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An International Data Analysis on the Level of Maternal and Child Health in Relation to Socioeconomic Factors

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ABSTRACT

International data on health and socioeconomic factors were analyzed to understand the trends and the determinants of maternal and infant mortality in the late years. Multivariate analyses were carried out to summarize the structure of the data. Multiple regression analyses were also carried out with these two mortality rates as dependent variables. The range of independent variables included health resource availability, immunization, GNP, illiteracy rates, distribution in working area, the indicators of living standards such as percentage of telephone lines and television sets per capita and the percentages of working children, population with access to safe water and sanitation, people living in urban areas, among others.

In the preliminary analysis the indicators of living standards appeared highly correlated to maternal and infant mortality. Working area (industrial or agricultural) showed also an important correlation. In factor analysis indirect variables (economic and living condition) were summarized into two factors. Two regression analyses were executed. In the first the variables were used directly, while factors obtained by the factor analysis were used in the second. The second analysis confirmed the previous analysis: fertility rate, immunization and urbanization appeared as determinants of maternal mortality. Birth rate, percentage of females working in agriculture and total illiteracy appeared as determinants of infant mortality. The factors extracted in the factor analysis made a significant contribution to the second regression analysis.

We concluded: 1) The factors extracted by factor analyses from indirect variables had high explanatory ability on infant mortality rates, 2) The presence of immunization together with birth rate and fertility rate in the regression models pointed out the importance of investing in birth rate reduction and disease prevention methods.

Key words: *International health, Maternal and infant mortality, Immunization, Birth and fertility rates*

It is very difficult to define and assess the health of nations. In spite of the difficulty, it is very important to measure the health level of nations to plan and evaluate the effects of public health programs. In this respect, various mortality rates and life expectancy are in the first rank of measurements in public health. When health level is measured as mortality rates, discussion arises on the relationship between health and socioeconomic conditions of the nations. Sound health status is often related to good socioeconomic condition[5,14]. Statistical analyses on international data have largely revealed that illiteracy, safe water availability, industrialization and sanitation, etc. are highly correlated to health status. Maternal and infant mortality rates (MMR and IMR respectively) were selected for the study because they are regarded as most sensitive to socioeconomic indicators. It cannot be denied that certain countries have good health standards against what might be predicted from their economical situation, either because of other interacting variables or their particular health systems[6]. Both, developed and developing countries that show good health status have based the building of their health systems on maternal and infant health.

Since the situations of all countries change continually, the purpose of this paper is to analyze the present situation of maternal and child health and their determinants over the world. With this purpose we will study a series of health related and non-related variables in the belief that they are capable of explaining the factors affecting maternal and infant mortality in different countries with different health systems. Knowledge of appropriate indicators could lead us to the formulation of health policies that fit the real health situation of a country.

DATA AND METHODS OF ANALYSES

Data

The main source of the data used is "World Development Indicators 1998"[12] provided on a CD-ROM by the World Bank. Some missing values were supplemented with The World Health Report 1999[15] published by the World Health Organization. The total number of countries/areas was 210 and they were divided into 4 groups using the World's Bank classification of countries by GNP per capita: 1) Low-income countries ($785 or less), 2) Lower middle-income countries ($786–$3115), 3) Upper middle-income countries ($3116–$9635) and 4) High-income countries ($9636 or more).

Totally forty-two variables were used in the analysis. Maternal mortality rate and infant mortality rate were included. The abbreviations and explanations of the variables are summarized in Table 1.

Methods of Analyses

The data inevitably contained considerable missing values. Thus, if we analyze many variables simultaneously, the number of samples dramatically reduces. If we keep the number of samples above a certain level, the number of variables analyzed must be restricted. So we first investigated the correlation of each variable to maternal and infant mortality rates. In this pair-wise analysis the maximum number of samples can be used. Then we carried out multivariate analyses with the selected variables and samples. The data set for multivariate analyses was formed selecting the variables that had missing values less than 50. It contained 89 countries/areas and 29 variables. Infant mortality rate was included, but maternal mortality rate was not. Some important variables were also eliminated, but their influence was carefully considered based on the result of the pair-wise analysis.

