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STUDIECENTRUM VOOR ECONOMISCH EN SOCIAAL ONDERZOEK

DETERMINANTS OF HEALTH STATUS

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C O N T E N T

INTRODUCTION

Large numbers of the world's population live in developing countries in conditions of poverty, malnutrition and disease. Faced with insufficient resources to satisfy basic needs for all, the economic problem of optimal allocation of available resources among competing alternatives arises. With respect to the health objective the question could be raised : "Should funds be commited to hospital building, medical centers, water supply, a nutrition program, perhaps primary education ... ?

Within each sector problems of efficient resource allocation are not new. It may be a question of technical efficiency, of choice of appropriate material, of operationality of a project; it may be a question of allocation among similar but competing projects. The problem may be one of intersectoral allocation as well. Would the effect on health not be larger when spending 1 $ on a water supply project than when spending it on a vaccination program ?

It is not the purpose of this paper to answer this question. But looking at the economic history of medical care in developed countries the importance of other than the strict medical sector becomes clear. As summarized by Prof. Perlman : "Medical care delivery is only a subset of health protection systems. Indeed, from an historical standpoint, nutritional improvement, establishment of sanitary control an the spread of educational achievement in industrialized nations have been clearly more significant for improving health of nations than medical delivery has been." (*)

From looking at history, the question arose whether these past contributions of non-medical sectors to health can also be observed today in cross-section analysis among countries around the world, developed ones as well as developing countries.

(*) M. PERLMAN, (3), p. 21.

In a first paragraph the economic history of medical care will be summarized. A second paragraph briefly summarizes some literature on the effectiveness of health expenditures. In paragraph three results of a cross-section analysis will be reported. Some conclusions will close this paper in paragraph four.

§1. ECONOMIC HISTORY OF MEDICAL CARE

The economic historian R.M. Hartwell described the history of mankind as the history of poverty, dirt and disease. Life for most men for most of history has been a constant struggle for survival, in an insanitary environment, against poverty and disease. Shortage of food and malnutrition, with recurring crop failures and famines, living conditions which ignored the basic elements of public health, and constant exposure to infectious diseases and onslaughts of great epidemies were the essential characteristics of human societies up to the 18th century.

For much of mankind today it is still so. Only in the advanced economies of the last two centuries the three major obstacles to wealth, health and population growth have been overcome. The vicious circle of poverty, dirt and disease was broken first by the industrial revolution, beginning in England in the 18th century. It dramatically increased man's capacity to produce goods and services; the breakthrough in the production of food enhanced the power to survive and brought down death rates. The nutritional decline in the death rate, however, was halted in the mid-nineteenth century as the health hasards of industrialization and urbanization increased. A public health revolution followed the industrial revolution with heavy investment in environmental improvements. It gradually enforced standards of hygiene in increasingly concentrated urban communities.

The next great steps in the conquest of disease were medical. Investments in medical research reinforced the ability to survive already boosted by the decline of universal chronic malnutrition and by the making of a healthier environment.

The industrial revolution (including an agricultural revolution and, therefore, a nutritional revolution) was followed by a public health revolution and a medical revolution. The former was induced by the obvious public bads of growing urban concentrations, the latter by the increasing demand for medical care as a consumer good from increasingly wealthy societies.

Medical care services had little effect on the incidence or cure of disease, or on mortality rates before the second half of the 19th century. "Whatever comfort medical care gave to individuals, and whatever its role in promoting increasing medical knowledge, it was irrelevant in the determination of social aggregates", P.M. Hartwell concludes his paper. "Medical care was important socially and intelectually, relatively unimportant economically and unimportant for vital statistics" (*).

Since the beginning of the 20th century medical care became increasingly effective, although nutrition and public health continued to dominate mortality trends. From an historical standpoint, nutritional improvement, establishment of sanitary control and the spread of educational achievement in industrialized nations have been clearly more significant for improving the health of nations, than medical care delivery, has been.

Only in the 20th century and only in the advanced economies there has been a convincing solution to the old historical problems of under-nourishment, lack of hygiene and endemic and epidemic disease. For much of mankind still today life is a struggle for survival, in an insanitary environment, against poverty and disease.

