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The Determinants of Health Improvements in Developing Countries: The Case of Thailand

Rugphong VONGSAROJ*

Abstract

This study investigates the sources of health improvement in Thailand during the greatest period of its advancement. In order to evaluate these sources, various health indicators and socioeconomic variables are used to analyze their causalities at multiple levels; national, regional, and provincial. The multivariate regression results confirm the existing theoretical concept of health determinants. These findings reveal that education, living conditions, and health resources significantly have a positive impact on health, while the net effect of income on health is unclear as its effect differs between health indicators and between regional levels. The results also disclose that the local-specific factor is another important source of health improvement and health status disparity.

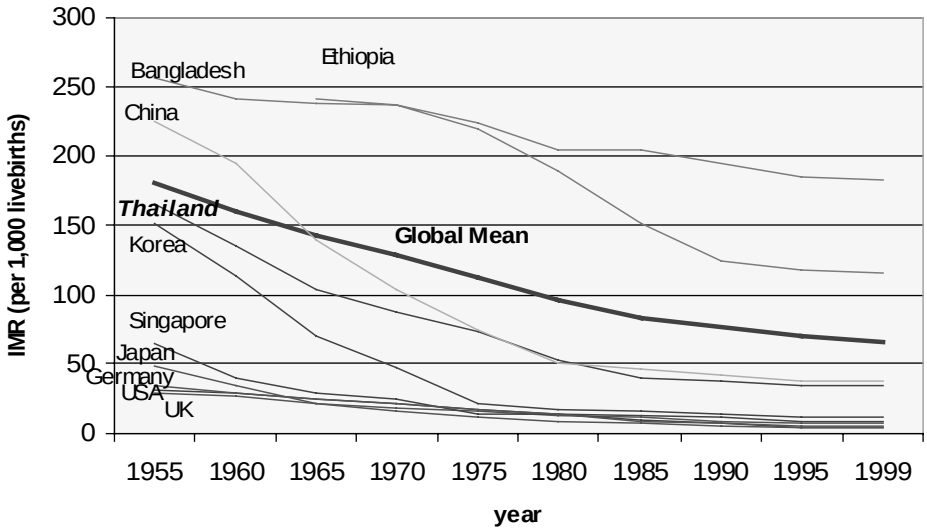
In addition, the dominant effect of health resources on health improvement is found in a long time-series national model. These results contradict the previous findings derived from cross-sectional data. This difference leads to the argument that in long-run health resources definitely play important roles in improving health status of a population, particularly in developing countries (as Thailand) where health resources typically seem inadequate.

1. Introduction

A health indicator is regularly used to assess the development progress of the nation because health is regarded as an important indicator of development and it functions as an essential source of social and economic development. During the late twentieth century, many health outcomes impressively improved more than whenever before (World Bank 1993), despite the fact that such progress in developed nations had already occurred during the end of ninetieth century (Ahmad 2000). As shown in Figure 1, the disparity gap in infant mortality rates (hereinafter IMR) between countries has become narrower. Moreover, the IMR in some middle-income countries has become parallel with those of high-income countries. However, the achievements in some countries are still far lower than the global mean, particularly in sub-Saharan African countries.

*Doctoral Student, Graduate School of International Development, Nagoya University

Figure 1 Trend of infant mortality rate in some selected countries

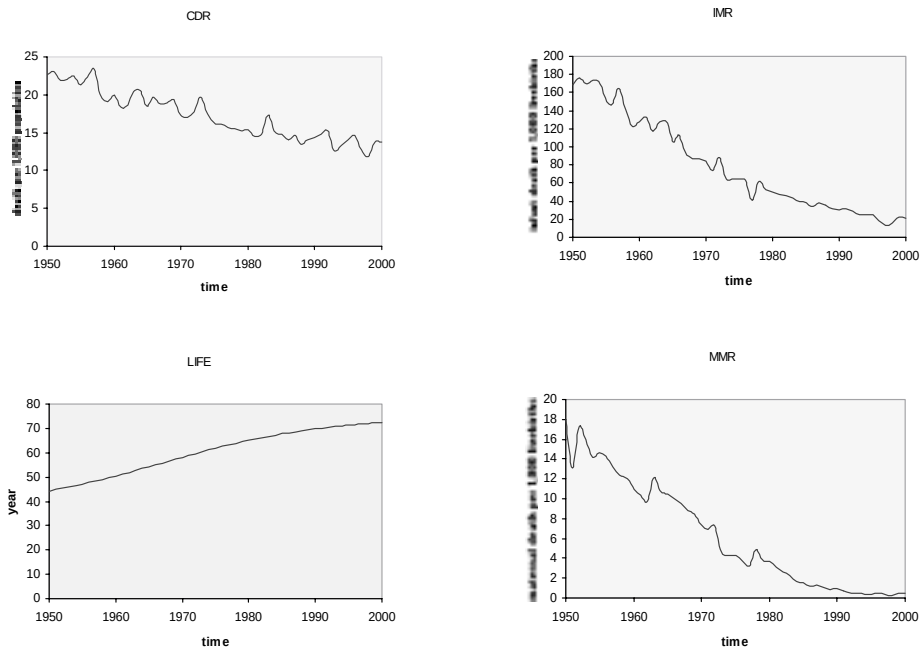


Source: Ahmad (2000)

The traditional measures of health status are mortality rate and life expectancy, which is derived from the age-specific mortality rate. The mortality rate can be further disaggregated according to age, sex, and region; for example, infant mortality rate, maternal mortality rate, and child mortality rate. Recently, some other health indicators have been developed to represent not only death or living but also the condition of people's health. These indicators are called the Disability Adjusted Life Year (DALY),[1] Quality Adjusted Life Year (QALY),[2] and Disability Adjusted Life Expectancy (DALE);[3] however, they are not generally used in all countries because of the very detailed data requirement.

In Thailand, different health indicators have shown an impressive improvement during the past fifty years. As in Figure 2, the crude death rate (hereinafter CDR), IMR and maternal mortality rate (hereinafter MMR) have declined; meanwhile, life expectancy (hereinafter LIFE) increased drastically. Despite these facts, overall health improvements have slowed down considerably after 1980. Such progressive advances are recognized as the highest achievement in the improvement of Thai people's health status. Various factors have been mentioned as the sources of these improvements. However, the significance and the extent of their effect have not been investigated.

Figure 2 Changes in some health indicators in Thailand during 1950-2000



Source: Compiled by author; based on data from MOPH (1954 - 2002) and Prasartkul & Rakchanyaban et al. (2002)

The analysis of health determinants is of value for policy implementation as it provides knowledge about the factors which improve or worsen the health status of population in the real world. As a result, policymakers can use this information to allocate resources efficiently. In addition, this analysis reveals the causes of disparity of health status between groups of people. The results of this analysis can be used to indicate the sources of health development and health disparity and also used to differentiate the sources of these incidences between countries or regions.

Much research has been done to explore the determinants of health by utilizing cross-national data. Although these analyses provide sufficient information on factors determining health, however, they are unable to explore health determinants in all dimensions. For example, they can explain the sources of difference but not the sources of change. Besides, they cannot absolutely control many factors that differ across nations. A few studies have employed the time-series data in their analysis due to the problems of unavailable and unreliable data and, moreover, the variation of data is normally less than those of cross-national data.

This study aims at exploring the factors that influence the change and the variation of the health status of the Thai population, with the focus on health resource factors. The advantages to this study are in the application of time-series data and analyzing health determinants at multiple levels. The analysis is divided into three levels which are: 1) a national model, from 1950 to 2000; 2) a regional model, including 4 regions from 1970 to 2000; and 3) a provincial model, including 75 provinces,

excluding Bangkok, from 1994 to 2000. The time-series regression analysis is used in the first part and the panel data analysis is applied in the second and third parts.[4] The similarity and the difference in results between these models were also expected to disclose knowledge on the determinants of health status and to propose some relevant policies as in the case of Thailand.

