Has South Africa's Investment in Public Health Care Improved Health Outcomes?

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Abstract

South Africa's total expenditure on health equates to almost 9% of its gross domestic product, which is above the average of other countries classified as middle-income countries. Notwithstanding this investment, indicators of health outcomes remain relatively lower when compared to the same countries. The aim of this paper is to investigate the effectiveness of public health expenditure in improving health outcomes in South Africa. Panel estimations techniques were used using data for the country's nine provinces over the period 2005 to 2014. Results have shown that, on average, an increase in public health expenditure per capita leads to improvement in the under-five mortality rate. With regards to life expectancy at birth, public health expenditure was found to be statistically not significant. Control variables such as real GDP per capita, female literacy rate, immunisation coverage ratio, access to formal housing and HIV/Aids prevalence were also found to be important determinants of health outcomes in the country. The key policy implications of these findings are that government should continue to prioritise greater resource allocation to public health spending, including towards improving access to formal housing, immunisation coverage, women education and increase targeted interventions on HIV/Aids.

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Keywords: Health Outcomes, Health Prodution Function, Public Health Expenditures, Effectiveness, Under-five Mortality Rate, Life Expectancy

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1 Introduction

The health status of a country's citizens is considered a key precondition for long-term economic growth as well as an outcome of sustainable economic development. Improving the health statuses or the health outcomes of its citizens is thus a key social and economic development goal for most countries. Furthermore, Moreno and Smith (2011) emphasize the importance of health by pointing out that adequate access to the highest attainable standard of health for every citizen is recognized as a fundamental human right and a central component in reversing socioeconomic and health system inequities.

In most countries, public health expenditures are the most common policy instrument to improve health outcomes (World Health Organization 2001). However, whereas some studies (Anyanwu and Erhijakpor 2007; Ashiabi 2013) support the notion that increased public investment in health care has a positive impact on health outcomes, others (Filmer and Pritchett 1999; Thornton 2002) argue that public health expenditure is ineffective in improving health outcomes. As a result, the true nature of this relationship has important policy implications, particularly for developing countries where the appropriate allocation of scarce public funds is key in achieving economic growth and other developmental goals.

In South Africa, investment in health in the form of public health expenditure is important given the need to reverse the legacy of apartheid characterised by poor health conditions for the majority of its citizens. Coovadia et al. (2009) noted that South Africa's history has had a pronounced effect on the health of its people and the health policy and services of the present day. In addition to the legacy effects of apartheid, improved access to health care and health outcomes are also considered a key driver of economic growth and is a highly prioritized developmental goal since the start of the democratic dispensation in 1994 (Burger et al. 2012). This prioritization of health is emphasised in the country's Constitution that promotes universal access to health care services (Republic of South Africa 1996).

To achieve these goals, South Africa invests a large share of its public funds in health care. For example, almost 13% of the consolidated government expenditure was allocated to health care over the 2015 medium term period (National Treasury 2015). This allocation makes the health component one of the biggest public expenditure items in South Africa and has shown significant real growth since the 2002/03 financial year[1] (National Treasury 2015). Based on the provincial health expenditure data (National Treasury 2007, 2014), the per capita public health expenditure increased from R864 in 2002/03 to R2855[2] in 2012/13, at an annual average rate of 12.7% in nominal terms.

Despite the rising allocations and different policy initiatives implemented over the years in South Africa, there is a view that the health system's performance is below the expected level (National Planning Commission 2012; Coovadia et al. 2009; Harris 2010; Hofman, and Tollman 2010). Table 1 compares

[1] The financial year commences in April and ends in March of the following year.

[2] All financial amounts used in this paper are in South African Rand (ZAR). R1 = $0.073

South Africa's investment in health and its health outcomes with a sample of low to high-income countries for 2012.

The country's total investment in health, that is public- and private investment, equates to around 8.8% of its gross domestic product (GDP), which is above the other middle-income countries, and mostly lower than high-income countries. Public health expenditure is also relatively high compared to other upper-middle-income countries. In 2014, public health expenditure as a percentage of GDP was 4.3% compared with the upper-middle income country average of 3.8% (World Bank 2014). Despite this relatively higher level of relative health care expenditure, South Africa seems to lag behind most countries in terms of health outcomes. For instance, South Africa recorded a life expectancy at birth of 57 years, which is the lowest in the sample. In fact, all selected low-income countries in Table 1 have recorded better life expectancy at birth than South Africa, despite the greater health care expenditure in the latter. Within Africa, Mauritius has better health outcomes despite South Africa spending almost double on health care as a percentage of GDP compared to Mauritius.

HIV and Aids prevalence in South Africa is the main reason for lower than expected life expectancy and high child mortality rates in South Africa. Globally, South Africa has the largest number of people living with HIV and Aids, with approximately 6.4 million South Africans infected with the disease in 2015 (Stats SA 2015).

On the contrary to the argument above, a recent review of provincial health expenditures by National Treasury (2014) showed that there have been significant improvements in health outcomes since 2009. For example, the review indicated that life expectancy at birth has increased from 51.6 years in 2005 to 59.6 years in 2013, while under-5 mortality rate has declined from 85.4 to 56.6 per 1 000 live births. This more favourable view is also supported by Mayosi et al. (2012, p. 1) who indicated that since "the 2009 Lancet Health in South Africa Series, important changes have occurred in the country, resulting in an increase in life expectancy to 60 years".

The ambiguity in the literature around the impact of public health expenditure on health outcomes in general is also mirrored in the South African context. The nature of this relationship is important for a developing country like South Africa, where scarce resources are being injected into health under the belief that such investments improve the health status of the general population. This paper empirically tests whether public health expenditure has resulted in an improvement in health outcomes in South Africa. In other words, the paper assesses the effectiveness of public health expenditure in South Africa. The paper specifically looks at two health outcomes, that is, under-five mortality rate, that is the number of children per 1000 live births that die before the age of five, and life expectancy at birth and estimates a health production function using panel data estimation techniques.

The nature of the relationship between public health spending and health outcomes is unclear in the existing literature. Such studies include cross-country studies (Musgrove 1996) using both cross sectional and panel data and, as well as country specific studies. In terms of the latter, this also includes studies

done for African countries (Akinkugbe and Mohanoe 2009; Yaqub et al. 2012). The results of these studies differed depending on the type of study and the data used. The World Health Organization (2007) importantly confirms that health systems are highly context-specific and hence there is no single set of best practices that can be put forward as a model for improved performance. Therefore, country specific studies are important for policy design and implementation. It is likely that results on the impact of public health expenditure on health outcomes differ given the socio-demographic, institutional and economic circumstances of specific countries.

