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Determinants of Public Health Expenditure Growth in Tanzania: An Application of Bayesian Model

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Abstract

This paper identifies some major drivers of per capita public health expenditure growth in Tanzania using nationally representative annual data between 1995 and 2014. It used Bayesian model based on Markov Chain Monte Carlo (MCMC) simulation. The empirical result shows that both the real GDP per capita and population age 65 years and older exert a positive effect on per capita public health expenditure growth in Tanzania. Advances in medical technologies represented by life expectancy seem to reduce real per capita public health expenditure growth in Tanzania. However, the credible intervals for life expectancy and population age 65 years and older are very wide suggesting a lot of uncertainty with these estimates. The results imply that, future trends in per capita public health spending would mainly depend on the development of the economy such as real per capita gross domestic product. The result suggests the rapid growth in real per capita public health expenditure is likely to continue in future when the country economy becomes more robust and increase of population age 65 years and above.

Keywords: Bayesian Approach, per capita GDP and Real per capita public health expenditure

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1. Introduction

Public expenditure growth is more related to budget decisions. It brings social changes in the public which in turn reduce poverty and inequalities in accessing a number of things including the health care services from the public to attain better health outcomes of the population. It is also essential for fighting major diseases to achieve Sustainable Development Goals (SDG) targets. To meet the SDG for healthy life for all in 2030, it is likely to reduce presence of many diseases externalities that require the need for government to involve in public provisions of quality health services to their citizens. The health sector interacts with socio, economic, demographic and environmental changes, thus affecting public health spending decisions at the national level (Abbas and Hiemenz, 2011). Thus, an understanding of the determinants of public health care expenditures is important to design effective health policies (Braendle & Colombier, 2016). For that case, there are a number of reasons to study the determinants of public health care expenditure growth in Tanzania.

First, the share of public health expenditure on total government expenditure was 11.3% in 2004 and 10% in 2014 (Tanzania Ministry of Finance, 2016). On average, from the year 2011 to 2014, the share of public health expenditure remains 10% of the total government expenditure. This share has never gone beyond 15% since Abuja Declaration of 2001 for every country to allocate 15% of its total budget to the health sector. This indicates low priority in planning, budgeting allocation and execution in the health sector. Furthermore, the failure to allocate 15% shares of public health expenditure requires the knowledge of what really determines public health expenditures in Tanzania. Over the years (1995 to 2014), public health expenditure as a percentage share of GDP fluctuates within 1% to 2% and averaged around 2.2%. It increased only from 1.8% in 2001 to 4.8% in 2006 (World Bank Indicators, 2016). Despite such increases, no evidence was found to suggest that public health expenditure as a percentage share of GDP to bring gains in child health outcomes in Tanzania over the year 1995 to 2013 (Byaro and Musonda, 2017a).

Second, there is an increase of population growth from 2.9% in 1995 to 3.2% in 2014 with similar trends of real public health care expenditure per capita over the years (World Bank Indicators, 2016; WHO Expenditure Database, 2017). While real per capita health expenditures peaked in 2006 at US dollars, it declined up to 2009 and increased thereafter to 2014. In general, it appears that there is an upward trend in health expenditure in Tanzania albeit with a little blip of a downward trend in Tanzania during the years of 2007 to 2011 when the upward trend was noted afterwards (See Figure 1).

