Original Article

FORECASTING MEASLES COVERAGE USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT:

OBJECTIVES: To propose the forecasting model for monthly measles infant immunization coverage a significant concern in disease management and control.

DESIGN: The reported data of monthly infant measles immunization coverage to National institute of health, Islamabad, Pakistan from January 2009 to October 2014 for the present study has been taken from Pakistan bureau of statistics with total time series entities 70. National institute of health, Islamabad took the record of per month number of doses administered (0-11 months) children by the registered health centre in Pakistan.

PERIOD: January 2009 to October 2014.

SETTING: Pakistan Bureau of Statistics (Statistics House) Methods: Artificial neural network (ANN) analysis has been carried out to develop a forecasting model.

RESULTS: Several combinations of input and hidden layers are executed by taking under consideration the root mean square error in the selection of final efficient model. The efficient ANN model has twelve input nodes, nine hidden nodes and one output node with back propagation learning rate 0.05 and preferred activation function as hyperbolic tangent function. The established ANN model revealed that the increment for infant measles coverage is 7.58% expected in next six month.

CONCLUSIONS: ANN 12-9-1 is an efficient model for forecasting the monthly measles infant immunization coverage in Pakistan.

KEYWORDS: Artificial neural network; forecasting model; measles coverage

INTRODUCTION:

Measles is a viral disease which belongs to paramyxovirus family. The disease occurs only in humans, which spreads in a body through by first infecting mucous membrane. Although, measles is curable and have economical treatment, yet it is still one of the largest reasons of mortality in young children. Globally, there were 400 deaths per day was found in 2013. During the past decade (2000-2013), the deaths due to measles has decreased substantially (75%); saving approximately 15.6 million children worldwide[1]. Before 2000, the Eastern Mediterranean Region (EMR) member countries of World Health Organization made a joint decision to eliminate measles from their countries by 2010[2]. The Expand Program on Immunization (EPI) was initiated among majority of these countries in 1980[3]. The program was firstly funded by UNICEF and later on handled by the respective governments. Ninety percent of goal was set to reduce the mortality due to measles, keeping the incidence rate limited to 1 per 1000000 cases. The reduction was reached to 96% in 2011 with an incidence rate of less than 2 cases per 100000 population, except for some parts of Sindh province where incidence rate was found even

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greater than 11 per million[4].

In 2011, 1 out of 11 million infants are those who did not receive MCV1, the figure surges to 1.7 out of 13.2 million infants in 2013[5]. According to WHO estimates[6], the coverage ratio was found to be 61 and 58 percent for MCV1 and MCV2 respectively. From 1990-2013, the measles vaccine coverage for children aged 12-23 months was increased from 50-61 percent[7]. Yet this ratio did not reach the targeted ratio set by World Health Organization in the past although, the number of outbreaks was substantially decreased in the previous years (35 cases as on 2014). Sindh has highest number of outbreaks compared with other provinces of country[8].

Artificial Neural Network in Medical Field:

Artificial neural network (ANN) approach has been achieved much popularity in last few years. Although the development of ANNs was mainly biologically motivated, but afterwards they have been applied in many different areas, especially for forecasting and classification purposes[9-11]. The basic objective of ANN was to construct a model for mimicking the intelligence of human brain into machine. Similar to the work of a human brain, ANN try to recognize regularities and patterns in the input data learnt from experience and then provide generalized results based on their known previous knowledge. From medical perspective the time series models play a significance role in disease prediction. Many researchers applied the ANN algorithm due to its accuracy than other time series models[12,13]. Acar et al'[14] used ANN to predict the diabetes mellitus and found that ANN 8-20-1 as optimum structure. Sapon et al[15] used the ANN and forecast the diabetes. Artificial neural networks were used for infectious diarrhea prediction and ANN 9-4-1found to be optimum structure for diarrhea forecast[16].

