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THE EFFECTIVENESS OF PUBLIC HEALTH SPENDING IN SOUTH AFRICA

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802000029

A minor dissertation submitted in partial fulfilment of the requirements for the degree of

Master of Commerce in Development Economics

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31 May 2015
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DECLARATION

I, Mr Mashudu Lucas Bidzha, declare that:

a) The research reported in this minor dissertation, except where otherwise indicated, is my original research.

b) This minor dissertation has not been submitted for any degree or examination at any other university.

c) This minor dissertation does not contain other person’s data, pictures, graphs or other information, unless specifically acknowledged as being sourced from that person.

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Signed at……………………………on the…………..day of……………………………2015

………………………………………………….
Mr Mashudu Lucas Bidzha
ABSTRACT

Health holds a unique position in sustainable economic development because it is a precondition for and an outcome of economic development. The aim of this minor dissertation was to investigate the effectiveness of public health expenditure on health outcomes by estimating the health production function for South Africa. In this minor dissertation, infant mortality rate and life expectancy at birth were used as measures of health outcomes. A panel of nine provinces over the period 2005 to 2012 was used. This minor dissertation uses data from National Treasury for public health expenditure while data on health outcomes is sourced from the Health Systems Trust. Fixed effects and random effects panel data estimation techniques were used in order to control for time effects and individual province heterogeneity. This study is essential in order to assess the effectiveness of South Africa’s health programmes and to enable evidence based policy design and implementation thereof. Results have shown that on average, an increase in public health expenditure per capita leads to improvement in health outcomes particularly infant mortality rate and life expectancy at birth. The estimated gains are largest with regards to infant mortality rate which has elasticity of -0.368 and smaller on life expectancy at birth with elasticity of 0.059. Therefore, these findings provide evidence to support the claim that public health expenditure improves health outcomes. HIV/Aids prevalence and female literacy rate were also found to be important determinants of health outcomes in South Africa. These findings are important for policy design and enhancement of our knowledge about the factors that affect health outcomes in South Africa. The key policy implication of these findings is that government should increase public health expenditure by increasing the share of public health spending within each province’s equitable share. Furthermore, the government should increase resources towards educating women and increase the targeted interventions on HIV/Aids especially prevention of new infections.

JEL Classifications: I12, I18, H51

Key Words: Health Outcomes, Health Production Function, Public Health Expenditures, Effectiveness, Infant Mortality Rate, Life Expectancy.
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<tr>
<td>AIDS</td>
<td>Acquired Immune Deficiency Syndrome</td>
</tr>
<tr>
<td>ART</td>
<td>Antiretroviral Therapy</td>
</tr>
<tr>
<td>ASSA</td>
<td>Actuarial Society of South Africa</td>
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<tr>
<td>BRICS</td>
<td>Brazil, Russia, India, China and South Africa</td>
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<tr>
<td>DBE</td>
<td>Department of Basic Education</td>
</tr>
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<td>DHIS</td>
<td>District Health Information System</td>
</tr>
<tr>
<td>DPME</td>
<td>Department of Planning, Monitoring and Evaluation</td>
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<tr>
<td>DORA</td>
<td>Division of Revenue Act</td>
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<td>FE</td>
<td>Fixed Effects</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
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<td>GHS</td>
<td>General Household Survey</td>
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<td>GLS</td>
<td>Generalized Least Squares</td>
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<tr>
<td>IMR</td>
<td>Infant Mortality Rate</td>
</tr>
<tr>
<td>IV-2SLS</td>
<td>Instrumental Variable Two Stage Least Squares</td>
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<tr>
<td>HIV</td>
<td>Human Immunodeficiency Virus</td>
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<td>HST</td>
<td>Health Systems Trust</td>
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<td>MDG</td>
<td>Millennium Development Goals</td>
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<td>MTEF</td>
<td>Medium Term Expenditure Framework</td>
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<tr>
<td>NDP</td>
<td>National Development Plan</td>
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<tr>
<td>NGO</td>
<td>Non-Governmental Organisation</td>
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<td>NHI</td>
<td>National Health Insurance</td>
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<td>NPC</td>
<td>National Planning Commission</td>
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<td>NSDA</td>
<td>Negotiated Service Delivery Agreement</td>
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<td>Acronym</td>
<td>Description</td>
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<tr>
<td>OLS</td>
<td>Ordinary Least Squares</td>
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<td>PFMA</td>
<td>Public Finance Management Act</td>
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<td>PMCT</td>
<td>Prevention of Mother to Child Transmission</td>
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<td>RE</td>
<td>Random Effects</td>
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<td>SADC</td>
<td>South African Development Community</td>
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<td>SADHS</td>
<td>South African Demographic and Health Survey</td>
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<td>SSA</td>
<td>Sub-Saharan Africa</td>
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<td>StatsSA</td>
<td>Statistics South Africa</td>
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<tr>
<td>UNAids</td>
<td>Joint United Nations Programme on HIV/AIDS</td>
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<tr>
<td>VIF</td>
<td>Variance Inflation Factor</td>
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<td>WHO</td>
<td>World Health Organization</td>
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CHAPTER 1: INTRODUCTION

1.1 Background of the Study

Health holds a unique position in sustainable economic development because it is a precondition for and an outcome of economic development. In other words, health is a contributor to the achievement of sustainable development and health outcomes can be improved through sustainable development. 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.

Homaie, Vahedi, Teimourizad, Esmaeilzadeh, Hadian and Torabi (2013) agree with this view when they concede that the improvement and expansion of health will always be a priority given its impact on development. Furthermore, the importance of health is also evident in the Millennium Development Goals for 2015 where three of the eight goals are aimed at improving health. These goals are to reduce child mortality, improve maternal health and combat HIV and malaria, amongst others.

To achieve these goals, Sartorius, Chirwa and Fonn (2011) suggest a range of investments such as; increased health sector spending, investments aimed at socio-economic progress to improve nutrition, housing, hygiene, education and gender equality amongst others. Given resource constraints, it is not clear which investment area should a country prioritise in order to achieve maximum impact in improving health outcomes. In most countries, public health expenditures are the most common policy instrument to improve health outcomes (World Health Organization, 2001). However, whereas some (Anyanwu & Erhijakpor, 2007; Ashiabi, 2013) are convinced that public investment in health care improves health outcomes, others (Filmer & Pritchett, 1999; Thornton, 2002) argue that public health expenditure is ineffective in improving health outcomes. As a result, a need to assess whether increased public health expenditure results in improvement in health outcomes or not arises.
1.2 Motivation for the Study

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 majority of the citizens. The negative impact of the apartheid legacy on health was emphasized by Coovadia, Jewkes, Barron, Sanders and McIntyre (2009). They 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. As a result of this legacy, health became highly prioritized in South Africa at the start of the democratic dispensation in 1994 (Burger, Bredenkamp, Grobler, & Van der Berg, 2012). The prioritization of health is demonstrated in Section 27 (1) (a) of the Constitution of South Africa which states that “everyone has the right to have access to health care services”.

Emanating from the country’s constitution is government’s outcome 2, which captures the government’s goal of achieving “a long and healthy life for all South Africans” (Department of Planning, Monitoring and Evaluation, 2014:1). In order to accomplish this goal, four priority goals have been identified as follows: (1) increase life expectancy, (2) decrease maternal and child mortality, (3) combat HIV and AIDS and decrease the burden of tuberculosis (TB), and (4) strengthen health system effectiveness (Department of Planning, Monitoring and Evaluation, 2014). These priorities formed part of an overarching strategy that influenced how public health resources were distributed for the period 2009-2014.

To achieve these goals, South Africa invests a large share of its public funds in health care as about 13 percent of the consolidated government expenditure will be 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. Furthermore, National Treasury (2015) pointed out that the average annual growth in spending on public health services has been above inflation since the 2002/03 financial year. Based on the provincial health expenditure data, the per capita public health expenditure increased from R864 in 2002/03 to R2855 in 2012/13, at an annual average rate of 12.7 percent in nominal terms.

1 These amounts are in South African Rand (ZAR).
However, these large investments in public provision of health do not necessarily imply that health outcomes of a country will improve. Given that public funds contribute significantly to the provision of health care and that these funds could be spent on other pressing priorities such as education or safety and security, there is a natural interest in assessing whether public funds are achieving their intended purpose.

Further motivation for focusing on the public health expenditure is that public health care benefits about 82.1 percent of the population (Health System Trust, 2014) while the remainder share of the population relies on private health care. The heavy reliance on the public sector occurs despite the public health expenditure having a lower share of the total health expenditure in South Africa.

1.3 Problem Statement

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, 2009; Hofman, & Tollman, 2010). The country’s low life expectancy at birth of 58.7 years in 2012, which is well below the global average of 70 years, is often cited to support the view that the country’s health care is performing poorly (World Bank, 2015; Statistics South Africa, 2013). In addition, the country’s relatively high infant mortality rate of 33.2 deaths per 1 000 is also pointed out as a reason that health system is performing below its potential (Statistics South Africa, 2013). Furthermore, these 2012 levels of health outcomes are well below the Millennium Development Goal’s targets for life expectancy at birth and infant mortality rate of 70 years and 18 deaths per 1 000 live births, respectively.

More evidence that supports the view that South Africa’s health system’s performance is below potential is provided by the annual World Economic Forum country rankings. In this ranking, South Africa’s health performance based on health outcomes is consistently ranked lower despite significant increases in public health expenditure in the recent years. In fact, the World Economic Forum (2014) ranks South Africa at 132 among 144 nations with regards to the performance of selected health indicators such as life expectancy at birth, infant mortality rate and prevalence of HIV/Aids.
In contrast to the negative view about South Africa’s health performance discussed above, there is an emerging view (especially from government) that paints a positive picture about South Africa’s health performance in recent times. A recent review of provincial health expenditures by National Treasury (2015) 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 positive view is also captured by Mayosi, Lawn, Van Niekerk, Bradshaw, Abdool-Karim and Coovadia (2012:1) 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”. Although there are different views in South Africa about the extent to which public health expenditure affects health outcomes, it is surprising that this issue has received little attention in the economic literature.

1.4 Research Question

The discussion above triggers the question: does public health care expenditure lead to improvement in health outcomes in South Africa? In other words, the aim of this minor dissertation is to assess the effectiveness of public health expenditure in South Africa. To achieve this goal, this minor dissertation will assess the relationship between public health expenditure and infant mortality rate as well as the relationship between public health expenditure and life expectancy at birth.

These relationships will be assessed through the estimation of the health production function using panel data estimation techniques. The assessment of these relationships is important especially in developing countries. One of the fiscal policy options available to governments in these countries is a change in the composition and direction of public expenditure in the attempt to improve the social welfare of their citizens (Akinkugbe & Mohanoe, 2009). This policy option is important for most developing countries in that government expenditures constitute a significant proportion of national income and the use of annual fiscal budget to increase the consumption of a specific goods and services of the poor has the capacity to transfer and redistribute income.
1.5 Contribution to the Literature

Although there has been several empirical studies assessing the relationship between health outcomes and health expenditures internationally (see Akinkugbe & Mohanoe, 2009; Anyanwu & Erhijakpor, 2007; Ashiabi, 2013; Baldacci, Guin-Siu & de Mello, 2003; Novignon, Olakajo & Nonvignon, 2012; Costa, 2011; Hu & Mendoza, 2013; Homaie et al., 2013 amongst others), there is no such study that has been conducted in South Africa to the best of my knowledge. Recent international studies (see Novignon et al., 2012; Costa, 2011; Hu & Mendoza, 2013; Homaie et al., 2013; Nasab et al., 2013) have assessed the relationship between public health expenditures and health outcomes. In Africa, most of these studies are conducted at a cross-country level with limited country specific studies. However, as pointed out by the World Health Organization (2007), 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.

Thus far, there are only two country level studies in Africa that looked at the relationship between public health expenditure and health outcomes (Akinkugbe & Mohanoe, 2009; Yaqub, Ojapinwa & Yussuf, 2012). These studies assessed the effectiveness of public health expenditure in Lesotho and Nigeria, respectively. Although these country-specific studies make a significant contribution to the literature, the omission of an important explanatory variable such as HIV/Aids prevalence in the estimated models makes these assessments incomplete given the high prevalence of HIV/Aids in Sub-Saharan Africa, especially within the SADC region. In this regard, UNAids (2013) estimated that the HIV/Aids prevalence in Lesotho among the age group of 15 to 49 years was 22.9 percent in 2013. This was even higher than South Africa’s prevalence rate of 19.1 percent during the same period.

In emphasizing the importance of HIV/Aids in the analysis, Grigoli and Kapsoli (2013) suggest that if factors such as contagious disease indicators (tuberculosis and HIV diffusion) are not incorporated in the analysis, then conclusions reached on the assessment of the relationship between public health spending and outcomes can be misleading. Mandl, Dierx & Ilzkovitz (2008) adds that environmental factors are crucial in the analysis of efficiency and effectiveness. In this regard, this minor dissertation makes a contribution to the previous country-specific
studies in that the study controls for the prevalence of HIV/AIDS and this is important for a country within sub-Saharan Africa.

Within the South African context, the approach of this minor dissertation builds on the recent studies conducted by Burger et al. (2012) and Ataguba et al. (2011) who addressed the question of whether the public health care financing led to improvements in access to health care or not. In these studies, access to health care represented the output when measuring the effectiveness of public health expenditure. This minor dissertation builds on these studies by assessing the impact of health expenditure on health outcomes directly. In other words, the minor dissertation assesses public health spending effectiveness in terms of health outcomes (infant mortality rate and life expectancy at birth) with output (access to health care and quality of health services) implicit in the process.

1.6 Significance of the Study

Understanding the relationship between public health spending and health outcome in South Africa is important. Although there is a rich literature that looked at the relationship between public health expenditure and health outcomes for many countries and regional economies, there appears to be a lack of empirical research in South Africa using recent provincial level data. Furthermore, South Africa has a constitutional framework that endorses the right to have access to health care for the population while at the same time the country is a signatory to a wide range of treaties and conventions that promote health care (Statistics South Africa, 2013). Therefore, it is essential for the country to assess the effectiveness of its programmes in order to design and implement better policy options when it comes to health.

1.7 Structure of Minor Dissertation

This minor dissertation is organised as follows: Chapter 2 presents a comparative overview of health expenditures and health outcomes in selected countries and also provides trends in health financing and health outcomes in South Africa. Chapter 3 provides a survey of both theoretical and empirical literature. It also discusses the concept of efficiency and effectiveness and their applications in assessing public health performance. Chapter 4 outlines the methodology followed to estimate the health production function, definitions of variables used as well as their
data sources, presentation of descriptive statistics, description of the empirical model and the estimation technique as well as the criteria to use when choosing between fixed effects and random effects models. Chapter 5 includes the presentation and discussion of the estimated results. Finally, chapter 6 concludes and presents some policy implications of the empirical analysis.
CHAPTER 2: HEALTH EXPENDITURES AND HEALTH OUTCOMES

2.1 Introduction

This chapter compares South Africa’s health expenditures and health outcomes with that of selected countries at different income levels. This is done in order to provide a comparative analysis and to demonstrate the limitations of static cross-country analysis. Furthermore, an overview of South Africa’s health financing structure is also provided. The overview is done by looking at South Africa’s intergovernmental system and its implications in the provision of public health care. The overview section also looks at the funding instruments for public health care in South Africa, composition of health expenditure in South Africa as well as the assessment of a share of private and public health expenditure to the country’s total health expenditure. This brief assessment is provided to demonstrate inequity in health financing in South Africa.

Thereafter, the chapter looks at the trends in health outcomes such as infant mortality rate and life expectancy at birth in South Africa. Finally, a section on the relationship between public health expenditure and health outcomes in South Africa is presented followed by a conclusion.

