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Covid-19 in Tamil Nadu: People's Life Expectancy vs. Impact of Economic

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Abstract:

The purpose of this article is to look at the Tamil Nadu People's Life Expectancy in terms of daily Mortality rates in Covid-19 and evaluate the possibilities of surviving for the people of Tamil Nadu and this study employs a stochastic model, such as Kaplan-Meier and Nelson-Aalen. In the first stage, stochastic models are used to predict the population's survival probability in Tamil Nadu. The variance of the stochastic models was computed in the second stage to ensure that the population's significance level was maintained and also this paper discuss at the economic impact of Tamil Nadu due to covid-19. The economy of Tamil Nadu is facing a number of difficulties at the moment, which are affecting supply and demand and slowing down economic growth in India. Tamil Nadu and India are both experiencing the effects of the corona virus epidemic, which is having an impact on the manufacturing and service sectors. This study uses the long-term distribution of a Markov Chain Analysis to determine the effects of the Covid-19 pandemic's contributors to Tamil Nadu's GDP as well as the financial compensations resulting from the outbreak. The study also looks at how the Covid-19 has affected the three economic sectors in Tamil Nadu. The findings of this report recommend that the Tamil Nadu government consider alternative approaches to economic planning in the impacted economic sectors. Furthermore, the data can be useful in creating an economic recovery strategy for the post-COVID-19 Tamil Nadu economy.

Keywords: Covid-19, People's Life Expectancy, Stochastic Model, Impact of Economic Markov Chain.

1. Introduction

In the insurance sector, life and health actuaries are responsible for predicting the population's longevity in a certain geographic location. As a result, actuaries typically use stochastic or survival models to assess people's survival prospects. Actuaries censor data in order to forecast an accurate outcome, and they can then create an insurance policy based on that information. [6] H.W. Hethcote (2000) talked the infectious diseases have remained the leading causes of death and suffering in underdeveloped countries. [13] The COVID-19 pandemic is expected to peak globally on May 22, 2020, having peaked in China on February 22, 2020, according to M. Li, Z. Zhang, et al. (2020). By early April 2020 in China, and late August 2020 worldwide, it will be largely under control. [1] According to Akhil Kumar Srivastav et al. (2020), the COVID-19 pandemic has caused misery for millions of people worldwide, making it one of the deadliest in human history. Since the start of the

