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# Predicting Medical Expenses Using Artificial Neural Network

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***Abstract**: In this research, the Artificial Neural Network (ANN) model was developed and tested to predict the rate of treatment expenditure on an individual or family in a country. A number of factors have been identified that may affect treatment expenses. Factors such as age, grade level such as primary, preparatory, secondary or college, sex, size of disability, social status, and annual medical expenses in fixed dollars excluding dental and outpatient clinics among others, as input variables for the ANN model. A model based on the multi-layer Perceptron topology was developed and trained using data on 5574 cases. The evaluation of the test data shows that the ANN model is capable of predicting correctly Medical Expenses.*

**Keywords**: Artificial Neural Networks, Medical Expenses, ANN, Predictive Model.

## 1. INTRODUCTION

The main objective of the system of predicting the rate of individual treatment expenses is to identify individuals who spend the lowest costs on treatment in this country. The high or low cost of treatment affects the individual positively or negatively, moreover, has a general effect on the progress of the country itself; The low cost of treatment in one country indicates a lack of disease and the progress of the state.

If you pay non-covered medical expenses or private health insurance, you can claim tax compensation for some of these expenses. These expenses include the costs involved in nursing home care.

Of course one expects to have a rate of treatment expenses of the jobs with a number of factors that include his health. On the other hand it is clear that it will be very difficult to find a mathematical model that may be an appropriate model for this relationship between performance / factors. However, one of the realistic methods of predicting the rate of treatment expenditure may be by examining historical data on its expenditure in treatment.

The practical approach to this type of problem is to apply a regression analysis in which historical data are better integrated into some functions. The result is an equation in which both input xj is multiplied by wj; the sum of all these products is constant,, and then an output of $y = \Sigma$ wj xj +, is given, where j = 0.n.

The problem here is that it is difficult to choose a suitable function to capture all data collection and to automatically adjust the output in case more information is obtained, because the filter's performance is controlled by a number of factors, and this control will not be any obvious regression model.

The artificial neural network, which simulates the human brain in solving a problem[3-28], is a more common approach that can address this type of problem. Thus, attempting to develop an adaptive system such as artificial neural network to predict student performance based on the results of these factors[29-40].

The objectives of this study are:

- To determine the factors affecting the rate of treatment expenditure
- To convert these factors into appropriate models for adaptive system coding
- Design of an artificial neural network that can be used to predict the rate of treatment expenditure based on some pre-defined individual data

## 2. LITERATURE REVIEW

Preceding medical care researches have mainly used linear regression to model medical care costs. Smith et al. [1] efforts to solve alike problem to the current one: predicting payments-to-charge ratios (PCR) for Medicare by hospital. The study used a regression model with features including casemix variables, hospital characteristics, and state characteristics. However, we used neural network.

The aim of the study of Mahboubi et. Al [2] was to determine the costs imposed on diabetic patients using Artificial Neural Network. In that study Artificial Neural Network using Multiple Layer Perception (MLP) was used to investigate the costs imposed on Diabetic patients. The variable related to treatment of diabetes was calculated through a neural network covering 8 different output layers.

## 3. THE ARTIFICIAL NEURAL NETWORKS

An Artificial Neural Network (ANN) is an arithmetical model that is motivated by the organization and/or functional feature of biological neural networks[41-51]. A neural network contains an interrelated set of artificial neurons, and it processes information using a connectionist form to computation. As a general rule an ANN is an adaptive system that adjusts its structure based on external or internal information that runs through the network during the learning process. Recent neural networks are non-linear numerical data modeling tools. They are usually used to model intricate relationships among inputs and outputs or to uncover patterns in data. ANN has been applied in numerous applications with considerable attainment [7-8]. For example, ANN have been effectively applied in the area of prediction, handwritten character recognition, evaluating prices of lodging [9-10].