2.2 International Comparison of Health Expenditures and Health Outcomes

Although South Africa is generally considered to be a middle-income country in terms of the size of its economy (see Coovadia et al., 2009; Blecher & Harrison, 2006), some of the country’s health outcomes are worse than those of low-income countries. As a result, comparative data presented in Table 1 is from selected countries with different income levels (high-income, middle-income and low-income countries). An additional group known as the BRICS countries was also included in the table given that South Africa belongs to the economic grouping of countries including Brazil, Russia, India and China. High-income countries were included to serve as a benchmark for financially well-resourced countries.
Table 1: Comparative Analysis of Health Expenditures and Health Outcomes, 2012²

<table>
<thead>
<tr>
<th>Country</th>
<th>Health Expenditure as a % of GDP</th>
<th>Health expenditure per capita (Current US $)</th>
<th>GDP per capita (Current US $)</th>
<th>Life expectancy at birth</th>
<th>Infant mortality rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Income Countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>9.1</td>
<td>6 140</td>
<td>67 525</td>
<td>82</td>
<td>4</td>
</tr>
<tr>
<td>Canada</td>
<td>10.9</td>
<td>5 741</td>
<td>52 409</td>
<td>81</td>
<td>5</td>
</tr>
<tr>
<td>Sweden</td>
<td>9.6</td>
<td>5 319</td>
<td>57 134</td>
<td>82</td>
<td>2</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>9.4</td>
<td>3 647</td>
<td>41 054</td>
<td>82</td>
<td>4</td>
</tr>
<tr>
<td>United States of America</td>
<td>17.9</td>
<td>8 895</td>
<td>51 496</td>
<td>79</td>
<td>6</td>
</tr>
<tr>
<td>BRICS Countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>9.3</td>
<td>1 056</td>
<td>11 320</td>
<td>74</td>
<td>13</td>
</tr>
<tr>
<td>China</td>
<td>5.4</td>
<td>322</td>
<td>6 093</td>
<td>75</td>
<td>12</td>
</tr>
<tr>
<td>India</td>
<td>4.0</td>
<td>61</td>
<td>1 503</td>
<td>66</td>
<td>44</td>
</tr>
<tr>
<td>Russia</td>
<td>6.3</td>
<td>887</td>
<td>14 091</td>
<td>70</td>
<td>9</td>
</tr>
<tr>
<td>South Africa</td>
<td>8.8</td>
<td>645</td>
<td>7 314</td>
<td>56</td>
<td>33</td>
</tr>
<tr>
<td>Middle Income Countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Botswana</td>
<td>5.3</td>
<td>384</td>
<td>7 255</td>
<td>47</td>
<td>41</td>
</tr>
<tr>
<td>Chile</td>
<td>7.2</td>
<td>1 103</td>
<td>15 246</td>
<td>80</td>
<td>8</td>
</tr>
<tr>
<td>Malaysia</td>
<td>3.9</td>
<td>410</td>
<td>10 440</td>
<td>75</td>
<td>7</td>
</tr>
<tr>
<td>Mauritius</td>
<td>4.8</td>
<td>444</td>
<td>8 862</td>
<td>74</td>
<td>13</td>
</tr>
<tr>
<td>Thailand</td>
<td>3.9</td>
<td>215</td>
<td>5 480</td>
<td>74</td>
<td>11</td>
</tr>
<tr>
<td>Low Income Countries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bangladesh</td>
<td>3.6</td>
<td>26</td>
<td>862</td>
<td>70</td>
<td>35</td>
</tr>
<tr>
<td>Cambodia</td>
<td>5.4</td>
<td>51</td>
<td>946</td>
<td>71</td>
<td>34</td>
</tr>
<tr>
<td>Kenya</td>
<td>4.7</td>
<td>45</td>
<td>1 166</td>
<td>61</td>
<td>49</td>
</tr>
<tr>
<td>Malawi</td>
<td>9.2</td>
<td>25</td>
<td>267</td>
<td>55</td>
<td>46</td>
</tr>
<tr>
<td>Nepal</td>
<td>5.5</td>
<td>36</td>
<td>699</td>
<td>68</td>
<td>33</td>
</tr>
<tr>
<td>Average</td>
<td>7.2</td>
<td>1 773</td>
<td>18 058</td>
<td>71</td>
<td>21</td>
</tr>
</tbody>
</table>


Despite increases in public health funding in South Africa over the years, the data (if compared to other countries such as high-income countries, BRICS countries, middle-income countries and low-income countries) shows low achievement of key health outcomes (see Table 1). In addition, Table 1 shows that South Africa spends about 8.8 percent of its GDP on health care which is

² 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 2012 was chosen because it is the most recent year where consistent data on all variables could be obtained from the World Bank database.
above the calculated 7.2 percent average for these selected countries (World Bank, 2015). Actually, only high-income countries, BRICS country like Brazil and surprisingly Malawi which is a lower income country, spent a higher percentage of their GDP on health care in 2012 than South Africa.

Apart from South Africa’s favourable health expenditure as a percentage of GDP, the country’s GDP per capita as a measure of economic progress also compares well with BRICS and middle-income countries, although South Africa has higher levels of inequality compared with these countries (Bhorat, Hirsch, Kanbur & Ncube, 2013). Within BRICS, only Brazil and Russia have higher GDP per capita than South Africa. Despite higher levels of per capita GDP, South Africa seems to lag behind when it comes to health outcomes. For instance, South Africa recorded a life expectancy at birth of 56 years and infant mortality rate of 33 deaths per 1 000 live births in 2012 and these outcomes are poor compared to most BRICS countries. Actually, South Africa recorded the lowest life expectancy at birth of all the BRICS countries with the highest being China at 75 years. Furthermore, with the exception of Malawi, all selected low-income countries in Table 1 have recorded better life expectancy at birth than South Africa while Nepal also equalled South Africa’s infant mortality rate.

Within Africa, Mauritius has better health outcomes despite South Africa spending almost double on health care as a percentage of GDP compared to Mauritius. To illustrate this point, Mauritius spent only 4.8 percent of its GDP on health care while South Africa spent 8.8 percent. However, Mauritius has recorded a higher life expectancy at birth of 74 years and a higher infant mortality rate of 13 deaths per 1000 live births in 2012. Overall, the presented data in Table 1 suggests that South Africa’s performance relating to health outcomes seems to be poor when compared with that of most countries at different income levels despite significant resources invested in health.

In South Africa, most economists and analysts assess the effectiveness of health spending through the use of expenditure reviews, programme evaluations, performance informed budgeting and static cross-country comparison like the one presented in Table 1 (see Blecher, Kollipara, De Jager & Zulu, 2011; Harris, 2010; Makube, 2011). The cross-country analysis
from Table 1 does not consider structural economic and social issues that may impact health outcomes and these are captured through the use of impact assessment approach.

2.3 Health Financing in South Africa

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). The government provides health care services to the nation through public hospitals and health clinics throughout the country. Services provided range from in- and out-patient care to preventive care and promotion of health services (Makube, 2011). In the next sections, I discuss South Africa’s intergovernmental system, funding instruments for public health care in South Africa, composition of health expenditure in South Africa and lastly the share of private and public health expenditures.

2.3.1 South Africa’s intergovernmental system and public health care

In order to understand South Africa’s public health financing and related spending on health, a brief look at the intergovernmental system is essential. South Africa’s intergovernmental system is a unitary but decentralized system in which government is made up of three spheres (Ajam & Aron, 2007). These spheres are national, provincial and local. Practically, the national sphere determines policy while the provincial and local spheres serve as implementing authorities.

In South Africa, 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 percent) was transferred directly to provinces as part of the provincial equitable share and conditional grants administered by the National Department of Health. The role of local government with respect to health is largely limited to environmental health and to a

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3 Provincial equitable share is an unconditional allocation or cash transfer of a nationally raised revenue to provinces to fund the provision of services. Equitable share component of nationally raised revenue is distributed equitably among the three spheres of government (National Treasury, 2015).

4 Environmental Health is the field of science that studies how the environment influences human health and disease (World Health Organization, 2014). Environment, in this context, means things in the natural environment like air, water and soil, and
limited extent on emergency medical health services (National Treasury, 2015). While there may still be some clinics still run by municipalities, all municipal clinics and primary health centres are supposed to be transferred to the provincial departments of health through the process known as the provincialisation of municipal clinics (see Naledi, Barron & Schneider, 2011).

2.3.2 Funding instruments for public health care in South Africa

Fiscal transfers to provinces are the core funding instrument of the South African public health system. The exception is local government which funds this function from local government equitable share, its own revenue sources and to a limited extent from the provincial transfers in cases where the provincialisation of municipal clinics is not yet completed. Fiscal transfers can either be conditional or unconditional (equitable share) and are allocated through the annual Division of Revenue (DOR) within the context of a three-year Medium Term Expenditure Framework commonly referred to as MTEF (Makube, 2011).

Public health services are funded mainly through the provincial equitable share (PES) formula. 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.

As previously discussed, the provision of public health care in South Africa falls under the provincial sphere of government (see Table 2). In this regard, the 2015 Division of Revenue Act indicates the health component of the provincial equitable share as 27 percent of the total allocated provincial equitable share budget (National Treasury, 2015). This equitable share is based on the risk-adjusted index, which is an index of each province’s health risk profile that is mainly based on the share of the population without medical aid cover (National Treasury, 2015).

also all the physical, chemical, biological and social features of our surroundings (World Health Organization, 2014). It also refers to the theory and practice of assessing, correcting, controlling, minimising and preventing those factors in the environment that can adversely affect the health of present and future generations.
However, public health expenditure at a provincial level can become a victim of competing priorities for limited provincial budgets. For example, funds are sometimes reprioritised away from health to other departments facing spending pressures which often leads to poor health care delivery in public hospitals. This argument has also been made by the National Planning Commission (2012), which observed that the share of the budget going to health has been erratic in all provinces for some time. For example, in 2011/12 financial year, Mpumalanga provincial government allocated the smallest share of 25 percent of the total provincial budget to health while the Western Cape provincial government allocated the largest share of 36 percent of the total provincial health budget (National Treasury, 2015).

The previous discussion has shown that provincial governments possess significant discretion on how provincial resources are allocated to various departments. With regards to resource allocation, the role of the National Department of Health is limited to conditional grants (Makube, 2011; Financial Mail, 2014). In recent times, there has been a debate on whether the current constitutionally based intergovernmental fiscal relations system contributes to the poor achievement or not of health outcomes in South Africa given the power that provinces possess with regards to resource allocations (see Financial Mail, 2014)\(^5\).

2.3.3 Composition of health expenditure in South Africa

From a funding perspective, this section explains the notion that South Africa has a dual health care system consisting of public and private health services. In other words, South Africa’s health care financing system is characterised by a public sector, financed through general tax revenue and a private system dominated by medical aid schemes (Blecher & Harrison, 2006). 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. Table 2 summarises the composition of the total health expenditure in South Africa over the 2007/08 to 2013/14 period.

\(^5\) It should be noted that the assessment of the impact of fiscal decentralization on health outcomes is beyond the scope of this minor dissertation.
Table 2: Health Expenditures (Rand million) in South Africa, 2007/08 - 2013/14

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>National Department of Health</td>
<td>1,210</td>
<td>1,436</td>
<td>1,645</td>
<td>1,736</td>
<td>1,846</td>
<td>1,961</td>
<td>2,064</td>
<td>8.4%</td>
</tr>
<tr>
<td>Provincial departments of Health</td>
<td>62,582</td>
<td>75,120</td>
<td>88,593</td>
<td>98,066</td>
<td>110,014</td>
<td>119,003</td>
<td>126,831</td>
<td>12.5%</td>
</tr>
<tr>
<td>Defence</td>
<td>1,878</td>
<td>2,177</td>
<td>2,483</td>
<td>3,150</td>
<td>3,400</td>
<td>3,733</td>
<td>3,733</td>
<td>12.1%</td>
</tr>
<tr>
<td>Correctional Services</td>
<td>261</td>
<td>282</td>
<td>300</td>
<td>318</td>
<td>339</td>
<td>356</td>
<td>374</td>
<td>6.2%</td>
</tr>
<tr>
<td>Local government (own revenue)</td>
<td>1,625</td>
<td>1,793</td>
<td>1,829</td>
<td>1,865</td>
<td>1,977</td>
<td>2,095</td>
<td>2,221</td>
<td>5.3%</td>
</tr>
<tr>
<td>Workmen’s Compensation</td>
<td>1,287</td>
<td>1,415</td>
<td>1,529</td>
<td>1,651</td>
<td>1,718</td>
<td>1,804</td>
<td>1,894</td>
<td>6.7%</td>
</tr>
<tr>
<td>Road Accident Fund</td>
<td>764</td>
<td>797</td>
<td>740</td>
<td>860</td>
<td>980</td>
<td>1,029</td>
<td>1,080</td>
<td>5.9%</td>
</tr>
<tr>
<td>Education</td>
<td>1,833</td>
<td>2,134</td>
<td>2,350</td>
<td>2,503</td>
<td>2,653</td>
<td>2,812</td>
<td>2,981</td>
<td>8.4%</td>
</tr>
<tr>
<td><strong>Total Public Health Expenditure</strong></td>
<td>71,440</td>
<td>85,154</td>
<td>99,469</td>
<td>110,149</td>
<td>122,865</td>
<td>132,424</td>
<td>141,075</td>
<td>12.0%</td>
</tr>
<tr>
<td>Medical Schemes</td>
<td>65,468</td>
<td>74,089</td>
<td>84,863</td>
<td>96,482</td>
<td>104,008</td>
<td>112,120</td>
<td>120,866</td>
<td>10.8%</td>
</tr>
<tr>
<td>Out of Pocket</td>
<td>14,694</td>
<td>15,429</td>
<td>16,200</td>
<td>17,172</td>
<td>18,202</td>
<td>19,294</td>
<td>20,452</td>
<td>5.7%</td>
</tr>
<tr>
<td>Medical Insurance</td>
<td>2,179</td>
<td>2,452</td>
<td>2,660</td>
<td>2,870</td>
<td>3,094</td>
<td>3,336</td>
<td>3,596</td>
<td>8.7%</td>
</tr>
<tr>
<td>Private Employer</td>
<td>1,041</td>
<td>1,172</td>
<td>1,271</td>
<td>1,372</td>
<td>1,479</td>
<td>1,594</td>
<td>1,718</td>
<td>8.7%</td>
</tr>
<tr>
<td><strong>Total Private Health Expenditure</strong></td>
<td>83,382</td>
<td>93,142</td>
<td>104,994</td>
<td>117,896</td>
<td>126,783</td>
<td>136,344</td>
<td>146,632</td>
<td>9.9%</td>
</tr>
<tr>
<td>Donors or NGOs</td>
<td>3,835</td>
<td>5,212</td>
<td>6,319</td>
<td>5,787</td>
<td>5,308</td>
<td>5,574</td>
<td>5,853</td>
<td>7.3%</td>
</tr>
<tr>
<td><strong>Total Health Expenditure</strong></td>
<td>158,657</td>
<td>183,508</td>
<td>210,782</td>
<td>233,832</td>
<td>254,956</td>
<td>274,342</td>
<td>293,560</td>
<td>10.8%</td>
</tr>
</tbody>
</table>

| Total as a % of GDP | 7.6 | 7.9 | 8.6 | 8.8 | 8.7 | 8.6 | 8.3 |
| Public Expenditures as a % of GDP | 3.4 | 3.7 | 4.1 | 4.1 | 4.2 | 4.0 | 4.0 |
| Private financing as a % of Total Health Expenditure | 45.0 | 46.4 | 47.2 | 47.0 | 48.1 | 48.2 | 48.0 |
| Donors or NGOs as a % of Total Health Expenditure | 52.6 | 50.8 | 49.8 | 50.5 | 49.8 | 49.7 | 50.0 |
| Private financing as a % of Total Health Expenditure | 2.4 | 2.8 | 3.0 | 2.5 | 2.1 | 2.0 | 2.0 |


Table 2 shows that the total public health expenditure is made up of funds from the National Department of Health, Department of Defence, Department of Correctional Services, local

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6 The public health expenditure data presented in Table 2 are based on the audited spending outcomes and the monetary values are in South African Rand (ZAR). The financial data are in nominal terms.
government, workmen’s compensation, Road Accident Fund and the Department of Education. The bulk of private health expenditure is mainly from the medical schemes followed by out of pocket financing. It is also shown in Table 2 that, on average, 89 percent of public health expenditure is allocated to provinces which confirms earlier observation that public health in South Africa is a provincial government competence.

2.3.4 Share of public and private health expenditures to total health expenditure

The gap between private and public health expenditures reveals a narrowing trend when assessing the expenditure data from 2007/08 to 2013/14 financial years (see Figure 1). This observation is also supported by the annual average growth rates in spending over the period 2007/08 to 2013/14, which showed that the total public health spending grew by 12 percent while the private health expenditure grew by 9.9 percent in nominal terms. The public health expenditure as a percentage of GDP has grown from 3.4 percent in 2007/08 to 4 percent of GDP in 2013/14. It must be noted that the public health expenditure remained constant around 4 percent of GDP for the period 2009/10 to 2013/14. Figure 1 summarises the share of public and private health expenditures to total health expenditure in South Africa since the 2007/08 financial year.