Cluster analysis was carried out to summarize the structure of the variables selected in the 89 country /area data. Factor analysis was performed to find out common background factors among the independent variables that were regarded as having an indirect effect on the dependent variable. On the other side, variables considered to have a direct effect on the dependent variables were used in the regression without associating them into factors. In addition, regression analyses including all the variables, and not only the variables restricted to the 89 country/area data, were carried out with the forward selection regression method. In the analyses we used statistical analysis package, SPSS 10.0J. AMOS 4.0 was also used for the analysis of covariance structure.

RESULTS

Correlations of Socio-economic Variables with Maternal Mortality Rate (MMR) and Infant Mortality Rate (IMR)

In the first place we make a list of the variables that were strongly correlated with MMR and IMR (Table 2). The two dependent variables show high positive correlation between them (0.926). Thus, as expected, an independent variable that showed high correlation with one of the two variables also had high correlation with the other variable.

Demographic Indicators: Age dependency rate (AGDR) and working children (WC) had a positive significant correlation with the two dependent variables; correlation is higher with MMR than with IMR. In the descriptive analysis the largest percentage of age dependency was found in low-income countries, where the percentage of working children was 25.6 on average. Female life expectancy (LEF) has a stronger correlation with IMR than LET or LEM. Birth and fertility rates (BR and FR) are significantly correlated with GNPC. The percentages of women and men working in agriculture (WAF and WAM) correlate positively with MMR and IMR. The proportion of females working in agriculture has a slightly stronger correlation with IMR than with MMR and a strong negative correlation with the percentage of urban population (UP)[14]. Female working in industry correlates negatively with both IMR and MMR, showing higher coefficients with MMR.

Medical Resources: Variables such as births attended by health staff (BAHS), number of medical doctors per capita (MDOC), health care access (HCA), health expenditure (HEXPC), etc. have significant correlations with GNPC.

GNP and living standard: Most variables that express people's living standards and health status have strong correlations with GNPC. The correlation between GNPC and HEXPC is high (0.833) and so is the correlation between GNPC and HCA. It is proposed that countries spending more money on HEXPC have less IMR and MMR. It is remarkable that some countries have attained low IMR and MMR without increasing their GNPC or their expenses in HEXPC[1,13].

Total illiteracy rate (ILLRT) correlates with MMR and IMR more strongly than isolated male or female illiteracy. Later in the regression analysis this variable will be selected as an explanatory variable for IMR. There is a negative correlation between HEXPC and ILLRT. Countries that do not invest in health are not likely to spend in education either[9]. HEXPC increases when the population reaches a reasonable level of welfare in many senses (number of TV sets, vehicles, etc). Arable land per capita correlates highly with GNPC and HEXPC explaining its presence among explanatory variables in the posterior analysis.

Since LE is an indicator that implies many factors, the primary cause of differences in longevity and health[11] cannot be simply attributed to eco-

Table 1. Variables from the World Health Indicators (World Bank) used in the study,their means by income level

