

COMMENTARY

Future prediction of Population, Birth and Fertility rates in India

Nomula Chandan Babu, Aluri Sai Padma

Bhavan's Vivekananda College of Science, Humanities and Commerce, Sainikpuri, Secunderabad, Telangana

CORRESPONDING AUTHOR

Dr. Aluri Sai Padma, Assistant Professor, Department of Biochemistry & Nutrition, Bhavan's Vivekananda College of Science, Humanities and Commerce, Sainikpuri, Secunderabad, Telangana 500094

Email: saipadmabhavans@yahoo.co.in

CITATION

Babu NC, Padma AS. Future prediction of Population, Birth and Fertility rates in India. Indian J Comm Health. 2024;36(1):153-155. <https://doi.org/10.47203/IJCH.2024.v36i01.025>

ARTICLE CYCLE

Received: 30/11/2023; Accepted: 18/01/2024; Published: 29/02/2024

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ABSTRACT

Background: Fertility rates have been declining worldwide over the past fifty years, part of a phenomenon known as "the demographic transition". **Aims & Objectives:** To draw on life history theory to examine the relationship between population density and fertility rate in India over 74 years. **Material & Methods:** The association between population versus Birth rate and population versus fertility rate was found using Correlation Analysis, to fit the models using Least square methods. **Results:** A robust association was found between population and fertility rate, population and Birth rate over the analyzed time period. Population, Birth rate, and Fertility rate for one decade were also forecasted using the best least square method. **Conclusion:** The analysis shows that the population is on an increasing trend and the Birth rate and fertility rate have decreased tendency.

KEYWORDS

Fertility Rate; Birth Rate; Population Density; Demographic Transition; Life History Theory

INTRODUCTION

Over the past fifty years, social scientists have documented a "demographic transition" i.e., a decline in lifetime birth rates and death rates across the world (1-3). These trends have caused concern in several societies where the birth replacement rate is now lower than the death rate (4,5). The adaptive behavioral responses depend on ecological constraints, which can differ in high- and low-density populations. Low-density environments are often characterized by high resource availability per individual and lower intra population competition for resources. In such conditions, it is more adaptive for individuals

to exploit resources at a faster pace, to reproduce earlier, and to have more children. In contrast, in more dense environments, there is greater competition between individuals. For individuals to compete successfully in such an environment, one needs to build relevant skills and knowledge, which in turn delays reproductive efforts. Moreover, it's likely that in high-density contexts, offspring also require more investment to become competitive enough to survive and reproduce. Thus, it is comparatively more advantageous to invest more heavily in fewer children in population-dense environments. This theoretical framework suggests that higher population

densities should be associated with lower fertility rates, consistent with prior empirical findings.

Objectives of the study

To find the association between Population versus fertility rate and Population versus birth rate. Identify the best model based on R2 value and also to forecast birth rate, fertility rate and Population for one Decade.

MATERIAL & METHODS

In the present study, the secondary data was collected from 1950 to 2023 from India - Historical Birth Rate, Fertility Rate and Population Data (Health and Family Welfare Statistics in India 2019-20) (7). And also forecasted from 2024 to 2033.

In the suggested context, Birth rate, Fertility rate and Population of India is fitted models by using least square approach (Linear, Polynomial, Exponential and Power curve). A

data set of 1950 to 2023 is experimented with using the suggested model.

The least squares method is a statistical procedure to find the best fit for a set of data points. The method works by minimizing the sum of the offsets or residuals of points from the plotted curve. Least squares regression is used to predict the behavior of dependent variables.

The prediction of time series is an essential field in which the variable's previous data are gathered and evaluated to build a model that outlines the relationship behind it. This model then interpolates the time series with the variable's future values. Data for Birth rate, Fertility rate and Population in India were obtained from the source Health and Family Welfare Statistics in India 2019-20 For 74 Years From 1950 To 2023 (8).

We fitted curves for Birth rate, Fertility rate and population of India using least squares method and the fitted curves are presented in the Table 1

Table 1 : Fitted equation, R² value for Birth rate, Fertility rate and Population

S. No	Model	Birth rate Equation	R ²	Fertility rate Equation	R ²	Population Equation	R ²
1	Linear	$y = -0.405x + 47.19$	0.981	$y = -0.062x + 6.602$	0.985	$y = 2E+07x + 3E+08$	0.99
2	Polynomial	$y = -0.002x^2 - 0.216x + 44.79$	0.995	$y = -0.000x^2 - 0.039x + 6.312$	0.983	$y = 69984x^2 + 1E+07x + 3E+08$	0.997
3	Power Curve	$y = 74.28x-0.26$	0.634	$y = 11.16x-0.30$	0.627	$y = 2E+08x0.434$	0.849
4	Exponential Curve	$y = 74.28x-0.26$	0.945	$y = 11.16x-0.30$	0.95	$y = 4E+08e0.019x$	0.991

The metrics R²determine the model identity and best model fitted to the data used. Obviously from all these models we found that for the Birth rate, the Polynomial model outperforms with the other models, for fertility rate Linear equation R2 is more and linear model outperforms with the other models and for population data polynomial of second order outperforms than the other models. From the best model forecasted values for birth rate, fertility rate and population values are presented in the

following table for a decade that is 2024 to 2033.

We can see from Table2 that the projections of Birth rate and fertility rate values are decreased from 2024 to 2033 and forecasted values of population increase from 2024 to 2033.

Correlation analysis was used to calculate the association between Population Versus Birth rate is -0.998 and Population versus Fertility rate is -0.996

Table 2: Forecasted values for Birth, Fertility rate and Population values for one decade

Year	Future_Birth rate	Future_Fertility rate	Future_Population
2024	17.565	1.952	1443660000
2025	17.05	1.89	1464227584
2026	16.531	1.828	1484935136
2027	16.008	1.766	1505782656

Year	Future_Birth rate	Future_Fertility rate	Future_Population
2028	15.481	1.704	1526770144
2029	14.95	1.642	1547897600
2030	14.415	1.58	1569165024
2031	13.876	1.518	1590572416
2032	13.333	1.456	1612119776
2033	12.786	1.394	1633807104

CONCLUSIONS

We conclude that for Polynomial model for Birth rate and population and linear model for fertility rate are showing best models and one decade predictions are showing downward tendency for Birth and fertility rate and upward tendency for population.

There is a strong negative association between population Versus Fertility rate and Population Versus Birth rate.

STRENGTHS AND LIMITATIONS

Population estimates are not perfect. A projection is a computation that illustrates the results under specific assumptions. The population estimates are based on trends. As such, they are not policy-based projections of the government's anticipated outcomes. Population change is influenced by a wide range of social and economic factors, including local and national government policies. There are many intricate and largely unknown relationships among the different components.

DISCUSSION

As per the data available, the current birth rate for India in 2023 is 16.949 births per 1000 people, a 1.25% decline from 2022 and there was a steady decrease in the birth rate by 1.2% from 2019 onwards (8). From the present study, it was predicted that by 2033 the birth rate would go down by 12.786 births per 1000 people with a steady decrease in the birth rates and this is due to a decrease in the fertility rates, which strongly suggests a positive correlation between both parameters.

ACKNOWLEDGEMENTS

Authors greatly acknowledge the financial assistance received from Management of the college under BVC-MRP/6 project.

AUTHORS CONTRIBUTION

All authors have contributed equally.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil

CONFLICT OF INTEREST

There are no conflicts of interest.

DECLARATION OF GENERATIVE AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors have not used any AI tools or services.

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