HEALTH, NUTRITION AND POPULATION – A 3D FACTORMODEL

Viorela Ligia Văidean, Lecturer, PhD, "Babeș-Bolyai"University of Cluj-Napoca,
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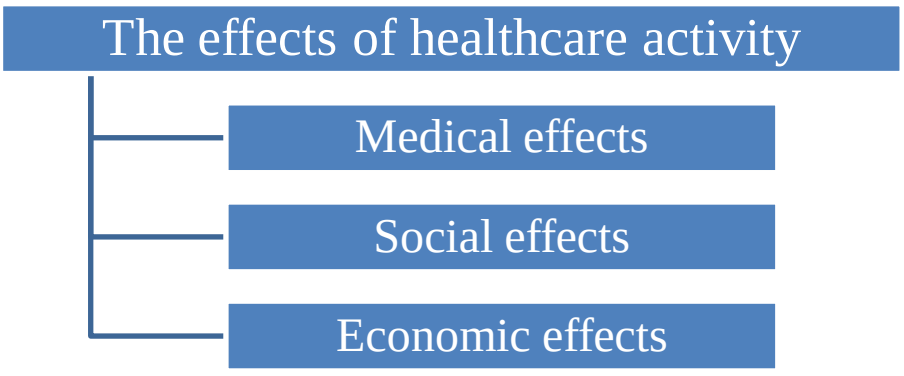
Abstract: The purpose of this paper is to review the existing models of determining factors that impact the health status of the population and to use principal component analysis in order to elaborate a new model. The health status of the population has always been influenced by human biology, the living environment and individual behaviors, the healthcare system and others. This study starts from 69 health, nutrition and population variables for 213 world countries, comprising these variables for dimension reduction of data into 3 components, linear combinations of the initial variables, that are capable to reflect the healthcare status of the world population in 2013.

Keywords*: healthcare, principal component analysis, population, economic and social environment*

The health status of the population has always been considered to be a complex phenomenon, both from the biological and social point of view. A precise delimitation of its level and characteristics has been difficult to evaluate because of the complex character and diverse determinants that influence the health status of a population. Still, the health status of a population is strongly related to its living standards and its systematic study allows, to a certain extent, the appreciation of the medical systems' quality and efficiency.

The healthcare activity is materialized into different categories of effects, according to Figure no 1.

Figure no. 1. The effects of the healthcare activity



Source: Authors' processings

These medical, social and economic effects, regarded as a whole, are strongly related to the efficacy in spending the allocated monetary resources, especially the public ones. The

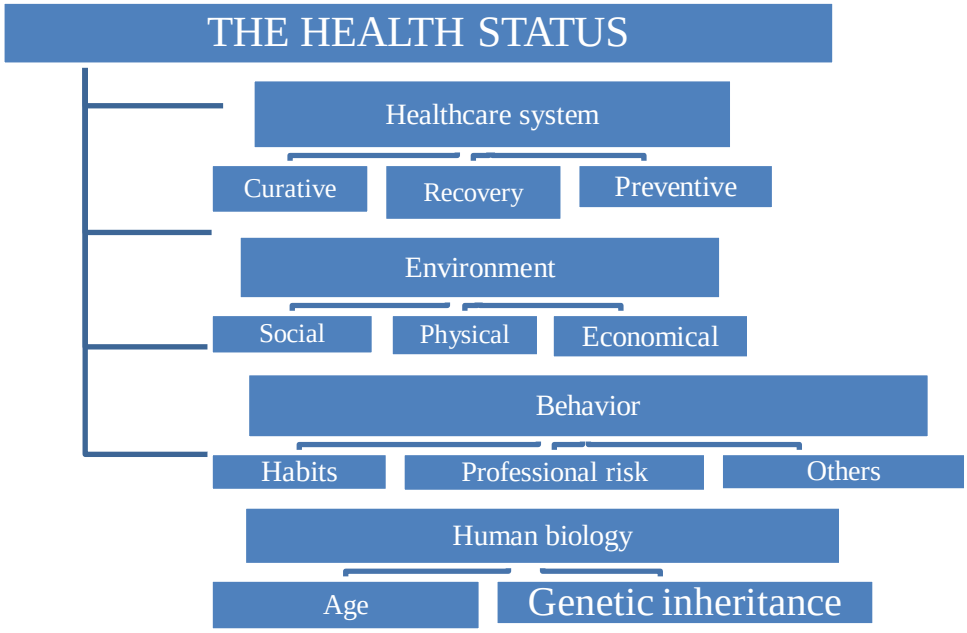
medical effects refer to the effective results of medical activities (consultations, tests, treatments, etc) and they refer to cures that rebuilt and keep the health status of the individuals that benefit from medical assistance. The social effects point towards the results of healthcare activities of the society made up of all individuals, thus these effects cover the entire population, reflected through a series of statistical indicators such as life expectancy at birth, infant mortality, maternal mortality, premature mortality, abortion rate, etc. Nevertheless the economic effects represent the economic benefits to be realised.

