Statistical assessment of the value of national income per capita as a general criteria for health status level

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In this study, the national income per capita of certain countries has been included as a principle component of analysis in order to determine if income per capita alone can be used as a general criteria to indicate the overall health status of the countries.

By analyzing 15 variables, 72 countries have been ranked as developed, developing, or underdeveloped according to (A) the national income per capita; (B) the first 5 eigen vectors, using all the variable; and (C) the first 4 eigen vectors, using only the health related indicators. Rank correlations have been found to be r = 0.89 between (A) and (B) and r = 0.84 between (A) and (C).

As a result of this study, it may be said that national income per capita levels are useful in determining the general health status of those countries where availability of health indicators is limited. [Journal of Turgut Özal Medical Center 1(4):251-256,1994]

Key Words: *National income, health status*

Kişi başına düşen milli gelirin sağlık düzeyini gösteren genel bir kriter olup olmayacağının istatiksel açıdan değerlendirilmesi

Bu çalışmada, ülkelerin kişi başına düşen milli gelirlerinin tek başına sağlık düzeyini gösteren genel bir kriter olup olmayacağını belirlemek için bazı ülkeler "temel bileşenler yöntemi" ile incelenmiştir.

72 ülkeye ait 15 değişken analiz edilerek ülkeler; (A) kişi başına düşen milli gelire, (B) tüm değişkenler dikkate alınarak ilk 5 özvektöre ve (C) sadece sağlık değişkenleri dikkate alınarak ilk 4 özvektöre göre gelişmiş, gelişmekte olan ve az gelişmiş olarak sıralanmıştır. Rank korelasyon katsayısı (A) ile (B) arasında r = 0.89 ve (A) ile (C) arasında r = 0.84 olarak bulunmuştur.

Sonuç olarak sağlık göstergelerinin elde edilme olanağının sınırlı olduğu durumlarda, ülkelerin kişi başına düşen milli gelir düzeylerine bakılarak sağlık düzeyleri konusunda genel bir kanıya varılabileceği söylenebilir. [Turgut Özal Tıp Merkezi Dergisi 1(4):251-256,1994]

Anahtar Kelimeler: *Milli gelir, sağlık düzeyi*

In numerous articles on international health problems and health statistics, countries are frequently ranked by the following criteria: infant mortality rate; national income level; ratio of deaths above 50 years of age to all deaths; life expectancy at birth, etc. Each time, depending on the criterion selected, the rank of the countries changes.

Presently, countries are being classified according to their national income levels as developed, developing or underdeveloped, and this classification is also accepted as indicating the overall health status of the countries. However, this classification alone does not provide enough information to positively answer the question: "Have the countries with sudden increases in their national income levels, been able to solve their health problems at a similar rate ?"

The objective of this research study was to investigate if national income per capita alone can be considered for use as a general criteria which will reflect the health levels of the countries.

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METHOD

Principle component analysis has been used to test if the inclusion of national income per capita as a general criteria is useful in attempting to determine the general health status of various countries.

As one of the multivariate statistical methods, this method has two main objectives: decreasing dimension and deleting dependence structure.

Concordance coefficient has been used to find out if there were any differences in the rankings of the countries which were listed according to principle component analysis. References (1) and (2) have been used as sources of data for the 72 countries under examination. The reliability of the statistical analysis depends on the accuracy of the information provided by the countries.

Fifteen variables have been included as the determinants of the general health status of the countries. These variables were grouped into three main categories: economics, health and education. These variables are listed below:

X1 : Incidence of tuberculosis
X2 : National income per capita (US $)
X3 : Adult literacy rate
X4 : Expected life period at birth (year)
X5 : Infant mortality rate
X6 : Low birth weight rate (LBW)
X7 : Percentage of population below absolute poverty level
X8 : Daily protein provision per capita (grams)
X9 : Animal protein amount per capita (Kg/year)
X10 : Percentage of protein utilization in daily calories
X11 : Yearly inflation rate
X12 : Loan percentage as an equivalent to importation of goods and services
X13 : Percentage of health sector allocation in central government's budget
X14 : BCG vaccination coverage rate of infants under one year of age
X15 : BCG vaccination coverage of infants under one year age

Before the implementation of principle component analysis, some of the missing observations about the countries were estimated, using linear and non-linear regression models. While using these models, cause and effect relations were considered and the correlation coefficient was $r \geq 70$.

