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Effects of Health Care Expenditure on the Infant Mortality Rate and Life Expectancy at Birth in Korea

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ABSTRACT

This study examines whether the infant mortality rate and life expectancy at birth are affected by health care expenditure in Korea. It can be provisionally concluded that the infant mortality rate tends to be affected by the health system itself in the long-run, whereas life expectancy at birth is immediately affected by health-related facilities such as the number of physicians and number of hospital beds in the short-run. Therefore, the health-related system should be well established to improve the infant mortality rate. On the contrary, physical capital such as life-prolonging medical technologies has to be accumulated to improve life expectancy at birth.

***Keywords**: Health Care Expenditure, Infant Mortality Rate, Life Expectancy at Birth*

1. INTRODUCTION

Health care expenditure as a proportion of GDP has continuously grown in Korea for the past two decades. Although recent research has been carried out to explore the significant determinants of this health care expenditure trend, empirical evidence on the linkage between health care expenditure and its outcomes remains elusive. The reason for this gap in the literature arises from the difficulty of isolating the contribution of health care expenditure among the many determinants of health-related services. Thus, the research in this area has failed to identify the overall effectiveness and efficiency of health care expenditure. Nevertheless, some studies [1] have been successful at finding a linkage between these two variables by applying factors such as diet, lifestyle, and environment to a structural model in order to explore the infant mortality rate and life expectancy at birth, which are considered to be the most important socioeconomic indicators in this regard.

Because the majority of health care expenditure is spent by the public sector, there is also a lack of consensus over whether governmental intervention in the health care sector is appropriate. The public sector, by nature, is vulnerable to market failures and externalities, which can easily lead to inefficient outcomes. Therefore, increasing private health care expenditure, namely that based on market activities, is a matter of concern. It is certainly expected that social wellbeing would be gradually improved by further investment into private health care. By contrast, it is widely recognized that further empirical research on public health care expenditure would help promote fiscal responsibility by providing information to policymakers, leading to efficient and innovative ways to improve the health care system. Further, the outcomes that result from changing the level of health care expenditure should be discussed by performing empirical analyses over time. For instance, the infant mortality rate and life expectancy at birth could be influenced not only by the medical infrastructure, such as long-term health care plans or medical programs, but also by instantly implemented health care policies.

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2. LITERATURE REVIEW

Previous research in this line has adopted various approaches. In a broad sense, Reference [2] measured how the method of financing health care expenditure affects the efficiency with which better health outcomes can be achieved. This allows the proposal of a specification that embeds health sector performance in a broad index of economic inputs and outputs in order to compare countries over time. Reference [3] analyzed the welfare-maximizing policy mix between explicit and implicit taxation, in which the probability of the survival of children depends on the share of government expenditure in health, education, and infrastructure. This study showed that increases in the survival probability lead to an increase in the reliance on seigniorage as a welfare-maximizing outcome.

Reference [4] emphasized that increased per capita GDP, which accordingly increases health care expenditure, could be a significant determinant of changes in the infant mortality rate. Reference [5] provided further economic evidence that links per capita government health care expenditure and per capita income to under-5s and maternal mortality. This study concluded that while economic growth is certainly an important contributor to health outcomes, government spending on health is just as important. Reference [6] tested the red-herring hypothesis that suggests that population aging has an almost negligible impact on health care expenditure in OECD countries.

Reference [7] investigated the relationship between aging and changes in per capita health care expenditure in EU-15 countries. This study suggested a positive short-run effect of aging on health care expenditure, but found virtually no long-run effect. By contrast, although the short-run effect of life expectancy on health care expenditure was shown to be approximately zero, the long-run effect was positive. Thus, increasing life expectancy leads to a more than proportional (on an exponential basis) increase in health care expenditure. Reference [8] examined whether age or life expectancy better predicts health care expenditure and concluded that age has little additional predictive power on health care expenditure, but that the predictive power diminishes as health status measures are introduced into the analysis. Reference [9] showed that when life expectancy increases, terminal costs are postponed but that the increases in health care expenditure that follow from longer life expectancy are small compared with the increase in the number of elderly persons.

