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CANONICAL HEALTH MODEL FOR THAILAND: RURAL HEALTH 1993

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ABSTRACT

At least two changes are needed to achieve the campaigns of Health For All as it was urged by the World Health Organization 1987: healthy environment and healthy lifestyles. In this paper, secondary data of rural provinces in Thailand were collected in the year 1993. The purpose was to investigate territorial health situation before the big economic crisis by use of canonical health model. Health, as a part of level of living components, was considered and represented by 5 subsets and 8 sub-subsets of health needs. Based on 26 admissible health and health-related phenomena, 14 admissible indicators were available. They consist of 5 input (predictor) indicators and 9 output (outcome) indicators. Selection of indicators was done, both for the input and output sets. Testing hypothesis, redundancy analysis and interpretation of coefficients were also examined. Result revealed finally a single canonical health model that existed to explain the rural health of Thailand.

KEYWORDS: input and output sets, canonical equations, canonical correlations, canonical loadings, canonical cross-loadings, redundancy analysis

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1. INTRODUCTION

One way of achieving greater efficiency of sustainable development is to ensure healthy and productive lives of the people. This is confirmed by the Alma-Ata Declaration (1978) that health as a level of living components is essential to social and economic development. The attainment of a high level of health, in addition, will permit a socially and economically productive life. Thailand, as one of the ten member countries in the South-East Asia region of the World Health Organization, entered the 21st century with major concerns about progress in health services, disease burden and its effects on health status of the people. Study of health and health-related needs is therefore necessary for Health For All revolution in Thailand although obtaining better health is an ever-changing task.

In the past, there were many investigations on health in Thailand such as health services and medical social science. They had been primarily concentrated in biomedical and clinical researches (Saenchaloen, 1996a). Since those conventional approaches sometimes had their certain limits in addressing the research questions, more complex approach as an alternative choice might be useful. Rooy (1978), for example, used canonical equation to determine the components of quality of life and to demonstrate the application in measuring the productivity of inputs as well as to construct indices of social indicators. Hopkins (1969) also discussed several applications of the canonical model to investigate the relationship between illness and housing quality. In case of Thailand, we put the hypothesis that introduction of a new methodology on the observation of the relationships between input and output sets of health and health-related phenomena would make it possible to monitor the changes in health needs satisfaction and better allocation of the inputs. Canonical Health Model accesses in this paper therefore enables us not only to investigate the influences of the input set to the output set but also to get benefit from the fact finding of the analysis on various aspects of rural health situation in Thailand in 1993.

2. MATERIALS AND METHODS

2.1 Health Indicators and Notations

In this paper, the system of health indicators is examined with respect to the structure of health system and health information system of Thailand. Those vital health statistics obtained through the system are in real terms, absolute value, percentage and ratio of the units of measurement specified in distinguished dimensions. As the purpose to define "state" of health of the people, these dimensions consist of numerous numbers of health and related-health indicators. They are representative of various aspects concerning health needs in Thai society. At the moment, input and output sets are determined. Inputs hereby are resources available to the health system that can affect human beings in social environment. They address on activities of all national organizations, as well as all individual requirements concerning health, trying to arrive at a situation where people in the countries are able to achieve their healthy and productive lives. Outputs are all results or outcomes of specific activities, either positive or negative, as performed by the inputs. Five subsets and 8 sub-subsets of health phenomena are built up (Table 1). Based upon these subsets and sub-subsets, 26 admissible health and related-health indicators are assigned. However, only 5 input and 9 output indicators are feasible (Table 2). With respect to those 72 territorial provinces of Thailand in 1993, health and related-health statistics are collected. The exception is Bangkok, the capital of Thailand, because data are not available.

Let g=1,2,...72 denotes territorial units of study. $[X_{ig}]$ and $[X_{img}]$ represent subset and sub-subset of the health needs phenomena. Input and output health indicators, in addition, denote by $X^{(I)}_{im.j}$ and $X^{(O)}_{im.j}$. Then, the full set of subsets and sub-subsets of the health needs $[X_{ig}]$ are written in (1) and (2) as follows:

(1)	$[X_{ig}] = [X^{(I)}_{ig}, X^{(O)}_{ig}]$,	g =1,2,..,72,
whereas	$[X^{(I)}_{ig}] = [X^{(I)}_{2g}, X^{(I)}_{3g}]$	is the input subset of the health needs,
and	$[X^{(O)}_{ig}] = [X^{(O)}_{4g}, X^{(O)}_{5g}]$	is the output subset of the health needs.

(2)	$[X_{img}] = [X^{(I)}_{img}, X^{(O)}_{img}]$,	g =1,2,..,72,
whereas	$[X^{(I)}_{img}] = [X^{(I)}_{21g}, X^{(I)}_{31g}]$	is the input sub-subset of the health needs,
and	$[X^{(O)}_{img}] = [X^{(O)}_{42g}, X^{(O)}_{51g}]$	is the output sub-subset of the health needs.

