Time Trend of the Suicide Incidence in India: a Statistical Modelling

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Abstract **Background:** It is estimated that over 100,000 people die by suicide in India every year. India alone contributes to more than 10% of suicides in the world. The suicide rate in India has been increasing steadily and has reached 11.2 (per 100,000 of population) in 2011 registering 78% increase over the value of 1980 (6.3). **Objective:** Objective of the study was to forecasts the suicide incidence of India up to 2020. **Material and Methods:** Theoretical statistics was used for the statistical modelling of the retrospective data of suicide incidence data of 1989-2011 years collected from National Crime Records Bureau (NCRB). **Results:** Using curve fitting method, Linear, Logarithmic, Inverse, Quadratic, Cubic, Compound, Power and Exponential growth models were validated. Cubic Model was the best fitted model with $R^2 > 0.90$, $p < 0.01$. Suicide incidence of India has an increasing trend. In 2020, it is estimated that the suicide incidence of India will be 109814 with CI [86593, 133034] for male, 76224 with CI [55151, 97297] for female and 186038 with CI [145605, 226471] for total [both male and female]. **Conclusion:** Suicide incidence of India has an increasing trend. India requires the involvement of all governments and other organizations to contribute to the cause of suicide awareness and prevention through activities, events, conferences and campaigns to solve this public health problem.

Keywords: suicide, incidence, forecasting, statistical modelling, India

1. Introduction

WHO predicts that almost 900000 people worldwide depart this life from suicide each year, counting about 200000 in China, 170000 in India, and 140000 in high-income countries [1]. The Government of India trust on its National Crime Records Bureau (NCRB) for national predicted values, and these reports show fewer suicide deaths (as regards 135000 suicide deaths in 2010) [2] than is predicted by WHO. The NCRB data is a foundation for police reports and suicide is still a crime in India, which might have an effect on the reliability of reporting.

Nowadays farmer's suicide is a threat in India [3]. Apart from these there is no clear picture of socio demographic factors wise information viz. the age-specific and sex-specific death totals, rates, and risks, and in addition the mode of suicide. Predicted suicide incidence is required for the Government of India to execute its 12th Year Plan for 2012–17 which includes strategies to embark upon mental health and chronic disease [4].

Sathian et al. have done several studies to project communicable diseases and non communicable diseases using statistical modelling procedures, which furnish trustworthy estimates [5-11]. The aim of our study was to forecasts the suicide incidence of India up to 2020 from the NCRB available data.

2. Material and Methods

2.1. Setting

A retrospective study was carried out on the Suicide data collected from the National Crime Records Bureau (NCRB) India, between 1989 and 2011.

2.2. Dependent Variables

Suicide Incidence of Male, Female and Total

2.3. Independent Variable

Year.

2.4. Statistical Analysis

The collected and coded data were analysed using Statistical Package for the Social Sciences (SPSS) for Windows Version 16.0 (SPSS Inc; Chicago, IL, USA). A p-value of < 0.05 (two-tailed) was used to establish statistical significance. The annual Suicide incidence plotted in y-axis in opposition to the consequent year in the x-axis. Curve fitting, also branded as regression analysis, was applied to obtain the "best fit" line or curve for a series of data points. Linear, Quadratic, Inverse, Logarithmic, and Cubic were selected to fit to the derived curve. F-test was applied for obtaining the best suitable curve for the testing of hypothesis. P-value was selected as statistically significant when $p< 0.05$ (two tailed). R^2 - value > 0.80 was selected as statistically significant for prediction [10]. The verdict concerning the choice of a appropriate forecasting approach is governed by the comparative performance of the models for monitoring. It should also sufficiently sufficiently cover the observable fact under study. The Cubic model obtained here could strongly fit curves for predicted and reported suicide incidence (Figure 1, Figure 3, Figure 5). While structuring the model, the extremities (maximums and minimums) take part in a immense role. If the points are spread more, the curve tries to fiddle with the highest number of observed points. The cubic model in the equation below is a third degree polynomial, where m_0 is the constant term and m_1, m_2, m_3 are coefficient terms [11,12]. Where Y is the number of number of suicide incidence annually and X is the consequent year; 1=1989, 2=1990, 3=1991 and so on.

