



## Effect of Communicable Diseases on the Economy: A Panel Data Analysis

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### Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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## Abstract

Communicable diseases are a major health challenge for the world. However, their negative impacts are felt most in Africa. This panel data study investigates the effect of communicable diseases and health expenditure on the economy. Gross Domestic Product (GDP) and current health expenditure are used as proxies for economic performance and health expenditure, respectively. Incidence of Tuberculosis, prevalence of Human Immunodeficiency Virus (HIV), and adults living with HIV (15 years - above) are the health indicators used in the study. Data for a period of ten years: 2007 to 2016 were collected from seven African countries in low and middle-income countries, according to World Health Organization (WHO) income groupings. Low-income countries are Gambia, Sierra Leone, and Togo, while Egypt, Ghana, Nigeria, and South Africa are middle-income countries. The three analytical panel data models; namely: Pooled Ordinary Least Squares Model (POLS), Fixed Effects Model (FEM) and Random Effects Model (REM) were used. Model selection tests were also performed, using the F Ratio Test, the Breush-Pagan Langrange Multiplier Test, and the Hausman Test, to choose the model that best describes the data. The results of the model selection tests show that the FEM is the most appropriate model for the data; therefore, the result of the FEM is used to interpret the impact of communicable diseases on the economy. First, the FEM analysis generally showed that HIV prevalence has a statistically significant negative effect on GDP, which is consistent with the existing literature. On the other hand, the incidence of tuberculosis and adults living with HIV have statistically

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positive effect. The result also shows that current health expenditure per capita is positively correlated with GDP, which implies that a unit increase in current health expenditure would lead to an increase of 961 units in GDP, based on the data used. Second, an additional analysis conducted in FEM to determine the effect of the variables in each country reveal that adults living with HIV and HIV prevalence have a statistically significant negative effect on economic performance. In conclusion, communicable diseases are an impediment to economic growth. The prevention and control of these diseases is a step in the right direction towards improving economic performance.

*Keywords: Communicable diseases; economy; GDP; HIV; panel data; TB.*

## 1 Introduction

Globally, the prevalence of communicable diseases remains a major health challenge with adverse effects on the economy. These effects are felt both directly (through the immediate impact of ill health on productive activities) and indirectly, through the effects of the disease on fertility, morbidity, mortality and intellectual capacity and, therefore, on the size, composition and quality of the workforce, and in the ability of countries to participate in the global economy Mills and Shillcutt [1]. The negative impacts of infectious diseases have been felt around the world, especially in developing countries such as countries in Sub-Saharan Africa.

The main goal of the Sustainable Development Goals (SDGs) in relation to infectious diseases is Target 3.3 which is to end the epidemics of Acquired Immune Deficiency Syndrome (AIDS), tuberculosis, malaria and neglected tropical diseases (NTDs) and combat hepatitis, waterborne diseases and other communicable diseases by 2030 [2]. According to the WHO [3] together, these diseases caused approximately 4.3 million deaths in 2016 (1.7 million females and 2.7 million male), compared to 5.3 in 2000 (2.2 million females and 3.1 million male). The WHO African Region and South-East Asia Region and low- and lower-middle-income countries have the highest risk of dying from these infectious diseases.

Basically, diseases influence economic performance through the productivity of the labour force and the accumulation of human capital Veenstra and Whiteside [4]; Couderc and Ventelou, [5]. In 2010, Goenka and Liu [6] opined that the main result of reduced productivity and capital accumulation is the immediate decline in the country's output. Diseases have a major impact in reducing the ability of infected people to work effectively and thus reduce their productivity, which can have significant economic consequences Nor et al. [7]. Audibert et al. [8] observed that several authors have considered that communicable diseases, among others, have contributed to slowing down economic development in low-income countries. According to Strauss and Thomas [9], the most commonly used indicators of health conditions at the macroeconomic level are life expectancy at birth and infant mortality rates. Bloom et al. [10] show that life expectancy has a positive, considerable and statistically significant effect on aggregate production, even when controlling for labor force experience.

Somayeh et al. [11] investigated the effect of health on economic growth using a sample of 16 developed and 14 developing countries for a period of 990 - 2010. The health indicators used are fertility rate, total (birth per woman), life expectancy at birth, total (years) and mortality rate, children under 5 years of age (per 1000 live births), as well as the social capital on economic growth. They found that capital stock and life expectancy have a statistically significant positive effect on economic growth in both groups of countries. The mortality rate has a statistically significant negative effect on economic growth in both groups of countries. On the other hand, the fertility rate has a statistically significant positive effect on economic growth in developed countries, while it has a statistically significant negative effect on economic growth in developing countries.

In 2018, Rajesh Sharma [12] examined the health-growth relationship using an unbalanced panel of 17 advanced economies over a 143-year period, 1870-2013, and uses an estimator from the generalized panel method of moments that addresses endogeneity issues. He used life expectancy at birth as a proxy for population health and control for endogeneity problems using the Generalized Panel Moment Method (GMM) technique, with alternative model specifications as well as its growth. In addition to life expectancy, another component of human capital, schooling is also positively associated with per capita income.

Audibert et al. [8], argue in their article that the health indicators commonly used in macroeconomic studies (examples are life expectancy, infant mortality or the prevalence rates of specific diseases such as malaria or HIV/AIDS ) imperfectly represent the overall health status of a population. However, they assessed the effect of health on growth using a global health indicator, the so-called disability-adjusted life year (DALY). Growth convergence equations were run in 159 countries during the 1999-2004 period. The result showed that health has a negative and statistically significant effect on economic growth.

Researchers also investigated the effect of specific diseases on economic growth. Nor et al. [7] examined the impact of diseases such as dengue, tuberculosis, and HIV on GDP per capita in selected countries in Southeast Asia between 1990 and 2011. Panel data analysis and the cointegration estimation technique: Johansen-Fisher, Kao and Pedroni techniques were adopted to achieve the objectives of the study. It was shown that shocks to human capital (diseases) have a great adverse impact on economic performance, especially; dengue, tuberculosis and HIV. The findings of this study suggest that reducing illness can lead to a considerable improvement in economic performance.

A considerable body of economic literature have tested the impact of disease on economic performance by focusing more on the two commonly accepted outcomes: life expectancy and infant mortality. However, the effects of communicable diseases such as HIV and tuberculosis have not been considered much [7]. Research provides information on the epidemiology, pathogenesis, genetic makeup and other areas of the disease necessary to eliminate or control it [13]. The limited number of existing studies that focus on the impact of communicable diseases forms the rationale behind the study.

The aim of this study is to investigate the effect of communicable diseases, as well as health care expenditure on the economy, using HIV and tuberculosis as indicators of communicable diseases, and GDP as a proxy for economic performance.