Variable	Abbrev.	Mean values according to Income Level				
		Total	Low	Lowmid.	Uppmd	High
1. Demographic Indicators						
Infant Mortality Rate	IMR	42.1	84.3	33.8	19.7	7.9
Maternal Mortality Rate	MATMOT	320.3	673.2	158.1	110.9	11.7
Under 5 Mortality Rate	MRU5	63.3	135.6	44.9	25.5	9.7
Adult Mortality Rate females, males	MRF MRM	178.9 252.1	315.5 382.5	146.2 226.5	109.6 190.9	71.5 138.2
Crude Death Rate	CDR	9.4	13.1	7.9	7.8	7.4
Life Expectancy at birth (females, males and total)	LEF LEM LET	68.6 63.7 66.1	56.6 53.4 54.9	70.3 65.2 67.7	74.7 68.5 71.5	79.3 73.4 76.3
Crude birth rate (per 1000)	BR	25.5	36.8	24.1	19.9	14.8
Total fertility rate	FR	3.4	5.1	3.1	2.6	1.9
2. Economic Development Indicators						
Gross National Product ($)	GNPC	5805.9	382.7	1760	4940	23165
Age Dependency Ratio (Pop. under 15 and above 65 to working age pop.)	AGDR	0.7	0.9	0.7	0.6	0.5
Arable land (Hectares)	ARLN	7091	7400	6434	5426	8684
Long-term debt (In dollars)	LTDEBT	11475	7195	11777	22796	—
Urban population (%)	UP	53.3	32.2	53.9	66.3	75.3
Communications (Computer, information and services as % of exp-import)	CMPEXP COMPIMP	35.5 32.8	46.1 33.7	30.3 31.2	24.9 32.7	34.1 33.7
Employees in forestry, fishing, agriculture, male and female (%)	WAM WAF	36.8 38.5	62.4 72.5	33.8 31.9	19 12.8	7.7 5.2
Employees in industry, mining, gas, manufacturing (%)	WIM WIF	25.7 14.7	14.6 7.6	28.8 19.1	34 21.8	35.3 15.9
Working Children (%10-14 years old)	WC	11.1	25.6	5.7	2.2	0.06
3. Indicators of Medical						
ResourcesBirths attended by health staff	BAHS	68.3	44.5	69.9	89.6	99.3
Access to health care (within 1 hour walk)	HCA	81.7	58.7	85.9	96.6	99.2
Total health expenditure	HEXPC	486.9	37.4	147.9	320.9	1331.7
Hospital Beds	HBEDS	4.2	2.3	4.1	4.8	7.4
Child Immunization (Coverage for children	IMDPT	79.8	64.5	85.1	91.7	87.6
less than one year age, measles, DPT)	IMM	79.0	65.9	83.6	88.6	85.6
Physicians (per 1000 people)	MDOC	1.3	0.6	1.3	1.7	2.3
4. Indicators of living standards						
Illiteracy rate (Adults, female, male and total)	ILLRF ILLRM ILLRT	37.5 23.4 26.9	55.8 35.5 42.5	25.6 15.1 17.2	18.7 11.4 14.1	12.7 7.9 9
Telephone mainlines (per 1000 people)	TEL	187.8	18.6	106.3	224.2	467.5
Television sets (per 1000 people)	TV	228.4	62.4	164.8	303.6	451.4
Motor vehicles (per 1000 people)	V	139.2	13.9	83.2	176.1	426.4
Daily newspapers (per 1000 people)	NEWSP	127.6	15.2	84.3	139.4	297.8
Access to safe water (Share of the population with access to an adequate amount of safe water, 20 liters/day)	SAFEW SAFEWAR SAFEWAU	70.5 60.5 78.3	49.7 41.8 60.0	72.9 62.7 85.8	85.6 68.5 92.2	98.3 99.6 99.7
Access to sanitation (Share of the population with adequate excreta disposal)	SANIA SANIAU	75.7 76.0	71.7 57.3	65.2 79.7	79.5 88.7	96.5 99.7

Table 2. Socioeconomic indicators with high Spearman rank correlation to maternal and infant mortality

Positive Correlation			Negative Correlation		
Variable	Infant Mortal.	Mat.Mortal.	Variable	Infant Mortal.	Mat.Mortal.
MRU5	0.992	0.924	LET	–0.946	–0.887
MRF	0.901	0.892	TEL	–0.931	–0.903
BR	0.889	0.884	GNPC	–0.873	–0.806
FR	0.868	0.879	NEWSP	–0.870	–0.840
WC	0.861	0.854	V	–0.852	–0.817
WAF	0.852	0.805	TV	–0.846	–0.869
WAM	0.846	0.799	SAFEWA	–0.806	–0.813
AGDR	0.839	0.845	BAHS	–0.805	–0.811
MRM	0.805	0.779	WIM	–0.794	–0.826
ILLRT	0.794	0.827	HCA	–0.767	–0.715
			SAFEWAU	–0758	–0.827
			HBEDS	–0.750	–0.728
			HEXPC	–0.735	–0.812
			SANIA	–0.728	–0.717
			SANIAU	–0.695	–0.677
			UP	–0.690	–0.697
			SAFEWR	–0.668	–0.652
			ARBLPC	–0.646	–0.648
			WIF	–0.637	–0.729
			HEXPUB	–0.595	–0693
			IMDPT	–0.572	–0.596
			IMM	–0.508	–0.555

