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Econometric estimation of the future prevalence of diseases in Mumbai

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Abstract:

The city of Mumbai, the financial capital of India is inhabited by more than 18 million people. It is sixth most populous city in the world. Its commercial feature attracts thousands of immigrants from all over the country. This has resulted into urban poverty which in turn is directly responsible for rise in slums in Mumbai. Unplanned development during last seventy years has been responsible for the urban chaos with pollution, improper disposal of garbage and waste products, unsafe sewage disposal and unplanned open drainage becoming a prominent feature for which this mega city is getting known and identified. Therefore the impact of the problem which comes with urbanization is felt throughout mega cities in India but more particularly in city like Mumbai. The current study takes Mumbai as the case study and based on secondary data applies the econometric method – SARIMA (Seasonal Autoregressive Integrated Moving Average) for time series forecasting by using univariate data containing trends and seasonality for four diseases – Tuberculosis, Diabetes, Diarrhea and Hypertension.

Keywords: Mumbai City, Life style Diseases, Improper Infrastructure

Introduction:

At different stages of economic growth, cities face different kinds of environmental problems and in turn health problems. For instance, cities that are less developed lack sanitation facilities. This results in unhygienic conditions and spread of infectious diseases. As the country progresses towards the path of economic growth, such problems slowly vanish. However, it unfolds different set of problems like pollution. With a further advancement in growth, the nature of environmental problems transforms. Higher energy consumption, increased waste generation and the related health problems are an offshoot of the rich lifestyle. Many Asian cities have passed through these stages and are exposed to environmental and health problems of varied kinds according to their respective economic growth levels.

According to (Bahl, 2018) the adoption of the sustainable development goals for 2030 by more than 150 countries at the United Nations Sustainable Development Summit reiterated the importance of cities in eradication of poverty, provision of clean drinking water and sanitation, eliminating diseases and so on.

Mumbai is located on the Western seacoast of India along the Arabian Sea. The geographical area of Mumbai is 468 square kilometers and its width is 17 kms. from east to west and 42 kms. from North to South [1]. Mumbai is merged by seven islands in the city area and four in the suburbs. Of the total population of India, Mumbai's population accounts for about 1 % (Jadhav, 2011). The infant mortality rate is (@1000 birth) – 34.57 (2006) and the maternal mortality rate is (@1000 birth) – 0.63 (2006) (ibid). As per Census 2011, Mumbai city has a population of 1.25 crores. Of this, 49% population lives in slums. They face multiple problems such as water shortage, living space shortage and inadequate sanitation facilities. Unplanned urbanization and industrialization has caused environmental degradation. Pollution from automobile emissions and industrial activities, has reached critical level in Mumbai, causing respiratory and bronchial problems. Mumbai is a home to estimated 6.5 million slum people (nearly 55% of the total population of Mumbai). Usually the living conditions in slums are unhygienic and are important factors in accelerating transmission of various diseases. The study aims to estimate the prevalence of certain diseases in Mumbai that are an offshoot of the sedentary life style and environmental pollution.

Review of Literature

It is observed that burden of the disease due to non-communicable diseases increased from 30 percent to 55 percent whereas communicable, maternal, neonatal and nutritional diseases dropped to 33 percent from 61 percent between 1990 and 2016 as per the report of India Council of Medical Research 2017.

Safe drinking water is one of the parameter for securing good health but it is estimated that more than 1.4 billion people in developing countries lack access to safe drinking water (World Resources (1998 – 99) - Poverty, Health

[1] MCGM. Statistics on Mumbai, Municipal Corporation of Greater Mumbai, 2007.

and the Environment). About 2.3 billion people suffer worldwide (Sundari 2003) due to diseases associated with poor water quality.

Around 3.3 million people die every year due to diseases associated with poor sanitation. A study conducted by Karn, et.al (2002) covering 1070 households of Mumbai depicted that 30% of the morbidity was due to poor sanitation.

As it is known that standing water is associated with increased risk of mosquito-borne and other vector-borne diseases in children, such as Dengue, which is further exacerbated by poor housing and high population densities (Gubler D, 2004).