2.5. Models

1 Linear Model

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

2 Logarithmic Model

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

3 Inverse Model

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

4 Quadratic Model

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

5 Cubic Model

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

6 Compoind Model

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

7 Power Model

$$Y = b_0 \times \left(t^{b_1} \right) \; or$$

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

8 S-curve Model

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

9 Growth Model

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

10 Exponential Model

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

3. Results

Table 1, Table 3, Table 5, Figure 1, Figure 3, and Figure 5 depict that using curve fitting method, Linear, Logarithmic, Inverse, Quadratic, Cubic, Compound, Power and Exponential growth models were validated. Cubic Model was the best fitted model with $R^2 > 0.90$, $p<0.01$ for Male, Female and Total Suicide incidence. Table 2, Table 4, Table 6, Figure 2, Figure 4, and Figure 6 reveal that the Male, Female and Total Suicide incidence is increasing by time.
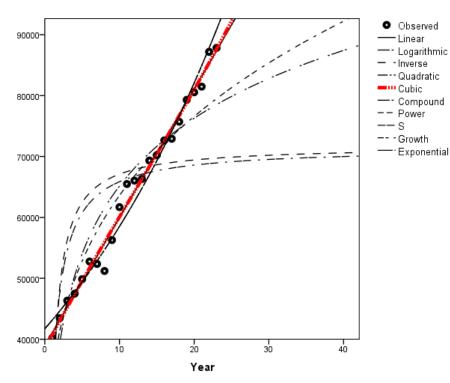

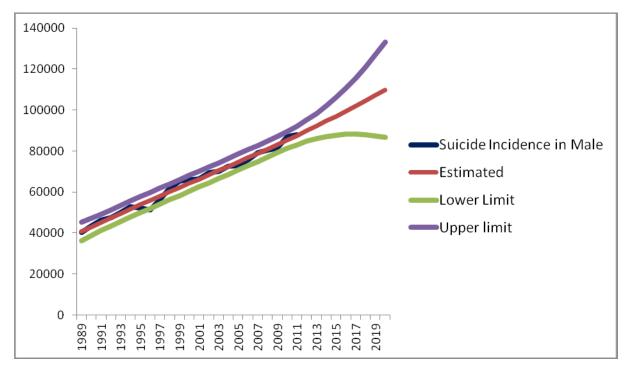**Figure 1.** Fitted curves and observed male suicide incidence in India

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Table 1. Model summary and parameter estimates for fitted equations for male suicide incidence

	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.987	1.597E3	1	21	0.0001	3.891E4	2.107E3		
Logarithmic	.852	120.838	1	21	0.0001	2.815E4	1.607E4		
Inverse	.474	18.889	1	21	0.0001	7.175E4	-4.652E4		
Quadratic	.987	760.506	2	20	0.0001	3.889E4	2.112E3	-.200	
Cubic	.987	484.653	3	19	0.0001	3.846E4	2.307E3	-20.076	.552
Compound	.976	842.841	1	21	0.0001	4.171E4	1.034		
Power	.908	206.966	1	21	0.0001	3.432E4	.268		
S	.553	25.956	1	21	0.0001	11.176	-.812		
Growth	.976	842.841	1	21	0.0001	10.638	.034		
Exponential	.976	842.841	1	21	0.0001	4.171E4	.034		

Table 2. Male suicide incidence up to 2020

Year	SIM	Estimated	Lower Limit	Upper limit
1989	40212	40751	36229	45274
1990	43451	43002	38858	47145
1991	46324	45219	41252	49186
1992	47481	47405	43494	51317
1993	49851	49565	45654	53476
1994	52752	51701	47778	55625
1995	52357	53817	49889	57745
1996	51206	55916	51996	59836
1997	56281	58001	54100	61902
1998	61686	60076	56197	63955
1999	65488	62144	58282	66006
2000	66032	64208	60352	68064
2001	66314	66272	62410	70134
2002	69332	68339	64459	72218
2003	70221	70412	66510	74313
2004	72651	72494	68574	76414
2005	72916	74589	70661	78518
2006	75702	76701	72777	80624
2007	79295	78832	74921	82743
2008	80544	80986	77074	84897
2009	81471	83165	79198	87132
2010	87180	85375	81231	89518
2011	87839	87617	83094	92139
2012		89895	84715	95075
2013		92212	86047	98377
2014		94572	87072	102073
2015		96978	87786	106170
2016		99433	88189	110678
2017		101941	88279	115604
2018		104505	88049	120961
2019		107128	87491	126765
2020		109814	86593	133034

Table 3. Model summary and parameter estimates for fitted equations for female suicide incidence