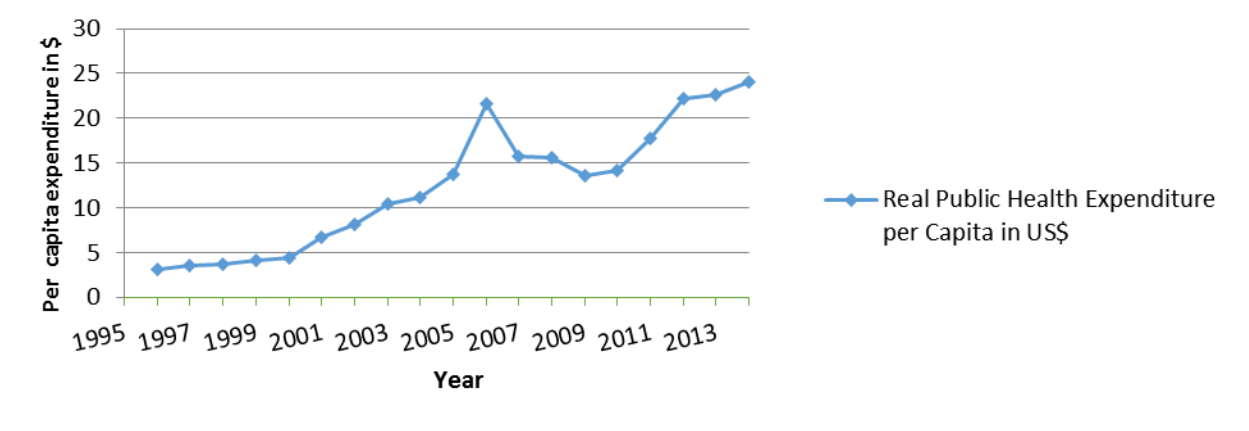


Figure 1: Trends of Real Public Health Expenditure per capita in Tanzania
Source: (WHO Expenditure Database, 2017)

Real public health expenditure per capita is calculated by dividing total public health care expenditure by the total population after adjusting inflation. The average per capita government expenditure on health in low income countries in Africa is US $ 15(WHO Expenditure Database, 2014). Figure 1 shows Tanzania is above the average per capita government expenditure devoted to health for the period between 2011 and 2014. Overall, the country has a total land area of 881,000 square kilometers and is one of the low income economies in the Eastern African Countries (Tanzania National Census, 2012). The projected total population in 2016 was 50.1 million (Tanzania Demographic Health Survey, 2015) with per capita gross national income of US $ 2467 (international Purchasing Power Parity) in 2015; and life expectancy rate ranging from 64 to 66 years at birth of male and female respectively (World Bank Indicators, 2016). The country spent 1.1% and 2.6% of its GDP on public health expenditure, in 2000 and 2014, respectively (World Bank Indicators, 2016). This shows the persistent rise in growth of public health expenditure. Thus, it is needed to model the determinants of public health expenditure and future trends in the health care spending in order to devise appropriate policies and affordable treatments for health care services provision to the people of Tanzania.

Third, due to the sample size taken in the previous literatures, most studies (for example, Boachie et al., 2014; Okunade and Murthy, 2016; Khan et al., 2016) in the determinants of public health expenditure used annual time series data with large observations (for example at least 30 annual periods of time) to avoid the problem of low ill powered sample for time series data analysis. Therefore, our study uses the Bayesian approach to estimate the parameters based on observed data by simulating a small sample using Markov Chain Monte-Carlo (MCMC) getting up to 10,000 samples to give posterior distribution which can provide stronger statistical power. The Bayesian approach can be used regardless of the sample size meaning that, the sample size does not affect inference method (Kruschke et al., 2012). Unlike maximum likelihood approaches, Bayesian estimation enables small sample sizes to be accounted for, by employing prior information on the model parameters (Gheorghe et al., 2016).

Given the background, this paper uses annual data for the period 1995-2014 in Tanzania to examine the determinants of public health expenditures growth. It seeks to contribute to the existing literature which is relatively scarce in Tanzania and departs from previous literature by adopting the Bayesian MCMC approach. As far as we are aware, the study is the first attempt to

analyze the determinants of public health expenditure growth using Bayesian MCMC methods. Our study findings suggest that, the real per capita income drives up real per capita public health expenditures growth in Tanzania. Moreover, it was found that population aging 65 years and older increases the real per capita public health expenditure growth as one would expect. However, the Bayesian credible interval for population aging 65 years and older is very wide suggesting a lot of uncertainty with this estimate.