2. Reviews of Theoretical Concepts and Empirical Studies

2.1 Theoretical Concepts

Normally, the studies of health determinants can be categorized into two types. Firstly, the micro-level studies mostly concentrate their analysis on the effects of the factors of individuals to health outcomes and, secondly, the macro-level studies which generally focus their analysis on the effects of both individual and environmental factors. This study focuses on the latter approach. For analytical purposes, this study classifies the health determinants into five groups: 1) economic, 2) education, 3) health services, 4) population and living conditions, and 5) others factors.

2.1.1 Economic Factors

Income critically correlates with health outcomes at both the aggregate (nation) and disaggregate (household) level. Increases in income enhance the population's health through: 1) higher incomes enable a country to expand its provision of health services and social security coverage, and these allows health services to become more accessible; 2) when people are richer, essential foods and health care services become attainable; 3) economic development leads to progress in technological innovation, particularly in medical treatment and prevention; and 4) individuals become more concerned about their health.

However, the extent of the effect of income on health is different from group to group. For example, the marginal effect of income among females and the poor is higher than among males and the rich. As a result, some authors suggest that narrowing the gender and income gap can improve the health status. In addition, it was not surprising when the studies found no, or even negative, relationships between income and health, especially in developed countries since this correlation can be explained by the law of diminishing in marginal effect. Furthermore, Deaton and Paxson (1999) found evidence that short-term increases of income may raise the risk of mortality, particularly for a young man. Thus, it can be concluded that income does not improve health directly but rather that health is determined by how that income is used.

The other economic factors, such as the structure of the economy, are often tested but their effects on health are ambiguous. Deaton and Paxson (1999) found insignificant effect of income inequality on health. However, Wikinson confirmed a negative relationship between income inequality and health

after controlling income effect, by comparing 11 OECD countries.[5] It can be interpreted from these results that inequality effect tends to be more significant when income effect declines. In addition, Pampel and Pillai (1986) found that unemployment rate has a negative effect on health, by using data from developed countries from 1950 to 1975.

2.1.2 Education

Education can improve the health status of people, notably child health, through enhancing a personal rational living style. People become more effective in the use of health improving goods and services, and they can properly rear their children with more capability to prevent illness and premature death. Previous studies, both national and international, have demonstrated that education plays a dominant role in explaining the differences in health status (Auster, Leveson, & Sarachek 1969; Hatasa 2002; Rutstein 2000). Similar to income, it was found that the marginal effect of education on health is larger among females than in males. Generally, few variables on education have been employed in the determinant analyses; for example, the school enrollment rate and educated level of population. Similar to income, it was found that the marginal effects of education on health declines as schooling increases (Wolfe & Behrman 1984; Wang et al. 1999).

2.1.3 Health Care Services

Both curative and preventive treatments play a significant role in improving one's health, although the curative care may have more significant role when people are ill. It has been argued that the most direct way of improving health is to provide medical goods and services (Gertler & van der Gaag 1990). However, such services can be less important when other goods and services, including clean water, nutrition, mosquito nets, and so on, are also available and used effectively. Like income, the marginal effect of utilizing health services on health status declines as more health service is used (Phelps 1997). Typically, due to the limits of data, the variables that are used to test for the effects of health care factors are health resources, including health expenditure, physician, nurse, hospital, and hospital beds. It is nonetheless important to note that these health resources are used to produce health services, and health status is the direct output of health services. However, the effect of health services can be disaggregated according to its operational level: primary, secondary, and a tertiary level. In spite of this, Starfield and Shi (2002) demonstrated that not only sound primary care but also an excellent referral system has a significantly positive impact on health indicators.

2.1.4 Population and Living Conditions

The population characteristics are often included in the health determinants model. Gender is one component. There is noticeable evidence that females live longer than males and that females visit hospitals more often than males. Since the probability of death is relatively high in the first five years, the woman's characteristics, including age of the mother, mother's health condition, and mother's education background, have repeatedly shown to be significant in effecting infant and child mortality. Obviously, age is also considered as an important factor since the probability of death is a function of age. The relationship between probability of death and age can be presented in U-curve. The level and the length of the bottom of the curve are, however, different from country to country.

The effect of household living conditions on health is broadly conducted, notably in survey studies. A number of these variables; for example, household sanitary condition, calorie intake, size of family, showed a significant influence on health (Pampel & Pillai 1986). Population behavior is another factor that affects heath status; for example, smoking, alcohol consumption, and daily activity. Phelps (1997) argued that the role of medical care is considerably small relative to the lifestyle.[6] Furthermore, Eyles et al. (2001) surveyed the attitude of people regarding determinants of health and found that personal health practice was ranked as having the most important effect on health by all occupational groups.

2.1.5 Other factors

There are a number of other factors that have been applied to health determinant analyses. For example, Wilson and Rosenberg (2002) introduced cultural and traditional activities in determining the health status of the ethnic Aborigine in Canada but their effect was not constantly significant. The social security system and public welfare are other elements that play relatively significant roles in determining the difference of health indicators between nations that are not much different in other factors, particularly income and education. For example, Pample and Pillai (1986) discovered that public welfare is a critical cause that leads to a difference in health status in the United States and other developed nations.

Technological progress is also regarded as a key factor that improves health status of a people. Empirically, technological progress is commonly introduced into the analysis by using time-trend variables to capture the shift in the relationship between health and other explanatory variables (Pritchett & Summers 1993; Wang et al. 1999).

In fact, these groups of health determinants are not only affecting health outcomes but they affect each others as well. In order to investigate the net effect of each factor on health outcome, one must control the effects of other variables or hold them constant. The regression techniques are extensively applied to estimate net effects of the health determinants. However these techniques can be

implemented with only the factors which are quantifiable. Several selected empirical analyses are reviewed in the next section.

2.2 Empirical Studies

The previous studies on health determinants can be generally categorized into two groups; macro and micro studies. The macro analyses employ the aggregate data from national statistics and provide general views of health determimants while the micro analyses utilize the survey data with aim at capturing specific information that is not measured routinely; for example, behavior, attitude, and living conditions. Due to the existing data, most of researchers embed their analysis on cross-regional or cross-national data. A few studies have been done by employing time-series data. Chronologically, some of the empirical researches are presented below.

Table 1 Some empirical studies on health determinants

	Auster el al. (1969)	Gertler et al. (1990)	Prichett and van der Gaag (1993)			Wang et al. (1999)
Targeting Data	all states in U.S.	both developed and developing countries in 1975	countries which GDPP below $6,000 from1960-1985 (5-year interval)			middle- and low- income countries from 1960-1990 (5-year interval)
Dependent Variables	log(CDR)	log(IMR)	log(IMR)	log(IMR)	log(IMR)	log (Child Mortality)
Technique / Explanatory Variables	OLS	OLS	OLS with time dummy variables	First Differential Form, OLS with time dummy	Fixed Effect with time dummy variables	Random Effect with time dummy and interaction variables
Income	0.023*	-	-	-		
log(GDPP[a])	-	-	- 0.420***	- 0.190***	- 0.313***	- 0.380***
Education	- 0.153	-	-	-	-	-
log(Education)	-	-	- 0.136***	- 0.019***	- 0.010	-
log (Female Education)	-	-	-	-	-	- 0.530***
log(Literacy rate)	-	- 0.400	-	-	-	-
Health Expenditure	- 0.084*	-	-	-	-	-
log(Health Exp)	-	- 0.412***	-	-	-	-
Population Density	-	- 0.169***	-	-	-	-
% in urban	- 0.012***	-	-	-	-	-
log(Calorie intake)	-	- 0.289	-	-	-	-
% in Manufaturing	0.049**	-	-	-	-	-
Alcohol Consumption	0.031**	-	-	-	-	-
Cigarette Consumption	0.141*	-	-	-	-	-
Medical School	- 0.020**	-	-	-	-	-
% of non-white	0.048***	-	-	-	-	-
Intercept	0.860	10.251**	- 0.206	-	-	8.110
Adjusted R^2	0.674	0.819	0.731	0.325	0.795	0.820
No. of observation	50	36	58/184	58/184	64/248	68/407