The consequences of life style, working conditions and socio-economic system are strongly reflected within the health status of the world population. Basically, the health status of a human population may be regarded as a synthesis of individual health statuses, within a global and systemic vision, and the diagnosis of the health status of a community may be given through a similar reasoning as a doctor in front of a patient, with some particular hues.

The life standard of a community is determined, among others, by its health status and demography. But the health status is also a result of the life standards. So, there exists a strong correlation between the research of population health status and life standards, between the sanitary factors and social-economic ones, that would give a complete imagine on the health status of the world population.

The model of determining factors for the health status of the population considers four main determinants according to Enăchescu et al., 1998. This grouping of determinants derives from Lalonde and considers the following determining factors for the health status of the population, as presented in Figure no 2:

Figure no. 2 The health status of the population – determinant factors



Source: Authors' processings based on Enăchescu and Lalonde

- biological factors (heredity and demographic characteristics of the population);
- environmental factors (the factors of social and physical environment, such as chemicals, socio-cultural, educational factors, etc);
- behavioural factors, the habits. The life style of the population depends on behaviours, which on turn, are conditioned by social factors, so one's life style is the result of one's social and behavioural factors;
- the healthcare services (the preventive, curative, recovery healthcare system, their financing and administrative costs, etc).

So, in order to attain the full health potential of an individual or of a community, the population, the public and private institutions and the authorities have to play their role in the general effort of increasing the health status of the world population.

Worldwide existing *healthcare systems* have been compared by many researchers. Boslaugh S. (2013) considers that each country's method of organizing healthcare delivery is unique and based on its specific situation, including its history and culture, the amount of money it has to spend, and the value it places on different outcomes. She considers the demand for healthcare services to be theoretically unlimited, although no government uses unlimited resources, so the design and operation of a healthcare system is difficult and almost guaranteed not to please everyone all the time. Boslaugh S. characterizes each country at one time. The financing methods of the healthcare system differ from one country to another,

ranging from public financing through taxes, to social insurance contributions dependent on individual income and private health insurance premiums. Anton S.G. and Onofrei M. (2012) consider that the study of healthcare expenditure may come with important conclusions on the health state of a population, as countries that registered high levels of health expenditure per capita also have the strongest healthcare systems and the best health outcomes, lower mortality rates and higher life expectancies. Investing in healthcare does pay off, their findings validating a direct relationship between per capita health expenditures and under-5 (child) mortality rate.

The *socio-economic* environment does affect the health status of the population, as previously presented. Furthermore, several associations have correlated the environmental regulations, air and waterpollution with health indicators such as the infant mortality rate. The quality of *physical environment* is given by all forms of pollution, and developed countries focus on monitoring and overtaxing large pollutant companies. The effects of physical environment protection and waste management upon the health status of the population and environment health have been discussed by Scorţar LM. (2013), as waste management affects the environment and the human health and it reflects the inefficient use of natural resources by the society. Developed European and even American countries have always emphasized the importance of recycling used goods for a healthier environment. According to Scorţar L.M. (2011), collecting recyclable household waste requires consistent effort from the physical persons, by selectively collecting paper, glass, plastics, metals (e.g. Aluminum in the USA), organic waste, etc and transporting old materials to collection points. The success of collection is based on each citizen's behavior and the efficiency of investments in this system depends on public awareness on the need of selective collection.