The rest of the paper is structured as follows. Section 2 deals with the literature reviews. Section 3 describes the methodology and data sources while section 4 presents the empirical results and discussion. Section 5 presents the conclusion and policy recommendations.

2. Literature Reviews

There is an extensive literature on the determinants of health expenditure in Organization of Economic Cooperation and Development (OECD) countries (United States, Switzerland, Canada, Norway, Sweden, Denmark, Italy, and United Kingdom among others) but the same is not true for developing countries like Tanzania. Previous literature has examined whether income of a country, controlling for other factors, is the major determinants of health expenditure (Gerdtham and Jonsson, 2000; Martin et al., 2011; Hartwig and Sturm, 2014; Smith et al., 2009; Ramashamole et al., 2015; Okunade and Murthy, 2016; Younsi et al., 2016). On other hand, the rising of income in a household or the economy lead to higher levels of the demand for health due to the increasing marginal utility from health care rather from other goods and services (Hall and Jones, 2007). Therefore, many past studies have considered income as a main contributing demand factor in explaining variations in health care expenditure. Furthermore, many studies included non-income variables such as demographic factor for determinants of health care expenditure. For instance, age structure of population is identified as a key indicator to explain changes in health care expenditure across nations (Cuyler, 1988; Okunade and Murthy, 2016; Khan et al, 2016). The share of population less than 15 years of age and elderly population such as 65 years and above was estimated in different models explaining changes in the health care expenditure per capita. Studies such as (Reihardt, 2003; Khan et al., 2016; Breyer and Felder 2006; Schulz et al., 2004; Ogura and Jakovljevic, 2014) found aging population as a contributing factor of accruing health care costs. This means, as population ages, total health care spending for elderly are growing (Mao and Xu, 2014). Demographic structures such as population aged 65 years and older are taken into account in many studies because the elderly demand more health care services, and ageing society is expected to increase public health care expenditures (Okunade and Murthy, 2016; Matteo and Matteo, 1998). The literature further documents that persons of 65 years and older spend a major portion of health expenditure about five fold as younger adults and this holds true for older Americans in treating chronic diseases (Hoffman et al., 1996). However, some previous studies found no evidence of aging population to impact on total per capita health care expenditure (Tchoe and Nam, 2010; Barros, 2010).

Technological progress is one of the key factors to explain variations of health care expenditures (Newhouse, 1992). Due to non-availability of appropriate proxy to capture variations in the medical care technologies, various studies used health care specific research and development expenditure (Okunade and Murthy, 2002), infant mortality and life expectancy at birth (Dreger & Reimers, 2005), time index as a proxy for the impact of technology change (Gerdtham and Lothgren, 2000). Innovations in technology were identified as the main contributing factor in

increasing health care cost (Newhouse, 1992). Increased life expectancy is a measure of technological changes, which enhances labor force skills and efficiency (Khan et al., 2016). Life expectancy indicates increase of overall health conditions of general public that could be due to provision of advance technology in the health care sector which have a positive influence on the health care spending (Khan et al., 2016).

After reviewed some of the literature on the determinants of public health expenditure, we found most literature to rely on frequentist time series and panel techniques methods. For instance, a study by (Gerdtham et al. 1998; Barros, 1998; Roberts, 1999; Hitiris and Posnett, 1992; Murthy and Okunade, 2009; Ke et al., 2011; Younsi et al., 2016) used frequentist panel data models. Studies such as (Chaabouni and Abednnadher, 2014; Boachie et al., 2014; Okunade and Murthy, 2016; Khan et al., 2016) used frequentist time series data analysis. The majority of previous study was based on frequentist econometric techniques to determine the health care expenditure. Our research paper is focused on another methodological route that is the Bayesian technique which brings two novel aspects: firstly, the Bayesian model employed in the current study as far as we aware, has not been used yet in the literature to analyze the determinants of public health care expenditure. Secondly, the study is based on data from Tanzania, not on OECD data like in most of the previous studies.