* Significance at 5%

nomic development, in itself.

Immunization: Among countries in the low-income level there was higher correlation between immunization (IMDPT and IMM) and infant mortality. Data for upper middle-income countries presents a higher correlation between mortality (IMR and MMR) and immunization among high-income countries; still, the correlation is not significant except for MMR and IMM (–0.633). For low-income countries the correlation is significant and negative, especially with maternal mortality[3]. For MMR IMDPT and IMM the coefficients were –0.655 and –0.650 respectively.

Immunization indicators were included in the analysis because they have a missing value less than 50; in the final analysis IMDPT appears as one of the explanatory variables. There was no significant correlation between HEXPC and percentage of children immunized, but immunization had a significant correlation (Pearson) with ILLRT, safe water (SAFEW), LE, WC, BAHS and FR. The significant correlation with ILLRT and SAFEW is explained later in the regression model.

Safe water, sanitation and Infant Mortality: Most countries with an IMR higher than 100 are low-income countries that have war problems or inadequate access to safe water. When populations reach a safe water level between 60–80%, even low-income countries improve their mortality rates[2]. Exceptions to this rule were Bhutan, Guinea and Gabon (Table 3). Examples of countries with low infant mortality and good water provision are Honduras with IMR 40 and 64% of the population with safe water and Nicaragua with IMR 40 and 62% of the population with safe water.

Cluster Analysis of Mortality and Socio-economic Variables

Cluster analysis using Pearson correlation coefficients was carried out to group the variables. In the analysis 89 countries/areas were included. The variables related to mortality were concentrated in one group except for crude death rate (CDR). As to the socioeconomic variables, some groups of variables were recognized. The variables BR, FR and AGDR were very close to each other and relatively close to IMR, confirming the observation in the pair-wise correlation analysis. The variable of working children (WC) was close to the percentages of population working in agriculture and to urban population. This suggests that most working children would participate in agricultural activities in countries with a larger percentage of rural areas. Low-income countries have a mean of 25.6 children in legal work. The groups described in Table 1 as indicators of living standards appear very close to each other and to GNP. The result is illustrated in Fig.1.

Regression Analysis of Maternal Mortality Rate (MMR) and Infant Mortality Rate (IMR)

Regression analyses with a forward selection method based on the p value were carried out on maternal mortality and infant mortality. In this first regression analysis we used all the variables

Table 3. Infant mortality rate and safe water availability by income level

Safe water%	Income	INFANT MORTALITY RATE			
		150–200	100–150	50–100	Up to 50
0–20	Low	Afghanistan	Cambodia	Central Africa	Vietnam
20–40	Low	Sierra Leona, Liberia	Guinea Bissau, Angola, Chad, Mozambique Mali, Lao PDR, Ethiopia,	Madagascar, Congo Dem., Nigeria, Myanmar Uganda, Haiti	
	Low-mid		Dijbouti, Chad	Papua New Guinea	Micronesia
40–60	Low		Niger, Malawi, Zambia	Yemen, Benin, Tanzania, Nepal, Congo Rep. Sudan, Lesotho, Ghana, Comoros, Senegal, Kenya	Cameroon, Sri Lanka
	Low-mid		Iraq	Namibia, Swaziland	Morocco, Guatemala, Peru, Paraguay, Cape Verde, El Salvador
60–80	Low		Bhutan, Guinea	Burkina Faso, Mauritania, Bangladesh, The Gambia, Cote d'Ivoire, Togo, Pakistan, Guyana	
	Low-mid			Bolivia	
	Upp-mid			Gabon	
80–100	Low		Equatorial Guinea	India	
	Low-mid			Kiribati	

