Time Trend and prediction of Grade 2 Disability among new cases of leprosy in Nepal: A Statistical Modelling

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Abstract

Background

It is estimated that globally there are around 2 million people with grade 2 disabilities attributed to leprosy. Objective of the study was to find out the time trends of Grade 2 Disability among the new cases of Leprosy in Nepal.

Materials and Methods

A retrospective study was carried out on the data collected from the Health ministry records of Nepal, between 2009 and 2013. The annual reported numbers of Grade 2 Disability among new cases of leprosy plotted in y-axis against the corresponding year in the x-axis. Curve fitting, also known as regression analysis, was used to find the "best fit" line or curve for a series of data points. Linear, Logarithmic, Inverse, Quadratic, and Cubic were chosen to fit to the obtained curve. Descriptive statistics and statistical modelling were used for the analysis and forecasting of data.

Results

Including the constant term from the equation, the inverse model was the best fit, for the forecasting of the Grade 2 Disability among new cases of leprosy in Nepal [R^2=0.739, p=0.062]. Using inverse model, it is estimated that 78 with CI [0, 170] of Grade 2 Disability among new cases of leprosy

can be expected in Nepal by the year 2020.

Conclusion

Our study proves Inverse model is the best fit for epidemiological modelling of Grade 2 Disability among the new cases of Leprosy in Nepal. Prevention of disabilities should begin with diagnosing leprosy.

Keywords: Grade 2 Disability, leprosy, statistical modelling, Nepal

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Background

Leprosy is a chronic disease caused by Mycobacterium leprae. Official figures from 115 countries show that 232 857 new cases of leprosy reported in 2012[1]. Globally there are estimated 2 million Grade 2 Disability among the cases of Leprosy. The current strategy focuses on reducing the disease burden in terms of reducing the occurrence of new cases and occurrence of grade-2 impairments and disabilities along with the issues such as human rights, gender equality and initiatives to reduce stigma and discrimination faced by leprosy patients and their families[1].

Nepal is a leprosy eliminated country from early 2010. But the district level elimination of leprosy should be improved then only the constant trend of every year more than 3000 new reported leprosy cases will reduce. There were reported 3253 new cases and 2228 under treatment cases in 2013 with an estimated figure of 30,000 leprosy affected people who are in need of medical and social rehabilitation. Leprosy control division of Nepal has been implementing various programmes related to improving the knowledge regarding leprosy, capacity building, active case detection and management. But the importance is given to complete treatment and prevent Grade 2 Disability through early case detection. Case based surveillance both in high and low endemic districts required for attaining these goals[2].

Chen XS et al. used exponential model to predict the elimination of leprosy in leprosy endemic areas of China. [3] Sathian B et al. had done several successful attempts to forecast communicable and non-communicable diseases in Nepal[4-9]. Objective of the study was to find out the time trends of Grade 2 Disability among the new cases of Leprosy in Nepal.

Material and Methods

Study setting

A retrospective study was carried out on the Grade 2 Disability among new cases of leprosy data collected from the Health ministry records of Nepal, between 2009 and 2013.

Grading

Disability is a broad term covering any impairment, activity limitation or participation restriction offering a person. Grading 0 means no visible disability found. Grading 1 means that loss of sensation has been noted in the palm of the hands or sole of the feet. Grading 2 means that visible damage or deformities is noted in eyes or hands or feet.

Study methodology

The annual reported numbers of Grade 2 Disability among new cases of leprosy plotted in y-axis against the corresponding year in the x-axis. Curve fitting, also known as regression analysis, was used to find the "best fit" line or curve for a series of data points. Linear, Logarithmic, Inverse, Quadratic, and Cubic were chosen to fit to the obtained curve.

Curve Fitting Method

The Curve Estimation procedure produces curve estimation regression statistics and related plots for 10 different curve estimation regression models. A separate model is produced for each dependent variable. You can also find out predicted values, residuals, and prediction intervals as new variables.

For each model, we can find out the regression coefficients, multiple R, R^2, adjusted R^2, standard error of the estimate, analysis-of-variance table, predicted values, residuals, and prediction intervals. Models: linear, logarithmic, inverse, quadratic, cubic, power, compound, S-curve, logistic, growth, and exponential.

1. Linear Model
Model whose equation is

$$Y = b_0 + (b_1 \times t)$$

2. Logarithmic Model
Model whose equation is

$$Y = b_0 + [b_1 \times \ln(t)]$$

3. Inverse Model
Model whose equation is

$$Y = b_0 + \left[\frac{b_1}{t}\right]$$

4. Quadratic Model
Model whose equation is

$$Y = b_0 + (b_1 \times t) + (b_2 \times t^2)$$

The quadratic model can be used to model a series that "takes off" or a series that dampens.

