Assessing the impact of non-pharmaceutical (NPI) interventions and the role of mutations on the SARS-CoV-2 Virus spread in India using a discrete renewal process

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ABSTRACT

In recent years, the world has not suffered so much compared to the devastation caused by Covid 19. The present study aims to investigate the impact of various comprehensive and stringent interventions (as advised by the government of India) implemented to decelerate the spread of the SARS-CoV-2 virus. Studying the effects of different mutations found in India is equally important. We consider a stochastic model based on a discrete renewal process that includes various controlling measures to systematically evaluate their effects on the disease transmission dynamics through three inter-linked components. A Bayesian model has been considered for the infection cycle to observe deaths with upper and lower bounds of the total population infected (attack rates), case detection probabilities, and the reproduction number over time. The MCMC technique was adopted to analyze the data. This model is related to the widely used susceptible-infected-recovered (SIR) model, except the renewal is not expressed in differential form. In this study, we treat interventions as covariates in modeling the average reproduction number. Here, the time-varying reproduction number (R_t) has been assumed to be a piece-wise constant function that starts from a baseline prior, and mutations are used as covariates alongwith the NPIs.

1 Supplementary Materials

The supplimentary material like the Code, Dataset is available in the given link: https://github.com/Prithwish-ghosh/Biostatistics

The dataset and other details about the significant mutation and GLM results are uploaded in the given link: https://doi.org/10.7910/DVN/6TOIJV

1.1 NPI

1.2 Tables

2 Plots

Mutation ID	P-Value
Mut 3	0.023196
Mut 10	0.004302
Mut 16	5.16e-05
Mut 17	0.004467
Mut 21	0.026451
Mut 24	4.10e-05
Mut 32	0.004369
Mut 34	1.82e-05
Mut 36	0.000743
Mut 50	0.000400
Mut 53	0.010251
Mut 88	1.48e-05
Mut 118	1.39e-11

Table S 1. Mutation ID and the P-values for Kerala State with respect to infections

Mutation ID	P-Value
Mut 3	$<$ 2e-16
Mut 6	0.016362
Mut 15	$<$ 2e-16
Mut 16	8.26e-07
Mut 20	1.22e-06
Mut 35	0.000956
Mut 39	0.004416
Mut 52	3.54e-05

Table S 2. Mutation ID and the P-values for Punjab State with respect to infections

Mutation ID	P-Value
Mut 31	$<$ 2e-16
Mut 44	$<$ 2e-16
Mut 174	$<$ 2e-16
Mut 187	$<$ 2e-16
Mut 259	1.29e-09
Mut 428	$<$ 2e-16
Mut 431	$<$ 2e-16

Table S 3. Mutation ID and the P-values for UP State with respect to infections

Mutation ID	P-Value
Mut 7	0.00469
Mut 11	0.00835
Mut 66	0.01960
Mut 69	0.01106
Mut 84	0.00428
Mut 750	0.00124

Table S 4. Mutation ID and the P-values for Tamilnadu State with respect to infections

3 NPI table

Mutation ID	P-Value
Mut 31	< 2e-16
Mut 33	< 2e-16
Mut 47	< 2e-16
Mut 51	< 2e-16
Mut 91	< 2e-16
Mut 137	< 2e-16
Mut 138	< 2e-16
Mut 140	< 2e-16
Mut 160	1.30e-05
Mut 190	3.49e-14
Mut 215	2.87e-08
Mut 252	5.49e-16
Mut 312	< 2e-16
Mut 315	< 2e-16
Mut 317	< 2e-16
Mut 360	1.27e-08
Mut 378	0.02718
Mut 384	< 2e-16
Mut 440	< 2e-16
Mut 441	< 2e-16
Mut 443	< 2e-16
Mut 445	8.37e-05
Mut 796	< 2e-16
Mut 797	< 2e-16
Mut 816	0.00012
Mut 869	< 2e-16
Mut 917	1.71e-10
Mut 927	< 2e-16
Mut 943	< 2e-16
Mut 953	< 2e-16
Mut 977	1.40e-05
Mut 985	1.43e-08
Mut 992	< 2e-16

Table S 5. Mutation ID and the P-values for Maharashtra State with respect to infections

Mutation ID	P-Value
Mut 44	0.003273
Mut 61	8.77e-10
Mut 63	0.029918
Mut 64	0.031481
Mut 76	0.012531
Mut 102	7.92e-08
Mut 104	0..021949
Mut 187	0.006573
Mut 257	0.000244
Mut 258	0.016372
Mut 267	0.042409
Mut 278	8.50e-08

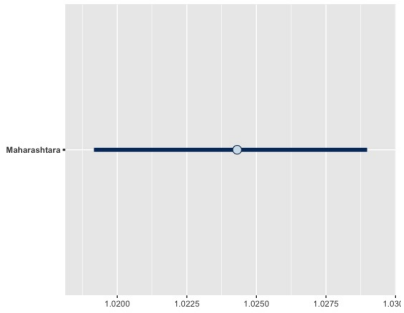
Table S 6. Mutation ID and the P-values for West Bengal State with respect to infections

Mutation ID	P-Value
Mut 76	0.02911
Mut 386	0.00740
Mut 548	0.04330

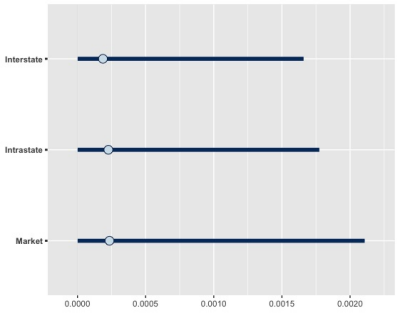
Table S 7. Mutation ID and the P-values for Gujrat State with respect to infections