	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.827	100.547	1	21	0.0001	3.117E4	720.552		
Logarithmic	.879	152.775	1	21	0.0001	2.614E4	6.096E3		
Inverse	.615	33.518	1	21	0.0001	4.303E4	-1.980E4		
Quadratic	.876	70.652	2	20	0.0001	2.821E4	1.430E3	-29.577	
Cubic	.924	76.852	3	19	0.0001	2.426E4	3.219E3	-211.976	5.067
Compound	.812	90.803	1	21	0.0001	3.144E4	1.019		
Power	.908	207.062	1	21	0.0001	2.730E4	.164		
S	.673	43.135	1	21	0.0001	10.672	-.548		
Growth	.812	90.803	1	21	0.0001	10.356	.019		
Exponential	.812	90.803	1	21	0.0001	3.144E4	.019		

Figure 2. Time trend of estimated and observed male suicide incidence in India

Table 4. Female suicide incidence up to 2020

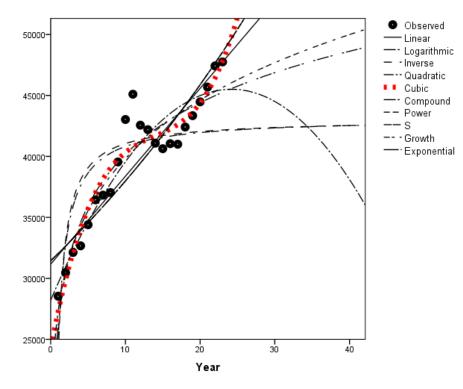| Year	SIF	Estimated	Lower Limit	Upper limit
1989	28532	27270	23166	31374
1990	30460	29889	26129	33649
1991	32126	32144	28544	35744
1992	32668	34067	30517	37616
1993	34393	35687	32137	39236
1994	36443	37035	33474	40596
1995	36821	38142	34577	41707
1996	37035	39037	35480	42595
1997	39548	39752	36212	43292
1998	43027	40316	36796	43837
1999	45099	40761	37256	44266
2000	42561	41116	37617	44615
2001	42192	41412	37907	44917
2002	41085	41679	38158	45199
2003	40630	41947	38407	45488
2004	41046	42248	38691	45806
2005	40998	42611	39046	46176
2006	42410	43067	39507	46628
2007	43342	43647	40097	47196
2008	44473	44379	40830	47929
2009	45680	45296	41696	48896
2010	47419	46428	42668	50188
2011	47746	47804	43700	51908
2012		49455	44755	54156
2013		51413	45817	57008
2014		53706	46899	60513
2015		56365	48023	64707
2016		59422	49218	69626
2017		62906	50507	75304
2018		66847	51913	81781
2019		71276	53455	89097
2020		76224	55151	97297

Figure 3. Fitted curves and observed suicide incidence of females in India
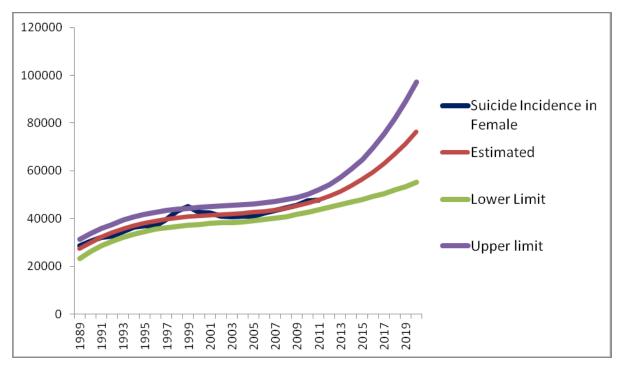

Figure 4. Time trend of estimated and observed female suicide incidence in India

Table 5. Model summary and parameter estimates for fitted equations for total suicide incidence

	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.970	688.421	1	21	0.0001	7.008E4	2.828E3		
Logarithmic	.885	161.687	1	21	0.0001	5.429E4	2.216E4		
Inverse	.525	23.250	1	21	0.0001	1.148E5	-6.632E4		
Quadratic	.974	377.071	2	20	0.0001	6.710E4	3.542E3	-29.777	
Cubic	.979	290.283	3	19	0.0001	6.272E4	5.526E3	-232.052	5.619
Compound	.952	419.694	1	21	0.0001	7.293E4	1.029		
Power	.930	277.823	1	21	0.0001	6.128E4	.228		
S	.598	31.260	1	21	0.0001	11.650	-.710		
Growth	.952	419.694	1	21	0.0001	11.197	.028		
Exponential	.952	419.694	1	21	0.0001	7.293E4	.028		