COVID-19 epidemic in India on March 2, 2020, the number of cases has been continuously rising. [17] M. Majumder, K.D. Mandl (2020) expressed, nearly 3000 instances of respiratory disease caused by a novel coronavirus (2019–nCoV) have been diagnosed in connection with an outbreak that began in Wuhan, China, beginning December 1, 2019. [20] The male population in India is more vulnerable to COVID-19 because of common co-morbidities and long-standing male chauvinism, according to Sampurna Kundu, Kirti, and Debarghya Mandal (2020). [19] Sukumar Rajendran, Prabhu Jayagopal (2021) articulated that the as of June 3, 2020, the Tamil Nadu had 25,872 confirmed cases and 208 deaths and death rate is 1.8%. [9] According to the study conducted by Joseph A. Lewnard, Ayesha Mahmud, et al. (2021), there were 87, 870 recorded deaths in the Chennai district between March 1, 2020, and June 30, 2021, which was 25 990 more than the number of deaths that were projected. [10] Kuralayanapalya, Puttahonnappa Suresh et.al (2021) articulated that the number of people increase infected quickly in Kerala, at that time West Bengal, Tamil Nadu, Uttar Pradesh, and Rajasthan, however, dramatic reductions. [23] Youngkyoung Min et.al. (2011) articulated that the most popular way of examining mortality is the survival analysis. Biology, public health, epidemiology, economics, and engineering all require it. [8] When using typical statistical tools to analyze data, James N. McNair et al. (2012) found that non-parametric techniques like life-table and Kaplan-Meier estimators are more helpful in determining the time-to-event. [16] Dr Monem A.Mohammed (2014) revealed that survival analysis is a field of statistics that examines the time it takes for events to occur, such as death in biological organisms and mechanical system failure. [5] Enrico Colosimo et.al. (2002) disclosed that the KM estimator of the survival function is the most often employed, whereas the NA estimator is an alternative. [4] MJ Bradburn et.al., (2003) expressed that the Kaplan–Meier plots, log rank tests and Cox models are most common methods for analyzing survival data and now included in commercial statistical software. [11] E.L.Kaplan & Paul Meier (2009) expressed that the most efficient technique can be derived from Kaplan-Meier survival function estimation, which has also been proven to have strong consistency. [15] The Kaplan-Meier estimate is one of the best techniques for determining the proportion of individuals that survive for a specific amount of time following therapy, according to Manish Kumar Goel et al. (2010). [18] Patricia Guyot et.al. (2012) disclosed the Kaplan-Meier approach is used to calculate the likelihood of encountering the event till the end of the time period. [12] S. Kharroubi (2020) expressed that the generated models be used to predict and explain COVID-19 infections, could be extremely helpful to health-care decision-makers. [2] According to Abere, Omotayo Johncally (2021), the cost of a pandemic insurance premium must be significantly higher than that of any other type of insurance due to the possibility of significant, potentially catastrophic losses. [14] The corona virus was discovered on December 31, 2019, according to J Leo et al. (2002). From there, the illness spread to more Chinese provinces and the rest of the world. The global economy has been under jeopardy since the beginning of COVID-19 in China. The effects on the economy have not only been felt in Europe and China, but also in India—more especially in Tamil Nadu.

This study employs a long-term Markov chain model distribution to estimate the economic impact of Tamil Nadu. Determining the corrective measures for the affected Tamil Nadu economy is also helpful. Furthermore, the study utilizes stochastic models, specifically Kaplan-Meier and Nelson-Aalen, to ascertain the variance and surviving probability among them.

2. Development of the Model

2.1 The Kaplan -Meier Estimator - [22] The Kaplan Meier Estimator is used to estimate the survival function using lifetime data. This non-parametric statistical method's goal is to calculate the survival time for a given event, like a significant medical trial or other important event, as well as the precise moment of death.

2.1.1 The Kaplan -Meier Estimate of the distribution function

F_{KM} (t) = 1- Π (1-λ_j)

S_{KM} (t) = 1- F_{KM} (t)

2.1.2 The variance of the Kaplan -Meier Estimator

$$\text{Var}[\ F(t)] = (1 - F(t))^2 \sum \frac{d_j}{n_j(n_j - d_j)}$$

2.2 The Nelson–Aalen Estimator – [22] The Nelson–Aalen estimate is a non-parametric cumulative hazard rate function estimator that can be used in the case of missing data. It is used to determine the total number of predicted deaths in life insurance.

2.32.2.1 The Nelson–Aalen Estimate of the distribution function

F_{NA} (t) = 1- $e^{-\Lambda_j}$

S_{NA} (t) = 1- F_{NA} (t)

2.3.2 The variance of the Nelson-Aalen Estimator

$$\text{Var}[\Lambda_j] = \sum \frac{d_j\,(n_j - d_j)}{n_j^3}$$

2.4The notations

The symbols that are being used in our models are as follows

j - Observed lifetime.

t_j - Deaths caused with Covid-19 were observed at specific times.

d_j - Covid-19-related deaths were observed at particular times.

D_j - The entire count of Covid-19-related deaths

n_j - Total number of people who are at risk at any one moment t_j^-, that is just before the observed life time. i.e., the difference between the estimated population and numbers of daily death count.$t_{\bar{j}}$

S_{KM} (t) - The survival function's Kaplan Meier estimate.

S_{NA} (t) - An estimation of the survival function by Nelson - Aalen.