Neurons are often grouped into layers. Layers are groups of neurons that perform similar functions. There are three types of layers. The input layer is the layer of neurons that receive input from the user program. The layer of neurons that send data to the user program is the output layer. Between the input layer and output layer are hidden layers. Hidden layer neurons are only connected only to other neurons and never directly interact with the user program. The input and output layers are not just there as interface points. Every neuron in a neural network has the opportunity to affect processing. Processing can occur at any layer in the neural network. Not every neural network has this many layers. The hidden layer is optional. The input and output layers are required, but it is possible to have on layer act as both an input and output layer [10].

ANN learning can be either supervised or unsupervised. Supervised training is accomplished by giving the neural network a set of sample data along with the anticipated outputs from each of these samples. Supervised training is the most common form of neural network training. As supervised training proceeds the neural network is taken through several iterations, or epochs, until the actual output of the neural network matches the anticipated output, with a reasonably small error. Each epoch is one pass through the training samples. Unsupervised training is similar to supervised training except that no anticipated outputs are provided. Unsupervised training usually occurs when the neural network is to classify the inputs into several groups. The training progresses through many epochs, just as in supervised training. As training progresses the classification groups are “discovered” by the neural network [9].

## 4. METHODOLOGY

By looking deeply through literature and soliciting the experience of human experts on the rate of individual treatment expenses, a number of factors were identified that have an impact on student performance in the second year. These factors were carefully studied and synchronized with an appropriate number suitable for coding the computer within the modeling environment ANN. These factors were classified as input variables. Output variables reflect some potential levels

### 4.1. The Input Variables

The specific input variables are those that can be obtained simply from the individual treatment expenses system. Input variables are:

1 annual medical expenditures in constant dollars excluding dental and outpatient mental
2. log(coinsrate+1) where coinsurance rate is 0 to 100,
3. individual deductible plan ?,
4 log(annual participation incentive payment) or 0 if no payment,
5 log(max(medical deductible expenditure)) if IDP=1 and MDE>1 or 0 other,
6. physical limitation ?,
7. number of chronic diseases,
8. self–rate health (excellent, good, fair, poor),
9. log of annual family income (in \$),
10. log of family size
11. years of schooling of household head
12. exact age
13. sex (male, female)
14. age less than 18 ?
15. is household head black ?

**Table 1.** Input Data Transformation

| S/N | Input variable | Domain | S/N | Input variable | Domain |
|---|---|---|---|---|---|
| 1 | Lc | 0 – 4.564348 | 8 | linc | 0 - 10.28324 |
| 2 | idb | Yes – 1<br>No - 0 | 9 | lfam | 0 - 2.564949 |
| 3 | lpi | 0 – 7.163699 | 10 | educdec | 0 - 25 |
| 4 | fmde | 0 – 8.294049 | 11 | age | 0.0253251 – 63.27515 |
| 5 | physlim | Yes – 1<br>No - 0 | 12 | sex | Female – 0<br>Male - 1 |
| 6 | ndisease | 0 – 58.6 | 13 | child | Yes – 1<br>No - 0 |
| 7 | health | Poor – 0<br>Fair – 1<br>Good – 2<br>Excellent - 3 | 14 | black | Yes – 1<br>No - 0 |

### 4.2. The Output Variable

The output variable of the ANN model as in table 2.

