ORIGINAL ARTICLE

FORECASTING HEALTH INDICATORS OF PAKISTAN

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Background: Forecasting of health indicators is of great importance for health policy makers. This study is aimed to forecast some important health indicators like crude death rate (CDR), crude birth rate (CBR), and infant mortality rate (IMR) and total fertility rate (TFR) of Pakistan. **Methods:** In this retrolective study, annual data of these indicators for years 1984–2010 have been used. The simple linear regression model with time as independent variable has been used to forecast these health indicators. **Results:** The within-sample forecast results are close enough to the actual values. All the forecast values of the stated indicators tend to decrease with time. The forecast values of CDR, CBR, IMR and TFR for year 2020 are 12.85, 5.61, 43.61 and 0.93, respectively. **Conclusion:** Although the forecast values show an improvement in health indicators of Pakistan but the IMR is expected to remain high even in 2020, a concern for the health policy makers.

Keywords: Crude birth rate; Crude death rate; Health indicator; Infant mortality rate; Time trend model; Total fertility rate

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INTRODUCTION

The health indicators for any country reflect the public health conditions in that country. The health indictors are widely used to describe the public health problems, to indicate change over time in the level of health of a population and to assess the extent the objectives of several health programs running in a country are achieved. There are several health indicators available in the literature[1–7] that are used to assess the health conditions of a country like, crude birth rate (CBR), crude death rate (CDR), infant mortality rate (IMR) and total fertility rate (TFR) etc. These indicators throw light on health conditions and medical facilities of a country.

Crude birth rate is the number of live births in a population during a specified year per thousand population of the same year. The CBR provides an overall picture of the fertility in the country. A high birth rate causes problems including education of growing number of children, creating jobs for these children when they enter the labour force, etc. On the other hand, the CDR provides an overall picture of the level of mortality in the country. A high death rate point towards the poor health conditions of a country.[8,9]

The IMR is an important indicator to judge health situation in the country. It is considered as a useful indicator to display level of health or development of a country. It is defined as the number of deaths in children under one year of age per 1000 live registered births in the same year.[1,10]

TFR measures the average number of children that would be born per woman if all women lived to the end of child bearing age.[2] The TFR is a more direct measure of the level of fertility than the CDR, since it refers to births per woman. This indicator shows the potential for population change in a country.

In Pakistan, health status of the population at large has improved considerably over time. However, by international comparison, the status is mixed, but generally improvements on this front have been reported.[11] Table-1 shows a comparison of different countries regarding the stated health indicators. Relatively high levels of CBR, IMR and TFR in Pakistan have been observed as compared to rest of the countries. Due to the chief importance of the above indicators for the assessment of a country's health status and other dimensions, it is important to estimate and forecast these indicators. These forecast will provide guideline for the relevant policy makers. Many researchers have focused in their studies on modeling and forecasting the health indicators of different countries by various approaches.[3–5] Time trend model and autoregressive integrated moving average (ARIMA) models have been used to forecast the CBR, TFR, gross reproduction rate (GRR) and net reproduction rate (NRR) of Bangladesh.[6]

The forecasting of Pakistan's health indicators could not attain much attention of researchers. Though an attempt[7] has been made to forecast some health facilities like number of hospitals, number of dispensaries, number of total beds etc. of Pakistan but nothing has been done for the forecast of the above stated health indicators. Present article addresses the same area of forecasting the CDR, CBR, IMR and TFR of Pakistan. There are several other health indicators, i.e., life expectancy at birth, maternal mortality rate and child mortality etc. that could be included but the availability of data restricts to the above mentioned indicators only.

MATERIAL AND METHODS

This was a retrolective study in which data about CDR, CBR, IMR and TFR for 27 years (1984–2010) have been obtained from the Handbook of Statistics on Pakistan Economy, published by the State Bank of Pakistan.[11] The missing observation of IMR for year 1999 and the same of TFR for year 2002 were obtained by interpolation method. The missing observations of CDR for year 2005 and TFR for year 2003, 2004 and 2005 were obtained from Economic Census of Pakistan of various years.[9]

