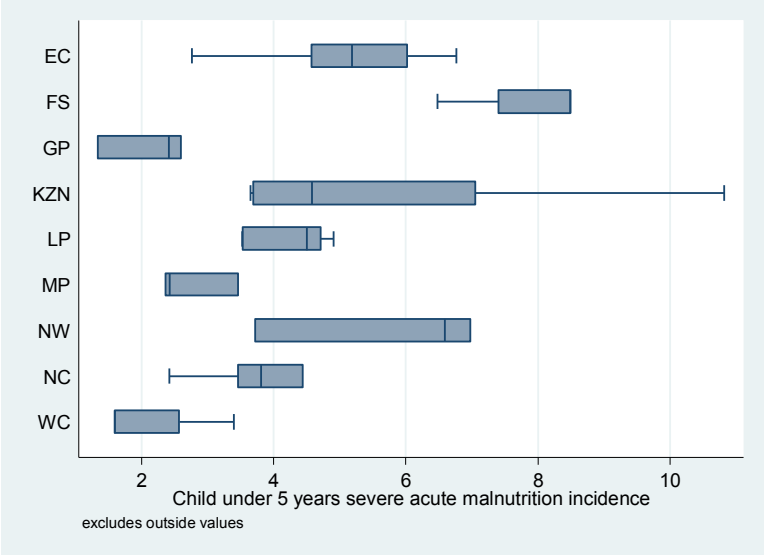
Figure 9: Percentage of positive PCR tests in infants by district in 2013[9]

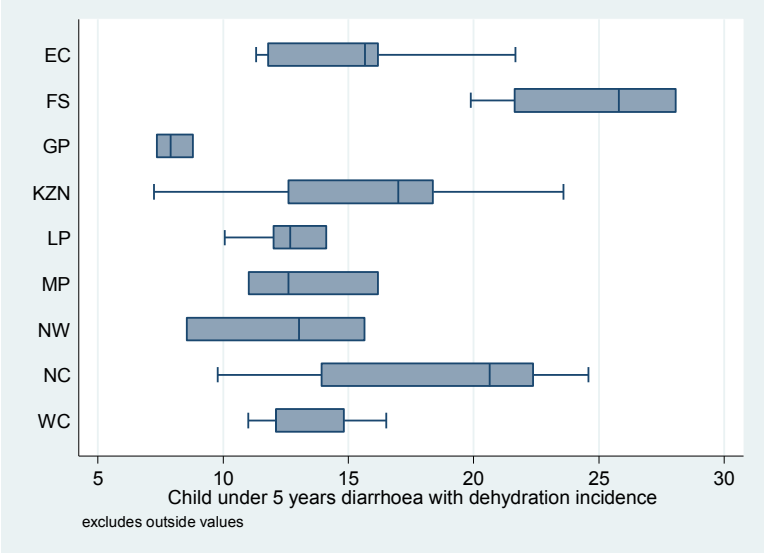
[9] Vertical red line indicates mean PCR positive percentage of 2.4% in 2013

3.1.4 Child Health

The indicators used to measure child health performance include incidence of diarrhoea, malnutrition and pneumonia for children under five, and vitamin A coverage for children between ages one and five. As illustrated in Figure 10, the incidence of pneumonia is much greater than the incidence of malnutrition or diarrhoea. Kwa-Zulu Natal was the worst performing province in 2013, followed by the Free State. For other provinces, there were a number of districts with considerably higher rates. For example, Western Cape on average had similar rates to most other provinces, but the Cape Winelands and West Coast districts had much higher incidence rates of diarrhoea (outliers not indicated).

Vitamin A coverage also varied substantially by district. The district indicators (averaged over the 2011 to 2013 period) are illustrated in Figure 11 below. The best performing district was Xhariep with average coverage of 83.6%, and the district with the poorest coverage was Bojanala with an average of 23.5%. The mean coverage (unweighted) across all districts was 44.3%.





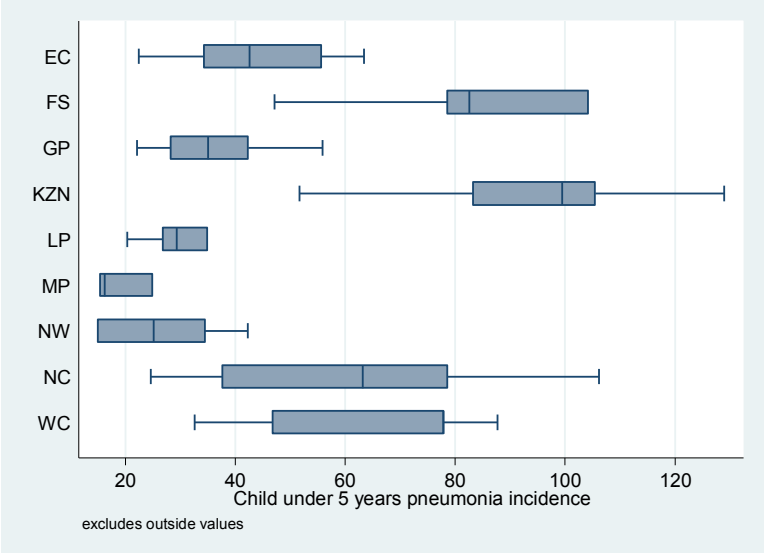


Figure 10: Selected child health indicators by province in 2013 per 1,000 children (outliers not indicated)

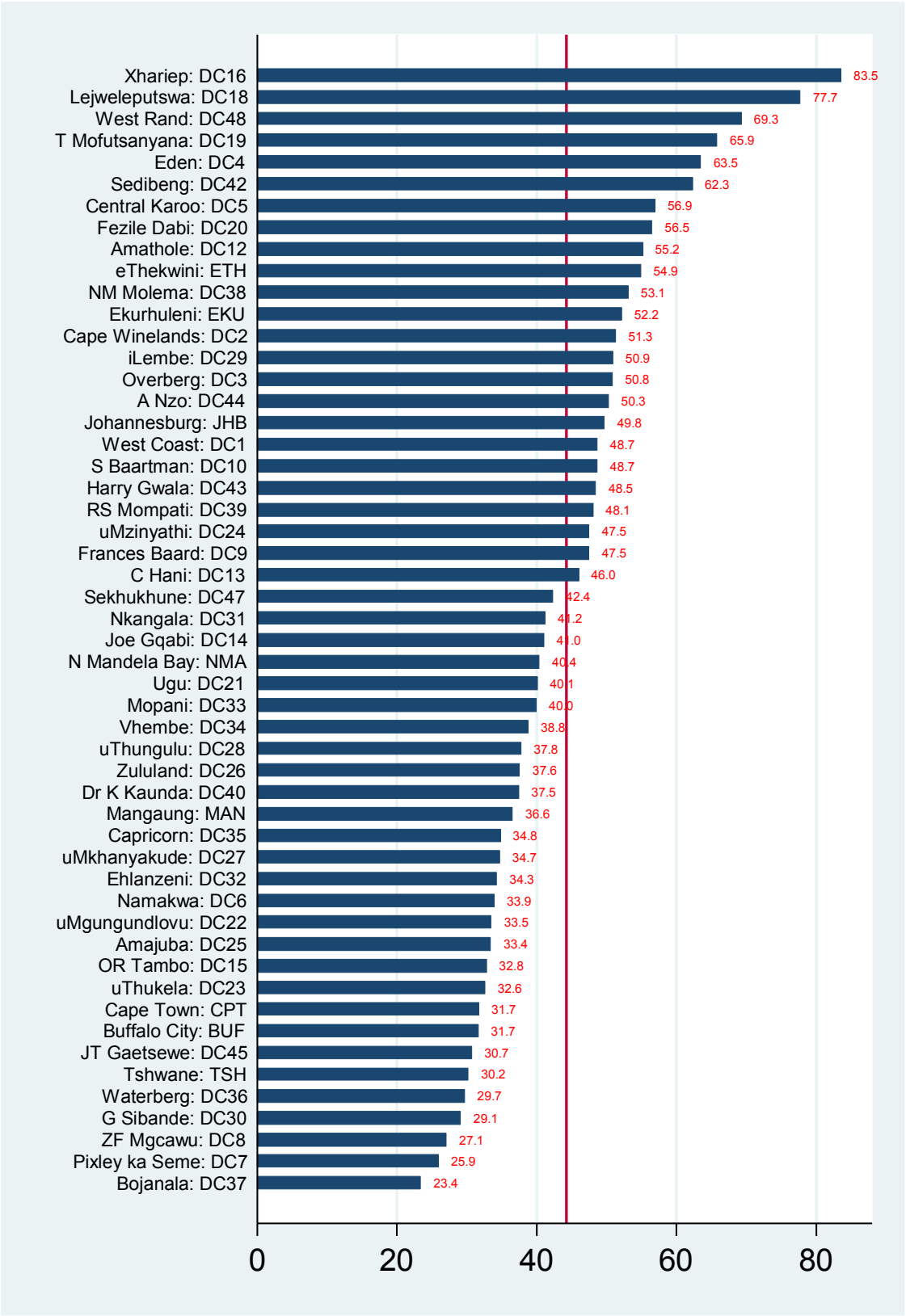


Figure 11: Average Vitamin A coverage for 12-59 month old children by district for 2011 to 2013[10]