From these historical considerations the hypothesis can be suggested that also at cross-sectional level among countries a more significant influence on health will be attributed to nutrition, sanitary control and educational achievement, than to medical care delivery. Further in this paper this hypothesis will be tested.

(*) P. HARTWELL, (2), pp. 16-17.

§2. THE EFFECTIVENESS OF HEALTH CARE EXPENDITURES

Whatever the origine of aid to developing countries may be, different attempts to alleviation of poverty and disease have been seen through history : hospital building, medical centers, out-patient care, water supply, agricultural development, health education. etc.

The problems of mere survival and eradication of disease reached among the highest priorities. Mostly operational problems have been discussed in the past. Recently the debate of preventive versus curative care has been extended into other long term programs of education, nutrition ...

Questions of economic efficiency however, hardly come up. Scarce resources have to be allocated to competing projects. Which one is more effective in terms of the country's objectives ?
Are medical care expenditures effective with respect to health anyhow ? This problem has been tackled only rarely in the literature. A brief summary can be found in Sorkin (*). Some evidence for developed, intermediate and low income countries will be summarized next.

There is increasing evidence that in developed countries as the US and GB increases in health expenditures have had relatively little impact on health status. Holding the state of the art constant, the marginal contribution of medical care to life expenditure is very small. At least these are results found by Fuchs (**), using three types of date (cross-section within countries, cross-section among countries, time series). The negative association between health and per capita income seems to disappear, and differences in mortality are primarily related to life-style : diet-exercise- smoking-stress.

(*) A. SORKIN, (5), pp. 107-125.
(**) V. FUCHS, (1), p. 174.

These findings are confirmed also by a study on the impact of medical care on the health of a rural community of american indians. In the absence of other social and environmental changes medical care was found to have little impact on health. In spite of rapid expenditure increases, health status does not show great improvement; low socio-economic status and substandard housing seem to be relevant arguments.

§3. CROSS-SECTION ANALYSIS

1. Hypothesis and methodology

For most of history medical care has been irrelevant to the determination of health whatever impact it may have brought to particular individuals. Nutritional improvement, the establishment of sanitary control and the spread of educational achievement have been more significant for improving health than medical care delivery.

The question is raised whether this evolution through nutrition, public health and medical care can also be seen in a cross-section sample of data among countries at different stages of development. In this paragraph an attempt will be made to answer this question through multiple regression analysis of cross-section data on 68 countries around the world. A proxy for health status has been regressed on a set of proxies for three potential determinants : nutrition, environment and medical care.

2. Data

For reason of comparability internationally collected and adjusted data from World Bank sources have been used, rather than official national data. Proxies have been chosen taking into account availability and reliability of data. They all refer to the period 1970-1976.

As a proxy for health status life expectancy at birth (LEX) has been used.
Alternative indices as crude mortality, child mortality, infant mortality have been suggested. On child mortality, which is considered a better health status indicator, too little reliable

data are available for developing countries. Morbidity hardly could be used by lack of comparable data.

For medical care population per physician (POP/PH) has been used as proxy.

Per capita calorie supply as percentage of daily requirements (CAL/REQ) has been retained as measure for nutritional status.

As environmental factors the percentage of population with access to safe water (WA) and the adult literacy rate (LIT) are used. Per capita GNP (GNP/CAP) has been added to control for other environmental factors as housing, clothing,...

A list of the countries considered and data used is included in appendix.

3. Estimation results

Assuming a constant linear relationship among life expectancy on the one hand, population per physician, calorie supply, access to safe water, literacy, income and a constant term on the other hand, following regression results have been obtained :

$$LEX = \underset{(.00004)}{-.0001^{*}}POP/PH + \underset{(.044)}{.124^{*}}CAL/REQ + \underset{(.026)}{.087^{*}}WA$$

$$+ \underset{(.030)}{.192^{*}}LIT + \underset{(.0003)}{.0002}GNP/CAP + \underset{(4.0)}{28.5^{*}}$$

$R^2 = .92$

number of observations : 68

standard errors are given between parenthesis

* = coefficient significantly different from zero at 1 % level

All coefficients have the expected signs. An increase in the population per physician will decrease life expectancy, an increase in calorie supply, access to safe water or the literacy rate will increase life expectancy. As far as per capita income is concerned a positive effect will be expected in developing countries; for highly developed countries a negative income effect would be explained by the consumption of unhealthy luxury goods, excessive diets, etc. Our coefficient is positive

but not significantly different from zero. At a 1 % level all other coefficients are significantly different from zero.