Figure 5. Fitted curves and observed suicide incidence of total cases in India

Table 6. Total suicide incidence up to 2020

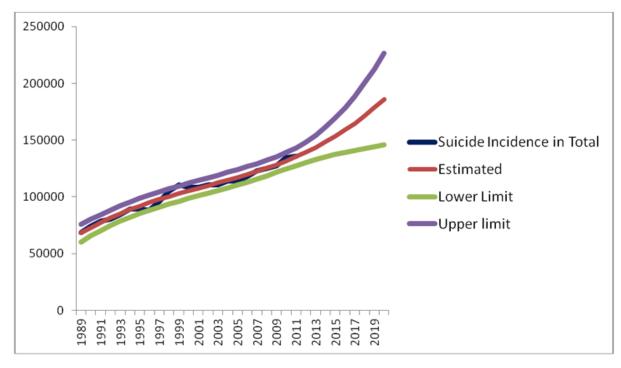| Year	SIT	Estimated	Lower Limit	Upper limit
1989	68744	68022	60147	75896
1990	73911	72890	65676	80105
1991	78450	77363	70455	84270
1992	80149	81472	74661	88283
1993	84244	85252	78442	92062
1994	89195	88736	81904	95568
1995	89178	91959	85118	98799
1996	88241	94953	88127	101779
1997	95829	97753	90960	104546
1998	104713	100393	93638	107148
1999	110587	102905	96180	109630
2000	108593	105324	98610	112038
2001	108506	107684	100959	114409
2002	110417	110017	103262	116772
2003	110851	112359	105566	119152
2004	113697	114742	107916	121568
2005	113914	117201	110360	124041
2006	118112	119768	112936	126600
2007	122637	122478	115668	129289
2008	125017	125365	118554	132176
2009	127151	128462	121554	135369
2010	134599	131802	124588	139017
2011	135585	135421	127546	143295
2012		139350	130330	148370
2013		143625	132889	154360
2014		148278	135217	161338
2015		153343	137337	169350
2016		158855	139276	178434
2017		164847	141057	188637
2018		171352	142698	200006
2019		178404	144211	212598
2020		186038	145605	226471

Figure 6. Time trend of estimated and observed total suicide incidence in India

4. Discussions

In the Curve fitting method accumulated data depicted in a graph to assess the relationship between the dependent variable and time by joining the `points' with a line. After that the researcher should search out the best fitted model to the observed data. Once the best fitted model is obtained then it will be utilized to predict the trend of the dependent variable for a time variable [13,14]. Sathian et al. have successfully applied this methods to predict the non-communicable and communicable disease trends in Nepal [5-11]. Our study hereby commences the appropriateness of statistical modelling in estimating the annual incidence of suicide in the Indian context.

It is scientifically proven that the suicide prevalence have an association with age and sex [12,13,14]. Some studies reveals that it is more among adults aged 18-29 years than others [13-16]. It was supported by few other surveys like the National Comorbidity Survey [NCS], the National Comorbidity Survey Replication [NCS-R], and the Injury Control and Risk Survey [ICARIS] [12,13,14,15]. In contrary to the Indian scenario, previous studies without fail have established female preponderance in rates of having suicidal thoughts [12,13,14,15,16]. In these analyses, the incidence of suicide was more among the males compared to female in India.

It should be mandatory to provide psychiatric interventional programmes towards suicidal ideation of all psychiatric disorder patients because they carry an increased risk of suicide. Even pregnant women are at risk of psychiatric illness [17]. However, 90% of suicides can be traced to depression, linked either to bipolar disorder, major depressive disorder, schizophrenia or personality disorders, and particularly borderline personality disorder. Comorbidity of mental disorders increases suicide risk, especially anxiety or panic attacks.

Most common methods of committing suicide are bleeding: wrist cutting, hanging, suffocation, hypothermia, drowning, electrocution, firearms, vehicular impact – rail, traffic collisions, Jumping from a height, Poisoning – pesticide, drug overdose, and Immolation.

5. Conclusion

Suicide incidence of India has an increasing trend. India requires the involvement of all governments and other organizations to contribute to the cause of suicide awareness and prevention through activities, events, conferences and campaigns to solve this public health problem.

Authors' Contributions

BS: Conceptualized the research, planned and conducted the data analysis, interpreted the results, wrote the first draft of the manuscript for publication and is the guarantor; AD, EvanT and PS: Conceptualized the research, co-drafted the first draft of the manuscript for publication; IB, BR, SHS, SD and RE: Helped conceptualizing the research, planned data analysis and revised earlier drafts of the manuscript. All the authors read and approved the final version of the manuscript to be submitted for publication in a scientific journal.

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