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The Real Effect of Aging Population on Health Expenditures in OECD Countries*

Byongho Tchoe** , Sangho Nam***

Background: Most studies in the 1980s and 1990s conclude that population aging is not a major cause of health spending. Advanced countries have been attracting attention as them with the extension of life expectancy, coupled with low income growth but increasing health expenditures in the last 20 years. Whether population aging contributes to health care spending is still an issue that needs to be reexamined.
Methods: We verify the determinants of health expenditures for 24 Organization for Economic Cooperation and Development (OECD) countries during 1970-2016. To do this, we conducted the three-stage least squares (3SLS) panel regression method to alleviate the endogenous relationship among healthcare expenditures, income, and population aging. The results were compared with those derived by the panel regression method.
Results: The results for 24 OECD countries show that population aging turned to be negative in the 3SLS analysis, but insignificant in the panel regression. Income was a strongly positive driver (income elasticity=1.74) on 3SLS, and a rather positive (income elasticity=0.58) on panel analysis.
Conclusion: Age did not significantly affect health expenditures in the advanced countries. The reality is that the income thought to cause population aging contributes to higher health expenditure, although advanced countries have experienced decades of sluggish economy.

JEL Classification: H51, I10
Keywords: population aging, determinants of health expenditure, panel regression, three-stage least squares

1. INTRODUCTION

Studies using aggregate data in the 1980s and 1990s argue that population aging is not a cause but a weak predictor of health expenditures (Newhouse, 1997; Fuchs, 1984; Hertzman, 1985; Getzen, 1992; Gerdtham, Sogaard, Anderson, and Jonsson, 1992; Hitiris and Posnett, 1992; Gerdtham and Jonsson, 1992; Barrows, 1998; Reinhardt, Hussey and Anderson, 2002; Seshamani

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** First and corresponding author, University of Seoul, Dongdaemun-gu, Seoulsiripdae-ro, 163, Seoul, Republic of Korea, Tel: 82(10)3734-6942, E-mail: choice1313@hanmail.net,

*** Co-author, Korea Institute of Health and Social Affairs, 370 Sicheong-daero, Sejong City, Republic of Korea, Tel: 82(10)3688-4351, E-mail: johnnam@gmail.com

and Gray, 2004a). However, studies using micro-data contend that the medical expenses before death, so called "proximity to death," are a major reason behind the high cost for old-age cohorts (Fuchs, 1984; Bloom and Kissick, 1980; Scitovsky, 1984; Mendelson and Schwartz, 1993; Kimberlyn et al., 2000; Seshamani and Gray, 2004b). This "red herring" claim has been vindicated by Werblow et al. in 2007 (Werblow, Felder, and Zweifel, 2007). According to the so called "red herring claim," rising health care costs seem to be due to aging populations, but the actual causes are pre-death medical costs, health care intensity and technology advances.

Since the 2000s, the share of national health expenditure (NHE) to GDP has continued to increase in European countries, but research on its determinants has not been as active as in the past. The purpose of this study is to clarify the determinants of NHE in advanced Western countries for the period from 1970 to 2016. Previous studies using aggregate data from OECD countries reported that income was a major cause of the increase in healthcare expenses, and explored whether the income elasticity of medical expenses exceeded 1.0. Some studies pointed to the public share of healthcare or examined the adoption of fee-for-service based payment (Roberts, 1998; Gertham, 1993; Gerdtham, Jonsson, MacFarlan, and Oxley, 1998). The problem with these studies, however, is that it is difficult to separate the net effect of population aging on the rising healthcare expenses, because healthcare expenditure, income and population aging move in the same direction as the passage of time. In other words, rising income or population aging are likely to increase healthcare demand, but conversely, the health expenditure is also likely to contribute to extend life expectancy, positively affecting the aging of population; also, the increase in medical expenditures leads to the expansion of the healthcare market which may create income growth. Thus, because the variables are placed in an endogenous interdependence relationship, it is difficult to obtain the pure effect of the explanatory variables that affect the health expenditure. We used the simultaneous equations model to resolve the endogeneity problem in order to verify the real effect of population aging on health expenditures.