2.2 Selection of Indicators and Model

The best two sets are required in order to meet the restriction of canonical model, one for the input and the other for the output set. This is applied by putting the Overall Health Needs Index (OHI) as a dependent indicator and the admissible health indicators as a group of independent indicators. The model was repeated twice, once for the input set and the other for the output set as shown by equation (3) and (4). The purpose was to find out the most appropriate number of health indicators, separately for input and output set that would satisfy those constrains of matrix operation in the canonical analysis.

(3) $$\text{OHI}_g = f_g[X^{(I)}_{im.j}] + e_g ,$$

whereas :

OHI_g is the Overall Health Needs Index in the specific unit g,

$[X^{(I)}_{im.j}]$ is a vector of input health indicators listed in Table 2, i=2,3 , m=1,2,..., k_i , j=1,2,..., p_{im} ,

e_g is a vector of error term.

(4) $$\text{OHI}_g = f_g[X^{(O)}_{im.j}] + e_g ,$$

whereas :

OHI_g is the Overall Health Needs Index in the specific unit g,

$[X^{(O)}_{im.j}]$ is a vector of output health indicators listed in Table 2, i=4,5 , m=1,2,..., k_i , j=1,2,..., p_{im} ,

e_g is a vector of error term.

Iterations for formulas (3) and (4) have been taken place using three different techniques, i.e., Forward Selection Method, Backward Elimination Method and Stepwise Procedure. We got finally the rural Canonical Health Model for Thailand as follows:

$$(5) \quad U_l = a_{l(21.1)}X_{21.1}^{(I)} + a_{l(21.2)}X_{21.2}^{(I)} + a_{l(21.3)}X_{21.3}^{(I)} + a_{l(31.4)}X_{31.4}^{(I)} + d_{l(31.5)}X_{31.5}^{(I)}$$

$$V_l = b_{l(42.1)}X_{42.1}^{(O)} + b_{l(42.2)}X_{42.2}^{(O)} + b_{l(51.1)}X_{51.1}^{(O)} + b_{l(51.2)}X_{51.2}^{(O)}$$

whereas :

$a_{l(im.j)}$ and $b_{l(im.j)}$ are standardized coefficients of canonical variates U_l and V_l ; $l = 1,2,3,4$,

$X_{im.j}^{(I)}$ and $X_{im.j}^{(O)}$ are health indicators of the input and output sets.

3. RESULTS AND DISCUSSION

Table 3 shows result of the final 4 canonical equations for rural provinces of Thailand. The hypothesis testing (Table 4), however, indicates a statistically significant (P<0.05, two-tailed test) of the first canonical correlation alone. This confirms by the first redundancy coefficient, $R^2_{(1)V/U}$ compared with $R^2_{(2)V/U}$ of the second equation in Table 5. Interpretation therefore depends on the first canonical equation. Thus, situation of territorial health of Thailand was revealed in this manner. Rural health was characterized by a large Average Number of Persons per Household with some problems that were shown directly to affect health status. These problems were, i.e., small number of Beds in Hospital, Medical Personnel as Doctors and Nurses, inadequate of Access to Safe Water, Death Rate Caused by Tuberculosis and Mortality Rate of Children Under 5 Years of Age. However, Diseases of the Heart as well as Accident and Poisoning and Infant Mortality Rate were not serious problems of rural health. We also got more information from those cross-loadings and standardized coefficients from the first equation as follows:

1. Increase of the output set (health status, mother & child health package) depended on one input health indicator: Average Number of Persons per Household.
2. Three input health indicators mainly dominated situation of rural health in the study: Average Number of Persons per Household, Access to Safe Water and Beds in Hospital. Meanwhile, Death Rate Caused by Accident and Poisoning took part as an influentially output indicator.
3. We found that Average Number of Persons per Household was the most productive indicator of the input set that took its positively relationship to the output set.

4. CONCLUSIONS

Studies of Canonical Health Model for territorial provinces of Thailand, in fact, brought us two distinct conceptions. Firstly, the application of Canonical Correlation Analysis in health is existent. This is a relationship between input resources and outcome phenomena of health activities. Secondly, the findings show a very clear image about rural health of Thailand before the serious economic crisis in 1997. The process illustrated well the complementary nature of the various disciplines and indicators operating in health needs. The results of study therefore should be further utilized. It is expected that they may useful for the government to allocate effectively the scarce government budget to rural provinces. We also expect that the results can be used as an alternative way for the Ministry of Public Health of Thailand to formulate the national health policy to obtain better health for Thai citizen.