A warmer climate could also cause water-borne diseases like Cholera and Diarrhea (Hales S., 2003). The cause for Diarrheal diseases was unsafe drinking water and lack of basic sanitation; resulting an increase in the incidence of such diseases (Ezzati M., et.al.2004).

As per the World Bank estimates, India loses 6.4% of its GDP every year due to water and sanitation-related diseases (The World Bank, 2010).

Need for the Study

Diabetes has emerged as a serious health challenge in India. Only about 0.7% of India's disease burden in 1998 was due to diabetes. However, the recent data suggest heavy prevalence load of diabetes in India. The number of diabetes cases has increased from 2.6 crore in 2000 to approximately 4.6 crore in 2015. More importantly it is particularly concentrated in the urban areas. The data also revealed that the prevalence of diabetes is highly significant among the age group of 30–39 years' (6%) and this prevalence rate sharply increased to 13% in the 40–49 years' age bracket , and to just about one-fifth of the population of 70 years and above. Moreover, the prevalence rate of diabetes among women above 40 years of age is higher (NCMH, 2005).

Nearly 40% of the Indian population of all ages has tubercle bacillus infection; and there are about 85,00,000 people with TB at any given time. With quite 400,000 dying annually (Yajnik et al. 2002; Tuberculosis Research Centre [TRC] 2004), Tuberculosis is the single most vital explanation for death in India at the present.

Hypertension is another lifestyle problem in India and is increasing at a rampant rate. 1.63 million deaths in India in 2016 was due to hypertension alone (Gakidou E., et. al 2017). High BP was a prime reason for over half of the deaths due to heart disease (54.2%), stroke (56.2%) and chronic kidney disease (54.5%) (GBD, 2019). India has also been experiencing an increase in the prevalence of hypertension (Gupta et.al 2018). A cross-sectional, population-based study on an outsized nationally stratified sample of 1.3 million individuals administered between 2012 and 2014 revealed that the crude prevalence of hypertension in India was 25.3% (Geldsetzer P et.al 2018). Prevalence of hypertension was common even among younger age groups, with approximately one out of every 10 individuals aged 18-25 years suffering from it (ibid).

Despite the reduction in mortality, diarrhea remained among the leading causes of death in Indian children below the age of five. It is estimated that 321 children every day died in 2015, according to data from the World Health Organization (WHO Factsheet, 2017) due to it. Diarrhea, which ends up in dehydration--is also a number one explanation for malnutrition globally. In 2016, India ranked 114 of 132 nations on stunting (Nie P., et.al 2019). In 2015, deaths from diarrhea in Indian children under five accounted for 10% (117,285) of all deaths in the age-group, higher than 7% (3,273 children) in Myanmar, 7% (5,442 children) in Kenya and 9% (39,484 children) in Pakistan (Indiaspend, 2018). Between 2000-2012, India's under-five mortality declined by an average of 3.7% annually (Liu L., et.al 2015). "Even though the deaths among children under five years have declined, the proportional mortality accounted by diarrheal diseases still remains high." (ibid).

Prevalence estimates of the four diseases, viz., Tuberculosis, Diabetes, Hypertension and Diarrhea are urgently needed for realistic description of the magnitude of the problem. The study applies Seasonal Autoregressive Integrated Moving Average (SARIMA) for estimating the future trends of the above mentioned diseases by taking Mumbai as the case study. Based on the results of the analysis of variables the study aims to provide recommendations.

Objective of the Study

1) To forecast the trends in the prevalence of Tuberculosis, Diabetes, Diarrhea and Hypertension in the future in Mumbai City

Research Methodology

Data Source: Secondary Data published as A White Paper by Praja.org. The title of the paper is: Report on The STATE of HEALTH in MUMBAI, September 2018

Descriptive Statistics: For each of the 24 wards in Mumbai, the rate of prevalence per 1000 population was estimated for all the diseases (Tuberculosis, Diabetes, Diarrhea and Hypertension) from 2013-14 till 2017-18. On the basis of this, ward with highest prevalence of each of these diseases was ascertained. Findings of our analysis point out that, Tuberculosis was highly prevalent in L ward, Diabetes was highly prevalent in R/S ward, Diarrhea was highly prevalent in L ward and Hypertension was highly prevalent in D ward. Then Seasonal Autoregressive Integrated Moving Average was calculated for the above wards to forecast the prevalence of these diseases from 2019 till 2021.