2. METHODS

We determine the drivers of NHEs in 24 OECD countries (Western and Southern European countries and Japan; Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Iceland, Israel, Italy, Japan, Luxemburg, the Netherlands, Norway, New Zealand, Portugal, Sweden, and Turkey) using econometric analysis based on longitudinal data for the period between 1970 and 2016. The Eastern European countries were excluded as the historical context of the development of the health system of these countries is significantly different from that of Western and Southern European countries since these moved from socialism to capitalism in the 1990s. Our analysis was conducted by two steps: the first step was to estimate the determinants of health expenditures using multivariate panel regression as in equation (1) which is a modification of the model used

in Tchoe and Nam (2010) (Tchoe and Nam, 2010).

$$NHE=f(GDP, 65over; PUB, doctor, inpatient, fLabor, TEC, FFS, GTK). \quad (1)$$

In this model, NHE represents per capita national health expenditure. Independent variables are classified with socio-economic and health system-related factors (Tchoe and Nam, 2010). As socio-economic factors, we used GDP per capita, the ratio of people older than 65 to the total population, and the ratio of women to the whole work force (Tchoe and Nam, 2010). As health system-related factors, the public share of health expenditure (Gerdtham and Jonsson, 1992; Gerdtham, Jonsson, MacFarlan, and Oxley, 1998), the number of physicians in the population (Gerdtham, Jonsson, MacFarlan, and Oxley, 1998), the share of inpatient expenditure to total health expenditure (Gerdtham, Sogaard, Anderson, and Jonsson, 1992; Gerdtham and Jonsson, 1992; Gerdtham, Jonsson, MacFarlan, and Oxley, 1998), and the provision of new medical technology (Tchoe and Nam, 2010) are chosen. Other health system factors such as the adoption of fee-for-service (FFS) based payments (Gerdtham, Sogaard, Anderson, and Jonsson, 1992; Gerdtham and Jonsson, 1992; Gerdtham, Jonsson, MacFarlan, and Oxley, 1998) and the existence of gatekeepers were included (Gerdtham, Jonsson, MacFarlan, and Oxley, 1998) as institutional variables. In an FFS system, physicians are reimbursed with a fee assigned for each medical service that they provide to patients. These institutional variables were treated as dummy variables. Each quantitative variable is converted to natural logarithms to obtain the elasticity estimate. The logarithmic transformation of variables also contributes to mitigate the heteroscedasticity of coefficients. The variables used in the models are defined in table 1.

The above panel regression method is a way to overcome the limitations of cross-sectional analysis; however, it introduces endogeneity problems between dependent variables and explanatory variables in regression analysis using aggregate data. To mitigate these limitations,

Table 1 Definitions of Determinants of NHEs

Variables	Definition
NHE	Per capita real national health expenditures (PPP 1995 US dollars)
GDP	Per capita real GDP (PPP US dollar of 1995)
65over	Share of 65+ population of total population (%)
PUB	Public share of health expenditures (percentage)
Doctor	Number of doctors per one thousand people
Inpatient	Share of inpatient expenditures of national health expenditure (%)
fLabor	Share of female labor forces (%)
TEC	New technologies (number of CT, MRI)
FFS	Adoption of Fee-for-service (dummy variable)
GTK	Existence of gatekeepers (dummy variable)

we used the three-stage least squares (3SLS) method (Zellner and Thei, 1962) in the second step comprising the following simultaneous equations:

$$NHE = f(GDP, 65over; PUB, inpatient, doctor, GTK, TEC), \quad (2)$$

$$65over = f(NHE, GDP; PUB, inpatient, doctor, GTK, fLabor), \quad (3)$$

$$GDP = f(NHE, 65over; PUB, doctor, FFS, fLabor, TEC). \quad (4)$$

It is well-known that it is not possible to get parameter estimates if an equation or model is under-identified. Thus, in order to estimate the parameters of the model, the equation (or model) must be identified; the appropriate estimation technique will depend upon whether it is exactly identified or over-identified. The order condition for the identification of the model can be stated as follows: for an equation to be identified, the total number of variables excluded from it must be equal to or greater than the number of endogenous variables in the model less one (Zellner and Theil, 1962). In our model, the parameters were identified and the 3SLS estimation technique was employed. In order to estimate the parameters, some of the explanatory variables were excluded from each equation. The variables excluded were *FFS* and *fLabor* in the *NHE* equation, *TEC* in the *65over* equation and Inpatient and *GTK* in the *GDP* equation.

3. RESULTS

On panel regression analysis, population aging was a non-significant factor in the rising health expenditures during 1970-2016 in both model 1 and model 2 shown in table 2, from which we conclude that both income and public share were significant determinants of *NHE*. Technological advancement was another significant factor. When the analysis is confined to the years 1970-1999, population aging appears to be non-significant; this is in line with the results of previous studies. Both income and public share are seen to be significant factors, especially the latter, which has the greatest effect on health expenditures. Most previous studies conducted for the period 1970-1990s showed that income is the most significant determinant of health expenditure; however, in this study, public share played a more important role than income. This implies that as the proportion of public financing increases, direct payments by patients decrease, which leads to greater demand for health care, that is, health expenditure is more likely to be influenced by the “price effect” rather than the “income effect”. In addition, the number of physicians positively affects health expenditure, which also supports the physician-induced demand hypothesis, while the inpatient share has a negative effect. The Hausman test showed that the fixed-effect model was statistically significant rather than the random-effect model.