Furthermore South Africa is very different from other countries in the global context because of its unique quadruple burden of disease. According to the National Department of Health (2014), South Africa is burdened by; (i) a very high prevalence of HIV and AIDS which has a synergistic relationship with (ii) TB, (iii) maternal and child morbidity and mortality and an exploding prevalence of (iv) non-communicable diseases[3] mostly driven by risk factors related to life-style as well as violence, injuries and trauma (Mayosi et al., 2009) Added to this is the lack of infrastructure of the country to cope with the increased occurrence of chronic diseases. These facts highlight the uniqueness of the health environment in South Africa and the exceptional challenges the government faces to improve the health outcomes in South Africa.

To date, no previous analysis explicitly tested the relationship between public health spending and health outcomes for South Africa. Whereas recent studies conducted by Burger et al. (2012) and Ataguba et al. (2011) addressed the question of whether the public health care financing led to improvements in access to health care or not, this study directly tests the impact of health expenditure on health outcomes to ascertain the empirical relationship.

2 Health Financing and Outcomes in South Africa - An Overview

South Africa has a dual health care system consisting of public and private health services with minimal financing from donors or non-governmental organisations (NGOs). Public health care expenditure is financed through general tax revenue while the private health care system is dominated by medical aid schemes (medical insurance) (Blecher and Harrison 2006). The government provides health care services to the nation through public hospitals and health clinics throughout the country. According to Blecher and Harrison (2006), the public health system provides virtually universal coverage i.e. all citizens are entitled to use the widely distributed service points and primary health care services are free at the point of service. Most of the population, currently at

[3] Non communicable - or chronic diseases are diseases of long duration and generally slow progression. The four main types of noncommunicable diseases are cardiovascular diseases (like heart attacks and stroke), cancer, chronic respiratory diseases (such as chronic obstructed pulmonary disease and asthma) and diabetes (World Health Organisation (WHO), 2013).

82.1%, depend on public health care provision (Health System Trust 2014) while the remainder share of the population relies on private health care.

Government service delivery is done within a decentralised system with three spheres of government, that is, a national, nine provincial and 278 local governments. The provision of public health care falls mainly under the provincial sphere of government. To illustrate this point, the National Treasury (2015) indicated that the consolidated government expenditure on health was R144.6 billion in 2014/15 financial year of which R140.8 billion (97.4%) was spent by provinces. The role of local government with respect to health is largely limited to environmental health[4] and to a limited extent on emergency medical health services (National Treasury 2015). In terms of this arrangement, health policy is formulated by the National Department of Health while such policies are implemented at a provincial level. In terms of the latter, provinces are responsible for the bulk of the country's health care system through its expenditures.

Unconditional and conditional intergovernmental fiscal transfers from national government to the nine provinces are the main funding instruments of the South African public health system. Public health services are funded mainly through unconditional grants, the largest of which is the provincial equitable share (PES[5]). On the other hand, national health priorities are funded through conditional grants such as health revitalisation grant (for infrastructure), comprehensive HIV/AIDS grant, health professions training and development grant, national health insurance grant and national tertiary services grant. Provincial health expenditure is the key variable used in this study, as the provinces undertake the bulk of the spending on public health care provision in the country.

2.1 Expenditure Trends and Health Outcomes

Over the past decade, public health spending in South Africa via the provinces has increased considerably. One of the primary goals of the increased spending was to improve access to previously disadvantaged and disenfranchised people as a result of apartheid. Ultimately though, improving access to health with increased spending intends to achieve certain changes in the health status of individuals or health outcomes.

The paper uses two measures of health outcomes, namely, the under-five mortality rate and life expectancy at birth. Under-five mortality rate reflects the probability of dying between birth and exactly five years of age expressed per 1000 live births. According to Anyanwu and Erhijakpor (2007), under-five mortality rate is also regarded as a sensitive indicator of the availability, utilization and effectiveness of health care. Figure 1 illustrates the relationship between public health expenditure and under-five mortality rate in South Africa.

[4] Environmental Health is the field of science that studies how the environment influences human health and disease (World Health Organization, 2014).

[5] Provincial equitable share is an unconditional allocation or cash transfer of nationally raised revenue to provinces to fund the provision of services and is formula based. The equitable share component of nationally raised revenue is distributed equitably among the three spheres of government (National Treasury, 2015). Health funding forms part of the provincial equitable share allocation.

Source: Authors calculations using data from National Treasury (2007; 2015) and Health Systems Trust (2014)

Figure 1 confirms the steady increase in public health spending from 2002 onwards. However, this has not been mirrored by the trends in the under-five mortality rate. The under-five mortality rate for South Africa has been on a declining trend since 2002 although the rate of decline has slowed since 2009 onwards despite significant increases in public health spending over the same period. A general observation is that under-five mortality rate decreases as nominal public health expenditure rises. For the period 2002 to 2014, the annual average rate of growth in public health expenditure was 12.8% while the annual average rate of decline in under-five mortality was 4.3%. In nominal terms, the public health expenditure grew from R32.3 billion in 2002/03 to R140.9 billion in 2014/15. This may be due to a lag effect of expenditure where current expenditure impacts outcomes in future time periods.

Figure 2 demonstrates the relationship between public health expenditure and life expectancy at birth in South Africa.

The Health Systems Trust (2014) defines life expectancy at birth as the average number of additional years a person could expect to live if the current mortality trends were to continue for the rest of that person's life. Overall, life expectancy at birth improved from 52.5 years in 2002 to 59.5 years in 2014. It should be noted that although the life expectancy measure is showing an improvement, this is still well below the MDG target of 70 years by the end of 2015.

The relationship between public health expenditure and life expectancy at birth was negative for the period 2002 to 2005. From 2006 onwards, a positive relationship between public health expenditure and life expectancy at birth emerged although there are signs of negative relationship re-emerging since 2013. Public health expenditure rose at an annual average rate of 12.8% while life expectancy at birth rose at an annual average rate of 1% for the period 2002 to 2014.

The observations above about the relationship between health outcomes (under-five mortality rate and life expectancy at birth) must be interpreted with caution as there are many factors other than public health expenditure that influence health outcomes. As a result, the impact of public health expenditure on health outcomes needs to be assessed while taking into account other control variables such as income, female literacy rate, the number of physicians, among others.