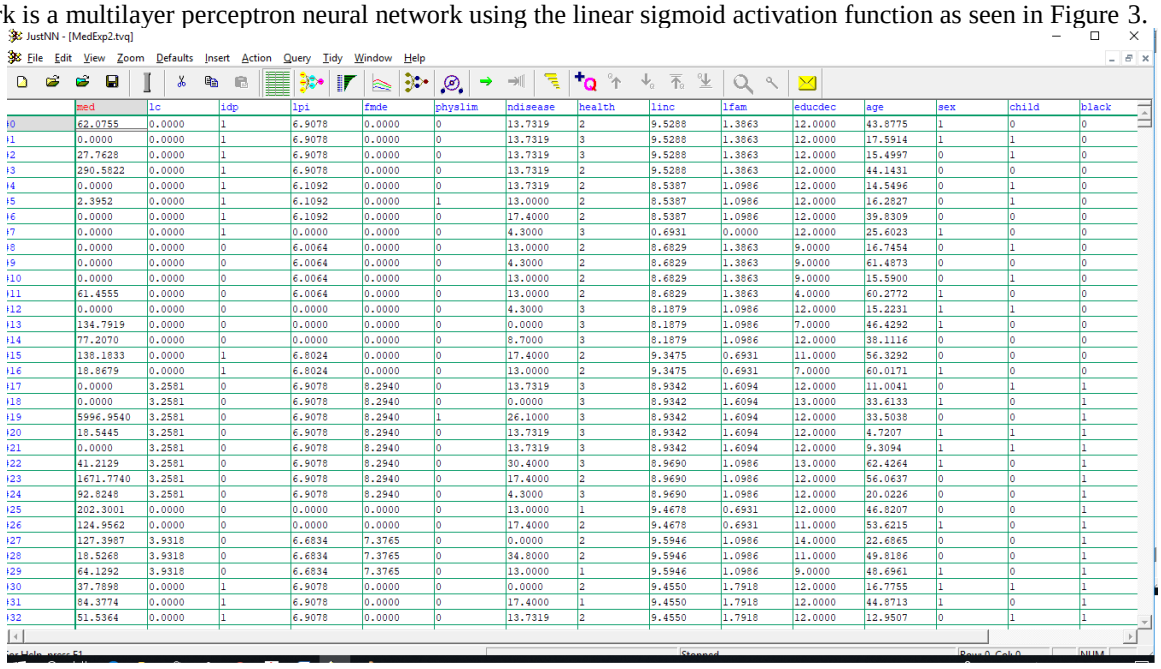
**Table2:** output variable

| S/N | Output Variable | Domain |
|---|---|---|
| 1 | med | 0 - 39182.02 |

## 5. Design of the Neural Networks

### 5.1. Network Architecture

The network is a multilayer perceptron neural network using the linear sigmoid activation function as seen in Figure 3.