![Figure 1: Percentage Share of Public and Private Health Expenditures to Total Health Expenditure, 2007/08-2013/14](image)

*Source: Author’s calculations using data from the National Planning Commission (2012) and National Treasury (2014)*
Figure 1 shows that the gap between public and private expenditures seems to have remained constant since 2011/12 financial year with private share continuing to be above the public share of the total health expenditure. It is also shown in Figure 1 that the private share of health expenditures has always been above the public share since 2007/08 financial year despite the private health care benefiting only about 17.9 percent of the total population (Health Systems Trust, 2014).7

The observation that private share of health spending is higher than the public share is also supported by the respective per capita health expenditure data. For example, in 2012/13 financial year, the per capita public health expenditure (total) was R3 086 while the per capita private health expenditure was R14 571 over the same period (National Treasury, 2014; Statistics South Africa, 2013).

The fact that the private share of health expenditure per capita is more than four times higher than the public share of health expenditure per capita reveals inequities in the financing of health in South Africa. This observation was also made by Blecher and Harrison (2006), who noted that the most significant challenge facing the South African health system is to address the inefficient and inequitable distribution of resources between the public and private health sectors relative to the population served by each sector.8 In this financing arrangement, the public health sector has lesser resources compared with the private sector but has to deal with the higher disease burden among the uninsured population. According to the National Treasury (2015), government seeks to address this through the introduction of the National Health Insurance (NHI), which aims to provide universal health coverage to all citizens.

7 Trends in medical aid coverage rate per province are presented in Figure 10 under Appendix 1.

8 Detailed discussions about inequities in health financing in South Africa are beyond the scope of this minor dissertation.
2.4 Health Outcomes in South Africa

During the period 2009-2014, South Africa (through the National Department of Health) committed itself to the Negotiated Service Delivery Agreement (NSDA)\(^9\), which focused on improving health outcomes. Despite this well-intended approach and significant increases in public health expenditure over time, the health outcomes presented in this section suggest that South Africa has not performed to the expected level although there have been significant improvements in health outcomes since 2007.

For the period 2014 to 2019, South Africa’s strategic focus for the health sector has been revised to align it with the country’s National Development Plan 2030 vision for health. According to the Department of Planning, Monitoring and Evaluation (2014), by 2030, South Africa should have; raised the life expectancy of South Africans to at least 70 years, produced a generation of under-20s that is largely free of HIV, reduced the burden of disease, achieved an infant mortality rate of less than 20 deaths per thousand live births, including an under-5 Mortality rate of less than 30 per thousand, achieved a significant shift in equity, efficiency and quality of health service provision, achieved universal coverage and significantly reduced the social determinants of disease and adverse ecological factors. By extension, the NDP acknowledges health as an important pillar of South Africa’s developmental goals.

The next section discusses two measures of health outcomes, which are infant mortality rate and life expectancy at birth. Although maternal mortality ratio is an important measure of health outcome to monitor and the fact that the National Planning Commission (2012) identified a reduction in maternal mortality as one of its key objectives to improve the health outcomes in South Africa, it will not be discussed in this section due to data issues. Statistics on the maternal mortality ratio in South Africa remains contentious due to estimates from different data sources and different estimation procedures.

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\(^9\) The Negotiated Service Delivery Agreement (NSDA) for the health sector was a strategic document for the period 2009-2014 identifying priorities for the sector and served as a performance agreement between the President and the Minister of Health. It was also signed by the provincial Members of the Executive Council (MECs) responsible for health and their respective Premiers committing themselves to achieve key health outcome of a ‘long and healthy life for all South Africans’ (NDoH, 2014).
There are two main sources of maternal mortality ratio statistics in South Africa. These are Statistics South Africa and the National Department of Health’s institution based maternal mortality ratio (IMMR) captured through the National Committee for the Confidential Enquiries into Maternal Deaths (NCCEMD) and District Health Information System (DHIS). Statistics South Africa’s estimates of maternal mortality ratio are based on data on causes of deaths from the civil registration systems and it acknowledges the shortcomings of the reported data. The inconsistencies of both data sets affect reliability of the maternal mortality ratio data thereof.

2.4.1 Infant mortality rate in South Africa

The first health outcome discussed in this section is the infant mortality rate. Infant mortality rate reflects the probability of dying before the age of one expressed per 1000 live births. According to Anyanwu and Erhijakpor (2007), infant mortality rate is also regarded as a sensitive indicator of the availability, utilization and effectiveness of health care. In this dissertation, infant mortality rate is used as one of the measures of health outcomes.

As a measure of well-being, infant mortality rate for South Africa has been on a declining trend since 2007 although it seems to have remained static just above 33 deaths per 1000 live births since 2010 onwards. Figure 2 summarizes infant mortality rate trends in South Africa for the period 2002 to 2012.

![Figure 2: Infant Mortality Rate in South Africa, 2002 – 2012](Source: Health Systems Trust (2014))
The rate of decline in infant mortality rate has not been to the expected or desired level according to the Millennium Development Goal targets and this may lead to non-achievement of the Millennium Development Goal number 4. This goal seeks to achieve a target of 18 deaths per 1000 live births on infant mortality in South Africa by the end of 2015. In fact, infant mortality rate increased from 42.5 per 1000 live births to 48 per 1000 live births for the period 2003 to 2005 before decreasing again to 33.2 in 2012.

According to Statistics South Africa (2013), the internationally set target for MDG 4 is a two-thirds reduction in child mortality between 1990 and 2015. Given the current infant mortality rate and the limited amount of time left to the end of 2015, South Africa may not achieve this MDG target despite significant progress in recent years.

2.4.2 Life expectancy at birth in South Africa

The second health outcome that will be used as a measure for health outcome in this minor dissertation is the life expectancy at birth. 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 and it is commonly cited as life expectancy at birth. This measure of health outcomes has shown improvement since 2008 and this was preceded by four years of constant life expectancy at birth of 52 years (from 2004 to 2007).

Overall, life expectancy at birth improved from 52.5 years in 2002 to 58.7 years in 2012. 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. Figure 3 illustrates the trend in life expectancy at birth in South Africa over the period 2002 to 2012.
2.5 Relationship between Health Expenditure and Health Outcomes in South Africa

Figure 4 illustrates the relationship between public health expenditure and infant mortality rate in South Africa. A general observation is that infant mortality rate decreases as nominal public health expenditure rises. For the period 2002 to 2012, the annual average rate of growth in public health expenditure was 13.9 percent while the annual average rate of decline in infant mortality was 5.6 percent. In nominal terms, the public health expenditure grew from R32.3 billion in 2002/03 to R122.6 billion in 2012/13.
It should be noted that the provincial public health expenditures were used in both Figure 4 and 5 as well as for the calculation of the annual average rate of growth. It is notable that the decline in infant mortality rate was almost negligible for the period 2003 to 2009 despite significant increases in public health spending over the same period. This may be due to a lag effect of expenditure where current expenditure impacts outcomes years down the line. Figure 5 demonstrates the relationship between public health expenditure and life expectancy at birth in South Africa.

![Figure 5: Public Health Expenditure versus Life Expectancy at Birth in South Africa, 2002-2012](image)

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

The relationship between public health expenditure and life expectancy at birth was negative for the period 2002 to 2005. From 2006 onwards, the positive relationship between public health expenditure and life expectancy at birth emerged. Public health expenditure rose at an annual average rate of 13.9 percent while life expectancy at birth rose at an annual average rate of 1.1 percent for the period 2002 to 2012.

The observations about the relationship between health outcomes (infant mortality rate and life expectancy at birth) must be interpreted with caution as there are many factors other than public health expenditure which influence health outcomes. As a result, this minor dissertation will assess the impact of public health expenditure on health outcomes taking into account other control variables such as income, female literacy rate, the number of physicians, among others.
2.6 Conclusion

In summary, discussions in this chapter reveal three important observations. The first observation is that when compared to other countries, South Africa’s health performance is poor. A comparison of South Africa with other countries at different levels of income revealed that South Africa lagged behind in terms of health performance to countries that spends lower proportion of GDP to health as well as countries with lower GDP per capita.

The second observation is that, despite significant progress in lowering infant mortality rate and increasing life expectancy at birth in recent years, South Africa’s health outcomes are still below the Millennium Development Goals targets. Lastly, the analysis has also shown that the share of public health expenditures to total expenditures differ across the various provinces and such differences can lead to varying outcomes.
CHAPTER 3: LITERATURE REVIEW

3.1 Introduction

This chapter provides the theoretical framework for the minor dissertation. It defines the concept of health and the importance of investing in health for economic growth and development. Furthermore, the concepts of effectiveness and efficiency are also defined in order to show how these concepts differ and to demonstrate how effectiveness is measured when assessing public health performance.

The analytical framework used in this minor dissertation is discussed in this chapter. The last section of the chapter provides a review of previous empirical literature. The review provides details on the nature of the relationship between health expenditures and health outcomes as well as a critique of various approaches and data related issues when estimating the health production function. The critique is provided in order to demonstrate gaps in the empirical literature. These gaps are summarised in the conclusion section of the chapter.

3.2 Health Expenditure and Health Outcomes: Theoretical Framework

3.2.1 Defining Health and the Importance of Investing in Health

According to Grossman (1972), health can be viewed as a capital stock or according to Becker (1964), it can be viewed as a component of human capital stock. This ‘human capital stock’ (health stock) is assumed to depreciate over time at an increasing rate after some stage of the life cycle (DaVanzo & Gertler, 1990). Furthermore, the stock of health can be increased by the individual’s investments in health such as eating a nutritious diet, exercising and medical care among others, while some behaviour such as smoking can lead to lower levels of health. Along the same lines, both public sector and private sector investments can increase the health stock of the population.

On the importance of investing in health, Rajkumar and Swaroop (2008) pointed out that every country (rich or poor, developed or underdeveloped) undertakes public health spending with a
single dominant objective of improving the health of its citizens. Furthermore, different countries adopt different approaches in order to improve the health of their citizens. Some countries spend more on health than others; while some spend more on preventive than curative care while some countries rely more on the private sector for the delivery of health care service.

Moreover, there is a wide variation in public health spending across countries ranging from less than 1 percent to more than 8% of GDP (World Bank, 2015; Rajkumar & Swaroop, 2008). However, countries that spend a greater share of their GDP on health and have highest health care expenditure per capita are not necessarily those with healthiest populations (Ogloblin, 2011). For example, in 2012, per capita health expenditure in the United States was 8.1 times that in Chile, but life expectancy at birth in Chile was 1 year longer than that in the United States (World Bank, 2014).

This means that, although the potential link between public health expenditure and health outcome has played an important role in the argument that more public funds should be invested in health, empirically, the expected relationship between health outcomes and public health expenditure is a priori ambiguous.

3.2.2 Measuring Effectiveness when Assessing Public Health Performance

The focus of this minor dissertation will be on the effectiveness of public health expenditure on health outcomes. As such, defining concepts such as the effectiveness and efficiency becomes important in order to avoid any ambiguity. According to Mandl, Dierx & Ilzkovitz (2008), the analysis of efficiency and effectiveness is about the relationships between inputs, outputs and outcomes. The focus of this paper is on effectiveness measurement although efficiency is defined in this section in order to clarify the difference between the two concepts since these words are at times used interchangeably.

With regards to efficiency, the greater the output for a given input or the lower the input for a given output, the more efficient the activity is. On the other hand, effectiveness relates the input or the output to the final objectives to be achieved, i.e. the outcome (Mandl et al., 2008). Therefore, the outcome is often linked to welfare or growth objectives and therefore may be influenced by multiple factors (including outputs but also exogenous environment factors).
Given these definitions, it can be argued that effectiveness is more difficult to assess than efficiency, since the outcome is also influenced by political choice and an outcome is ultimately defined by the norms and standards a country or organisation decides as a minimum or preferred level of service or human state. Mandl et al. (2008) acknowledges the difficulty in differentiating between output and outcome by indicating that these words are often used in an interchangeable manner, even if the importance of the distinction between both concepts is recognised.

According to Roos (2009:18), outputs refer to “tangible results such as how much or how many and output may also be defined as the final goods and services provided or delivered”. In the context of health, an example of output can be the number of children immunised for pneumonia. On the other hand, outcomes are defined as “the end social and economic result of public policies or programmes and mainly refer to changes in the general state of wellbeing of the community” (Roos, 2009:18).

In the context of health, an example of outcome is healthy citizens that have a long life. From these definitions, it can be said that outputs contribute towards the achievement of outcomes. As already discussed in chapter 2, the health outcomes indicators used in this minor dissertation are infant mortality rate and life expectancy at birth.

Most studies of health care effectiveness use the production-function framework, where health outcomes such as infant mortality rate and life expectancy at birth are modelled as the outputs of a health production function (see Filmer & Pritchett, 1999; Fayissa & Gutema, 2005; Anyanwu & Erhijakpor, 2007; Akinkugbe & Mohanoe, 2009; Ashiabi, 2013 amongst others). On the other hand, these studies treat health care resources such as spending on health, other socio-economic factors and environmental factors that influence health are treated as its inputs. In other words, outcomes are used as outputs in the health production function.

3.2.3 Analytical Framework

Following from the discussion above, the analytical framework used in this minor dissertation is that of a health production function. 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, economists
suggest that households combine purchased goods and services and their time (inputs) to produce health (DaVanzo & Gertler, 1990; Schumann & Mosley, 1994).

Therefore, the demand for goods and services and behaviours that influence health is often derived from the demand for health (DaVanzo & 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 rather than in themselves. In this framework, the demand for health theory is explained with the use of the health production function.

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 & Gertler, 1990). Therefore, 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 socio-economic status influences the proximate determinants of health and risk of disease and these in turn directly influence health and mortality outcomes (Hu & Mendoza, 2013; Mosley & 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:

\[ \text{Socio-economic status} \rightarrow \text{proximate determinants} \rightarrow \text{risk of disease} \rightarrow \text{health outcomes} \]

Therefore, in general, the socio-economic inputs such 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 influences of health outcomes treats all inputs (socio-economic status inputs, proximate determinants inputs and risk of disease inputs) as explanatory variables. As much of the empirical research on the influences of health outcomes treats all inputs as explanatory variables, there is likely to be a potential endogeneity problem. However, estimation of the health production function requires that explanatory variables must not be correlated with unobserved factors that also influence health outcome.

In cases where the explanatory variable is endogenous, Schmidheiny (2014) states that the pooled ordinary least squares estimators will be biased and inconsistent. As a result, either instrumental variables estimation, structural equations models or fixed effects panel models must be used to resolve the problem of Ordinary Least Squares (OLS) bias due to endogeneity (McManus, 2011). Overall, the health production function links a nation’s health inputs to its health outcome, which can be measured in terms of life expectancy, infant mortality, child mortality and maternal mortality, amongst others.

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. Hence this minor dissertation focuses on South Africa to evaluate the effectiveness of public health expenditure.

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

3.3.1 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. As already indicated in this chapter, a priori expectation on the relationship between public health expenditures and health outcomes is ambiguous. Empirical evidence suggests mixed results with some studies supporting the positive effect of public health expenditure while some studies suggest a negative relationship and statistical insignificant relationship.

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 increase in public health spending might also lead to insignificant 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 & Smith, 2011). Examples of these inputs are better tertiary care when the real gains are in extended primary care and services without complementary network such as more hospitals and clinics when no roads are available (Wagstaff & Claeson, 2004).
3.3.2 The use of cross-sectional data when estimating the health production function

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) findings that there is no systematic relationship between health expenditures and health outcomes was supported by a more rigorous empirical study conducted by Filmer and Pritchett (1999) which found that, at best, small public spending impacts on under-five and infant mortality. In this study, Filmer and Pritchett (1999) used 1992 cross-sectional data of 98 developing countries. They used three estimation techniques - ordinary least squares (OLS) regression, median regression and the two stage least squares (2SLS) instrumental variable regression. The use of 2SLS instrumental variable regressions was meant to resolve the problem of potential endogeneity as a result of measurement error and reverse causality although the results of the endogeneity tests were not presented in the study. However, it was indicated by Filmer and Pritchett that the 2SLS model was the chosen model.