3 Health Expenditure and Health Outcomes: A Theoretical Framework

The theoretical framework used in this paper is the health production function approach. The health production function framework draws from the work undertaken by Mosley and Chen (1984) regarding the economics of household

production of health and Grossman's (1972) model of demand for health. With respect to health, households combine purchased goods and services and their time (inputs) to produce health (DaVanzo and Gertler 1990; Schumann and Mosley 1994). The demand for goods and services and behaviours that influence health is often derived from the demand for health (DaVanzo and Gertler 1990; Grossman 1972). In other words, Grossman (1972) suggests that most health influencing behaviours such as obtaining medical care are valued for their effect on health. In this framework, the demand for health is explained with the use of the health production function, where health is being "produced" into a health status.

The health production function is a technological process that converts the use of goods, services and time that affect health into a health status (DaVanzo and Gertler, 1990). Grossman (1972) made an important contribution to the literature by separating the biological health production function from the behavioural input demand function thereby allowing the use of socio-economic inputs such as income and government expenditure in the production function estimation. According to DaVanzo and Gertler (1990), individuals' decisions to use the proximate determinants of health inputs such as nutrition and the use of medical care are determined by socio-economic variables like income and education. Therefore, the analytical framework by Mosley and Chen (1984), which incorporates social, economic, biological and environmental variables in the production of health, is an extension of the health production function by Grossman (1972).

Essentially, the argument follows that the socio-economic status influences the proximate determinants of health and risk of disease and these in turn directly influence health and mortality outcomes (Hu and Mendoza 2013; Mosley and Chen 1984). In summary, the following pattern governs the relationship between health outcomes and health spending in terms of Mosley and Chen (1984) analytical framework:

$$Socio-economic\ status \rightarrow\ proximate\ determinants\ \rightarrow\ risk\ of\ disease \rightarrow health\ outcomes$$

Therefore, in general, the socio-economic inputs such as public health expenditure, income (GDP) and level of education do not directly impact health outcomes but indirectly through proximate determinants. For example, public health expenditures provides resources for the purchase of vaccines while the literacy level of the mother may assist with correct usage of the prescribed medication leading to better health outcomes. Mosley and Chen (1984) group these proximate determinants as maternal factors (age, parity and birth interval), environmental contamination (air, food, water etc.), nutrient deficiencies (calories, protein and micronutrients), injury (accidental and intentional) and personal illness control (personal preventative measures and medical treatment). With regards to the risk of disease, Mosley and Chen (1984) identified both chronic and acute diseases as the ones directly influencing health status or outcome.

According to DaVanzo and Gertler (1990), much of the empirical research on factors influencing health outcomes treats all inputs (socio-economic status inputs, proximate determinant inputs and risk of disease inputs) as explanatory variables. However, the treatment of all inputs as explanatory variables might introduce an element of endogeneity, in which the explanatory variables correlate with the error term, due to unobserved factors. Therefore in the estimation of health production functions possible endogeneity issues should be considered in the analyses.

According to Ashiabi (2013), one of the main features of the health production function is the law of diminishing marginal productivity. This implies that as more health inputs are used, more health is produced but successive additions to the quantity of health inputs employed results in smaller increments in health. Hence, the relationship between health inputs and health outcome is expected to be non-linear and non-monotonic. The principle of diminishing marginal productivity in the production of health is portrayed in the difference in the experiences of developing and developed countries. In developing countries where both health outcomes and health inputs are very low, small increases in health inputs results in relatively larger impacts on health outcomes than the advanced countries where health outcomes and health inputs are very high. It is for this reason that the evaluation of measures designed to promote health must be conducted within the same context in which they are being considered.

4 Health Expenditure and Health Outcomes: The Nature of the Relationship in Previous Empirical Work

4.1 A general ambiguity on the nature of the relationship

The empirical assessment of the relationship between health expenditures and health outcomes has received increased attention since the 1990s. Empirical evidence suggests mixed results with some studies finding a positive-, other a negative- and yet some other statistically not significant relationships between public health expenditure and health outcomes.

Although an increase in public health expenditure may be expected to improve health outcomes through increase in access to health care services, Moreno and Smith (2011) argued that the increase in public health spending might also lead to not significant improvement in health outcomes. This may be due to an increase in public health expenditure being accompanied by a commensurate reduction in private health expenditures. In turn, this could lead to no changes in total spending and potentially no significant changes in health status. Furthermore, positive consequences in terms of health outcomes may not arise if the additional funds are spent mainly on low productivity inputs (Moreno and Smith 2011). Examples of such inputs are better tertiary care when the real gains are in extended primary care and services (Wagstaff and Claeson, 2004).

Moreno-Serra and Smith (2011) observed that much of the research (especially in the early 1990s) had focused on identifying simple correlations between public health expenditures and health outcomes using cross-sectional data. In this regard, earlier work by Musgrove (1996) found no systematic evidence of an effect of health expenditures on mortality indicators such as child death rates. In this study, Musgrove (1996) used a cross-sectional data of 69 randomly chosen countries from the Organisation for Economic Co-operation and Development (OECD), developing and other developed countries in 1991. An analysis was done through ordinary least squares regression.

Musgrove's (1996) finding of no systematic relationship between health expenditures and health outcomes was supported by other empirical studies. These include Filmer and Pritchett (1999) which found that, at best, low levels of public spending impacts on under-five and infant mortality and that of Thornton (2002), which found that additional medical care expenditure is relatively ineffective in lowering mortality and increasing life expectancy. In contrast, a later cross-sectional study by Bokhari et al. (2007) found that a 10% increase in government health expenditure per capita leads to average reductions of 3.3% and 5% in under-five and maternal mortality rates, respectively. They used cross-sectional data for 127 countries for the calendar year 2000.

However, by focusing on cross-sectional data, these studies neglected the importance of time effects when assessing the effectiveness of public health expenditures, which has an impact on the overall conclusion of these studies. Generally, one would expect a lag in terms of the impact of public expenditure on health outcomes. For example, the effects of higher expenditure on antiretrovirals to treat HIV/Aids will only be evident a few years later after the expenditure took place. As to be expected, these changes over time will not be captured through cross-sectional data analysis, as there is no time effect.

Further studies looking at the impact of health expenditure on health outcomes expanded on the initial use of cross sectional data to focus more on panel data. A study by Cremieux et al. (1999) used a panel data for 10 Canadian provinces over the period 1978–1992. The number of observation in the study was 150 and fixed effects estimation technique was used. The study found that lower health care spending is associated with a statistically significant increase in infant mortality and a decrease in life expectancy in Canada. In other words, public health expenditure was found to be an important determinant of health outcomes. Apart from the fact that this was a provincial specific study, the study by Cremieux *et al.* (1999) differed with other earlier studies in that it accounted for the time effects of the impact of public expenditure on health outcomes.