[10] Vertical red line indicates mean coverage or 44.3% over 3 year period

3.1.5 Child Mortality

The child mortality indicators collected by the DHIS are the in-hospital case fatality rates for pneumonia, diarrhoea and malnutrition in the under-five age group. The data for pneumonia and malnutrition fatality for 2012 for the Western Cape districts was missing. As can be seen in Figure 12 the fatality percentage for malnutrition was greater than for pneumonia and diarrhoea. The mean for all three indicators has reduced from 2011 to 2013. OR Tambo district was an outlier for diarrhoea fatality for all three years. Namakwa district was an outlier for pneumonia fatality.

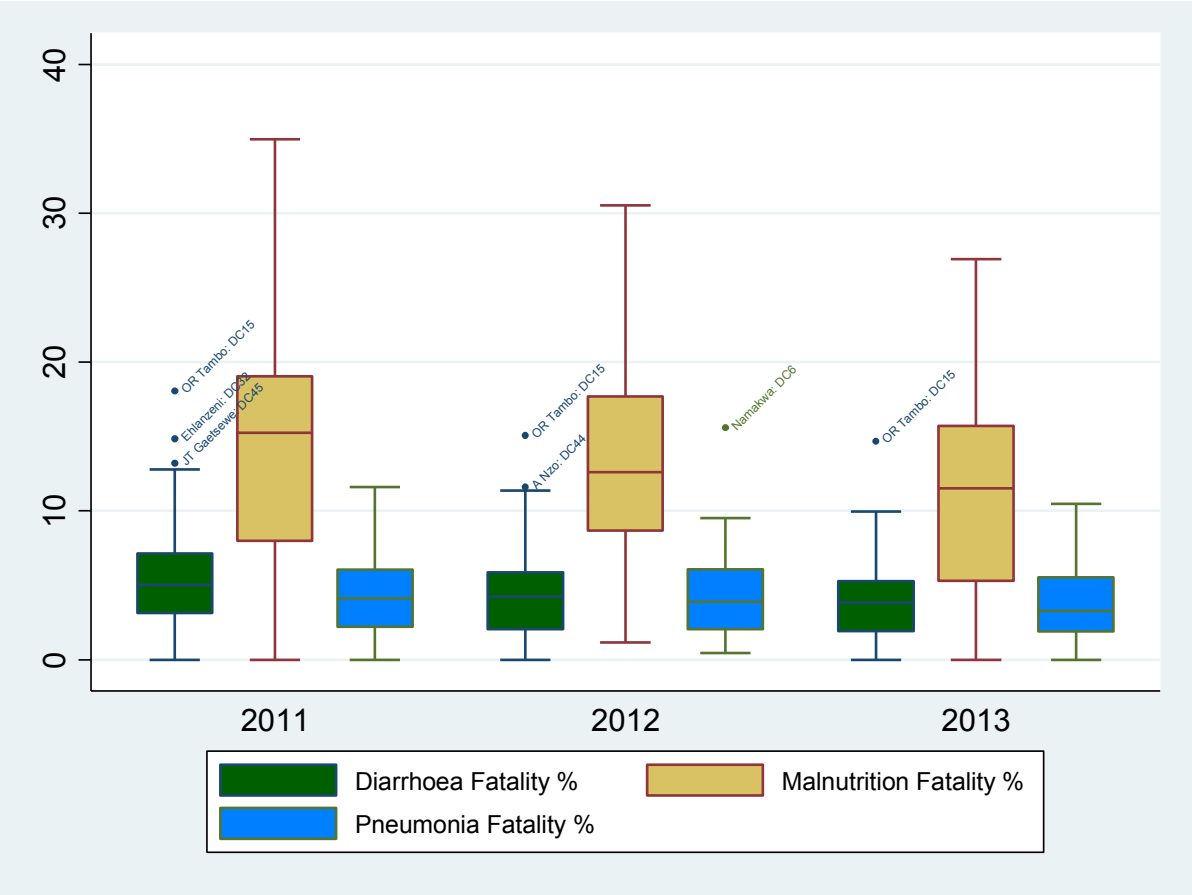


Figure 12: Variation in child mortality indicators across all districts for years 2011 to 2013

As the descriptive statistics for the maternal and child health indicators have shown, there was variation between districts, between provinces and over time. The variation however was inconsistent, with districts performing well on some indicators and very poorly on others. For example, Overberg rated the second highest in women visiting the clinic before 20 weeks of pregnancy, whereas it performed the second worst in the proportion of antenatal clients that initiated ART (Appendix 1). The variation over time was less marked

than the variation between districts. However, the indicator trends were also inconsistent, with steady decreases for some indicators, and fluctuations for others. These variations make it difficult to categorise districts by overall performance. The next study objective investigates the creation of a composite measure that would allow for easier categorisation of district performance.

3.2 Objective 2: Development of a composite index using principal component analysis

The DHB groups the maternal and child health indicators into five broad categories. It is unclear whether the indicators in each category measure the same underlying construct, and whether all of the indicators together are consistent in measuring maternal and child health performance. To investigate this, we calculated Cronbach's alpha for the indicators in each category, and for all 18 indicators together. The results from the Cronbach's alpha test (standardised) on the five categories of indicators show that there is little internal consistency within most of the categories (Table 4). The only category that showed some internal consistency was child mortality with a coefficient of 0.85. The lowest consistency was found with the PMTCT indicators. When all of the indicators were tested together, the Cronbach's alpha coefficient was 0.72.

Table 4: Cronbach's Alpha coefficients by category (standardised)

Category	Cronbach's Alpha	Items
Child Health	0.54	4
Child Mortality	0.85	3
Delivery	0.52	4
Immunisation	0.75	2
PMTCT	0.34	5
All Indicators	0.72	18

Table 5 shows an itemised evaluation of the internal consistency of the 18 indicators taken together, showing the calculated direction of the relationship of each indicator with the scale, the correlation of each indicator with the overall scale (item-test), the correlation of each indicator with the other indicators (item-rest), and the impact on Cronbach's alpha if that particular indicator is removed from the scale (alpha). A consideration of the signs suggests that indicators with higher values for worse performance should be positively

correlated with the scale, whereas the opposite relationship should hold for indicators where higher values indicate better performance. The majority of the indicators' signs in Table 5 are in the expected direction. However, a few anomalies exist: the child health incidence indicators relating to diarrhoea, pneumonia and malnutrition, and the PCR uptake indicator, do not reflect the expected relationship. The PCR uptake indicator seems problematic with low correlation with the other items, and Cronbach's alpha would increase to 0.74 if it was removed from the scale.