3. Data Analysis

The life expectancy of the Tamil Nadu people during COVID-19 was determined by this study, which took place from March 7, 2020, to February 5, 2022, using the state's daily death count. In addition we have collected data at the Central Statistics Office regarding the GSDP and GVA from 2014–15 to 2021–22.

Economic Sector	% of Contribution to GVA
Agriculture	13%
Manufacturing	34%
Service	53%

Table 1: % of sectors contribution to the Gross Value Added

Economic Sector	% of Growth in GSDP
Agriculture = E_1	8.3%
Manufacturing = E_2	7.45%
Service = E_3	7.5%

Table 2: % of sectors growth in GSDP

Economic Sector	Weight Index
Agriculture = E_1	$\frac{E_1}{\sum_1^3 \pi i} = \frac{8.3}{23.25} = 0.3570$
Manufacturing = E_2	$\frac{E_2}{\sum_1^3 \pi i} = \frac{7.45}{23.25} = 0.3204$
Service = E_3	$\frac{E_3}{\sum_1^3 \pi i} = \frac{7.5}{23.25} = 0.3226$

Table 3: Weight index per Growth in GSDP

The economy's vector will be represented as a vector $\Pi = (\pi_1, \pi_2, \pi_3)$

$= (0.3570, 0.3204, 0.3226)$

4. Calculation

4.1 To determine the life expectancy of the Tamil Nadu population during COVID-19, data was collected from an official government website and then calculated using MS-EXCEL and Python programming.

4.2 With Table 1, we may fill the probability transition matrix below in the method shown below.

$$P_{x,j}^{ij} = \begin{vmatrix} 0.13 & 0.34 & 0.53 \\ 0.13 & 0.34 & 0.53 \\ 0.13 & 0.34 & 0.53 \end{vmatrix}$$

We will use the results of a long run test to determine what occurs in steady state.

$$\Pi * P = \Pi$$

$$(\pi_1, \pi_2, \pi_3) \begin{vmatrix} 0.13 & 0.34 & 0.53 \\ 0.13 & 0.34 & 0.53 \\ 0.13 & 0.34 & 0.53 \end{vmatrix} = (\pi_1, \pi_2, \pi_3)$$

$\pi_1 = 0.13\pi_1 + 0.13\pi_2 + 0.13\pi_3$ ------ (1)

$\pi_2 = 0.34\pi_1 + 0.34\pi_2 + 0.34\pi_3$ ------ (2)

$\pi_3 = 0.53\pi_1 + 0.53\pi_2 + 0.53\pi_3$ ------ (3)

To make the preceding three equations easier to answer, we can rearrange them as follows:

$-0.87\pi_1 + 0.13 + 0.13 = 0$ ------ (4)

$0.34\pi_1 - 0.66\pi_2 + 0.34\pi_3 = 0$ ------ (5)

$0.53\pi_1 + 0.53\pi_2 - 0.47\pi_3 = 0$ ------ (6)

$\pi_1 + \pi_2 + \pi_3 = 1$------ (7)

Once more, the first three equations above can be arranged as follows for easy solving:

$\pi_1 = 0.26\pi_2$ ------ (8)

$\pi_3 = 0.8901\pi_2$ ------ (9)

Then substituting (8) & (9) in (7), In the manner that follows, we can solve the simultaneous equations to get the values of $\Pi = (\pi_1, \pi_2, \pi_3)$ ------ (10)

5. Results

5.1 The daily death count has climbed after 100 days, according to the results.

Period of Observation (In days)	No. of deaths due to Covid-19	Mortality Rate in Tamil Nadu @ 10000000 Population	Mortality Rate in Tamil Nadu @ Percentage	Severity Rate
$1 \leq t_j \leq 100$	475	0.0000475	0.00%	No Severity
$101 \leq t_j \leq 200$	1778	0.0001778	0.02%	No Severity
$201 \leq t_j \leq 300$	4646	0.0004646	0.05%	High Severity
$301 \leq t_j \leq 400$	5086	0.0005086	0.05%	High Severity
$401 \leq t_j \leq 500$	643	0.0000643	0.01%	No Severity
$501 \leq t_j \leq 600$	3689	0.0003689	0.04%	Less Severity
$601 \leq t_j \leq 701$	6712	0.0006712	0.07%	High Severity