Mutation ID	P-Value
Mut 29	0.003189
Mut 53	$<$ 2e-16
Mut 58	1.61e-08
Mut 62	0.000396
Mut 74	1.16e-12
Mut 75	0.031116
Mut 92	0.015712
Mut 93	0.0431055
Mut 100	0.015980
Mut 123	2.52e-08
Mut 161	5.27e-13
Mut 234	0.000645
Mut 237	$<$ 2e-16
Mut 241	2.13e-08
Mut 255	2.17e-10
Mut 272	6.30e-16
Mut 292	4.18e-07
Mut 300	0.013475
Mut 346	0.012744
Mut 511	$<$2e-16
Mut 542	1.06e-07
Mut 552	0.000290
Mut 612	1.64e-14
Mut 641	0.001146
Mut 725	3.45e-07
Mut 727	4.94e-07
Mut 761	0.000319
Mut 820	0.001198

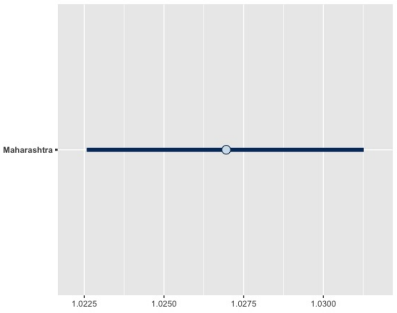
Table S 8. Mutation ID and the P-values for karnataka State with respect to infections



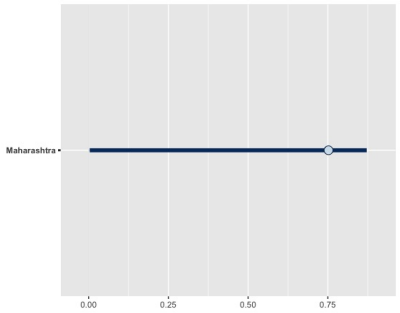
(a) Plot for The state Maharashtra with respect to R_t for without mutation



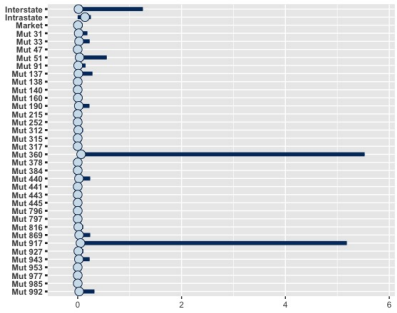
(b) Plot for The state Maharashtra with respect to α for without mutation



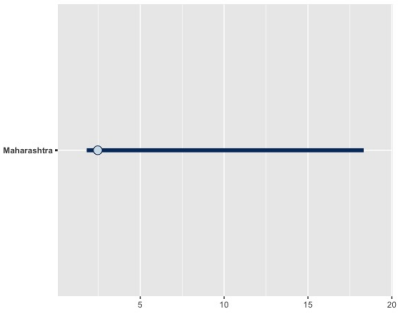
(c) Plot for The state Maharashtra with respect to μ for without mutation



(d) Plot for The state Maharashtra with respect to R_t for with mutation

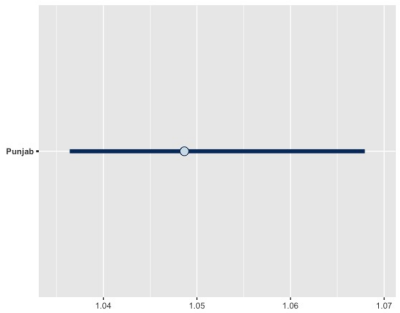


(e) Plot for The state Maharashtra with respect to α for with mutation

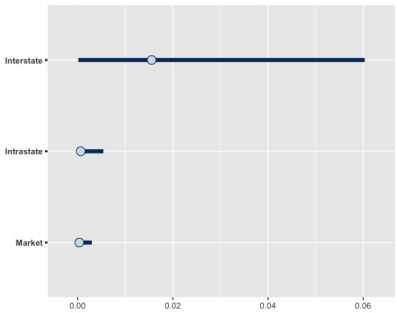


(f) Plot for The state Maharashtra with respect to μ for with mutation

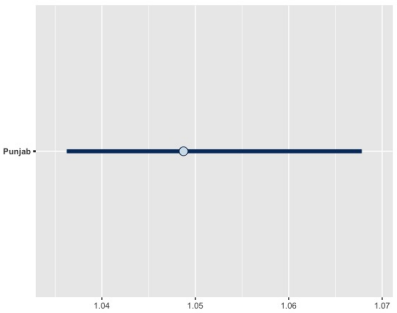
Figure S 1. Maharashtra



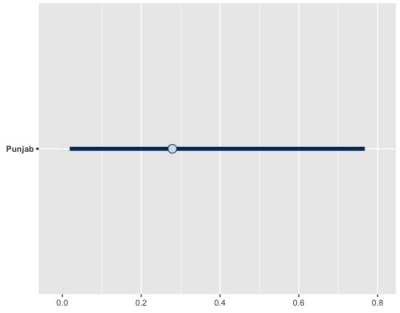
(a) Plot for The state Punjab with respect to R_t for without mutation



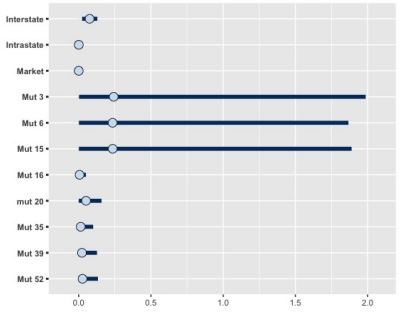
(b) Plot for The state Punjab with respect to α for without mutation