Table 5: Cronbach's alpha coefficients for all indicators (standardised)

Item	N	Sign	Item Test Correlation	Item Rest Correlation	Alpha
Delivery in facility under 18 years	156	+	0.326	0.196	0.715
Inpatient early neonatal death rate	156	+	0.387	0.261	0.708
Maternal mortality rate	156	+	0.433	0.313	0.704
Stillbirth rate in facility	156	+	0.379	0.253	0.709
Antenatal 1st visit before 20 weeks	156	-	0.648	0.557	0.678
Antenatal client initiated on ART	156	-	0.410	0.287	0.705
HIV prevalence among antenatal clients	104	+	0.307	0.184	0.712
Infant 1st PCR test around 6 weeks uptake	156	+	0.041	-0.096	0.742
Infant 1st PCR test positive around 6 weeks	156	+	0.213	0.078	0.726
Child under 5 years diarrhoea fatality	156	+	0.752	0.683	0.664
Child under 5 years pneumonia fatality	150	+	0.697	0.614	0.674
Child under 5 years severe acute malnutrition fatality	150	+	0.644	0.551	0.680
Child under 5 years diarrhoea with dehydration incidence	156	-	0.501	0.386	0.696
Child under 5 years pneumonia incidence	156	-	0.320	0.191	0.715
Child under 5 years severe acute malnutrition incidence	156	-	0.219	0.083	0.725
Vitamin A coverage 12 to 59 months	156	-	0.493	0.380	0.697
Immunisation coverage under 1 year	156	-	0.444	0.325	0.702
Measles 2nd dose coverage	156	-	0.268	0.134	0.720
Test scale					0.717

3.2.1 Principal Component Analysis (PCA)

We then used PCA to better characterise the relationship between these indicators and to explore if the information about maternal and child health performance could be captured in fewer composite indicators.

The value for the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy for this PCA was 0.69, which is considered mediocre (71). The results of the PCA analysis showed that five components have an eigenvalue greater than one (Table 6). The first component explains 26% of the variance, the second component explains 18% of the variance and the third component explains 12% of the variance. Seventy two percent of the variance is explained cumulatively by the first five components generated by the PCA. The scree plot in Figure 13

shows that less variance is explained by components four and five (9% and 7% respectively). Nevertheless, the first five components were retained for further analysis.

Table 6: Principal Component Analysis results (n=52)

Component	Eigenvalue	Proportion	Cumulative
Comp1	4.685	0.260	0.260
Comp2	3.254	0.181	0.441
Comp3	2.109	0.117	0.558
Comp4	1.646	0.091	0.650
Comp5	1.296	0.072	0.722
Comp6	0.967	0.054	0.776
Comp7	0.695	0.039	0.814
Comp8	0.621	0.035	0.849
Comp9	0.566	0.032	0.880
Comp10	0.465	0.026	0.906
Comp11	0.419	0.023	0.929
Comp12	0.307	0.017	0.946
Comp13	0.243	0.014	0.960
Comp14	0.215	0.012	0.972
Comp15	0.175	0.010	0.981
Comp16	0.150	0.008	0.990
Comp17	0.095	0.005	0.995
Comp18	0.091	0.005	1.000

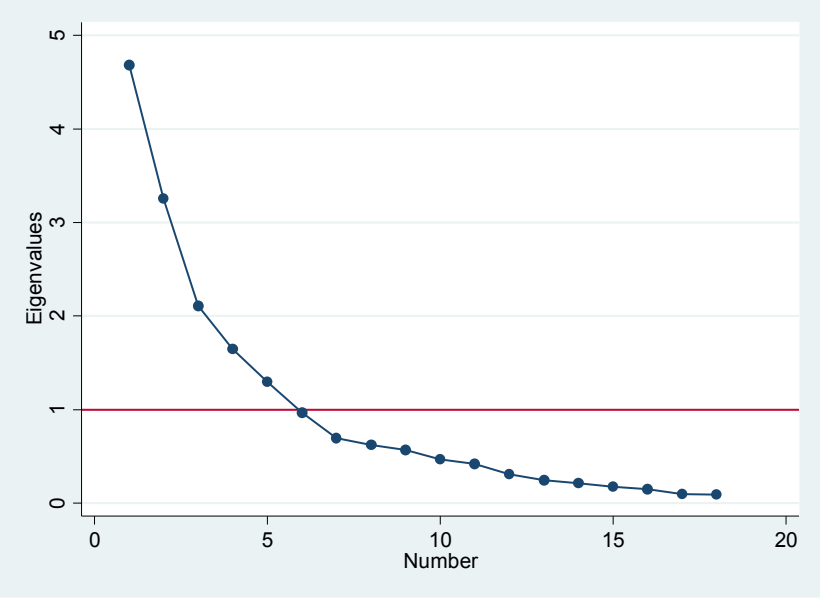


Figure 13: Scree plot of eigenvalues after PCA

Table 7 shows the factor loadings of the variables on the five components. No rotation was performed. The variables that load most highly on component one include all the child

mortality indicators as well as the proportion of women who have their first ANC visit before 20 weeks. The indicator that loads highest on component one is the pneumonia fatality rate (0.4022), followed closely by the diarrhoea fatality rate (0.3988). The direction of these relationships are the same as in Table 5; indicators with positive factor loadings are those with higher values for worse performance, whereas indicators with higher values for better performance have negative loadings. The indicators that load on component two are varied and include HIV prevalence among ANC clients, the incidence of pneumonia in under-five children, the two immunisation indicators and the infant PCR positive rate. The infant PCR positive rate also loads highly on component five but in the opposite direction. This indicator has the highest factor loading score (0.557). Both the immunisation indicators that load on component two also load on component three, but in the opposite direction.

Table 7: Unrotated component loadings for components 1 to 5

Variable	Component 1	Component 2	Component 3	Component 4	Component 5	Unexplained
Child under 5 years pneumonia fatality	**0.402**	0.005	0.035	0.166	0.016	0.194
Child under 5 years diarrhoea fatality	**0.399**	0.016	0.096	0.214	-0.002	0.160
Child under 5 years severe acute malnutrition fatality	**0.374**	0.068	0.058	0.271	-0.111	0.187
Antenatal 1st visit before 20 weeks	**-0.360**	-0.132	0.134	0.053	0.197	0.243
HIV prevalence among antenatal clients	0.185	**0.364**	0.092	-0.099	-0.255	0.290
Infant 1st PCR test around 6 weeks uptake	0.028	**0.300**	0.225	**0.431**	0.092	0.280
Infant 1st PCR test positive around 6 weeks	0.007	**-0.305**	-0.024	0.215	**0.557**	0.218
Immunisation coverage under 1 year	-0.141	**0.317**	**-0.417**	0.068	0.034	0.204
Measles 2nd dose coverage	-0.076	**0.377**	**-0.327**	0.250	0.080	0.174
Child under 5 years pneumonia incidence	-0.158	**0.360**	**0.324**	-0.062	0.161	0.199
Child under 5 years severe acute malnutrition incidence	-0.053	0.266	**0.341**	-0.006	**0.351**	**0.353**
Delivery in facility under 18 years	0.110	-0.094	**0.512**	0.145	-0.027	**0.326**
Maternal mortality rate	0.264	0.259	-0.089	**-0.359**	0.115	0.208
Stillbirth rate in facility	0.197	0.186	-0.023	**-0.384**	**0.355**	**0.300**
Vitamin A coverage 12 to 59 months	-0.195	0.249	-0.153	**0.373**	0.117	**0.324**
Inpatient early neonatal death rate	0.204	0.043	-0.032	-0.251	**0.334**	**0.549**
Antenatal client initiated on ART	-0.223	0.194	0.253	-0.149	**-0.370**	**0.295**
Child under 5 years diarrhoea with dehydration incidence	-0.267	0.083	0.218	-0.129	0.086	**0.507**

3.3 Objective 3: Rank districts using the composite index developed

As it was not possible for the five principal components to be interpreted and subsequently labelled, the comparison of components between districts is of limited value. Principal component (PC) scores for the first component were therefore generated by Stata for each district. This score was then used to rank the districts.

Figure 14 shows the variation between districts for the average PC score, with more negative values indicating higher levels of performance. The five districts with the highest scores are located in the Western Cape.