In some countries, such as Sweden, municipalities have a greater responsibility in the provision of health services, and as a result, the value of the 14th variable appears to be much less than expected. For this reason it was necessary to make some adjustments for the 14th variable.

RESULTS

Correlation matrix of the variables

The correlation matrices of the 15 variables in this study are listed in Table I. When the correlation matrix is examined in detail, the relation between national income per capita and the criteria for economics and health, does not appear to be as high as might have been expected. However, after examining a greater number of countries, tha relation proves statistically significant ($p<.05$).

The relation between the national income per capita and the other economic indicators of the countries ranges between $r = 0.57$ and $r = 0.69$. However, it was interesting to find a very low correlation, ($r = 0.13$) between the national income per capita and the yearly inflation rate of the countries. This indicates that inflation is not a permanent problem, but that it is a problem which varies from year to year.

The relation between the health status indicators and national income per capita ranges between $r = 0.41$ and $r = 0.67$. Among all the health status indicators, expected life period at birth shows the highest correlation with national income.

Pre-test for principle component analysis (H O : R = I)

This study was carried out in two stages: the first with all the variables included, and the second with only with health indicators included. As a result of the pre-tests for principle component analysis performed for correlation matrices of these variables, principle component analysis resolution was considered to be significant ($p<.05$).

Matrices regarding eigen vector and eigen value

The first 5 eigen vectors, eigen values and their percentages, are listed in Table II. In this table, all variables are considered and the figures reflect approximately 82 % of the total variation.

In the Table III., only the health variables (X1, X3, X4, X5, X6, X7, X8, X9, X10, X13, X14, X15) are considered and the first 4 eigen vectors, eigen values and their percentages are given. These reflect approximately 83 % of the total variation.

Ranking the countries

The 72 countries under examination have been listed according to three different criteria: national income levels; the sum of the 5 equations composed

of the first 5 principle components (eigen vector) where all the variables are taken into consideration; and the sum of the 4 equations composed of the first 4 principle components where only the variables related to health are considered.

Table IV shows the ranking of the countries according to the three methods used.

Investigation of differences in rank according to method

The differences in the ranks of the countries which resulted from the use of the three different approaches were investigated with the rank correlation method. Using this method, "r" was found to be 0.99 when the list based on national income levels was compared to the list where all the variables were considered. On the other hand, when the list based on national income level was compared to the list using only health variables, "r" was equal to 0.84.

DISCUSSION

As a result of the study, two different correlation coefficients were found. The first, r = 0.99, was obtained by taking into consideration (A) the national income levels and (B) all other variables. The second, r = 0.84, was obtained by taking into consideration (A) the national income levels and (C) only the health related variables.