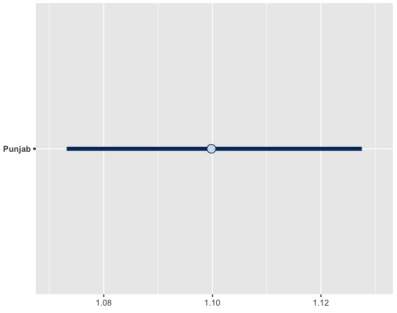
(c) Plot for The state Punjab with respect to μ for without mutation



(d) Plot for The state Punjab with respect to R_t for with mutation

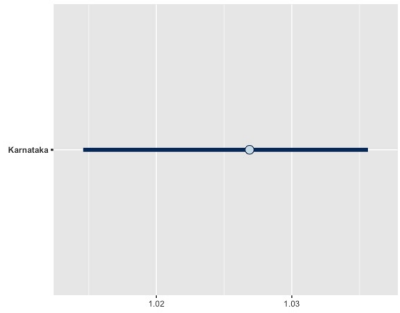


(e) Plot for The state Punjab with respect to α for with mutation

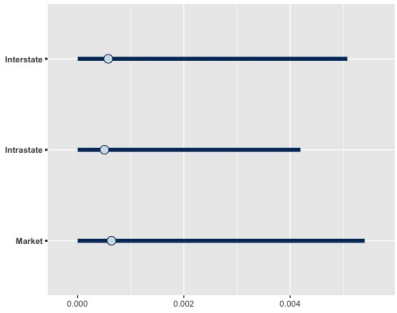


(f) Plot for The state Punjab with respect to μ for with mutation

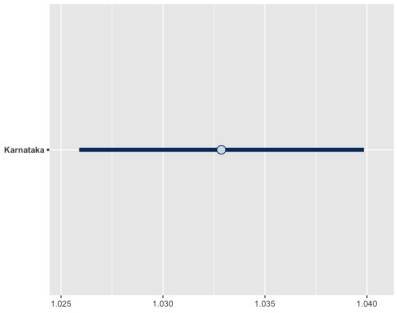
Figure S 2. Punjab



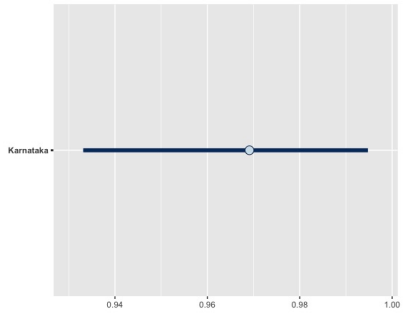
(a) Plot for The state Karnataka with respect to R_t for without mutation



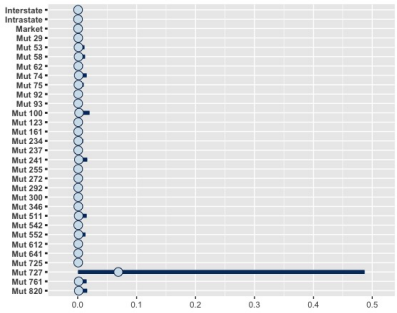
(b) Plot for The state Karnataka with respect to α for without mutation



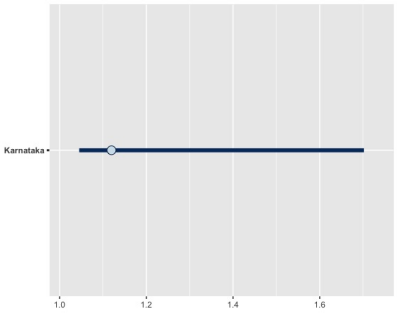
(c) Plot for The state Karnataka with respect to μ for without mutation



(d) Plot for The state Karnataka with respect to R_t for with mutation

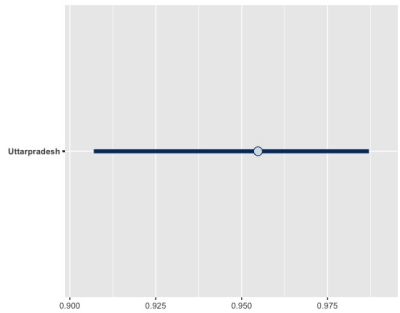


(e) Plot for The state Karnataka with respect to α for with mutation

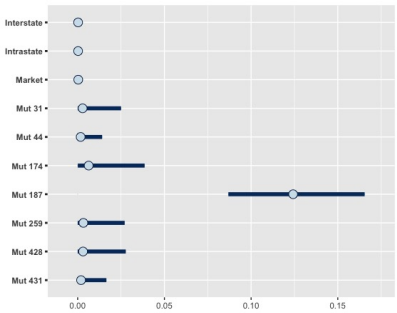


(f) Plot for The state Karnataka with respect to μ for with mutation

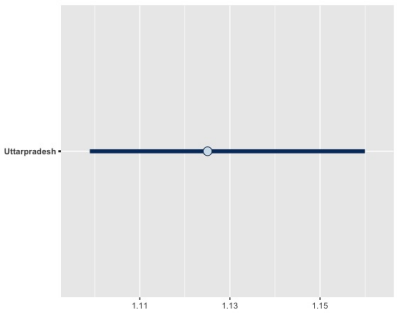
Figure S 3. Karnataka



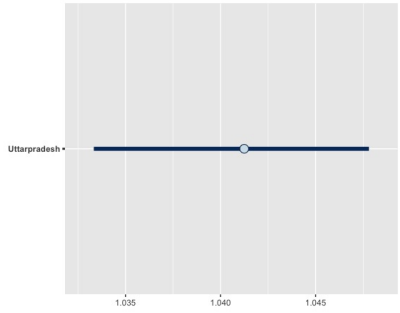
(a) Plot for The state Uttarpradesh with respect to R_t for with mutation