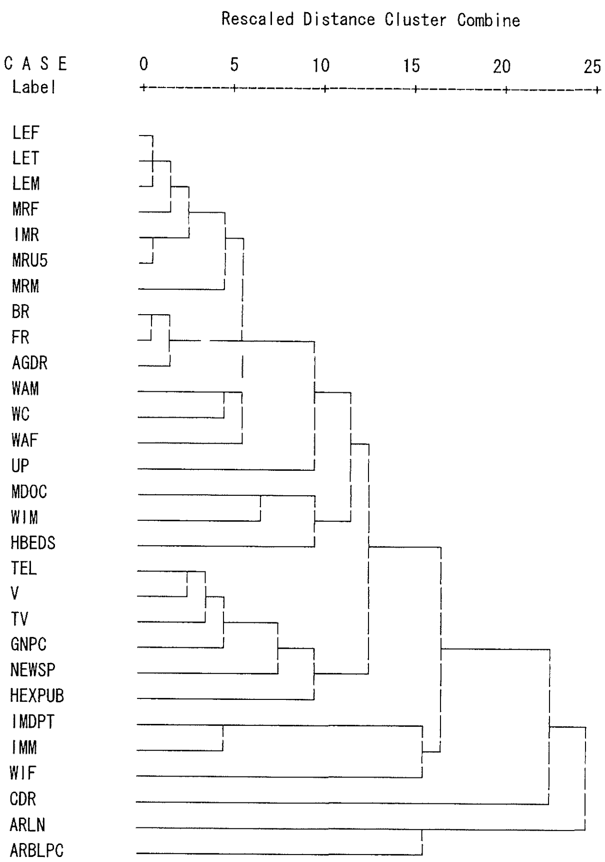

Fig. 1. Hierarchical cluster analysis of the variables (Dendogram using average linkage between groups). N=89.

Table 4. Regression analysis of maternal mortality ($R^2 = 0.779$)

Variables	Regression Coefficient	Standardized Regression Coefficient (Beta)	p value
Fertility rate (FR)	92.327	.387	.000
Immunization with DPT (IMDPT)	−5.420	−.266	.001
Urban Population (UP)	−4.057	−.232	.005
Female working in Industry (WIF)	−7.073	−.201	.015
Constant	757.490		.001

Table 5. Regression analysis of infant mortality ($R^2 = 0.875$)

Variables	Regression Coefficient	Standardized Regression Coefficient (Beta)	p value
Birth rate (BR)	.738	.222	.050
Women working in Agriculture (WAF)	.328	.288	.001
Safe water (SAFEW)	−.415	−.269	.001
Illiteracy rate (ILLRT)	.479	.267	.003
Constant	27.029		.067

in order to include as many variables and characteristics as possible. The results are shown in Tables 4 and 5. In the case where the maternal mortality rate was the response variable (dependent variable), selected explanatory variables (independent variables) were FR, IMDPT, the percentage of urban population (UP) and the percentage of females working in industry (WIF). MMR increases as FR becomes larger whereas it becomes smaller if IMDPT, UP or WIF increases. The coefficient of determination (R^2) was 0.779. On the contrary, an increase in birth rate (BR), percentage of females working in agriculture (WAF) and illiteracy (ILLRT) results in an increase in infant mortality. In contrast, an increase in the supply of safe water (SAFEW) leads to a decrease in the infant mortality rate. The coefficient of determination (R^2) was 0.875.