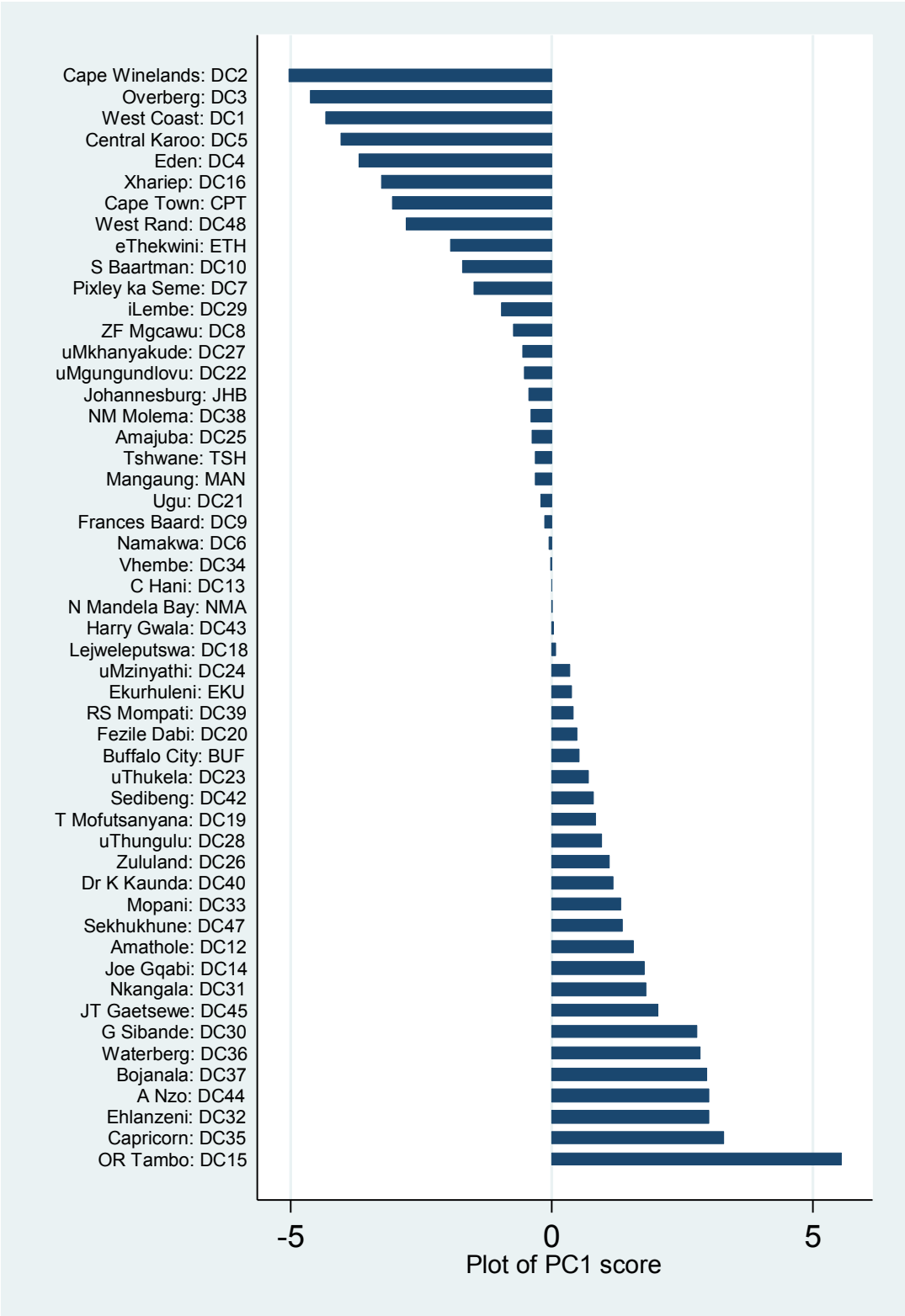


Figure 14: Plot of first PC score for all 52 districts

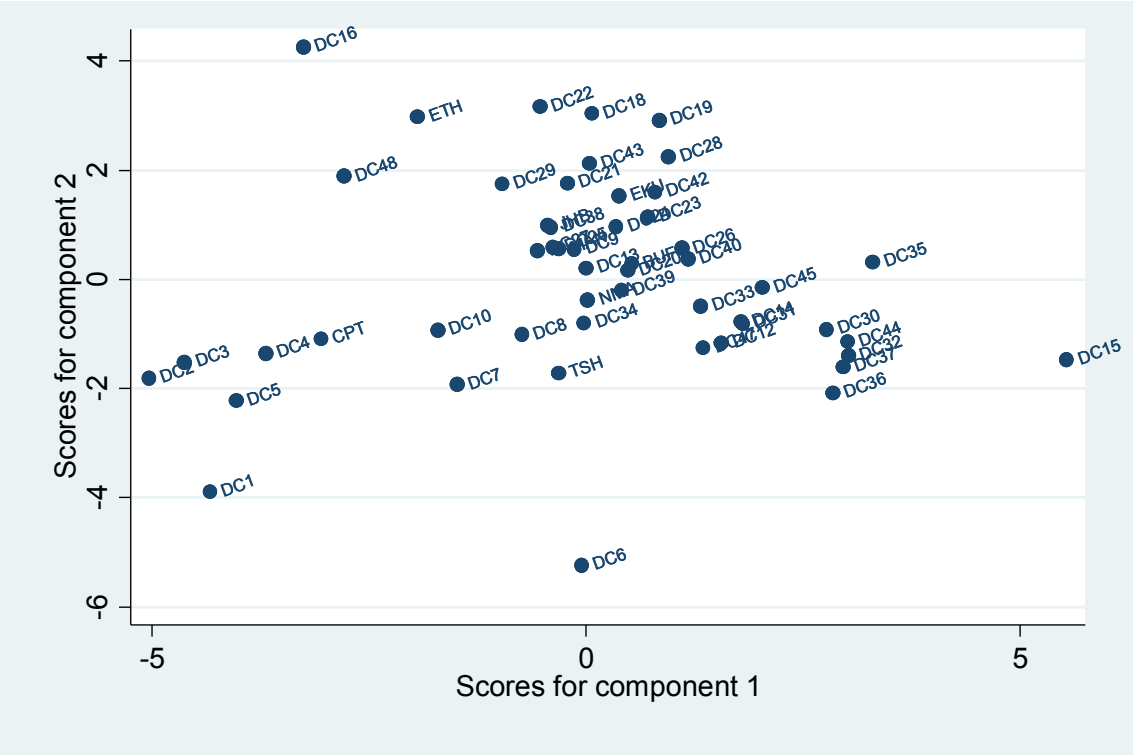


Figure 15: Score plot of component 1 and component 2

Figure 15 plots the scores of component 1 against component 2. If only the first component is considered, many of the districts have similar scores and could be clustered together. When considering the second component, it is possible to differentiate further between most of the districts. A number of outliers exist, such as OR Tambo district (DC15) and Namakwe district (DC6).

3.4 Objective 4: Associations between the composite performance indicators, district financing and deprivation levels

3.4.1 Deprivation and Health Financing Indicators

The summary statistics for the health financing indicators are shown in Table 8. The mean DHS expenditure per capita increased from R1,512 in 2011 to R1,591 in 2013. The proportion of DHS expenditure on district management has fluctuated around 6%, although the share for PHC increased slightly from 54.9% in 2011 to 57.4% in 2013. The variation between districts has not changed dramatically. The standard deviation of per capita expenditure increased slightly from R363 to R394, but did not change for the other two indicators. The

range for DHS expenditure on PHC was quite large, reducing from 58.9% in 2011 to 54.1% in 2013.

Table 8: Summary statistics for financing indicators (real 2014/2015 prices)[11]

Variable	Mean	Range	Standard Deviation	Min	Max
2011					
District Health Services expenditure per capita (uninsured)	R 1 512	R 1 805	R 363	R 858	R 2 663
DHS expenditure on District Management	5.7%	14.3%	3.3%	0.8%	15.1%
DHS expenditure on Primary Health Care	54.9%	58.9%	12.5%	31.7%	90.6%
2012					
District Health Services expenditure per capita (uninsured)	R 1 566	R 1 790	R 382	R 913	R 2 702
DHS expenditure on District Management	6.2%	12.6%	3.2%	1.0%	13.6%
DHS expenditure on Primary Health Care	56.5%	55.5%	12.3%	35.0%	90.5%
2013					
District Health Services expenditure per capita (uninsured)	R 1 591	R 1 837	R 394	R 917	R 2 754
DHS expenditure on District Management	5.9%	13.4%	3.2%	0.8%	14.2%
DHS expenditure on Primary Health Care	57.4%	54.1%	12.2%	34.1%	88.2%

A plot of the SAIMD score by district is shown in Figure 16. A low score indicates a low level of deprivation. Cape Town district was the least deprived district and Alfred Nzo district the most deprived district. The metropolitan districts are generally less deprived than the rural districts.

