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THE IMPLICATIONS OF POPULATION AGING ON LOCAL HEALTH CARE EXPENDITURE: A 22-YEAR PANEL DATA ANALYSIS

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ABSTRACT

The purpose of this study is to examine the implications of population aging on local health expenditures in South Africa. A balanced panel of annually observed observations from South Africa over the period of 22 years (1995–2017) was used. The study used gross domestic product (GDP), health expenditure, labor force, and age structure as control variables and pooled OLS, fixed effect, and random effect tests to estimate the relationships among the variables. The results show that the old-age dependency ratio, gross domestic product (GDP), unemployment rate, and gross value added (GVA) are all explanatory variables that are related to healthcare spending and are shown as a base model in the pooled OLS. The results indicate that healthcare expenditure and the old-age dependency ratio have a positive relationship in South Africa. Considering the implications for policy, this study suggests that the South African economy should account for the aging population when policies are designed and that the government should make an effort to improve the healthcare system in order to meet the demands of elderly people.

Authors contribution: "Introduction, Adanlawo.; Literature review, Adanlawo.; Methodology and data, Nkomo.; Research results and comments, Nkomo.; Conclusion, Adanlawo."

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1. Introduction.

The expeditious aging of the population is a phenomenon experienced worldwide. Mohapatra, Arora, and Giri (2022); Nkomo and Adanlawo (2023) describe population aging as a term explaining a change in the age structure of a population towards older ages. Population aging is a worldwide phenomenon, as life expectancy has rapidly risen over recent years. In recent years, according to Chaka and Adanlawo (2023a), the life expectancy has increased quickly in both developed and the majority of developing nations. The trend is a direct consequence of demographic shifts, as seen in the continuous global decline in both the fertility rate and mortality rates of older people. Li, Du, and Hu (2020) state that in many industrialized countries such as Japan, China, and Korea, population aging has a rapid and progressive trend. Likewise, rapid increases in the proportion of elderly people are also recorded in developing countries (Chaka and Adanlawo, 2023b). The majority of study investigations make it clear that the trend is anticipated to persist over the next few decades and eventually influence the entire world. Several questions have been raised about the effect that population aging would have on countries' economies. Lorenz, Ihle, and Breyer (2020); Adanlawo Reddy, and Rugbeer (2021); Adanlawo (2017) highlight how population aging has consequences for socio-economics and health, which include an increase in the old-age dependency ratio, employment, savings, consumption, and economic growth. Kye et al. (2014) state that socio-economic consequences arise as the age structure of the population determines the ratio of net producers and net consumers. Among the socio-economic challenges presented by an aging population, health and healthcare expenditure are two of the most common. Research studies have shown that a change in the age structure presents dynamic challenges for public health (Li, Du, and Hu, 2020; Mohapatra, Arora, and Giri, 2022; Trpkova-Nestorovska, 2022). This study is needed to find out if an aging population has implications for South Africa's health care expenditure. The paper is structured as follows: an introduction, followed by an empirical review. The rest are method and data, the empirical analysis and results, and lastly, the conclusion and the policy recommendation from the findings.

2. Empirical review.

Studies have investigated the effect of population aging on the growth of health expenditure (Lorenz, Ihle, and Breyer, 2020; Mohapatra, Arora, and Giri, 2022). However, the empirical findings from previous studies remain at the national level and, thereby, inconclusive at the district level. By merging knowledge from epidemiology and health economics researchTo evaluate the impact of population aging on the growth of health expenditures, Breyer, Costa-Font, and Felder (2010) used pseudo-panel data for eleven years. The age of individuals over 60 has a favorable impact on per capita health-care expenditure, according to the results of fixed-effects regression.

Breyer and Lorenz (2021) looked into how population aging may affect the cost of healthcare. The results demonstrate that, as much as the growth rate does not exceed GDP growth, publicly funded health care systems are not jeopardized. Von Wyl (2019) used a 15-year panel analysis of elderly people in Switzerland to investigate age-associated health care expenditure growth. The study confirmed population aging as a factor driving health care expenditures. Li, Du, and Hu's (2020) study, Healthcare Demand Perspective Among Different Age Groups, looked at the impact of population aging on healthcare spending. The fixed effect model and parameter estimation approach were employed in the study. According to the finding, the People's Republic of China's future economic and social development will face significant obstacles due to the expansion of health care.