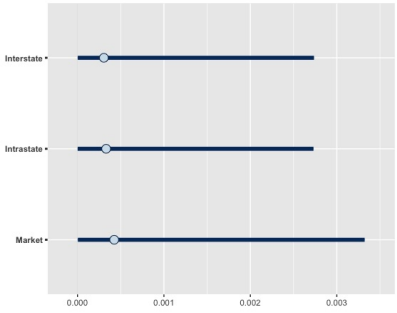
(b) Plot for The state Uttarpradesh with respect to α for with mutation



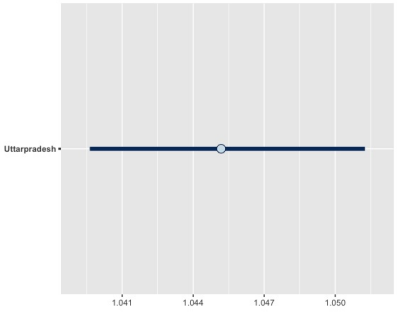
(c) Plot for The state Uttarpradesh with respect to μ for with mutation



(d) Plot for The state Uttarpradesh with respect to R_t for without mutation

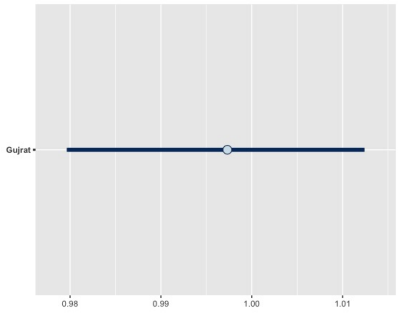


(e) Plot for The state Uttarpradesh with respect to α for without mutation

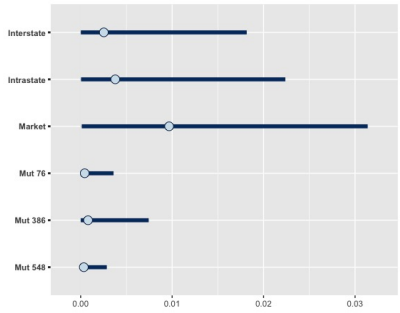


(f) Plot for The state Uttarpradesh with respect to μ for without mutation

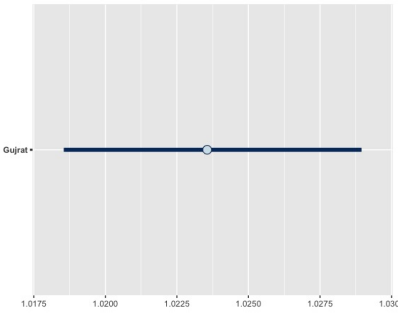
Figure S 4. Uttar Pradesh



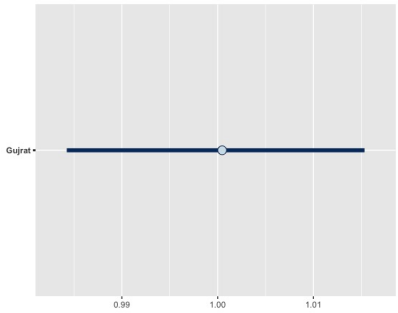
(a) Plot for the state Gujrat respect to R_t for With mutation



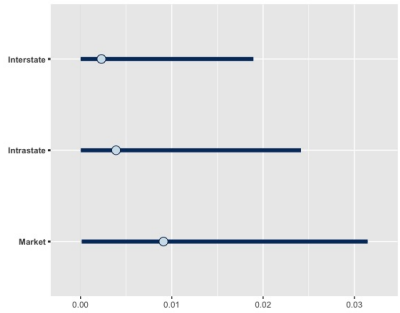
(b) Plot for the state Gujrat respect to α for With mutation



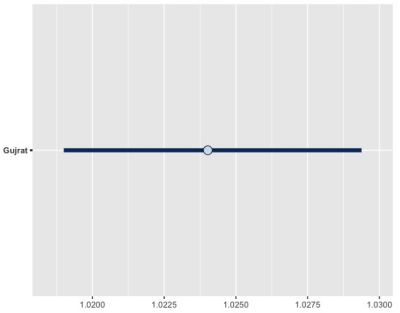
(c) Plot for the state Gujrat respect to μ for With mutation



(d) Plot for The state Gujrat with respect to R_t for without mutation

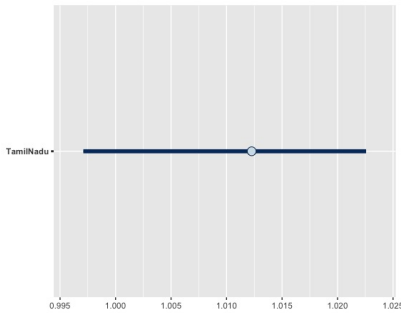


(e) Plot for The state Gujrat with respect to α for without mutation

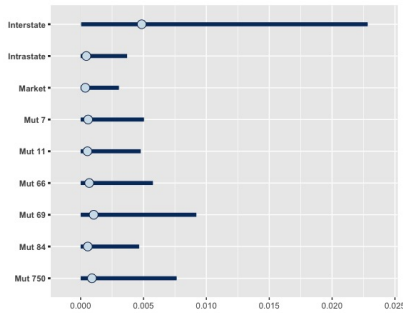


(f) Plot for The state Gujrat with respect to α for without mutation

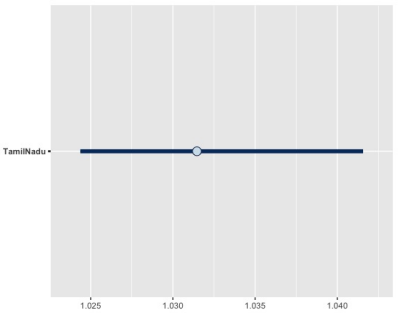
Figure S 5. Gujrat



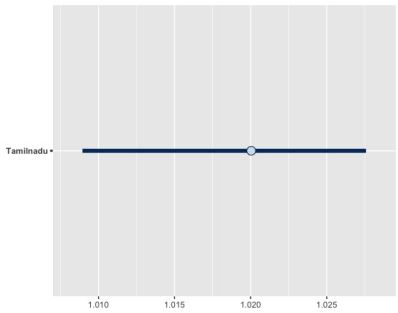
(a) Plot for the state TamilNadu respect to R_t for With mutation