[11] The 2014/2015 dataset was used to extract data for 2011 to 2013 to ensure data consistency.

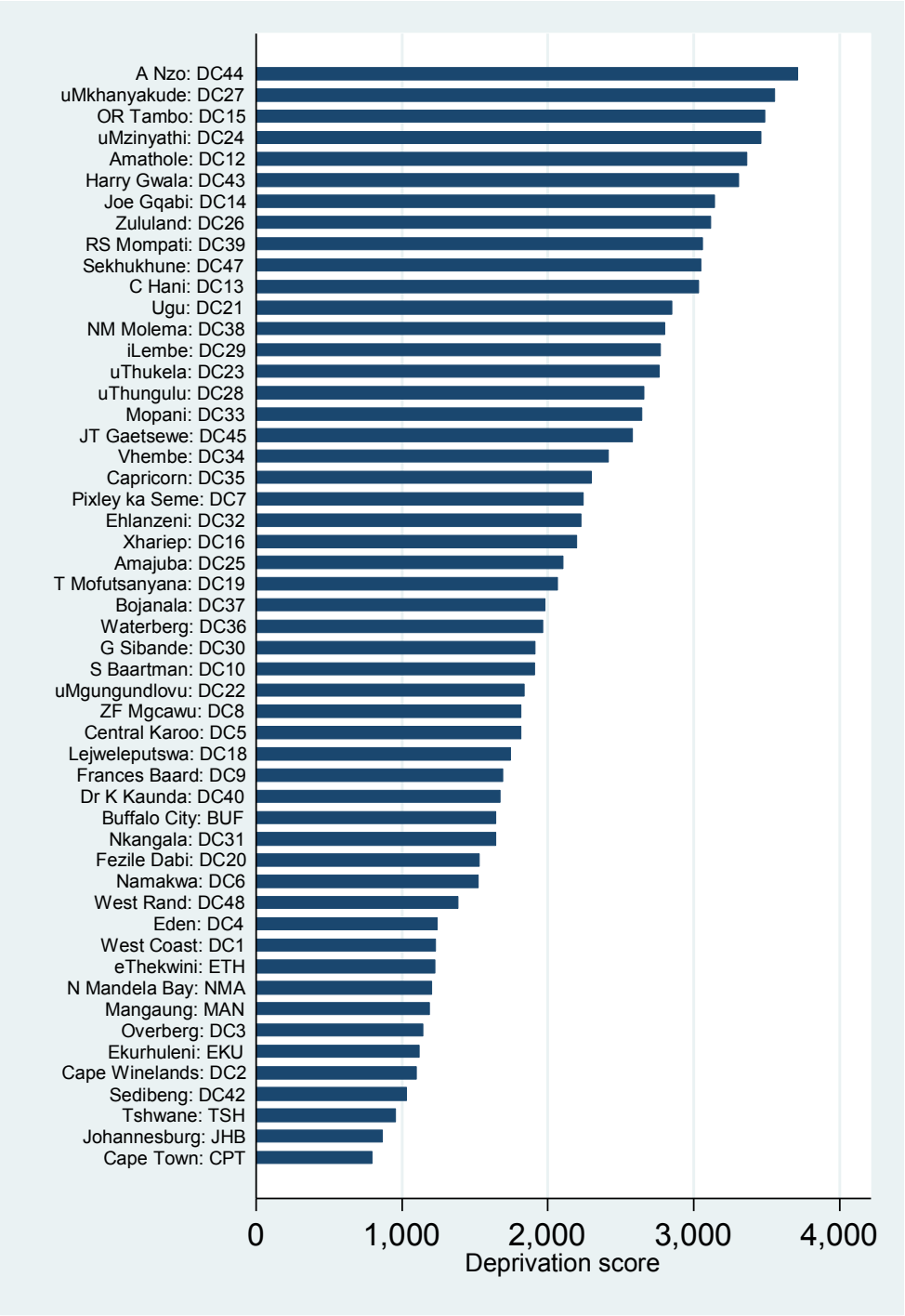


Figure 16: Deprivation score for all 52 districts (most to least deprived)

The correlation between these four independent variables was also explored (Table 9). Deprivation is directly correlated with DHS expenditure per capita and inversely correlated with the percentage of the DHS budget spent on management and the percent of DHS budget spent on PHC. In other words, as the deprivation level increases, there is more expenditure per capita, but less DHS expenditure on management and PHC. Interestingly,

DHS per capita expenditure was strongly negatively correlated with the proportional PHC spending.

Table 9: Correlation of independent variables

	SAIMD	p-value	DHS per Capita	p-value	DHS Management	p-value	PHC %	p-value
SAIMD	1							
DHS per Capita	0.229	0.103	1					
DHS Management %	-0.027	0.848	0.079	0.328	1			
PHC %	-0.526	<0.001	-0.533	<0.001	-0.173	0.312	1	

3.4.2 Multiple Regression Analysis

A regression with each of the PC scores and the average of the PC scores was performed with the SAIMD score, and the three health finance indicators. These results are shown in Table 10.

Table 10: Regression results for the PC score

	PC1	p-value
SAIMD	0.001	**0.002**
DHS per Capita	-0.002	**0.016**
DHS Management %	0.054	0.523
PHC %	-0.030	0.318
Model-fit		
N	52	
P-value (F-test)	**0.001**	
R-squared	0.327	

The results of the multiple regression model was statistically significant. Thirty-three percent of the variation in the PC score could be explained by the deprivation and financing indicators (Table 10). The deprivation index was significantly associated with the PC score. For each one increment change in the deprivation index (SAIMD), performance on the PC1 score increased by a coefficient of 0.0013. Since higher SAIMD scores indicate higher deprivation, and higher PC scores indicate worse performance, this means that performance for PC1 decreased significantly as the districts became more deprived. The PC1 score was also significantly associated with DHS per capita expenditure. For each one increment increase in DHS per capita expenditure (R1), performance improved by 0.002 units. The other two finance indicators were not statistically significant. The PC2 score was significantly

associated with a different finance indicator, namely the percentage of the DHS budget spent on management. For each one increment change in DHS budget spent on management (1%), performance improved by 0.181. Unexpectedly, the PC5 score was inversely related with DHS per capita expenditure and the percent of DHS budget spent on PHC. As expenditure on these two items increased, performance worsened. Only deprivation had a significant association with the average PC score.

Chapter 4: Discussion

In this chapter, a brief summary of the results will be provided. The discussion will then consider the limitations of the study, before discussing what has been achieved with PCA. Finally, the chapter will examine the relationships between performance measure scores and deprivation and financing.

4.1 Summary of results

Analysis of the maternal and child health variables for the 52 districts over the three year period from 2011/12 to 2013/14 showed a wide range of variation. Variation exists across the three year period, between districts and provinces and between the various indicators. Some districts performed consistently well on many indicators, whereas others performed well on some but poorly on other indicators. We then used PCA to explore whether it is possible to reduce the number of indicators and create a composite measure of performance. The PCA analysis revealed five important components which were able to explain 72% of the variation in performance. However, the patterns of factor loadings did not clearly identify different performance constructs, and the direction of the weights was not always in the expected direction. The principal component score that was created was used to rank the districts by performance.

The multiple regression analysis revealed that performance decreased as districts become more deprived while increased DHS per capita expenditure improved performance.