Table 4. The severity of the mortality rate Vs. Time Interval

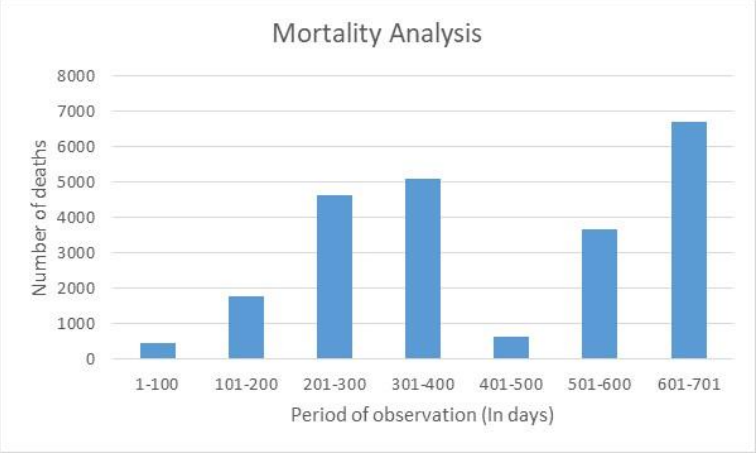

Figure 1. Analysis of mortality with impacts from observation periods vs. number of deaths due to Covid-19.

5.2 The Result indicates that in nature, the survival probability appears to be high.

	Survival Probability	Period of Observation (In days)
S_{KM} (t) & S_{NA} (t)	1.0000000	0
	0.999994	$1 \leq t_j \leq 100$
	0.999971	$101 \leq t_j \leq 200$
	0.99991	$201 \leq t_j \leq 300$

	0.999935	$301 \leq t_j \leq 400$
	0.999927	$401 \leq t_j \leq 500$
	0.99988	$501 \leq t_j \leq 600$
	0.999795	$601 \leq t_j \leq 701$

Table 5. Survival function of Kaplan-Meier & Nelson-Aalen Models Vs Time Interval

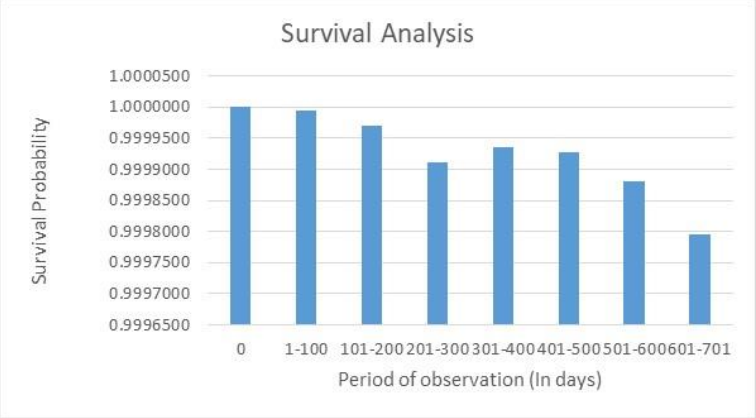

Figure 2. Kaplan Meier &Nelson-Aalen Analysis predicts survival probability

5.3 After analysing the previously mentioned equation (10), we determined that the values of Π are as follows

$\Pi = (\pi_1 = 0.1209, \pi_2 = 0.4651, \pi_3 = 0.4140)$

It is evident from the findings about the state's economic sectors' influence that the proportionate rates have decreased as compared to the equational rates. The totals are listed in Table 6 after the proportions are multiplied by the initial estimated rise of GSDP quantities prior to the detection of the Covid-19 virus.