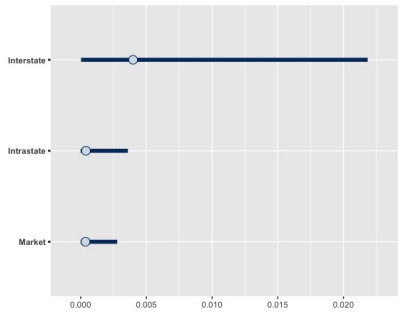
(b) Plot for the state TamilNadu respect to α for With mutation



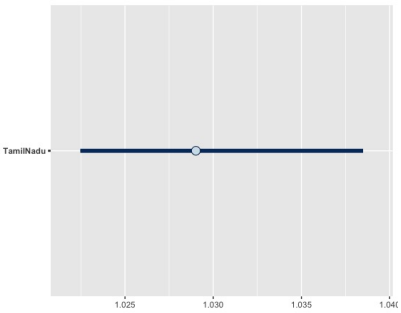
(c) Plot for the state TamilNadu respect to μ for With mutation



(d) Plot for The state TamilNadu with respect to R_t for without mutation

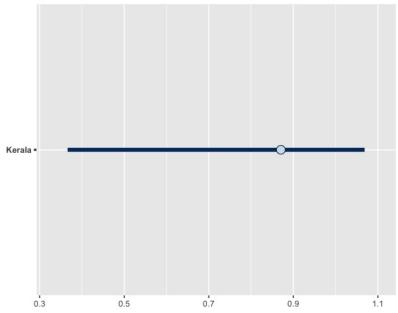


(e) Plot for The state TamilNadu with respect to α for without mutation

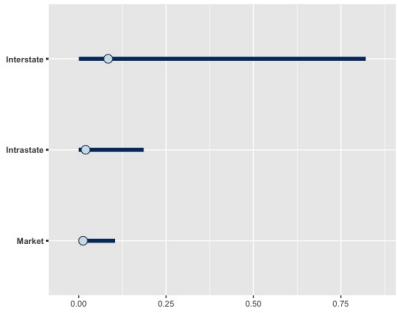


(f) Plot for The state TamilNadu with respect to μ for without mutation

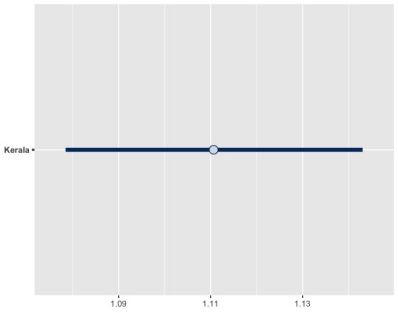
Figure S 6. Tamilnadu



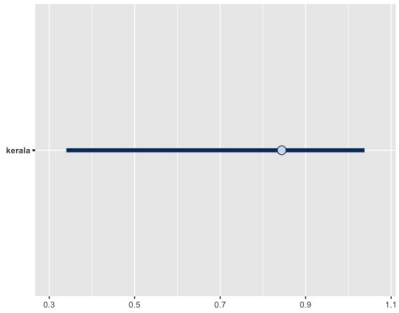
(a) Plot for The state Kerala with respect to R_t for without mutation



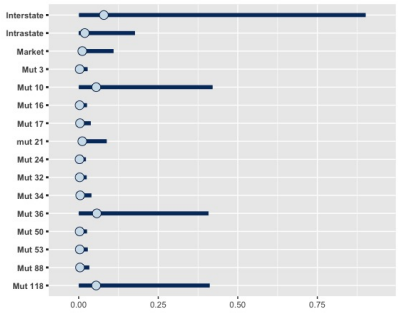
(b) Plot for The state Kerala with respect to α for without mutation



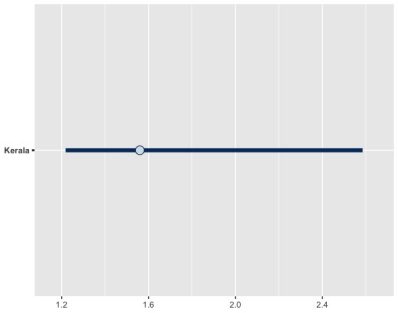
(c) Plot for The state Kerala with respect to μ for without mutation