Using the ARDL technique, Mohapatra, Arora, and Giri (2022) investigate the link that exists between population aging and per capita HCE in India. The findings show that population aging significantly and statistically positively affects per capita health spending. This suggests that when the proportion of the country's population over the age of 65 rises, more health issues arise, and the economy's spending on healthcare also rises.

Morgan and Cunningham (2011) evaluated current trends and variables affecting the cost of hospital, medical, and pharmaceutical care in British Columbia using population-based administrative data. According to the study, the annual increase in spending on medical, hospital, and pharmaceutical care was less than 1% due to population aging. The study also discovered that population aging would have a minimal effect on healthcare spending in the future. Trpkova-Nestorovska (2022) examined the aging population's effect on government health expenses. The study's findings revealed an inverse relationship between population aging and health expenditure. Werblow, Felder, and Zweifel's (2007) study also found that population aging is too small to significantly affect health care costs.

3. Method and data.

The empirical methodology is explored in this study. This paper analyzed the implications of population aging on healthcare expenditure with the use of dynamic econometric models, including fixed-effect analysis, random effect analysis, and the Hausman test. The models were estimated using panel data that includes the following variables: Gross domestic product is a monetary measure of a country's output of final products and services over a specified time (every year for the purposes of this analysis). The total output within a country's borders is recorded (GDP), healthcare expenditure(HCE), labour force, and age structure. The analysis makes use of the GDP and Gross Value Added (GVA).

Gross value added (GVA) is the value added to a product to improve its many features, while gross domestic product (GDP) is the sum of all things produced in a country, The data used in this study is a balanced panel of annually observed observations in South Africa over the period of 22 years (1995–2017). The data was collected from Quantec Easy, with a total of 207 observations. According to Bai and Li (2021), panel data is widely used to estimate dynamic econometric models, which include both time series and cross-sectional dimensions. Panel data analysis is appropriate for this study since it uses South African that have been observed over a period of time as its analytical framework. Two indices are used to represent the cross-sectional and time-series dimensions, respectively, of a panel data model's variables (Epskamp, 2020).

$$Y_{it} = \alpha_0 + \beta_x X_{it} + \varepsilon_{it} \tag{1}$$

Where:

- Y_{it} Represent the dependent variable.
- X_{it} Represent the k-dimensional vector of the explanatory variables that vary over time.
- ε_{it} Represents an idiosyncratic error term.

An N x N weighting matrix W is used to determine the correlation strength in a cross-sectional technique, which then tests whether the proportional component, represented by p, equals zero (Spector, 2019). This approach examines the diagonal error covariance matrix of a system of equations that appears to be unrelated and does not rely on spatial weighting.
A simple model is represented by:

$$Y_{it} = \phi Y_{i,t-1} + \beta_x X_{it} + \varepsilon_{it} \quad |\phi| < 1 \tag{2}$$

Cross-sectional units *i* = 1, N, and time periods *t*=1, T, The dependent variable is denoted by Y_{it} , the k-dimensional vector of time-varying explanatory variables by X_{it} the fixed time-invariant effects are denoted by $\varepsilon_{it} = \mu_i + \eta_{it}$.
The time-lag dependent variable, which is linked with the error term due to its correlation with the time-invariant component of the error term, creates a simultaneity problem. Using fixed effects or least squares dummy variables in the presence of them causes an estimation to be skewed, according to Moody and Marvell (2020). The fixed effect eliminates the heterogeneity bias when omitted regressors are considered to be constant throughout time. By convention, the bias will continue if the missing variables are not constant. Additionally, if the dependent variable and additional independent variables are included in the regression, this does not address the endogeneity bias that will be present.
Unrelated effects are the first characteristic of the random effect; the second characteristic of the RE is that the effect variance assumes a constant variance of the individual-specific effect. The third characteristic of the RE assumes that the regressors, including a constant, are not perfectly collinear. Hausman outlines a method that may be applied with any asymptotically effective estimator to determine whether the regressors are independent of the equation disturbance term. Time-fixed effects cannot be included in the Hausman test since it is only valid under homoscedasticity.