***Econometric Model Adopted*: SARIMA MODELLING**

Autoregressive Integrated Moving Average, or ARIMA, is one of the most widely used forecasting methods for univariate time series data forecasting. Although the method can handle data with a trend, it does not support time series with a seasonal component. An extension to ARIMA that supports the direct modelling of the seasonal component of the series is called SARIMA (Seasonal Autoregressive Integrated Moving Average). SARIMA method for time series forecasting uses univariate data containing trends and seasonality.

Findings

A) For the purpose of this study SARIMA (0,1,1) (0,1,1) model was used with a specified repeated interval of 12, signifying the cyclical twelve months in a year. The trend difference order (d) was 1, and seasonal difference order (D) was also 1. The value of μ was -8.74, with σ being 98.85.

Summary of SARIMA Model for total monthly patient admissions

SARIMA (0,1,1)(0,1,1)12

Param	Value
M	-8.74
θ_1	0.00
Θ_1	0.00
Σ	98.85
D	1
S	12
D	1

Goodness-of-fit

LLF	AIC	CHECK
-138.29	286.57	1

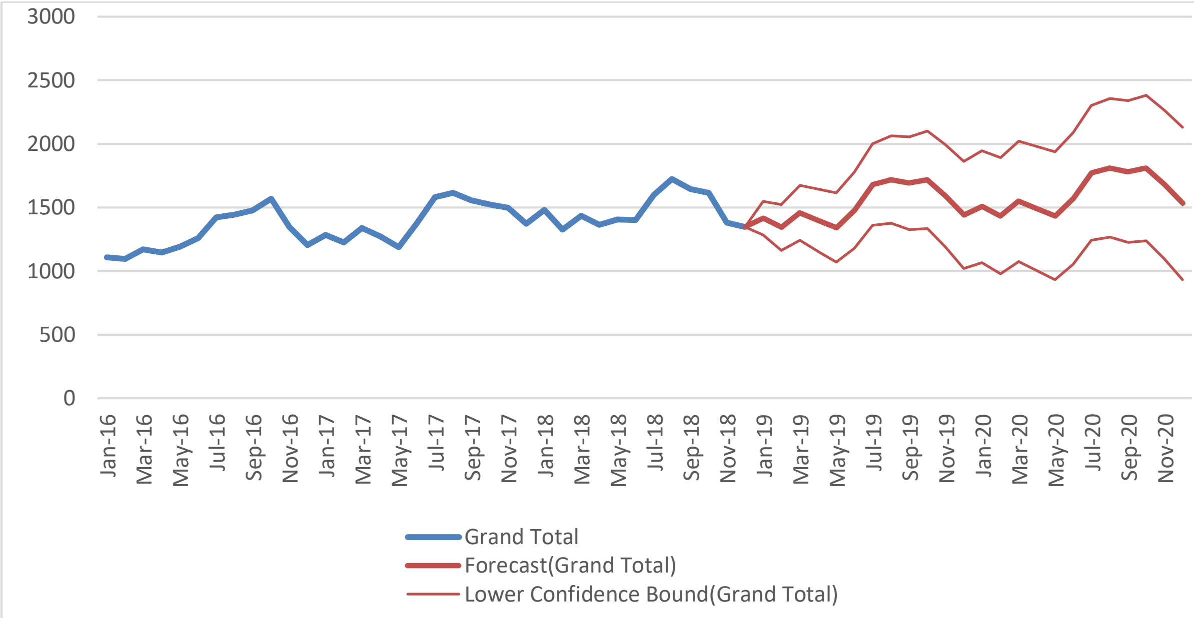
After establishing the parameter values the next step that was done is to forecast the patient admissions for the next period of 24 months. The model extrapolated the upper limits and lower limits for the next cycle and with that calculated the standard deviation. The mean of the two is taken as the most probable value and is taken as the predictor. As we move away from the date of prediction in to the future, the confidence of prediction decreases and the standard deviation keeps on increasing. This is in line with the basic premise of ARIMA modelling that moving average gets harder to calculate as we extrapolate the trend to the future.