(d) Plot for The state Kerala with respect to R_t for with mutation

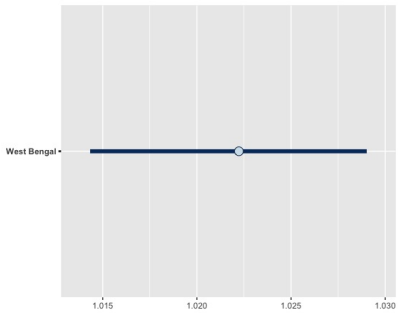


(e) Plot for The state kerala with respect to α for with mutation

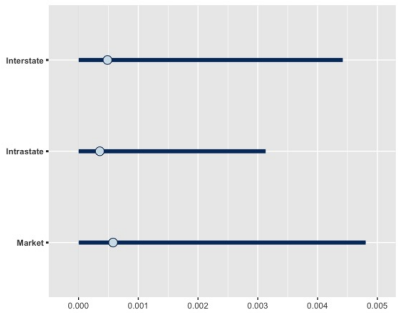


(f) Plot for The state Kerala with respect to μ for with mutation

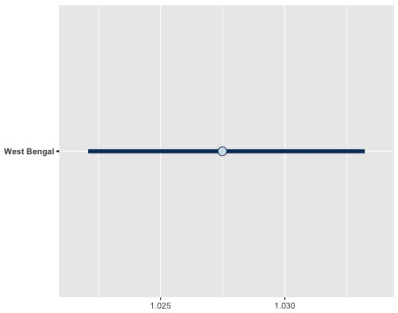
Figure S 7. Kerala



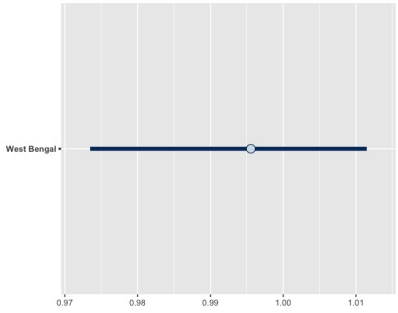
(a) Plot for The state West Bengal with respect to R_t for without mutation



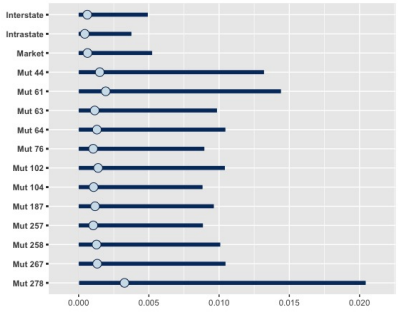
(b) Plot for The state West Bengal with respect to α for without mutation



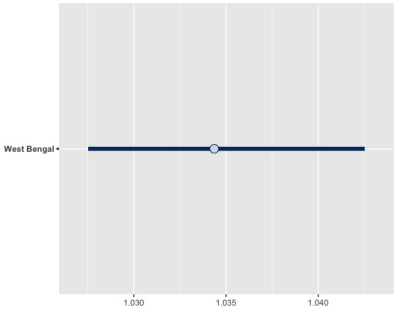
(c) Plot for The state West Bengal with respect to μ for without mutation



(d) Plot for The state West Bengal with respect to R_t for with mutation



(e) Plot for The state West Bengal with respect to α for with mutation



(f) Plot for The state West Bengal with respect to μ for with mutation

Figure S 8. West Bengal

State	Mutation	Region	Amino acid substitution	Functional effect
Punjab	G210T			
	G374A	ORF1a	E37K	decreases susceptibility to covid19 as it destabilizes ACE2 and lessens its affinity to Spike protein
	C934T	ORF1a		Not found in literature
	C1076T	ORF1a	P271S	Not found in literature
	C1385T	ORF1a	H374Y	Not found in literature
	C2644T	ORF1a		Not found in literature
	A3064G	ORF1a		Not found in literature
	A3951G	ORF1a	D1229G	Not found in literature
Uttar Pradesh	G713R	ORF1a		Not found in literature
	C1267T	ORF1a		Not found in literature
	G7996A	ORF1a		Not found in literature
	C8664T	ORF1a	T2800I	Not found in literature
	G13850A	ORF1b	G128D	Not found in literature
	C24784T	S		Not found in literature
	G24914C,S	S	D118H	Leads to reduction in infectivity
Tamil Nadu	C100T,M			Not found in literature
	G210T			Not found in literature
	G1048T	ORF1a	K261N	Was prevalent in samples from International travelers but nothing found on its biological effect
	G1161K	ORF1a		Not found in literature
	G2095A	ORF1a		Not found in literature
	G28712A	N	G147S	Not found in literature

State	Mutation	Region	Amino acid substitution	Functional effect
Maharashtra	G124T			Not found in literature
	C147T			Not found in literature
	G252T			Not found in literature
	C364T	ORF1a		Not found in literature
	C981T	ORF1a	A239V	Not found in literature
	C1613T	ORF1a	L450F	Was a common mutation in Pakistan but nothing was found on its biological impact
	T1626G	ORF1a	L454R	Not found in literature
	G1681T	ORF1a	E472D	Not found in literature
	C1919A	ORF1a	L552I	Not found in literature
	C2232T	ORF1a	A656V	Found in high concentration in SARS-CoV-2 genetic material from sewage water but nothing found on its functional effect
	A2712G	ORF1a	K816R	Not found in literature
	G3340T	ORF1a		Not found in literature
	T4273/4G	ORF1a	Y1337N	Not found in literature
	G4289T	ORF1a	A1342S	Not found in literature
	C4320T	ORF1a	A1352V	Is a prevalent mutation especially in samples from Brazil but nothing found on its functional effect
	C5167T	ORF1a		Not found in literature
	C5467T	ORF1a		Not found in literature
	G5578A	ORF1a	M1771I	Not found in literature
	A6497G	ORF1a	K2078E	Not found in literature
	T6511C	ORF1a		Not found in literature
	G6532T	ORF1a		Not found in literature
	C6539T,Y	ORF1a	H2092Y	Predominantly found in Delta strains and has been associated with asymptomatic infections
	G12167T	ORF1a	V3968F	Not found in literature
	T12181C	ORF1a		Not found in literature
	T12535C	ORF1a		Not found in literature
	G13843A	ORF1b	D126N	Not found in literature
	G14829T	ORF1b	M454I	Not found in literature
	T15096C	ORF1b		Not found in literature