5. Cubic Model
Model that is defined by the equation

$$Y = b_0 + (b_1 \times t) + (b_2 \times t^2) + (b_3 \times t^3)$$

6. Compound Model
Model whose equation is

$$Y = b_0 \times b_1^t$$

7. Power Model

Model whose equation is

$$Y = b_0 \times (t^{b_1})$$

or

$$\ln(Y) = \ln(b_0) + (b_1 \times \ln(t))$$

8. S-curve Model

Model whose equation is

$$Y = \exp\left(b_0 + \frac{b_1}{t} \right)$$

9. Growth Model

Model whose equation is

$$Y = \exp(b_0 + b_1 t)$$

10. Exponential Model

Model whose equation is

$$Y = b_0 e^{b_1 t}$$

F-test was used for selecting the best fitting curve for the testing of hypothesis. P-value was taken as significant when < 0.10 (two-tailed). R^2 value > 0.70 was taken as significantly better for prediction[10].

The decision regarding the selection of a suitable prediction approach is governed by the relative performance of the models for monitoring and prediction. It should also adequately interpret the phenomenon under study. Inverse model selected here could closely fit curves for estimated and reported Grade 2 Disability among new cases of leprosy [Figure 1]. While building model, the extremities (maximums and minimums) play a great role. If the points are scattered more, the curve tries to adjust with maximum number of observed points. The inverse model represented by the equation

$$Y = b_0 + \left[\frac{b_1}{X} \right]$$

where b_0 is the constant term and b_1 are coefficient terms[11,12]. Where Y is the number of number of Grade 2 Disability among new cases of leprosy annually and X is the corresponding year; 1=2009, 2=2010, 3=2011, 4=2012 and so on.

Statistical Analysis and Data Analysis:

The data was analysed using Excel 2003, R 2.8.0, Statistical Package for the Social Sciences (SPSS) for Windows Version 16.0 (SPSS Inc; Chicago, IL, USA) and EPI Info 3.5.1 windows version. A p-value of < 0.10 (two-tailed) was used to establish statistical significance.

Result

The data was modelled using the curve fitting method. [Tables 1 and Figure 1] depicts the model summary and the parameter estimates including the constant term for different models. Including the constant term in the equation, the inverse model was the best fit, for the forecasting of Grade 2 Disability among new cases of leprosy [R^2=0.739, p=0.062]. The inverse model equation below contain X and Y, which are the corresponding year and frequency of Grade 2 Disability among new cases of leprosy respectively. b_0 and b_1 calculated from the observed data.

Table 1: Model summary and parameter estimates including the constant term for different models for the reported number of Grade 2 Disability among new cases of leprosy in Nepal

Equation	Model Summary	
	R Square	p-value
Linear	0.402	0.250
Logarithmic	0.577	0.136
Inverse	0.739	0.062
Quadratic	0.642	0.358
Cubic	0.949	0.284
Compound	0.349	0.294
S	0.662	0.094
Growth	0.349	0.294
Exponential	0.349	0.294

The equation for the inverse model for the reported number of Grade 2 Disability among new cases of leprosy in Nepal is

$$Y = 68.735 + \left[\frac{105.689}{X} \right]$$

(Where Y is the number of number of reported Grade 2 Disability among new cases of leprosy in Nepal annually and X is the corresponding year; 1=2009, 2=2010, 3=2011, 4=2012 and so on)

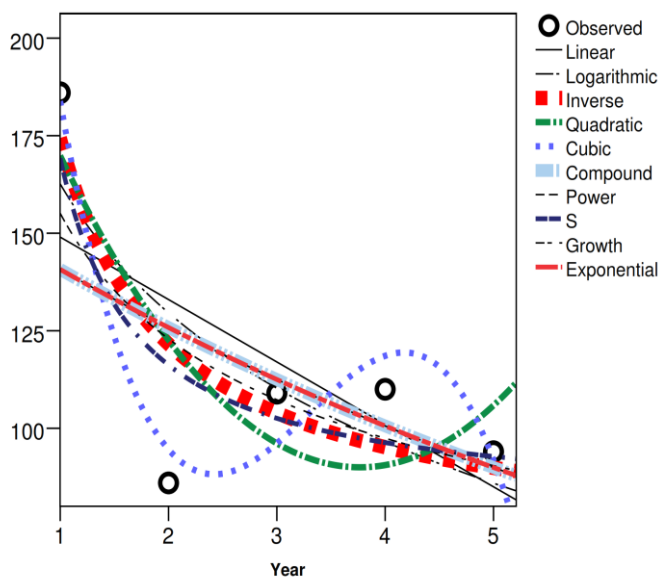**Figure 1: Fitted curves for Grade 2 Disability among new cases of leprosy**

Table 2: Reported and estimated number of Grade 2 Disability among new cases of leprosy.