| | med | lc | idp | lpi | fmde | physlim | ndisease | health | linc | lfam | educdec | age | sex | child | black |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 62.0755 | 0.0000 | 1 | 6.9078 | 0.0000 | 0 | 13.7319 | 2 | 9.5288 | 1.3863 | 12.0000 | 43.8775 | 1 | 0 | 0 |
| 1 | 0.0000 | 0.0000 | 1 | 6.9078 | 0.0000 | 0 | 13.7319 | 3 | 9.5288 | 1.3863 | 12.0000 | 17.5914 | 1 | 1 | 0 |
| 2 | 27.7628 | 0.0000 | 1 | 6.9078 | 0.0000 | 0 | 13.7319 | 3 | 9.5288 | 1.3863 | 12.0000 | 15.4997 | 0 | 1 | 0 |
| 3 | 290.5822 | 0.0000 | 1 | 6.9078 | 0.0000 | 0 | 13.7319 | 2 | 9.5288 | 1.3863 | 12.0000 | 44.1431 | 0 | 0 | 0 |
| 4 | 0.0000 | 0.0000 | 1 | 6.1092 | 0.0000 | 0 | 13.7319 | 2 | 8.5387 | 1.0986 | 12.0000 | 14.5496 | 0 | 1 | 0 |
| 5 | 2.3952 | 0.0000 | 1 | 6.1092 | 0.0000 | 1 | 13.0000 | 2 | 8.5387 | 1.0986 | 12.0000 | 16.2827 | 0 | 1 | 0 |
| 6 | 0.0000 | 0.0000 | 1 | 6.1092 | 0.0000 | 0 | 17.4000 | 2 | 8.5387 | 1.0986 | 12.0000 | 39.8309 | 0 | 0 | 0 |
| 7 | 0.0000 | 0.0000 | 1 | 0.0000 | 0.0000 | 0 | 4.3000 | 3 | 0.6931 | 0.0000 | 12.0000 | 25.6023 | 1 | 0 | 0 |
| 8 | 0.0000 | 0.0000 | 0 | 6.0064 | 0.0000 | 0 | 13.0000 | 2 | 8.6829 | 1.3863 | 9.0000 | 16.7454 | 0 | 1 | 0 |
| 9 | 0.0000 | 0.0000 | 0 | 6.0064 | 0.0000 | 0 | 4.3000 | 2 | 8.6829 | 1.3863 | 9.0000 | 61.4873 | 0 | 0 | 0 |
| 10 | 0.0000 | 0.0000 | 0 | 6.0064 | 0.0000 | 0 | 13.0000 | 2 | 8.6829 | 1.3863 | 9.0000 | 15.5900 | 0 | 1 | 0 |
| 11 | 61.4555 | 0.0000 | 0 | 6.0064 | 0.0000 | 0 | 13.0000 | 2 | 8.6829 | 1.3863 | 4.0000 | 60.2772 | 1 | 0 | 0 |
| 12 | 0.0000 | 0.0000 | 0 | 0.0000 | 0.0000 | 0 | 4.3000 | 3 | 8.1879 | 1.0986 | 12.0000 | 15.2231 | 1 | 1 | 0 |
| 13 | 134.7919 | 0.0000 | 0 | 0.0000 | 0.0000 | 0 | 0.0000 | 3 | 8.1879 | 1.0986 | 7.0000 | 46.4292 | 1 | 0 | 0 |
| 14 | 77.2070 | 0.0000 | 0 | 0.0000 | 0.0000 | 0 | 8.7000 | 3 | 8.1879 | 1.0986 | 12.0000 | 38.1116 | 0 | 0 | 0 |
| 15 | 138.1833 | 0.0000 | 1 | 6.8024 | 0.0000 | 0 | 17.4000 | 2 | 9.3475 | 0.6931 | 11.0000 | 56.3292 | 0 | 0 | 0 |
| 16 | 18.8679 | 0.0000 | 1 | 6.8024 | 0.0000 | 0 | 13.0000 | 2 | 9.3475 | 0.6931 | 7.0000 | 60.0171 | 1 | 0 | 0 |
| 17 | 0.0000 | 3.2581 | 0 | 6.9078 | 8.2940 | 0 | 13.7319 | 3 | 8.9342 | 1.6094 | 12.0000 | 11.0041 | 0 | 1 | 1 |
| 18 | 0.0000 | 3.2581 | 0 | 6.9078 | 8.2940 | 0 | 0.0000 | 3 | 8.9342 | 1.6094 | 13.0000 | 33.6133 | 1 | 0 | 1 |
| 19 | 5996.9540 | 3.2581 | 0 | 6.9078 | 8.2940 | 1 | 26.1000 | 3 | 8.9342 | 1.6094 | 12.0000 | 33.5038 | 0 | 0 | 1 |
| 20 | 18.5445 | 3.2581 | 0 | 6.9078 | 8.2940 | 0 | 13.7319 | 3 | 8.9342 | 1.6094 | 12.0000 | 4.7207 | 1 | 1 | 1 |
| 21 | 0.0000 | 3.2581 | 0 | 6.9078 | 8.2940 | 0 | 13.7319 | 3 | 8.9342 | 1.6094 | 12.0000 | 9.3094 | 1 | 1 | 1 |
| 22 | 41.2129 | 3.2581 | 0 | 6.9078 | 8.2940 | 0 | 30.4000 | 3 | 8.9690 | 1.0986 | 13.0000 | 62.4264 | 1 | 0 | 1 |
| 23 | 1671.7740 | 3.2581 | 0 | 6.9078 | 8.2940 | 0 | 17.4000 | 2 | 8.9690 | 1.0986 | 12.0000 | 56.0637 | 0 | 0 | 1 |
| 24 | 92.8248 | 3.2581 | 0 | 6.9078 | 8.2940 | 0 | 4.3000 | 3 | 8.9690 | 1.0986 | 12.0000 | 20.0226 | 0 | 0 | 1 |
| 25 | 202.3001 | 0.0000 | 0 | 0.0000 | 0.0000 | 0 | 13.0000 | 1 | 9.4678 | 0.6931 | 12.0000 | 46.8207 | 0 | 0 | 1 |
| 26 | 124.9562 | 0.0000 | 0 | 0.0000 | 0.0000 | 0 | 17.4000 | 2 | 9.4678 | 0.6931 | 11.0000 | 53.6215 | 1 | 0 | 1 |
| 27 | 127.3987 | 3.9318 | 0 | 6.6834 | 7.3765 | 0 | 0.0000 | 2 | 9.5946 | 1.0986 | 14.0000 | 22.6865 | 0 | 0 | 1 |
| 28 | 18.5268 | 3.9318 | 0 | 6.6834 | 7.3765 | 0 | 34.8000 | 2 | 9.5946 | 1.0986 | 11.0000 | 49.8186 | 0 | 0 | 1 |
| 29 | 64.1292 | 3.9318 | 0 | 6.6834 | 7.3765 | 0 | 13.0000 | 1 | 9.5946 | 1.0986 | 9.0000 | 48.6961 | 1 | 0 | 1 |
| 30 | 37.7898 | 0.0000 | 1 | 6.9078 | 0.0000 | 0 | 0.0000 | 2 | 9.4550 | 1.7918 | 12.0000 | 16.7755 | 1 | 1 | 1 |
| 31 | 84.3774 | 0.0000 | 1 | 6.9078 | 0.0000 | 0 | 17.4000 | 1 | 9.4550 | 1.7918 | 12.0000 | 44.8713 | 1 | 0 | 1 |
| 32 | 51.5364 | 0.0000 | 1 | 6.9078 | 0.0000 | 0 | 13.7319 | 2 | 9.4550 | 1.7918 | 12.0000 | 12.9507 | 0 | 1 | 1 |