Use of SARIMA for Patient Forecasting

Table No.1 Forecasting of Patient Admissions for the years of 2019 and 2020

Month	Forecast (Grand Total)	Lower Confidence Bound (Grand Total)	Upper Confidence Bound (Grand Total)
Jan-19	1414.94	1282.38	1547.50
Feb-19	1343.06	1164.63	1521.50
Mar-19	1457.13	1242.34	1671.92
Apr-19	1400.08	1154.18	1645.97
May-19	1342.62	1069.08	1616.17
Jun-19	1478.48	1179.79	1777.17
Jul-19	1680.46	1358.52	2002.39
Aug-19	1719.28	1375.62	2062.93
Sep-19	1691.02	1326.90	2055.15
Oct-19	1717.76	1334.21	2101.30
Nov-19	1589.58	1187.51	1991.65
Dec-19	1440.35	1020.53	1860.16
Jan-20	1506.42	1065.73	1947.10
Feb-20	1434.54	977.54	1891.55
Mar-20	1548.61	1075.81	2021.40
Apr-20	1491.55	1003.45	1979.66
May-20	1434.10	931.12	1937.08
Jun-20	1569.96	1052.49	2087.42
Jul-20	1771.94	1240.36	2303.52
Aug-20	1810.75	1265.39	2356.11
Sep-20	1782.50	1223.67	2341.33
Oct-20	1809.23	1237.22	2381.25
Nov-20	1681.06	1096.14	2265.98
Dec-20	1531.82	934.24	2129.41

Figure No.1 Graph of SARIMA Forecasting of Total Monthly Admissions



SARIMA is also a great tool for forecasting patient admissions in hospitals, as it not only takes into account the trends in admissions but also the seasonality in admissions. Admission patterns in many specialties show relation to time periods and vary according to the season. In this case if we extrapolate our dataset to December 2020, we get the above time series graph. Based on the grand total lower confidence bound and the grand total upper confidence bounds, a mean is calculated that is basically the predicted value for the particular time period. As we move away from the most recent value the confidence in the prediction is decreased as signified by the greater standard deviation. In the case of our dataset it is seen that the patient admissions go on increasing, but the three phases of patient admissions – i.e. Plateau Phase, Ascending Phase and Descending Phase remain intact and are repeated in the next forecast too.

B) Tuberculosis

Table No.2 Forecasting of the prevalence of Tuberculosis for the years of 2019 and 2021

Ward L

Date	L	Forecast (L)	Lower Confidence Bound(L)	Upper Confidence Bound(L)
01-01-2013	1.15			
01-01-2014	1.31			
01-01-2015	1.58			
01-01-2016	0.14			
01-01-2017	0.88	0.88	0.88	0.88
01-01-2018		(0.16)	(1.34)	1.03
01-01-2019		(0.30)	(1.52)	0.93
01-01-2020		(0.81)	(2.07)	0.45
01-01-2021		(0.95)	(2.25)	0.35

Statistic	Value
Alpha	0.25
Beta	0.00
Gamma	0.00
MASE	0.78
SMAPE	0.75
MAE	0.51
RMSE	0.61