Furthermore, recent econometric studies using panel data have found evidence of increased public health spending leading to better health outcomes (Moreno-Sera and Smith 2011; Anyanwu and Erhijakpor 2007; Brown et al. 2014; Craigwell et al. 2012; Hu and Mendoza, 2013; Rajkumar and Swaroop 2008; Wagstaff and Claeson 2004). For example, using panel data for up to 120 countries from 1960 to 2000, Wagstaff and Claeson (2004) found statistically significant beneficial effects of government spending (as a proportion of GDP)

on under-five and maternal mortality.

Several studies have attempted to provide further explanations on why results of studies assessing the effectiveness of public health expenditure are mixed. For example, studies by Farahani et al. (2010) and that by Anyanwu and Erhijakpor (2007) suggested that the mixed results were due to the fact that public health expenditure has different effects on people of different socio-economic status. In other words, these studies emphasized that that the relationship between public health expenditure and health outcomes is stronger in low-income countries than in high-income countries. This argument is often validated by the earlier cross-country studies limited to poor countries (Anand and Ravallion, 1993; Bidani and Ravalion, 1996) that found that public health spending has a statistically significant effect on health outcomes. The empirical finding of greater returns to health care financing in developing countries as opposed to developed countries conforms to the theory of diminishing returns associated with a health production function, as discussed above. It is likely that health outcomes in developing countries are at lower levels, thus making the returns to health care financing higher and significant when compared to their developed counterparts.

The survey of literature thus far has shown that cross-country studies dominate the literature, although there are some country specific studies in the literature. One of the earliest country-specific studies is that of Cremieux *et al.* (1999) already discussed above. In Africa, a country specific study was conducted by Akinkugbe and Mohanoe (2009). The study looked at the impact of public health expenditure on the health status in Lesotho using time series analysis (Error Correction Model). The study found that, in addition to public health expenditures, the availability of physicians, female literacy and child immunisation significantly influences health outcomes in Lesotho.

In South Africa, most empirical studies examined the relationship between increased public health spending and inequities in access to health, as opposed to actual impacts on health outcomes (see Ataguba et al. 2010; Burger et al. 2012). The conclusions of these studies are mixed with Ataguba et al. (2010) showing that increased public health funding has not improved access to health care while Burger et al. (2012) show that increased public health funding has resulted in significant improvement in the access to primary health care in South Africa. It should be noted that an increase in access could lead to an improvement in health outcomes. This study extends the current research on health care financing in South Africa by assessing the direct relationship between public health expenditure and health outcomes to explicitly test for a relationship. The study also contributes to general literature by contributing to country specific studies using panel estimates, with a focus on a middle-income developing country.

5 Methodology and Data

This paper estimates an aggregate health production function for South Africa using provincial level data in order to assess the effectiveness of public health expenditure on health outcomes. As already explained, the health production function model is based on the Grossman (1972) theoretical model. According to Fayissa and Gutema (2005), the model treats social, economic and environmental factors as inputs of the production system.

This approach is in line with that of Filmer and Pritchett (1999) although it differs in that panel data estimation techniques are followed. It is suggested in the literature that the major advantages of estimating an aggregate health production function is that estimates of the overall effect of medical care utilization (health expenditures) on the health status of the population can be obtained (Thornton 2002; Fayissa and Gutema 2005). It is also argued that this information can assist policy makers and practitioners in the search for cost effective mechanisms of providing health services and the reallocation of health resources in such a way that the gains from health spending could be optimized (Fayissa and Gutema 2005; Fayissa and Traian 2011). The Grossman (1972) health production function that incorporates the conceptual framework of Mosley and Chen (1984) will take the following functional form:

$$Health = f\,(socio-economic\ variables,\ proximate\ determinants,\ risk\ of\ disease) \quad (1)$$

In line with the approach by Novignon et al. (2012), the health production function model specified in a panel form as follows:

$$y_{it} = X_{it}\beta + \varepsilon_{it}, t = 1 \ldots T \quad (2)$$

$$\varepsilon_{it} = \mu W_i + v_{it} \quad (3)$$

Where y_{it} is a vector of dependent variables in a province i at time t, X is a vector of exogenous variables including the constant, and β is a vector of coefficients while ε_{it} is a vector of random error terms. The error process in equation (2) is decomposed into a summation of two components in equation (3); time invariant μW and the remainder error process v_{it}.

As observed by Anyanwu and Erhijakpor (2007), the specification in equation (2) is consistent with the literature and allows for the identification of the channels through which government expenditure and other policy interventions affect health outcomes over time. In other words, the panel data specification exploits the time dimension of the subjects and controls for the unobserved provincial specific effects.

Based on the general form estimation in equation 2, the following model was estimated for under-five mortality rate and life expectancy at birth.

$$InHEA_{it} = \beta_0 + \beta_1 InPh\exp_{it} + \beta_2 InGDPpc_{it} + \beta_3 Flr_{it} + \beta_4 Atw_{it} + \beta_5 Phiv_{it} + \beta_6 Icr_{it} + \beta_7 InPhys_{it} + \beta_8 Atfd_{it} + \beta_9 AgeDistr_{it} + \varepsilon_{it} \quad (4)$$

Where *Hea* represents health outcomes such as, under-five mortality rate and life expectancy at birth (outputs) while inputs are assumed to be *Phexp* (public health expenditure per capita i.e. the variable of interest), *GDPpc* (real GDP per capita), *Flr* (female literacy rate), *Atw* (access to piped water), *Phiv* (HIV/Aids prevalence level), *Icr* (immunisation coverage ratio), *Phys* (the number of physicians per 100 000 of the population), $Atfd$ (access to formal dwelling or housing) and *AgeDistr* (the share of the population aged less than 0 to 14 years). Equation 4 was estimated using pooled OLS, fixed effects, random effects and two stage least squares (2SLS) instrumental variable estimation methods. The Hausman and Breusch-Pagan Lagrange multiplier tests determined the appropriate choice of estimation method.

With the exception of HIV/Aids prevalence, all other control variables have been used consistently in other studies (Homaie et al. 2013; Craigwell et al. 2012; Filmer and Pritchett 1999; Ashiabi 2013; Akinkugbe and Mahanoe 2009; Anyanwu and Erhijakpor 2007; Novignon et al. 2012). Natural logarithms are used in the specified econometric model in equation 4 in order to normalize the data and capture elasticities, which helps with interpretation of results in the assessment of the strength of the relationship between health outcomes and public health expenditures in South Africa. However, natural logarithms are not applied to variables that are already in percentages.