METHODOLOGY:

Source of data: A monthly registered data for the infant measles immunization coverage from January 2009 to October of 2014 total time series entities 70 was taken from Pakistan Bureau of Statistics (Statistics House) government of Pakistan, Islamabad, Pakistan for the present study. Artificial neural network[9,11]. is carried out to uncover the infant measles immunization coverage trend and the development of forecasting model by using the statistical software Zaitun time series.

ANN which involve of a large number of simple and highly interconnected computing components, called layers or nodes or neurons are a branch of artificial intelligence methods. The formulation of ANNS depends upon a set of layers namely input layer, hidden layers, and output layer. These layers further comprise interconnections between the nodes of successive layers through the weights. The internal weights of the network are adjusted by an iterative process termed training and the algorithm used for this purpose called training algorithm. An appropriate ANN model can be selected by taking into account the various sets of nodes. Among various activation functions like logistic sigmoid function, linear, hyperbolic tangent, Gaussian, etc. can also be used[17]. In our study the preferred activation function was hyper bolic tangent function.

Measures of Forecast Accuracy:

To compare forecasted values with actual values to see how well one model works or to compare models[18]. Some popular and very useful accuracy measures are (i) Mean Square Error (MSE). Square root of mean square error is termed as root mean square error (RMSE) (ii) mean absolute error (iii) mean absolute percentage error.

Forecast error = Actual value – Forecast value

Mean square error$=\frac{\sum(A_t-F_t)^2}{n}$(1)

Where A_t and F_t is actual and forecast value respectively.

RESULTS:

Monthly number of Measles doses administered (011 months) children during January 2009 to November 2014 with measure of central tendency, lower quartile (Q1), upper quartile

(Q3), absolute measure of dispersion, minimum and maximum immunization coverage are given in Table 1. On the average per month infant immunization coverage is (441544).

To achieve an efficient ANN model for forecasting the monthly infant immunization coverage different set of parameters .i.e. input and hidden layers (weights) are executed by using the learning rate 0.05 and hyperbolic tangent function as an activation function while the maximum number of iteration used 3000. The detail description of various set of nodes and root mean square error are illustrated in table 2. The established efficient ANN model is 12-9-1with least root mean square error 6213.

Table 1: Descriptive statistics

Coverage	Mean	StDev	Minimum	Q1	Q3	Maximum
Measles	441544	44359	307165	424407	463027	631982

Table 2: ANN model selection using various combinations of input and hidden layers and RMSE

	Input layer											
	1	2	3	4	5	6	7	8	9	10	11	12
Hidden layer	Root mean square error											
1	402	398	394	364	390	384	389	384	350	239	238	239
	81	43	13	81	88	90	69	45	55	19	19	97
2	402	399	392	331	353	327	256	340	276	236	238	233
	20	00	90	78	07	21	99	26	76	46	39	32
3	402	389	387	330	269	281	256	264	231	176	157	193
	15	83	22	18	52	65	20	21	39	11	93	26
4	402	398	384	309	259	226	226	231	178	146	152	117
	46	96	71	26	05	05	39	65	39	71	82	09
5	402	380	384	308	256	242	208	208	148	134	136	110
	13	55	69	64	15	97	78	94	11	08	91	48
6	402	382	385	305	256	208	269	214	144	105	150	108
	26	75	66	97	53	51	00	75	79	22	57	54
7	402	377	384	310	234	240	215	210	153	130	107	811
	12	78	64	31	41	29	06	24	12	96	86	8
8	402	377	381	313	245	223	202	181	119	878	109	966
	19	54	66	81	99	85	60	87	98	9	73	2
9	402	377	383	315	244	255	197	167	777	126	116	*62
	17	17	40	63	37	37	61	70	5	03	19	13
10	402	377	387	315	249	242	167	208	143	931	139	100
	96	32	97	36	96	44	31	88	84	9	45	75
11	402	373	382	318	258	228	213	208	867	115	118	753
	19	46	89	14	97	81	43	75	9	12	38	2
12	402	373	382	306	266	237	202	181	110	119	969	714
	60	06	50	06	71	39	66	49	04	38	4	4