On the other hand, the median regressions were conducted because the median regression estimator is much less sensitive to influential observations than OLS (Filmer & Pritchett, 1999). Furthermore, other factors such as income per capita, inequality, extent of female education, level of ethnic fragmentation and predominant religion were found to explain 95 percent of cross-national variation in mortality (in both infant and child mortality rates).

Another study that found no statistically significant relationship between medical care expenditure and health outcomes was that of Thornton (2002). Using the 2SLS estimation technique, his study estimated a health production function for a sample of American states in 1990. It was found that additional medical care expenditure is relatively ineffective in lowering mortality and increasing life expectancy. The most important factors that influence these
outcomes were found to be socio-economic factors such as income and education as well as lifestyle factors such as alcohol and cigarette consumption.

The similarity of these earlier studies is that cross-sectional data was used and the estimation technique was mainly the ordinary least squares regressions and instrumental variable regressions. The general conclusion emerging from these studies is that public health expenditure has no effect on health outcomes; although Musgrove (1996) went further to suggest that the effectiveness of public health expenditure is dependent on the income level of countries under consideration. In contrast, a later cross-sectional study by Bokhari, Gai and Gottret (2007) found that a 10 percent increase in government health expenditure per capita leads to average reductions of 3.3 percent and 5 percent in under-five and maternal mortality rates, respectively. They used cross-sectional data for 127 countries for the calendar year 2000. However, the study by Bokhari et al. (2007) differed with other cross-sectional studies in that it used the Generalized Method of Moments (GMM) instrumental variable technique, thereby taking into account the potential lag of government expenditure on health outcomes through the use of previous year’s expenditure as an instrument.

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 anti-retrovirals 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. The overall lesson here is that it is difficult to credibly estimate the effects of public health expenditure on health outcomes through a cross-sectional econometric analysis.

3.3.3 The use of panel data when estimating the health production function

The earlier studies reviewed above revealed important methodological limitations. For example, the studies failed to account for the fact that public health expenditure may take some time to yield the intended benefits. These time effects can be captured through the use of panel data.
Contrary to other earlier studies, a study by Cremieux, Ouellette and Pilon (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 & Smith, 2011; Anyanwu & Erhijakpor, 2007; Brown, Martinez-Gutierrez & Navab, 2014; Craigwell et al., 2012; Hu & Mendoza; Rajkumar & Swaroop, 2008; Wagstaff & 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.

Recently, a study by Craigwell et al. (2012), using pooled OLS for the 19 Caribbean countries for the period 1995 to 2007, revealed that health expenditure has a significant positive effect on health status. Similarly, Hu and Mendoza (2013) used a panel data set of 136 developing countries over a period 1960-2005 and found that both public spending on health care and the quality of governance matter for the reduction of child mortality rates. Brown (2014) using the Koyck distributed lag model on California county departments of public health found that an additional $10 per capita of public health expenditures reduces all-cause of mortality by 9.1 deaths per 100 000.

In Africa, Anyanwu and Erhijakpor (2007) conducted a study on the effects of health expenditures on health outcomes by using a panel data of 47 African countries between 1999 and 2004. In this study, health expenditures were disaggregated into public health expenditure and private health expenditure. They found that the total health expenditure (as well as the public component) has a statistically significant effect on infant mortality and under five mortality rates.
Another related study by Novignon et al. (2012) used a panel data of 47 sub-Saharan African (SSA) countries over the period 1995 to 2010. The study found that both public and private health care spending significantly influences health status although public health spending had a relatively higher impact. These panel studies are of interest to this study in that they account for time effects on the impact of public health expenditure on health outcomes.

Essentially, all studies reviewed in this section revealed that, when panel data is used to assess the relationship between public health expenditure and health outcome, the public health expenditure variable is found to be a determinant of health outcome. These results are in contrast with the findings of most studies that used cross-sectional data perhaps suggesting the importance of accounting for the time effects on the impact of public health expenditure on health outcomes. Further observation is that the results of the studies that used panel data are independent of whether the study is cross-country or country specific and are also independent of whether the countries being studied are low or high-income countries.

3.3.4 Disaggregating countries by income level when assessing relationship between health expenditure and health outcomes

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, Subramanian and Canning (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 & Ravallion, 1993; Bidani & Ravallion, 1996) who found that public health spending has a statistically significant effect on health outcomes.

Baldacci, Guin-Siu and De Mello (2003) also found that the relationship between public health expenditure and health outcomes is stronger in low-income countries than in high-income countries. Along the same lines, Gupta, Verhoeven and Tiongson (2003) found that the poor are affected more favourably by public spending on health care than the non-poor because the poor
have significantly lower health status than the rich. These observations are consistent with the principle of diminishing marginal productivity embedded in the health production function as discussed earlier. Therefore, in developing countries where both health and health inputs are very low, small increases in health inputs results in relatively larger impacts on health than the advanced countries where health and health inputs are very high.

However, there are instances where public health expenditures are found to have no impact on health outcomes in low-income countries. For example, a study by Burnside and Dollar (1998) found no significant relationship between health expenditure and the change in infant mortality in low-income countries. Likewise, a study by the World Bank (2004) using a panel data for the Indian states for the period 1980-1999 found no effect of health expenditures on mortality rates once state fixed effects and linear time trend were included in the model.

Similarly, there are also studies where public health expenditures are found to have strong positive impact on health outcomes in high-income countries. For example, a recent study by Kim and Lane (2013) using panel data from 17 developed countries over the period 1973 to 2000 found that there is a statistically significant association between government health expenditure and public health outcomes. Particularly, the findings showed a negative relationship between government health expenditure and infant mortality rate and a positive relationship between government health expenditure and life expectancy at birth.

3.3.5 Country specific studies when assessing the effectiveness of public health expenditure

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). In this study, data on the Canadian provinces was analysed using fixed effects estimation technique. Total health expenditures were found to positively influence health outcomes.

An earlier country specific study in Africa 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. Yaqub, Ojapinwa and Yussuf (2012) conducted another country specific study in Africa.

The study investigated how the effectiveness of public health expenditure is affected by governance in Nigeria using the ordinary least squares and the two-stage least squares estimation techniques on time series data for the period 1980 to 2008. The governance variable was captured by the use of corruption perception index. It was found that public health expenditure has a negative effect on infant mortality rate and under 5 mortality rate when governance indicator is included. Essentially, these two country-specific African studies found public health expenditures to be an important determinant of health outcomes. This minor dissertation extends the analysis on these studies to South Africa. To the best of my knowledge, this type of analysis has not been conducted in the country.

In the US, a country specific study was conducted by Costa (2009) who used a panel data of US states for the period 1991 to 2004. It was found that the total health spending (either calculated from the total residence health expenditure or total provider health expenditure) has either lowered or has no statistically significant effect on infant mortality, depending on the regression model followed (instrumental variable regressions, fixed effects regressions etc.). Another US study is that of Brown, Martinez-Gutierrez and Navab (2014). This study assessed the effectiveness of public health on health outcomes using county-level data and dynamic panel estimation techniques combined with the Lewbel instrumental variable technique. Public health expenditures were found to be a determinant of the all-cause mortality and value of life saved.

In Brazil, De Mello and Pisu (2009) assessed the impact of government spending on education and health outcomes using the household survey and budgetary data for nearly 4 000 Brazilian municipalities. In this study, a structural equation model with latent variables using a limited-information two-stage least square (2SLS) was used. The study found that government spending is a powerful determinant of education outcomes, but it was found not to be the case for health outcomes.

In South Africa, most empirical studies examined the relationship between increased public health spending and inequities in access to health and health statuses (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. In other words, an increase in outputs can lead to an increase or improvement in outcomes. Therefore, there seems to be no South African study that has assessed the relationship between public health expenditure and health outcomes explicitly.

Most country specific studies reviewed above revealed that public health expenditure is an important determinant of health outcomes, although the study by Costa (2009) was inconclusive. Therefore, contrary to the mixed findings of cross-country studies, the findings of country-specific studies are in support of the view that health is an important determinant of health outcomes. The key observation from this section is that it is important to conduct a country-specific study in order to design policies that are relevant to local conditions.

3.3.6 The importance of local conditions when assessing the effectiveness of public health expenditure

In the literature, there is another strand of empirical studies (Rajkumar & Swaroop, 2008; Yaqub, Ojapinwa & Yussuf, 2012; Hu & Mendoza, 2013) that offered an alternative explanation for the mixed evidence found on the link between public health expenditure and health outcomes. According to these studies, it is not simply true that public health spending is unimportant in influencing health outcome however, government effectiveness (governance) and quality of bureaucracy influence the efficacy of public health spending. What these studies suggest is the importance of accounting for local conditions when assessing the effectiveness of public health expenditure. Hence this study uses provincial level data in order to account for local conditions.

As a result of the contribution made by these studies by adding an important variable such as governance, this minor dissertation will extend this analysis to South Africa by controlling for HIV/AIDS prevalence given its high prevalence in the country. Given data limitations, governance control variable is not included in this minor dissertation.
3.4 Conclusion

Overall, the review of the literature shows that the exact nature of the relationship between public health expenditure and health outcomes remains unclear. Given that \textit{a priori} the link between public health expenditure and health outcomes seems ambiguous, establishing the nature of the relationship in order to guide policy-making in a country essentially requires empirical analysis.

The literature review highlighted several gaps in the empirical literature, such as the importance of accounting for the time effects of the impact of public health expenditure on health outcomes when estimating the health production function, the importance of country specific studies especially for national policy design and intervention and the importance of including unique variables relevant to the country under analysis.

Given these weaknesses in the existing literature, this dissertation aims to improve the shortcomings of these studies by using panel data estimation technique in order to account for the time effects of public health expenditure on health outcomes. When analysing the impact of public health expenditure on health outcomes, one must consider changes over time for a given individual rather than compare across individuals who may differ from one another in an unobserved way (DaVanzo & Gertler, 1990).

This study will use input-outcome approach when estimating the health production function. In assessing the relationship between public spending and health outcomes, intermediate outputs such as increased access to health care, increased bed utilization among others are inherent in the process. Chapter 4 provides a detailed discussion on the data used and the research approach used in this minor dissertation.
CHAPTER 4: METHODOLOGY AND DATA

4.1 Introduction

The analysis in this minor dissertation is based on the empirical model that estimates the health production function using panel data estimation techniques. This chapter starts with the specification of the health production function. After specifying the health production function model, the discussion moves to data related issues, the reasons behind the choice of the dependent variables and independent variables as well as the nature of the expected relationship between them are provided.

Data sources and definitions of the variables used in the estimation of the health production function are also provided. Thereafter, descriptive statistics summary is presented followed by the description of the empirical model. Given that panel data is used in this minor dissertation, estimation techniques such as the fixed and random effects are briefly described followed by discussion on the theoretical as well as practical consideration for choosing either fixed or random effects models.

4.2 Model Specification

This minor dissertation 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 in the previous chapter, 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 & 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 & Gutema, 2005; Fayissa & Traian, 2011). In this minor dissertation, the Grossman (1972) health production function that incorporates conceptual framework of Mosley and Chen (1984) will take the following basic mathematical form:

\[ \text{Health} = f(\text{socio-economic variables, proximate determinants, risk of disease}) \] .......................... (1)

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

\[ y_{it} = X_{it} \beta + \varepsilon_t, t = 1 \ldots T \] .......................................................... (2)

\[ \varepsilon_t = \mu W_i + v \] .......................................................... (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 \( \beta \) is a vector of coefficients while \( \varepsilon_t \) 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 \( \mu W_i \) and the remainder error process \( v \).

The health status model (social production function) to be estimated by equation (1) is a conventional approach to estimating the relationship between social spending and social indicators (Baldacci et al., 2004). In the social production function, health indicators are treated as outputs and public health expenditure per capita and other exogenous variables such as real GDP per capita are used as inputs. In this instance, the issue of multi-dimensionality in the outcome indicators is not dealt with explicitly and separate regressions are run for each indicator to ensure robustness of the results.

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 to control for the unobserved provincial specific effects.
4.3 Data

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 & Mulaudzi, 2010:60). South Africa, for example, started reporting official infant mortality rates and maternal mortality rates from only 1998 onwards. In addition, the first data sets since democracy were only produced in 1998 and this was based on the South African Demographic and Health Surveys (SADHS). The survey is conducted after every five-year period. As a result, there has not been a consistent series of data on infant mortality and life expectancy until the year 2002.

In this minor dissertation, the study will cover a period of eight years from 2005 to 2012. This means that the study will have a balanced panel of 72 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 percent) occurs at this sphere of government (National Treasury, 2015). Although it would have been desirable to have a longer time series and use data available datasets from 2002 to 2012, there are missing values for the years 2003 and 2004 in the datasets of all provinces for the life expectancy at birth dependent variable. Along the same lines, there are missing values for the physician per 100 000 of the population independent variable for the year 2004.

4.3.1 The choice of the health outcomes dependent variables

As already discussed, the most common and widely used measures of health outcome are infant mortality rate, child mortality rate, maternal mortality ratio and life expectancy at birth. Generally, the choice of representative health outcome variable (dependent variable) is influenced by the availability of data and the need to assess health sector performance based on

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10 It should be noted that with the exception of data on the public health expenditure per capita variable, all other data sets used in this minor dissertation are in calendar years. However, given that the financial year for provincial public health expenditure runs from 01 April to 31 March of the following year, it means that about 75 percent of expenditure occurs during the corresponding calendar year. Although in an ideal situation one would prefer consistency in terms of the data when analyzing relationships, this was not possible in this case due to different data collection methods. Therefore, financial year datasets were not converted into calendar year but were aligned to the calendar in which the bulk of expenditure is happening. For example, the 2005/06 financial year corresponds with the 2005 calendar year. See Mahabir (2013) for related arguments.
the key health indicators as prescribed by the MDGs. Furthermore, the choice can also be influenced by the need to have robust estimates. In other words, addition of another regression can be done as a way to check robustness of the estimates.

In the empirical literature, the number of health outcome dependent variables (the number of regressions) used in assessing the effectiveness of health expenditure varies considerably. For example, there are studies that use single health outcome variable as a representative of overall health outcome of a country when assessing the effectiveness of public health expenditure (Nasab et al., 2013; Rajkumar & Swaroop, 2008; Bayati, Akbarian & Kavosi, 2013; Craigwell, Bynoe & Lowe, 2012). However, the bulk of studies assessing the relationship between public health expenditure and health outcome use more than one dependent variable to represent overall health outcome of a country (see Anyanwu & Erhijakpor, 2007; Ashiabi, 2013; Filmer & Pritchett, 1999; Hu & Mendoza, 2013; Gupta, Verhoeven & Tiongson, 1999). In other words, more than one regression is conducted using different health outcome indicators.

In this minor dissertation, two separate regressions using infant mortality rate and life expectancy at birth will be conducted in order to capture the impact of public health expenditure on health outcomes. Infant mortality rate is defined as the number of infants who die before reaching age one per thousand live births in a given year while life expectancy at birth indicates the number of years a new born infant would live if prevailing patterns of mortality at the time of birth were to stay the same throughout life (Kim & Lane, 2013). Data on these variables is sourced from the Health Systems Trust database. Although it would have been desirable to run three separate regressions by including maternal mortality ratio as a third proxy for health outcome, maternal mortality ratio data is highly unreliable in South Africa (see Statistics South Africa, 2013; Health Systems Trust, 2014)\textsuperscript{11}.

\textsuperscript{11} Although the Health Systems Trust has complete data sets on facility or institutional maternal mortality ratio (IMMR) across provinces in South Africa, it strongly cautions against the use of such data for empirical work as cross provincial comparisons may be misleading.
4.3.2. Independent variables and their expected signs

The aim of this minor dissertation is to assess the effectiveness of public health expenditure on health outcomes (infant mortality rate and life expectancy at birth) in South Africa by estimating the health production function using panel data estimation techniques. This section provides definitions of independent variables and discussions on the nature of the relationship between independent variables and the dependent variables. Given the limitations of data, this minor dissertation assumes that health outcomes (outputs) depend on the provinces’ public health expenditures, income (real GDP), HIV/Aids prevalence, female literacy rate, access to piped water, immunisation coverage ratio and the number of physicians per 100 000 of the population.