Economic Sector	% of Prior to and During Growth in GSDP	% of Post Covid-19 Growth in GSDP
Agriculture	8.3%	2.82%
Manufacturing	7.45%	10.81%
Service	7.5%	9.62%

Table 6: Prior to and During vs. Post-Covid-19 growth in GSDP

6. Findings

The findings indicate that the Tamil Nadu People's survival prospects during Covid-19 appear to be favorable. The result therefore reveals that no population variance exists during COVID-19. The graphs demonstrate that the overall survival chance is decreasing slightly. Similarly, after 100 days, the daily death count has climbed. The preceding overview clearly illustrates that the stochastic models suit the data and match with a practical meaning after carrying out each step in the modelling operations with accuracy. As a result, shows that non-parametric method would provide the most accurate result. This demonstrates that both the model and the data are completely matched. As a result of the curfew, labor shortages, transportation problems, and market closures, the growth of the gross state domestic product (GSDP) in the agriculture sector has decreased from 8.32% to 2.82% since COVID-19. The population growth and the conversion of agricultural land for urbanization and

industry are other factors contributing to the decline in the GSDP. As a result of Tamil Nadu's diversified manufacturing sector, which includes the production of electronics, cars, textiles, chemicals, and leather, the state's economy has become more industrialized and innovation-driven, creating competition for land and its resources. As a result, the growth of the gross state domestic product (GSDP) in the manufacturing sector has increased from 7.45% to 10.81% post-COVID-19. Between the late 20th and the early 21st centuries, the services sector has grown extremely swiftly, becoming Tamil Nadu's largest source of economic growth.

As a result, we can observe that the growth of the GSDP in the service sector grew from 7.5% to 9.62% post-COVID-19. One of the state's top priorities for economic development has been the growth of the information technology sector.

7. Conclusion

The life expectancy of Tamil Nadu residents remained unaltered during the first two years of Covid-19. However, as more people got afflicted with diseases, more people died over the observation periods, with 95 percent of deaths occurring in the fifty and above fifty age groups. As a result, that age group of mortality rates should be taken into additional considered when life and health insurance companies calculate premiums and settle claims. Furthermore, the state's GSDP rating has significantly increased since COVID-19. Except for agriculture, every economic sector is expanding. In the aftermath of the COVID-19 pandemic, this article seeks to assist the state in providing appropriate planning options for its population by applying the way forward methodologies to three sectors, as will be mentioned below. In order to maintain the growth of the manufacturing sector, we must take action in the agriculture sector to expand harvesting technology and guarantee that farmers can easily sell their products at direct procurement stations. The state government should also grant more concessions to micro, small, and medium-sized businesses for their successful operations, and increase funding to the service sectors for infrastructure improvements in the areas of health, education, tourism, and transportation. Cultural activities, etc.

Ultimately, the influence of COVID-19 on the life expectancy and economic position of Tamil Nadu residents is negligible.

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Annexure

Python Programming

“Survival Analysis

The discrete hazard function:

Surv = Survfit(Surv(Time,Death) ~ 1)

The Kaplan - Meier Estimator: (Dist-Func & Surv-Func)

from lifelines import KaplanMeierFitter

from lifelines.datasets import load_waltons

waltons = load_waltons()

-----> kmf = KaplanMeierFitter(label="waltons_data")

kmf.fit(waltons['T'], waltons['E'])

kmf.plot()

Variance:

kmf = KaplanMeierFitter(var_type = 'greenhood', label="waltons_data")

The integrated hazard function:

Surv = sum(Survfit(Surv(Time,Death) ~ 1))

The Nelson–Aalen Estimator: (Dist-Func & Surv-Func)

from lifelines import NelsonAalenFitter

from lifelines.datasets import load_waltons

waltons = load_waltons()

-----> naf = NelsonAalenFitter(nelson_aalen_smoothing=True)

naf.fit(waltons['T'], waltons['E'])

naf.plot()

Variance:

naf = NelsonAalenFitter(nelson_aalen_smoothing = True, var_type = 'aalen')".