The use of the HIV/Aids prevalence variable highlights the importance of estimating country specific health functions. South Africa is characterised by a relatively high level of people living with HIV/Aids, unlike other countries globally. This country specific effect has a significant impact on health outcomes. According to Statistics South Africa (2013), although the leading natural causes of death in South Africa is TB, influenza and pneumonia and intestinal infectious diseases, HIV/Aids consistently increased its share as a natural cause of death in recent years. It was also pointed out that these leading causes of death are generally some of the most common opportunistic infections associated with HIV/Aids. Statistics South Africa (2013) indicated that HIV/Aids accounted for the largest share of 46% on the causes of under-five deaths in 2008. Therefore, controlling for this effect not only improves on the estimation but would also assist policy makers in understanding the impacts of this disease on the general health status of the population.

Table 2 summarises descriptive statistics for both dependant variables and independent variables (regressors). Generally, South Africa suffers from a lack of mortality and life expectancy data. The unavailability of these data is due to a "lack of data completeness and comprehensiveness" (McKerrow and Mulaudzi 2010, p. 60) in data collection processes. South Africa, for example, started reporting official infant mortality rates and maternal mortality rates from only 1998 onwards. This data was initially collected via the South African

Demographic and Health Surveys (SADHS), which were conducted after every five-year period. As a result, there has not been a consistent series of data on under-five mortality and life expectancy until the year 2002.

The study will cover a period of ten years from 2005 to 2014. This means that the study will have a balanced panel of 90 observations given that there are nine provinces in South Africa. The use of provincial level data is motivated by the fact that the bulk of public health spending (about 90%) occurs at this sphere of government (National Treasury 2015). Although it would have been desirable to have a longer time series, there are missing values in the datasets for the period prior to 2005 for most variables.

The time period covered in this study coincides with the roll-out of antiretroviral therapy (ART) programmes in South Africa, which were introduced in September 2004 and was supported and in part funded by the US Emergency Plan for AIDS Relief (PEPFAR). The introduction of ART most likely affected the health outcome variables used in this study as was shown in the study of Bor et al. (2013) which analysed data for rural areas in Kwa-Zulu Natal. They found that the life expectancy at birth rate improved markedly after the roll-out of ARTs from 49.2 years in 2003 to 60.5 years in 2011 (Bor et al. 2013). Furthermore a study by Bendavid et al (2012) found that PEPFAR, which was operated in twelve African countries contributed to the improvement of adult life expectancy. However, the authors report that South Africa did not have suitable data and was not included in the analysis, therefore it cannot inconclusively be said that this also applies to South Africa (Bendavid et al., 2012) As data on PEPFAR- and donor funding is not available across all provinces over the study period it was not possible to include spending on public health derived from donor funding. Furthermore the funding of ART by province for the time period under analysis suffer from missingness across provinces and within the time period under investigation is, hence spending on ART was not separated out from the public health expenditure variable used in this paper. Availability of such data would make for interesting future research. .Therefore, in this paper the authors assume that ART spending is included in the public health expenditure variable. Nevertheless all results should be interpreted by keeping the effects of the roll-out of the ART programme in mind, which might bias the estimated coefficient on public health expenditure somewhat. Two separate regressions using under-five mortality rate and life expectancy at birth will be conducted in order to capture the impact of public health expenditure on health outcomes. Data on these variables is sourced from the Health Systems Trust database (Health Systems Trust. 2014). Provincial financial data on public health expenditure was sourced from the National Treasury yearly audited expenditure outcomes (National Treasury 2007, 2014). Data on population, female literacy rates, households with access to piped water, access to formal dwelling or housing were all sourced from Statistics South Africa's General Household Survey (Statistics South Africa 2014). The regional GDP figures per province were sourced from Statistics South Africa's GDP publication (Statistics South Africa 2015). HIV/Aids prevalence data was sourced from the National Department of Health's annual national antenatal sentinel HIV and Herpes Simplex

Type-2 prevalence surveys (National Department of Health 2014). Lastly, the Health Systems Trust was the source of data on immunisation coverage ratio and physicians per hundred thousand of the population (Health Systems Trust 2014)..

6 Estimation Results[6]

6.1 Under-Five Mortality Rate Results

According to Baum (2008), the public health care expenditure variable has the potential to have reverse causality (simultaneity) with health outcomes because the level of expenditure is likely to be partially determined by the historical incidence of the disease in each jurisdiction. In this regard, Moreno-Serra and Smith (2015) argue that studies that fail to account for this simultaneity explicitly through instrumental variable regressions will have their empirical conclusions substantially biased. As such, in addition to pooled OLS, FE and RE estimations, 2SLS instrumental variable regressions for panel data are estimated in this paper. The lagged public health expenditure was used as an instrument. The results of the F-statistic and the Hansen J-statistic revealed that the instrument is strong and valid. The choice of the model to interpret results is based on the Hausman specification test, Breusch Pagan Lagrange Multiplier test and the endogeneity test. See Table 3 for the estimation results and the test statistics.

Although endogeneity was assumed to be present in the model and hence the IV-2SLS specification, the endogeneity test on the public health expenditure has a chi-square of 1.625 ($p = 0.2$) suggesting that the variable is exogenous. Therefore, in this analysis we assume that there is no reverse causality between public health expenditure and the under-five mortality rate and that the causality runs from public health expenditure to the under-five mortality rate. This finding indicates that other variables, such as provincial budgets, might be a more likely predictor of the level of public health expenditure than the under-five mortality rate. The Hausman test in Table 3 shows that the fixed effects model is the preferred model as the null hypothesis stating that the difference in coefficients is not systematic is rejected (*chi-square* = 7423.2, (p=0.00)).

From Table 3, *public health expenditure per capita* (variable of interest) has the expected sign and is statistically significant in the four specifications presented. In the FE model, it is statistically significant at a 1% level of significance. Using the chosen fixed effects model, the public health expenditure per capita variable has an elasticity of -0.350 suggesting that a 1% increase in public health expenditure per capita will on average result in about 0.4% decline in under-five mortality rate in South Africa holding other influences constant. In other words, public health expenditure positively influences improvements in the under-five mortality rate. The finding is consistent with cross-country studies in Africa

[6] All models were tested for violations including heteroskedasticity and autocorrelation. These issues were corrected using robust standard errors and clustering respectively.

(see Anyanwu and Erhijakpor 2007; Novignon *et al.*, 2012; Ashiabi 2013). The finding is also consistent with the country specific study conducted in Lesotho by Akinkugbe and Mahanoe (2009), which also found that public health expenditure is significantly negatively related to infant mortality rate. The elasticity on the public health expenditure per capita found in this study is slightly higher than the -0.21 elasticity reported by Anyanwu and Erhijakpor (2007) for African countries.