**Figure 1 :** Data set in JustNN tool environment

### 5.2. The Back-propagation Training Algorithm

- Initialize each wi to some small random value
- Until the termination condition is met, Do
- For each training example <(x1,…xn),t> Do
- Input the instance (x1,…,xn) to the network and compute the network outputs ok
- For each output unit k: &k=ok(1-ok)(tk-ok)
- For each hidden unit h: &h=oh(1-oh) Σk wh,k &k
- For each network weight wj Do
- wi,j=wi,j+ delta wi,j, where delta wi,j= n &j xi,j and n is the learning rate.

## 6. EVALUATION OF NEURAL NETWORK

As mentioned above, the purpose of this experiment was to predict the rate of treatment expenses for the individual and the family in a country.
We used feed Forward Backpropagation, which provides facility to perform neural testing Network and its own learning algorithm. Our neural network is a feeding forward network, with one input layer (15 inputs), a hidden layer (14 inputs) and one output layer (1 output). A total of 5561 Bill of Expense were used in the analysis as seen in Figure 1.
After training and validation, the network was tested with the test data set obtained. This involves inputting variable input data to the grid without output variable results. The output from the grid is then compared with actual variable data. Furthermore, the most important attributes of ANN model was identified as in figure 3.
The neural network was able to accurately predict 88% of the test cases with average error 0.00023 as shown in figure 2.