A determination coefficient of .92 shows that 92 % of the variance of LEX around its mean is explained by the variance of the explanatory variables, POP/PH, CAL/REQ, WA, LIT, GNP/CAP. The importance of each explanatory variable separately relative to the other explanatory variables can be measured by the share of its standard deviation in the explained standard deviation of the dependent variable. After normalization so that they sum up to one, the contribution of variable j to the total explanation will be given by :

$$|\beta_j| \frac{\sigma_{x_j}}{\sigma_y} \Big/ \sum_j |\beta_j| \frac{\sigma_{x_j}}{\sigma_y}$$

The explanatory power of the variables in the above regression are given in Table 1 below.

Table 1. Explanatory power of variables in above regression, and single correlation coefficients

Explanatory variable	Explanatory power	Single correlation
POP/PH	.13	-.71
CAL/REQ	.14	.77
WA	.22	.84
LIT	.46	.98
GNP/CAP	.05	.74

A 46 % share of the explanation of the standard deviation of LEX is taken by the literacy rate, 22 % by access to safe water, 14 % by nutrition, 13 % by medical care and only 5 % by income. Deviations from the mean value of the literacy rate are twice as important for the contribution to life expectancy than access to safe water. When taking into account the above explanatory variables together health status seems more sensitive to education and sanitary environment than to medical care and income.

The role of nutrition will be discussed in more detail later in this paper.

High single correlation exists between each of the explanatory variables separately and health status, as shown in table 1 above. However, in reality the explanatory variables do not influence health independently from each other as expressed by the single correlation coefficients. Reality is a resultant of many forces. Five of them : POP/PH, CAL/REQ, WA, LIT and GNP/CAP have been isolated here. Considering them jointly in the regression analysis above their marginal impacts on health are discussed.

4. Regression analysis and cost-effectiveness of health programs

From the regression results above it can be inferred that among the 68 countries considered a marginal increase in the population per physician ceteris paribus will decrease life expectancy with .0001 times the increase. An increase of calorie supply relative to daily requirements with one percentage point analogously will increase life expectancy at birth with .124 year or a little more than 6 weeks.
Coefficients of other variables in the equation above can easily be interpreted in the same manner.

Thus a 1 year increase of life expectancy will result from following efforts or any combination of them.

Table 2. Health delivery efforts required for one year of life expectancy

LEX	1 year
POP/PH	-10000
CAL/REQ	+8.1
WA	+11.5
LIT	+5.2
GNP/CAP	+5000

A program which decreases the population per physician with 10000 will have the same effect on life expectancy, namely an increase with one year, as an increase of calorie supply relative to a person's daily requirements with 8.1 percentage points, an increase of access to safe water with 11.5 percentage

points, an increase in the literacy rate with 5.2 percentage points or an incrase in per capita GNP with 5000.
An increase of one year in life expectancy can as well be obtained by any combination of the above efforts : f.i. a decrease of the population per physician by 5000 and an increase of per capita GNP by 2500.

It will depend on the cost of various alternative ways to reach the same goal, which effort combination will be more effective. For an economy in equilibrium we would expect they all imply the same marginal cost.

5. Differences according to the stage of development

Separate regressions are estimated to check wheter factors have a different impact according to the level of development as measured by per capita GNP.

Observations have been splitted in three categories : group I of 19 low income countries (with per capita income of US $ 250 and below), group II of 31 middle income countries (with per capita income above US $ 250) and group III of 18 industrialized countries.

Regression results are given in Table 3 below.