[a] Gross Domestic Product per Capita
* , ** , *** Significant at the 10%, 5% and 1% level, respectively

The Determinants of Health Improvements in Developing Countries:

In an earlier study, with an attempt to explore the contribution of health services to health outcomes in United States, Auster, Levesonn and Rarachek (1969) employed the regression analysis to analyze health determinants across all states by using data in 1960. Their estimates are shown in column two of Table 1. It can be observed from Figure 1 that in 1960 the U.S. already passed a rapid decline in mortality incidence. Therefore, income and education in this analysis did not have a great effect on health compared to other variables such as: living conditions, individual's behavior, employment, and heredity. In spite of this, the percentage of the non-white variable may highly correlate with income and education variables and make the latter two variables become insignificant.

Thereafter, Gertler and van der Gaag (1990) estimated correlation between health outcomes and some development indicators by using data from 36 countries in 1975, including both developed and developing countries. Due to the presence of a high correlation between health expenditure and income, the income variable was dropped from the model. Some of the results are reproduced in column three. The most interesting result in this estimation concerns the correlation of health care expenditure with health. In addition, living condition, which was represented in the population density variable, also has a significant effect on health status. However, this cross-national analysis has its own drawback in that it can not entirely control the country's specific features, moreover, this limitation seems to be very serious in the study employing data from both developed and developing countries.

Pritchett and Summer (1993) investigated the effects of income on health among countries in which per capita income was below $6,000 from 1960 to 1990, with a five-year interval. Different techniques were applied to analyze this panel data set and some results are presented in column four, five, and six. The time-trend dummy variables were also introduced in this analysis. However, all of the results confirm the significant effect of income on health, although the first differential model has a relatively low adjusted R^2 value.

In addition, by comparing the results between Auster et al. (1969) and Prichett and Summer (1993), it can be clearly noticed that education plays a relatively important role in the latter model compared to the former model. However, it is not easy to identify the sources of this difference since the models are greatly diverse; for example, sources of data, health indicators, and model structures. Therefore in order to compare the results across geographical areas or regional levels, it would be more meaningful if the model specification was rather identical and comparable.

More recently, Wang et al. (1999) divided their analysis of health determinants into male and female health determinants. They employed aggregate country data from 1960 to 1990, focusing on 119 low- and middle-income countries. The explanatory variables included in this analysis were income per capita, education levels, and time, which represents technological progress. The interaction variables, the multiplications of two explanatory variables, were also introduced in this study in order to control the interrelationship between explanatory variables. Their results are briefly shown in the last column of Table 1.

These results reveal the highly significant effect of income and education on health. The authors also confirmed the diminishing of education effect when education years are increased, especially in the male mortality model. The most interesting finding of this study is that when the impact of education on improving health outcomes increased, the impact of income decreased (from 1965 to 1975), and when the impact of income increased, the impact of education decreased (from 1975 to 1990). Therefore, education and income represent a substitute for each other.

From this literature survey, it is clear that health resource has been often neglected from the analysis of health determinants. Even though there is some literature that included this variable in the explanatory variables, their results frequently showed an insignificant relationship between health resource and health outcome (Peabody 1999). From this ambiguity, the effect of health resource is one of the main focuses of this study. Various health resource indicators are employed in order to test whether they have a significant effect in producing good health.

In sum, by comparing literature, it is clear that the effect of income and education are greater in the studies which employed data from developing countries, especially in the period from 1960 to 1990. In addition, the analytical technique has shifted from cross-section analysis towards panel data analysis due to the innovation in regression analysis and the fact that cross-section time series data sets have recently become available. However, the empirical study on health determinants by employing time-series data is still very rare. Moreover, most of the studies report and conclude their result from only one level of analysis; the national or regional level, without confirming the results at other levels. In this analysis, different data sets from a single developing country, Thailand, are examined at multiple levels with different regression techniques. The methodologies are described in next section.

3. Data Description and Model Specification

3.1 Data Description

In this study and according to the existing data, analytical models are separated into three main parts which are: 1) national models (1950-2000), 2) regional models (4 regions, 1970-2000), and 3) provincial models (75 provinces, 1994-2000). The health indicators that are used in these models are the CDR, IMR, neonatal mortality rate (hereinafter NEO) and MMR, some of them are not analyzed in some models due to a lack of data. A number of explanatory variables belong to five groups: population and living conditions, education, economic, health resources and technological progress. All of the included variables and sources for them are shown in Table 2 below (the time-trend variable will be introduced in section 3.2).

Table 2 Variables in this analysis and the sources for them

Variables	Definition	Model	Sources
CDR	Crude Death Rate	①②❷③	MOPH (1954 - 2002) adjusted by using data estimated by Prasarkul and Rakchanyaban (2002)
IMR	Infant Mortality Rate	①②❷③	
NEO	Neonatal Mortality Rate	①②❷	
MMR	Maternal Mortality Rate	①②	
POPDN	Population Density (per sq.km.)	①②❷③	NSO(1953 - 2001)
URBAN	% of population residing in municipal areas	①②❷③	NSO(1953 - 2001)
LARG	% of total labor participating in agricultural activity	① ❷③	①NSO (1953-2001) ❷③NSO (1994-2002)
UNEMPLOY	% of labor force who are not employed	① ❷③	
LPE	% of labor completed at least primary education	① ❷③	①SO (1953-2001) ❷③NSO (1994-2002)
LSE	% of labor completed at least secondary education	① ❷③	
LUE	% of labor completed at least university education or equivalence	❷③	
SCH	Gross Secondary School Enrollment	①②❷③	MOE (1974- 2000)
GDPP	Gross Domestic Product per capita at 1988 price	①	NESDB (2003)
GRPP	Gross Regional Product per capita at 1988 price	②❷	NESDB (1977-2000)
GPPP	Gross Provincial Product per capita at 1988 price	③	NESDB (1977-2000)
GARG	% of agricultural product in GDP, GRP and GPP	①②❷③	①calculated from NESDB (2003) ②❷③calculated from NESDB (1977-2000)
GINI	Gini Coefficient Index	①	NSO (1975-2000)
HBUDP	Health Budget per capita at 1988 price	①	NSO (1953-2001)
HHHE	Household Health Expenditure at 1988 price	①②	NSO (1975-2000)
PHYP	Physicians per 1,000 population	①②❷③	①NSO (1953-2001) ②❷③MOPH(1978 -2000)
HOSP	General Hospital per 1,000 population	①②❷③	
BEDP	Inpatient Bed per 1,000 population	①②❷③	
HCP	Health Center per 1,000 populatio	①	

Notes: ①national model, ②regional model 1970-2000, ❷regional model 1994-2000 and ③provincial model

Most of the health indicators data were collected from registration statistics which were broadly claimed to be underestimated or underregistered. There have been a number of attempts to estimate the reliable health indicators data from both international organization (Bourgerois 1974) and government agencies (Prasithrathsint 1986; Rungpitarangsi 1974). Although these estimates are considered to be accurate (Chamratrithirong 1980), they are not continuously calculated. This study adjusts the health indicator statistics from the Minister of Public Health (MOPH 1954-2002) in accordance with the life table data estimated by Prasartkul and Rakchanyaban (2002).