State	Mutation	Region	Amino acid substitution	Functional effect
Maharashtra(Cont)	G15406T	ORF1b	A647S	Leads to spike protein stabilization and has been associated with SARS-CoV-2 breakthrough infections in vaccinated individuals due to its vaccine evasion potential
	C15656T	ORF1b	T730I	Not found in literature
	C15895T	ORF1b		Not found in literature
	G15982T	ORF1b	V839L	Not found in literature
	C16134T	ORF1b		Not found in literature
	G284T	ORF1a		Not found in literature
	C799T	ORF1a		Not found in literature
	C835T	ORF1a		Not found in literature
	G839A	ORF1a	G192S	Not found in literature
	C1170T	ORF1a	S302F	Not found in literature
	A1622G	ORF1a	I453V	Not found in literature
	G1681T	ORF1a	E472D	Not found in literature
	T3793C	ORF1a		Not found in literature
	A5533G	ORF1a		Not found in literature
	G5558T	ORF1a	V1765L	Not found in literature
	C5869T	ORF1a		Not found in literature
West Bengal	C6285T	ORF1a	T2007I	Not found in literature
Gujarat	C1403A	ORF1a	P380T	Not found in literature
	G8102T	ORF1a	V2613F	A neutral mutation associated with asymptomatic infections
	G12718A	ORF1a		Not found in literature
Karnataka	C106T			Not found in literature
	G425A	ORF1a	V54I	Not found in literature
	A548G	ORF1a	I95V	Not found in literature
	C629T	ORF1a	L122F	Not found in literature
	C835T	ORF1a		Not found in literature
	C853T	ORF1a		Not found in literature
	C1060T	ORF1a		Not found in literature
	A1119T	ORF1a	Q285L	Not found in literature
	C1267T,Y	ORF1a		Not found in literature
	C1912T	ORF1a		Not found in literature
	T2019C	ORF1a	M585T	Not found in literature

State	Mutation	Region	Amino acid substitution	Functional effect
Karnataka(Cont.)	C3157T	ORF1a		Not found in literature
	C3177T	ORF1a	P971L	Not found in literature
	A3314G	ORF1a	T1017A	Not found in literature
	A3652G	ORF1a		Not found in literature
	C3990T	ORF1a	T1242I	Not found in literature
	G4444A	ORF1a		Not found in literature
	A4659G	ORF1a	Y1465C	Not found in literature
	A5608G	ORF1a		Not found in literature
	C9559T	ORF1a		Not found in literature
	C10336T	ORF1a		Not found in literature
	C13730T	ORF1a	A88V	Present at low frequency globally, it was widespread in India during the first wave of Covid-19. It has been predicted to affect protein function but no further information is available on its impact
	C11344T	ORF1a		Not found in literature
	A12121T	ORF1a		Not found in literature
	T15096C,Y	ORF1b		Not found in literature
	T15163C	ORF1b		Not found in literature
	C16349T	ORF1b	S961L	Not found in literature
	T17385G	ORF1b	D1306E	Not found in literature
Kerala	Pos C28A,*			Not found in literature
	Pos C222T			Not found in literature
	Pos A513G	ORF1a	H83R	Not found in literature
	Pos G521T	ORF1a	V86F	Signature mutation of the Pango lineage A .28.It was widely reported in France and Egypt

State	Mutation	Region	Amino acid substitution	Functional effect
Kerala(Cont.)	Pos G862A	ORF1a		Not found in literature
	C1059T	ORF1a	T265I	Responsible for increase in virulence and transmission
	C1498T	ORF1a		Not found in literature
	C1758T	ORF1a	A498V	Widely present in Malaysian and Tunisian samples, its impact has not been investigated
	G1855A	ORF1a		Not found in literature
	C3225T	ORF1a	T987I	Not found in literature
	G3403T	ORF1a		Not found in literature
	C6706T	ORF1a		Not found in literature
	G9494A	ORF1a	V3077I	Not found in literature

State	Mutation ID	α-Value without mutation	α-Value with mutation
Gujrat	Market	0.004878123	0.0051218414
	Interstate	0.006986736	0.0067013011
	Intrastate	0.011364911	0.0118070876
	Mut 76		0.0009374718
	Mut 386		0.0018702121
	Mut 548		0.0007322725

Table S 9. the α-values for Gujrat State with respect to mutation and other interventions.

State	Mutation ID	α-Value without mutation	α-Value with mutation
Tamil Nadu	Market	0.0066391912	0.0072999640
	Interstate	0.0008927825	0.0009619719
	Intrastate	0.0007612796	0.0007854808
	Mut 7		0.0013147135
	Mut 11		0.0015162284
	Mut 66		0.0022863502
	Mut 84		0.0012386405
	Mut 750		0.0019410614

Table S 10. the α-values for Tamilnadu State with respect to mutation and other interventions.

State	Mutation ID	α-Value without mutation	α-Value with mutation
West Bengal	Market	0.0011303383	0.0012980341
	Interstate	0.0008019726	0.0009754937
	Intrastate	0.0012614741	0.0013948529
	Mut 44		0.0034284759
	Mut 61		0.0038713042
	Mut 63		0.0025040022
	Mut 64		0.0027211806
	Mut 76		0.0023296051
	Mut 102		0.0028065653
	Mut 104		0.0023302627
	Mut 187		0.0025057252
	Mut 257		0.0019410614
	Mut 258		0.0026400803
	Mut 267		0.0027581335
	Mut 278		0.0057897456

Table S 11. the α-values for WestBengal State with respect to mutation and other interventions.

State	Mutation ID	α-Value without mutation	α-Value with mutation
Uttarpradesh	Market	0.0006925534	0.0005388315
	Interstate	0.0007220298	0.0005184791
	Intrastate	0.0008863270	0.0006990124
	Mut 31		0.0065007381
	Mut 44		0.0037391518
	Mut 174		0.0115539591
	Mut 187		0.1249861450
	Mut 259		0.0070586987
	Mut 428		0.0070744101
	Mut 431		0.0043313216

Table S 12. the α-values for Uttarpradesh State with respect to mutation and other interventions.

