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Original Research Article

Polynomial approach modeling among diabetic patients associated with age in rural hilly population of Dehradun district, Uttarakhand

Shubham Pandey, Ankit Singh*, Ashish Gaur

Department of Biostatistics, Himalayan Institute of Medical Sciences, SRHU, Dehradun, Uttarakhand, India

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***Correspondence:**
Dr. Ankit Singh,
E-mail: ankitbiostat@gmail.com

ABSTRACT

Background: Diabetes mellitus is a form of infections that includes issues with the hormone insulin. It is described by constant rise of blood glucose level surprising ordinary esteem. In this paper, an exertion has been made to fit scientific model to diabetic patients and additionally its total dispersion for both genders related with time of rural population from Dehradun district, Uttarakhand.

Methods: For this reason, the information have been taken from field overview in rural hilly population of Dehradun district. In this investigation, an endeavor has been given to demonstrate that the polynomial model is attempted to fit to the conveyance of diabetic patients related with age and also its cumulative distribution.

Results: The fitted model provides statistically significant values with R^2=0.9997 and ρcv^2= 0.994857. This is the polynomial of degree four, i.e. bi-quadratic polynomial model. The polynomial model is assumed for the cumulative distribution of diabetic patients associated with age and the fitted model provides statistically significant values providing R^2= 0.99998 and ρcv^2= 0.999983 and shrink-age coefficient=0.00001414. This is the polynomial of degree three, i.e. cubic polynomial model. From this statistic we see that the fitted models are highly cross-validated, and their shrinkages are 0.004842857 and 0.00001414 for the models (1) and (2) respectively.

Conclusions: It is discovered that the distribution of diabetic patients for both genders related with age takes after bi-quadratic polynomial model. In addition, it is found that cumulative distribution of diabetic patients takes as cubic polynomial model. Cross validity prediction power is utilized to the fitted model to verify the stability of the model in this study.

Keywords: Cross Validity Prediction Power (CVPP), Distribution of Diabetic Patients, F-Test, Polynomial Model, Variance Explained (R^2)

INTRODUCTION

Diabetes mellitus (DM), normally known as Diabetes, is a gathering of metabolic issue in which there are high glucose levels over a drawn-out period.[1] It likewise depicts as a gathering of metabolic sicknesses in which the individual has high blood (glucose), either as a result of insulin creation is insufficient or the body's cells don't react legitimately to insulin or both. Patients with high glucose will normally encounter polyuria (frequent urination), polydipsia (increased thirst) and polyphagia (increased hunger).[2] Diabetes influences individuals of all socio-economic conditions through the world. In the era of globalization, an attention is made to build mathematical model for the diabetic patients. In fact, mathematical model is a very practical approach to express data in mathematical formulation.[3,4] Mathematical models are tremendously useful to all discipline of applied knowledge in distinguishing important and unimportant variables. Last but not the least, model is important for estimation, prediction as well as forecasting purposes.[5,6]

In this study, deterministic models are used to build some mathematical relation between diabetic patients associated with age of Dehradun district, Uttarakhand.

Conventionally, one can draw graphs from any type of data, but it is very important to know that what types of models are appropriate for that study. For this reason, a polynomial model is fitted for diabetic patients which are associated with age.[7] A short dialog about polynomial model is tended to in the accompanying that will be utilized in different branches of health sciences:

A general expression of the structure is as below:

y = f (x) = a0+ a1x + a2 x2 + a3 x3 + ... + an xn (an≠0)

where a_0 indicates the constant term, ai represents the coefficient of Xi (i=1,2,3,……..n) but $a_1,a_2,a_3,\ldots\ldots\ldots.a_n$ are also constants. In addition, these constants belong to a field indicating a nonempty set in which group for addition, group for multiplication and left as well as right distributive law hold and (n) is the positive integer. This is called a polynomial of degree n and the symbol x is called an indeterminate.[8,9] An effort has been made here to find out what types of models are appropriate for the distribution of diabetic patients associated with age. Thus, the fundamental objectives of this study are briefly mentioned below

- To build up mathematical models to the distribution of diabetic patients associated with age of Dehradun district in Uttarakhand.
- To fit a mathematical model to the cumulative distribution of diabetic patients related to age of Dehradun district in Uttarakhand.
- To apply cross-validity prediction power (CVPP) to the model to verify the stability of the model.

This study is mainly divided into five sections. First section is introduction and sources of data are included in second section, Section third contains materials and methods in which data smoothing, model fitting, model validation, shrinkage coefficient of the fitted model, F-test as well as velocity and acceleration curve of a function are briefly described. Results of this study are narrated in section four. Lastly, section five concludes with the discussion of this paper

Sources of data

The data of diabetic patients for both sexes (jointly male and female) associated with age has been taken from field survey of hilly rural population of Dehradun district in Uttarakhand is used in this paper.