Year	Observed cases	Estimated Cases	Lower limit	Upper Limit
2009	186	174	71	278
2010	86	122	39	204
2011	109	104	21	187
2012	110	95	10	181
2013	94	90	3	177
2014		86	0	175
2015		84	0	174
2016		82	0	173
2017		80	0	172
2018		79	0	171
2019		78	0	171
2020		78	0	170

Using the equation, reported numbers of Grade 2 Disability among new cases of leprosy in Nepal were estimated [Table 2].

Discussion:

Statistical Modelling

A plot is a graphical representation of the collected data (independent and dependent variables) involved in a study. The relationship between these variables is then assessed by connecting the `points' with a line. Though very true, this association cannot be relied upon to predict the future trend of this data. Now a `model', which `fits best' to the observed data has to be worked out. This is then `fitted' and used to replace the existing set of data points as `the appropriate model'. After `modelling' the observed data, this model can be used to predict future trend of the dependent variable for a given change in the other. The foregoing statement covertly mentions several requirements which often ensure confident achievement in any subsequent extrapolation from the model. The model selected must be the most appropriate for the collected data. A usable and understandable curve-fitting method is to be available from which the model facts those are reflective of future behaviour can be obtained[13,14].

Model Building

Using the curve fitting method, we estimated the number and trend of reported Grade 2 Disability among new cases of leprosy at Nepal from the year 2009 to 2020. Inverse model provided closely fitted curves for estimated and reported Grade 2 Disability among new cases of leprosy (Figure 1). Our study is contradictory to the other studies done in communicable and non communicable diseases by Sathian B et al. which showed cubic and quadratic models are the best fitted models[4-12].

While building model, the extremities (maximums and minimums) play a great role[4-6]. If the points are scattered more, the curve tries to adjust with maximum number of observed points. Therefore, it might give over- and under-estimation inevitably, but that is not the case in all the situations. A sudden annual decrease and increase in the trend is possible, as the curve cannot exactly connect these data points because of its shape. For adjusting the over-and under-estimation, the model gave wide confidence intervals in case of some years (Table 2)[4-7]. In our study, the future annual reported Grade 2 Disability among new cases of leprosy (Table 2) shows a decreasing trend.

Leprosy and grade 2 disability management

Leprosy is a leading cause of permanent disability among communicable diseases. An estimated three million people live with disability due to leprosy and it is expected that up to one million people will continue to suffer from disability in the next decades[15, 16]. The International Classification of Functioning, Disability and Health (ICF) definition goes beyond the concept of considering disability in medical terms only, and recognizes the social context of disability and it lead to a negative image towards leprosy. Leprosy patients with grade 2 disability fear about stigmatization and discrimination, and experience serious psychosocial and economic problems[17-19].

Mycobacterium leprae residues can remain for many years after MDT that can lead to development of disability due to

nerve injury in these patients. So, the primary health care (PHC) medical officers should be trained to identify possible development of lepra reaction and disabilities, so that they can refer such cases to the hospitals which have advanced facilities. There is an urgent need of rehabilitation for the patients who have already developed disabilities which are irreversible which emphasise on legal, social, religious, medical and occupational aspects.

Limitation of the study

Inverse model is the best fit for epidemiological modelling of Grade 2 Disability among the new cases of Leprosy in Nepal but the number of cases is very less so we had to set the cut off point for the p value as 0.1 instead of 0.05. Scientific literatures show a p value up to 0.2 is acceptable to fix for cut off points in testing of hypothesis.

Conclusion

Our study proves inverse model is the best fit for epidemiological modelling of Grade 2 Disability among the new cases of Leprosy in Nepal. Prevention of disabilities should begin with early diagnosis and treatment. Nepal need a community level approach towards leprosy patients which will reduce and possibly eliminate leprosy, grade 2 disability and stigma.

What's known?

1.   Annual reported Grade 2 Disability among new cases of leprosy from 2009 to 2013
2.   Trend of annual reported Grade 2 Disability among new cases of leprosy up to 2013

What's new?

1.   Annual reported Grade 2 Disability among new cases of leprosy from 2014 to 2020
2.   Trend of annual reported Grade 2 Disability among new cases of leprosy up to 2020

Key Messages

Curve fitting method is a powerful tool to forecast epidemiological data. Inverse model is the best fit for epidemiological modelling of Grade 2 Disability among the new cases of Leprosy in Nepal. The future annual reported Grade 2 Disability among new cases of leprosy shows a decreasing trend in Nepal.

Future scope of the study

There is an urgent need of qualitative research in this area which can also amend a counseling programme with the help of Psychiatrists to reduce the problems of leprosy patients with grade 2 disability viz. stigmatization, discrimination, and serious psychosocial and economic problems.

Author's Contribution

BS designed the study, collected the data and drafted manuscript. JS helped in designing the study and revision of the manuscript. AK critically revised the manuscript. IB and BR assisted in manuscript write up. JS and RE helped in data analysis and interpretation. All the authors approved the final document.

Conflict of interest

None

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