C) Diabetes

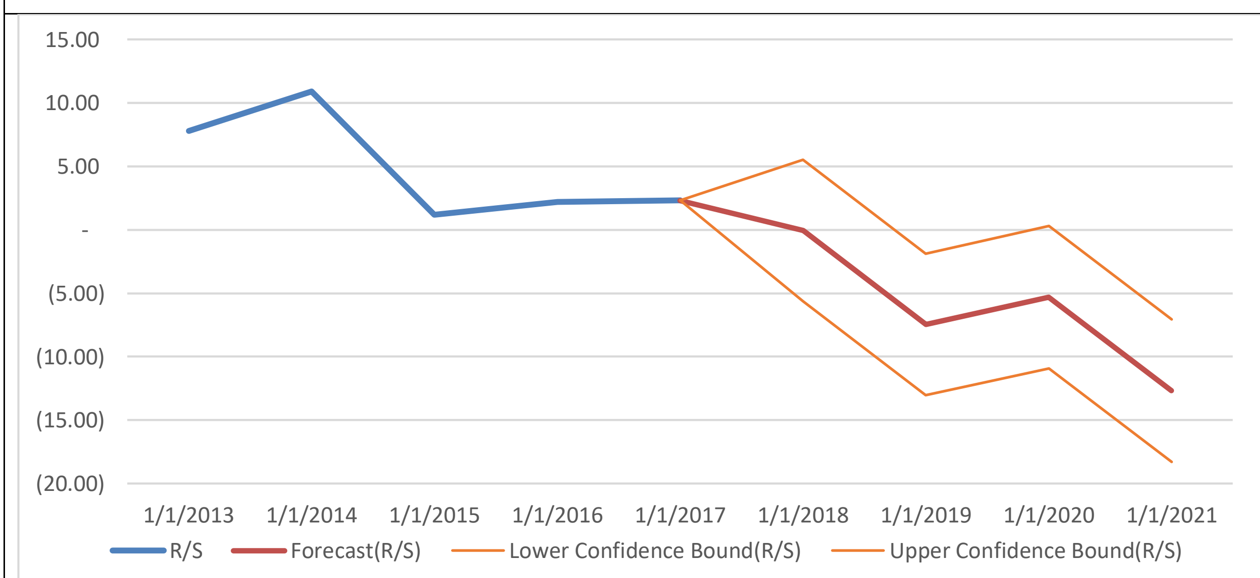
Table No.3 Forecasting of the prevalence of Diabetes for the years of 2019 and 2021

Ward	R/S	Forecast(R/S)	Lower Confidence Bound(R/S)	Upper Confidence Bound(R/S)
01-01-2013	7.80			
01-01-2014	10.91			
01-01-2015	1.20			
01-01-2016	2.19			
01-01-2017	2.32	2.32	2.32	2.32
01-01-2018		(0.06)	(5.64)	5.51
01-01-2019		(7.45)	(13.02)	(1.87)
01-01-2020		(5.30)	(10.92)	(0.32)
01-01-2021		(12.69)	(18.31)	(7.07)

Statistic	Value
Alpha	0.00
Beta	0.00
Gamma	0.13
MASE	0.58
SMAPE	0.72
MAE	2.01
RMSE	2.84

Fig No.2 Forecasting of the prevalence of Tuberculosis for the years of 2019 and 2021

Fig No. 3 Forecasting of the prevalence of Diabetes for the years of 2019 and 2021



As evident from Table Nos. 2 and 3 and Figure Nos. 2 and 3, if we extrapolate our Tuberculosis and Diabetes prevalence to year 2021, we get the above time series graph. Based on the grand total lower confidence bound and the grand total upper confidence bounds, a prevalence rate is calculated that is basically the predicted value for the particular time period in specific ward. As we move away from the most recent value towards 2021, our dataset shows that the Tuberculosis patients and Diabetes patients will be declining, and predicted values shows negative predicted rate and its confidence interval. Descending Phase remain intact and are repeated in the next forecast too.

D) Diarrhea

Table No.4 Forecasting of the prevalence of Diarrhea for the years of 2019 and 2021

Ward	L	Forecast(L)	Lower Confidence Bound(L)	Upper Confidence Bound(L)
01-01-2013	10.70576			
01-01-2014	11.24221			
01-01-2015	13.64516			
01-01-2016	12.78506			
01-01-2017	13.40021	13.40020505	13.40	13.40
01-01-2018		14.04380797	12.57	15.52
01-01-2019		14.68031058	13.20	16.16
01-01-2020		15.31681319	13.83	16.81
01-01-2021		15.95331581	14.46	17.45

Statistic	Value
Alpha	0.10
Beta	0.00
Gamma	0.00
MASE	0.33
SMAPE	0.03
MAE	0.36
RMSE	0.75

E) Hypertension

Table No.5 Forecasting of the prevalence of Hypertension for the years of 2019 and 2021

Ward	D	Forecast(D)	Lower Confidence Bound(D)	Upper Confidence Bound(D)
01-01-2013	0.882185			
01-01-2014	1.135885			
01-01-2015	6.656749			
01-01-2016	6.70576			
01-01-2017	6.509718	6.50971845	6.51	6.51
01-01-2018		8.675784305	5.84	11.51
01-01-2019		10.23475142	7.40	13.07
01-01-2020		11.79371854	8.95	14.63
01-01-2021		13.35268566	10.51	16.19

