



Transition Probability for Analysis of Covid Test Positivity Rate

By

Hrishikesh K S

Limna Salim

Objective

- To determine the probability of movement of test positivity rate using the two-state Markov transition probability matrix.

Steps Involved

- Defining states for TPR value.
- Compute Transition Probability Matrix and Steady State Probability for decision making.
- Application of this methodology in different scenarios expected in test positivity rate.

Scope

- Introducing a new methodology in the pharmaceutical Industry.
- Can be applied to study about the infection in the current and future situations
- Can be implemented to compare between two vaccines based on TPR of getting injected.
- The concept can be further expanded to define a threshold or interval and can be analyzed using a three-state model

Basic Terminology

- The test positivity rate or TPR is a common measure through which the public health system keeps track of the current level of Covid transmission.
- The formula used is to divide the number of positive tests by the total number of tests done and multiply this result by 100.
- **Markov Chain:** A Markov chain is a stochastic model describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event.

Basic Terminology

- The maximum likelihood method will be applied to estimate the transition probabilities

$$\hat{P}_{ij} = \frac{n_{ij}}{\sum_j n_{ij}}$$

- A **steady state** is an eigen vector for a stochastic matrix. If $V_{1 \times 2} = V_{1 \times 2} A_{2 \times 2}$, we say v is a steady state distribution for the Markov Chain and probability is the limiting probability.

Methodology

Based on TPR data we will have four possible cases of transition:

- From state 0 to 0 (i.e, yesterday test positivity was in decreasing state compared to previous day and today it is in decreasing state compared to yesterday)
- From state 0 to 1
- From state 1 to 0
- From state 1 to 1

The above states can be represented as a random variable X_n denoted by

$$X_n = \begin{cases} 0, & \text{if TPR is decreasing} \\ 1, & \text{if TPR is increasing} \end{cases}$$

Methodology

So, we get a transition frequency (A), and transition matrix (B), obtained from estimating the transition probabilities.

State	Decrease	Increase	Sum
Decrease	N_{00}	N_{01}	S_0
Increase	N_{10}	N_{11}	S_1

(A)

		X_n	
		0(Decrease)	1(Increase)
X_{n-1}	0(Decrease)	P_{00}	P_{01}
	1(Increase)	P_{10}	P_{11}

(B)

Under the assumption of steady state and using this values, Steady state V is computed using $V = VA$ which will give the probability of following transitions to 0 and 1 states.

Scenario 1: Test Positive Rate To Keep On Increasing In Almost All Days.

Based on a random sample created, the methodology was implemented, and Transition probabilities will be obtained.

	0	1
0	0.4790419	0.5209581
1	0.4467005	0.5532995

From this transition probability matrix, the corresponding steady state probabilities is obtained

0	1
0.4616303	0.5383697

Cont.

Performing limiting probability for the random sample resulted in same value as steady state probability.

This can be repeated for many simulations of data and similar pattern of transition probabilities and steady state probabilities will be obtained.

Computation of probability can be done for two more scenarios

- The scenario of test positive rate to keep on increasing in almost all days.
- The scenario of test positive rate to keep on decreasing in almost all days

Conclusion

- The methodology can be helpful in studying the probability of transition of TPR across time. This in turn can clarify how the TPR will be affected over a geographical area. These ideas can be applied to study covid growth and help in taking the appropriate preventive measure.
- This can also be applied to understand the effectiveness of vaccine development based on TPR measure and in future, where similar studies are needed.

*Thank
you*

Questions