One of research topics in this technical area in the future is to apply further the methodological approaches that have been developed with a bigger and well-defined list of admissible health indicators. The task should be, able to ensure a more precise and accurate measure how strong the relationship is. Comparisons of the results in the panel study, in addition, should be the most interesting.

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REFERENCES

Galtung, J. and Wirak, A. (1977) : Human Needs, Human Right and the Theories Development. In : *Indicators of Social and Economic Change and Their Application*, Report and Papers in the Social Sciences No.37, UNESCO

Hair, J.F. and others (1995) : *Multivariate Data Analysis with Readings*, Fourth Edition, Prentice Hall, U.S.A., pp.345-352

Hawkes, G.R. et al. (1980) :*Quality of Life :Perspectives and Review*, Special Report 86, North Central Regional Research Publication, Iowa, pp.8-10

Hopkins, C.E (1969) : Statistical Analysis by Canonical Correlation : A Computer Application, *Health Services Research*, Vol.4 (Winter)

Hotelling, H. (1936) : Relation between two sets of variables, *Biometrika,* Vol.28, pp.321-77

Horn, R.V. (1978) : Assessment of Living Levels -the Social Indicator Approach, *International Journal of Social Economics*, Vol.5, No.3

Horn, R.V. (1993) : *Statistical Indicators for the Economic & Social Sciences*, Cambridge University Press, Hong Kong, pp.1-82

Maslow, A.H. (1970) : *Motivation and Personality*, second edition, Harper & Row, New York

Manly, B.F.J. (1986) : *Multivariate Statistical Methods :A Primer*, Chapman and Hall, New York, pp. 1-150

Manly, B.F.J. (1994) : *Multivariate Statistical Methods :A Primer*, Chapman and Hall, second Edition, India, pp.1-175

Meredith, W. (1964) : Canonical Correlation with Fallible Data, *Psychometrika,* Vol.29

Muller, K.E. (1981) : Relationships between Redundancy Analysis, Canonical Correlation, and Multivariate Regression, *Psychometrika,* Vol.46

Rencher, A.C. (1995) : *Methods of Multivaritate Analysis,* John Wiley & Sons Inc, U.S.A.

Rooy, J.D. (1978) : A Canonical Quality of Life Model, *American Journal of Economics and Sociology*, Vol.37 No.4

Saenchaleon, P. (1996a) : *Study of Research and Development of Thailand 1993: Medical and Public Health Aspect,* MOPH, Bangkok , pp. 56-89

Saenchaleon, P. (1996b) : *The Utilization of Medical and Health services by Thai People,* Research Council, Bangkok, pp.1-45

Shenouda, S. (1977) : *Welfare and Economic Development*, Ph.D disseratation, SGPiS, Warsaw

Panek, T. (1989) : On the Measurement of the Level of Living, *Metron*, Vol.XLVII, No.1/4

Panek, T. (1990) : The Statistical Measurement of the Level of Living : Case Study of Poland, *Economic Notes* , Vol.19, No.2

Poleszynski, D. (1981) : On Indicators for Health. In. *Indicators of Development : Early Identification of Imminent Dangers in Social Life*, Conference held by the United Nations University, UNESCO and Commitee Poland "2000", Warsaw

Table 1. Subsets and Sub-subsets of Health Needs

Subsets of Health Needs	Sub-subsets of Health Needs
$X_1^{(I)}$ = Medical Care,	$X_{11}^{(I)}$ = Medical Care,
$X_2^{(I)}$ = Health Care Services,	$X_{21}^{(I)}$ = Health Care Services,
$X_3^{(I)}$ = Environmental Health,	$X_{31}^{(I)}$ = Population & Housing,
	$X_{32}^{(I)}$ = Employment,
	$X_{33}^{(I)}$ = Access to Basic Education,
$X_4^{(O)}$ = Health Status,	$X_{41}^{(O)}$ = Life Expectancy,
	$X_{42}^{(O)}$ = Death Rate Classified by Major Causes,
$X_5^{(O)}$ = Mother & Child Health,	$X_5^{(O)}$ = Mother & Child Health.

Table 2. Health Indicators of the Input and Output Sets

Input Health Indicators	Output Health Indicators
$X^{(I)}_{21.1}$ = Medical Personnel-Doctors	$X^{(O)}_{42.1}$ = Death Rate Caused by Diseases of the Heart
$X^{(I)}_{21.2}$ = Medical Personnel-Nurse	$X^{(O)}_{42.2}$ = Death Rate Caused by Accident and Poisoning
$X^{(I)}_{21.3}$ = Beds in Hospital	$X^{(O)}_{42.3}$ = Death Rate Caused by Tuburculosis.
	$X^{(O)}_{42.4}$ = Death Rate Caused by Pneumonia
$X^{(I)}_{31.4}$ = Average Number of Persons per Household	$X^{(O)}_{42.5}$ = Death Rate Caused by Malaria
	$X^{(O)}_{42.6}$ = Death Rate Caused by Diseases of Stomach and Duodenum
$X^{(I)}_{31.5}$ = Access to Safe Water	
	$X^{(O)}_{42.7}$ = Death Rate Caused by Diseases of Pregnancy Childbirth and the Pueperium
	$X^{(O)}_{51.1}$ = Infant Mortality Rate
	$X^{(O)}_{51.2}$ = Mortality Rate of Children Under 5 Years of Age