The following are the research objectives:

- i. To determine which panel data model best interprets the data.
- ii. To determine the effect of communicable diseases on economic performance in Africa.
- iii. To examine the relationship between health expenditure and economic performance.

This study is imperative at this time as it will serve as a complementary study to previous studies on the relationship of health and economic performance and also aid policy making and implementation in the health sector by leaders especially in African countries.

The main limitation in this research is non – availability of data: as at 2019 when the data were sourced from the World Health Statistics, a publication of the WHO, only data up to 2016 were available. Hence, the study covers a period of 2007 to 2016. Again, data on other communicable diseases as recognized by WHO as indicators of progress for SDG could not be accessed. The reason only HIV and TB are used in this study.

The Economic data used in this study are gross domestic product and current health expenditure per capita (current US \$). The GDP data used in this paper is past and projected (nominal) GDP as classified by the IMF. The tables are based on official exchange rates, not on the purchasing power parity (PPP) methodology. Values are in millions of dollars and have not been adjusted for inflation [14].

Proxies for communicable diseases used are Tuberculosis and Human Immunodeficiency Virus (HIV). The data on tuberculosis used in this study are the incidence of tuberculosis, which is the estimated number of new and recurrent tuberculosis cases that arise in a given year, expressed as a rate per 100,000 inhabitants. All forms of tuberculosis are included, including cases of people living with HIV. Data on prevalence of HIV and the number of adults living with HIV are used. HIV prevalence refers to the percentage of people aged 15 to 49 who are infected with HIV and Adults living with HIV refers to the number of people aged 15 to 49 who are infected with HIV.

## 2 Methodology

### 2.1 Data

The database used in this study comes from the combination of different statistical sources. Data on GDP in US dollars were obtained from the International Monetary Fund database [14]. Data on adults living with HIV (15 years and older) and HIV prevalence were obtained from World Bank health, nutrition, and population statistics. Data on current health expenditure per capita (current US dollars) were obtained from World Bank national accounts data and OECD national accounts data files. Finally, the Tuberculosis Incidence data was obtained from the World Health Statistics (WHS) series 2009-2018: a WHO publication.

The study covers a period of ten years from 2007 to 2016 of seven African countries of low- and middle-income groupings. They are, Egypt, Gambia, Ghana, Nigeria, Sierra Leone, South Africa, and Togo. Based on WHO income groupings, Gambia, Sierra Leone, and Togo are low-income countries, whereas, Egypt, Ghana, Nigeria, and South Africa are middle income countries.

### 2.2 Univariate data analysis

The univariate data analyses for the study were performed using descriptive statistics. This is done to ascertain if the variables are normally distributed as well as their respective directions. The Shapiro-Wilk test is used to test for normality of the variables. The null hypothesis is that the population is normally distributed.

### 2.3 Panel unit root test

If the variables in a panel data set are nonstationary, estimates are inefficient and may result in erroneous regression unless they are cointegrated. Four panel unit root tests are performed to determine the order of integration of the variables utilized in the study: Levin, Lin, and Chu (LLC) [15]; Im, Pesaran, and Shin (IPS) [16]; Fisher - Dickey Fuller (ADF) [17]; and Fisher – Philips - Perron [18]. The null hypothesis indicates that there is a unit root in all of these tests.

### 2.4 Method of estimation

One of the objectives of this study is to determine which panel data model best interprets the data. For this reason, the three panel data analytical models will be employed in this study; namely: Pooled Ordinary Least Squares Model (POLS), Fixed Effects Model (FEM) and Random Effects Model (REM). The variables are GDP, denoted by *gdp*; incidence of tuberculosis, denoted by *intub*; prevalence of HIV, denoted by *prehiv*; number of adults living with HIV, denoted by *adhiv*; and current health care expenditure, denoted by *chxpp*. *Gdp* is the dependent variable, while *intub*, *prehiv*, *adhiv*, and *chxpp* are the independent or explanatory variables.

### 2.5 Model specification

The following parameters are used in the models:

$\beta$  is the coefficient of the explanatory variables.

$v_i$  denotes the unobservable individual-specific effect.

$\varepsilon_{it}$ ,  $u_{it}$  denotes the remainder disturbance, known as the idiosyncratic error term.

Mishra [19] commented that these three panel data analytical models differ in their assumptions about the intercept ( $\alpha$ ) and the disturbance term ( $u_{it}$ ).

### 2.5.1 Specification of Pooled Ordinary Least Squares Regression model (POLS)

According to Adesete [20] and Zulfikar [21], the POLS Regression model ignores the panel structure of the data, that is, the time and individual dimensions are not considered, it treats all observation as equivalent.

The POLS regression model for the study is

$$gdp_{it} = \alpha + \beta_1 * \text{intub} + \beta_2 * \text{prehiv} + \beta_3 * \text{adhiv} + \beta_4 \text{chxpp} + u_{it} \quad (2.1)$$

Where,

$i = 1, 2, \dots, 7$  (countries)

$t = 1, 2, \dots, 10$  (year)

$\alpha$  is the common intercept.

$u_{it}$  is the idiosyncratic error term.

$\beta$  is the coefficient of the parameter estimates.

### 2.5.2 Fixed effect model

The fixed effects model arises from the assumption that the omitted, unobserved effect  $v_i$  are correlated with the regressors,  $x_{it}$ , it can be estimated in two ways: the within group estimator and the least squares dummy variable (LSDV) estimator.

#### 2.5.2.1 Specification of fixed effect within group model [FEM (WG)]

The WG regression model is,

$$\left( gdp_{it} - \overline{gdp}_i \right) = \beta_1 \left( \text{intub}_{it} - \overline{\text{intub}}_i \right) + \beta_2 \left( \text{prehiv}_{it} - \overline{\text{prehiv}}_i \right) + \beta_3 \left( \text{adhiv}_{it} - \overline{\text{adhiv}}_i \right) + \beta_4 \left( \text{chxpp}_{it} - \overline{\text{chxpp}}_i \right) + \left( \varepsilon_{it} - \overline{\varepsilon}_i \right) \quad (2.2)$$

Where,

$\overline{gdp}$ ,  $\overline{\text{intub}}$ ,  $\overline{\text{prehiv}}$ ,  $\overline{\text{adhiv}}$ ,  $\overline{\text{chxpp}}$  are the sample mean values of gdp, intub, prehiv, adhiv, and chxpp respectively.

#### 2.5.2.2 Specification of fixed effect least squares dummy variable model [FEM (LSDV)]

An alternative way to estimate the fixed effects model is by least squares of  $y_{it}$  on  $x_{it}$  including a set of  $N - 1$  dummy variables which identify the individuals and hence an additional  $N - 1$  parameters. The individual effect is picked up by the dummy variable  $D_{mi}$  where  $m = N - 1$ . The [FEM(LSDV)] allows for heterogeneity among subjects by allowing each country to have its own intercept value.