The Bayesian methods admit the subjectivity given by prior distribution that consists of beliefs regarding coefficients and error variance. These beliefs are determined by researcher experience and theory based on the previous studies.

3. Methodology

3.1 Modeling Techniques.

Our model is adapted using ideas by Ntzoufras (2009) where the likelihood part of the multiple linear regression models can be viewed as:-

$y_i \sim N(\mu_i, \tau)$, where $\mu_i = \mathbf{X'}_i \beta$, $i=1\ldots, n$ and $\tau = \frac{1}{\sigma 2}$ ..... (1)

Where y_i = dependent variables (real per capita public health expenditure)

$\mathbf{X'}_i$ = vector of explanatory variables (Real GDP per capita, population aging 65 years & life expectancy)

$\beta =$ Coefficient of unknown parameter

μ_i= represent mean from the estimated regression coefficients

τ = represent precision or tau

The prior distribution assumed is

$$P(\beta, \tau) = \prod_{j=0}^{k} P\left(\beta_j\right) P(\tau)$$

Where $\beta_j \sim N(\mu_{\beta_j}, c_j^2)$ and $\tau \sim gamma(a, b)$

The resulting posterior density is given by: $P(\beta_0, \beta_i, \tau/y) \propto P(y/\beta_0, \beta_i, \tau)\, P(\beta, \tau)$..... (2)

Where β_0, β_i,represents the set of (real GDP per capita, population aging 65 and life expectancy) parameter θ, β_0, represent intercept, y represents the real per capita public health expenditure;

$P(\beta)$ is the prior distribution of the parameter which is derived from theoretical or other prior knowledge. $P(y/\beta_0, \beta_i, \tau)$ is the likelihood function which describes the real per capita public health expenditure (y) given (life expectancy, population aging 65 and real GDP per capita) as parameter β_0, β_i,.

$P(\beta_0, \beta_i, {}^{\tau}/_{y})$ is the posterior distribution for parameter β_0, β_i that is (life expectancy, population aging 65 and real GDP per capita) given the real per capita public health expenditure, (y). The equation (1) is from the theoretical literature, that the determinants of public health expenditure are based on the income (per capita real Gross Domestic Product), Age (percent of the population aged 65 and above) and life expectancy. The variables used in this paper was previous used by (Murthy and Okunade, 2016; Khan et al., 2016). The real per capita health expenditure is taking account of adjusted inflation and population growths. It hosts both economic and non-economic factors including population age structure and life expectancy. As the number of elderly grows, there is a possibility of rising public health expenditure (for example, drug expenditures). The real gross domestic product (GDP) per capita is taken after dividing the real gross domestic product by the total population. It is used as a proxy of income.

3.2 Data and Variable Sources Selection.

The primary data sources used in this paper were obtained from: - (i) World Development Indicators (WDI) compiled by the World Bank (2016) and (ii) WHO NHA (National Health Account). The real public health expenditure per capita is obtained from a WHO NHA indicator called General Government Expenditure on health per capita which includes both domestic and foreign funds. Real GDP per capita, population aged 65 and above and life expectancy were obtained from WDI. Per capita monetary terms variables (real GDP and public expenditure per capita) were adjusted for inflation at constant 2010 US international dollars. Real GDP per capita (income) was included due to the factor that, higher income is associated with greater health care spending (Murthy and Okunade, 2016; Zurn et al., 2004).