3.2 Model Specification

In order to estimate the effect of each determinant on health outcomes, this study applied multivariate regression analysis. The time series regression was applied in the national models and the panel data regression was utilized in the regional and provincial models. The available variables which are included in each model are shown in column three of Table 2.

3.2.1 National Model

In the national model, from 1950 to 2000, the Ordinary Least Square (OLS) times-series regression analysis was employed to estimate the parameter of each health determinants from equation of, so called, aggregate "health production function", as shown below:

$$H_t = \alpha + (X_t)\beta + \varepsilon_t \quad (1)$$

where H_t is health outcomes, X_t is the vector of health determinants variable, α is an intercept, β is parameter to be estimated, ε_t is an error term and t denotes time.

In order to avoid the problem of spurious regression[7] from time-series data, this study applies two methods; the first one is to perform unit root test to all variables to justify whether they are stationary or not[8] and the second means is to introduce time-trend variable. According to unit root test[9] (augmented Dickey-Fuller or ADF test), most variables are non-stationary or they are I(1). This means that their current value is determined by their previous value, at least one year, or they follow a random walk. Therefore, the cointegration test is to be performed to justify whether the variables are in the same trend, or they are cointegrated.[10] If they are cointegrated, then, the result is not spurious and the interpretation is reliable. The cointegration test is performed by testing whether the residuals of the estimates are stationary or not. By testing for stationary of the residual of the regression results, it is found that these residuals are stationary and, therefore, the included variables are cointegrated. As a result, the regression results are significantly reliable. In addition, a trend variable is introduced into the model as an effect of time. The trend variable can be interpreted broadly because it captures all excluding effects that change overtime. For instance, it covers changes in technology; increases in health insurance coverage; and diseases transition incidence. Subsequently, the health production function will become an equation:

$$ln H_t = \alpha + (ln X_t)\beta + (ln T)\gamma + \varepsilon_t \quad (2)$$

where T denotes trend variables

The next specification problem is a function form. All variables are transformed into logarithm form, as in equation (2). The reasons behind this transformation are: 1) to capture a non-linear relationship between some variables and health outcomes; and 2) to standardize unit of measure into percentage change, not the absolute change in level. As a result, the estimated parameters indicate elasticity of each health determinant to health outcome.

3.2.2. Regional Model

In the regional model, all of the four cross-regional data were observed annually from 1970 to 2000, the cross-section time-series regression method or panel data method is utilized. Accordingly, the aggregate health production function can be written as:

$$H_{it} = (X_{it})\beta + c_i + \varepsilon_{it} \quad (3)$$

where i denotes individual region, t denotes time and c_i is the individual-specific effect.

Similar to the national model, the variables are transformed into logarithm form. The added term c_i is called an unobserved effect in panel data analysis. It captures specific features of an individual region which is constant overtime. For example, c_i may represent the regional culture or climate which is rather constant overtime and differs across region. The problem of how to treat c_i is, however, a critical procedure in panel data analysis. The c_i can be viewed as a parameter to be estimated (in fixed effect model)[11] or as a random variable (in random effect model).[12] This study considers c_i as a parameter to be estimated, or a group of specific constant terms in regression model, with the following reasons. Firstly, the observations are not drawn from the population randomly, and the analysis result should be inferred as the effect of these only four regions. Secondly, the c_i may correlate with X_{it}, since X_{it} covers most of the socioeconomic variables. However, it was argued that the results between fixed effect and random effect regression were not different when t was large (Hsiao 2003).

Since this model has a relatively large *t* compared with *i*, it is more oriented toward time-series data analysis. In order to avoid the spurious regression problems, a trend variable is utilized. The trend variable represents the common excluding effects that change overtime, as exemplified in the national model.

3.2.3 Provincial Model

The methodology of this model is almost the same as the regional model, although this model has a rather large *i* compared with *t* or it is more oriented toward cross-section data analysis. However, in this model, the c_i represents the individual provincial effect; for example, the governance of provincial administration or the geographical characteristic.

4. Results and Discussion

The simple regression results of the national model are shown in Appendix A. It is interesting to observe that all explanatory variables have a greater relationship with IMR and NEO than with CDR. This result can be explained by the fact that CDR is considered as a crude health indicator due to the

fact that dying is unavoidable regardless of health. For instance, the CDR in the developed countries has been rather constant while the IMR and NEO have declined drastically. In contrast with CDR, the IMR and NEO are regarded as preventable deaths. This reason leads to IMR and NEO that are more meaningful in representing health outcomes.

Nevertheless, it should be noted that the findings should not be interpreted from simple correlation results because, in fact, the health determinants not only relate to health outcome but they relate to each other as well. In order to investigate the net relationship of each determinant on health outcome the effect of other variables must be controlled, or held constant, by using multiple regression techniques. Accordingly, the results of a national model time-series analysis from 1967 to 2000 are presented in Table 3.

Table 3 The multiple regression results of national model from 1967 to 2000[a]

	CDR[b]	IMR	NEO	MMR
POPDN	-2.74 (-1.01)	-6.55 (-1.65)	-1.97 (-0.30)	5.56 (0.51)
LPE	-2.86 (-0.80)	-9.90 (-1.92)*	-11.99 (-1.40)	-29.75 (-2.11)*
SCH	0.28 (0.54)	-0.29 (-0.38)	-0.76 (-0.61)	1.24 (0.06)
GDPP	0.49 (1.53)	0.63 (1.36)	-0.10 (-0.13)	-0.75 (-0.60)
HBUDP	-0.29 (-1.89)*	-1.02 (-4.59)***	-0.99 (-2.70)**	-1.56 (-2.57)**
PHYP	-0.37 (-0.86)	-2.39 (-3.85) ***	-3.89 (-3.77)***	-3.53 (-2.08)*
BEDP	-0.11 (-0.41)	-0.70 (-1.84)*	-1.99 (-3.14)***	-0.24 (-0.24)
HCP	0.16 (0.47)	-1.16 (-2.41)**	-3.47 (-4.33)***	-2.59 (-1.97)*
Year	2.03 (0.95)	10.48 (3.37)***	15.52 (3.00)***	9.95 (1.17)
Constant	-2.52 (-0.30)	-18.47 (1.53)	-58.76 (-2.93)**	-64.68 (-1.96)*
Adjusted R^2	0.78	0.97	0.90	0.96
n	22	22	22	22

[a] the t-test values are given in parenthesis below the estimated coefficient
[b] all variables are in logarithm form
*, **, *** Significant at the 10%, 5% and 1% level, respectively

It can be seen from the table that health resource variables, HBUDP, PHYP, BEDP and HCP, are very dominant in determining health improvement. They have a significantly expected sign of relation, especially in case of the IMR, NEO, and MMR models. Another two dominant socioeconomic variables are living conditions (POPDN) and education (LPE). The high value of the estimated coefficient of LPE confirms that education plays very important role in improving health. In contrast, the role of income is somewhat unclear as its coefficients are insignificant and inconsistent. In addition, the results also confirm a greater sensitivity of IMR, NEO, and MMR to these socioeconomic variables compared to CDR.

In an attempt to compare the result across regional levels and across health indicators, two things have to be sacrificed in this study. Firstly, the length of national data must be cut to 1979-2000 in order to make it comparable with the regional model. Secondly, a number of explanatory variables which do not exist in all models should be dropped to make all models identical and to have reliable comparative results. These variables are LARG, UNEMPLOY, GINI, HBUDP, HHHE, and HCP. The regression results of all models are summarized in Table 4 and Table 5. The difference between Table 4 and 5 is the health resource variable, the BEDP is used to represent health resource in the former while the PHYP is utilized in the latter.