The LSDV regression model for this study is,

$$gdp_{it} = \gamma_1 + \gamma_2 D_{2i} + \gamma_3 D_{3i} + \gamma_4 D_{4i} + \gamma_5 D_{5i} + \gamma_6 D_{6i} + \gamma_7 D_{7i} + \beta_1 * \text{intub} + \beta_2 * \text{prehiv} + \beta_3 * \text{inhiv} + \beta_4 * \text{chxpp} + u_{it} \quad (2.3)$$

Where,

$D_{2i} = 1$  for Gambia, 0 otherwise

$D_{3i} = 1$  for Ghana, 0 otherwise  
 $D_{4i} = 1$  for Nigeria, 0 otherwise  
 $D_{5i} = 1$  for Sierra Leone, 0 otherwise  
 $D_{6i} = 1$  for South Africa, 0 otherwise  
 $D_{7i} = 1$  for Togo, 0 otherwise

$\gamma_2 - \gamma_7$  are respectively parameter estimates of the dummy variables.

### 2.5.3 Specification of random effects model (REM)

The REM assumes that the errors  $v_i$  and  $\varepsilon_{it}$  are conditionally mean zero, uncorrelated and homoskedastic.

The Random Effect Model for the study is,

$$gdp_{it} = \alpha + \beta_1 * intub_{it} + \beta_2 * prehiv_{it} + \beta_3 * adhiv_{it} + \beta_4 * chxpp_{it} + v_i + \varepsilon_{it} \quad (2.4)$$

where;

$v_i$  is the individual-specific (unobserved) effects, assumed to be random variables that are independent of the regressors (explanatory variables), with a mean value of zero and a variance of  $\sigma_v^2$ .

$\varepsilon_{it}$  is the idiosyncratic error term since it varies over cross section as well as time.

## 2.6 Model selection tests

Following the difference in assumptions and estimations of the panel data models, one is left with the question of; which is the best model. The F – test, the Breusch - Pagan Langrange Multiplier Test, and the Hausman Test are carried out to ascertain the most appropriate panel data model for the data set.

### 2.6.1 The F – ratio test

According to Greene [22], the F- Ratio Test is used to decide between the POLS and the FEM. Under the null hypothesis that the constant terms (dummy parameters except for one that is dropped) are all equal to zero. The null hypothesis is:

$$H_0 = \gamma_1 = \gamma_2 = \dots = \gamma_{n-1} = 0 \quad (2.5)$$

The F – Ratio test statistic is:

$$F_{(N-1, NT-N-K)} = \frac{(RRSS - URSS)/(N-1)}{(URSS)/(NT-N-K)} = \frac{(R_{LSDV}^2 - R_{POOLED}^2)/(N-1)}{(1 - R_{LSDV}^2)/(NT-N-K)} \quad (2.6)$$

### 2.6.2 The Breusch - pagan langrange multiplier test (LM)

Breusch and Pagan in 1980 [22] devised a Langrange Multiplier (LM) Test for the random effects model based on the OLS residuals. The LM is used to decide between a RE regression and a simple OLS regression. The null hypothesis is that there is no significant difference across cross – sectional units (that is, no panel effect) implying that RE model is inappropriate. That is,

$$H_0 : \sigma_u^2 = 0 \text{ versus } H_1 : \sigma_u^2 \neq 0 \quad (2.7)$$

The Breusch - Pagan Langrange Multiplier test statistic is:

$$LM = \frac{NT}{2(T-1)} \left[ \frac{\sum_{i=1}^N \left( \sum_{t=1}^T \varepsilon_{it} \right)^2}{\sum_{i=1}^N \sum_{t=1}^T \varepsilon_{it}^2} - 1 \right]^2 = \frac{NT}{2(T-1)} \left[ \frac{\sum_{i=1}^N (T\bar{\varepsilon}_i)^2}{\sum_{i=1}^N \sum_{t=1}^T \varepsilon_{it}^2} - 1 \right]^2 \tag{2.8}$$

Under the null hypothesis, the limiting distribution of LM is Chi – squared with one degree of freedom.

### 2.6.3 The hausman test

In 1978, Hausman devised a specification test for the test of orthogonality of the common effects and the regressors [22]. The Hausman test is used to decide between the REM and the FEM. The null hypothesis is that there is no dependence between the individual effects and the explanatory Variables.

The Hausman test statistic is

$$H = (\hat{\beta}_{fe} - \hat{\beta}_{re})' \text{var}(\hat{\beta}_{fe} - \hat{\beta}_{re})^{-1} (\hat{\beta}_{fe} - \hat{\beta}_{re}) \\ = (\hat{\beta}_{fe} - \hat{\beta}_{re})' (V(\hat{\beta}_{fe}) - V(\hat{\beta}_{re}))^{-1} (\hat{\beta}_{fe} - \hat{\beta}_{re}) \tag{2.9}$$

Where both  $V(\hat{\beta}_{fe})$  and  $V(\hat{\beta}_{re})$  take the classical (non-robust) form [23].

## 3 Results and Discussion

### 3.1 Results

The summary of the results of statistical data analysis using STATA 15 are presented below. The discussions are also presented thereafter.

**Table 1. Descriptive statistics for test of normality**

|              | <b>gdp</b> | <b>intub</b> | <b>prehiv</b> | <b>adhiv</b> | <b>chxpp</b> |
|--------------|------------|--------------|---------------|--------------|--------------|
| Mean         | 151490.3   | 325.6286     | 4.14          | 1151489      | 129.1643     |
| Std. Dev.    | 172557.7   | 301.0755     | 6.278936      | 2131592      | 152.2379     |
| Skewness     | 0.6697721  | 0.9967521    | 1.993062      | 1.903806     | 1.970279     |
| Kurtosis     | 1.989008   | 2.791931     | 5.11301       | 5.014866     | 5.527109     |
| Minimum      | 1259       | 14           | 0.1           | 4200         | 19.5         |
| Maximum      | 568496     | 1003         | 20.4          | 7200000      | 597.4        |
| Shapiro-Wilk | 0.80259    | 0.85001      | 0.64906       | 0.53488      | 0.5662       |
| Probability  | 0.00000    | 0.00000      | 0.00000       | 0.00000      | 0.00000      |