Statistic	Value
Alpha	0.00
Beta	0.00
Gamma	0.00
MASE	0.76
SMAPE	0.30
MAE	1.15
RMSE	1.45

Fig. No. 4 Forecasting of the prevalence of Diarrhea for the years of 2019 and 2021

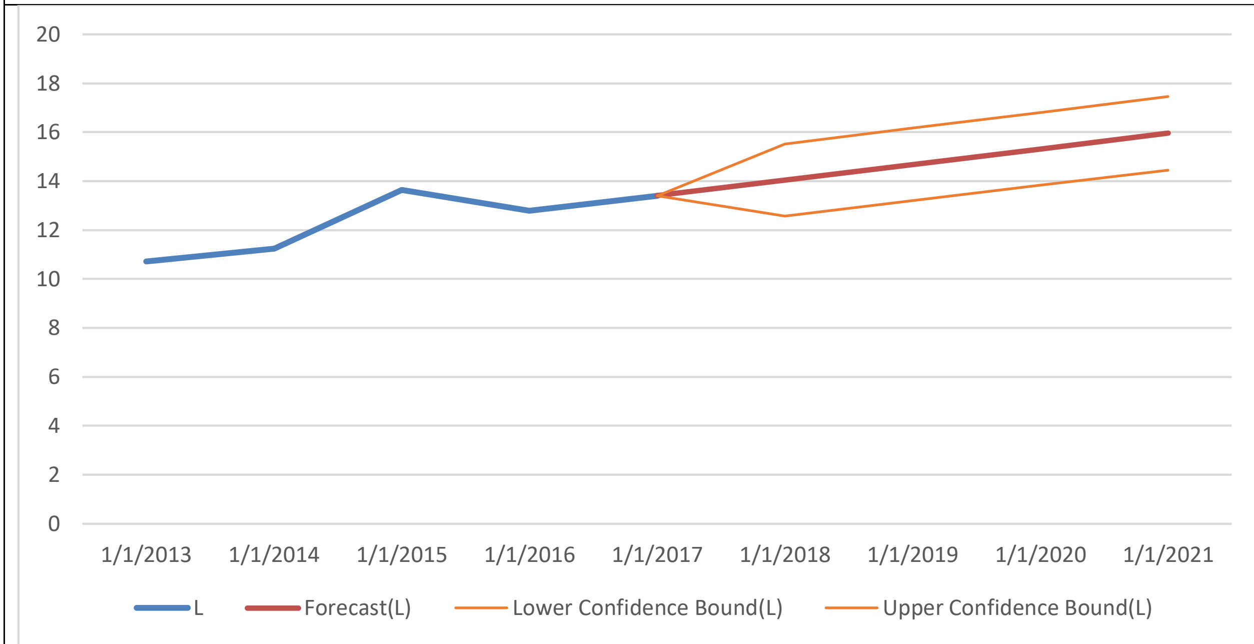
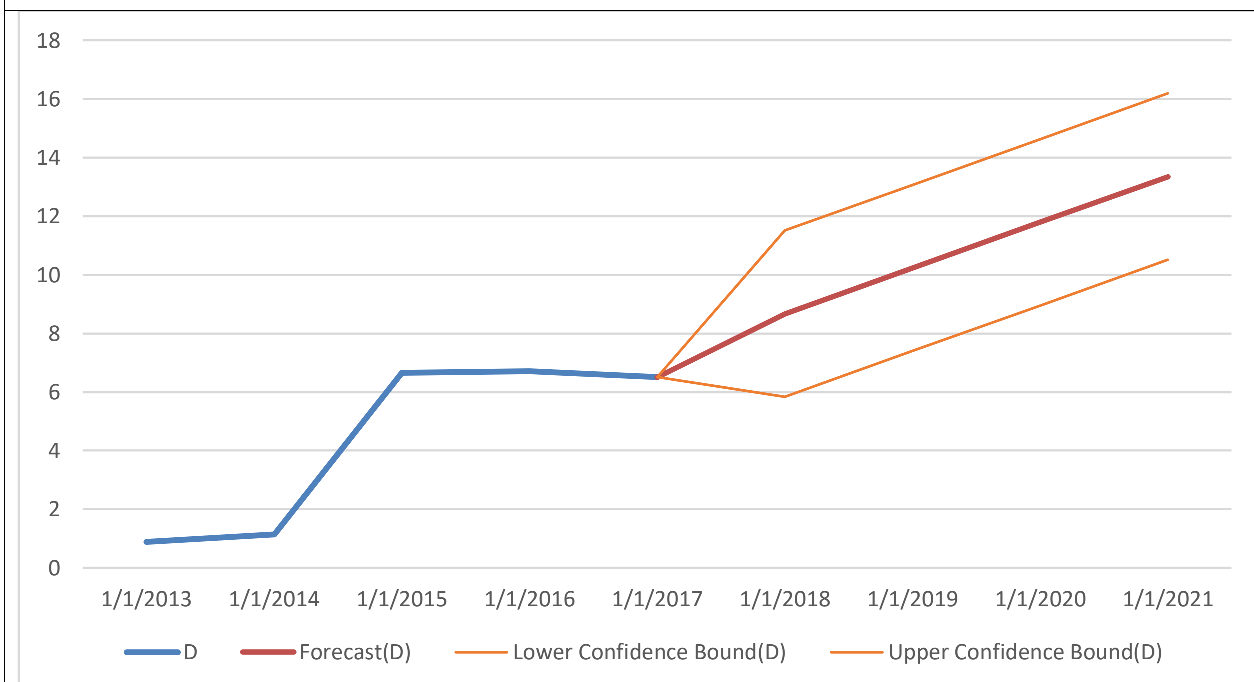