Regarding *behavior* aspects that determine the health status of the population, specialists have focused on determining the impact of vices such as alcohol and tobacco consumption upon the health of individuals. Chopra A., Rao N.C., Gupta N. and Vashisth S. (2014) studied the fact that although health hazards of tobaccoare well known, only a small numbers of tobacco users are fully aware of the harmful effectsoftobacco, despite the warning labels on tobaccoproducts that are supposed to bring behavioral changes like quitting and reducing the tobacco consumption. Reichmann G. and Sommersguter-Reichmann M., 2012 examined the effectiveness of smoking bans in Austrian public places such as restaurants and bars. The customers widely adhered to the partial smoking bans, but many of them were dissatisfied with the fragmented Austrian solution, as well as restaurant owners. Glawischning M,

Reichmann G. and Sommersguter-Reichmann M. (2009) consider there exist little data on the smoking behavior of the population of Austria, at most figures on the number of regular smokers and the amount of cigarettes consumed per person per year. Equally, statutory anti-smoking measures in Austria lag considerably behind those of other countries, especially the U.S.A.

Moreover, the behavior factors include eating habits and obesity prevalence. Healthy eating habits include a diversified died that includes proteins and carbs. Specialists recommend the consumption of bio or eco produced fruit, vegetables, eggs and meats. Superfoods have also gained popularity in the last year, such as goji fruit, berries, chlorella, guarana, ganoderma, and many others. Apostu S., Pop C., Rotar A.M., Salanţă L, Pop A, Găvruş I. (2014) researched the benefits of goat milk cheeses consumption, that have gained popularity due to the increased interest of consumers in both the tradition of cheesemaking and the sensorial and nutritional value attributed to goat milk. This study aimed to assess and compare the chemical and sensory characteristics of fresh cheese with a mixture of cranberry fruits in different concentrations. The increased worldwide consumption of sugars, genetically engineered foods and others have lead towards the continuous increase in the obesity rates of adults and children. The BMI index is one of the widest used indexes, obesity diagnosis being set at BMIs above 25.

Nevertheless, stress also affects human health. Alternative medicine therapies such as acupuncture and Bowen therapy have been used in order to reduce work related stress levels. Moreover, a number of medicinal plants have always been used in the traditional medicine, aiming to maintain health and to cure diseases, as plants produce a lot of antioxidants they can represent a source of novel compounds with promising antioxidant activity. In this context, Salanta L.C., Tofană M., Socaci S., Mudura E., Pop C., Pop A., Cuceu A., Nagy M. (2015) presented a summary of the spices and aromatic herbs to be used for the development of functional foods, that can only bring benefits upon the health status of the population.

Human biology also influences the healthcare status of the population, and it refers to one's genetic inheritance and age. Many researchers have been preoccupied by the study of the human genome and chromosomal changes of genes. Furthermore, besides one's genes, one's increasing age influences one's health status by decreasing it as decades pass by.

The data used in this study have been downloaded from the World Bank database on Health Nutrition and Population Statistics, by initially selecting 69 variables (out of the 322 potential

ones) for all the 247 countries available. The most recent data have been used, i.e. for the year 2013, in order to get a nowadays perspective on the health status determinants of the worldwide population. Factor analysis requires a proportion of at least 5 times as many countries as number of variables to submit. As such, out of the 17043 initial observations, the variables with more that 10% missing observations were eliminated, and countries as well. 213 countries were left, and 24 variables have initially been imported into the SPSS software: Adolescent fertility rate (births per 1,000 women ages 15-19); Age dependency ratio (% of working-age population); Birth rate, crude (per 1,000 people); Death rate, crude (per 1,000 people); Fertility rate, total (births per woman); GNI per capita, Atlas method (current US$); Health expenditure per capita (current US$); Health expenditure, private (% of GDP); Health expenditure, public (% of GDP); Immunization, DPT (% of children ages 12-23 months); Immunization, HepB3 (% of one-year-old children); Immunization, Hib3 (% of children ages 12-23 months); Immunization, measles (% of children ages 12-23 months); Immunization, Pol3 (% of one-year-old children); Incidence of tuberculosis (per 100,000 people); Labor force, total; Out-of-pocket health expenditure (% of total expenditure on health); Population ages 65 and above (% of total); Population, total; Prevalence of tuberculosis (per 100,000 population); Rural population (% of total population); Tuberculosis death rate (per 100,000 people); Unemployment, total (% of total labor force) and Urban population (% of total). By further analyzing the number of missing observations per variable, some variables were further deleted because of having 17 missing countries data, and some missing data were replaced with the mean value. By leaving variables 11, 12, 15 and 20 out, the study continued on the 20 available variables with no missing data within. As such, the descriptive statistics for the variables to undergo principal components analysis are to be found in Table no 1:

Table no 1 Descriptive statistics of the variables candidate to PCA

	Mean	Std. Deviation	No of countries
Adols_fertility	48.327041	39.0669634	213
Age_dep_ratio	59.108428	17.4808690	213
Birth_rate	21.631590	10.2994778	213
Death_rate	8.227115	3.0189103	213
Fertility_rate	2.822510	1.3602856	213
GNI_per_capita	13024.288596	17765.3820227	213
HE_per_capita	1106.747068	1867.5359272	213
Priv_HE	2.738907	1.5524343	213
Public_HE	3.985147	2.1904076	213

Immuno_DPT	88.723506	13.0541328	213
Immuno_measles	88.007032	12.4446945	213
Immuno_Pol	88.865470	11.8131965	213
Labour_force	110618614.84	375624784.114	213
OOP_HE	32.059472	17.1606967	213
Pop_65	7.932876	5.4801846	213
Pop_Total	231494465.27	803763740.478	213
Rural_pop	44.080976	22.2964778	213
Tubercul_death	13.819502	19.0934927	213
Unemployment	8.600401	5.4337518	213
Urban_pop	55.919024	22.2964778	213

Source: Author's processings in SPSS

All these variables are ordinal variables, obtained by applying different measuring scales. Moreover, these variables are correlated, as the correlation matrix points out. The main objective of exploratory factor analysis is to reduce the data and their dimensions, in order to better interpret them. The new components are linear combinations of the initial variables.

Articol II. The principal component analysis technique was carried out, and for the dimension reduction of data, several factors were extracted. Table no 2 presents the communalities after extraction, i.e. how much of the initial information is further found within the reduced dimensional space. A communality represents the amount of variance in that variable accounted for by all the components. For example, all six extracted components account for 74.8% of the variance in variable Adolescent fertility ($h^2 = .748$). Generally, h^2 values above 0.5 are to be considered.

Table no 2 Variables' communalities, initial and extracted by PCA extraction method

	Initial	Extraction h^2
Adols_fertility	1.000	.748
Age_dep_ratio	1.000	.901
Birth_rate	1.000	.939
Death_rate	1.000	.743
Fertility_rate	1.000	.929
GNI_per_capita	1.000	.826
HE_per_capita	1.000	.871
Priv_HE	1.000	.823
Public_HE	1.000	.816
Immuno_DPT	1.000	.916

Immuno_measles	1.000	.914
Immuno_Pol	1.000	.941
Labour_force	1.000	.981
OOP_HE	1.000	.833
Pop_65	1.000	.853
Pop_Total	1.000	.977
Rural_pop	1.000	.764
Tubercul_death	1.000	.446
Unemployment	1.000	.592
Urban_pop	1.000	.764

Source: Author's processings in SPSS

When deriving factors, several criteria may be applied in order to determine the number of factors to extract. As such, the latent root criterion considers significant only the factors having latent roots (or eigenvalues) greater than 1. Then, the percentage of variance criterion applied in social sciences considers solutions that account for 60 percent of the total variance, or even less, as satisfactory. According to table no 3, six factors have the initial eigenvalues higher than 1, and for these six factors, the cumulative percentage in the extraction sums of squared loadings is above 60% for the first three factors, and above 82% for the six factors.

The scree test criterion indicates the maximum number of factors to extract, at the point at which the curve first begins to straighten out (i.e. factors before the inflection point). The scree plot is represented in Figure no 3.