**Table 2. Panel unit root tests result**

|               | <b>LLC t-statistics</b> |                         | <b>IPS W-statistics</b> |                         | <b>ADF-Fisher Chi-square</b> |                         | <b>Philips-Perron Z-test</b> |                         |
|---------------|-------------------------|-------------------------|-------------------------|-------------------------|------------------------------|-------------------------|------------------------------|-------------------------|
|               | <b>Level</b>            | <b>First Difference</b> | <b>Level</b>            | <b>First Difference</b> | <b>Level</b>                 | <b>First Difference</b> | <b>Level</b>                 | <b>First Difference</b> |
| <b>gdp</b>    | -3.6538***              | -6.5857***              | -0.8004                 | -3.2649***              | 14.7346                      | 46.4736***              | -1.6306*                     | -3.9716***              |
| <b>intub</b>  | -1.4313*                | -8.4716***              | 1.1471                  | -4.2577***              | 5.8882                       | 68.1974***              | 1.5594                       | -5.0964***              |
| <b>prehiv</b> | -5.5740***              | -1.3755*                | -                       | -                       | 34.6071***                   | 27.2032**               | -2.4503***                   | -2.0244**               |
| <b>adhiv</b>  | 4.5750                  | -9.1733***              | -1.4954*                | -5.6960***              | 37.9232***                   | 115.6412***             | 5.5394                       | -7.6713***              |
| <b>chxpp</b>  | -2.4997***              | -5.6614***              | 0.0124                  | -2.5853***              | 11.0077                      | 44.8334***              | 0.1438                       | -3.0610***              |

\*\*\* denotes significance at 1% level, \*\* denotes significance at 5% level, and \* denotes significance at 10% level.

**Table 3. Estimation results of the panel data models**

|                        | Pooled OLS   | Fixed effect LSDV model | Fixed effect within group model | Random effect model |
|------------------------|--------------|-------------------------|---------------------------------|---------------------|
| Intub                  | -40.05828    | 147.0038***             | 147.0038***                     | 112.6095**          |
| Prehiv                 | -75746.15*** | -169269.9***            | -169269.9***                    | -55559.88***        |
| Adhiv                  | .2179217***  | .2181367***             | .2181367***                     | .1172465***         |
| Chxpp                  | 745.5142***  | 960.773***              | 960.773***                      | 897.5714***         |
| Intercept              | 130763.1***  | 145583.9***             | 428853.9***                     | 93793.78***         |
| countryid_2            |              | 107730.6                |                                 |                     |
| countryid_3            |              | 60341.91                |                                 |                     |
| countryid_4            |              | 98434.02**              |                                 |                     |
| countryid_5            |              | -43545.59               |                                 |                     |
| countryid_6            |              | 1516499***              |                                 |                     |
| countryid_7            |              | 243429.8**              |                                 |                     |
| F – test (model)       | 103.30       | 154.51                  | 14.53                           |                     |
| Prob (F-test)          | 0.0000       | 0.0000                  | 0.0000                          |                     |
| Wald chi2              |              |                         |                                 | 62.11               |
| Prob > chi2            |              |                         |                                 | 0.0000              |
| DF                     | 65           | 59                      | 59                              | 1                   |
| R <sup>2</sup>         | 0.8641       | 0.9632                  | 0.4962                          | 0.3762              |
| Adj R <sup>2</sup>     | 0.8557       | 0.9570                  |                                 |                     |
| Number of observations | 70           | 70                      | 70                              | 70                  |

\*\* denotes significance at the 5% level, and \*\*\* denotes significance at 1% level.

**Table 4. Results of model selection test**

|                   | F – Ratio Test | Breusch-Pagan Langrange Multiplier Test (LM) | Hausman Test |
|-------------------|----------------|--|--------------|
| F – Test          | 26.51          | -  | -            |
| Chi – square      | -              | 31.56  | 9.34         |
| Degree of freedom | 6, 59          | 1  | 3            |
| P – value         | 0.000          | 0.000  | 0.0251       |

Decision rule: reject  $H_0$  if  $p - \text{value} < 0.05$

**Table 5. Summary of the model selection test results**

|                       | POLS | FEM | REM | Selection |
|-----------------------|------|-----|-----|-----------|
| <b>F – Ratio Test</b> | No   | Yes | N/A | FEM       |
| <b>B-P LM Test</b>    | No   | N/A | Yes | REM       |
| <b>Hausman Test</b>   | N/A  | Yes | No  | FEM       |

**Table 6. An in-depth analysis of each country with its explanatory variables**

|              | intub     | Prehiv    | adhiv     | chxpp     |
|--------------|-----------|-----------|-----------|-----------|
| Egypt        | -10356.73 | -220.0332 | 5.432027  | 986.0197  |
| Gambia       | 10350.88  | -1423.276 | -5.246057 | -858.7654 |
| Ghana        | 10309.07  | -34326.62 | -5.222676 | -774.7469 |
| Nigeria      | 10248.31  | 412719.60 | -5.179971 | 4340.329  |
| Sierra Loene | 10354.51  | 0         | -5.413821 | -969.2858 |
| South Africa | 10263.50  | -14845.62 | -5.436538 | -292.7051 |
| Togo         | 10357.00  | 0         | -5.368295 | -920.5351 |

$p > |t| = 0.000$  for all estimates



### 3.2 Discussion

The data used in this study are from seven African countries spanning a period of ten years, from 2007 to 2016 making the number of observations 70.

Table 1 presents the Summary of the Descriptive Statistics for each unit variable, also known as univariate data analysis, with the findings revealing that all variables have positive means, standard deviations, and Skew statistics. This indicates they are all skewed to the right and are positive mean reverting. However, given that Shapiro – Wilk test statistics are significant, the null hypothesis of normal univariate distribution is rejected and the conclusion is that not all variables are normally distributed. The relationship between the variables must therefore be further studied.

The panel unit root test results shown in Table 2 show that not all data at level are stationary, however at first difference, all data are conclusively and consistently stationary.

The results of the three panel data models are displayed on Table 3. The result of the POLS shows that the estimated coefficient or parameter of the marginal effects of tuberculosis incidence on GDP is not significant at the 0.05 level of significance. HIV prevalence has a statistically significant negative effect on GDP; while adults living with HIV, current per capita health spending and the constant term (intercept) have a statistically significant positive effect on GDP.

The F-test tests the joint null hypothesis that all the coefficients of the model excluding the constant are zero [24]. The p-value associated with the F statistic is zero (0), therefore, we strongly reject the null hypothesis and conclude that the model as a whole is highly significant. The R - square ( $R^2$ ) for the regression model represents the goodness of fit measure or the coefficient of determination, its value is 0.8641, indicating that our model with four explanatory variables accounts for (or explains) around 86% of the variation in GDP it leaves 14% unexplained. The t-test in the table of estimated coefficients tests the individual significance of the explanatory variables.

The result of the Fixed Effect Least Squares Dummy Variable Regression Model [FEM (LSDV)] fits the data well at the 0.05 level of significance ( $F = 154.51$  and  $p < 0.0000$ ).  $R^2$  of 0.9632 indicates that this model explains 96% of the total variation in GDP of the countries.