The scatter plots of these indicators, given in figure-1 show that the aforementioned indicators are linearly related with time. So the linear regression models with time (t) as independent variable are estimated for each series by the method of ordinary least squares (OLS). Following is the stated linear regression model:

$$Y_t = \alpha + \beta t + \varepsilon_t ;\ (t = 1, 2, \ldots, T), \qquad (1)$$

where Y_t represents CDR, CBR, IMR or TFR at time t, α and β are unknown parameters and ε_t is the random error meeting the classical assumptions. Similar model has also been adopted by various researchers in their studies for forecasting purpose.[6,7,12]

For estimation of the models, the data for years 1984–2005 have been used. The remaining five-year (2006-2010) data have been used for the evaluation of our within sample forecast that would assess the quality of forecast. For such assessment, various measures are available in the literature[13] which are mainly mean error (ME), mean absolute error (MAE) and root mean square error (RMSE) etc. These measures are as under:

$$\textit{Mean Error (ME)} = \frac{\sum_{t=1}^{T}(Y_t - \hat{Y}_t)}{T},$$

$$\textit{Mean Absolute Error (MAE)} = \frac{\sum_{t=1}^{T}|Y_t - \hat{Y}_t|}{T},$$

$$\textit{Root Mean Square Error} = \sqrt{\frac{\sum_{t=1}^{T}(Y_t - \hat{Y}_t)^2}{T}},$$

where T is the number of observation for the period of forecast assessment.

RESULTS AND DISCUSSION

Using Eq. (1), the resulting estimated models are:

$$\hat{CBR}_t = 46.1350 - 0.8995t, \qquad (2)$$

$$\hat{CDR}_t = 11.3416 - 0.1550t, \qquad (3)$$

$$\hat{IMR}_t = 118.0779 - 2.0127t, \qquad (4)$$

$$\hat{TFR}_t = 7.4143 - 0.1752t. \qquad (5)$$

Figure-2 presents the actual and estimated values of the health indicators CBR, CDR, IMR and TFR for Pakistan. It is obvious from the signs of the estimated slope coefficients that all the health indicators have negative slopes when regressed on time. It shows that with the passage of time, the health indicators tend to decline.

This is a notion about the improvement of health conditions in Pakistan over time. For instance, for each upcoming year, the IMR decreases by 2 deaths per 1,000 live registered births in the same year.

Using the estimated models, Eq. (2)-(5), the forecast values of the indicators under study for years 2006-2010 (i.e., out-of-sample forecasting) are obtained. Table-3 presents the actual and forecast values of the said indicators. It can be seen, in mostly cases, that the forecast values are fairly closer to the actual values.

For the evaluation of the forecast values, ME, MAE, and RMSE are computed and presented in Table 4. All the measures display almost similar results for each of the indicators showing reasonably adequate forecast values.

Finally, Equations (2)-(5) are used to forecast health indicators for years 2015 and 2020. The results are presented in table-5. The CBR and IMR are expected to remain high enough by the end 2020. On the other hand, the TFR forecast shows a dramatic decline with the passage of time.

Table-1: Health indicators of various countries

Country	CBR	CDR	IMR	TFR
Pakistan	24.30	6.80	61.27	3.07
India	20.60	7.43	46.07	2.58
Bangladesh	22.53	5.71	48.99	2.55
Sri Lanka	17.04	5.96	9.47	2.17
China	12.31	7.17	15.62	1.55
USA	13.68	8.39	5.98	2.06
Japan	8.39	9.15	2.21	1.39

Source: CIA world fact book – the figures are as on January 1, 2012

Table-2: Summary of the estimated models

Indicator	Parameters	Estimates	Standard Error	*t*-statistic	*p*-value	R^2
CBR	Intercept	46.1350	0.4415	104.4937	0.0000	0.97
	Slope	-0.8995	0.0336	-26.7578	0.0000	
CDR	Intercept	11.3416	0.1640	69.1747	0.0000	0.89
	Slope	-0.1550	0.0125	-12.4163	0.0000	
IMR	Intercept	118.0779	2.1911	53.8892	0.0000	0.88
	Slope	-2.0127	0.1668	-12.0645	0.0000	
TFR	Intercept	7.4143	0.0679	109.1849	0.0000	0.98
	Slope	-0.1752	0.0052	-33.8775	0.0000	

Table-3: Comparison between the actual and (out-of-sample) forecast values of the health indicators