With regard to control variables, immunisation coverage ratio, access to formal dwelling or housing and the age share of the population aged 0-14 years are statistically significant. This means that a 1% increase in immunisation coverage will on average result in a decline of 0.1% in under-five mortality rate in South Africa holding other influences constant. This finding is in line with that Akinkugbe and Mahanoe (2009). Along the same line, a 1% increase in the access to formal dwelling/housing will on average, result in a decline of 0.6% in under-five mortality rate in South Africa holding other influences constant. On the other hand, a 1% increase in the share of the population aged 0-14 years will on average, result in an increase of 1% in under-five mortality rate in South Africa holding other influences constant.

It is interesting to find that the FE results reveal that although the signs of the estimated coefficients of real GDP per capita and female literacy rate are as expected, the variables are not statistically significant in explaining the under-five mortality rate. This might be due to the indirect relationship between these variables and especially the health outcome variables of young children, where the availability of vaccines, a direct predictor of health, might play a bigger role than indirect predictors (Hu and Mendoza 2013; Mosley and Chen 1984). Furthermore these results might also reflect the lack of quality data around the estimates of child mortality in South Africa (see Nannan et al. 2012). This is because the vital registration data of births is incomplete, and the methods for estimating mortality from household surveys and censuses are biased in high HIV prevalence settings, which underestimate child mortality (Nannan et al. 2012). Nevertheless the results warrants further investigation into the relationship between socio-economic status indicators such as GDP per capita and female literacy rate, and the mortality rate of young children.

6.2 Life Expectancy at Birth Results

Table 4 provides results of the life expectancy at birth regressions. The Hausman specification test shows that the fixed effects model is preferred over random effects model (chi - $square$ = 47.3, p=0.00). However, the test statistic for endogeneity is 3.629 (p= 0.05) meaning that the null hypothesis that the public health expenditure is exogenous is rejected and the 2SLS-IV model is used for the interpretation of results.

Public health expenditure per capita (Logphexp) as the main explanatory variable is statistically not significant although it has the expected sign. This outcome shows that it seems that there is no statistically significant relationship between public health expenditure and the health outcome variable life

expectancy at birth. This finding can suggest that there are other factors that impact on life expectancy at birth that play a greater role in improving this health outcome. This finding is inconsistent with the findings of the other studies (Novignon et al. 2012; Anyanwu and Erhijakpor 2007; Akinkugbe and Mahanoe 2009; Craigwell et al. 2012; Cremieux et al. 1999). However, the finding of statistical not significant is in line with the finding by Filmer and Pritchett (1999), De Mello and Pisu (2009) and Thornton (2002).

With regard to control variables, GDP per capita, female literacy rate (Flr), HIV/Aids prevalence and access to formal dwelling/housing were statistically significant. The GDP per capita is statistically significant at 10% level of significance. This means that a 1% increase in GDP per capita will on average, result in improvement in life expectancy by 0.2% holding other influences constant. The female literacy rate is statistically significant at 1% level of significance. This means that a 1% increase in female literacy rate will on average, result in an increase of 0.2% in life expectancy at birth in South Africa holding other influences constant. Furthermore, an increase of 1% in access to formal dwelling/housing will on average, result in an increase of life expectancy at birth by 0.3% holding other influences constant.

On the other hand, a 1% increase in HIV/Aids prevalence will on average, result in a decline of 0.4% in life expectancy at birth in South Africa holding other influences constant. Once again, the negative influence of HIV/Aids prevalence on life expectancy at birth is consistent with the finding of Novignon *et al.* (2012). The positive influence of female literacy rate on life expectancy at birth supports the findings by Akinkugbe and Mahanoe (2009).

In summary, results have shown that life expectancy at birth is influenced by real GDP per capita (income), female literacy rate, HIV/Aids prevalence and access to formal dwelling/housing. Contrary to most cross-country studies in Africa, there is no statistically significant relationship between public health expenditure and life expectancy at birth in South Africa.

7 Conclusion

The aim of this paper was to assess the effectiveness of public health expenditure by estimating the health production function for South Africa using panel data and instrumental variable estimation techniques. Results have shown that on average, an increase in public health expenditure leads to improvement in under-five mortality. Although there is a positive relationship between public health expenditure and life expectancy at birth, such a relationship was found to be statistically not significant.

Nonetheless tests on reversed causality showed that it is likely that simultaneity exists between public expenditure and life expectancy, implying that life expectancy also has an effect on public expenditure.

From the results it seems that the under-five mortality rate is more sensitive to changes in public health expenditure than life expectancy at birth. As such, public expenditure directed to increases in health care spending on

improvements in under-five mortality as opposed to life expectancy, should be prioritised.

In line with most studies, real GDP per capita is an important determinant of life expectancy at birth in South Africa. This means that for South Africa, measures to increase real GDP per capita, female literacy rate, immunisation coverage ratio, access to formal dwelling or housing and the reduction of HIV/Aids prevalence are more likely to be successful in improving health outcomes.

Based on the findings, the key policy implication for the government of South Africa is that it should continue to prioritise public health expenditure through an increase of the share of public health spending within each province's equitable share in order to improve health outcomes such as under-five mortality rate. Furthermore, the government should implement measures to improve income by growing the economy, increase the immunisation coverage, increase resources towards educating women, implement policies that improves access to formal housing, and the targeted interventions for HIV/Aids prevention. The analysis suggests that these measures can lead to improvement in health outcomes in South Africa. The finding that there is no statistically significant relationship between the life expectancy at birth and public health expenditure needs further investigation as this finding is counter intuitive though it is similar to the finding of Filmer and Pritchett (1999), De Mello and Pisu (2009) and Thornton (2002).

Given that HIV/Aids prevalence is found to play a statistically significant role in reducing life expectancy at birth in South Africa, the country's approach of significantly improving the roll-out of ART programme and the prevention of mother to child transmission (PMCT) programme is justified and it was shown in the literature to positively impact health outcomes (Bor et al., 2013). Although this is commendable, the number of new infections remains high in South Africa and more emphasis should be placed on preventing new HIV infections if more gains in increasing life expectancy are to be realized.

Although the results have shown a statistically significant relationship between public health expenditure and under-five mortality rate in South Africa and a statistically not significant relationship between public health expenditure and life expectancy at birth, interpretations of these results must always be made with caution. For instance, the study was unable to account for the impact of private health expenditure and governance (bureaucratic capacity) as well as HIV/Aids development assistance programmes such as PEPFAR and the Global Fund on the reported health outcomes due to unavailability of data at a provincial level for the specified time period. Furthermore, it seems that the quality of data on the under-five mortality rate in South Africa might be of poor quality and results in which this data is used should be interpreted with caution.