Table I. Correlation Coefficients of 15 Variables

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
X1	1.00														
X2	-0.27	1.00													
X3	-0.43	0.54	1.00												
X4	-0.48	0.67	0.87	1.00											
X5	0.53	-0.59	-0.92	-0.94	1.00										
X6	0.29	-0.41	-0.51	-0.51	0.51	1.00									
X7	0.32	-0.58	-0.71	-0.79	0.79	0.55	1.00								
X8	-0.35	0.57	0.64	0.75	-0.72	-0.57	-0.70	1.00							
X9	-0.29	0.69	0.65	0.71	-0.66	-0.46	-0.62	0.70	1.00						
X10	-0.34	0.63	0.78	0.82	-0.78	-0.47	-0.67	0.74	0.76	1.00					
X11	0.13	-0.13	0.08	-0.06	0.10	-0.01	0.21	-0.01	0.12	0.07	1.00				
X12	0.20	-0.57	-0.33	-0.30	0.31	0.14	0.19	-0.20	-0.34	-0.27	0.28	1.00			
X13	-0.43	0.58	0.75	0.87	-0.84	-0.47	-0.77	0.76	0.63	0.75	-0.19	-0.30	1.00		
X14	-0.25	0.62	0.47	0.52	-0.50	-0.45	-0.47	0.39	0.46	0.52	-0.13	-0.38	0.48	1.00	
X15	-0.31	0.36	0.57	0.56	-0.63	-0.44	-0.55	0.47	0.41	0.40	-0.21	-0.25	0.50	0.33	1.00

Table II. First 5 eigen vector eigen value and their percentages when all variables are taken into consideration

Variables	1	2	3	4	5
X4	0.942	0.084	-0.074	0.086	0.119
X5	-0.933	-0.056	0.181	-0.122	-0.069
X13	0.811	0.001	-0.151	0.010	0.218
X3	0.879	0.171	-0.044	0.158	0.017
X10	0.861	0.204	0.169	0.049	0.148
X7	-0.843	-0.018	0.185	0.253	-0.146
X8	0.822	0.197	-0.027	-0.135	0.111
X9	0.797	0.159	0.317	0.012	0.099
X2	0.754	-0.275	0.427	-0.024	0.019
X15	0.637	-0.133	-0.356	-0.172	-0.147
X6	-0.634	-0.138	0.060	0.366	0.549
X14	0.632	-0.259	0.320	-0.159	-0.346
X11	-0.104	0.804	0.416	0.217	-0.195
X12	-0.414	0.649	-0.399	-0.250	0.016
X1	-0.499	0.088	0.348	-0.619	0.346
Eigen values	9.275	1.400	1.122	0.814	0.733
%	55.170	9.336	7.477	5.429	4.889

Table III. First 4 eigen vector, eigen value and their percentages when health variables are taken into consideration

	Eigen vector			
Variable	1	2	3	4
X4	0.947	0.051	0.142	0.004
X5	0.944	0.157	0.090	0.042
X3	0.892	0.078	0.092	0.041
X13	0.887	0.022	0.171	0.021
X10	0.864	0.202	0.226	0.135
X7	0.852	0.087	0.018	0.171
X8	0.852	0.149	0.105	0.101
X9	0.785	0.272	0.167	0.063
X6	0.645	0.119	0.561	0.025
X15	0.644	0.238	0.359	0.493
X14	0.603	0.254	0.412	0.506
X1	0.507	0.744	0.017	0.359
Eigen values	7.605	0.869	0.770	0.694
%	63.373	7.229	6.414	5.782

Table IV. The rank order of the countries from developed to underdeveloped countries according to: (A) National Income Levels, (B) All Variables, (C) Only Health Variables

A	B	C
1. U.S.A.	U.S.A.	U.S.A.
2. Switzerland	Switzerland	Canada
3. Canada	Canada	Austria
4. Sweden	Sweden	W.Germany
5. Japan	Japan	Hungary
6. W.Germany	W.Germany	France
7. Finland	Finland	Spain
8. France	Austria	Switzerland
9. Austria	France	Sweden
10. United Kingdom	United Kingdom	United Kingdom
11. Oman	Italy	Finland
12. Italy	Oman	Italy
13. Czechoslovakia	Czechoslovakia	Argentina
14. U.S.S.R.	U.S.S.R.	Uruguay
15. Spain	Spain	Greece
16. Greece	Greece	Portugal
17. Venezuela	Venezuela	Czechoslovakia
18. Yugoslavia	Argentina	Japan
19. Algeria	Yugoslavia	Poland
20. Argentina	Algeria	Costa Rica
21. Panama	Poland	Jamaica
22. Mexico	Hungary	Yugoslavia
23. Poland	Panama	Chili
24. South Africa	Portugal	Venezuela
25. Malaysia	Mexico	U.S.S.R.
26. Portugal	Malaysia	Colombia
27. Hungary	South Africa	Jordan
28. Uruguay	Uruguay	Panama
29. Brazil	Brazil	Sri Lanka
30. Syria	Jordan	Malaysia
31. Jordan	Syria	Turkey
32. Iran	Chili	Brazil
33. Chili	Iran	China
34. Colombia	Colombia	Syria
35. Costa Rica	Equador	Thailand
36. Tunus	Tunus	Mexico
37. Equador	Turkey	Tunus