Year	CBR		CDR		IMR		TFR	
	Actual	Forecast	Actual	Forecast	Actual	Forecast	Actual	Forecast
2006	26.10	25.44	7.10	7.89	76.70	71.85	4.10	3.27
2007	29.10	24.54	7.90	7.74	72.40	69.84	3.90	3.09
2008	28.70	23.64	7.70	7.59	70.20	67.83	3.80	2.91
2009	28.40	22.74	7.60	7.44	68.20	65.82	3.70	2.73
2010	28.00	21.84	7.40	7.29	73.50	63.81	3.60	2.55

Table-4: Measures for goodness of forecast of health indicators

Measurement	Health Indicator			
	CBR	CDR	IMR	TFR
ME	4.41	0.07	4.44	0.78
MAE	4.41	0.34	4.44	0.78
RMSE	4.83	0.38	5.26	0.79

Table-5: Forecast of health indicators for year 2015 and 2020

Year	Forecast			
	CBR	CDR	IMR	TFR
2015	17.35	6.38	53.67	1.81
2020	12.85	5.61	43.61	0.93

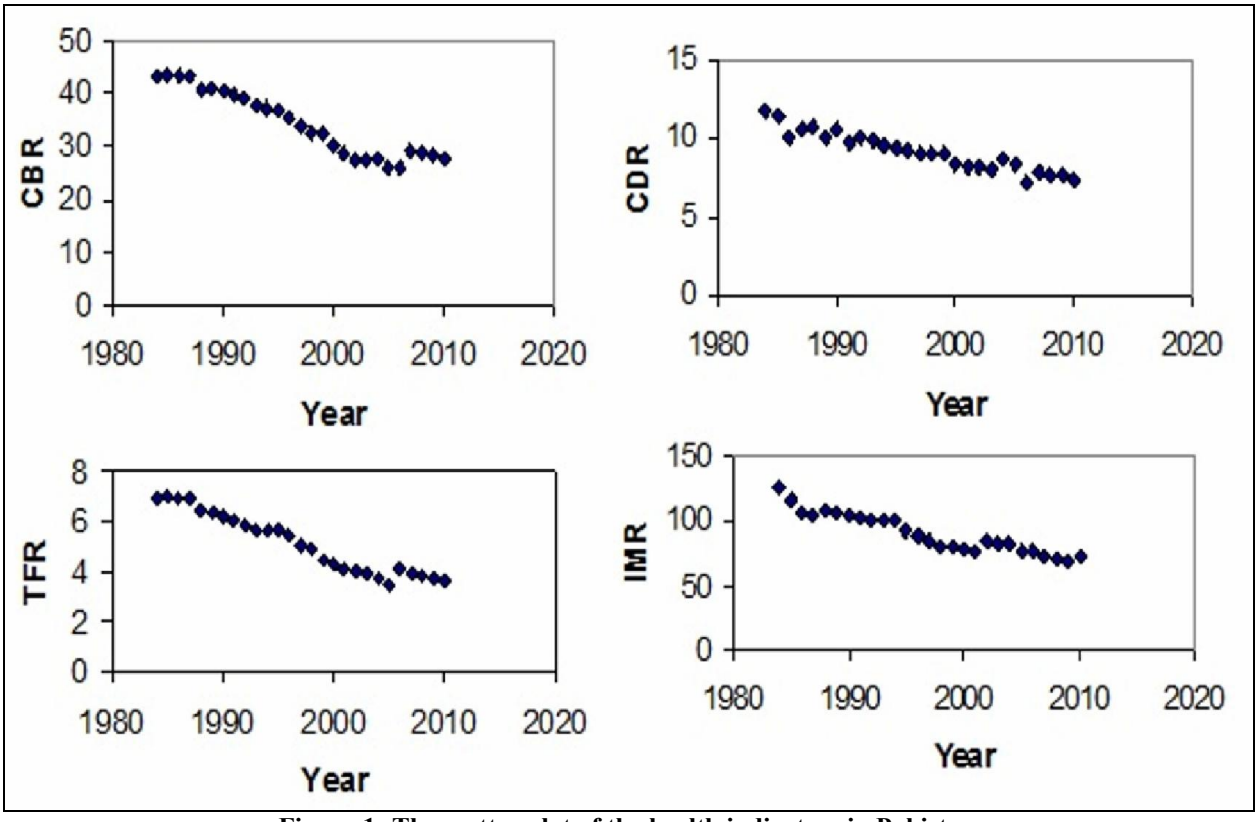

Figure-1: The scatter plot of the health indicators in Pakistan

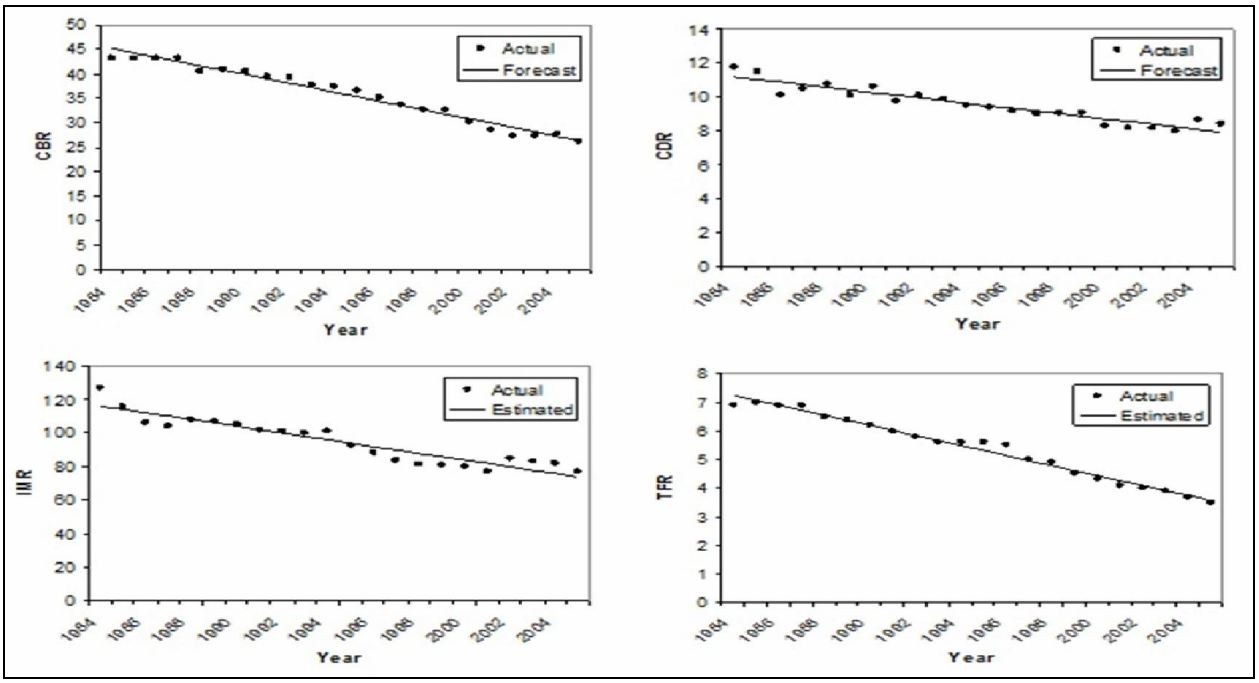

Figure-2: Actual and estimated health indicators of Pakistan

CONCLUSION

In this study, an attempt has been made to forecast health indicators of Pakistan. The models have been developed to forecast health indicator of Pakistan. The data for the period of twenty two years (1984–2005) are used to estimate the models. The data for years, 2006–2010, are used for the evaluation of within sample forecast. Finally, the developed models are used to forecast health indicators for years 2015 and 2020. The forecast values of all the indicators tend to decrease with time. The TFR tends to decrease, dramatically with time. However, in order to meet the Millennium Development Goals (MDG's) set by the United Nations (UN) in 2000, Pakistan is required to reduce the IMR to 40 deaths per 1000 live births up to 2015[14] that does not seem to be fulfilled even by the end of 2020 as this year forecast is 43.61.

AUTHOR'S CONTRIBUTION

AM gave the statistical framework and primary draft. MA conceived the idea and laid out the design. MK obtained the data and performed the statistical analysis. SA interpreted the results, reviewed and edited the draft.

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