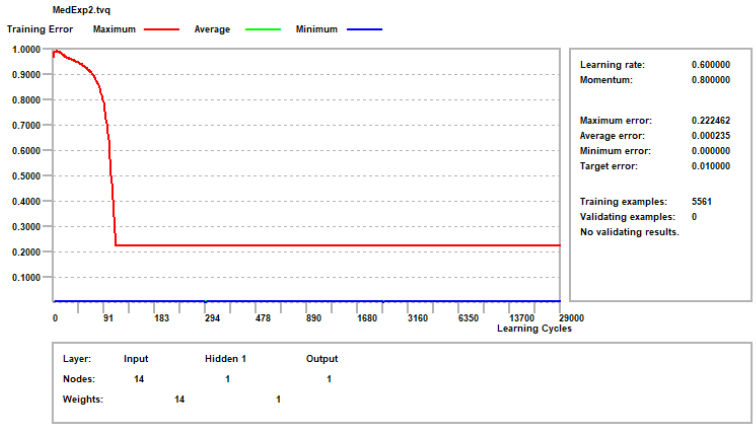



**Figure 2 :** Training progress of the ANN model

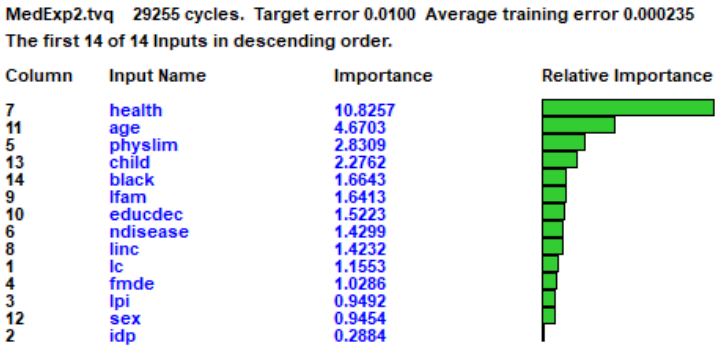



**Figure 3 :** Most important attributes of the ANN model

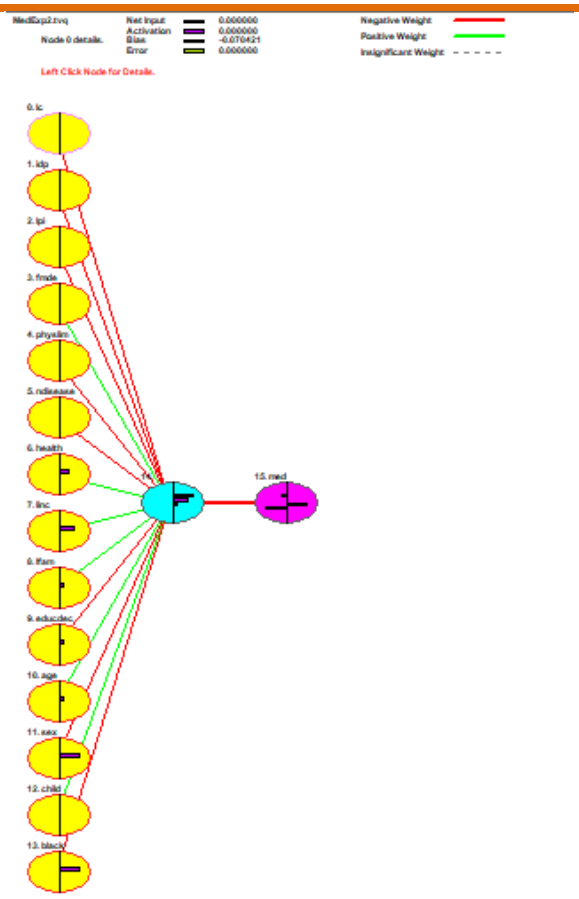



**Figure 4 :** Architecture of the ANN model

## 7. CONCLUSION

Artificial neural network model to determine rates of treatment expenditure in State. The user model feeds forward Backpropagation algorithm for training. Form factors were obtained from the individual. The model was tested and the total score was 88%. This study demonstrate the potential of artificial neural network to determine rates of treatment expenditure.

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