Factor Analysis of Indirect Variables

To find out a common factor behind the indirect variables, factor analysis was carried out using the data of the 89 countries/areas. Independent variables included in the analysis were urban population, age dependency rate, females and males working in agriculture and industry, working children, availability of telephone lines and TV sets, newspapers, vehicles, GNPC and public health expenditure. Two factors in which Eigen values were larger than unity were obtained. These two factors could explain 80% of the total variation, 66% and 14% respectively. After the rotation of the axes, the two derived factors were considered to represent the following components: The first factor had high correlation to living conditions and the expenditure in health, expressing the importance of GNPC and its distribution. The second factor had high correlation to the degree of industrialization (women and men working in industry and agriculture and working children.

Regression Analysis of Infant Mortality Rate (IMR) using common factors of indirect variables

Most socio-economic variables had correlation with each other; regression analyses of infant mortality rate using the factors in the factor analysis as described above were also carried out. We used the two extracted factors in the regression modeling, and obtained a coefficient of determination (R^2) of 0.908. The model emphasized the importance of family planning and immunization programs. Fertility rate had the largest standardized coefficient ($\beta = 0.472$). The factor representing living standards had the second largest coefficient ($\beta = -0.313$) and the factor representing level of industrialization, the third one ($\beta = -0.349$). Immunization solely had a significant effect on infant mortality ($\beta = -0.183$). The contribution of the variable that represents the number of medical doctors was also significant ($\beta = -0.117$).

Analysis of Covariance Structure

This analysis was carried out following the pattern proposed in the regression analysis above. The results confirmed our explanatory regression model for IMR (Fig. 2). The performance indicators of the analysis of covariance structure GFI and AGFI were 0.575 and 0.439 respectively. The

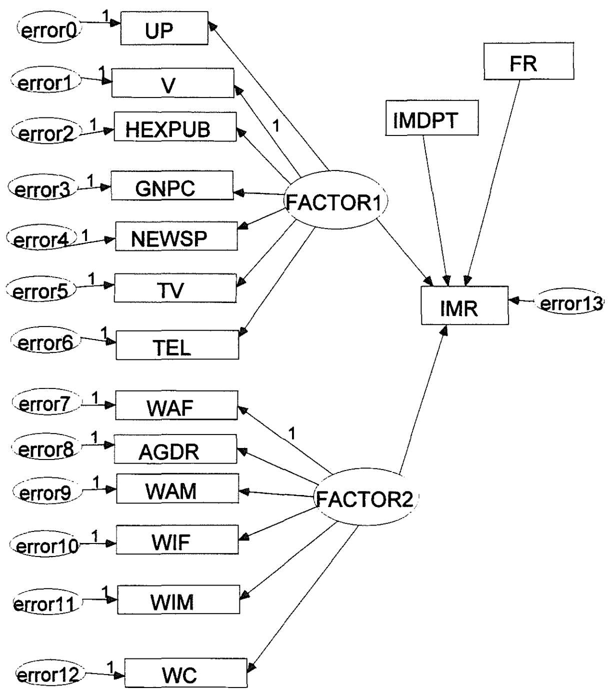

Fig. 2. Analysis of covariance structure.

coefficient of determination (R^2) of the dependent variable IMR was 0.797.

DISCUSSION

In the presence of missing values, working with a large number of variables is difficult when we attempt to include as many countries as possible. We tried to use as wide a range of variables as possible in the analyses, but not all of the selected variables had high correlation to maternal and infant mortality. If we had selected variables from the viewpoint of influence on mortality rates in addition to maintaining the sample size, a different set of samples would have been constructed. This problem can be compensated for the use of pair-wise correlation. The fact that the result of cluster analysis provided an overview similar to that of pair-wise correlation may assure that the set of samples used would be a good representative of the whole samples.

The problem of missing values may be overcome differently. Some variables in the data show very high correlation with one another. In the absence of a certain variable in a sample we could estimate the missing value by using another variable that has high correlation to the missing variable. For example hospital beds (HBEDS) and medical doctors (MDOC) were so close that we could use one of the two to predict the correlation value of the other.

There were many difficulties in working with international data. Usage of different analysis methods could be of help to avoid disparity in judgments. The analyses carried out in this study supported each other and were complementary in their results. We suggest the use of this kind of analysis for each group of different economic levels for further research. This might be helpful for detecting the causal relationship among the variables more clearly. Determinant factors of mortality can be different among different economic groups[8,10].