The parameter estimates of the individual regressors are all significant. Prehiv has a negative correlation with GDP, whereas intub, adhiv, chxpp, and the constant term are positively correlated. The FEM (LSDV) model postulates that each country has its own intercept but shares the same regressor slopes. The estimation of the parameter of  $D_1$  (dropped dummy) is presented in the FEM (LSDV) intercept (145583.9) which is the baseline intercept. Each of  $\gamma_2 - \gamma_7$  represents the deviation of the other country's specific intercept from the baseline intercept; the intercept of Egypt.

The result obtained from the FEM (WG) is similar to that of the FEM (LSDV); the parameter estimates and their standard errors are the same. However, the estimate of the constant intercept is different. This model returns incorrect F – statistic and  $R^2$ . The  $R^2$  for the model is 0.4962, which indicates that the model accounts for about 50% of the variance the GDP of the countries. For this model, Stata reports a Poolability test at the bottom of the results; Stata uses  $u_i$  for  $\gamma_i$  as used in this work. The F statistic rejects the null of homogeneity of zero countries and affirms that the countries are unique, the FEM must be selected.

The result of a Wald chi-square test (REM) indicates that the model as a whole (that is, all the coefficients taken together) is significant. The reported  $R^2$  is 0.3762, indicating that the model represents approximately 38% of the total variance of GDP. Prehiv is negatively correlated with GDP, while intub, adhiv, chxpp and the constant term are positively correlated. All parameters are significant as shown in the p-value of the z tests.

Table 2 contains the results of the model selection tests. The result of the F-test shows that the P-value ( $P[F > 26.481] = 0.000$ ) is statistically significant. Therefore, we reject the null hypothesis and conclude

that at least one country's intercept  $\gamma_i$  is different, which follows the FEM assumption. Therefore, we choose the FEM model over the POLS model.

This result corresponds to the poolability test reported at the bottom of the FEM (WG) model.

From the result of the Breusch-Pagan Langrangian test shows that the test is significant since  $\text{prob} > \chi^2_{1,0.05} = 0.0000$ , so we reject the null hypothesis and conclude that the REM is more appropriate.

The result of the Hausman test shows that the p-value is less than the 0.05 level of significance. Therefore, we reject the null hypothesis and conclude that the FEM is more appropriate.

The model selection was performed using the F – Ratio Test, the Breush – Pagan Langrange Multiplier Test, and the Hausman Test. The F –Ratio Test shows that the FEM is more appropriate, in the LM test, the null hypothesis was rejected in favour of the REM. Finally, the Hausman test indicates that the FEM should be selected over REM.

In conclusion, based on the model selection tests, the most appropriate model for the data is the FEM. Therefore, the result of the FEM will be used to interpret the effect of communicable diseases on the economy.

The regression equation of the data using the FE (WG) is shown below:

$$gdp = 428854 + 147 * \text{intub} - 169270 * \text{prehiv} + 0.2181 * \text{adhiv} + 961\text{chxpp} \quad (3.1)$$

The regression model is interpreted as follows:

In the event that there are no cases of communicable diseases and no current health expenditure, each country is expected to have 428,854 units of GDP ( $p < 0.0020$ ).

For a one-unit increase in tuberculosis incidence, each country's GDP is expected to increase by 147 units, holding all other variables constant ( $p < 0.0000$ ).

Provided there is a unit increase in the proportion of people infected with HIV (HIV prevalence), each country's GDP is expected to decrease by 169,270 units holding all other variables constant ( $p < 0.0000$ ).

Holding all other variables constant, a unit increase in the number of adults living with HIV will cause a 0.2182 unit increase in each country's GDP ( $p < 0.0000$ ).

Finally, if the current per capita health expenditure of each country increases by one unit, the GDP of each country will increase by 961 units ( $p < 0.0000$ ).

The regression equation shows there exist a relationship between GDP and communicable diseases for the countries as a whole. Additional analysis will be conducted to show how each country's GDP is affected by communicable diseases.

A detailed analysis of each country and how communicable diseases affect each country is carried out using the FEM (WG). The result shows that adults living with HIV have a statistically significant negative effect in both low- and middle-income countries. This means that as the number of adults living with HIV (15 years and older) increases, the economic performance of countries decreases. On the other hand, if the number of adults living with HIV decreases, the economy increases.

The result also shows that HIV prevalence has a statistically negative impact on Gambia. This implies that a decrease in the HIV prevalence rate will increase economic performance in The Gambia. However, the coefficients for Sierra Leone and Togo were omitted due to multicollinearity.

For middle-income countries, the HIV prevalence rate has a statistically significant negative impact on GDP, except for Nigeria, which has a positive correlation. Therefore, the decrease in the HIV prevalence rate will

have a positive impact on the economy. The incidence of tuberculosis has a statistically significant and positive impact on the economy for both low- and middle-income countries. This does not in any way rule out the fact that Tuberculosis still poses a real threat to both individuals and the government concerning economic progress. The data on the incidence of tuberculosis used in this study is expressed as a rate of per 100,000 inhabitants per year, the inhabitants include people within and outside the productive age. This could be possibly why its negative impact is not strongly felt. That notwithstanding, its complete eradication will boost our economy. Finally, current health expenditure per capita has a statistically significant negative impact on GDP in both groups of countries, except Nigeria, which has a positive correlation.

## **4 Conclusion**

This work seeks to contribute to the growing literature on the impact of health on economic growth with a focus on communicable diseases. The indicators for communicable disease used are incidence of tuberculosis (intub), prevalence of HIV (prehiv), and adults living with HIV (adhiv). Gross Domestic Product (GDP) was used as proxy for economic performance, and current health expenditure per capita as proxy for health expenditure. Data were collected from seven countries from 2007 – 2016. The three panel data analytical models were used, and then Model selection tests conducted to ascertain the model that best describes the data. Based on the result of the selection tests, the most suitable model for the data is the FEM.

The findings show that economic performance is affected negatively by communicable diseases. Prevalence of HIV has a statistically significant negative effect on the GDP. This result is supported by those of Nor et al. [7], who used a panel of five south-east Asian countries from a period of 1990 – 2011 to show that HIV prevalence has a statistically significant and negative impact on economic performance using the Fully Modified Ordinary Least Squares (FMOLS) model. However, the results of incidence of tuberculosis and adults living with HIV are not consistent with existing literature as they have a statistically significant positive effect on the GDP.