Table 4 The health determinants regression results at multi levels model 1[a]

	CDR[c]				IMR				NEO		
	NM[b] 79-00	RM 79-00	RM 94-00	PM[d] 94-00	NM 79-00	RM 79-00	RM 96-00	PM 96-00	NM 79-00	RM 79-00	RM 94-00
POPDN	-2.92 (-0.63)	-1.73 (-2.38)**	-3.18 (-1.95)*	0.21 (0.58)	-19.91 (-3.69)***	-0.38 (-0.23)	5.38 (0.75)	2.64 (1.43)	-32.63 (-4.83)***	-4.48 (-2.05)**	-7.39 (-1.43)
SCH	0.26 (0.38)	0.05 (0.35)			-1.95 (-2.50)**	-0.78 (-2.50)**			-2.81 (-2.88)**	-1.51 (-3.69)***	
LPE			-0.52 (-1.62)	0.00 (0.04)			-2.93 (-2.26)**	-0.07 (-0.22)			-3.29 (-3.25)**
GDPP	0.59 (1.01)	0.09 (0.77)	0.57 (1.16)	0.27 (3.90)***	-0.41 (-0.61)	-0.51 (-1.91)*	-2.76 (-1.11)	0.70 (2.26)**	-0.31 (-0.37)	-0.48 (-1.38)	-1.44 (-0.93)
GARG	0.81 (1.12)	-0.17 (-1.88)*	-0.73 (-0.90)	-0.02 (-0.21)	-0.66 (-0.78)	-0.32 (-1.58)	-8.06 (-1.52)	-0.09 (-0.19)	-1.04 (-0.99)	-0.60 (-2.28)**	-2.10 (-0.82)
BEDP	-0.42 (-1.19)	0.01 (0.23)	-0.55 (-1.89)*	-0.05 (-1.43)	-1.35 (-3.30)***	-0.12 (-1.28)	-3.73 (-1.93)*	-0.28 (-1.21)	-2.86 (-5.57)***	-0.19 (-1.62)	-4.33 (-4.73)***
YEAR	1.46 (0.50)	0.15 (0.76)	1.49 (2.24)**	0.08 (4.87)***	11.24 (3.30)***	-0.33 (-0.75)	5.70 (1.74)	0.26 (1.74)*	19.56 (4.59)***	0.90 (1.55)	5.90 (2.80)**
Cons	-0.30 (-0.03)				51.16 (3.71)***				77.74 (4.51)***		
CEN		9.31 (3.77)***	5.63 (0.74)			11.32 (1.99)*	-26.86 (-0.69)			26.09 (3.52)***	32.59 (1.35)
NORTH		8.53 (4.14)***	4.64 (0.69)			10.55 (2.23)**	-22.02 (-0.65)			22.37 (3.62)***	25.73 (1.22)
NE		9.30 (3.79)***	5.96 (0.81)			10.21 (1.81)*	-29.34 (-0.80)			23.76 (3.23)***	26.57 (1.15)
SOUTH		8.99 (3.84)***	5.88 (0.77)			10.66 (1.98)*	-19.54 (-0.52)			24.21 (3.45)***	30.73 (1.28)
Adj.R^2	0.23	0.75	0.86	0.72	0.95	0.78	0.33	0.34	0.93	0.80	0.72
n	17	72	28	519	17	72	20	372	17	72	28

[a] the t-test values are given in parenthesis below the estimated coefficient
[b] NM = National Model, RM = Regional Model, and PM = Provincial Model
[c] all variables are in logarithm form
[d] the intercept and t-statistic value of 75 provinces are shown in Appendix B
* , ** , *** Significant at the 10%, 5% and 1% level, respectively

From Tables 4 and 5, POPDN shows a significantly negative relation with all health outcomes. This result confirms the hypothesis that when a population become dense, the infrastructures and facilities are likely to be available and expanded. In addition, it also modernizes a community and affords people more accessibility to health improving goods; for example, nutritious foods and medicine.

The results also confirm the strong and significant link between education (SCH and LPE) and

health as an expected sign. Since the LPE data in the regional model from 1979 to 2000 were not available, then, SCH was used in the first two models instead. It is obvious to find that the effect of education increases as the health indicators change to the more sophisticated one, from CDR to IMR and then NEO. Although these results reveal that education plays an important role in improving health, it can also be observed that the educational effect tends to be less significant when the level of analysis changes from the regional to provincial level. These insignificant results suggest that when provincial characteristics are introduced the effect of education declines. It implies that the community characteristic is also important in determining health.

Similar to the results of the national model from 1967 to 2000, the effect of income is somewhat unclear. In the case of CDR, income constantly has a negative effect on health improvement. In general, this means that income is used in a way that deteriorates health status; for example, consuming alcohol, tobacco, and detrimental foods. In the case of more sensitive indicators (IMR and NEO) at the national and regional level, income shows a positive relationship with health improvement. In contrast, when specific characteristic of a province is controlled, income tends to be negatively correlated with health improvement. This negative relationship can be explained from the evidence that the health insurance coverage has expanded to cover approximately 80% of the population in the same period that income has increased. The role of income in affording accessibility to health care services has declined as the government-managed health insurance has expanded. Moreover, in reality, when the economy developed, it creates some negative effects on health; for example, people's behavior (more busy and serious, less relax time and exercise) and deteriorates environmental conditions.

The next variable is GARG representing the structure of economic activity, in terms of income shared. This variable shows a significantly negative relation with mortality. This indicates that as an economic structure shifted toward manufacturing and services sector, either overtime or across provinces, the health status of a people deteriorated. However, it should be noted that the changes in economic structure does not apply to the changes in occupation of the labors. The employment structure variable structure (LARG) is also tested but its effect on mortality is inconsistent and insignificant.

On health resource variable, the hospital bed ratio to population clearly plays an important role in declining mortality. It undoubtedly has a significantly negative effect on all mortality rates at all levels. Compared with other countries, Thailand has a high growth rate of hospital beds (World Bank 2002) and appears to have an excess supply of private hospitals in the city recently. Although having hospital beds is a good indicator in representing the level of health service facilities, it is not a good index for representing the distribution of health service facilities since it tends to be concentrated in big hospitals, particularly in private ones. Despite the fact that the ratio of the number of hospitals to population is regarded as a better measure of distributing health facilities, it has an insignificantly

negative effect on mortality in this study. The result is not presented in the Tables 4 and 5.[13]

Table 5 The health determinants regression results at multi levels model 2[a]