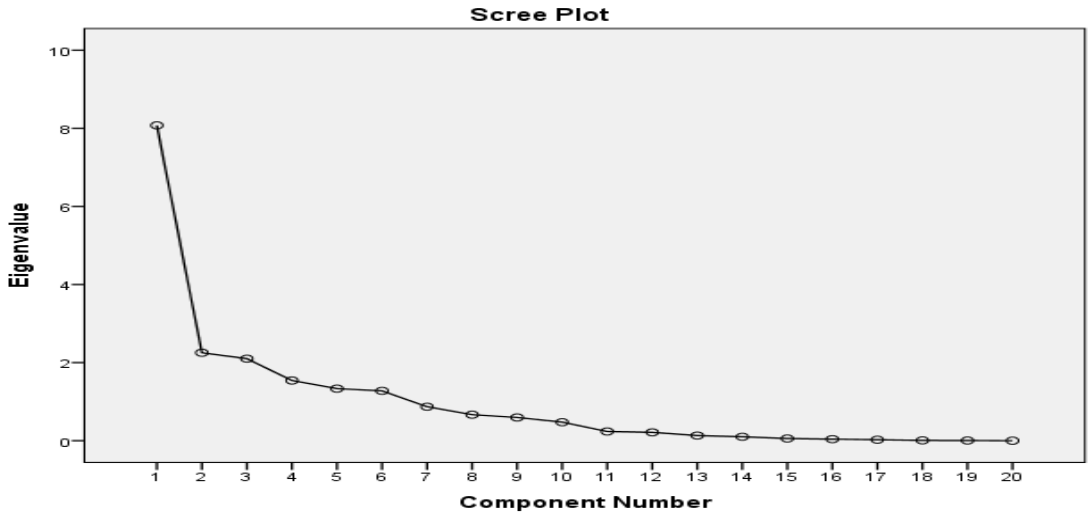
Table no 3 Total variance explained by components in PCA

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.075	40.373	40.373	8.075	40.373	40.373
2	2.253	11.263	51.636	2.253	11.263	51.636
3	2.100	10.502	62.138	2.100	10.502	62.138
4	1.541	7.705	69.843	1.541	7.705	69.843
5	1.333	6.665	76.508	1.333	6.665	76.508
6	1.276	6.380	82.888	1.276	6.380	82.888
7	.871	4.354	87.242			
8	.667	3.335	90.577			
9	.595	2.975	93.552			
10	.474	2.371	95.923			

11	.236	1.181	97.104			
12	.214	1.072	98.176			
13	.132	.661	98.837			
14	.100	.500	99.337			
15	.056	.278	99.615			
16	.040	.202	99.817			
17	.025	.124	99.940			
18	.008	.039	99.979			
19	.004	.021	100.000			
20	8.350E-016	4.175E-015	100.000			

Source: Author's processings in SPSS

Figure no 3 The scree plot



Source: Author's processings in SPSS

The component matrix with the six extracted components has the following loadings above 0.3 for each variable, as presented in Table no 4. Factor loadings are the correlation of each variable and the factor. Higher loadings make those variables representative of the factor. Factor loadings are the means of interpreting the role each variable plays in defining each factor. Table no 4 presents the correlation coefficients between the initial 20 variables and the extracted components.

Table no 4 Component matrix

	Component					
	1	2	3	4	5	6
Adols_fertility	-.811					

Age_dep_ratio	-.805					
Birth_rate	-.908					
Death_rate		.484		.579		
Fertility_rate	-.877					
GNI_per_capita	.697	.512				
HE_per_capita	.662	.578				
Priv_HE				.433	-.420	.661
Public_HE	.638	.445		.336		
Immuno_DPT	.675	-.470		.356		
Immuno_measles	.708	-.514				
Immuno_Pol	.703	-.476		.343		
Labour_force			.965			
OOP_HE	-.470	-.318			-.611	.361
Pop_65	.776	.364				
Pop_Total			.966			
Rural_pop	-.738			.348		
Tubercul_death	-.623					
Unemployment				.369	-.376	-.493
Urban_pop	.738			-.348		

Source: Author's processings in SPSS

Several iterations have been carried out until a final solution has been achieved. *Cross loadings* from table no 4 are undesirable and they have been eliminated through deletion of variables and rotations. Finally, KMO and Bartlett's test of sphericity tests the null hypothesis of uncorrelated variables and a bad quality PCA to the alternative hypothesis of an existing correlation between variables and a high quality PCA. Essentially, the Kaiser-Meyer-Olking (KMO) statistic should be greater than 0.600 and the Bartlett's test should be significant (e.g. $p < .05$).The closer the KMO measure of sampling adequacy is to 1, the better the analysis. A rule of thumb is to have a KMO of at least 0.5. Table no 5 gives a KMO statistic of 0.653, which is good.