Table 3. Canonical Equations for Canonical Health Model

Health Indicators		Abbreviations	Equation 1 Canonical Loadings	Cross-Loadings	Standardized Coefficients
Input Set					
Medical Personnel - Doctors		DOC	-.529	-.369	.444
Medical Personnel - Nurses		NUR	-.421	-.293	.096
Beds In Hospital		BED	-.780	-.543	-.507
Average Number of Persons per Household		POP	.599	.417	.538
Access to Safe Water		SAF	-.171	-.119	-.518
Explained Variance		29.00%			
Redundancy Coefficient	0.485				
Output Set					
Death Rate Caused by Diseases of the Heart		DIH	-.715	-.498	-.332
Death Rate Caused by Accident and Poisoning		ACC	-.921	-.642	-.739
Infant Mortality Rate		IMR	-.368	-.256	-.221
Mortality Rate of Children Under 5 Years of Age		UND	.155	.108	.008
Explained Variance		38.00%			
Redundancy Coefficient	0.184				
Canonical Correlation	0.697				

Table 3. **Canonical Equations of Canonical Health Model (Cont.)**

Health Indicators (Abbreviations)	Equation 2 Canonical Loadingss	Equation 2 Cross-Loadings	Equation 2 Standardized Coefficients	Equation 3 Canonical Loadings	Equation 3 Cross-Loadings	Equation 3 Standardized Coefficients	Equation 4 Canonical Loadings	Equation 4 Cross-Loadings	Equation 4 Standardized Coefficients
Input Set									
DOC	-.424	-.212	.494	-.620	-.150	-1.823	-.392	-.025	.359
NUR	-.473	-.236	-.752	-.207	-.050	1.157	-.700	-.044	-1.066
BED	-.354	-.177	-.485	.156	.038	.371	.461	.029	.667
POP	.139	.069	-.446	-.187	-.045	-.334	.228	.014	.376
SAF	.767	.383	.971	.147	.035	-.064	-.007	.000	-.218
Explained Variance		22.70%			10.20%			18.20%	
Redundancy Coefficient	0.057			0.006			0.001		
Output Set									
DIH	.377	.188	.200	.305	.074	.468	.504	.032	1.081
ACC	-.225	-.112	-.615	.120	.029	.030	-.093	-.019	-.604
IMR	.163	.081	.713	-.884	-.213	-.977	.240	.015	-.255
UND	-.641	-.320	-1.045	-.615	-.148	.016	.432	.027	.783
Explained Variance		15.70%			35.10%			14.60%	
Redundancy Coefficient	0.039			0.018			0.001		
Canonical Correlation	0.499			0.241			0.064		

Table 4 **Measures of Overall Model Fit for Canonical Health Model**

Canonical equation	Canonical correlation	Eigenvalue	Test Statistic Wilk' s	Test Statistic ChiSQ	df.	Sig.
1	.697	.485	.362	67.034	20	.000
2	.499	.249	.704	23.142	12	.027
3	.241	.058	.938	4.228	6	.646
4	.064	.004	.996	.267	2	.875

Table 5 Redundancy Analysis

Input Variate	Eigenvalue	Proportion of Variance of the Input Set Explained by Its own Canonical Variate (Shared Variance)		Proportion of Variance of the Input Set Explained by the Opposite Canonical Variate (Redundancy)	
		Proportion	Cumulative Prop.	Proportion	Cumulative Prop.
U_l	λ_l	$R^2_{(l)U}$	$\sum R^2_{(l)U}$	$R^2_{(l)U/V}$	$\sum R^2_{(l)U/V}$
U_1	.485	.290	.290	.141	.141
U_2	.249	.227	.517	.057	.198

Output Variate	Eigenvalue	Proportion of Variance of the Output Set Explained by Its own Canonical Variate (Shared Variance)		Proportion of Variance of the Output Set Explained by the Opposite Canonical Variate (Redundancy)	
		Proportion	Cumulative Prop.	Proportion	Cumulative Prop.
V_l	λ_l	$R^2_{(l)V}$	$\sum R^2_{(l)V}$	$R^2_{(l)V/U}$	$\sum R^2_{(l)V/U}$
V_1	.485	.380	.380	.184	.184
V_2	.249	.157	.537	.039	.223