	CDR[c]				IMR				NEO		
	NM[b] 79-00	RM 79-00	RM 94-00	PM[d] 94-00	NM 79-00	RM 79-00	RM 96-00	PM 96-00	NM 79-00	RM 79-00	RM 94-00
POPDN	-0.91 (-0.21)	-1.69 (-2.33)**	-2.32 (-1.36)	0.06 (0.42)	-13.94 (-2.30)*	-0.33 (-0.19)	4.17 (0.56)	1.63 (0.86)	-17.89 (-1.66)	-4.22 (-1.91)*	-0.25 (-0.03)
SCH	0.03 (0.04)	0.03 (0.24)			-2.77 (-2.31)**	-0.86 (-2.66)***			-4.19 (-2.21)*	-1.73 (-4.10)***	
LPE			-0.27 (-0.86)	0.02 (0.19)			-2.59 (-1.97)*	-0.13 (-0.38)			-1.35 (-0.98)
GDPP	0.94 (1.45)	0.07 (0.69)	0.57 (1.07)	0.26 (3.69)***	0.79 (0.87)	-0.41 (-1.58)	-4.02 (-1.25)	0.52 (1.66)*	1.90 (1.18)	-0.36 (-1.06)	-1.52 (-0.66)
GARG	0.99 (1.27)	-0.18 (-2.28)**	-0.27 (-0.30)	-0.00 (-0.00)	0.01 (0.01)	-0.21 (-1.13)	-17.61 (-1.91)*	-0.00 (-0.00)	0.13 (0.07)	-0.46 (-1.89)*	0.38 (0.09)
PHYP	-0.28 (-0.69)	-0.05 (-0.55)	-0.07 (-0.36)	-0.02 (-0.65)	-1.00 (-1.79)*	-0.04 (-0.18)	1.44 (1.57)	-0.36 (-2.42)**	-1.66 (-1.64)	-0.30 (-1.11)	0.39 (0.45)
YEAR	-0.15 (-0.06)	0.19 (0.95)	0.77 (1.26)	0.08 (4.69)***	6.45 (1.85)*	-0.36 (-0.76)	7.53 (1.95)*	0.38 (2.41)**	7.87 (1.26)	1.05 (1.67)*	-1.01 (-0.39)
Cons	-7.79 (-0.75)				27.09 (1.87)*				26.47 (1.02)		
CEN		9.07 (3.61)***	4.25 (0.51)			10.19 (1.74)*	-34.36 (-0.85)			22.71 (2.98)***	24.22 (0.68)
NORTH		8.28 (3.93)***	3.67 (0.50)			9.47 (1.92)	-23.34 (-0.65)			19.07 (2.97)***	21.80 (0.69)
NE		9.00 (3.57)***	4.80 (0.60)			9.18 (1.55)	-29.33 (0.75)			20.29 (2.65)***	22.07 (0.61)
SOUTH		8.75 (3.67)***	4.25 (0.51)			9.47 (1.70)*	-15.07 (0.37)			20.69 (2.86)***	22.07 (0.61)
Adj.R^2	0.16	0.79	0.83	0.72	0.92	0.78	0.26	0.35	0.78	0.80	0.38
n	17	72	28	519	17	72	20	372	17	72	28

[a] the t-test values are given in parenthesis below the estimated coefficient
[b] NM = National Model, RM = Regional Model, and PM = Provincial Model
[c] all variables are in logarithm form
[d] the intercept and t-statistic value of 75 provinces are shown in Appendix B
* , ** , *** Significant at the 10%, 5% and 1% level, respectively

Another important health resource is the number of physicians per 1,000 populations. As shown in Table 5, the significant results indicate a negative correlation with health indicators. This result confirms that the physician is another important input in producing good health. However, from the empirical data, it is worth noting that the inequality in physician distribution, both between regions and between provinces, is still a serious problem. Most of the physicians are concentrated in a major city of the region. For example, in 2000 excluding Bangkok, the province having the highest ratio of physician to the population had ten times the number compared to the lowest province. It is interesting to measure this inequality and estimate its effect on population's health status.

The obviously positive sign of YEAR reveals that mortality rate increases as time passes. This finding reflects that, after controlling other variables, the positive effects of time to health improvement are less significant than its negative effects. After the population transition and the expansion of vaccine immunization in the 1960s and 1970s, it is fairly difficult to find major progress

which effects health improvement. In contrast, the negative effect tends to increase gradually; for example; the negative trend in population consumption behavior, the emerging of new incurable diseases, and the deterioration in environment.

In sum, except for GDPP and GARG, most of the results confirm that the theoretical concept and previous empirical findings are valid in explaining the health improvement in developing and a middle-income country such as Thailand. Nonetheless, though health resources have been often neglected in previous studies, the results in long time-series model disclose that they are a crucial factor in producing health.

5. Concluding Remarks

This research investigates the sources of health improvement in Thailand in the most significant period of advancement. For this purpose, various health indicators (CDR, IMR, NEO, and MMR) are used to analyze at multiple levels: national, regional and provincial. The results from the multivariate regression analyses above confirm the existing theoretical concepts. These findings lead to the conclusion that education, living conditions, and health resources have a considerably positive impact on health, while the net effect of income on health is unclear as its effect differs between health indicators and between regional levels. However, it is also obvious that when provincial characteristics are controlled, these effects tend to be insignificant. This result reveals that the local-specific factor is another important source of health improvement as well as cause of the disparity in health status.

In addition, the dominant effect of health resources on health improvement is found in the long time-series national model. These results contradict the previous findings which are derived from cross-sectional data. This difference leads to the argument that in long-run health resources definitely play important roles in improving population health status, particularly in developing countries where health resources always seem inadequate.

It is worth noting that the positive effects of the socio-economic factors are a net effect: positive effect minus negative effect. These effects are in fact not constant overtime. Most empirical results have reaffirmed the decline in marginal effects on these socioeconomic determinants which implies that positive effects are declining or that negative effects are increasing. Therefore, to take advantage of these determinants, the policymakers should not focus only on maximizing the positive effect of these factors overtime but also to minimize their negative effect. Policy to maximize their positive effect should be more emphasized on the better distribution of these determinants; for example, income, education, and health resources between regions and provinces. Alternatively, policy to minimize their negative effect should be relied on promoting a healthy lifestyle for individual who are well-off.

Although these selected health indicators have become almost unchanged recently, there is still a

big room for their improvement, as can be seen in Sri Lanka and in developed countries. The recent implementation of universal health insurance policy is expected to yield the significant improvement in the health status of Thai people. Thus, the future study on the contribution of this policy to health status is worth to be investigated. In addition, other sets of health indicators should be developed and estimated routinely. More attention should be paid to measuring the level of health conditions in a population because the objective of a health system is not only to reduce the risk of preventable death but also to promote the healthy life. Health expenditure at the regional and provincial level is another significantly deficient area of data. In addition, the statistics on inequality of health status and health resources distribution are also valuable indicators needed. These proposed indicators should be regarded as a vital data for policymakers in managing health system in order to achieve a greater overall improvement.

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Appendix A: Simple regression results between health outcomes and health determinants in different time periods in national model[a]

	CDR			IMR			NEO		
	19__-2000	19__-1980	1981-2000	19__-2000	19__-1980	1981-2000	19__-2000	19__-1980	1981-2000
IMR [50]	0.236	0.279	0.154						
NEO [50]	0.282	0.284	0.133	1.205	1.040	0.856			
LARG [56]	0.620	1.680	0.338	3.206	5.249	2.346	2.750	3.986	2.549
POPDN [50]	-0.478	-0.432	-0.613	-1.938	-1.497	-3.860	-1.506	-1.331	-4.002
URBAN[52]	-0.961	-0.673	-1.380	-4.046	-2.575	-5.411	-2.921	-1.988	-7.478
LPE [67]	-2.12	-1.780	-3.636	-9.729	-4.974	-21.618	-7.258	-3.466	-22.246
LSE [74]	-0.106	-0.073	-0.145	-0.711	-0.099	-0.931	-0.644	-0.035	-1.018
SCH [50]	-1.458	-1.414	-0.162	-6.003	-4.733	-2.440	-4.863	-4.239	-2.574
GDPP [51]	-0.251	-0.332	-0.133	-1.091	-1.173	-0.930	-0.833	-0.989	-0.939
GARG [51]	0.474	0.704	0.221	2.027	2.456	1.527	1.545	2.039	1.532
GHEP [67]	-0.122	-0.237	-0.101	-0.575	-0.664	-0.653	-0.417	-0.268	-0.719
HBUDP[61]	-0.132	-0.161	-0.079	-0.615	-0.623	-0.571	-0.442	-0.385	-0.597
HHHE [66]	-0.181	-0.398	-0.135	-0.825	-1.140	-0.879	-0.580	-0.622	0.844
PHYP [53]	-0.415	-0.553	-0.209	-1.854	-2.130	-1.354	-1.388	-1.346	-1.430
HOSP [53]	-0.229	-0.249	-0.316	-0.949	-0.799	-2.253	-0.693	-0.605	-2.436
BEDP[53]	-0.212	-0.158	-0.230	-0.879	-0.567	-1.557	-0.681	-0.489	-1.787
HCP[53]	-0.229	-0.187	-0.269	-1.019	-0.753	-2.451	-0.717	-0.589	-2.637
Year	-0.179	-0.124	-0.332	-0.713	-0.422	-2.169	-0.561	-0.381	-2.273