Population age structures age 65 and above represent the health care needs within the population (Murthy and Okunade, 2016; Hitiris and Posnett, 1992). Elderly population consumes health spending due to age. Diseases like diabetes and cardiovascular affects more elderly and it needs high cost in treatment which in turn induces higher spending. Moreover, health outcome variable (life expectancy) is used as a proxy to capture the effects of technology change on health care expenditure (Dreger & Reimers, 2005). Life expectancy indicates increase of overall health conditions of general public that could be due to provision of advance technology in the health care sector which have a positive influence on the health care spending (Khan et al., 2016). Health outcome can be measured using three major indicators; infant mortality, under-five mortality and life expectancy at birth. However, we choose life expectancy to represent the health status. It is defined as the time (in years) that an individual is expected to live after birth. Overall, this study included aging population, life expectancy and real GDP per capita to estimate the real per capita public health expenditure growth.

3.3 Data Analysis

All empirical estimation is undertaken using WinBUGS. For the Bayesian approach, the data was drawn with a normal distribution of mean (μ_i) and precision(τ). Mean (μ_i) is given a normal prior with mean 0 and precision 0.001, and τ is given a gamma (0.0, 0.01). The estimation method was based on Markov Chain Monte Carlo (MCMC) simulation to get posterior distribution. We run 10,000 iterations sample with a burn in of 1000 and 1 thinning parameter. The iteration was important to observe and monitor stationary distribution (convergences). Similarly, thinning is done to reduce autocorrelations which is common in time series data. To see whether the model was appropriate, diagnosis test performed based on MCMC post estimation (Figure 2) through history plots, autocorrelation plots and kernel density. Kernel density is done to observe normal distribution of the parameters. All the models were free from autocorrelation, showed normal distribution and convergence to equilibrium, thus ready for interpretation (See Table 1).

4.0 Empirical Results and Discussion

Table 1 shows the result from Bayesian modeling estimates for the determinants of public health expenditure growth in Tanzania over 1995 to 2014. Diagnostic test based on MCMC post estimation from Figure 2 shows normal distribution of the parameters, no autocorrelation and convergence to equilibrium.

Table 1: Bayesian Posterior Results of Public Health Expenditure

			(95 % Credible interval)	
Parameter	**Mean**	**SD**	**2.5%**	**97.5%**
Model				
β_0(intercept)	-1.17	26.95	-54.38	51.24
β_1(Real GDP per capita)	0.14	0.06	0.02	0.25
β_2(Population aging 65 and older)	11.81	19.61	-27.57	50.1
β_3(Life expectancy)	-1.91	1.49	-4.82	1.13

Source: (Authors computation, 2017)

The expected mean for real GDP per capita and population aging 65 and above are expected to be positive. The results of the Bayesian posterior (Table 1) are interpreted within the credible intervals and the association between explanatory variables and dependent variables is observed on the signs of the posterior summaries (mean, 2.5% and 97.5% percentiles). If the sign of posterior results are all positive or negative, the corresponding association can be concluded (Byaro and Musonda, 2017a). The 95% credible interval is the probability that the true parameter value lies within the interval equals 95%. From the results, both real GDP per capita and populations aging sixty five and older showed positive signs of the posterior summaries (Mean, 2.5% and 97.5% percentiles). This means the real GDP per capita is positively related to per capita public health care expenditure growth. The result implies that, as real GDP per capita increase, it raises the real per capita public health expenditure in Tanzania. Similarly as the