Table 2 Determinants of National Health Expenditures in 24 OECD Countries Using Panel Regression

	Model 1 (1970-2016) Fixed effect	Model 2 (1970-2016) Random effect	Model 3 (1970-1999) Fixed effect	Model 4 (1970-1999) Random effect
ln(*GDP*)	0.3935**	0.5828**	0.4992**	0.7467**
ln(*65over*)	0.0855	– 0.0261	– 0.0152	0.3111
ln(*pub share*)	0.2639**	0.1935**	1.1315**	0.8986**
ln(*inpatient*)	– 0.0635*	– 0.0746*	0.0892	– 0.0447
ln(*flabor*)	– 0.3937*	– 0.2140	1.3944**	0.6936
ln(*doctor*)	0.1557*	– 0.0149	0.5209**	0.0793
ln(*Tec*)	0.1602**	0.0876**	– 0.0046	– 0.0420
FFS	–	0.0864	–	0.0965
GTK	–	0.0292	–	0.8356**

Note: ** $p < 0.05$, * $p < 0.1$.

The results of 3SLS analysis which is performed to control the endogeneity problem among determining factors of health expenditure are shown in table 3. The main factor explaining health expenditure during the period 1970-2016 was found to be income, not population aging. Population aging works negatively to the *NHE*. The elasticity of income is estimated around 1.74, far exceeding 1.0, and the public share affects *NHE* negatively. These results are quite a different with those of panel regression. Among the determinants of population aging, the public share of health expenditure was a major factor. A possible explanation for this is that the increased public share reduces direct payments by elderly patients and improves their access to healthcare, which leads to population aging. It is notable that the *NHE* did have a significant effect on population aging, while the number of physicians had a positive effect on *NHE* (+0.56), which suggests that a higher number of physicians is likely to extend population longevity. Female labor participation has a strongly negative effect (−1.43), indicating that female labor participation harms the health status of women, and reduces female life expectancy. It is surprising to note that the effect of primary care physicians was negative, which implies that gatekeepers may not be any help in extending the life expectancy of the elderly. Finally, in terms of the determinants of income, both *NHE* and population aging have a significant effect on the national growth (GDP), from which we may conclude that income, population aging, and health spending are likely to follow similar trends. However, we did not find any significant factors explaining the *NHE* for the years 1970-1999.

Table 3 Determinants of National Health Expenditures in 24 OECD Countries Using The 3SLS Method

	1970-2016			1970-1999		
	ln(*NHE*)	ln(*65over*)	ln(*GDP*)	ln(*NHE*)	ln(*65over*)	ln(*GDP*)
ln(*NHE*)	–	0.7873**	1.015**	–	1.2371**	1.3364**
ln(*GDP*)	1.7429**	– 0.5495	–	– 1.1462	– 0.5104	–
ln(*65over*)	– 0.7320**	–	0.9980**	1.4305	–	0.8298*
ln(*pub share*)	– 1.0366**	0.9241**	0.2271	– 2.1632	1.6547**	0.3039
ln(*inpatient*)	0.4483*	– 0.1246	0.2210*	– 0.1858	– 0.0215	0.4216*
ln(*flabor*)	0.6625	– 1.4314**	– 0.5658	– 0.3299	– 0.3144	– 2.0033**
ln(*Tec*)	–	0.5575**	– 0.3195	–	0.0685	– 0.608**
FFS	– 0.1891**	–	–	0.2733	–	–
GTK	–	–	– 0.1771	–	–	– 0.4595**

4. DISCUSSION

Although population aging is generally perceived as a leading cause of the increase in health expenditure, most macroeconomic studies using OECD data have shown that income is a major determinant of health expenditure rather than population aging. However, since the 1990s, most studies using microdata have shown that before-death medical expenses are the main driver of health expenditures rather than population aging. In fact, however, medical needs before death are unlikely to increase when out-of-pocket payment of patients or their families is excessively high. However, generous public sector coverage of medical expenses which is possible when national incomes go up may encourage physicians and hospitals to provide more care to patients.

This is a macroeconomic study based on recent OECD data of 24 Western countries from 1970 to 2016 on national health expenditure in aging populations. Indeed, the historical trends in OECD countries suggest that health expenditure, population aging, and income levels have moved in the same direction. We adopted the 3SLS method to deal with the endogenous relationship in health expenditure-related variables.