Public health expenditure per capita\textsuperscript{12} – In this minor dissertation, public health expenditure per capita is defined as the ratio of the total provincial public health expenditure per total uninsured population (National Treasury, 2015; Health Systems Trust, 2014). In other words, the public health expenditure per capita data is calculated by dividing the audited expenditure estimates of each province by the uninsured population estimates of each province\textsuperscript{13}. This explanatory variable is logged in order to interpret it in percentages or as a ratio. Data to measure this variable is sourced from National Treasury’s yearly audited expenditure outcomes for provinces while population data is sourced from Statistics South Africa (StatsSA).

The theoretical framework suggests that there will be a negative relationship between public health expenditure and infant mortality rate (see Akinkugbe & Mahanoe, 2009; Brown, 2014). In other words, theoretically we expect the benefits to result in a decrease in infant mortality rate (a positive health outcome). On the other hand, a positive relationship between public health expenditure and life expectancy is expected theoretically. In this case, an increase in public health expenditure should lead to an increase in life expectancy (positive health outcome). However, as already argued under the literature review section, increase in public health

\textsuperscript{12} The public health expenditure per capita used in this minor dissertation is in nominal terms.

\textsuperscript{13} See Figure 11 under Appendix 1 for the provincial trends on public health expenditure per capita. In this minor dissertation, uninsured population is used to calculate public health expenditure per capita. This approach is based on the fact that the health component of the provincial equitable share uses the uninsured population which is the population of those not covered by medical aid (Division of Revenue Act, 2015). Furthermore, other related studies in South Africa also uses the uninsured population to calculate public health per capita (see McIntyre & Thiede, 2007; Blecher, Day, Dove & Cairns, 2008).
expenditure does not always result in improvement of health outcomes and hence its effectiveness is subject to empirical enquiry.

Real GDP per capita – This control variable is defined as the ratio of provincial real GDP per total provincial population (Statistics South Africa, 2013). Real GDP is measured using constant 2005 prices\(^{14}\). According to Ashiabi (2013), GDP is the total monetary value of all the goods and services produced in a country over a period of time, usually one year. The real GDP per capita data used in this minor dissertation is calculated using the population estimates from Statistics South Africa’s annual General Household Survey while GDP figures are also from Statistics South Africa.

Real GDP per capita is an important variable in that several studies have shown it to be an important determinant of health outcomes (Anyanwu & Erhijakpor, 2007; Baldacci et al., 2004; Filmer & Pritchett, 1999). These studies argue that health status improves as per capita income rises. In addition, Musgrove (1996) argued that health status is very strongly associated with a country's income and that the effect of income needs to be accounted for in any comparison of spending and results. If this is not done, it is argued that it may falsely appear that more health expenditure is extremely effective in producing better health outcomes and also, because the public share of spending rises with income, that more public expenditure in particular yields better health. According to Filmer and Pritchett (1999), the income variable impacts health through a variety of indirect channels such as better nutrition, better housing and better sanitation. Real GDP per capita is expected to be positively correlated with life expectancy at birth and negatively correlated with infant mortality rate.

Female literacy rate – This control variable is defined as the percentage of females aged 20 years and above with highest level of education of greater than Grade 7 (Statistics South Africa, 2013). Female literacy rates have been calculated using data from Statistics South Africa’s Revised General Household Surveys for the period 2005 to 2012.

\(^{14}\) See Figure 12 under Appendix 1 for the provincial trends in real GDP per capita. It should be noted that all expenditure related data used in this minor dissertation are in nominal terms and are based on the South African currency the rand (ZAR) while the real GDP per capita data is at constant 2005 prices.
It is generally argued that education is intrinsically linked to all developmental goals such as supporting gender empowerment, improving child health and maternal health, reducing hunger, fighting the spread of HIV/AIDS and diseases of poverty, encouraging economic growth and building peace (Department of Basic Education, 2013). Specifically related to female literacy rate, the World Bank (2004) found that a child born to an educated mother is more than twice likely to survive to the age of five than a child born to an uneducated mother. Furthermore, it was indicated that educated mothers are also 50 percent more likely than mothers with no schooling to immunise their children against diseases. According to DaVanzo and Gertler (1990), education affects the overall ability to understand and use inputs effectively to influence health. For example, the ability to follow treatment plans is crucial in the treatment of diseases. Female literacy rate is expected to be positively correlated with life expectancy at birth and negatively correlated with infant mortality rate.

**HIV/AIDS prevalence** – Another critical variable included in the model is the HIV/AIDS prevalence. This variable represents HIV/AIDS prevalence level and is proxied by the provincial HIV prevalence estimates among antenatal women. Although it would have been desirable to use the overall HIV/AIDS prevalence level among the reproductive age population of 15–49 years, most databases (Human Sciences Research Council, Statistics South Africa and the National Department of Health) do not have this data across provinces for the period under consideration in this study. According to the National Department of Health (2014), the extrapolation of HIV/AIDS to the general population across provinces was only started in 2013 using the 2012 antenatal care HIV surveillance data. The data used in this minor dissertation is sourced from the National Department of Health’s annual national antenatal sentinel HIV & Herpes Simplex Type-2 prevalence surveys.

This variable is important within a South African context given that there is high prevalence of HIV/AIDS in South Africa. According to UNAids (2014), South Africa has the largest population of people living with HIV/AIDS compared to any other country in the world with 6,3 million people living with HIV in 2013 while 200,000 AIDS related deaths were also recorded in 2013. In addition, Statistics South Africa (2014) ranks AIDS related diseases such as Tuberculosis, Influenza and Pneumonia and intestinal diseases as leading causes of death in
South Africa. It is expected that a reduction in HIV/AIDS prevalence will improve health outcomes by reducing infant mortality rate and increasing life expectancy.

**Access to piped water** – This control variable is defined as the percentage of households with access to piped or tap water in the dwelling, off-site or on-site by province (Statistics South Africa, 2012). The data sets for access to piped water variable are sourced from Statistics South Africa’s annual General Household Survey.

According to Ashiabi (2013), environmental factors such as air quality and sanitation and access to piped water among others have equally important effects on health. Environmental cleanliness reduces the outbreak and spread of communicable diseases thereby reducing mortality. During the outbreak of communicable diseases, children (both infants and under-fives), pregnant and or lactating mothers are the most vulnerable. As such, improving environmental conditions, such as improved access to piped water, helps prevent the outbreak and spread of diseases. Such conditions support lower infant mortality rates and a higher life expectancy at birth. This study will use the percentage of population with access to piped water and this is expected to have a positive influence on health outcomes.\(^{15}\)

**Immunisation coverage ratio** – Data for this control variable is sourced from the Health Systems Trust. It is defined as the proportion of children under 1 year who are fully immunised (Health Systems Trust, 2014). The choice of the immunisation coverage ratio as a control variable for health outcomes follows the approach of the related study by Akinkugbe and Mahanoe (2009) who showed that child immunisation is an important determinant of health status in Lesotho. The expected coefficient is negative for infant mortality rate and positive for life expectancy at birth.

**The number of physicians** – This control variable is logged during estimation and is sourced from the Health Systems Trust database.\(^{16}\) It is defined as the ratio of the number of medical practitioners (doctors) per 100 000 of the population. According to Anyanwu and Erhijakpor (2007), the number of physicians per 100 000 of the population is a direct medical input and is a

\(^{15}\) See Figure 15 under Appendix 1 for provincial trends in household with access to piped water.

\(^{16}\) See Figure 14 for the data on the immunisation coverage ratio per province in 2012 while Figures 16 and 17 provides data on female literacy rate by province and medical practitioners per 100 000 of the population, respectively.
vector of knowledge facilitating medical technology absorption that is expected to lower infant mortality rates. This variable is an important determinant of a health system’s ability to deliver health services. Akinkugbe and Mahanoe (2009) indicated that an increase in the number of physicians is expected to reduce mortality and increase life expectancy (positive health outcomes).

4.3.3. Descriptive Statistics

In this section, statistics that are discussed include the mean, standard deviation, minimum and maximum values of the variables used in the study. Table 3 summarises descriptive statistics for both dependant variables and independent variables (regressors).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Name of variable used in the analysis</th>
<th>Obs</th>
<th>Mean</th>
<th>Std.Dev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health Outcomes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant Mortality Rate</td>
<td>Logimr</td>
<td>72</td>
<td>39.6</td>
<td>12.4</td>
<td>18.3</td>
<td>62.0</td>
</tr>
<tr>
<td>Life Expectancy at Birth</td>
<td>Logle</td>
<td>72</td>
<td>57.1</td>
<td>4.7</td>
<td>47.8</td>
<td>65.0</td>
</tr>
<tr>
<td><strong>Regressors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Health Expenditure per Capita</td>
<td>LogPhexp</td>
<td>72</td>
<td>1 955</td>
<td>658</td>
<td>801</td>
<td>3 385</td>
</tr>
<tr>
<td>Real GDP per Capita</td>
<td>LogGDPpc</td>
<td>72</td>
<td>33 559</td>
<td>10 284</td>
<td>19 393</td>
<td>55 643</td>
</tr>
<tr>
<td>Female Literacy Rate</td>
<td>Flr</td>
<td>72</td>
<td>79.8%</td>
<td>9.5%</td>
<td>64.2%</td>
<td>95.1%</td>
</tr>
<tr>
<td>Access to Piped Water</td>
<td>Atw</td>
<td>72</td>
<td>89.4%</td>
<td>8.3%</td>
<td>68.8%</td>
<td>99.6%</td>
</tr>
<tr>
<td>Prevalence of HIV/Aids</td>
<td>Phiv</td>
<td>72</td>
<td>27.7%</td>
<td>7.4%</td>
<td>15.1%</td>
<td>39.5%</td>
</tr>
<tr>
<td>Immunisation Coverage Ratio</td>
<td>Icr</td>
<td>72</td>
<td>83.4%</td>
<td>10.2%</td>
<td>68.0%</td>
<td>114.6%</td>
</tr>
<tr>
<td>Physicians</td>
<td>Logphys</td>
<td>72</td>
<td>25.29</td>
<td>6.42</td>
<td>15.80</td>
<td>38.80</td>
</tr>
</tbody>
</table>

† The time period covered is 2002-2012 and there are nine provinces covered
Source: Own computation using STATA 13

The standard deviation of public health expenditure per capita (nominal) of R658 is high (almost closer to half of the mean of the variable of R1 955) and this reflects the inclusion of provinces with high spending per capita. Table 3 also shows that the average HIV/AIDS prevalence of 27.7 percent proxied by the population of women visiting antenatal clinic is very high given that the Millennium Development Goal’s HIV prevalence target is 4.2 percent among population aged 15-24 years (Statistics South Africa, 2013). The average immunisation coverage ratio of 83.4 percent is higher than the global benchmark of 80 percent while the average number of physicians (doctors) per 100 000 of the population is low at 25.3 per 100 000 of the population.
against the global benchmark of 228 physicians per 100,000 of the population (World Health Organization, 2008).

### 4.4 Empirical Model

As already shown in the previous sections of this chapter, this minor dissertation uses an econometric approach based on panel data regressions to estimate the relationship between health outcomes and public health expenditure per capita\(^{17}\). In this minor dissertation, the health production function that incorporates all the control variables discussed under the data section is given by the following mathematical expression:

\[
Hea = f (Phexp, GDPpc, Flr, Atw, Phiv, Icr, Phys) \tag{4}
\]

Where \(Hea\) represents health outcomes such as infant mortality rate and life expectancy at birth (outputs) while inputs are assumed to be \(Phexp\) (public health expenditure per capita), \(GDPpc\) (real GDP per capita), \(Flr\) (female literacy rate), \(Atw\) (Access to piped water), \(Phiv\) (HIV/Aids prevalence level), \(Icr\) (immunisation coverage ratio) and \(Phys\) (the number of physicians per 100,000 of the population). Econometrically, the mathematical expression in equation (4) will be modelled as follows:

\[
\ln HEA_{it} = \beta_0 + \beta_1 \ln Phexp_{it} + \beta_2 \ln GDPpc_{it} + \beta_3 Flr_{it} + \beta_4 Atw_{it} + \beta_5 Phiv_{it} + \\
\beta_6 Icr_{it} + \beta_7 \ln Phys_{it} + \beta_8 Dgov_{it} + \epsilon_{it} \tag{5}
\]

The econometric specification in equation (5) adapts regression models of Anyanwu and Erhijakpor (2007), Ashiabi (2013) and Novignon et al. (2012). However, the selection of key variables and control variables in the specified regression is also influenced by the availability of data and the local context such as the high prevalence of HIV/AIDS in South Africa. Although it would have been desirable to control for governance given differences in the quality of provincial bureaucracies, data for this control variable is unavailable at provincial level. An

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\(^{17}\) See Figure 8 and Figure 9 for provincial data on measures of health outcomes in South Africa. The data (series) used in each of the graphs uses single data source in order to avoid a problem of inconsistencies in the time series due to differences in estimation. However, care has been taken to verify data from the secondary source with the primary source and both sources are acknowledged accordingly. Uninsured population is used to calculate public health expenditure per capita and refers to the share of the population that is not covered by medical aid. In South Africa, the bulk of the population is not covered by medical aid and is dependent on public health services.
attempt was made to use annual provincial health departments’ audit opinions as a measure of governance. However, this data is qualitative in nature and as such, it has shown low variability across provinces over the period under consideration. For example, Western Cape received only unqualified audit opinions over the period while a province like Northern Cape received a disclaimer audit opinion throughout with the exception of one year where it received a qualified audit opinion (see Auditor General of South Africa, 2015).

With the exception of HIV/AIDS prevalence all other control variables have been used consistently in the studies already reviewed in this minor dissertation (Homaie et al., 2013; Craigwell et al., 2012; Filmer & Pritchett, 1999; Ashiabi, 2013; Akinkugbe & Mahanoe; 2009; Anyanwu & Erhijakpor, 2007; Novignon et al., 2012). Logarithms are used in the specified econometric model in equation (5) 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, all control variables that are already in percentages are not logged for ease of interpretation of results.

4.5 Estimation Techniques

Before the estimation of the fixed effects and random effects models, the baseline pooled OLS model is estimated. The choice between pooled OLS and fixed effects or random effects models is made through the use of the F-test for time fixed effects and the Breusch Pagan Lagrange Multiplier test for random effects. If pooled OLS model is used although the tests show that either fixed effects or random effects models are preferred, the differences (heterogeneity or time-invariant individual specific effects) can lead to correlation between the independent variable and the error term leading to endogeneity problem. As a result, the estimates would be biased and inconsistent. Actually, Bond (2002) asserts that such estimates would be biased upward. In this minor dissertation, test for endogeneity will be conducted.

In this minor dissertation, the random effects model is estimated using Generalized Least Squares and the within effects of the fixed effects model is estimated using Generalized Least Squares (GLS). The choice between random effects model and fixed effects model is based on the Hausman specification test and theoretical considerations. For example, DaVanzo and Gertler (1990) suggest that studies that assess the relationship between public health expenditure
and health outcomes should account for time effects and time-invariant individual specific effects. Theoretically, fixed effects model would be more suitable for this study although this will be balanced against the Hausman test results, the F-test for time fixed effects and the Breusch Pagan Lagrange Multiplier test for random effects.

Although most applied researchers rank the fixed effects’ ability to deal with unobserved heterogeneity across units most prominently (Plumper & Troeger, 2007), Clark and Linzer (2012) as well as Bell and Jones (2013) argue that the choice between fixed effects and random effects models should not be solely based on the Hausman test. The choice between fixed effects and random effects panel models is more of a balance between efficiency and bias (Clark & Linzer, 2012). In other words, random effects estimates tends to be biased due to the potential correlation between explanatory variable and the time invariant omitted variables in the error term. On the other hand, Clark and Linzer (2012) suggest that fixed effects model produces inefficient estimates due to variables that have very little within variance.

The analysis in this minor dissertation is performed using STATA 13 statistical software package. All diagnostic tests such as a test for model specification, heteroscedasticity, autocorrelation, endogeneity among others are conducted in this minor dissertation. In cases where there is endogeneity on the public health per capita explanatory variable on the chosen fixed effects or random effects model, instrumental variable estimation techniques is applied on the affected regression model. Multicollinearity test is also conducted given that there are several explanatory variables used in the study and there is a potential for correlations among the regressors. Furthermore, in the empirical analyses, panel-robust standard errors clustered at the provincial level are used since fixed effects estimations with longitudinal data require the estimated standard errors to be adjusted for arbitrary types of serial correlation and heteroscedasticity (Moreno-Serra & Smith, 2011). The next section discusses the theoretical and practical basis for choosing either fixed effects or random effects estimation techniques.