Notes: the values in [...]are the first year (19...) that data are available

[a] all variables are in logarithm form

Appendix B: The health determinants regression results in provincial models

	CDR 1994 - 2000		IMR 1996 - 2000	
	Coefficient	t-Statistic	Coefficient	t-Statistic
POPDN	0.21	0.58	2.64	1.43
LPE	0.00	0.04	-0.07	-0.22
GPPP	0.27	3.91***	0.70	2.26**
GARG	-0.02	-0.21	-0.09	-0.19
BEDP	-0.05	-1.44	-0.28	-1.21
YEAR	0.08	4.87***	0.26	1.74*
Central Region				
Ang Thong	-2.00	-0.85	-20.41	-1.80*
Chachoengsao	-2.36	-1.15	-19.20	-1.97**
Chai Nat	-1.91	-0.91	-18.36	-1.83*
Chanthaburi	-1.81	-0.96	-17.31	-1.93**
Chon Buri	-2.48	-1.08	-21.42	-1.92*
Kanchanaburi	-2.09	-1.26	-15.64	-2.00**
Lop Buri	-2.05	-1.00	-18.30	-1.88*
Nakhon Nayok	-1.91	-0.95	-18.70	-1.95**
Nakhon Pathom	-2.34	-0.97	-21.32	-1.82*
Nonthaburi	-2.71	-0.95	-25.50	-1.81*
Pathum Than!	-2.80	-1.14	-22.33	-1.86*
Phetchaburi	-1.89	-1.02	-16.86	-1.90*
Phra Nakhon Si Ayutthaya	-2.35	-1.00	-21.48	-1.90*
Prachin Buri	-1.96	-1.01	-17.71	-1.91*
Prachuap Khiri Khan	-2.14	-1.14	-17.16	-1.92*
Ratchaburi	-2.04	-0.96	-19.33	-1.89*
Rayong	-2.57	-1.18	-19.99	-1.93**
Sa Kaeo	-2.11	-1.14	-17.09	-1.95**
Samut Prakan	-3.06	-1.09	-24.58	-1.81*
Samut Sakhon	-2.69	-1.05	-22.73	-1.84*
Samut Songkhram	-2.27	-0.90	-22.47	-1.84*
Saraburi	-2.11	-0.97	-19.97	-1.92*
Sing Buri	-1.85	-0.80	-20.55	-1.84*
Suphan Buri	-2.02	-0.94	-19.24	-1.88*
Trat	-2.04	-1.07	-17.12	-1.90*
Northern Region				
Chiang Mai	-1.53	-0.81	-16.96	-1.89*
Chiang Rai	-1.44	-0.73	-17.45	-1.85*
Kamphaeng Phet	-2.22	-1.14	-18.06	-1.97**
Lampang	-1.50	-0.82	-16.18	-1.88*
Lamphun	-1.57	-0.80	-17.06	-1.84*
Mae Hong Son	-1.76	-1.30	-12.57	-1.97**
Nakhon Sawan	-2.01	-0.99	-17.88	-1.85*
Nan	-1.59	-0.96	-14.68	-1.88*
Phayao	-1.27	-0.67	-16.53	-1.85*
Phetchabun	-2.04	-1.08	-17.24	-1.93*
Phichit	-2.07	-1.00	-18.15	-1.85*
Phitsanulok	-1.87	-0.99	-16.61	-1.85*
Phrae	-1.36	-0.74	-16.50	-1.87*
Sukhothai	-1.96	-1.01	-17.48	-1.89*
Tak	-1.92	-1.25	-14.14	-1.96**
Uthai Thani	-1.75	-1.02	-15.97	-1.97**
Uttaradit	-1.82	-1.01	-16.17	-1.90*
Northeastern Region				
Amnat Charoen	-1.98	-1.00	-17.34	-1.83*
Buri Ram	-2.16	-1.04	-18.81	-1.90*

	CDR 1994 - 2000		IMR 1996 - 2000	
	Coefficient	t-Statistic	Coefficient	t-Statistic
POPDN	0.16	0.42	1.63	0.86
LPE	0.02	0.19	-0.13	-0.38
GPPP	0.26	3.69***	0.52	1.66*
GARG	0.00	-0.01	0.00	0.00
BEDP	-0.02	-0.65	-0.36	-2.42**
YEAR	0.08	4.69***	0.38	2.41**
Central Region				
Ang Thong	-1.60	-0.68	-13.86	-1.19
Chachoengsao	-1.98	-0.96	-13.34	-1.33
Chai Nat	-1.56	-0.74	-12.62	-1.23
Chanthaburi	-1.50	-0.79	-12.00	-1.30
Chon Buri	-2.06	-0.89	-14.46	-1.26
Kanchanaburi	-1.79	-1.08	-11.07	-1.37
Lop Buri	-1.69	-0.83	-12.64	-1.26
Nakhon Nayok	-1.57	-0.78	-13.16	-1.33
Nakhon Pathom	-1.91	-0.78	-14.27	-1.18
Nonthaburi	-2.21	-0.77	-17.16	-1.18
Pathum Than!	-2.34	-0.95	-14.89	-1.20
Phetchaburi	-1.54	-0.83	-11.53	-1.26
Phra Nakhon Si Ayutthaya	-1.91	-0.81	-14.62	-1.25
Prachin Buri	-1.62	-0.83	-12.28	-1.29
Prachuap Khiri Khan	-1.81	-0.96	-11.94	-1.30
Ratchaburi	-1.69	-0.79	-13.29	-1.26
Rayong	-2.19	-1.00	-13.71	-1.29
Sa Kaeo	-1.77	-0.96	-12.16	-1.35
Samut Prakan	-2.56	-0.91	-16.28	-1.16
Samut Sakhon	-2.24	-0.87	-15.25	-1.20
Samut Songkhram	-1.85	-0.73	-15.37	-1.22
Saraburi	-1.73	-0.80	-13.63	-1.27
Sing Buri	-1.47	-0.63	-14.04	-1.22
Suphan Buri	-1.65	-0.77	-13.35	-1.27
Trat	-1.73	-0.90	-11.81	-1.27
Northern Region				
Chiang Mai	-1.20	-0.64	-11.49	-1.24
Chiang Rai	-1.09	-0.55	-12.08	-1.25
Kamphaeng Phet	-1.88	-0.97	-12.91	-1.37
Lampang	-1.20	-0.65	-11.26	-1.27
Lamphun	-1.21	-0.62	-11.62	-1.22
Mae Hong Son	-1.52	-1.11	-8.93	-1.36
Nakhon Sawan	-1.66	-0.82	-12.32	-1.24
Nan	-1.30	-0.78	-10.27	-1.28
Phayao	-0.94	-0.50	-11.47	-1.25
Phetchabun	-1.71	-0.90	-12.29	-1.34
Phichit	-1.71	-0.83	-12.51	-1.24
Phitsanulok	-1.54	-0.81	-11.32	-1.23
Phrae	-1.03	-0.56	-11.43	-1.26
Sukhothai	-1.63	-0.83	-12.18	-1.28
Tak	-1.66	-1.07	-10.05	-1.36
Uthai Thani	-1.45	-0.84	-11.29	-1.35
Uttaradit	-1.51	-0.84	-11.31	-1.29
Northeastern Region				
Amnat Charoen	-1.62	-0.81	-11.97	-1.23
Buri Ram	-1.78	-0.85	-13.19	-1.29