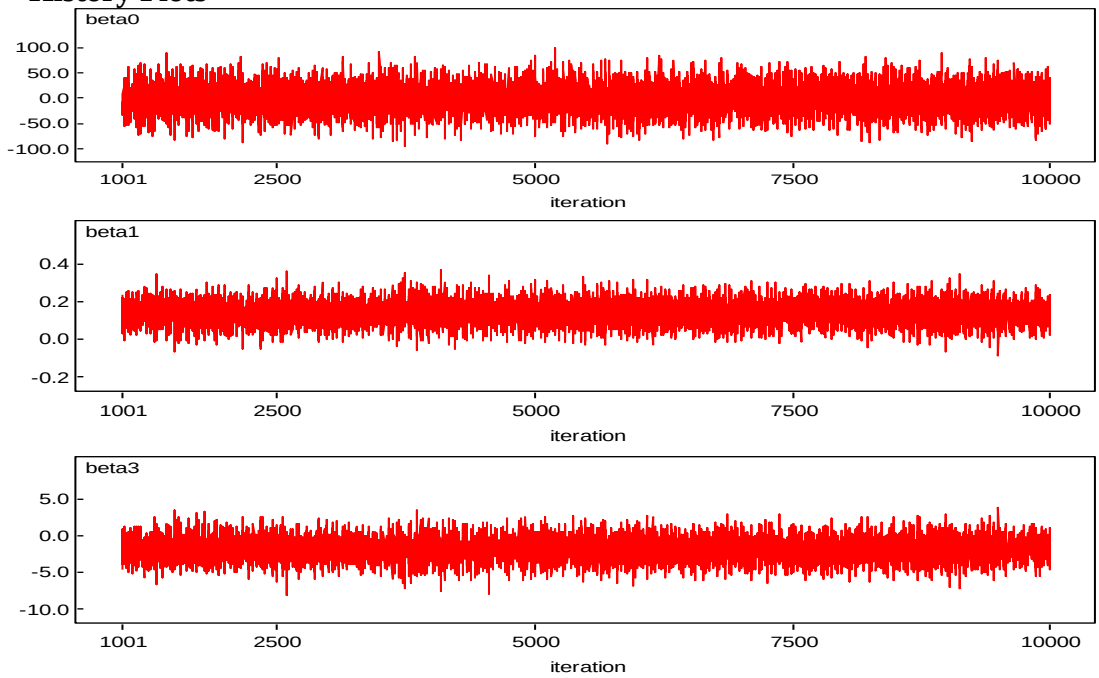
population aging 65 and older increases, it raises the real per capita public health expenditure in Tanzania albeit the credible interval is very wide suggesting a lot of uncertainty with this estimate.

As per capita income increases, there is also a pressure on the government to increase better and varied health services. This might change lifestyle of the people, as a result diseases such as cancer, diabetes and cardiovascular can develops which put pressure on the government to spend more on heath sector. This might be among the reasons why richer countries allocate high public funds in the health sector. Countries with higher GDP per capita spend more on health care than countries with lower GDP per capita, and they tend to have larger workforces (Zurn et al., 2004). That's why in implementing solutions to problems in health care systems and shortage of human resources in developing countries, GDP per capita is an important factor to consider (Byaro and Musonda, 2017b).

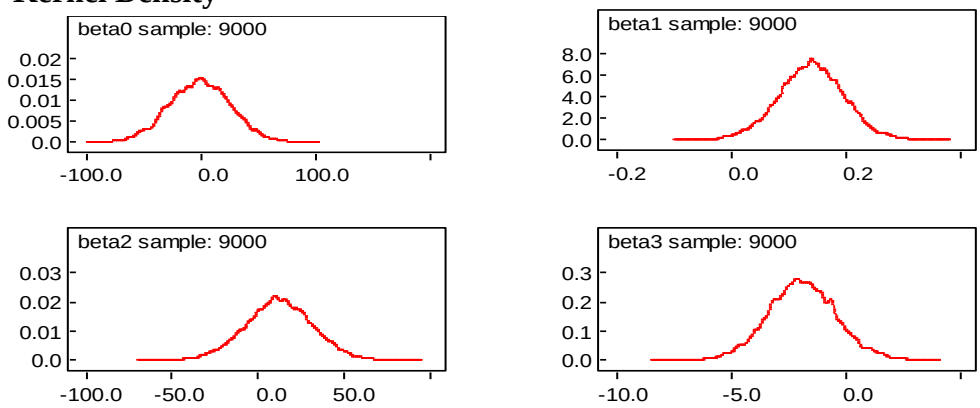
The link between population aging and national health expenditure is due to the fact that per capita health spending increases with age (González-González et al., 2011). This increase corresponds with the increase in proportion of population aging observed in different countries (González-González et al., 2011). Similarly with life expectancy, there is an indication that, as life expectancy increases, the real per capita public health expenditure declines in Tanzania, although there is a lot of uncertainty to this estimate due to wide credible intervals.