4.6 The Choice between Fixed Effects and Random Effects Models

As already explained in the previous section, fixed (within) effects model or random effects model will be applied in this minor dissertation. However, the choice of which model to use is made more difficult by the theoretical and practical considerations. In addition, each model poses
its own advantages and disadvantages that should also be considered. Clark and Linzer (2012) summarised the key differences of the two models by indicating that the fixed effects model will produce unbiased estimates of $\beta$ although the estimates will be subject to high sample-to-sample variability. On the other hand, Clark and Linzer (2012) pointed out that random effects model will introduce bias in estimates of $\beta$ except in rare circumstances although the model can greatly constrain the variance of the estimates leading to estimates that are on average closer to the true value of a particular sample.

Most applied studies base their choice between random effects model and fixed effects model on the Hausman specification test. The null hypothesis is that there are no differences in the estimates of fixed effects and random effects models. In other words, if the null hypothesis is rejected, the fixed effect model is used. However, due to the potential difficulty of meeting the necessary condition that there should be no correlation between the individual specific effects and the explanatory variables for random effects model to be used, most studies tend to use fixed effects estimates (Bell & Jones, 2013).

Bell and Jones (2013) advise that extra care should be taken when selecting between the fixed effects and the random effects models and the decision should not be solely based on the Hausman test results but also consider theoretical arguments. In fact, Clark and Linzer (2012:2) argue that it is “neither necessary nor sufficient” to use the Hausman test as the sole basis of a researcher’s ultimate methodological decision. Bell and Jones (2013:32) agree with this observation by indicating that “no statistical model can act as a substitute for intelligent research design and forethought regarding the substantive meaning of parameters”.

Bell and Jones (2013) also argue that random effects model is preferable in most instances because it analyses and separates both the within and between components of an effect explicitly and assesses how those effects vary over time and space rather than assuming heterogeneity away with fixed effects. Deaton (2010:430) adds that “heterogeneity is not a technical problem calling for an econometric solution but a reflection of the fact that we have not started on our proper business of trying to understand what is going on”. Furthermore, Bell and Jones (2013) argue that the aim of researchers is to understand the world but fixed effects models attempt to
do this by cutting out much of what is going on, leaving only a supposedly universal effect and controlling out differences at the higher level.

4.7 Conclusion

This chapter has shown that the panel data to be used in this minor dissertation has a time frame of 8 years and the cross-section dimension has nine units made up of the provinces in South Africa. The public health expenditure per capita data were sourced from the National Treasury’s provincial database with the use of uninsured population shares calculated using data from Statistics South Africa and the Health Systems Trust. Data for other variables was sourced mainly from the Health Systems Trust.

With regards to the estimation technique, it was indicated that panel data estimation techniques such as fixed effects and random effects models will be used to estimate the health production function. This estimation approach is consistent with theory requirements that the public health effectiveness studies should account for the time effects of the impact of public health expenditure on health outcomes. Infant mortality rate and life expectancy at birth are used as proxies for health outcomes. The choice between fixed effects model and random effects model is based on the Hausman test and theoretical considerations. The instrumental variable estimation techniques in panel data are only employed if endogeneity tests on the public health per capita explanatory variable show the evidence of endogeneity.
CHAPTER 5: ESTIMATION RESULTS

5.1 Introduction

This chapter begins with a discussion on the robustness of estimates through the use of diagnostic tests as these tests determine the most feasible regression estimates for the interpretation of results. The estimated results for the two indicators representing health outcomes (infant mortality rate and life expectancy at birth) are presented in this chapter taking into account all the diagnostic tests conducted.

In order to demonstrate the nature of the relationship between public health expenditure and health outcomes in South Africa, scatter plots of these variables are presented in this chapter. The regression results for the two health outcomes include pooled Ordinary Least Squares, fixed effects and random effects estimates. The summarised findings are provided in the conclusion section of this chapter.

5.2 Robustness of Estimates

An important consideration when presenting results from econometric estimations is the diagnostic tests in order to determine the robustness of estimates. In other words, diagnostic tests determine the estimation technique and validity of the findings. Furthermore, diagnostic checks are conducted to ensure that the reported results are consistent, unbiased, efficient, and reliable. The findings of the diagnostic tests are discussed in this section.

5.2.1 Heteroscedasticity tests

According to Gujarati and Porter (2009), if the error terms do not have constant variance, they are said to be heteroscedastic and this is a violation of the OLS assumption that variance of the error terms must be constant. If there is violation of the homoscedasticity assumption in OLS, Gujarati and Porter (2009) argue that the OLS parameter estimates will still be unbiased and consistent but will be inefficient. Heteroscedasticity tests were conducted on the pooled OLS estimates using the White’s general test for heteroscedasticity. White’s general test is a special case of the Breusch-Pagan test, where the assumption of normally distributed errors has been
relaxed (Gujarati & Porter, 2009; Ashiabi, 2013). Heteroscedasticity tests were conducted on the infant mortality rate outputs and the life expectancy at birth outputs with the null hypothesis of homoscedasticity or constant variance. Table 4 summarises tests results for heteroscedasticity for both infant mortality rate and life expectancy at birth regressions.

Table 4: White's general test for heteroscedasticity

| Output for Infant Mortality Rate | chi2 (1) | 45.85 |
| Output for Life Expectancy at Birth | chi2 (1) | 56.8 |

Source: Own computation using STATA 13

The null hypothesis of homoscedasticity is not rejected at all conventional level of significance with a p-value of 0.1070 in the regression output for infant mortality rate and this means that the estimated parameters of the model are efficient. On the other hand, the test for heteroscedasticity on the life expectancy model reveals the presence of heteroscedasticity. The null hypothesis of homoscedasticity is rejected at the 5 percent level of significant with a p-value of 0.0316. This means that the estimated parameters of the model are inefficient. In order to account for heteroscedasticity, estimates were computed using robust standard errors in STATA.

5.2.2 Test for serial autocorrelation

According to Drukker (2003), serial autocorrelation in linear panel-data models biases the standard errors and causes the results to be less efficient. In this minor dissertation, the Wooldridge (2002) test for serial autocorrelation in panel-data models is used. This test is very attractive because it requires relatively few assumptions and is easy to implement (Drukker, 2003). Table 5 summarises the outputs from the Wooldridge test for autocorrelation in panel data.

Table 5: Wooldridge Test for Autocorrelation in Panel Data

| Output for Infant Mortality Rate | F(1, 8) | 13.48 |
| Output for Life Expectancy at Birth | F(1, 8) | 666.59 |

Source: Own computation using STATA 13
The Wooldridge test in Table 5 shows that there is presence of autocorrelation in data since the null hypothesis that there is no first-order autocorrelation is rejected at the 1 percent level of significance for both infant mortality rate outputs and life expectancy at birth outputs given the p-value of 0.0063 and 0.0000, respectively. In order to account for the serial autocorrelation, estimates were computed using clustered robust standard errors in STATA.

5.2.3 Test for endogeneity

As already explained in chapter 4, this dissertation relies on the estimates of the fixed effects and random effects models to estimate the health production function in order to assess the effectiveness of public health expenditure in South Africa. According to Ashiabi (2013), the fixed effects and random effects estimation techniques are developed under the assumption that all explanatory variables are exogenous.

However, the strict exogeneity condition is not always met which makes either fixed effects or random effects estimation techniques inappropriate. Endogeneity can be caused by omitted variables, measurement errors and simultaneity which could in turn result in biased estimates (Gujarati & Porter, 2009). 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.

Although Moreno-Serra and Smith (2015) are right in arguing that accounting for endogeneity is important, it seems that they have not taken into account the fact that instrumental variable regressions can only be conducted after testing the existence of such suspected endogeneity. Therefore, the view that public health expenditure is endogenous and hence must be instrumented does not always fit the facts and must be based on the endogeneity tests. In this minor dissertation, the endogeneity is undertaken on the chosen fixed effects or random effects model using the Durbin-Wu-Hausman test for endogeneity in line with the approach by Wooldridge (2012). In STATA 13, this is a four step test conducted as follows:
The reduced form regression was run using the expected endogenous variable (public health per capita) as a dependent variable against other control variables;

- The residuals from the reduced form regression were extracted through the ‘predict residuals’ syntax in STATA;

- The main equation (either RE or FE depending on the choice of the model) was run including the extracted residuals as explanatory variable; and

- The residual variable ‘logphexp_res’ was tested if it is significantly from zero using f-test through the STATA syntax ‘test logphexp_res’. The decision of whether there is endogeneity or not was based on the significance of this test. In other words, if the test shows significance, then there are endogeneity issues in the model.

Results of the Durbin-Wu-Hausman test for endogeneity under the null hypothesis that public health expenditure per capita variable is exogenous are summarised in Table 6.

### Table 6: Durbin-Wu-Hausman Test for Endogeneity

<table>
<thead>
<tr>
<th>Variable</th>
<th>chi2 (1)</th>
<th>Prob &gt; chi2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output for Infant Mortality Rate</td>
<td>0.40</td>
<td>0.5260</td>
</tr>
<tr>
<td>Output for Life Expectancy at Birth</td>
<td>1.30</td>
<td>0.2540</td>
</tr>
</tbody>
</table>

Source: Own computation using STATA 13

Table 6 shows that there is no endogeneity of the public health expenditure per capita variable on both the infant mortality rate and life expectancy at birth regressions. In other words, the tests for significance on the residual variable were statistically insignificant with the p-value of 0.5260 and 0.2540 respectively. The null hypothesis that public health expenditure per capita variable is exogenous was not rejected.

In this instance, there is no need to conduct instrumental variable regressions for both infant mortality rate and life expectancy at birth regressions. In summary, either fixed effects or random effects model is used for the interpretation of estimated results of the infant mortality rate and life expectancy at birth regressions since there is no endogeneity in the estimates. Model specification tests and test for multicolinearity are presented under Appendix 2.
5.3 Infant Mortality Rate Results

A simple correlation analysis of the dependent variable (infant mortality rate) and the regressors is conducted using scatter plots before detailed regression analysis. The scatter plots of the relationship between infant mortality rate and other control variables are presented in Appendix 3. Figure 6 shows a negative relationship between log of public health expenditure per capita (independent variable of interest) and log of infant mortality rate (health outcome).

![Figure 6: Log of Infant Mortality Rate and Log of Public Health Expenditure per Capita](image)

*Source: Own computation using STATA 13*

Along the same lines, the simple scatter plots correlation analysis between infant mortality rate and other control variables such as real GDP per capita, female literacy rate, access to piped water and immunisation coverage ratio also show a negative relationship. On the other hand, the scatter plot between infant mortality rate and HIV/Aids prevalence control variable shows an unambiguous positive relationship as per *priori* expectation. Table 7 provides the results of the regression on infant mortality rate.
Table 7: Regression Results for Infant Mortality Rate (Health Outcome)

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Pooled OLS</th>
<th>FE</th>
<th>RE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logphexp</td>
<td>-0.168</td>
<td>-0.463***</td>
<td>-0.368***</td>
</tr>
<tr>
<td></td>
<td>(0.104)</td>
<td>(0.084)</td>
<td>(0.056)</td>
</tr>
<tr>
<td>Loggdppc</td>
<td>-0.4870</td>
<td>0.5023</td>
<td>-0.2032</td>
</tr>
<tr>
<td></td>
<td>(0.314)</td>
<td>(0.519)</td>
<td>(0.164)</td>
</tr>
<tr>
<td>Flr</td>
<td>-0.869**</td>
<td>-0.0587</td>
<td>-0.369***</td>
</tr>
<tr>
<td></td>
<td>(0.257)</td>
<td>(0.242)</td>
<td>(0.141)</td>
</tr>
<tr>
<td>Atw</td>
<td>0.1390</td>
<td>-0.9067</td>
<td>-0.7411</td>
</tr>
<tr>
<td></td>
<td>(1.414)</td>
<td>(0.535)</td>
<td>(0.481)</td>
</tr>
<tr>
<td>Phiv</td>
<td>2.815***</td>
<td>1.2221</td>
<td>2.001***</td>
</tr>
<tr>
<td></td>
<td>(0.509)</td>
<td>(0.854)</td>
<td>(0.377)</td>
</tr>
<tr>
<td>Icr</td>
<td>0.0163</td>
<td>0.398**</td>
<td>0.472***</td>
</tr>
<tr>
<td></td>
<td>(0.308)</td>
<td>(0.133)</td>
<td>(0.127)</td>
</tr>
<tr>
<td>Logphys</td>
<td>0.2060</td>
<td>0.0241</td>
<td>0.0944</td>
</tr>
<tr>
<td></td>
<td>(0.149)</td>
<td>(0.210)</td>
<td>(0.171)</td>
</tr>
<tr>
<td>Intercept</td>
<td>9.0670</td>
<td>1.9850</td>
<td>8.1900</td>
</tr>
<tr>
<td></td>
<td>(2.191)</td>
<td>(4.751)</td>
<td>(1.434)</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.83</td>
<td>0.96</td>
<td>0.74</td>
</tr>
</tbody>
</table>

BP-LM Test for Random Effects: chibar2 (01) 85.44

Prob > chibar2 0.000

F-statistic 267.36 29.25

P-value 0.000 0.000

Hausman Test for FE vs RE: chi2 (7) 4.96

Prob > chi2 0.6649

Durbin-Wu-Hausman Test for Endogeneity: 0.40

Prob > chi2 0.526

The number of observations in these regressions is 72. Cluster robust standard errors (in parentheses under the co-efficient or test output) were obtained in order to control for arbitrary heteroscedasticity and auto-correlation. ***Indicates significance at 1 percent confidence level, **indicates significance at 5 percent confidence level and * indicates significance at 10 percent confidence level using two-tailed tests. Overall R-Squared is used for RE model while the FE model uses the R-Squared from the areg estimator.

Source: Own computation using STATA 13

Although outputs from different regression models (pooled OLS, FE and RE) are also presented for comparison and robustness check, the outputs of the random effects model are preferred over those of the fixed effects model based on the results of the Hausman test. Generally, in most empirical literature, the choice between fixed effects and random effects model is based on the Hausman (1978) specification test (Ashiabi, 2013; Anyanwu & Ehrijakpor, 2007; Fayissa & Traian, 2011).
The random effects estimation technique is developed under the assumption that all explanatory variables are strictly exogenous and this assumption is generally difficult to comply with in practice. On the other hand, the fixed effects model accounts for time-invariant individual specific effects (DaVanzo & Gertler, 1990). The choice between the pooled ordinary least squares (OLS) and the random effects model is made based on the Breuch Pagan Lagrange Multiplier test. The null hypothesis of Breusch-Pagan Lagrange Multiplier test (BP-LM test) is that variance across entities is zero or there are no random (panel) effects in the model.

Apart from the BP-LM test for random effects, an additional test for the presence of time fixed effects was also conducted in this minor dissertation. This test is the F-test with the null hypothesis that there are no time fixed effects in the model and is implemented after running the fixed effects regression with year dummy variables. According to Park (2011), the F-test compares a fixed effects model and pooled OLS model to see how much the fixed effects model improves the goodness of fit.

The Hausman specification test in Table 7 shows that the random effects model is the preferred specification based on the failure to reject the null hypothesis that the random effects model and fixed effects are not systematically different from each other or the random effects model is the preferred model. The Hausman test statistics has a chi-square of 4.96 with a p-value of 0.6649, which is greater than 0.05 suggesting that the random effects model is more appropriate for the interpretation of the results.

Furthermore, the choice between pooled OLS model and random effects model is made easier by the application of the Breusch Pagan Lagrange Multiplier test. This test has a chi-square statistics of 85.44 with a p-value of 0.0000 meaning that the null hypothesis of no random effects (no individual province specific effects) in the model is rejected. This means that the random effects estimates are preferred over the pooled OLS estimates. However, the test for the presence of time fixed effects rejected the null hypothesis that the dummies for all years are equal to zero (no time
fixed effects in the model). Therefore, there are fixed effects in the panel data and estimates from the fixed effects model are preferable over pooled OLS estimates. As already indicated, random effects estimates are used for the interpretation of results of the infant mortality rate regressions.

The pooled OLS model has an R-Squared statistics of 0.84 with a significant F-statistics while the fixed effects model has an R-Squared of 0.96 and our model of choice (random effects model) has R-Squared of 74 percent. Therefore, about 74 percent of variation in infant mortality rate is explained in the random effects model.