METHODS

Data smoothing

Before starting to fit a mathematical model to the data, first it is plotted in this graph paper, at that point we see that there is a type of distortions. It is unforeseen. Therefore, to evacuate any inconsistencies in the information, the information is smoothed by Free Hand Curve Method. The smoothed information is demonstrated in Table 1 and thereafter, it is used to fit mathematical model for the fulfillments of aims and objectives in this study.[10]

Table: 1 Distribution of diabetic patients associated with ages.

Age group (in years)	Observed number of diabetic patients	Smoothed number of diabetic patients	Fitted number of diabetic patients	Smoothed cumulative number of diabetic patients	Fitted cumulative number of diabetic patients
11-20*	19	19	20	19	18
21-30	47	42	38	62	60
31-40	172	181	186	243	254
41-50	278	286	288	528	523
51-60	300	277	269	807	788
61-70	130	144	149	949	971
70-80**	54	51	49	1000	993

Model fitting

Using the scattered plot for the distribution of diabetic patients associated with age, it is observed that the distribution of diabetic patients can be fitted by polynomial model with respect to age.[11] Therefore, an nth degree polynomial model is considered. The form of the model is:

$$y = a_0 + \sum a_i x^i + u \quad (i=1, 2, 3\ldots n)$$

where, x indicates mid value of age group; y represents distribution of diabetic patients associated with age, a_0 is the constant, a^i is the coefficient of x^i (i=1, 2, 3,……...n) and u is the stochastic error term of the model. Here a suitable (n) has been selected for which the error sum of square is minimum. The statistical software SPSS version 22 was used to fit the mathematical model to this data aggregate.

Model validation

To check the stability of the model, the cross-validity prediction power (CVPP) is applied. The Formula for CVPP is given in the following.

$$\rho_{cv^2} = 1 - \frac{(n-1)(n-2)(n+1)}{n(n-k-1)(n-k-2)}(1-R^2)$$

where, n is the number of cases, k is the number of regressors in the model and the cross-validated R is the correlation between observed and predicted values of the dependent variable. We develop (CVPP) as model validation or accuracy test of the fitted model.[12,13]

Shrinkage coefficient of the model

The shrinkage coefficient of the model is the absolute value of the difference of ρcv^2 and R^2. The stability of R^2 of this model is equal to 1-shrinkage. The smaller quantity of shrinkage value indicates the better fit of the model. According to study shrinkage coefficient can be used as the better fit of the model.[14,15]

F-test

To verify the measure of the overall significance of the fitted model as well as the significance of R^2, the F-test is employed to this model. The formula for F-test is as follows:

$$F = \frac{R^2/(k-1)}{(1-R^2)/(n-k)}$$

Where, k is the number of parameters to be estimated, n is the number of cases and R^2 is the coefficient of determination in the model.

Velocity and acceleration curve of the diabetic patients

Let any curve can be represented by y = f (x) in which x is argument and y are entry. Then, the velocity curve of y with respect to x is symbolized by dy/dx (= v) is defined by

$$\frac{dy}{dx} = \underset{\partial x \to 0}{\mathrm{Lt}} \frac{f(x+\partial x) - f(x)}{\partial x}$$

that is, the velocity is the rate of change of y with respect to x 16. More-over, acceleration is defined by the rate of change of velocity due to age x. In this paper, the velocity and acceleration curve only for the fitted model of diabetic patients in terms of age are enumerated and depicted in Figure 3 and Figure 4 respectively in result and discussion section.

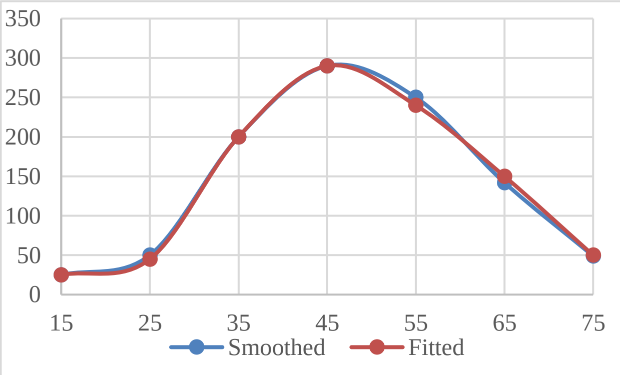

Figure 1: Smoothed and fitted diabetic patients associated with age.

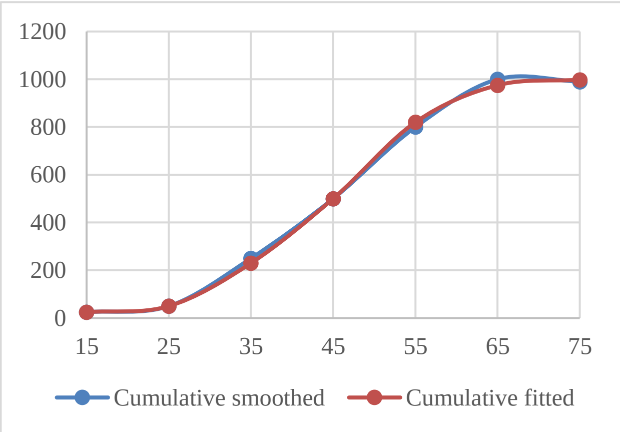

Figure 2: Cumulative smoothed and cumulative fitted diabetic patients associated with age.