Despite these limitations, the study provides important insights about the determinants of health outcomes in South Africa. It is recommended that future studies should look at the efficiency of public health expenditures in order to assess if public investments in health yields value for money given the current

tight fiscal space. Such a study will not only complement the findings of this paper but would be important in justifying South Africa's current proposal for a National Health Insurance scheme. Furthermore, the assessment of public health expenditure effectiveness at a programme level will provide insights about which programmes have the most impacts and this will determine how public health expenditure should be prioritised.

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Table 1: Comparative analysis of health expenditures and health outcomes, 2014[1]

Country	Total health Expenditure as a % of GDP	Health expenditure per capita (Current US $)	GDP per capita (Current US $)	Life expectancy at birth	Infant mortality rate
High Income Countries					
Australia	9.4	6 031	61 996	82	3
Canada	10.4	5 292	50 186	82	4
Sweden	11.9	6 808	58 900	82	2
United	9.1	3 935	46 278	81	4
USA	17.1	9 403	54 398	79	6
Middle Income Countries					
Botswana	5.4	385	7 153	64	36
Brazil	8.3	947	8 539	74	14
Chile	7.8	1 137	14 566	82	7
Malaysia	4.2	456	11 301	75	6
China	5.5	419	7 587	76	9
Mauritius	4.8	483	10 003	74	12
Russia	7.1	893	13 902	70	9
South	**8.8**	**570**	**6 472**	**57**	**34**
Thailand	6.5	360	5 970	74	11
Low Income Countries					
Bangladesh	2.8	31	1 087	72	32
Cambodia	5.7	61	1 095	68	26
India	4.7	75	1 577	68	39
Kenya	5.7	78	1 369	62	37
Malawi	11.4	29	362	63	45
Nepal	5.8	40	701	70	31
Average	**7.6**	**1 872**	**18 172**	**73**	**18**

Source: World Bank, 2014

[1] This table uses data from the World Bank in order to conduct cross-country comparisons and hence the monetary values are in USA Dollar ($). The year 2014 was chosen because it is the most recent year where consistent data on all variables could be obtained from the World Bank database.

Table 2: Descriptive statistics

†

Variable	Name of variables used in the analysis	Obs	Mean	Std.Dev	Min	Max
Health Outcomes						
Under-five mortality rate	Umr	90	52.6	17.3	23.9	91.9
Life Expectancy at Birth	Le	90	57.1	4.7	47.8	65.0
Regressors						
Public Health Expenditure per Capita	Phexp	90	2 197	792	801	3 962
Real GDP per Capita	GDPpc	90	51 956	13 462	28 659	80 966
Female Literacy Rate	Flr	90	81.7%	9.4%	64.2%	95.1%
Access to Piped Water	Atw	90	89.4%	8.1%	68.8%	99.6%
Prevalence of HIV/Aids	Phiv	90	27.8%	7.4%	15.1%	40.4%
Immunisation Coverage Ratio	Icr	90	84.6%	12.0%	58.3%	115.1 %
Physicians per hundred thousand	phys	90	26.38	7.08	15.80	45.00
Access to formal dwelling/housing	Atfd	90	87.2%	5.9%	76.2	96.3%
Age share of the population (0-14) years	AgeDistr	90	31.4%	3.3%	23.6%	39.8%

†

The time period covered is 2005-2014 for the nine provinces in South Africa
Source: Own computation using STATA 13

Table 3: Regression results for under-five mortality rate (health outcome)

Regressors	Pooled OLS	FE	RE	IV-2SLS
Logphexp	-0.246**	-0.350***	-0.246***	-0.355***
	(0.082)	(0.065)	(0.082)	(0.043)
Loggdppc	-1.119***	-0.283	-1.119***	-0.336
	(0.157)	(0.314)	(0.157)	(0.223)
Flr	-0.719***	-0.213	-0.719***	-0.166
	(0.165)	(0.123)	(0.165)	(0.147)
Atw	1.291*	-0.255	1.291**	-0.088
	(0.640)	(0.341)	(0.640)	(0.293)
Phiv	3.160***	0.377	3.160***	0.105
	(0.298)	(0.578)	(0.298)	(0.364)
Icr	0.353**	-0.139**	0.353***	-0.130**
	(0.107)	(0.056)	(0.107)	(0.061)
Atfd	0.045	-0.565***	0.045	-0.424
	(0.368)	(0.136)	(0.368)	(0.317)
AgeDistr	-2.372*	0.978**	-2.372*	1.045***
	(1.310)	(0.394)	(1.310)	(0.397)
Logphys	0.018	0.137	0.018	0.131
	(0.147)	(0.088)	(0.147)	(0.078)
Intercept	16.78***	9.775***	16.78***	10.51***
	(1.805)	(2.804)	(1.805)	(2.227)
R-Squared	0.93	0.99	0.93	0.93
Test statistics				
BP-LM Test for Random Effects: chibar2 (01)				0.000
Prob > chibar2				1.000
Hausman Test for FE vs RE: chi-sq (9)				7423.200
Prob > chi2				0.000
F-test for Excluded Instruments				240.810
P-value				0.000
Endogeneity Test for Endogenous Regressor Logphexp: chi-sq (1)				1.625
P-value				0.200

N=90. Cluster robust standard errors (in parentheses) were obtained in order to control for arbitrary heteroscedasticity and auto-correlation. ***Indicates significance at 1 % confidence level, **indicates significance at 5 % confidence level and * indicates significance at 10 per cent confidence level using two-tailed tests. Overall R-Squared is used for the RE model while the within R_Squared is used for the FE model. For IV-2SLS regressions, the lagged public health expenditure per capita (L.Logphexp) was used as instrument for the public health expenditure per capita explanatory variable. For the IV-2SLS-FE, the xtivreg2 estimator was used in order to get tests for the used instrument while the intercept is from the xtivreg estimator.