From Table 7, public health expenditure per capita (variable of interest) has the expected sign in the three specifications presented and is statistically significant at 1 percent level of significance on both the random effects and fixed effects models. Using the chosen random effects model, the public health expenditure per capita variable has elasticity of -0.368 suggesting that a 1 percent increase in public health expenditure per capita will on average result in 0.4 percent decline in infant mortality rate in South Africa holding other influences constant.

In other words, public health expenditure positively influences infant mortality rate. The finding is consistent with cross-country studies in Africa (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 expenditures 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. Actually, Bokhari (2007) found that the elasticity of under-five mortality with respect to government expenditures ranged from -0.25 to -0.42 with a mean value of -0.33 for the 127 selected countries in the world. The elasticity found in this dissertation is slightly higher to the reported mean value. However, this elasticity is comparable to the findings by Cremieux et al.

\[18\] See section A2.3 under Appendix 2 for the results of the Hausman test to choose between FE and RE, the Breusch Pagan Lagrange Multiplier test for the choice between pooled OLS and RE and the test for the presence of the time fixed effects in the infant mortality rate model.
Cremieux et al. (1999) reported elasticities of -0.399 and -0.539 for male and female infant mortality rate, respectively.

As noted by Cremieux et al. (1999) on his finding about the statistically significant relationship between total health expenditure and infant mortality rate in Canada, the qualitative relationship between health expenditure per capita and infant mortality rate is clear and its significance in quantitative terms could become particularly relevant during the time period characterized by tighter government budgets. This point is more relevant in South Africa where there are more competing needs to be funded from the fiscus.

With regard to control variables, only female literacy rate and prevalence of HIV/AIDS are statistically significant. The female literacy rate variable has elasticity of -0.369 while the prevalence of HIV/AIDS has elasticity of 2.001. This means that a 1 percent increase in female literacy rate will on average result in a decline of 0.4 percent in infant mortality rate in South Africa holding other influences constant.

This finding validates DaVanzo and Gertler’s (1990) assertion that education affects the overall ability to understand and use inputs effectively to influence health. In other words, the mother’s ability to follow treatment plans is crucial in the treatment of diseases of new-born babies. The significance of the female literacy control variable on infant mortality rate is consistent with the finding by Akinkugbe and Mahano (2009) who found that female literacy reduces infant mortality.

On the other hand, a 1 percent increase in HIV/AIDS prevalence will on average, result in an increase of 2 percent in infant mortality rate in South Africa holding other influences constant. The significance of HIV/AIDS prevalence on infant mortality rate is consistent with the findings of the two cross-country studies that included HIV/AIDS prevalence as a control variable (see Anyanwu & Erhijakpor, 2007; Novignon et al., 2012).

Contrary to most studies (see Filmer & Pritch, 1999; Gupta et al., 1999; Anyanwu & Erhijakpor, 2007; Cremieux et al., 1999; Thornton, 2002; Fayissa & Traian, 2011; Yaqub et al., 2012; Bokhari, Gai & Gottret, 2007), the real GDP per capita (income control variable) and other control variables such as access to piped water and the number of physicians per 100 000 of the
population were found to be statistically insignificant in this study. Fayissa and Traian (2011) reported a negative and statistically significant elasticity of 0.23 on the GDP per capita variable and this was in line with theoretical expectation. However, the finding of insignificant relationship between GDP per capita and infant mortality rate is in line with the finding by Akinkugbe and Mahanoe (2009), although the study found immunisation coverage ratio and physician per 100,000 of the population variables to be statistically significant in lowering infant mortality rate in Lesotho.

Although the immunisation coverage ratio (Icr) control variable was found to be statistically significant, the variable has a positive sign and this is in contrast with the *priori* expectation that Icr decreases infant mortality rate. This finding is counter intuitive and makes interpretation difficult which is perhaps suggestive of errors in measurement on this control variable.
5.4 Life Expectancy at Birth Results

As with the previous results, a simple correlation analysis of the dependent variable (life expectancy at birth) and the regressors is conducted using scatter plots before detailed regression analysis is done. The scatter plots of the relationship between life expectancy and other control variables are presented in Appendix 4. Figure 7 below shows a positive relationship between public health expenditure (independent variable of interest) and life expectancy at birth.

![Figure 7: Log of Life Expectancy at Birth and Log of Public Health Expenditure per Capita](image)

*Source: Own computation using STATA 13*

Similarly, the simple scatter plots correlation analysis between life expectancy at birth and other control variables with the exception of HIV/AIDS prevalence, also suggest a positive relationship. As to be expected, HIV/AIDS prevalence control variable shows a negative relationship with life expectancy at birth. Table 8 provides results of the life expectancy at birth regressions.
### Table 8: Regression Results for Life Expectancy at Birth (Health Outcome)

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Pooled OLS</th>
<th>FE</th>
<th>RE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logphexp</td>
<td>0.031**</td>
<td>0.0255</td>
<td>0.059**</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.041)</td>
<td>(0.028)</td>
</tr>
<tr>
<td>Loggdppc</td>
<td>0.0456</td>
<td>0.3154</td>
<td>0.1114</td>
</tr>
<tr>
<td></td>
<td>(0.061)</td>
<td>(0.202)</td>
<td>(0.079)</td>
</tr>
<tr>
<td>Flr</td>
<td>0.236**</td>
<td>0.2192*</td>
<td>0.159**</td>
</tr>
<tr>
<td></td>
<td>(0.084)</td>
<td>(0.115)</td>
<td>(0.075)</td>
</tr>
<tr>
<td>Atw</td>
<td>-0.0612</td>
<td>-0.0347</td>
<td>-0.0337</td>
</tr>
<tr>
<td></td>
<td>(0.274)</td>
<td>(0.110)</td>
<td>(0.116)</td>
</tr>
<tr>
<td>Phiv</td>
<td>-0.875***</td>
<td>-0.2194</td>
<td>-0.610***</td>
</tr>
<tr>
<td></td>
<td>(0.094)</td>
<td>(0.125)</td>
<td>(0.136)</td>
</tr>
<tr>
<td>Icr</td>
<td>0.1236</td>
<td>0.0097</td>
<td>-0.0002</td>
</tr>
<tr>
<td></td>
<td>(0.088)</td>
<td>(0.068)</td>
<td>(0.068)</td>
</tr>
<tr>
<td>Logphys</td>
<td>-0.060**</td>
<td>-0.0369</td>
<td>-0.0369</td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td>(0.057)</td>
<td>(0.043)</td>
</tr>
<tr>
<td>Intercept</td>
<td>3.5280</td>
<td>0.6022</td>
<td>2.6297</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(1.778)</td>
<td>(0.699)</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.89</td>
<td>0.97</td>
<td>0.79</td>
</tr>
<tr>
<td>BP-LM Test for Random Effects: chibar2 (01)</td>
<td>60.41</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Prob &gt; chibar2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>1342.41</td>
<td>35.50</td>
<td></td>
</tr>
<tr>
<td>P-value</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Hausman Test for FE vs RE: chi2 (7)</td>
<td>11.77</td>
<td>0.108</td>
<td></td>
</tr>
<tr>
<td>Prob &gt; chi2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durbin-Wu-Hausman Test for Endogeneity: chi2 (1)</td>
<td>1.30</td>
<td>0.254</td>
<td></td>
</tr>
<tr>
<td>Prob &gt; chi2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The number of observations in these regressions is 72. Cluster robust standard errors (in parentheses under the co-efficient or test output) were obtained in order to control for arbitrary heteroscedasticity and autocorrelation. ***Indicates significance at 1 percent confidence level, **indicates significance at 5 percent confidence level and * indicates significance at 10 percent confidence level using two-tailed tests. Overall R-Squared is used for the RE model while the FE model uses the R-Squared from the areg estimator.

Source: Author’s estimations using STATA 13

As with the previous discussion, the choice of the baseline pooled OLS model is based on the Ramsey RESET specification test. The Durbin-Wu-Hausman test for endogeneity on the public health per capita explanatory variable assist with the decision of whether instrumental variable estimation technique is required or not. As already discussed in this chapter, the baseline model
used for estimation and interpretation of results is based on the Ramsey RESET specification test\(^{19}\).

The Hausman specification test shows that the random effects model is the preferred specification for the interpretation of results based on the failure to reject the null hypothesis that the random effects model and fixed effects are not systematically different from each other. Hausman test statistics has a p-value of 0.1083 which is higher than the recommended p-value of 0.05\(^{20}\). The choice between pooled OLS model and random effects model is based on the application of the Breusch Pagan Lagrange Multiplier test.

This test shows a chi-square statistics of 60.41 with a p-value of 0.000 meaning that the null hypothesis that there are no random effects in the model is rejected and the random effects model is chosen over pooled OLS. Therefore, for interpretation of results and statistical inference, the random effects model will be used. The random effects model has an overall R-squared of 0.79 meaning that about 79 percent of variation in life expectancy at birth is explained in the model.

Public health expenditure per capita (Logphexp) as the main explanatory variable is statistically significant at 5 percent level of significance with a p-value of 0.035 and elasticity of 0.059. The co-efficient has the expected positive sign and this means that a 1 percent increase in public health expenditure per capita will on average, result in about 0.06 percent increase in life expectancy at birth in South Africa holding other influences constant. This outcome shows that there is a positive relationship between public health expenditure and life expectancy at birth in South Africa.

The result that public health expenditure per capita positively influences life expectancy at birth is consistent with the findings of the related studies (Novignon \textit{et al.}, 2012; Anyanwu & Erhijakpor, 2007; Akinkugbe & Mahanoe, 2009; Craigwell \textit{et al.}, 2012; Cremieux \textit{et al.}, 1999). Using data from the 10 Canadian provinces over a 15 year period, Cremieux \textit{et al.} (1999) reported positive total health expenditure elasticities of 0.049 for male life expectancy at birth.

\(^{19}\) See the Ramsey RESET specification test results for life expectancy at birth regressions in section A2.1 under Appendix 2.

\(^{20}\) Results for the Hausman Test, BP-LM test for random effects and the F-test for time fixed effects on the chosen life expectancy at birth model are presented under Appendix 2 in section A2.4.
and 0.024 for female life expectancy at birth. The magnitude of these elasticities is closely related with the elasticity of 0.059 found in this minor dissertation.

With regard to control variables, only the female literacy rate (Flr) and HIV/Aids prevalence level were statistically significant. The female literacy rate is statistically significant at 5 percent level of significance with a p-value of 0.035 and recorded elasticity of 0.159. This means that a 1 percent increase in female literacy rate will on average, result in an increase of 0.14 percent in life expectancy at birth in South Africa holding other influences constant.

On the other hand, the HIV/Aids prevalence level control variable is statistically significant at 1 percent level of significance with a p-value of 0.000 and has elasticity of -0.610. This means that a 1 percent increase in HIV/Aids prevalence will on average, result in a decline of 0.61 percent 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 public health expenditure, female literacy rate and HIV/Aids prevalence. Contrary to most cross-country studies, real GDP per capita (income) has no influence on life expectancy at birth in South Africa and this is probably due to the high-income inequality in the country that leads the greater share of the population to be dependent on publicly funded health facilities for improvement in their health outcomes.

According to Bhorat, Hirsch, Kanbur and Ncube (2013), the Gini-coefficient for overall income inequality was estimated at 0.66 in 2010 using the latest income and expenditure survey data suggesting that South Africa is one of the most unequal countries in the world. With regards to country specific studies, the finding is consistent with the study in Lesotho by Akinkugbe and Mahanoe (2009) who also found income per capita to be an insignificant determinant of health status. However, Cremieux et al. (1999) found GDP per capita to be positively influencing both male and female life expectancies with elasticities of 0.010 and 0.018 respectively.
5.5 Conclusion

The aim of this minor dissertation was to investigate the effectiveness of public health expenditure on health outcomes in South Africa using provincial level panel data. Diagnostic tests were conducted to ensure that estimates from the chosen model (either fixed effects or random effects) were robust. The theoretical model for both infant mortality rate and life expectancy at birth were subjected to specification tests and endogeneity tests to ensure that the chosen model is well-specified and free from bias as a result of endogeneity. Tests suggest that there is no endogeneity on the public health expenditure per capita explanatory variable on the chosen infant mortality rate and life expectancy at birth models.

Results from infant mortality rate and life expectancy at birth regressions showed that there is a statistically significant relationship between public health expenditures and health outcomes in South Africa. The null hypothesis that increase in public health expenditure leads to no statistically significant improvement in either infant mortality rate or life expectancy at birth was rejected. This suggests that public health expenditure is effective in improving health outcomes in South Africa.

This finding was consistent with related studies in Africa and developing countries. Apart from the public health expenditure per capita, female literacy rate and HIV/Aids prevalence were also found to be important determinants of infant mortality rate and life expectancy at birth in South Africa. The magnitudes of HIV/Aids prevalence elasticities were higher than other statistically significant variables for both infant mortality rate and life expectancy at birth regressions.
CHAPTER 6: CONCLUSION

The aim of this minor dissertation was to assess the effectiveness of public health expenditure by estimating the health production function for South Africa using panel data estimation techniques. Results have shown that on average, an increase in public health expenditure leads to improvement in health outcomes particularly infant mortality rate and life expectancy at birth.

The estimated gains are largest with regards to infant mortality rate which has elasticity of -0.368 and smaller on life expectancy at birth with elasticity of 0.059. This means that infant mortality rate is more sensitive to changes in public health expenditure than life expectancy at birth. This observation is consistent with intuition that the more infants are saved from death, these children are more likely to live longer. This dissertation could not assess the relationship between public health expenditure and maternal mortality ratio due to unreliability of the maternal mortality ratio data.

Although income per capita (real GDP per capita) is generally considered another important determinant of health outcomes (infant mortality rate and life expectancy at birth), this minor dissertation found that such a relationship was statistically insignificant. This means that for South Africa, measures that will increase public health expenditure per capita, female literacy rate and reduction of HIV/AIDS prevalence are more likely to be successful than measures aimed at improving real GDP per capita.

Elasticities cited above imply that on average, a 10 percent increase in public health expenditure per capita will result in 3.7 percent decline in infant mortality rate holding other influences constant. On the other hand, a 10 percent increase in public health expenditure per capita will on average result in increase in life expectancy at birth by 0.6 percent.

All other control variables such as access to piped water, immunisation coverage rate and the number of physicians per 100 000 of the population and governance do not have a statistically significant relationship with health outcomes considered in this study. However, given that immunisation coverage rate and physicians per 100 000 of the population are proxies for access
to health (Moreno-Serra & Smith, 2015), the immediate health benefits of these variables are probably captured by the public health expenditure per capita explanatory variable.

Overall, results from this minor dissertation suggest that increasing public health expenditure is necessary but insufficient to significantly improve health outcomes in South Africa. Measures aimed at improving female literacy rate and prevention of HIV/AIDS are also important.

Based on the findings of this minor dissertation, the key policy implication for the government of South Africa is that it should increase public health expenditure per capita through an increase of the share of public health spending within each province’s equitable share in order to improve health outcomes. Furthermore, the government should increase resources towards educating women and include targeted interventions for HIV/AIDS. Analysis suggests that these measures can lead to improvement in health outcomes in South Africa.

Given that HIV/AIDS prevalence is found to play a statistically significant role in increasing infant mortality rate and reducing life expectancy at birth in South Africa, the country’s approach of significantly improving the roll-out of anti-retrovirals and the prevention of mother to child transmission (PMCT) programme is justified. In this regard, South Africa has made significant progress in the roll-out of HIV/AIDS treatment. The National Treasury (2015) reported that the number of people on anti-retroviral treatment has increased from 1.46 million in March 2011 to 2.68 million in March 2014. Although this is commendable, the number of new infections remains high in South Africa and more emphasis should be placed at preventing new HIV infections if more gains in reducing infant mortality rate and increasing life expectancy are to be realized.

Although the results of this minor dissertation have shown a statistically significant relationship between public health expenditure and health outcomes in South Africa, interpretations of these results must always be done with caution. For instance, the study was unable to account for the impact of private health expenditure and governance (bureaucratic capacity) on the reported health outcomes due to unavailability of data at provincial level for the specified time period.