Finally, reference [1] confirmed that steady trends towards improved health outcomes and increasing health care expenditure exist in industrialized countries. However, establishing causal relationships between them is complex because health care expenditure is merely one of the many quantitative and qualitative factors that contribute to health outcomes. The analysis examined how life expectancy and infant mortality are influenced by various lifestyle, environmental, and occupational factors and found that increases in health care expenditure are significantly associated with large improvements in infant mortality but only marginal improvements in relation to life expectancy.

3. EMPIRICAL ANALYSIS

3.1 Data Specifications

The infant mortality rate per 1,000 live births (i.e., imr) and life expectancy at birth (i.e., le) were separately used for the empirical analysis as dependent variables. In addition, the independent variables were as follows: total health care expenditure (i.e., het, % of GDP), physicians per 1,000 people (i.e., ph), hospital beds per 1,000 people (i.e., hos), public health care expenditure (i.e., hpd, % of GDP), public health care expenditure (i.e., hpg, % of government expenditure), public health care expenditure (i.e., hph, % of total health care expenditure), and private health care expenditure (i.e., hpv, % of GDP). The source of the data was the World Bank database [10], while the period 1985–2010 was used for the empirical analysis. Because secondary data were employed in this research, the data set was carefully reviewed and compared with the data published by the OECD to avoid any possible errors [11]. Moreover, we identified that the data set derived from the World Bank was superior to that from the OECD in terms of its accuracy and the length of time series.

3.2 Methodology

Following reference [1], the infant mortality rate and life expectancy at birth were selected as the dependent variables of the model in this research, while various forms of health care expenditure, such as the number of physicians and number of hospital beds, were used as the independent variables. Because health care expenditure, in general, is positively related to the increased social wellbeing that results from improved physical health, the infant mortality rate and life expectancy at birth could be indicators of health care expenditure. Thus, they could act as proxy variables not only for increasing health care expenditure, but also for other factors related to improved social wellbeing. The implicit functional forms of the model were as follows:

$$imr = f[(het, hpd, hpg, hph, hpv), ph, hos]$$
$$le = g[(het, hpd, hpg, hph, hpv), ph, hos]$$

The models for the empirical analysis were formulated based on the functional forms shown above. Depending on the different forms of health care expenditure, the following 10 equations were then formulated:

< Eq.1–Eq.10 >

$$\ln imr = \alpha_1 + \beta_1 \ln(het, hpd, hpg, hph, hpv) + \varepsilon_1 \quad (1)$$

$$\ln imr = \alpha_1 + \beta_1 \ln(het, hpd, hpg, hph, hpv) + \gamma_1 \ln ph + \delta_1 \ln hos + \varepsilon_2 \quad (2)$$

< Eq.11–Eq.20 >

$$\ln le = \alpha_2 + \beta_2 \ln(het, hpd, hpg, hph, hpv) + \nu_1 \quad (3)$$

$$\ln le = \alpha_2 + \beta_2 \ln(het, hpd, hpg, hph, hpv) + \gamma_2 \ln ph + \delta_2 \ln hos + \nu_2 \quad (4)$$

3.3 Results

The descriptive statistics of the variables were reviewed before performing the empirical analysis, and the results are shown in Table 1. They show that the standard deviation was comparatively low in most cases except public health care expenditure as a proportion of total health care expenditure. Skewness is a measure of the asymmetry of a distribution. If the skewness value is positive, the distribution of the variable is taken to be right-skewed, whereas if it is negative, the distribution is taken to be left-skewed. Therefore, life expectancy at birth and private health care expenditure were left-skewed, whereas the other variables were right-skewed. Further, kurtosis is a measure of the thickness of the tails of the distribution. The kurtosis for a normal distribution is 3. Therefore, because the kurtosis value of the infant mortality rate was 4.1 and that of private health care expenditure was 4.5, we assumed that they are leptokurtic. Finally, the other variables were assumed to be platykurtic since the kurtosis values for them were all less than 3.