Table 3. Regression results by level of development

Group	n	PCL/PH	CAL/REQ	WA	LIT	GNP/CAP	c^{th}	R^2
I	19	-.0001	.240°	-.029	.131°	.016	20.1	.68
		(.0001)	(.120)	(.087)	(.068)	(.036)	(13.6)	
II	31	-.0001	.088	.104*	.223*	.001	27.9*	.88
		(.0002)	(.066)	(.041)	(.038)	(.001)	(6.02)	
III	18	.0011	-.020	-	-	.0001	73.2*	.07
		(.0033)	(.046)			(.0002)	(7.65)	
all	68	-.0001*	.124*	.087*	.192*	.0002	28.5*	.92
		(.00004)	(.044)	(.026)	(.030)	(.0003)	(4.0)	

standard errors are given between parentheses

* : significantly different from zero at 1 %

° : significantly different from zero at 5 %

It is evident that the quality of these regressions is poor due to the small number of degrees of freedom. Furthermore, no precise estimates of the impact of water supply and the literacy rate can be obtained for industrialized countries as the variance of both variables within the subsample is negligible.

A covariance analysis does not lead to the rejection of the hypothesis that the marginal effects of different health determinants do not differ substantially according to the level of development (*).

However, from the estimates of the coefficient of calory supply one gets the impression that the marginal effect of this factor decreases with the level of development. In low income countries this effect is about double that of middle income countries. In industrialized countries, where calorie supply exceeds requirements, its effect even is negative.

When looking at the relative explanatory power of the independent variables, given in table 4 below, calorie supply seems more than twice as important for low income countries than for middle income countries. The negative effect for industrialized countries seems to have a high explanatory power as well.

Table 4. Relative explanatory power of independent variables

Group	n	POP/PH	CAL/REQ	WA	LIT	GNP/CAP	R^2
I	19	.25	.28	.05	.35	.08	.68
II	31	.04	.10	.24	.53	.09	.88
III	18	.24	.31	-	-	.44	.07
all	68	.13	.14	.22	.46	.05	.92

(*) The appropriate F-test whether the gain in explanation from unrestricted regressions (i.e. allowing for different estimates of coefficients in each group) versus a single regression (i.e. marginal effects are equal) leads to an F-value of 1.70 with (10,52) degrees of freedom.

§4. CONCLUSIONS

In this paper an attempt was made to test the hypothesis that nutrition, sanitary control and educational achievement are more important determinants of improving health status of developing countries than medical delivery.

A cross-section analysis on 68 countries around the world has been made. For these countries, life expectancy at birth has been regressed linearly on population per physician, calorie supply relative to daily requirements per capita, access to safe water, the adult literacy rate and per capita GNP.
The literacy rate and access to safe water have largest explanatory power, followed by nutrition and medical care. Health delivery efforts to increase life expectancy with one year have been discussed.

Observations have been splitted into three categories to check different impacts according to the level of development. Although the hypothesis that marginal effects of health determinants do not differ substantially according to the level of development could not be rejected, one gets the impression that the marginal effect of nutrition decreases with the level of development.

Thus taking into account the limitations of available data, especially the small number of data in group I and III and insufficient variance in two variables of group III, some evidence has been yielded in this paper that the hypothesis that nutrition and sanitary control matter in the first place (which was based on a few historical considerations) also holds with respect to health status in different countries around the world.

Cost analysis are required on different programs before decisions on their effectiveness can conciously be made, before decisions on concrete health programs can be taken.