Table no 5 KMO and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.653
Bartlett's Test of Sphericity	Approx. Chi-Square	2225.685
	df	36
	Sig.	.000

Source: Author's processings in SPSS

After deleting some of the variables and applying several rotation methods, the Varimax solution proved best, and the following matrices have been obtained:

Table no 6 Component matrix before and after Varimax rotation

Component Matrix[a]

	Component		
	1	2	3
Age_dep_ratio	-.774		.469
Fertility_rate	-.851		.347
GNI_per_capita	.763		.521
HE_per_capita	.746		.606
Public_HE	.683		.419
Immuno_measles	.662		-.447
Labour_force		.990	
Pop_Total		.990	
Tubercul_death	-.667		

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	HEALTH	ECONOMIC	SOCIAL
Age_dep_ratio	.901		
Fertility_rate	.877		
GNI_per_capita		.903	
HE_per_capita		.954	
Public_HE		.768	
Immuno_measles	-.789		
Labour_force			.997
Pop_Total			.997
Tubercul_death	.684		

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 4 iterations.

Source: Author's processings in SPSS

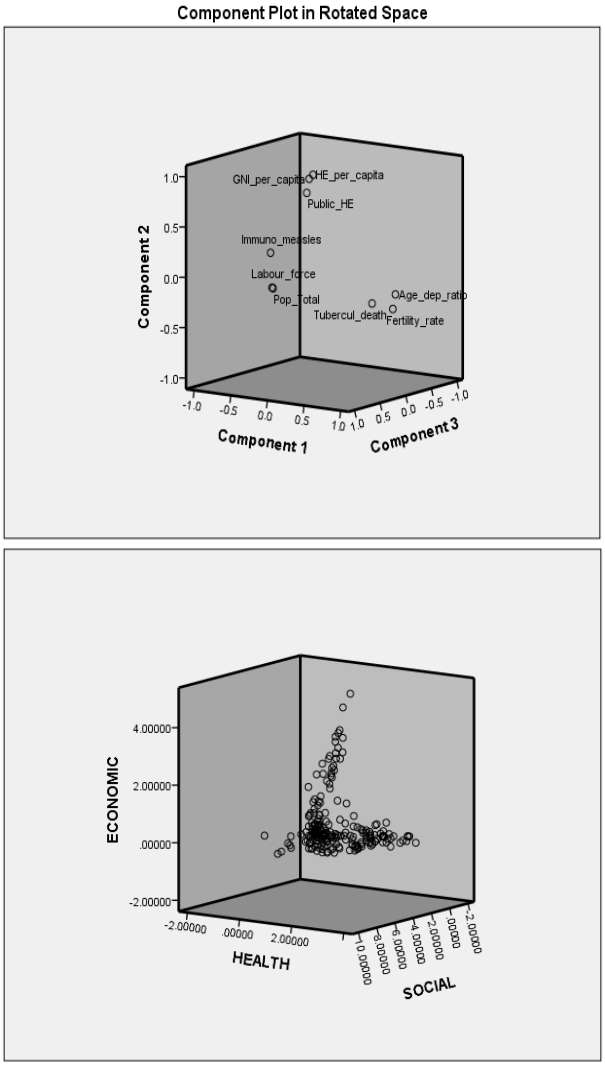
Factor rotation should simplify the factor structure. The rotated factor loadings are interpreted for each variable in order to determine the variable's role and contribution in determining the factor structure.

The total variance explained is of 81.114%, through three components. The eigenvectors are orthogonal, so they're not correlated, hence 0 covariance. Some variables have been eliminated from the rotated component matrix because their correlation with one of the factors was below 0.3. Furthermore, the rotated component matrix is used because variables have to load on a single factor mainly. Basically, the ultimate effect of rotating the factor matrix by using Varimax orthogonal factor rotation is to redistribute the variance from earlier factors to later ones, to achieve a simpler, theoretically more meaningful factor pattern.

Variables are found on a linear combination on each component, as Figure no 4 points out. For the first component, suggestively entitled *Health*, higher coefficients are held by the age dependency ratio and the fertility rate. The second component, suggestively entitled *Economic*

is obtained as 0.903 per capita GNI + 0.954 per capita Health Expenditure + 0.768 Public Health Expenditure. The larger the absolute size of the factor loading, the more important the loading is in interpreting the factor matrix, as the third component, *Social*, is given by Labor force loadings and Total population loadings.

Figure no 4 The three dimensional factor model of Health, Economic and Social Environments



Source: Author's processings in SPSS

These components are independent variables and may be used for some other multivariate data analysis. Future research perspectives would focus on using these factors as explanatory variables for the life expectancy at birth of mortality ratios of the 213 countries. Moreover, the same type of analysis may be applied for data covering different years, in order to evaluate the changes that occurred from one decade to another.

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