4. Model Specification.

This paper uses a growth equation that is augmented with demographic variables. More precisely, healthcare expenditure is expressed as a function of aging in addition to growth determinants, which include gross domestic product (GDP) and labour. Presented formally, Healthcare expenditure= f (age dependency, GDP, employment level, GVA) (2).
A combination of equation (1) can be parametrised as follows in a panel format:

$$HCE_{it} = \alpha_0 + \beta_1 aged_{it} + \beta_2 gdp + \beta_3 emp_{it} + \beta_4 gva_{it} + \varepsilon_{it}$$

I=1………N, *t*=1…………T refers to provincial and time dimensions, respectively: the dependent variable in this study is the healthcare expenditure abbreviated as (HCE). HCE_{it} is the total expenditure on healthcare services in South Africa; GDP_{it} is the gross domestic product; $Labour_{it}$ is the population that makes up the labour force; and ε_{it} Is the error term.

5. Empirical results and interpretation.

This section of the paper provides quantitative findings on the implications that an aging population has on South Africa's health expenditure. The study makes use of pooled OLS, fixed effect, and random effect tests. The regression estimates are represented in Table 1 below:

Table 1: Pooled OLS, fixed effect and random effect results computed on STATA

Dependent variable $loghce_{it}$

Explanatory variables	Pooled OLS	Fixed Effect	Random Effect
$lagedr_{it}$	0.9901989 (0.000) ***	2.125027 (0.000) ***	0.9630838 (0.000) ***
$lGDP_{it}$	-0.971042 (0.000) ***	0.4626539 (0.009) ***	-0.5725971 (0.001) ***
$luemp_{it}$	-1.964902 (0.003) ***	0.9128279 (0.000) ***	0.0083904 (0.934) ***
$lGVA_{it}$	1.337435 (0.000) ***	0.3360522 (0.000) ***	1.194505 (0.000) ***
α_0	-5.07023 (0.000) ***	-39.37855 (0.000) ***	-10.61466 (0.000) ***

Note: ***, **, * denote statistical significance at 1%, 5% and 10% level of significance respectively.

Table 1 provides results from the estimation of the ordinary least squares, fixed effect, and random effect tests. The variables were transformed into logarithmic form for the analysis to be more symmetric and to eliminate the heteroscedasticity in the regressions. The old-age dependency ratio, gross domestic product (GDP), unemployment rate, and gross value added (GVA) are all explanatory variables that are related to health care spending and are shown as a base model in the pooled OLS. The average rise in healthcare spending in South Africa will be 0.99 percent for every percentage point increase in the old-age dependency ratio, all things held constant. This indicates that healthcare expenditure and the old-age dependency ratio have a positive relationship on the provincial level in South Africa. The old-age dependency ratio has an influence on healthcare expenditure, as the coefficient is statistically significant at a level of 1 percent. As the population ages, on average, they inevitably require more health care than the young (Yenilmez, 2015). Moreover, the demand for healthcare will rise as the proportion of elderly people in the population increases.

The South African gross domestic product (GDP) is statistically different from zero, which shows the significance of the coefficient at a significant level of 1 percent. The provincial healthcare spending of South Africa will reduce by roughly 0.97 percent for every percentage point growth in GDP. Spending on healthcare and the gross domestic product (GDP) exhibit a negative relationship. Yang and Usman (2021) assert that there is a reciprocal relationship between GDP and healthcare spending because population health is an input into the macroeconomic production function. An increase in healthcare costs results in a drop in the nation's overall production.

The unemployment population level, which is the working-age population that is without employment, also shows to be statistically significant at a level of 1 percent. When the unemployed population increases, it will lead to a decrease of approximately 0.20 percent in healthcare expenditures, ceteris paribus. The inverse relationship implies that population aging will result in a decline in the number of employed workers as the ratio of potential workers to elderly people declines. Adanlawo, Nkomo, and Vezi-Magigaba (2023) aver that social reforms in the form of elderly benefits will contribute to the shift.