Figure 2: Diagnostic Tests

a) History Plots

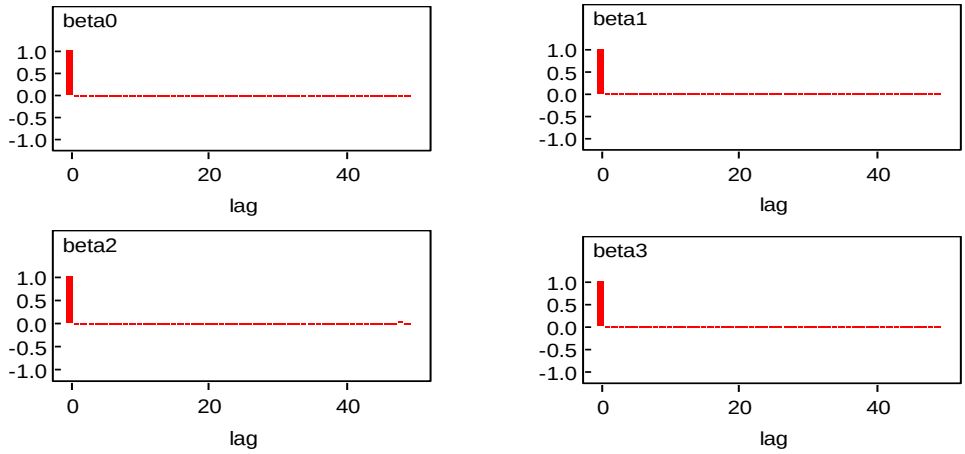


b) Kernel Density



All the necessary diagnostic tests for assessing convergence such as history, kernel density and autocorrelation were performed and the results were observed in the chains (i.e. the chain for each parameter was stationary). A good chain shows rapid mixing and implies the stationary distribution is reached (See figure 2a).

c) Autocorrelation Plots



5. Conclusions

This paper addresses the determinant factors affecting per capita public health expenditure growth at the national level in Tanzania using annual data from 1995 to 2014. Our paper included population aging 65 years and older, life expectancy and real per capita GDP to explain variations in per capita public health expenditure growth. Generally, it is observed that, with advancing economy (i.e. such as increase of real GDP per capita) per capita public health expenditure increases. This means that, an increase in real per capita income (GDP) was associated with more public health spending. Moreover, our study finding implies that per capita public health expenditure would grow steadily with increases in future economic wealth of the country.

Also, aging population increases the real per capita public health expenditure and life expectancy seem to indicate that, it reduces the real per capita public health expenditure growth in Tanzania. It imply that advance in medical technologies could result in disease prevention and decreased

health care cost. This may suggest that an increase in life expectancy, there is a possibility of an increase in the workforce in the country and hence increasing gross domestic product (GDP). Previous research such as Okunade and Murthy (2016), Matteo and Matteo (1998) showed that age exerts a positive impact on public health expenditure growth. Overall, our result findings suggest future forecast on public health expenditure growth projections will base on the country GDP and population aging 65 years and older.

Future studies will also look for other factors that might determine the public health expenditure growth in the country using different estimation techniques. Finally, our study recommends policies that aim to increase the real GDP per capita which result in per capita public health expenditure growth to deliver adequate and affordable health services in the country.

This study has got its own limitations. First, there might be other factors apart from real per capita income and population aging 65 years and older that could explain the public health expenditure growth in Tanzania. Our study was limited by the use of aggregate data. Further studies will consider other factors and methodology in the determinants of public health expenditure growth in Tanzania.

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