Lastly, the missing data on the life expectancy at birth variable for the years 2003 to 2004 and the missing data on the physicians per 100 000 of the population control variable for the year
2004, made the time period of the panel to be relatively short (8 years) and this led to only 72 observations. Furthermore, if data permitted, it would have been important to study the short-run and long run effects of public health expenditure on health outcomes. However, in future this may be possible once longer time series data are available.

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. Furthermore, 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.
REFERENCES


Clark, T.S. & Linzer, D.A. (2012). *Should I use fixed or random effects?* Atlanta GA: Emory University, Department of Political Science.


APPENDIX 1: DATA ON KEY VARIABLES USED

**Figure 8**: Trends in Infant Mortality Rate in South Africa by Province, 2002-2012  
*Source: Own computation using data from the Health Systems Trust (2014)*

<table>
<thead>
<tr>
<th>Year</th>
<th>Eastern Cape</th>
<th>Free State</th>
<th>Gauteng</th>
<th>KwaZulu-Natal</th>
<th>Limpopo</th>
<th>Mpumalanga</th>
<th>Northern Cape</th>
<th>North West</th>
<th>Western Cape</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>72.0</td>
<td>68.3</td>
<td>62.2</td>
<td>62.0</td>
<td>60.1</td>
<td>58.8</td>
<td>57.7</td>
<td>47.9</td>
<td>46.5</td>
</tr>
<tr>
<td>2003</td>
<td>63.0</td>
<td>48.1</td>
<td>57.2</td>
<td>58.0</td>
<td>54.0</td>
<td>56.0</td>
<td>52.6</td>
<td>41.9</td>
<td>40.7</td>
</tr>
<tr>
<td>2004</td>
<td>46.0</td>
<td>33.5</td>
<td>34.2</td>
<td>37.0</td>
<td>32.9</td>
<td>35.3</td>
<td>33.4</td>
<td>25.2</td>
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<tr>
<td>2005</td>
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<td>30.4</td>
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<tr>
<td>2006</td>
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<td>34.1</td>
<td>38.6</td>
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<td>35.2</td>
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<td>27.2</td>
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<tr>
<td>2007</td>
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<td>40.5</td>
<td>55.8</td>
<td>53.0</td>
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<td>48.9</td>
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<td>32.5</td>
<td>26.3</td>
<td>25.5</td>
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<tr>
<td>2009</td>
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<td>44.0</td>
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<td>42.6</td>
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<td>30.6</td>
<td>29.6</td>
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<tr>
<td>2010</td>
<td>30.0</td>
<td>43.5</td>
<td>24.5</td>
<td>26.0</td>
<td>22.9</td>
<td>25.3</td>
<td>24.4</td>
<td>19.7</td>
<td>18.3</td>
</tr>
</tbody>
</table>

**Figure 9**: Trends in Life Expectancy at Birth in South Africa by Province, 2002-2012  
*Source: Own computation using data from the Actuarial Society of South Africa (2014) and Health Systems Trust (2014)*

<table>
<thead>
<tr>
<th>Year</th>
<th>Eastern Cape</th>
<th>Free State</th>
<th>Gauteng</th>
<th>KwaZulu-Natal</th>
<th>Limpopo</th>
<th>Mpumalanga</th>
<th>Northern Cape</th>
<th>North West</th>
<th>Western Cape</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>54.0</td>
<td>52.0</td>
<td>55.0</td>
<td>48.0</td>
<td>54.0</td>
<td>50.0</td>
<td>59.0</td>
<td>53.0</td>
<td>63.0</td>
</tr>
<tr>
<td>2003</td>
<td>51.0</td>
<td>51.0</td>
<td>57.0</td>
<td>48.0</td>
<td>60.0</td>
<td>51.0</td>
<td>60.0</td>
<td>53.0</td>
<td>64.0</td>
</tr>
<tr>
<td>2004</td>
<td>52.0</td>
<td>51.0</td>
<td>57.0</td>
<td>48.0</td>
<td>60.0</td>
<td>51.0</td>
<td>61.0</td>
<td>53.0</td>
<td>64.0</td>
</tr>
<tr>
<td>2005</td>
<td>52.0</td>
<td>51.0</td>
<td>57.0</td>
<td>49.0</td>
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<td>51.0</td>
<td>61.0</td>
<td>55.0</td>
<td>64.0</td>
</tr>
<tr>
<td>2006</td>
<td>53.0</td>
<td>52.0</td>
<td>59.0</td>
<td>51.0</td>
<td>52.0</td>
<td>62.0</td>
<td>53.0</td>
<td>61.0</td>
<td>65.0</td>
</tr>
<tr>
<td>2007</td>
<td>54.0</td>
<td>54.0</td>
<td>60.0</td>
<td>53.0</td>
<td>63.0</td>
<td>54.0</td>
<td>62.0</td>
<td>56.0</td>
<td>65.0</td>
</tr>
<tr>
<td>2008</td>
<td>55.0</td>
<td>55.0</td>
<td>60.0</td>
<td>53.0</td>
<td>63.0</td>
<td>56.0</td>
<td>62.0</td>
<td>57.0</td>
<td>65.0</td>
</tr>
<tr>
<td>2009</td>
<td>56.0</td>
<td>56.0</td>
<td>61.0</td>
<td>54.0</td>
<td>63.0</td>
<td>56.0</td>
<td>61.0</td>
<td>58.0</td>
<td>65.0</td>
</tr>
<tr>
<td>2010</td>
<td>56.0</td>
<td>56.0</td>
<td>61.0</td>
<td>54.0</td>
<td>63.0</td>
<td>57.0</td>
<td>61.0</td>
<td>58.0</td>
<td>65.0</td>
</tr>
</tbody>
</table>
Figure 10: Trends in Medical Aid Coverage Rate per Province, 2002-2012
Source: Own computation using data from the Health Systems Trust (2014)

Figure 11: Trends in Nominal Public Health Expenditure per Capita in South Africa by Province, 2002/03-2012/13
Source: Own computation using expenditure data from National Treasury (2007;2014) while uninsured population figures were calculated from Statistics South Africa’s (2014) General Household Survey data and the medical aid coverage rate from the Health Systems Trust (2014)
Figure 12: Trends in Real GDP per Capita in South Africa by Province, 2002-2012
Source: Own computation using data from Statistics South Africa (2014)

Figure 13: Trends in HIV/Aids prevalence among antenatal women by province, 2002-2012
Source: Own plot using data from National Department of Health (2013)
Figure 14: Immunisation Coverage Ratio by Province in 2012
Source: Own computation using data from the Health Systems Trust (2014)

Figure 15: Trends in the Percentage of Households with Access to Piped Water in the Dwelling, Off-Site or On Site in South Africa by Province, 2002-2012
Source: Own computation using General Household Survey Data from Statistics South Africa (2014)
Figure 16: Percentage of Female Population Aged 20 and above who Completed Grade 7 and above in 2012 per Province
Source: Own computation using Revised General Household Survey data from Statistics South Africa (2014)

<table>
<thead>
<tr>
<th>Province</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Cape</td>
<td>83.6%</td>
</tr>
<tr>
<td>Western Cape</td>
<td>78.0%</td>
</tr>
<tr>
<td>North West</td>
<td>84.5%</td>
</tr>
<tr>
<td>Northern Cape</td>
<td>86.6%</td>
</tr>
<tr>
<td>Mpumalanga</td>
<td>88.5%</td>
</tr>
<tr>
<td>Limpopo</td>
<td>83.6%</td>
</tr>
<tr>
<td>KwaZulu-Natal</td>
<td>87.2%</td>
</tr>
<tr>
<td>Gauteng</td>
<td>93.4%</td>
</tr>
<tr>
<td>Free State</td>
<td>86.8%</td>
</tr>
<tr>
<td>Northern Cape</td>
<td>89.6%</td>
</tr>
<tr>
<td>Western Cape</td>
<td>93.1%</td>
</tr>
</tbody>
</table>

Figure 17: Medical Practitioners per 100 000 of Uninsured Population per Province in 2012
Source: Own computation using data from Statistics South Africa (2014) and Health Systems Trust (2014)

<table>
<thead>
<tr>
<th>Province</th>
<th>Medical Practitioners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Cape</td>
<td>24.9</td>
</tr>
<tr>
<td>Western Cape</td>
<td>25.0</td>
</tr>
<tr>
<td>North West</td>
<td>27.2</td>
</tr>
<tr>
<td>Northern Cape</td>
<td>21.6</td>
</tr>
<tr>
<td>Mpumalanga</td>
<td>38.8</td>
</tr>
<tr>
<td>Limpopo</td>
<td>23.1</td>
</tr>
<tr>
<td>KwaZulu-Natal</td>
<td>33.9</td>
</tr>
<tr>
<td>Gauteng</td>
<td>34.6</td>
</tr>
<tr>
<td>Free State</td>
<td>20.2</td>
</tr>
<tr>
<td>Northern Cape</td>
<td>34.7</td>
</tr>
</tbody>
</table>
APPENDIX 2: DIAGNOSTIC TESTS

A2.1 Model Specification Tests

According to Gujarati and Porter (2009), specification errors can occur due to omitted variables, including an irrelevant explanatory variable and due to incorrect functional form. The omission of important control variable leads to biased estimates whereas an inclusion of irrelevant variable violates the BLUE condition. In other words, the estimated parameters are not the best linear unbiased estimators and therefore the estimated standard errors will generally be inefficient (Gujarati & Porter, 2009).

In this minor dissertation, a Ramsey RESET specification test was conducted to test for model specification error on the pooled OLS regressions. The null hypothesis in this test is that the model has no omitted variables (the model is well-specified). In both regressions involving infant mortality rate and life expectancy at birth, the null hypothesis that the specified model has no omitted variables could not be rejected suggesting that both models were correctly specified. The p-values in these instances were 0.2620 and 0.1392, respectively. Therefore, both models of infant mortality rate and life expectancy at birth are well-specified and can be used for inference making. The tests outputs for infant mortality rate and life expectancy at birth are presented below:

Model specification test for infant mortality rate

```
. estat ovtest

Ramsey RESET test using powers of the fitted values of logimr
   Ho:  model has no omitted variables
   F(3, 61) =      1.36
   Prob > F =      0.2620
```

The null hypothesis that the model has no omitted variables (model is well-specified) is not rejected based on the reported p-value of 0.2620. This suggests that this is the correct specification for infant mortality rate.
Model specification test for life expectancy at birth

The null hypothesis that the model has no omitted variables (model is well-specified) is not rejected based on the reported p-value of 0.1392. This suggests that this is the correct specification for life expectancy at birth model.

### A2.2 Multicolinearity test

The use of many explanatory variables in the model may result in the problem of multicolinearity. This is a problem where explanatory variables have exact co-linear relationship in a regression model (Gujarati & Porter, 2009; Ashiabi, 2013). In this minor dissertation, seven explanatory variables have been used to estimate the primary models representing health outcomes as required by the literature. According to Gujarati and Porter (2009), multicolinearity makes it hard to get coefficient estimates that are efficient. In other words, the resulting estimates will be imprecise making any statistical inference difficult. Section A2.2 under Appendix 2 provides results from the variance-inflating factor (VIF) test for multicolinearity.

According to Gujurati and Porter (2009), the VIF test is a test for the degree of multicolinearity and as a rule of thumb, if the VIF of a variable exceeds 10, that variable is said to be highly collinear. Therefore, from Table 9, all explanatory variables have a VIF of less than 10 suggesting that there is no problem of high multicolinearity in the estimated regressions.

#### Table 9: VIF Test for Multicolinearity

<table>
<thead>
<tr>
<th>Variable</th>
<th>VIF</th>
<th>1/VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loggdppc</td>
<td>7.19</td>
<td>0.1390</td>
</tr>
<tr>
<td>Atw</td>
<td>4.65</td>
<td>0.2152</td>
</tr>
<tr>
<td>Flr</td>
<td>3.82</td>
<td>0.2616</td>
</tr>
<tr>
<td>Loghexp</td>
<td>3.81</td>
<td>0.2623</td>
</tr>
<tr>
<td>Logphys</td>
<td>2.72</td>
<td>0.3683</td>
</tr>
<tr>
<td>Icr</td>
<td>2.21</td>
<td>0.4532</td>
</tr>
<tr>
<td>Phiv</td>
<td>1.32</td>
<td>0.7586</td>
</tr>
<tr>
<td>Mean VIF</td>
<td>3.44</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Own computation using STATA 13*
A2.3 Tests for Fixed Effects/Random Effects: Infant Mortality Rate Regressions

Hausman test to choose between fixed effects and random effects: Infant mortality rate

The null hypothesis that random effects model is preferred is not rejected at all conventional levels with a p-value of 0.6649. In this case, random effects model is preferred.

Breusch and Pagan Lagrangian multiplier test for random effects: Infant mortality rate

The null hypothesis that random effects model is preferred is not rejected at all conventional levels with a p-value of 0.6649. In this case, random effects model is preferred.

Breusch and Pagan Lagrangian multiplier test for random effects: Infant mortality rate

The null hypothesis that there are no random effects in the model is rejected at 1 percent level of significance since the p-value is 0.0000. In this case, random effects model is preferred over pooled OLS.
The F-test for the choice between fixed effects and pooled OLS: Infant mortality rate

```
. testparm i.year
( 1)  2006.year = 0
( 2)  2007.year = 0
( 3)  2008.year = 0
( 4)  2009.year = 0
( 5)  2010.year = 0
( 6)  2011.year = 0
( 7)  2012.year = 0

F(  7,    49) =   50.04
Prob > F =  0.0000
```

The null hypothesis that there are no time fixed effects in the model is rejected since the p-value of the F-test is 0.0000. In this case, the fixed effects model is preferred over pooled OLS.

### A2.4 Tests for Fixed Effects/Random Effects: Life Expectancy at Birth Regressions

**Hausman test to choose between fixed effects and random effects: Life expectancy at birth**

```
. hausman fixed ., sigmamore
```

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Coefficients</th>
<th>Coefficients</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td>(B)</td>
<td>(b-B)</td>
<td>sqrt(diag(V_b-V_B))</td>
</tr>
<tr>
<td>fixed</td>
<td>.</td>
<td>Difference</td>
<td>S.E.</td>
</tr>
</tbody>
</table>

| logphexp     | .0255076     | .0592946     | -.033787     | .0143443 |
| loggdppc     | .3154173     | .1114043     | -.204013     | .0957425 |
| flr          | .2192349     | .1585575     | .0606774     | .0369453 |
| atw          | -.0347133    | -.033704     | -.0010093    | .0534535 |
| phiv         | -.2194403    | -.6098556    | -.3904154    | .1813426 |
| icr          | .0096669     | .1002104     | .0098773     | .0154187 |
| logphys      | -.0369388    | -.0369092    | -.0000297    | .0145708 |

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

```
chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 11.77
Prob>chi2 = 0.1083
```

The null hypothesis that random effects model is preferred is not rejected based on a p-value of 0.1083. In this case, random effects model is preferred.
Breusch and Pagan Lagrangian multiplier test for random effects: Life expectancy at birth

The null hypothesis that there are no random effects in the model is rejected at 1 percent level of significance since the p-value is 0.0000. In this case, random effects model is preferred over pooled OLS.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Var</th>
<th>( \text{sd} = \sqrt{\text{Var}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \logle )</td>
<td>0.006842</td>
<td>0.0827167</td>
</tr>
<tr>
<td>( e )</td>
<td>0.0002452</td>
<td>0.0156579</td>
</tr>
<tr>
<td>( u )</td>
<td>0.0015868</td>
<td>0.0398341</td>
</tr>
</tbody>
</table>

Test: \( \text{Var}(u) = 0 \)

\[ \text{chibar2}(01) = 60.41 \]
\[ \text{Prob} > \text{chibar2} = 0.0000 \]

The null hypothesis that there are no random effects in the model is rejected at 1 percent level of significance since the p-value is 0.0000. In this case, random effects model is preferred over pooled OLS.

The F-test for the choice between fixed effects and pooled OLS: Life expectancy at birth

```
. testparm i.year
```

\( F(7, 49) = 1.75 \)
\[ \text{Prob} > F = 0.1188 \]

The null hypothesis that there are no time fixed effects in the model is not rejected since the p-value of the F-test is 0.1188. In this case, the pooled OLS is preferred over fixed effects model.
APPENDIX 3: SCATTER PLOTS FOR INFANT MORTALITY RATE
APPENDIX 4: SCATTER PLOTS FOR LIFE EXPECTANCY AT BIRTH