The overall statistical significance of the regression analysis is shown by the p-value of the F-statistic at 1 percent. The test for an overall significant hypothesis is:

$$H_0: B_1 = B_2 = B_3 = B_4 = 0$$
$$H_1: B_1 \neq B_2 \neq B_3 \neq B_4 \neq 0$$

When the p-value of the F-statistic is less than 1%, the judgment criterion for this hypothesis test is to reject the null hypothesis. Table 1 demonstrates our rejection of the null hypothesis. All variables are significant at the 1% level, and all computed coefficients have the predicted signs as previously indicated. The model is fit, as the adjusted value is 0.8744, which means that only 87044 percent of the variation in healthcare expenditure is explained by the old age dependency ratio, gross domestic product (GDP), unemployment, and the gross added value. On the other hand, it is crucial to remember that the pooled OLS method does not take into account the problem of unobserved heterogeneity, which will not be examined in this study.

Fixed Effect test.

The results are presented in Table 1. The model is fit as the overall is a high 0.824523. This implies that about 82.45 percent of the variation in healthcare expenditure is explained by old-age dependency, gross domestic product (GDP), unemployment, and gross value added. At a significance level of 5%, the explanatory variable coefficients are statistically different from zero, which implies that there is a strong relationship between the independent and dependent variables when we observe the p-value of the F-statistic in Table 1. There is a 0.9538 observed correlation between the residuals and the explanatory factor, and the interclass correlation is 0.9311, which shows that 93.11 percent of the variance is the result of the differences across the country.

Additionally, Table 1's computed coefficients demonstrate that all explanatory factors are statistically significant at the 1% level. Therefore, the explanatory variables have a significant influence on healthcare expenditure. The estimated coefficients of old-age dependency and unemployment rate possess the expected relationship with healthcare expenditure. In contrast, gross domestic product (GDP) and gross value added possess a different sign than expected and result from the pooled OLS. As reflected by Table 1, the impact magnitude of gross domestic product, unemployment, and gross value added is relatively lower than that of old age dependency.

Random effect test.

The regression results are shown in Table 1. The estimated coefficients of old-age dependency, unemployment, and gross value added are statistically different from zero at a significance level of 1 percent. The estimated coefficient of the gross domestic product is statistically significant at the 10 percent level of significance. The estimated results also show that the overall 08245 implies that approximately 82.45 percent of the variation in healthcare expenditure is due to and explained by old-age dependency, gross domestic product, unemployment, and gross value added.

Gross value added, unemployment, and old age reliance all have a positive impact on healthcare expenditures. Comparing gross value added to unemployment and old-age reliance, the coefficient of magnitude is high. The random effect assumption, which states that separate effects are uncorrelated with the independent factors, is reflected by the zero correlation between the residual and explanatory variables. The interclass correlation coefficient of 0.8811 indicates that approximately 88.11 percent of the variation is due to the dissimilarities in South Africa.

Hausman Test.

The Hausman test is performed to compare the performance of the random effect estimator and the fixed effect estimator. To choose the most preferable technique, the hypothesis:

$$H_0: cov\ (a_{i\,,} x_{it}\ ) = 0$$
$$H_1: cov(a_{i\,,} x_{it}) \neq 0$$

The preferable estimator is the random effect model if the null hypothesis is accepted, and the alternative fixed effect model if the null hypothesis is not rejected. Moreover, an alternative way to choose between the two techniques is to look at the P-value at the 5% significant level (P <0.05) and reject the null hypothesis, leaving the fixed effects models as the preferred. The p-value of the Chi^2 is 0.00; thus, the random effect is rejected, and the fixed effect is preferred for this study at the significant level of 5% and employed for interpretation.

Cross-sectional dependency test.