Table 1. Descriptive Statistics of the Variables

	imr	le	het	ph	hos	hpd	hpg	hph	hpv
mean	5.6	74.7	4.8	1.3	5.8	2.2	9.1	44.7	2.5
max	9.4	80.3	6.5	2.0	12.3	3.5	12.3	54.1	2.6

min	4.2	68.5	3.9	0.6	2.4	1.4	7.1	36.2	2.3
std.dev.	1.4	3.6	1.0	0.4	2.9	0.8	2.0	6.8	0.1
skewness	1.4	-0.1	0.7	0.1	0.7	0.6	0.5	0.2	-0.9
kurtosis	4.1	1.8	2.0	1.8	2.3	1.8	1.5	1.3	4.5

Before identifying the size of the estimated coefficients between the dependent and independent variables in Eq.1–Eq.20 using the ordinary least squares (OLS) technique, covariance analysis and the Granger causality test were carried out. The existence of meaningful relationships between the variables was easily identified through these procedures. Table 2 depicts the covariance matrix of the variables, showing that the infant mortality rate was negatively correlated with most variables. Intuitively, increasing the various forms of health care expenditure (het, hpd, hpg, hph, and hpv) as well as the number of physicians and number of hospital beds would decrease the infant mortality rate. By contrast, since life expectancy at birth was positively correlated with most variables, increasing the various forms of health care expenditure as well as the number of physicians and number of hospital beds would increase life expectancy at birth. The various forms of health care expenditure, number of physicians, and number of hospital beds were also positively correlated with one another. Finally, private health care expenditure was relatively uncorrelated compared with the other variables.

Table 2. Covariance Analysis of the Variables

	imr	le	het	ph	hos	hpd	hpg	hph	Hpv
imr	1								
le	-0.9	1							
het	-0.6	0.9	1						
ph	-0.9	0.9	0.9	1					
hos	-0.8	0.9	0.9	0.9	1				
hpd	-0.7	0.9	0.9	0.9	0.9	1			
hpg	-0.7	0.9	0.9	0.9	0.9	0.9	1		
hph	-0.7	0.9	0.9	0.9	0.9	0.9	0.9	1	
hpv	-0.1	0.3	0.5	0.3	0.4	0.5	0.4	0.2	1

Exogeneity is easily identified using the Granger causality test since Granger non-causality is necessary for strong exogeneity. To evaluate whether such a condition holds, the null hypothesis should be tested [12]. The results of the Granger causality test are presented in Tables 3 and 4. The null hypotheses of the test were tentatively rejected at the 5% significance level in both cases. Importantly, the infant mortality rate showed unidirectional causalities with the number of physicians, the number of hospital beds, public health care expenditure as a proportion of GDP, and public health care expenditure as a proportion of total health care expenditure. Further, bidirectional causalities between total health care expenditure, health care expenditure as a proportion of government expenditure, and private health care expenditure were also found.

With respect to life expectancy at birth, there existed bidirectional causalities in all cases except with the number of physicians. This finding implies that life expectancy at birth strongly Granger causes the various forms of health care expenditure, the number of physicians, and the number of hospital beds. Therefore, it could be concluded that life expectancy at birth maintained a stronger relationship with the independent variables compared with the infant mortality rate.

Table 3. Granger Causality Test: Infant Mortality Rate

Equation	F-statistics	p-value
lhet ⇏ limr	2.17	0.14*
limr ⇏ lhet	2.25	0.13*
lph ⇏ limr	0.89	0.43*
limr ⇏ lph	0.43	0.65
lhos ⇏ limr	1.58	0.23*
limr ⇏ lhos	0.59	0.56
lhpd ⇏ limr	2.12	0.15*
limr ⇏ lhpd	0.70	0.51
lhpg ⇏ limr	2.23	0.13*
limr ⇏ lhpg	0.73	0.49*
lhph ⇏ limr	2.12	0.15*
lmtr ⇏ lhph	0.70	0.51
lhpv ⇏ limr	1.56	0.24*
limr ⇏ lhpv	6.53	0.01*

Note: (*) indicates that the null hypotheses are tentatively rejected at the 5% significance level.

Table 4. Granger Causality Test: Life Expectancy at Birth

Equation	F-statistics	p-value
lhet ⇏ lle	0.87	0.43*
lle ⇏ lhet	5.65	0.01*
lph ⇏ lle	1.96	0.17*
lle ⇏ lph	0.62	0.55
lhos ⇏ lle	13.10	0.01*
lle ⇏ lhos	6.47	0.01*
lhpd ⇏ lle	1.72	0.21*
lle ⇏ lhpd	7.65	0.01*
lhpg ⇏ lle	0.22	0.80*
lle ⇏ lhpg	6.94	0.01*
lhph ⇏ lle	1.73	0.20*
lle ⇏ lhph	7.66	0.01*
lhpv ⇏ lle	0.82	0.46*
lle ⇏ lhpv	3.67	0.04*

Note: (*) indicates that the null hypotheses are tentatively rejected at the 5% significance level.