Fig. No.5 Forecasting of the prevalence of Hypertension for the years of 2019 and 2021



As evident from Table Nos. 4 and 5 and Figure Nos. 4 and 5, if we extrapolate our Diarrhea and Hypertension prevalence to year 2021, we get the above time series graph. Based on the grand total lower confidence bound and the grand total upper confidence bounds, a prevalence rate is calculated that is basically the predicted value for the particular time period in specific ward. As we move away from the most recent value towards 2021, our dataset shows that the Diarrhea patients and Hypertension patients will be increasing, and predicted values shows positive predicted rate and its confidence interval. Ascending Phase remain intact and are repeated in the next forecast too.

Suggestions and Recommendations

This study has several important implications for health policy makers. It is shown from the findings that hypertension still remained a serious public health problem in Mumbai. Both non-medical and medical approaches for treatment of hypertension should be considered. Mass media should be used to educate the general population, brochures and leaflets should be delivered to hypertensive patients and leadership from social and professional organizations should be provided to promote healthy lifestyles. Improving the capacity of the community health centers would be a crucial activity for enhancing the speed of early detection, treatment, and control of hypertension. Healthy cities should be constructed by changing the design of the cities. Neighborhoods should be made more activity-friendly and walkable.

As far as Diarrhea is concerned, awareness regarding different aspects of prevention and treatment of diarrheal diseases needs to be created among people especially among parents. Prolonged breast feeding, spoon feeding instead of bottle feeding should be emphasized in preventing diarrhea. Utility of measles immunization in prevention of diarrhea should be popularized. Knowledge regarding ORS, its preparation and its use in diarrhea and vomiting should be spread. Vaccines to prevent Diarrhea should be made available at reasonable cost.

Limitations of the Study

In order to calculate the prevalence rate of diseases, due to non-availability of ward-wise population data for the years 2014-15, 2015-16 and 2016-17, the ward-wise population for 2013-14 is considered for analysis.

Scope for further research

Ward- wise microscopic evaluation of social, economic, political and cultural factors can provide in-depth insights for establishing causal relationship with the prevalence of diseases in Mumbai.

Conclusion

Indian Cities are plagued by plethora of diseases, and Mumbai city is not an exception. By encouraging the event of proper infrastructure, enabling alternative infrastructures and disease prevention mechanisms in informal and vulnerable places, and build up a public health system to watch and respond to outbreaks, Mumbai will be better prepared to prevent diseases from afflicting their residents, and to fight them when they do. Recognizing that many diseases are spread because of cramped conditions and poor ventilation, architectural designs should be prepared to prevent spread of diseases.