The use of the cross-sectional dependence test is applied in this study to investigate the degree of dependence in healthcare expenditure in South Africa. If the regression is estimated without considering the unobserved heterogeneity, then the estimated regression would present a problem with serial correlation. The test's p-value is 0.00, which means that at the 5% level of significance, the null hypothesis of cross-sectional dependency is rejected in favour of it. As a result, the model exhibits cross-sectional dependence.

Heteroscedasticity test.

To test for heteroscedasticity, we use the Breusch-Pagan or Cook-Weisberg test. The null hypothesis for this test is a constant variance. Only the explanatory variances are included in the test, as we are testing whether the residuals and independent terms are correlated. The null hypothesis of homoscedasticity is rejected at the 5% level of significance since the p-value for the $Chi^2$is 0.000. Therefore, the variance is not constant, and the model suffers from heteroscedasticity.

Diagnostic test.

The Feasible Generalised Least Square (FGLS) analysis.

The feasible generalized least squares analysis is applied to control for cross-sectional dependency, heteroscedasticity, and any autocorrelation. A feasible generalized least squares analysis is applied, and the results are presented in Table 2.

Table 2: Regression results of the generalised least squares analysis.

Dependent: LogHCE	Coefficient	standard error	z stat	p-value
$lagedr_{it}$	0.9901989	0.747199	13.25	(0.000) ***
$lGDP_{it}$	-0.971042	0.1106155	-8.78	(0.000) ***
$luemp_{it}$	-0.1964902	0.0650291	-3.02	(0.003) ***
$lGVA_{it}$	1.337435	0.0589156	22.70	(0.000) ***
a_0	-5.07023	0.6210962	-8.16	(0.000) ***

Note: ***, **, * denote statistical significance at 1%, 5% and 10% level of significance respectively.

Table 2 represents the regression results of the feasible generalised least squares analysis. At a threshold of 1%, there is statistical significance for each estimated coefficient. The F-statistic's p-value is also significant at the 1% level. This affirms that the estimated coefficients of the independent variables have a statistical effect on healthcare expenditure. There is no autocorrelation present; the model shows homoscedastic panels and cross-sectional dependency. The results of the estimated coefficients and the p-value match those of the pooled OLS model results. Accordingly, the same interpretation of the estimates applies. The same impact the explanatory variable had on the dependent in Table 1 is shown in Table 2.

6. Conclusion.

Most countries around the world are experiencing rapid demographic and structural changes. Population aging has begun to be among the most important phenomena in economics and has taken the attention of scholars globally due to the possible implications it has on all economies. The continued rise in the aging population, as shown by the South African statistics, brings forth concerns about various economic variables and the overall performance of the economy. The relationship between the old age dependency ratio, gross domestic product, unemployment, gross value added, and healthcare spending was therefore explored in this study in South African, using annual data collected from Quantec Easy data for the period of 1995 to 2017. The study employed econometric methodologies that are used for panel data, namely pooled OLS, fixed effect, random effect, and the Hausman test that is applied to test for preference between the FE and RE models. Moreover, the cross-sectional dependency analysis and the diagnostic test were used to control for heterogeneity and CD. The estimates were used by the research to analyse the effects of an aging population with the use of old age dependency to measure the change in the age structure, gross domestic product, unemployment, and the gross value added on healthcare expenditure.

The change in age structure as measured by the old-age dependency ratio is positively related to the expenditure on healthcare services, which was in line with the researchers' expectations. Similarly, the unemployment explanatory variable and gross value added exhibited a positive relationship with healthcare expenditure, yielding to expectations. While the gross domestic product (GDP) has shown a negative relationship with healthcare expenditure. Considering the implications for policy, this study suggests that the South African economy should account for the aging population when policies are designed. The concern placed on the slow growth in the country's GDP is as a result of an aging population, as exhibited in Tables 1 and 2. The government should make an effort to improve the healthcare system in order to meet the demands of elderly people. This research is crucial for forecasting future resource needs and creating acceptable models for budget allocation that are equitable in light of population health care needs. The supply-side effects on expenditure growth and the structure and delivery of health care services are not extensively discussed in this study. These are topics call for further research, but we do not address them here. Also, future research could look at the same study from an econometric analysis perspective when working with panel data and the problem of unobserved heterogeneity.

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