Since uni- or bidirectional causality relationships between the infant mortality rate, life expectancy at birth, the various forms of health care expenditure, the number of physicians, and the number of hospital beds were shown in the first step, the scales of these relationships were determined in the next step. To perform such a procedure, OLS is a useful econometric method. First, the AR(1) procedure proposed by Cochrane–Orcutt was performed to capture and adjust the auto-correlated components in the Gaussian error term ($\hat{\varepsilon}_t$) in both cases. The procedure can be identified by the innovational equation such that $\hat{\varepsilon}_t = \rho\hat{\varepsilon}_{t-1} + \nu_t$, and it involves a series of iterations, each of which produces a better estimate of ρ than the previous one. Here, $\hat{\varepsilon}_{t-1}$ is a lagged estimated error term and ρ is the correlation coefficient associated with the errors in adjacent time periods [12]. Because the estimated correlation coefficients ($\hat{\rho}$) in both cases were less than 1 (unity) in absolute value, any possible auto-correlated components were captured by $\hat{\rho}$, thereby improving the stability of the estimated coefficients.

Tables 5 and 6 show the estimated results of the infant mortality rate and life expectancy at birth, which were obtained from Equations (1) to (4), respectively. The elasticity of the infant mortality rate and life expectancy at birth with respect to the number of physicians and number of hospital beds ranged from 0.04 to 0.13 in absolute value, while the estimates with respect to the various forms of health care expenditure ranged from 0.01 to 0.02 in absolute value. In other words, the elasticity estimates in both cases were larger in magnitude for the number of physicians and number of hospital beds than those reported in the various forms of health care expenditure. This finding implies that the various forms of health care expenditure tend to be effective in the long-run, whereas the number of physicians and number of hospital beds are effective in the short-run.

As far as the signs of the estimated coefficients are concerned, the infant mortality rate was negatively related to the various forms of health care expenditure and the number of physicians. This makes sense because increasing health care expenditure and the number of physicians decreases the infant mortality rate. However, the number of hospital beds was positively related to the infant mortality rate, which is ambiguous. Further, the signs of the estimated coefficients with respect to the various forms of health care expenditure in the equation of life expectancy at birth altered depending on the different forms of public expenditure, while the signs with respect to the number of physicians and number of hospital beds were positive. This finding implies that increasing the number of physicians and number of hospital beds results in increasing life expectancy at birth. Moreover, the debate about whether private health care expenditure is more efficient than public health care expenditure remained not answered, since there were no significant differences in the estimated coefficients in both cases. This implies that the health care system in Korea is primitive and still dominated by the public sector.

To this end, it can be provisionally concluded that the infant mortality rate tends to be affected by the health system itself in the long-run, whereas life expectancy at birth is immediately affected by health-related facilities such as the number of physicians and number of hospital beds in the short-run. Therefore, the health-related system should be well established to improve the infant mortality rate. On the contrary, physical capital such as life-prolonging medical technologies has to be accumulated for life expectancy at birth. In addition, it should be recognized that increasing health care expenditure improves efficiency in two ways. Therefore, better outcomes can be achieved by taking into account such a point.