4.2 Study Limitations

It is important to reflect on the limitations of the study when considering the results. As this study relied on secondary data, it was limited to the indicators that are used in the DHB. Data quality has always been of concern in the DHB. Data quality issues include poor recording of information within the facility such as missing data or double counting, as well as issues related to the assumptions made for calculating rates and proportions. The fact that percentages for immunisation coverage and antenatal clients initiated on ART rates exceed 100% suggests that the denominators used for these indicators are not completely accurate. In addition, the out-referral of patients to other districts tends to skew the data and may unfairly reflect on a district's performance as is the case with maternal mortality (29). Interventions have been implemented in some districts to increase the quality of the data collected (72) and annual workshops have been held by the HST to discuss data quality

issues with participants and to interrogate data discrepancies (29). Even though data quality is an issue, the DHB is a well-respected publication that is widely used by a multitude of stakeholders in South Africa, including the National Department of Health (29). In a resource limited country such as South Africa, it is necessary to find methods that make better use of the available routine data collection systems.

This study was also limited to the variables already available in the DHB. Many of the available indicators are perhaps not the best indicators for comparing district performance. Some of the indicators reflect the status of social determinants of health. The incidence of diarrhoea in under-fives, for example, is probably more indicative of access to clean water and sanitation than the functioning of district health services (73, 74).

The finance indicators used in the regression analysis only include government expenditure. Many non-governmental organisations (NGOs) operate in the South African health system, especially in the field of HIV (75). This expenditure is not captured in the finance indicators used in the DHB. This could possibly affect the observed relationship between funding and performance, as the health outcomes related to NGO activities may improve certain DHB indicators, such as HIV prevalence rates or PCR rates for infants, but the financing used in these health services are not captured. In addition, private expenditure through out-of-pocket payments will impact health outcomes. The DHB makes a crude adjustment for private expenditure by using the uninsured population as the denominator in per capita expenditure calculations. This is unlikely to account for the full impact of private expenditure, especially in urban areas where many uninsured people seek private primary level care. In rural areas this is perhaps less of a problem as the availability of private health care is more limited (76).

Lastly, this study only explored data for a particular 3 year period. The study results may differ if different periods were used for the same analysis as variation clearly exists over time in the MCH indicators.

4.3 Implications of the Analysis

PCA can be used as an exploratory or confirmatory factor analysis method (77). In this study, PCA has been used as an exploratory method in an effort to develop a composite measure of district health performance. The PCA was partly helpful in achieving this objective, but also had a number of limitations.

This study has found that PCA may be a somewhat useful method in aggregating health system performance across a number of maternal and child health indicators. The weighting derived from PCA is perhaps preferable to the use of equal weights which are used in most other applications of health composite indices (9, 37, 57, 58). PCA also has advantages over the use of explicit weights which have been used in some studies (36, 53, 55). PCA is a purely statistical method that depends on calculating the components that explain the most variation across the indicators. Consequently no judgements need to be made about the weights of different indicators as these are obtained from the factor loadings of the components explaining the most variance (78). As the assumptions made around assigning weights can generate controversy, users and policy makers may resist using the resulting composite indices (20). This is especially true if weighting decisions are not transparent or are arbitrarily assigned as is the case with the Ugandan District League Table (53). In addition, the changing of weights will markedly affect the score of entities being measured. This was the case in a study of UK local authorities and hospitals where local authorities changed rankings by between six and 13 places on average when weightings of performance indicators were changed (40). However, the process of assigning explicit weights to different indicators does serve the purpose of ensuring that the values of society have been taken into account during the development process, although reaching consensus amongst all stakeholders may often be difficult (20).

The number of variables available to assess health system performance can be overwhelming and traditional league tables by individual indicators are cumbersome and difficult to interpret (29, 53). In this study the use of PCA allowed the data to be reduced from 18 indicators to one component. One ranking table using the principal component score to summarise MCH performance is somewhat simpler than the 18 ranking tables for each individual MCH indicator, as is currently done in the DHB (29). The reduction in indicators allowed districts to be ranked more easily in overall performance and is a useful step towards investigating determinants of performance.

PCA studies in a range of health areas, including public health, mental health and psychology, have often found that the extracted principal components clearly reflect particular constructs (79-83). For example, a study in Brazil aimed to ascertain the social determinants of public dental service use by adults. They found that at the municipal level three constructs could be identified, and at the neighbourhood level, two constructs were

identified. At the neighbourhood level, for instance, these constructs reflected "neighbourhood conditions" and "socioeconomic status of households" (83). An Egyptian study on the utilisation of maternal health services identified five dimensions of women's empowerment associated with access to maternal health services through the use of PCA. These dimensions included freedom of movement, economic security and stability, supportive family and freedom from domination, decision-making in daily life, and participation in communities and society (82). Components are often renamed based on the variables that load most highly on the components. This allows for easier interpretation and analysis of the newly created components. A possible reason for the tidy components from such studies, is that the research is often constructed with the constructs in mind (77). For example, questionnaires on motivation will include questions on different aspects of motivation identified in the literature and then load clearly on different components (84).

The factor loadings of the MCH indicators on the five relevant components identified by PCA do not reflect easily identifiable constructs related to performance. This is because different types of indicators seem to load on each component and some indicators load on more than one component (Table 7). Even when problematic indicators are removed, the patterns are not made clearer. In addition, the sign of the factor loadings was not always in the expected direction. Components are easier to interpret when several variables are highly correlated with the components and variables correlate with only one component (77). The variables that load on component one for instance include child mortality indicators as well as the proportion of women who have their first ANC visit before 20 weeks if a factor loading cut-off of 0.30 is used for significance. However, if factors with a factor loading of between 0.20 and 0.30 are also considered, additional variables such as maternal mortality and incidence of diarrhoea also related to component one. In contrast, the variables that load highest on component two are more diverse, including immunisation rates, HIV prevalence among ANC clients, the proportion of infants who are HIV positive at six weeks and the incidence of pneumonia. These indicators do certainly not follow the categories used in the DHB, such as PMTCT, child health or delivery. Nor do they create new constructs that make sense, such as if the health service indicators had loaded on different components to the social determinant indicators. It is important for the constructs to make logical sense if such analyses are to be used (77). In contrast, a PCA study assessing the quality of male circumcision services in Kenya was able to identify two clear components of quality from the

factor loadings of their variables, namely “preparedness to deliver male circumcision” and “safety of performance” (52) . As the quality assessment tool in this study was adapted from a WHO assessment toolkit, underlying constructs may have already been considered when the tool was developed, and could explain the identification of meaningful constructs.

One reason for the lack of clear constructs in this study may be that the indicators used measure a number of different aspects of performance. Some of the indicators are health service coverage measures such as immunisation rates; others are more related to social determinants of health. For example, the proportion of deliveries in facility to women under 18 years of age may be a reflection of societal norms rather than related to access to health care (67, 85). This is not necessarily a problem for PCA analysis. One would expect that these different aspects of performance would load on different components. However, this was not the case in this study. Because the child health indicators (incidence of malnutrition, pneumonia and diarrhoea), seemed more related to social determinants of health and sometimes loaded in the wrong direction, we repeated the PCA without these variables. However, this did improve the pattern of components and factor loadings or reveal clearer performance constructs.

An important consideration in health system performance is efficiency because resources are limited in most health systems. Those districts, programmes or facilities that are able to maximise health outcomes with the available resources will better serve their populations, and may also be able to convince policy makers to provide them with a greater share of the limited resources in future (86). This study explored the relationship of performance with financing through a regression analysis of the derived principal component score and available health financing indicators. Alternative methods have been used to assess efficiency within the same analysis, instead of a two-step process as was done in this study. The two main statistical methods used for evaluating efficiency are data envelopment analysis (DEA) and stochastic frontier analysis, which are non-parametric and parametric approaches respectively (87). A number of studies in Africa have used DEA to assess relative efficiencies of health organisations (88-93). Many of the evaluations have been done on hospitals (89, 91, 92), although primary care facilities such as health centres (88) and clinics (90) have also been assessed. This method evaluates the relative performance of decision making units, such as clinics or hospitals, from multiple input and output variables. Inputs include human resources, capital items (such as beds available) and expenditure on supplies

(such as pharmaceuticals and consumables) and outputs are generally health outputs such as antenatal visits, child care visits, deliveries or children immunised. An added advantage of frontier methods such as DEA is that they allow for efficiency to be assessed against a maximum level of performance given the available inputs. In other words, the comparison allows for districts to be assessed on their performance based on the resources available to each district. Unfortunately, other than financing indicators, inputs such as staff and drugs were unavailable for analysis in this study.