(continued)

Table IV. (continued)

38. Congo	Costa Rica	Paraguay
39. Turkey	Jamaica	Botswana
40. Peru	Peru	Equador
41. Egypt	Egypt	Algeria
42. Jamaica	Congo	Egypt
43. Paraguay	Bolivia	South Africa
44. Botswana	Paraguay	Peru
45. Thailand	Thailand	Philippines
46. Honduras	Botswana	Indonesia
47. Philippines	Honduras	Iran
48. Yemen	Philippines	Honduras
49. Indonesia	Indonesia	Madagascar
50. Lesotho	Sri Lanka	Congo
51. Bolivia	China	India
52. Liberia	Lesotho	Sudan
53. Mauritania	Yemen	Tanzania
54. Sri Lanka	Liberia	Bolivia
55. Pakistan	Madagascar	Uganda
56. China	Sudan	Pakistan
57. Haiti	Tanzania	Haiti
58. Sudan	India	Togo
59. Tanzania	Pakistan	Lesotho
60. Rwanda	Haiti	Chad
61. Somalia	Mauritania	Liberia
62. India	Uganda	Zaire
63. Madagascar	Zaire	Malawi
64. Togo	Togo	Bangladesh
65. Uganda	Rwanda	Yemen
66. Zaire	Malawi	Oman
67. Malawi	Somalia	Mali
68. Nepal	Nepal	Nepal
69. Bangladesh	Bangladesh	Mauritania
70. Mali	Mali	Rwanda
71. Afghanistan	Chad	Somalia
72. Chad	Afghanistan	Afghanistan

To illustrate, four of the basic health indicators have been used to rank Afghanistan, Oman, Italy and the USA, and the results are shown in Table V.

As shown on Table V, Oman, has an infant death rate of 104/1000. Oman placed 12th on Table IV when all variables were used. However, when we consider only the health related variables, Oman dropped farther back to 66th place. This is significant.

This example explains why the correlation coefficient obtained by the comparison of tle variables (A) and (C) is relatively lower than the one obtained from variables (A) and (B). It is evident that the economic indicators (X2, X11, X12), affect the ranking in a direct manner.

The differences in the ranking of countries by national health levels or by health related indicators is demonstrated more clearly when the correlation coefficient goes up from r = 0.84 to r = 0.89 after eliminating Oman from the list.

In conclusion, it can be said that in cases where the availability of basic health indicators is limited, since it is a well accepted fact that it is not always possible to obtain health indicators, it would be possible to obtain a general indication of the health status of various countries only by using the national

Table V. Three essential health indicators for four countries (1985)

Countries	IMR* (per thousand)	ELP**	Rate of infants with BCG
USA	10	75	95
Italy	11	75	93
Oman	104	55	90
Afghanistan	185	39	16

* : Infant mortality rate ** : expected life period at birth (year)

income per capita level excluding the countries with high petroleum incomes.

REFERENCES

1. UNICEF. The State of World's Children. Oxfordshire, 1988.
2. FAO. Basic Data On The Agricultural Sectors. Rome, 1986.
3. FAO. The World Meat Economy In Figures. Rome, 1985.
4. Mardia, K.V., Kent, J.T., Biby, J.M.; Multivariate Analysis. London, 1969.

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