Table 5. Estimated Coefficients: Infant Mortality Rate

	α_1	β_1	γ_1	δ_1	R^2	DW	$AR(1)$
Eq1	1.64	-0.01	-	-	0.99	1.45	0.88
	(3.23)*	(-0.42)					(63.0)*
Eq2	1.79	-0.02	-0.13	0.07	0.99	1.48	0.88
	(3.77)*	(-0.92)	(-2.16)*	(1.70)			(46.7)*
Eq3	1.66	-0.01	-	-	0.99	1.43	0.88
	(3.08)*	(-0.44)					(57.9)*
Eq4	1.71	-0.01	-0.13	0.07	0.99	1.40	0.88
	(3.39)*	(-0.69)	(-2.06)*	(1.60)			(45.0)*
Eq5	1.80	-0.02	-	-	0.99	1.47	0.88
	(3.57)*	(-0.74)					(57.3)*
Eq6	1.81	-0.02	-0.12	0.07	0.99	1.43	0.88
	(3.84)*	(-0.95)	(-2.06)*	(1.65)			(44.9)*
Eq7	1.66	-0.01	-	-	0.99	1.43	0.88
	(3.08)*	(-0.43)					(57.9)*
Eq8	1.71	-0.01	-0.13	0.07	0.99	1.40	0.88
	(3.38)*	(-0.69)	(-2.06)*	(1.60)			(45.0)*
Eq9	1.52	-0.01	-	-	0.99	1.41	0.88
	(3.39)*	(-0.21)					(67.4)*
Eq10	1.71	-0.02	-0.13	0.07	0.99	1.47	0.88
	(4.00)*	(-0.84)	(-2.16)*	(1.71)			(48.8)*

Notes: 1) The numbers in parentheses are t-statistics.
2) (*) indicates that the null hypotheses are tentatively rejected at the 5% significance level.

Table 6. Estimated Coefficients: Life Expectancy at Birth

	α_2	β_2	γ_2	δ_2	R^2	DW	$AR(1)$
Eq11	4.61	-0.01	-	-	0.99	1.00	0.97
	(36.8)*	(-0.84)					(94.8)*
Eq12	4.18	0.01	0.05	0.06	0.99	2.01	-0.10
	(33.8)*	(0.25)	(3.26)*	(7.00)*			(-0.47)
Eq13	3.20	0.05	-	-	0.98	1.67	0.50
	(45.5)*	(16.0)*					(2.56)*
Eq14	4.02	0.01	0.04	0.05	0.99	1.98	-0.07
	(31.2)*	(1.45)	(2.58)*	(5.76)*			(-0.33)
Eq15	4.54	-0.01	-	-	0.99	1.09	0.97
	(33.4)*	(-0.11)					(89.9)*
Eq16	4.06	0.01	0.04	0.05	0.99	1.98	-0.08
	(36.0)*	(1.31)	(2.71)*	(6.37)*			(-0.38)
Eq17	3.20	0.05	-	-	0.98	1.67	0.50
	(45.6)*	(16.1)					(2.55)*
Eq18	4.02	0.01	0.04	0.05	0.99	1.98	-0.07
	(31.1)*	(1.45)	(2.57)*	(5.76)*			(-0.33)
Eq19	4.61	-0.01	-	-	0.99	1.01	0.97
	(43.1)*	(-1.03)					(94.0)*
Eq20	4.26	-0.01	0.05	0.06	0.99	2.05	-0.13
	(38.4)*	(-0.48)	(3.62)*	(7.07)*			(-0.60)

Notes: 1) The numbers in parentheses is a t-statistics.
2) (*) indicates that the null hypotheses are tentatively rejected at the 5% significance level.

4. CONCLUSION

As the level of income has continuously increased in developed as well as in emerging economies such as Korea, health care expenditure has also rapidly increased. Therefore, much theoretical and empirical research on this topic has focused on uncovering the significant determinants of health care expenditure. This study specifically examined whether the infant mortality rate and life expectancy at birth are affected by health care expenditure in Korea. The infant mortality rate and life expectancy at birth were selected as the dependent variables, while the various forms of health care expenditure, number of physicians, and number of hospital beds were taken as independent variables. The Granger causality test and OLS were also employed as analytical techniques.

According to the results obtained from the empirical analysis, it can be provisionally concluded that the infant mortality rate tends to be affected by the health system itself in the long-run, whereas life expectancy at birth is immediately affected by health-related facilities such as the number of physicians and number of hospital beds in the short-run. Therefore, the health-related system should be well established to improve the infant mortality rate. On the contrary, physical capital such as life-prolonging medical technologies has to be accumulated for life expectancy at birth. In addition, we showed that increasing health care expenditure improves efficiency in two ways.

Although this research adopted a suitable structural model and carried out relevant empirical analyses, the outcome is limited in terms of its generalizability. Structural equations could be used in future research on this topic to increase the number of independent variables in order to explore the socioeconomic impact further.

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