Current health expenditure per capita has a statistically significant and positive effect on GDP. This means that a unit increase in health expenditure will lead to an increase in the GDP. This corroborates the work of Piabuo and Tieguhong [25] who carried out a comparative analysis on the impact of health spending between countries of the sub region of the Economic Community of Central African States CEMAC and five African countries that achieved the Abuja statement. Their result showed that health spending has a positive and significant effect on economic growth in both samples. In addition, Ke, Saksena, and Holly in 2011 [26] attempted to find out the trajectory of health spending in developing countries using panel data for 143 countries between 1995 and 2008. They applied standard FE and dynamic models that showed that an increase in GDP will lead to an increase in total health spending expenditure in all income groups, both in static and dynamic models.

Additional analysis conducted in FEM (Table 6) to determine the effect of the variables in each country reveals that adults living with HIV and HIV prevalence have a statistically significant negative effect on economic performance, which is consistent with the findings of the existing literature.

In summary, this study has shown that communicable diseases negatively impact the economy. Therefore, preventing and controlling its spread would be of immense benefit not only to individuals but also to the government in general, because healthy citizens produce a healthy workforce and that leads to higher productivity which in turn will improve economic performance.

## **5 Recommendations**

Sustainable Development Goal 3 seeks to guarantee and promote well-being for all at all ages. Target 3 of this goal is that by 2030: end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, waterborne diseases and other communicable diseases. To achieve this goal, in view of the findings of this study, the governments of African countries are advised to demonstrate their commitment to the prevention and control of communicable diseases. Such services include:

1. Expansion and improvement of existing prevention programs, such as the regional centers for disease control established by the African Union and ECOWAS.
2. Establish a good public health surveillance system in various African countries that collects, analyzes, and disseminates health information so that appropriate action is taken.
3. Invest more in communicable disease research in order to be well supplied with information on the epidemiology, pathogenesis, genetic makeup, and other areas of the disease necessary to eliminate or control it.
4. Invest in training more health and outreach personnel to help fight infectious diseases, and also increase health spending to reduce the prevalence of these diseases. In April 2001, African governments pledged to allocate at least 15% of their annual budget to the health sector, known as the Abuja Declaration. Most African countries are yet to comply, including Nigeria.
5. The result of this study can be verified using a different sample data from different countries.
6. A further research can also be carried out that includes all indicators of progress: HIV, tuberculosis, malaria, hepatitis and neglected tropical diseases (NTDs) as stated in the sustainable Development Goal, target 3.3 concerning infectious diseases. In order to fully ascertain the impact of communicable diseases on the economy.

## **Competing Interests**

Authors have declared that no competing interests exist.

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## Appendix A

### STATA Output of Descriptive Statistics of gdp

| gdp |             |          |             |          |
|-----|-------------|----------|-------------|----------|
|     | Percentiles | Smallest |             |          |
| 1%  | 1259        | 1259     |             |          |
| 5%  | 1370        | 1274     |             |          |
| 10% | 1466.5      | 1367     | Obs         | 70       |
| 25% | 3171        | 1370     | Sum of Wgt. | 70       |
| 50% | 50884       |          | Mean        | 151490.3 |
|     |             | Largest  | Std. Dev.   | 172557.7 |
| 75% | 299033      | 460952   |             |          |
| 90% | 400894      | 493841   | Variance    | 2.98e+10 |
| 95% | 460952      | 514965   | Skewness    | .6697721 |
| 99% | 568496      | 568496   | Kurtosis    | 1.989008 |

## Appendix B

### STATA Output of Descriptive Statistics of intub

| intub |             |          |             |          |
|-------|-------------|----------|-------------|----------|
|       | Percentiles | Smallest |             |          |
| 1%    | 14          | 14       |             |          |
| 5%    | 16          | 15       |             |          |
| 10%   | 18.5        | 15       | Obs         | 70       |
| 25%   | 73          | 16       | Sum of Wgt. | 70       |
| 50%   | 259         |          | Mean        | 325.6286 |
|       |             | Largest  | Std. Dev.   | 301.0755 |
| 75%   | 446         | 971      |             |          |
| 90%   | 847         | 981      | Variance    | 90646.47 |
| 95%   | 971         | 993      | Skewness    | .9967521 |
| 99%   | 1003        | 1003     | Kurtosis    | 2.791931 |

## Appendix C

### STATA Output of Descriptive Statistics of *prehiv*

| <i>prehiv</i> |             |          |             |          |
|---------------|-------------|----------|-------------|----------|
|               | Percentiles | Smallest |             |          |
| 1%            | .1          | .1       |             |          |
| 5%            | .1          | .1       |             |          |
| 10%           | .1          | .1       | Obs         | 70       |
| 25%           | 1.5         | .1       | Sum of Wgt. | 70       |
| 50%           | 1.8         |          | Mean        | 4.14     |
|               |             | Largest  | Std. Dev.   | 6.278936 |
| 75%           | 2.6         | 19.9     |             |          |
| 90%           | 18.7        | 20.1     | Variance    | 39.42504 |
| 95%           | 19.9        | 20.3     | Skewness    | 1.993062 |
| 99%           | 20.4        | 20.4     | Kurtosis    | 5.11301  |

## Appendix D

### STATA Output of Descriptive Statistics of *gdp*

| <i>adhiv</i> |             |          |             |          |
|--------------|-------------|----------|-------------|----------|
|              | Percentiles | Smallest |             |          |
| 1%           | 4200        | 4200     |             |          |
| 5%           | 6700        | 4900     |             |          |
| 10%          | 11000       | 5700     | Obs         | 70       |
| 25%          | 20000       | 6700     | Sum of Wgt. | 70       |
| 50%          | 89000       |          | Mean        | 1151489  |
|              |             | Largest  | Std. Dev.   | 2131592  |
| 75%          | 1300000     | 6500000  |             |          |
| 90%          | 5700000     | 6700000  | Variance    | 4.54e+12 |
| 95%          | 6500000     | 7000000  | Skewness    | 1.903806 |
| 99%          | 7200000     | 7200000  | Kurtosis    | 5.014866 |

## Appendix E

### STATA Output of Descriptive Statistics of chxpp

| chxpp       |        |          |             |  |          |
|-------------|--------|----------|-------------|--|----------|
| Percentiles |        | Smallest |             |  |          |
| 1%          | 19.5   | 19.5     |             |  |          |
| 5%          | 23     | 20.9     |             |  |          |
| 10%         | 29.8   | 21.9     | Obs         |  | 70       |
| 25%         | 36     | 23       | Sum of Wgt. |  | 70       |
| 50%         | 79.9   |          | Mean        |  | 129.1643 |
|             |        | Largest  | Std. Dev.   |  | 152.2379 |
| 75%         | 119.8  | 526.5    |             |  |          |
| 90%         | 420.65 | 539.6    | Variance    |  | 23176.38 |
| 95%         | 526.5  | 579.7    | Skewness    |  | 1.970279 |
| 99%         | 597.4  | 597.4    | Kurtosis    |  | 5.527109 |