ANN (12-9-1) architecture for infant measles coverage forecast is shown in figure 1. The graphical illustration of the final selected model is shown form Figure 2 through figure 5 (appendix A). The predicted values agree well the actual values are shown in Figure 2 by taking the monthly infant measles immunization coverage along y-axis and time (month) along x-axis. Half year forecast made successfully by using the ANN 12-9-1 (Figure 3) the expected increment 7.86% in next six month (Table 3). The plot of residual showing the pattern of randomness (Figure 4) and the plot of actual versus fitted is illustrated in Figure 5.

***lowest value of RMSE**

Table 3: Expected per cent change under ANN model

Actual (May 2014 to Oct 2014)	Forecast (Nov 2014 to Apr 2015)	% change
2,683,384	2,894,415	7.86

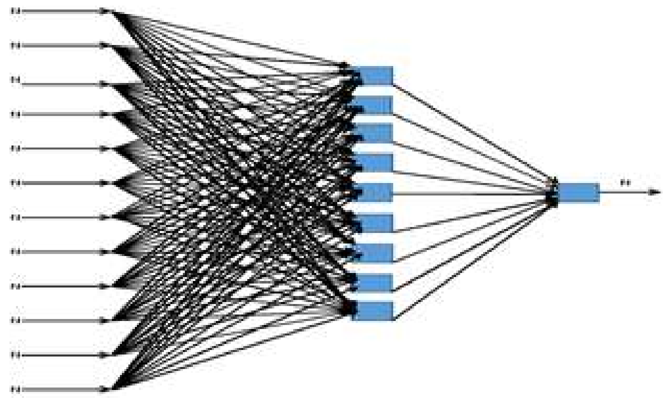

Figure 1: ANN (12-9-1) architecture for infant measles coverage forecast

Appendix A

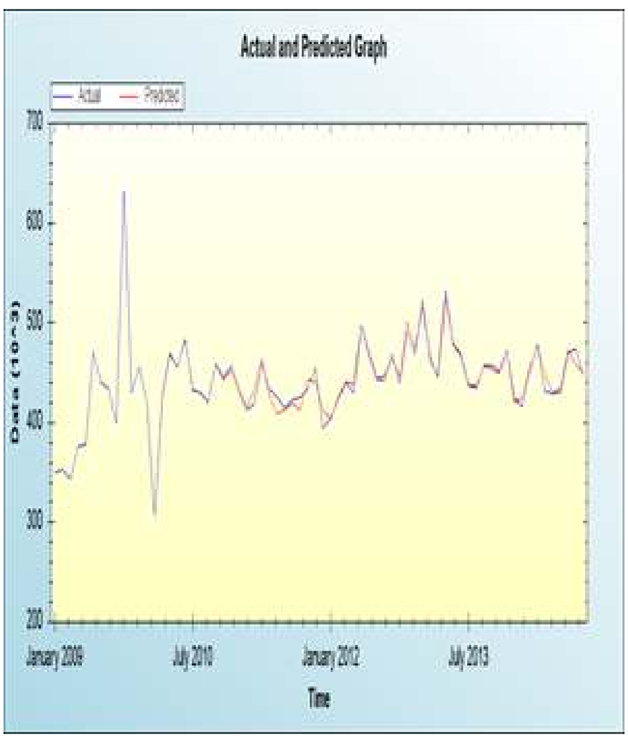

Figure 2: A plot of actual and predicted

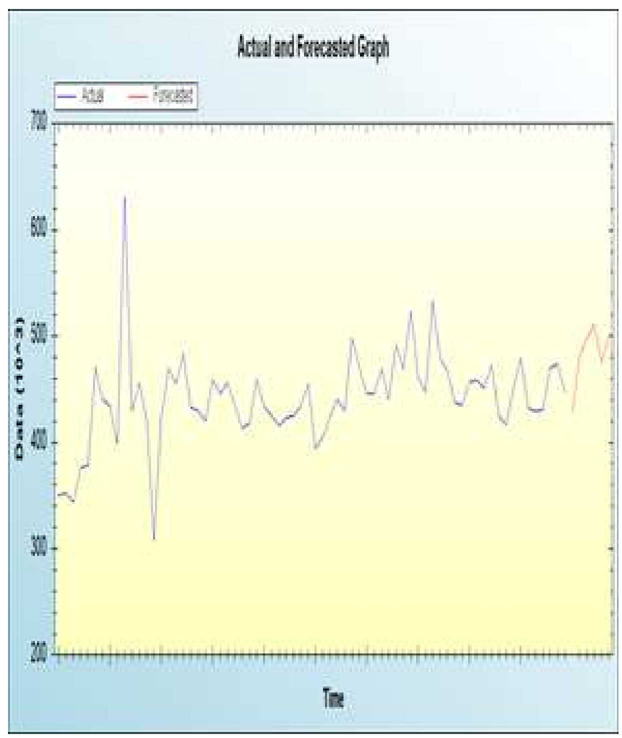

Figure 3: A plot of actual and forecasted

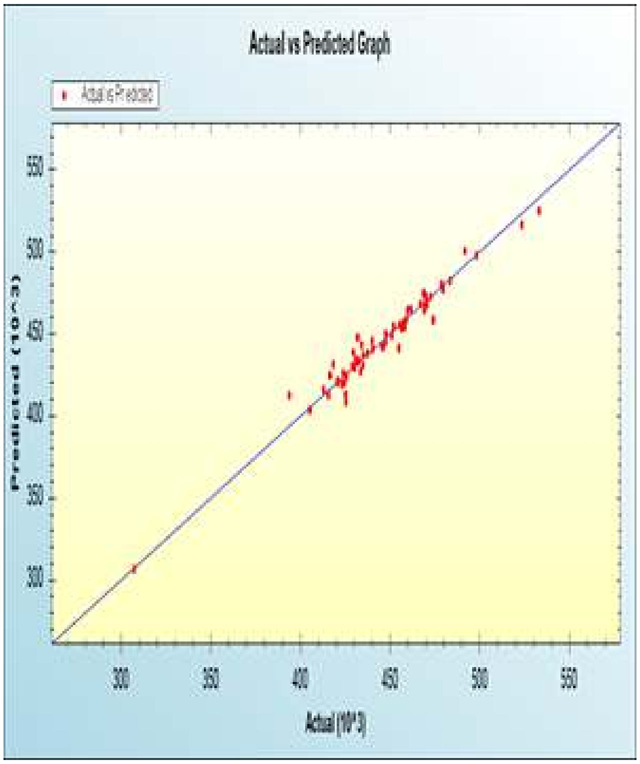

Figure 4: A plot of actual vs predicted

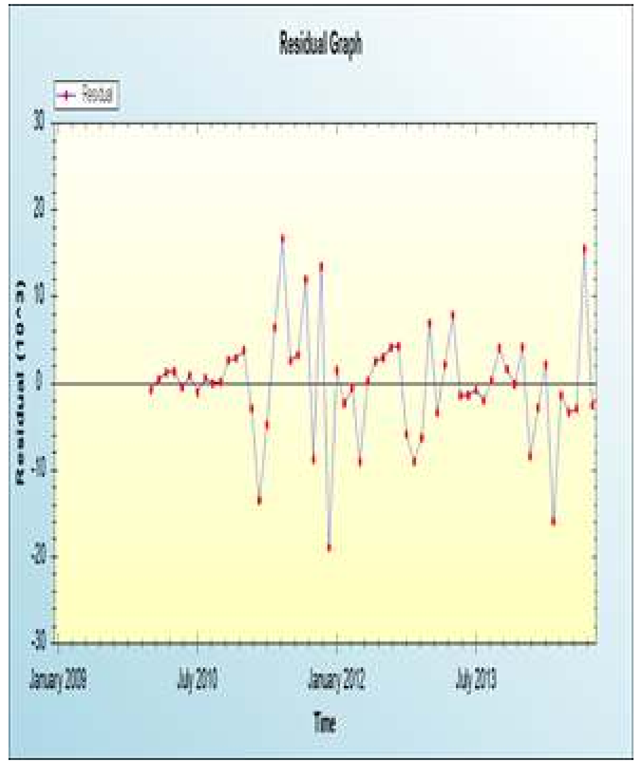

Figure 5: A plot of residual

DISCUSSIONS:

World Health organization measles surveillance data showed globally reduction in measles cases from 67524 in 2015 to 16846 cases in 2016 as well as reduction (79%) in deaths from 546800 to 114900 during the period of 2000 to 2014[19,20]. Many developing countries, particularly from Asia and Africa are still struggling to manage the adequate vaccination coverage and control the mortality due to measles. Although a rising trend in infant measles vaccine coverage is expected, but achieving a high level of coverage is not enough, the outbreaks have occurred in under vaccinated population. According to WHO report on measles the confirmed cases of measles in Pakistan increased as 6437 cases in 2017 as compared to the previous year 2806 cases[21]. There many reasons that caused for inadequate vaccination coverage that results the outbreaks of measles cases for instance poor vaccination coverage, corruption, infrastructure related issues, socio demographic constrains and religious leaders opposition for polio vaccine and other vaccination. A study from Karachi showed a very low measles vaccination about 34.9% and 22.7% at age 9 and 15 months respectively[22]. Corruption yet is another major obstacle to the Pakistani health care systems; in 2012 Pakistan Transparency International identified corruption is a main problem in the country. Inadequate source allocation and reckless attitude of the health care providers and inadequate governmental guideline for management of healthcare activities are the important factor to put at risk the Extended Program on immunization in Pakistan[23].

Socio-economic determinants have the potential to affect immunization programs. Many children remain unvaccinated due to many socio-economic constraints, poor marginalized people have a low awareness with respect to the importance of polio vaccine along with social hierarchies, and educational attainment of parents is a strong indicator of defining awareness level regarding immunization[24]. Immunization is varying geographical area. Large populations and fragile immunization structures make these children difficult to reach. Naeem et al (2011)[25] made a cross sectional study in Peshawar and found that immunization in rural areas is lower than urban areas due to many factors like of accessibility to health Centre's, lack of awareness and misconceptions, while parents in rural areas have a much lower education status and knowledge regarding immunization.

CONCLUSION:

Pakistan needs smart effective and proactive anti measles polices to eradicate measles. Although a rising trend in infant measles vaccination coverage is expected, but achieving a high level of coverage is not enough, the outbreaks of cases have occurred in under vaccinated population. After the implementation of artificial neural network algorithm, ANN 12-9-1 is an optimum forecasting model for monthly infant measles immunization coverage in Pakistan. The availability of these statistical outcomes will serve as a guide to improve measles vaccination and formulate adequate policies and program so that the morbidity and mortality due to measles can be declined in children.

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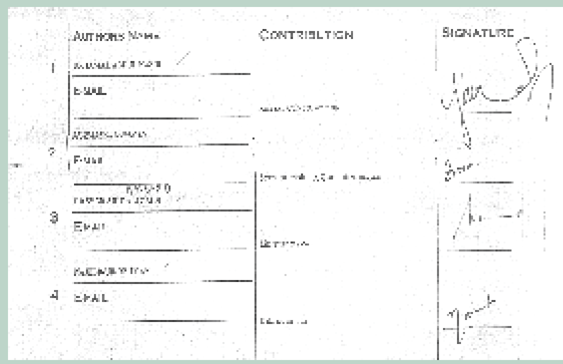
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When Imam Ali was asked about Faith in Religion, he replied that the structure of faith is supported by four pillars endurance, conviction, justice and jihad.

Hazrat Ali (Karmulha Wajhay)