A common criticism of standard league tables is that the epidemiological, demographic and infrastructural profile of the district is not taken into account when ranking districts on performance measures (53, 94, 95). In studies comparing the performance of hospitals or allocation of funding in pay-for-performance systems, performance results are adjusted for the different severity levels of patients, through case-mix adjustment (96). For example, a young woman of normal weight is less likely to require a caesarean section than an older woman suffering from comorbidities (97). Similarly, districts that provide health care services in areas with poor sanitation services, and a high burden of TB and HIV, would perform less well with the same resources than a district without these contextual problems. Had burden of disease data been available for each district, the PC score generated by this study could have been adjusted to reflect the epidemiological profile of the district.

The 2013/14 DHB report included an analysis which used a similar technique to DEA, called the free disposal hull (FDH) method, to evaluate relative district efficiencies and to adjust for contextual differences (29). Both DEA and FDH assume that inputs and outputs are freely disposable, i.e. no costs are involved in the underutilisation of goods. The primary difference between the two methods is that FDH does not assume convex technologies (98). An adapted version of the FDH method was used to provide a ranking that considers both efficiency in terms of financial inputs and a crude level of context in terms of district deprivation levels and antenatal HIV prevalence. It is difficult to compare the results of the FDH method with those in this study as the DHB included additional indicators such as TB indicators, cervical cancer screening indicators and hospital indicators whereas this study only used MCH indicators. The DHB also only used data for one year in contrast to this study that used an average over three years. However, it was noted by the authors of the FDH analysis that the adapted FDH method is computationally intensive and it was not repeated in the following year's DHB (29, 67).

When assessing performance, comparing performance to other districts may not always be the most appropriate approach. The best performing districts may be performing substantially better than the worst performing districts, but the best districts' performance could still be sub-standard in relation to achieving national or global targets of improved health. The process of benchmarking involves setting a point of comparison, or benchmark, against which all other things can be compared (99). PCA provides a measure of performance variation for the districts only compared to other districts. It would be useful for the Department of Health to know how districts are performing against national targets. A number of studies refer to benchmarking, but in fact are comparing districts, states or regions to one another, and not against a national or international standard (9, 37, 50, 58). The DEA and FDH methods already mentioned benchmark performance against the best performing district, relative to available resources, but not against a national or international norm (29, 88-93, 100). All these methods, including PCA, do however allow for identification of good and poor performers within their national contexts, enabling identification of the districts that require further investigation to discern reasons for differences in performance levels.

4.3.1 Influence of deprivation and financing on MCH performance

As PCA is unable to consider input or contextual factors in its analysis directly, this study also explored the relationship between the district performance score and indicators of health financing and deprivation. This analysis will be discussed next.

There are many factors that impact on the performance of district health systems. This study found an association between financing indicators and the principal component score generated by the PCA. Increased provincial and local government expenditure on district health (DH) services per capita for the uninsured population increased MCH performance as measured by the PC1 score. The factors that loaded highest on component one were the child mortality indicators, which require sufficient resources to reduce mortality rates. This result is plausible as appropriate financing of the health sector is the first step required to ensure that the health system is able to perform optimally. The recommended level of health spending for African countries was set at a minimum of 15% of total government expenditure with the signing of the Abuja declaration in 1989 (101). South Africa allocates 14% of total government expenditure to health, but the distribution among districts is unequal (102). This finding might suggest that additional district financing would improve

MCH performance. However, careful consideration should be given before additional funds are allocated to districts. For instance, both the West Coast district and JT Gaetsewe district spend similar amounts per capita on DH services (R1,625 per capita), yet the West Coast is ranked in the highest performing group and JT Gaetsewe is in the lowest performing group. Similarly, both the Cape Winelands and Alfred Nzo district spend R1,158 per capita on DH services, but they are ranked on opposite ends of the performance spectrum. It is clear that the performance of a district health system is dependent on more than financing. In these examples, both of the high performing districts are located in the Western Cape whereas Alfred Nzo is located in the Eastern Cape, and JT Gaetsewe in the Northern Cape. This could be indicative of different levels of efficiency in the different provinces. Also, if additional funds are to be allocated to poor performing districts, consideration of the absorptive capacity of the district is important (103-105). If the district is unable to employ more staff due to staff shortages or essential drugs are unavailable due to poor procurement processes, additional funding would be wasted. Due to the shortage of human resources for health, especially in rural areas in South Africa, low levels of staffing may continue even if additional funds are allocated to rural districts (106). It is imperative that the resources for health systems be used with a minimal amount of wastage as the available resources available for health care are limited (88, 107).

In addition, the way funding is allocated is also important. One primary debate on how health expenditure should be allocated includes the trade-off between horizontal and vertical spending (108). Vertical spending relates to funding provided for particular disease programmes, such as HIV or TB whereas horizontal spending focuses on financing to improve health system functioning. With the focus on the need to strengthen health systems in general, instead of focusing on specific programmes, there has been a move to develop primary health care delivery platforms which are able to address multiple diseases (109, 110). This is especially important in developing nations due to the epidemiological transition from infectious to non-communicable diseases, which impacts on maternal health through comorbidities. Studies of a number of countries have shown that good health can however be attained with limited resources if the resources are invested strategically (109).

One factor responsible for district health performance is leadership (111). As resources for health care expenditure become scarcer, resources need to be managed more efficiently. If this is not done, then health care will be affected negatively through reduced access, less

equity and poorer quality of treatment (112). In addition, the type of management is also very important and thought needs to be given to how the funds allocated to district management will be used. Studies have found that clinicians in management positions are able to effect greater change than non-clinicians (112). However, as South Africa already experiences a shortage of health care providers in the public sector, it may not be efficient for clinicians to be responsible for the administrative functioning of facilities (113). Effective managers can greatly impact on the resilience and resourcefulness of health facilities and are a worthwhile investment (109). The South African health minister has created the Academy for Leadership and Management in Health Care to act as a central point for all training activities and support for management and leadership at all levels of the health care system (114). It would be informative to explore the impact that such leadership training of district health managers has on district level performance.

The relationships with financing found in this study do need further analysis. For example, the finance indicators available in the DHB dataset only reflect financing through government structures. Other non-governmental funding such as PEPFAR HIV programmes fund health interventions in a number of districts (75). This would potentially impact the health outcomes in the district which skews the relationship between government financing and performance. Further research including the distribution of non-governmental funding is needed to understand the impact of donor funded programmes on the functioning of the district health system.

It is widely accepted that the social environment has a great impact on health (115). This study also found a significant relationship between deprivation and performance, with higher deprivation scores associated with worse performance the principal component score. The deprivation index that was used was developed by Noble et al. (63). This South African Index of Multiple Deprivation (SAIMD) was constructed from four different measures, namely income deprivation, employment deprivation, education deprivation and living environment deprivation. Another South African study also found that health status was associated with education, employment and housing, and infrastructure (116).

Health system performance is assessed based on three criteria: effectiveness, efficiency and equity. Equity relates particularly to providing access for disadvantaged groups to quality health care (117). Health outcomes in high-income countries are also impacted by deprivation levels. In the US, material deprivation was found to result in longer hospital stays

following injury (118), in Canada individual level financial hardship also increased hospital length of stays and early re-admission rates (119), and in the UK, mortality is found to be higher for more deprived groups (120, 121). Even in countries with universal health coverage, those who are more deprived tend to use health services less (122).

The negative impact of deprivation on health outcomes is even more severe in developing countries, particularly in relation to maternal and child health. In Nigeria large variation exists in pregnancy outcomes between rural and urban women, with poorer women tending to have less education, lower incomes and being younger mothers (123). In Uganda, distance from hospitals was identified as a risk factor for stillbirths (124).