## Appendix F

### Estimation Result of the Pooled Ordinary Least Squares Regression Model

```
. reg gdp intub prehiv adhiv chxpp
```

| Source   | SS         | df | MS         | Number of obs | = | 70     |
|----------|------------|----|------------|---------------|---|--------|
| Model    | 1.7772e+12 | 4  | 4.4429e+11 | F(4, 65)      | = | 103.30 |
| Residual | 2.7957e+11 | 65 | 4.3010e+09 | Prob > F      | = | 0.0000 |
| Total    | 2.0567e+12 | 69 | 2.9808e+10 | R-squared     | = | 0.8641 |
|          |            |    |            | Adj R-squared | = | 0.8557 |
|          |            |    |            | Root MSE      | = | 65582  |

| gdp    | Coef.     | Std. Err. | t      | P> t  | [95% Conf. Interval] |
|--------|-----------|-----------|--------|-------|----------------------|
| intub  | -40.05828 | 46.58523  | -0.86  | 0.393 | -133.0954 52.97884   |
| prehiv | -75746.15 | 5618.303  | -13.48 | 0.000 | -86966.68 -64525.63  |
| adhiv  | .2179217  | .0158606  | 13.74  | 0.000 | .186246 .2495975     |
| chxpp  | 745.5142  | 159.6599  | 4.67   | 0.000 | 426.6513 1064.377    |
| _cons  | 130763.1  | 14824.53  | 8.82   | 0.000 | 101156.4 160369.7    |



## Appendix G

### Estimation Result of the Fixed Effect Least Squares Dummy Variable Regression Model

```
. reg gdp intub prehiv adhiv chxpp i.countryid
```

| Source   | SS         | df | MS         | Number of obs | = | 70     |
|----------|------------|----|------------|---------------|---|--------|
| Model    | 1.9811e+12 | 10 | 1.9811e+11 | F(10, 59)     | = | 154.51 |
| Residual | 7.5647e+10 | 59 | 1.2821e+09 | Prob > F      | = | 0.0000 |
|          |            |    |            | R-squared     | = | 0.9632 |
|          |            |    |            | Adj R-squared | = | 0.9570 |
| Total    | 2.0567e+12 | 69 | 2.9808e+10 | Root MSE      | = | 35807  |

| gdp       | Coef.     | Std. Err. | t     | P> t  | [95% Conf. Interval] |
|-----------|-----------|-----------|-------|-------|----------------------|
| intub     | 147.0034  | 44.94836  | 3.27  | 0.002 | 57.06194 236.9449    |
| prehiv    | -169269.9 | 38635.46  | -4.38 | 0.000 | -246579.3 -91960.53  |
| adhiv     | .2181367  | .0518993  | 4.20  | 0.000 | .1142863 .321987     |
| chxpp     | 960.773   | 140.2461  | 6.85  | 0.000 | 680.1412 1241.405    |
| countryid |           |           |       |       |                      |
| 2         | 107730.6  | 71132.2   | 1.51  | 0.135 | -34604.64 250065.8   |
| 3         | 60341.91  | 57626.76  | 1.05  | 0.299 | -54968.96 175652.8   |
| 4         | 98434.02  | 37807.38  | 2.60  | 0.012 | 22781.64 174086.4    |
| 5         | -43545.59 | 51361.96  | -0.85 | 0.400 | -146320.6 59229.46   |
| 6         | 1516499   | 426323.9  | 3.56  | 0.001 | 663427.1 2369571     |
| 7         | 243429.8  | 100827.2  | 2.41  | 0.019 | 41675.01 445184.7    |
| _cons     | 145583.9  | 20288.52  | 7.18  | 0.000 | 104986.7 186181.2    |

## Appendix H

### Estimation Result of the Fixed Effect within Group Regression Model

```
. xtreg gdp intub prehiv adhiv chxpp, fe
```

```
Fixed-effects (within) regression      Number of obs   =      70
Group variable: Countryid             Number of groups =       7

R-sq:                                  Obs per group:
    within = 0.4962                    min =          10
    between = 0.0170                   avg =         10.0
    overall = 0.0125                    max =          10

corr(u_i, Xb) = -0.9449                F(4, 59)        =      14.53
                                          Prob > F         =      0.0000
```

| gdp     | Coef.     | Std. Err.                         | t     | P> t  | [95% Conf. Interval] |
|---------|-----------|-----------------------------------|-------|-------|----------------------|
| intub   | 147.0034  | 44.94836                          | 3.27  | 0.002 | 57.06194 236.9449    |
| prehiv  | -169269.9 | 38635.46                          | -4.38 | 0.000 | -246579.3 -91960.53  |
| adhiv   | .2181367  | .0518993                          | 4.20  | 0.000 | .1142863 .321987     |
| chxpp   | 960.773   | 140.2461                          | 6.85  | 0.000 | 680.1412 1241.405    |
| _cons   | 428853.9  | 96737.62                          | 4.43  | 0.000 | 235282.4 622425.5    |
| sigma_u | 551387.25 |                                   |       |       |                      |
| sigma_e | 35807.068 |                                   |       |       |                      |
| rho     | .99580051 | (fraction of variance due to u_i) |       |       |                      |

F test that all u\_i=0: F(6, 59) = 26.51

Prob > F = 0.0000

## Appendix I

### Estimation Result of the Random Effect Model

```
. xtreg gdp intub prehiv adhiv chxpp, re

Random-effects GLS regression           Number of obs   =           70
Group variable: Countryid              Number of groups =            7

R-sq:                                   Obs per group:
    within = 0.3762                      min =           10
    between = 0.8497                     avg =          10.0
    overall = 0.7990                     max =           10

Wald chi2(4) =           62.11
corr(u_i, X) = 0 (assumed)              Prob > chi2     =           0.0000
```

| gdp     | Coef.     | Std. Err.                         | z     | P> z  | [95% Conf. Interval] |
|---------|-----------|-----------------------------------|-------|-------|----------------------|
| intub   | 112.6095  | 47.27162                          | 2.38  | 0.017 | 19.95886 205.2602    |
| prehiv  | -55559.88 | 11908.55                          | -4.67 | 0.000 | -78900.21 -32219.54  |
| adhiv   | .1172465  | .0286872                          | 4.09  | 0.000 | .0610207 .1734723    |
| chxpp   | 897.5714  | 155.3097                          | 5.78  | 0.000 | 593.17 1201.973      |
| _cons   | 93793.78  | 32881.43                          | 2.85  | 0.004 | 29347.37 158240.2    |
| sigma_u | 57026.222 |                                   |       |       |                      |
| sigma_e | 35807.068 |                                   |       |       |                      |
| rho     | .71722372 | (fraction of variance due to u_i) |       |       |                      |