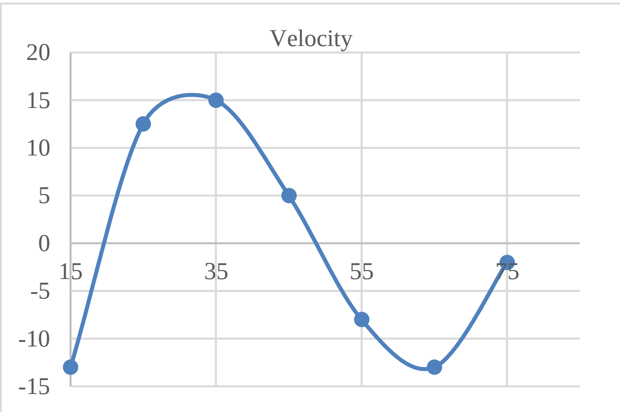

Figure 3: Velocity curve for the fitted model diabetic patients associated with age.

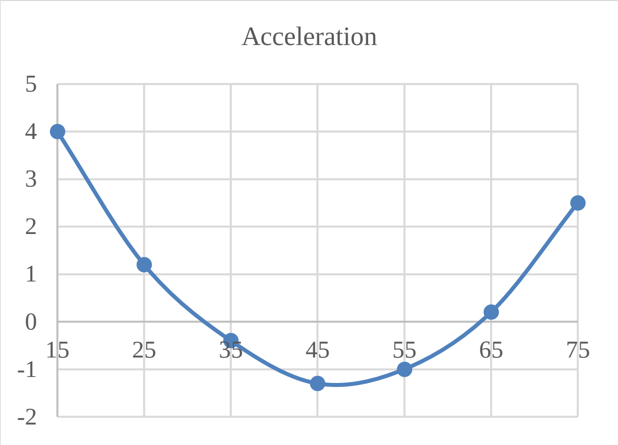

Figure 4: Acceleration curve for the fitted model diabetic patients associated with age.

RESULTS

The polynomial model is assumed for the distribution of diabetic patients associated with age in rural population of Dehradun district in Uttarakhand and the fitted model is

$$Y = 864.3376-114.386x+4.960512x^2-0.07856x^3+0.000411x^4..(1)$$

T-stats- 7.1771 -8.067 8.920692 -8.89111 8.399420

P-value- 0.0189 0.015 0.012334 0.01241 0.013880

Providing R^2=0.9997 and ρcv^2= 0.994857. This is the polynomial of degree four, i.e. bi-quadratic polynomial model. The polynomial model is assumed for the cumulative distribution of diabetic patients associated with age in rural population of Dehradun district in Uttarakhand and the fitted model is

$$y = 412.8274-49.5236x+1.74262x^2-0.0131x^3 \ldots\ldots\ldots\ldots\ldots (2)$$

T-stats- 4.9038 -7.0197 10.12432 -10.3118

P-value- 0.0162 0.0059 0.00205 0.0019

providing R^2= 0.99998 and ρcv^2= 0.999983 and shrink-age coefficient =0.00001414. This is the polynomial of degree three, i.e. cubic polynomial model. From this statistic we see that the fitted models are highly cross-validated and their shrinkages are 0.004842857 and 0.00001414 for the models (1) and (2) respectively.

These imply that both the fitted model is more than 99% stable. Moreover, all the parameters of the fitted model are highly statistically significant with exceeding 99% of variance explained.

Moreover, the stability of R^2 of these models is also more than 99%.

DISCUSSION

In this study, the calculated values of F-statistics are 1666.2 and 9999 for the models (1) and (2) respectively, that is, both the fitted model is overall significant at 1% level. Therefore, from these statistics it is seen that the fitted model and corresponding R^2 are highly statistically significant. As a result, both the models are better fit. Thereafter, the prediction is better done, and the predicted values of the model are also demonstrated in the Table 1. After the fitted model, velocity and acceleration curve are estimated only for the distribution of diabetic patients in terms of age.

CONCLUSION

In this paper, it is found that fourth degree polynomial model containing more than 99% variation is fitted to the distribution of diabetic patients associated with age of rural hilly population of Dehradun district in Uttarakhand. On the other hand, cumulative distribution of diabetic patients in accordance with age follow cubic polynomial model with explaining more than 99% variation. It should be noted that the usual models such as exponential model, Gompertz model and log-linear model were also applied for the distribution of diabetic patients and cumulative distribution of diabetic patients but seems to be worse fitted with respect to their coefficient of determination as well as shrinkage coefficients. Therefore, the results of the models were not shown here.

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