APPENDIX: DATA

COUNTRY	LEX (1)	POP/MD (2)	CAL (3)	WA (4)	LIT (5)	GNP/CAP (6)	et (7
1 ETHIOPIA	38	69340	92	8	7	100	1
2 RWANDA	41	53550	93	68	23	110	1
3 SOMALIA	41	15560	77	38	50	110	1
4 UPPER VOLT	38	59570	82	25	5 (**)	110	1
5 BURMA	50	6910	103	17	67	120	1
6 CHAD	39	44370	86	26	15	120	1
7 NEPAL	44	36450	93	8	19	120	1
8 BENIN	41	36060	98	34	10	130	1
9 ZAIRE	44	27950	92	19	15	140	1
10 INDIA	50	4160	93	31	36	150	1
11 AFGHANIS	35	26100	80	9	14	160	1
12 NIGER	39	41060	93	27	10 (*)	160	1
13 PAKISTAN	51	3970	99	25	21	170	1
14 TANZANIA	45	20800	73	39	63	180	1
15 HAITI	50	8510	76	12	20	200	1
16 MADAGASCAR	44	11610	104	25	40	200	1
17 SRI LANKA	68	6295	107	19	78	200	1
18 INDONESIA	48	18160	89	11	62	240	1
19 KENYA	50	5800	101	17	40	240	1
20 TOGO	41	22280	94	16	12	260	1
21 THAILAND	58	8530	105	25	82	380	1
22 BOLIVIA	47	2120	77	34	40	390	1
23 HONDURAS	54	3360	96	41	61	390	1
24 PHILIPPINE	58	3870 (*)	85	40	87	410	1
25 ZAMBIA	45	8110	88	42	43	440	1
26 EL SALVADO	58	4070	82	53	63	490	1
27 CONGO	44	6160	97	38	50	520	1
28 GHANA	44	11220	96	35	25	580	1
29 COLOMBIA	61	2180	97	64	74	630	1
30 GUATEMALA	53	3410 (*)	97	39	47	630	1
31 ECUADOR	60	2840	89	36	69	640	1
32 PARAGUAY	62	2220	121	13	81	640	1
33 KOREA	61	2010	103	66	92	670	1
34 NICARAGUA	53	1720	106	46	57	750	1
35 DOMINIC. R	58	1870	91	55	51	780	1
36 PERU	56	1800	98	47	72	800	1
37 MALAYSIA	59	4400	94	34	60	860	1
38 ALGERIA	53	7520 (*)	80	77	35	990	1
39 TURKEY	57	2130	110	68	55	990	1
40 COSTA RICA	68	1580	110	72	89	1040	1
41 CHILE	63	2420	101	70	90	1050	1
42 JAMAICA	70	3510	103	86	86	1070	1
43 MEXICO	63	1320 (*)	110	62	76	1090	1
44 PANAMA	67	1240	109	77	82	1310	1
45 IRAQ	53	2370	93	66	26	1390	1
46 URUGUAY	70	910	107	98	91	1390	1
47 ARGENTINA	68	450	119	66	93	1550	1
48 IRAN	51	2570	86	51	50	1930	1
49 TRINIDAD	70	2220 (*)	97	93	90	2240	1
50 SPAIN	72	670	107	100	94	2920	1
51 IRELAND	72	850	136	100 (*)	98	2560	1
52 ITALY	72	500	126	100 (*)	98	3050	1
53 U.K.	72	750	125	100 (*)	98	4020	1
54 N. ZEALAND	72	850	126	100 (*)	99	4250	1
55 JAPAN	73	870	105	100 (*)	99	4910	1
56 AUSTRIA	71	500	127	100 (*)	99	5330	1
57 FINLAND	70	750	111	100 (*)	100	5620	1
58 AUSTRALIA	72	720	115	100 (*)	100	6100	1
59 NETHERLAND	74	670	122	100 (*)	99	6200	1
60 FRANCE	73	680	127	100 (*)	99	6550	1
61 BELGIUM	73	570	128	100 (*)	99	6780	1
62 GERMANY FR	71	520	121	100 (*)	99	7380	1
63 NORWAY	75	610	109	100 (*)	99	7420	1
64 DENMARK	74	620	120	100 (*)	99	7450	1
65 CANADA	72	600	120	100 (*)	98	7510	1
66 USA	71	610	124	100 (*)	99	7890	1
67 SWEDEN	73	650	104	100 (*)	99	8670	1
68 SWITZERL	72	590	121	100 (*)	99	8860	1
AVERAGE	58	9253	102	58	64	2099	1
ST.DEVIATION	12	15002	14	32	31	2624	0

Notes to the appendix

(1) Life expectancy at birth, 1975
World Development Report, 1978, table 17

(2) Population per physician, 1974
World Development Report, 1978, table 17

(3) Per capita calorie supply as % of daily requirements, 1970
World Tables, 1976; Social Indicators, table 4

(4) Percentage of population with access to safe water, 1975
World Development Report, 1978, table 17

(5) Adult literacy rate, 1974
World Development Report, 1978,table 18

(6) Per capita GNP in US dollars, 1976
World Development Report, 1978, table 1

(7) constant

(*) SESO estimates based on W.B.-data

(**) 1970 data

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