	CDR 1994 - 2000		IMR 1996 - 2000	
	Coefficient	t-Statistic	Coefficient	t-Statistic
Chaiyaphum	-2.18	-1.14	-17.45	-1.93*
Kalasin	-2.00	-0.97	-18.28	-1.85*
Khon Kaen	-2.08	-0.98	-18.86	-1.85*
Loei	-1.97	-1.13	-15.94	-1.93*
Maha Sarakham	-2.03	-0.94	-19.11	-1.86*
Mukdahan	-2.00	-1.08	-16.19	-1.84*
Nakhon Phanom	-1.96	-0.96	-17.53	-1.81*
Nakhon Ratchasima	-2.17	-1.07	-18.52	-1.91*
Nong Bua Lam Phu	-2.03	-1.00	-17.45	-1.81*
Nong Khai	-2.06	-1.02	-18.00	-1.87*
Roi Et	-1.96	-0.93	-18.44	-1.83*
Sakon Nakhon	-1.97	-0.99	-17.50	-1.85*
Si Sa Ket	-2.10	-0.99	-18.31	-1.81*
Surin	-2.07	-0.97	-18.98	-1.86*
Ubon Ratchathani	-1.98	-1.00	-17.40	-1.84*
Udon Thani	-2.09	-1.03	-18.07	-1.86*
Yasothon	-1.90	-0.93	-17.82	-1.83*
Southern Region				
Chumphon	-2.08	-1.10	-17.66	-1.98**
Krabi	-2.38	-1.26	-17.07	-1.91*
Nakhon Si Thammarat	-2.43	-1.14	-19.31	-1.91*
Narathiwat	-2.31	-1.10	-18.53	-1.85*
Pattani	-2.47	-1.03	-20.53	-1.80*
Phangnga	-2.30	-1.27	-16.50	-1.95**
Phatthalung	-2.34	-1.12	-19.33	-1.93**
Phuket	-2.74	-1.09	-22.59	-1.86*
Ranong	-2.39	-1.36	-17.04	-2.07**
Satun	-2.42	-1.20	-18.43	-1.94**
Songkhla	-2.28	-1.05	-19.42	-1.88*
Surat Thani	-2.25	-1.21	-17.25	-1.96**
Trang	-2.24	-1.09	-18.19	-1.87*
Yala	-2.35	-1.20	-17.25	-1.86*
Adj R^2	0.72		0.34	
n	519		372	

	CDR 1994 - 2000		IMR 1996 - 2000	
	Coefficient	t-Statistic	Coefficient	t-Statistic
Chaiyaphum	-1.82	-0.95	-12.35	-1.33
Kalasin	-1.63	-0.79	-12.75	-1.26
Khon Kaen	-1.70	-0.80	-12.67	-1.21
Loei	-1.66	-0.95	-11.26	-1.33
Maha Sarakham	-1.64	-0.76	-13.32	-1.26
Mukdahan	-1.68	-0.90	-11.12	-1.23
Nakhon Phanom	-1.60	-0.78	-12.10	-1.22
Nakhon Ratchasima	-1.80	-0.88	-12.85	-1.29
Nong Bua Lam Phu	-1.65	-0.82	-11.99	-1.21
Nong Khai	-1.69	-0.84	-12.48	-1.26
Roi Et	-1.57	-0.75	-12.74	-1.23
Sakon Nakhon	-1.61	-0.81	-12.15	-1.25
Si Sa Ket	-1.72	-0.81	-12.70	-1.23
Surin	-1.70	-0.80	-13.33	-1.28
Ubon Ratchathani	-1.63	-0.82	-12.07	-1.24
Udon Thani	-1.72	-0.85	-12.42	-1.24
Yasothon	-1.53	-0.75	-12.28	-1.23
Southern Region				
Chumphon	-1.78	-0.94	-12.60	-1.37
Krabi	-2.06	-1.09	-11.96	-1.31
Nakhon Si Thammarat	-2.06	-0.96	-13.50	-1.30
Narathiwat	-1.94	-0.92	-12.82	-1.25
Pattani	-2.05	-0.85	-13.94	-1.19
Phangnga	-2.01	-1.10	-11.60	-1.33
Phatthalung	-1.98	-0.94	-13.63	-1.33
Phuket	-2.31	-0.92	-15.15	-1.21
Ranong	-2.11	-1.20	-12.26	-1.45
Satun	-2.07	-1.03	-12.93	-1.32
Songkhla	-1.92	-0.88	-13.21	-1.24
Surat Thani	-1.96	-1.05	-12.22	-1.35
Trang	-1.91	-0.93	-12.59	-1.26
Yala	-2.03	-1.04	-11.89	-1.24
Adj R^2	0.72		0.35	
n	519		372	

*, **, *** Significant at the 10%, 5% and 1% level, respectively.

World Bank. 2002. *World Development Indicators 2002.* World Bank. Washington D.C.

1. DALY is defined as "the resent value of the future years of disability-free life that are lost as the result of the premature deaths or cases of disability occurring in a particular year". For more details on DALY, see World Bank (1993).
2. QALY is the life expectancy minus years of potential life lost (YPLL). The YPLL gives more weight to deaths occurring at a younger age. For details on QALY definition and calculation, see Gardner and Sanborn (1990) (presented in Basch (1999)).
3. DALE can be simply explained as expectation of life in equivalent full health (WHO 2000). For details on DALE definition and calculation, see Mathers et al. (2001).
4. Regression analysis is concerned with the study of the dependence of one variable (dependent variable) on one or more other variables (explanatory variables), with view to estimating or predicting the (population) mean or average value of the former in terms of the known or fixed values of the latter. Panel data refers to a data set constructed from repeated cross sections over time and panel data analysis refers to the regression analysis of panel data set.
5. presented in Ruger, Jamison and Bloom 2000.
6. Phelps proposed the health production function $H = g(m, X_{positive}, X_{negative})$, where m is the consumption of medical service, $X_{positive}$ and $X_{negative}$ are the consumption of goods that has a positive and negative to health respectively. (see Phelps 1997)
7. A problem that arises when regression analysis shows a relationship between two or more unrelated time series processes simply because each has a trend or each is an integrated time series, or both (Wooldridge 2000).
8. Stationary process means a time series process where the marginal and all joint distribution are invariant across time.
9. Unit root test is a test performed for checking whether the time series data set is non-stationary, the state that the current value equal last period's value plus a weakly dependent disturbance.
10. Two I(1) variables, Y and X, are cointegrated if their linear combination (Y+bX) is I(0), stationary.
11. The panel data model that allows the unobserved effect variables to correlate with other explanatory variables. The estimators are obtained by applying pooled OLS to a time-demeaned equation.
12. The panel data model that unobserved effect is assumed to be uncorrelated with the explanatory variables in each time period. The estimators are obtained by General Least Square (GLS) method.
13. When HOSP is substituted for BEDP in Table 5, its coefficients estimated in national and regional model rank from -0.04 to -1.86 in IMR model but they are insignificant (t-ratio below 1) and ranks from -0.65 to -2.56 in NEO model but also insignificant (t-ratio below 1.64). In addition, the R^2 is averagely lower than the model presented in Table 5.