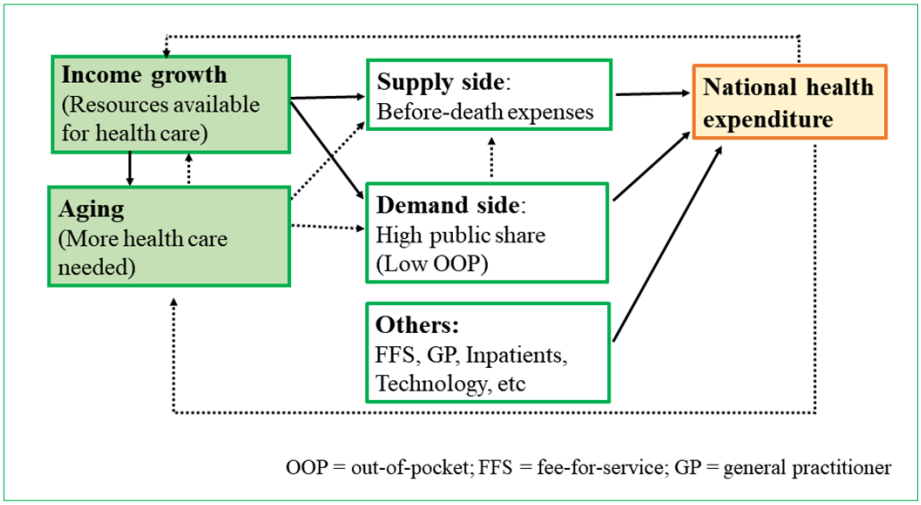
On 3SLS analysis, the most important determinant on health expenditure was found to be income. Population aging was found to have a negative effect on health expenditure. This indicates that health expenditure is likely to be determined by how much the healthcare expenditure can be available by economic resources, not by population aging per se. In this regard, before-death medical expenditures, which are considered to be a main driver of healthcare

expenditure in micro-data studies, could depend on how much out-of-pocket payment is available for patients or in other words, how the public coverage is generous for the healthcare cost. Meanwhile, in panel regression analysis, we found that the public share of health expenditure was decisive in explaining health expenditure during the period 1970-1999, while the effect of income was positive but weaker rather than that of the public share. This result implies that the price effect had overwhelmed the income effect in determining health expenditures, which is in contrast to the reports from previous studies from 1970-1990s, where the income effect was seen to dominate the price effect. The impact of population aging does not appear to be statistically significant.

Some studies have shown that the effect of population aging might be overwhelmed by the factors such as new technologies and increased utilizations (McClellan, 1996), for example, of drugs and diagnostic tests; and price inflation (Goetghebeur, Forrest, and Hay, 2003; Koenig et al., 2003). A study suggested that population aging leads to the "illusion of necessity" (Evans, 1985) by supposing that health care spending is higher in older age, which is diverted from the real causes of technological progress in medicine, increased income, moral hazard of providers and consumers caused by extensive social health insurance coverage (Evans, 1985; Zweifel, Felder, and Meier, 1999). Another study indicated the long-term care and medical technology rather than age (Hakkinen et al., 2008).

The causes of medical expenditure are therefore very complex. In macroeconomic sense, demand, supply and institutional factors will affect healthcare spending. Figure 1 illustrates the factors affecting healthcare expenditure. The mechanism by which income affects health expenditures can be summarized from the figure 1 as following. On the supply side, it is possible for a provider to spend a lot on medical bills before death; however, this cannot be supported without resources allocated by the public sector, which is why national income will likely determine the amount of healthcare provision. While aging requires greater pre-death medical costs, this must also be backed up by higher national income. On the demand side, as the income level improves, people demand greater health insurance coverage. Aging will further reinforce this trend, but eventually this has to be supported by income. Besides, from an institutional perspective, FFS is an incentive to increase spending on health care, and the establishment of a primary health care system is expected to drive down spending on health care. Increasing the proportion of costly hospitalization will also stimulate medical expenditures. Furthermore, the development of new technologies and diagnostic tools also tends to increase medical expenditures. Variations in health care systems across countries will result in variations of health care expenditures. The effects of institutional differences, however, will vary from country to country, and this may not result in statistically significant generalized results.

Figure 1 The Effect of Income and Population Aging on Health Expenditures



5. CONCLUSION

This study concludes that when population aging is considered to be an endogenous variable, and not an independent variable in its impacts on health expenditure, age is statistically non-significant to explain the rise in health expenditure. Age might be, at best, a parameter or a mediating cause for health care expenditure increase. This study confirms again that income is the strongest determinant of health expenditure. Therefore, it is necessary to make policy efforts to effectively control the increasing pressure of healthcare demand within the limits of available national income. Future research into cost-push factors, such as cost of dying, use of new technologies, and growth of innovative healthcare in advanced countries is therefore warranted.

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