Bibliography

Ezzati M, Lopez A, Rodgers A, Murray C.(2004), Comparative Quantification of Health Risks: Global and Regional Burden of Disease due to Selected Major Risk Factors, Geneva: World Health Organization. 2004; 1(2)

Gakidou E, Afshin A, AlemuAbajobir A, Hassen Abate K, Abbafati C, Abbas KM, *et al. (2017),* Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990-2016: A systematic analysis for the Global Burden of Disease study 2016. *Lancet* 2017; *390* : 1345-422.

GBD Compare | IHME Viz Hub. Global; both series, all ages, 2017, DALYS. Available from: *https://vizhub.healthdata.org/gbd-compare/#*, accessed on February 27, 2019.

Geldsetzer P, Manne-Goehler J, Theilmann M, Davies JI, Awasthi A, Vollmer S, *et al (2018).* Diabetes and hypertension in India: A nationally representative study of 1.3 million adults. *JAMA Intern Med* 2018; *178* : 363-72

Gubler DJ. (2004), Cities Spawn Epidemic Dengue Viruses. Nat Med. 2004; 10:129-30.

Gupta R, Gaur K, S Ram CV. Emerging trends in hypertension epidemiology in India. *J Hum Hypertens* 2018; doi:10.1038/s41371-018-0117-3

Hales S, Edwards SJ, Kovats R (2003), Impacts on health of climate extremes. In: McMichael AJ, Campbell-Lendrum DH, Corvalan CF, Ebi KL, Githeko A, Scheraga JD, Woodward A, editors. Climate change and human health: Risks and responses. Geneva, Switzerland: World Health Organization. 2003, 79-102

Indian Council of Medical Research (2017) India: Health of the Nation States, Ministry of Health and Family Welfare, Government of India.

Indiaspend (2018) *Child deaths from diarrhoea halved in 10 yrs, but 321 died every day in '15*, Business Standard, Available on https://www.business-standard.com/article/current-affairs/child-deaths-from-diarrhoea-halved-in-10-yrs-but-321-died-every-day-in-15-118032700122_1.html, accessed on 4.2.2020.

Jadhav, N. (2011), 'Role of Mumbai in Indian Economy', retrieved from www.drnarendra jadhav.info on 21st July.

Karn SK, Harada H. (2002), Field Survey on Water Supply, Sanitation and Associated Health Impacts in Urban Poor Communities – A Case from Mumbai City, India. Water Science and Technology, 46(1-12):269-275.

Li Liu, Shefali Oza, Daniel Hogan, Jamie Perin, Igor Rudan, Joy E Lawn, Simon Cousens, Colin Mathers, Robert E Black (2015), Global, regional, and national causes of child mortality in 2000–13, with projections to inform post-2015 priorities: an updated systematic analysis, Lancet 2015; 385: 430–40 Published Online October 1, 2014, http://dx.doi.org/10.1016/ S0140-6736(14)61698-6

NCMH (2005). Burden of Disease in India, Ministry of Health & Family Welfare, Government of India, New Delhi.

Peng Nie, Anu Rammohan , Wencke Gwozdz and Alfonso Sousa-Poza (2019), Changes in Child Nutrition in India: A Decomposition Approach, *International Journal of Environmental Research and Public Health*, doi:10.3390/ijerph16101815

Sundari S. (2003) Quality of Life of Migrant Households In Urban Slums in Martin J. Bunch, V. Madha Suresh and T. Vasantha Kumaran, eds., Proceedings of the Third International Conference on Environment and Health, Chennai, India., 537-552

The World Bank (2010) Water and Sanitation Program: The Economic Impacts of Inadequate Sanitation in India. New Delhi: World Bank, 2010. http://www.wsp.org/wsp/sites/wsp.org/files/publications/ wsp-esi-india.pdf

Tuberculosis Research Centre (2004), Estimation of the burden of pulmonary tuberculosis in India for the year 2000. Chennai: TRC.

Yajnik K, Chakraborty A, Jochem K. (2002) A mathematical model for determining the effect of tuberculosis control programmes on its prevalence in India (draft report). New Delhi: The World Bank.

WHO Factsheet (2017) Available on https://www.who.int/en/news-room/fact-sheets/detail/diarrhoeal-disease, accessed on 4.2.2020