## Appendix J

### Result of the Breusch – Pagan Langrangian Test

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

gdp[Countryid,t] = Xb + u[Countryid] + e[Countryid,t]

Estimated results:

```

|     | Var      | sd = sqrt(Var) |
|-----|----------|----------------|
| gdp | 2.98e+10 | 172649         |
| e   | 1.28e+09 | 35807.07       |
| u   | 3.25e+09 | 57026.22       |

```

Test:   Var(u) = 0
        chibar2(01) = 31.56
        Prob > chibar2 = 0.0000

```

## Appendix K

### Result of the Hausman Test

. hausman fixed random

|        | — Coefficients — |               |                     |                             |
|--------|------------------|---------------|---------------------|-----------------------------|
|        | (b)<br>fixed     | (B)<br>random | (b-B)<br>Difference | sqrt(diag(V_b-V_B))<br>S.E. |
| intub  | 147.0034         | 112.6095      | 34.39387            | .                           |
| prehiv | -169269.9        | -55559.88     | -113710             | 36754.38                    |
| adhiv  | .2181367         | .1172465      | .1008902            | .0432503                    |
| chxpp  | 960.773          | 897.5714      | 63.20164            | .                           |

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(3) = (b-B)'[(V\_b-V\_B)^(-1)](b-B)  
 = 9.34  
 Prob>chi2 = 0.0251  
 (V\_b-V\_B is not positive definite)

## Appendix L

### An In-depth Analysis of each Country with its Explanatory Variables

```
. xtreg gdp intub prehiv adhiv chxpp i.countryid#c.intub i.countryid#c.prehiv i.count
> ryid#c.adhiv i.countryid#c.chxpp, fe vce (robust)
note: 5.countryid#c.prehiv omitted because of collinearity
note: 7.countryid#c.prehiv omitted because of collinearity
```

```
Fixed-effects (within) regression      Number of obs   =      70
Group variable: Countryid             Number of groups =       7
```

```
R-sq:                                Obs per group:
  within = 0.9840                      min =      10
  between = 0.3747                     avg =     10.0
  overall = 0.3732                     max =      10
```

```
corr(u_i, Xb) = -0.9494                F(7,6)          =      .
                                          Prob > F        =      .
```

(Std. Err. adjusted for 7 clusters in Countryid)

|  | gdp                | Coef.     | Robust<br>Std. Err.               | t        | P> t  | [95% Conf. Interval] |
|--|--------------------|-----------|-----------------------------------|----------|-------|----------------------|
|  | intub              | -10356.73 | .000051                           | -2.0e+08 | 0.000 | -10356.73 -10356.73  |
|  | prehiv             | -220.0332 | .001322                           | -1.7e+05 | 0.000 | -220.0365 -220.03    |
|  | adhiv              | 5.432027  | 1.85e-08                          | 2.9e+08  | 0.000 | 5.432027 5.432027    |
|  | chxpp              | 986.0197  | 1.62e-06                          | 6.1e+08  | 0.000 | 986.0197 986.0197    |
|  | countryid#c.intub  |           |                                   |          |       |                      |
|  | 2                  | 10350.88  | .0000513                          | 2.0e+08  | 0.000 | 10350.88 10350.88    |
|  | 3                  | 10309.07  | .0000507                          | 2.0e+08  | 0.000 | 10309.07 10309.07    |
|  | 4                  | 10248.31  | .0000509                          | 2.0e+08  | 0.000 | 10248.31 10248.31    |
|  | 5                  | 10354.51  | .000051                           | 2.0e+08  | 0.000 | 10354.51 10354.51    |
|  | 6                  | 10263.5   | .0000495                          | 2.1e+08  | 0.000 | 10263.5 10263.5      |
|  | 7                  | 10357     | .0000506                          | 2.0e+08  | 0.000 | 10357 10357          |
|  | countryid#c.prehiv |           |                                   |          |       |                      |
|  | 2                  | -1423.276 | .0004417                          | -3.2e+06 | 0.000 | -1423.277 -1423.275  |
|  | 3                  | -34326.62 | .0001976                          | -1.7e+08 | 0.000 | -34326.62 -34326.62  |
|  | 4                  | 412719.6  | .003669                           | 1.1e+08  | 0.000 | 412719.6 412719.6    |
|  | 5                  | 0         | (omitted)                         |          |       |                      |
|  | 6                  | -14845.62 | .0003235                          | -4.6e+07 | 0.000 | -14845.62 -14845.62  |
|  | 7                  | 0         | (omitted)                         |          |       |                      |
|  | countryid#c.adhiv  |           |                                   |          |       |                      |
|  | 2                  | -5.246057 | 2.69e-08                          | -2.0e+08 | 0.000 | -5.246057 -5.246057  |
|  | 3                  | -5.222676 | 1.45e-08                          | -3.6e+08 | 0.000 | -5.222676 -5.222676  |
|  | 4                  | -5.179971 | 1.72e-08                          | -3.0e+08 | 0.000 | -5.179971 -5.179971  |
|  | 5                  | -5.413821 | 1.45e-08                          | -3.7e+08 | 0.000 | -5.413821 -5.413821  |
|  | 6                  | -5.436538 | 1.96e-08                          | -2.8e+08 | 0.000 | -5.436538 -5.436538  |
|  | 7                  | -5.368295 | 1.00e-07                          | -5.4e+07 | 0.000 | -5.368295 -5.368295  |
|  | countryid#c.chxpp  |           |                                   |          |       |                      |
|  | 2                  | -858.7654 | 9.15e-07                          | -9.4e+08 | 0.000 | -858.7654 -858.7654  |
|  | 3                  | -774.7469 | 6.52e-07                          | -1.2e+09 | 0.000 | -774.7469 -774.7469  |
|  | 4                  | 4340.329  | .0000121                          | 3.6e+08  | 0.000 | 4340.329 4340.329    |
|  | 5                  | -969.2858 | 1.79e-06                          | -5.4e+08 | 0.000 | -969.2858 -969.2858  |
|  | 6                  | -292.7051 | 4.06e-06                          | -7.2e+07 | 0.000 | -292.7051 -292.7051  |
|  | 7                  | -920.5351 | 9.66e-06                          | -9.5e+07 | 0.000 | -920.5351 -920.535   |
|  | _cons              | -47139.17 | .0064254                          | -7.3e+06 | 0.000 | -47139.19 -47139.16  |
|  | sigma_u            | 466103.61 |                                   |          |       |                      |
|  | sigma_e            | 8063.4192 |                                   |          |       |                      |
|  | rho                | .99970081 | (fraction of variance due to u_i) |          |       |                      |

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