The least deprived districts in South Africa tend to be in the more urban provinces of Gauteng and the Western Cape, whereas the most deprived districts are located in the more rural provinces of the Eastern Cape and Kwa-Zulu Natal. In addition to being more urban, Gauteng and the Western Cape also have much higher average household incomes than other provinces (125). Rural districts tend to have higher levels of deprivation with lower levels of educational attainment, lower income, and fewer material resources. In addition, infrastructure provision tends to be lacking in rural areas. As the goal of the health system is to reduce health inequities, governments should allocate resources in such a way as to mitigate the deleterious health effects of deprivation (7). This is especially true in South Africa as the Department of Health strives towards universal health coverage for all. Pro-poor policies such as the Newhints (Newborn Home Intervention Study) programme in Ghana are essential if South Africa is to address the existing health inequities (126). The Newhints programme uses community-based surveillance volunteers to do home visits on newborns to identify danger signs and if necessary, refer them on to health facilities for further care.

Financing and deprivation are intricately linked, as the association between deprivation and financing found in this study shows. As deprivation increases, there is some additional DHS expenditure per capita (uninsured), but the percentage of the budget spent on PHC decreases. With the move to universal health coverage, a focus on increased primary care services is essential to overcome health disparities (116).

Even though South Africa implemented a needs-based approach to financing health care, an insufficient amount of resources are allocated to the poorest provinces. One reason for this is that the Department of Finance partly allocates financing based on economic output

which means that wealthier provinces receive a larger share of resources than poorer provinces (127). However, another study found that the historical inequalities in the capacity of the health system are a bigger driver of inequalities in allocation of health care resources (76). The authors argue that an infrastructure-inequality trap has been created. In other words, the provinces that have little infrastructure for historical reasons, receive fewer resources as they are less able to spend the resources. This results in infrastructure remaining undeveloped, and a cycle of under-funding ensues.

Irrespective of the reasons, in a country as inequitable as South Africa, considerable effort should be given to reducing these financing inequities. When considering the allocation of resources, it is important to include equity decisions in the decision-making process so as to reduce inequitable health outcomes (58, 76). In addition, inter-sectoral action addressing the social determinants of health is required as the health system is unable to tackle health disparities alone (128).

Chapter 5: Conclusions and Recommendations

Traditional league tables for multiple health indicators, such as are used in the District Health Barometer, have been criticised for not providing an overall picture of performance. The use of PCA in this study has been somewhat useful in creating a composite measure of district MCH performance which could then be used to rank districts, and subsequently identify good and poor performers. However, the analysis did not produce clearly identifiable dimensions of district performance for MCH which would hinder wider application. Efficiency frontier methods may be more promising in future analyses as they incorporate inputs and compare performance to current best practice. The use of any method however requires better performance indicators that are able to accurately reflect health system performance. The available DHIS data are not always sufficient to assess district performance in a comprehensive way (37).

5.1 Recommendations for future research

There is benefit in further initiatives to develop composite indices of district performance in South Africa. However, it is important that consideration be given to the positive and negative responses that could result from performance measurement techniques (40). Methodological choices have a significant impact on the composite indicator results, and it is therefore recommended that a number of different methodologies be tested using the same dataset. This will allow for a comparison of methods to enable identification of the most practical and robust method. Unfortunately it was outside the scope of this research project to do this.

In addition, the selection of indicators impacts both on the results of the composite indicator and the acceptability of the performance measures by key stakeholders. A recommendation for future research would be to determine which set of indicators would best reflect health system performance, especially in light of universal coverage goals such as equity and access. Introduction of new indicators should only be done if the burden on health workers and current information systems is not too great. It would be prudent to first assess whether other existing performance indicators could be used for creating composite performance indices. These could include indicators related to the newly established Office of Health Standards Compliance or the National Health Insurance implementation plan, for example.

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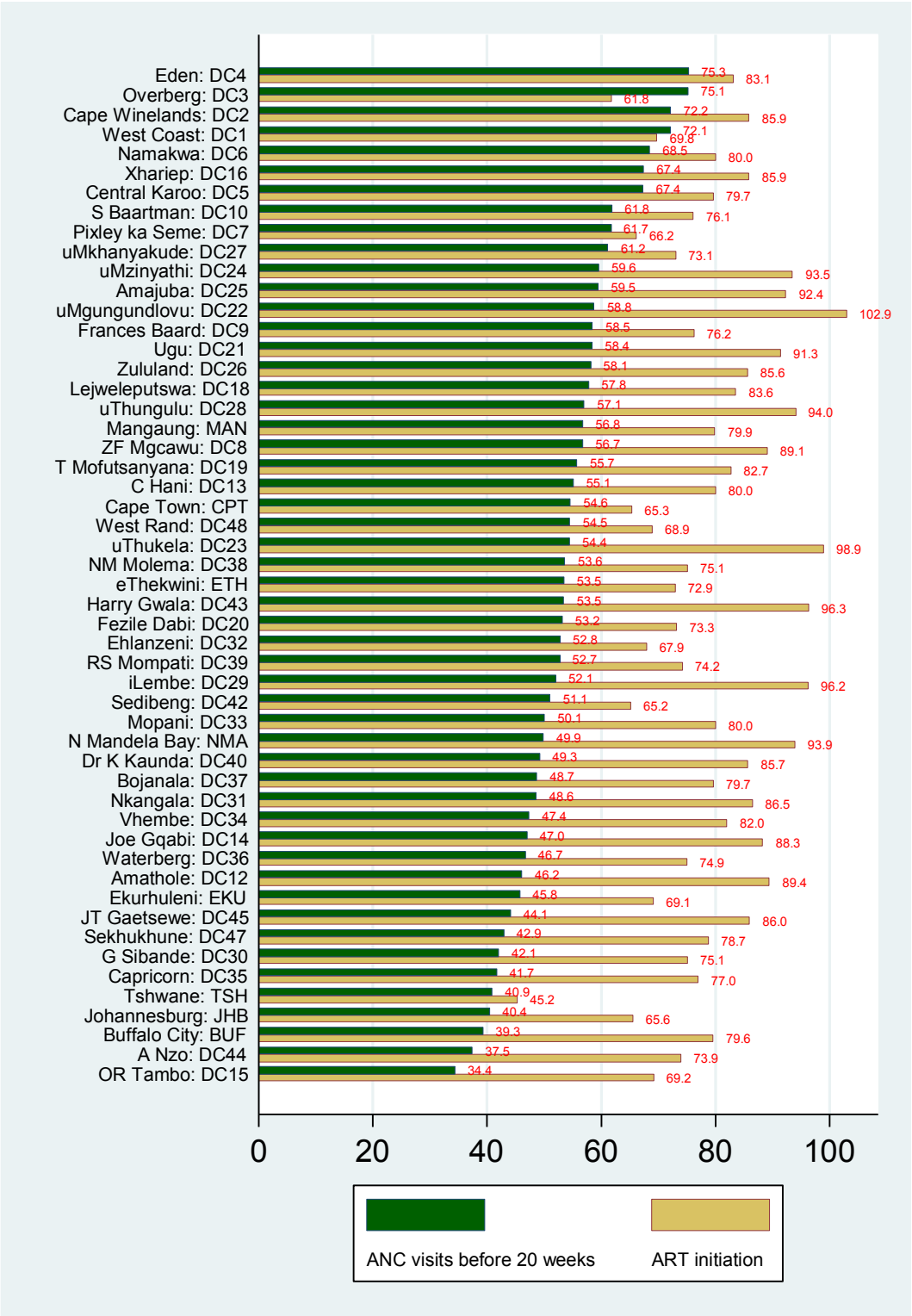
Appendices

Appendix 1: PMTCT indicators per district in 2013 (ANC visits and ART initiation)



Appendix 2: Ethics certificate

R14/49 Ms Jackie Roseleur

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M160258

NAME: (Principal Investigator)	Ms Jackie Roseleur
DEPARTMENT:	School of Public Health Centre for Health Policy
PROJECT TITLE:	Development of a Composite Indicator of Maternal and Child Health Perfomance among Districts in South Africa
DATE CONSIDERED:	26/02/2016
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr Duane Blaauw
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	29/02/2016

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 10004, 10th floor, Senate House/2nd Floor, Phillip Tobias Building, Parktown, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in February and will therefore be due in the month of February each year.

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix 3: Plagiarism Declaration

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG | FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I **Jacqueline Roseleur** (Student number: **A0011003**) am a student registered for the degree of **Master in Public Health** in the academic year **2016**.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature:  Date: 6 September 2016