Maternal and infant mortality have a very high correlation with each other. Moreover, the socioeconomic factors that had a close correlation to one or both of these mortality rates also had high correlations with one another. When variables are closely related to one another, it is difficult to determine the causal relationship among them. When we considered this problem, it was suggested that the factors obtained by factor analysis could explain infant mortality rates slightly better than a selected set of variables. Mortality rates might be more reasonably explained by characteristics of the society as a whole than by the effect of isolated variables[7].

Previous works[2] have discussed extensively the importance of illiteracy, safe water and sanitation on IMR and MMR. In addition, women's illiteracy has been considered crucial for IMR and MMR for a long time[16]. Our results are in a sense consistent with these hypotheses. They were supported by our results from the regression analysis directly using the variables. On the contrary, our result from regression using factors obtained by factor analysis may seem different, but it can be regarded as due to the emphasis placed on the common background that exists behind these hypothetical variables. In other words, the hypothetical factors work together interactively. It is important to realize a society's situation to understand and reduce maternal and infant mortality. Unfortunately, the improvement of socioeconomic levels cannot be considered as an immediate solution to improve maternal and child health.

One remarkable result in relation to what we mentioned above comes from the presence of immunization in the explanatory model. Immunization correlated not significantly with most of the variables and had small correlation with variables such as illiteracy, GNPC, hospital beds or healthcare access. Universal immunization programs could explain the low correlation among these factors[1]. The rate of births attended by health staff and the fertility rate could explain the importance of giving orientation on immunization and family planning to mothers that attend health centers to give birth. We also have to note that in developing countries, vaccination is sometimes carried out in campaigns out of health facilities or house-by-house. It could also be suggested that these campaigns are good to promote reproductive health care. Moreover immunization programs may work more quickly and at lower cost than the improvement of socioeconomic levels.

Social conditions that affect health in a country can be different from those affecting another country. Deviations are notable and lessons should be learned from both developed and developing countries. Observation of the situation of different countries sometimes leads us to deeply understand the effect of certain indicators on maternal and infant mortality, as shown in Table 3. Countries with clear improvement of water provision improve IMR. Safe water is related to diarrhea during the first eleven months of life, but it also means improvement in the quality of life of mothers who do not have to carry water for long distances[9]. The results of the regression analyses include SAFEW, as an explanatory variable. Differently from other works, sanitation did not appear as important as safe water in the modeling.

It is difficult to conclude causal relationships only from statistical analysis. But it is useful to find out plausible relationships between health outcomes and their possible causes. A path diagram based on the analysis of covariance structure was carried out to confirm the importance of socioeconomic variables interacting combined as factors. Covariance structure analysis allows us to use latent variables hidden behind the observed data as explanatory variables. Variables representing living standards have indirect ways of decreasing mortality rates: TV and NEWSP can facilitate access to health information, and vehicles and telephone lines are necessary for access to health services. These variables interacting with health expenditure explain the importance of the nation's level of GNP and its distribution.

Age structure and distribution of the work force have a strong correlation and may be connected to another aspect of the national level of wealth. In countries where most of the population works in the industrial sector, IMR decreases and so does the proportion of working children. The opposite relationship occurs when the proportion of people working in agriculture is large. It is likely that there are severe working conditions in agriculture, especially for women, wich raise mortality rates.

In our analysis the importance of fertility reduction and immunization were highlighted. Family planning is not the only factor contributing to fertility reduction, but it has proved its efficacy in many countries in the last decades[10]. Moreover investing in family planning and immunization together with health education might have a faster effect on maternal and infant mortality reduction than improving socioeconomic standards.

International experience teaches us that the results obtained in this study are possible to achieve. Programs intended to reduce maternal and infant mortality need to be based on health development strategies that combine socioeconomic and health indicators. Data collection at all levels is also important as a basis of planning and evaluation of public health policies.

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