Source: Own computation using STATA 13

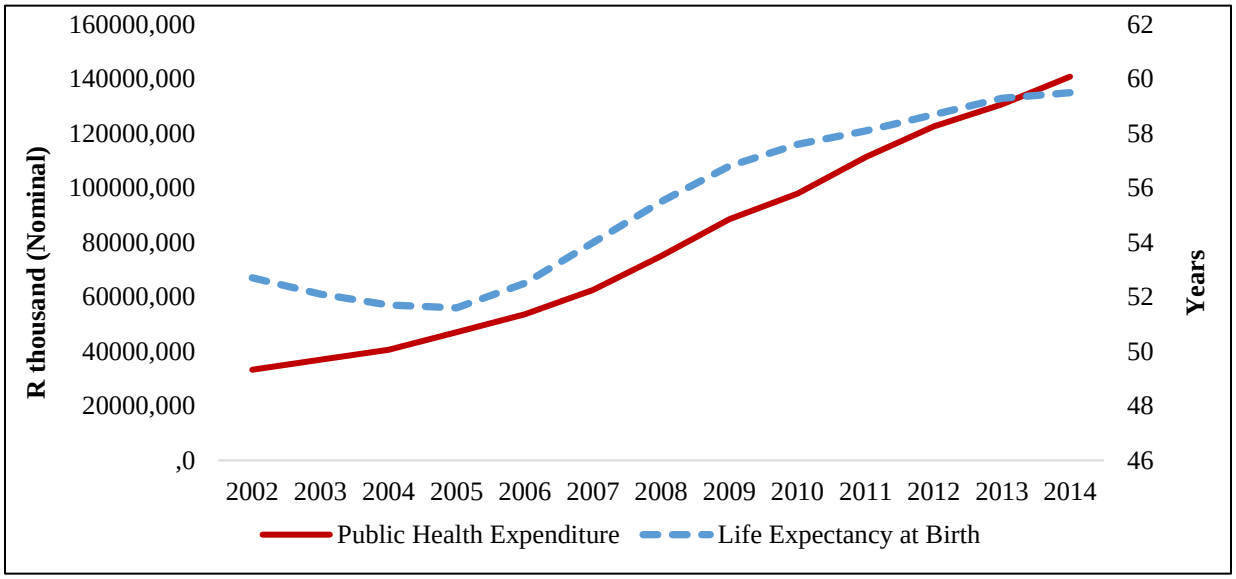
Table 4: Regression results for life expectancy at birth (health outcome)

Regressors	Pooled OLS	FE	RE	IV-2SLS
Logphexp	0.039	0.046	0.039*	0.027
	(0.023)	(0.040)	(0.023)	(0.026)
Loggdppc	0.211***	0.129	0.211***	0.244*
	(0.050)	(0.171)	(0.050)	(0.143)
Flr	0.232***	0.142	0.232***	0.198** *
	(0.060)	(0.093)	(0.060)	(0.075)
Atw	-0.304	0.130	-0.304	0.075
	(0.185)	(0.129)	(0.185)	(0.140)
Phiv	-0.826***	-0.331	-0.826***	-0.351*
	(0.075)	(0.277)	(0.075)	(0.190)
Icr	-0.033	0.008	-0.033	0.020
	(0.047)	(0.050)	(0.047)	(0.029)
Atfd	0.334**	0.335*	0.334**	0.312*
	(0.140)	(0.178)	(0.140)	(0.177)
Logphys	-0.065	-0.027	-0.065*	-0.018
	(0.034)	(0.059)	(0.034)	(0.035)
Intercept	1.722***	1.959	1.722***	1.992
	(0.480)	(1.707)	(0.480)	(1.625)
R-Squared	0.91	0.99	0.91	0.73
Test statistics				
BP-LM Test for Random Effects: chibar2 (01)				0.000
Prob > chibar2				1.000
Hausman Test for FE vs RE: chi-sq (9)				47.030
Prob > chi2				0.000
F-test for Excluded Instruments				101.500
P-value				0.000
Endogeneity Test for Endogenous Regressor Logphexp chi-sq (1)				3.629
P-value				0.050

N=90. Cluster robust standard errors (in parentheses) were obtained in order to control for arbitrary heteroscedasticity and auto-correlation. ***Indicates significance at 1 % confidence level, **indicates significance at 5 % confidence level and * indicates significance at 10 per cent confidence level using two-tailed tests. Overall R-Squared is used for the RE model while the within R-Squared is used with the FE model. For IV-2SLS regression, the lagged public health expenditure per capita (L.Logphexp) was used as an instrument for the public health expenditure per capita explanatory variable. For the IV-2SLS-FE, the xtivreg2 estimator was used in order to get endogeneity test for the instrumented variable while the intercept is from the xtivreg estimator.

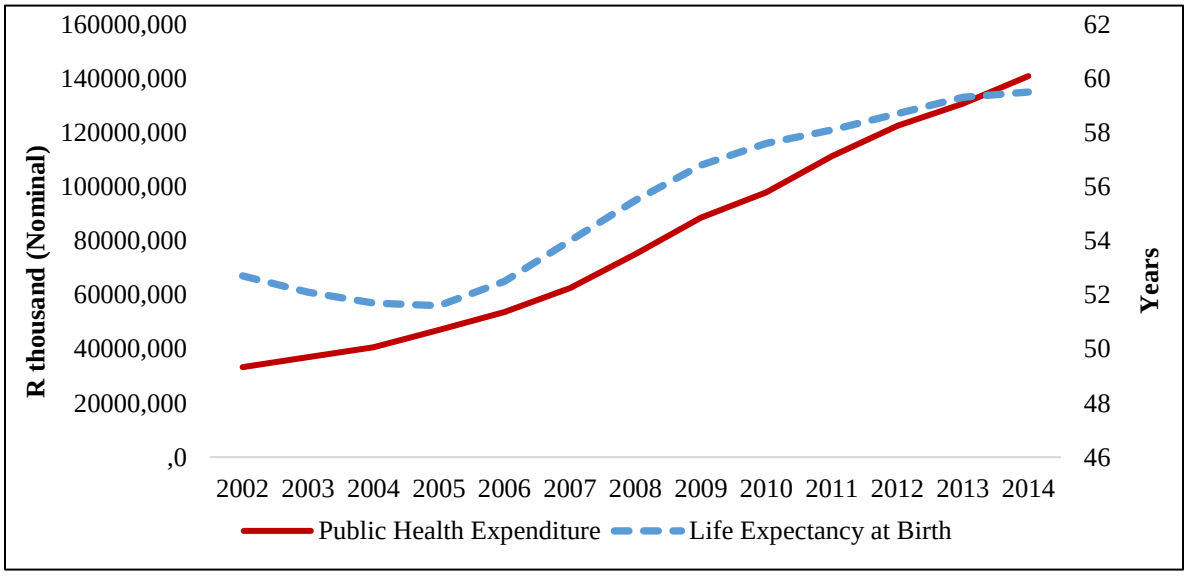
Source: Author's estimations using STATA 13

Figure 1: Public health expenditure versus under-five mortality rate in South Africa, 2002-2014



Source: Author's calculations using data from National Treasury (2007; 2015) and Health Systems Trust (2014)

Figure 2. Public health expenditure versus life expectancy at birth in South Africa, 2002-2014



Source: Author's calculations using data from National Treasury (2007; 2015) and Health Systems Trust (2014)