State	Mutation ID	α-Value without mutation	α-Value with mutation
Punjab	Market	0.0209317497	0.0765857933
	Interstate	0.0013934508	0.0015032323
	Intrastate	0.0007813232	0.0008592614
	Mut 3		0.5115648567
	Mut 6		0.5014128633
	Mut 15		0.4990800546
	Mut 16		0.0132292796
	Mut 20		0.0613281145
	Mut 35		0.0274242928
	Mut 39		0.0377600361
	Mut 52		0.0429190740

Table S 13. the α-values for Punjab State with respect to mutation and other interventions.

State	Mutation ID	α-Value without mutation	α-Value with mutation
Kerala	Market	0.20909607	0.218360163
	Interstate	0.04921649	0.045757821
	Intrastate	0.02782562	0.027632931
	Mut 3		0.007116809
	Mut 10		0.111329257
	Mut 16		0.006743130
	Mut 17		0.009784107
	Mut 21		0.023569836
	Mut 24		0.005922953
	Mut 32		0.006926804
	Mut 34		0.010625256
	Mut 36		0.110503682
	Mut 50		0.006790839
	Mut 53		0.007368808
	Mut 88		0.008811703
	Mut 118		0.111275155

Table S 14. the α-values for Kerala State with respect to mutation and other interventions.

State	Mutation ID	α-Value without mutation	α-Value with mutation
Karnataka	Market	0.001294128	0.001442592
	Interstate	0.001119574	0.001304051
	Intrastate	0.001401353	0.001495982
	Mut 29		0.001998624
	Mut 53		0.002990413
	Mut 58		0.002252846
	Mut 62		0.003972159
	Mut 74		0.002639403
	Mut 75		0.001899921
	Mut 92		0.001820182
	Mut 93		0.005275046
	Mut 100		0.002007517
	Mut 123		0.001997574
	Mut 161		0.002300310
	Mut 234		0.001930729
	Mut 237		0.004354395
	Mut 241		0.001808161
	Mut 255		0.002060412
	Mut 272		0.001935566
	Mut 292		0.001904035
	Mut 300		0.002257622
	Mut 346		0.003883520
	Mut 511		0.001976601
	Mut 542		0.003409617
	Mut 552		0.001929339
	Mut 612		0.002000348
	Mut 641		0.007368808
	Mut 725		0.001961796
	Mut 727		0.131116749
	Mut 761		0.003832304
	Mut 820		0.004241267

Table S 15. the α-values for Karnataka State with respect to mutation and other interventions.

State	Mutation ID	α-Value without mutation	α-Value with mutation
Maharashtra	Market	0.0004286037	0.387609653
	Interstate	0.0004773448	0.122700907
	Intrastate	0.0005398011	0.019219180
	Mut 31		0.048008142
	Mut 33		0.063609827
	Mut 47		0.009253089
	Mut 51		0.126909571
	Mut 91		0.032240017
	Mut 137		0.062513911
	Mut 138		0.011825214
	Mut 140		0.008948156
	Mut 160		0.018214430
	Mut 190		0.056084927
	Mut 215		0.010033719
	Mut 252		0.009566597
	Mut 312		0.025200497
	Mut 315		0.010368422
	Mut 317		0.009347521
	Mut 360		1.236996710
	Mut 378		0.009219394
	Mut 384		0.010973440
	Mut 440		0.061540868
	Mut 441		0.009388599
	Mut 443		0.009603974
	Mut 445		0.009045041
	Mut 796		0.010424165
	Mut 797		0.009377054
	Mut 816		0.026665355
	Mut 869		0.066649144
	Mut 917		0.645099011
	Mut 927		0.027048164
	Mut 943		0.057952061
	Mut 953		0.009845674
	Mut 977		0.011615179
	Mut 985		0.010798475
	Mut 992		0.076063877

Table S 16. the α-values for Maharashtra State with respect to mutation and other interventions.

State	Interstate Transport	Intrastate Transport	Markets, malls, shopping complexes
Uttar Pradesh	0	0	0
Tamil Nadu	0	0	0
Kerala	1	1	1
West Bengal	0	0	0
Karnataka	0	0	1
Gujarat	0	0	0
Punjab	0	0	1
Maharashtra	0	0	0

Table S 17. 14 March 2020

State	Interstate Transport	Intrastate Transport	Markets, malls, shopping complexes
Uttar Pradesh	0	0	0
Tamil Nadu	0	0	1
Kerala	1	1	1
West Bengal	0	0	0
Karnataka	0	0	1
Gujarat	0	0	1
Punjab	0	0	1
Maharashtra	0	0	1

Table S 18. 15 march 2020

State	Mutation	Region	Amino acid substitution	Functional effect	Mutation	Region	Amino acid substitution	Functional effect
Maharashtra	G124T	5'UTR		Not found in literature	G15406T	ORF1b	A647S	Leads to spike protein stabilization and has been associated with SARS-CoV-2 breakthrough infections in vaccinated individuals due to its vaccine evasion potential
	C147T	5'UTR		Not found in literature	C15656T	ORF1b	T730I	Not found in literature
	G252T	5'UTR		Not found in literature	C15895T	ORF1b		Not found in literature
	C364T	ORF1a		Not found in literature	G15982T	ORF1b	V839L	Not found in literature
	C981T	ORF1a	A239V	Not found in literature	C16134T	ORF1b		Not found in literature
	C1613T	ORF1a	L450F	Was a common mutation in Pakistan but nothing was found on its biological impact	G284T	ORF1a		Not found in literature
	T1626G	ORF1a	L454R	Not found in literature	G5578A	ORF1a	M1771I	Not found in literature
	G1681T	ORF1a	E472D	Not found in literature				
	C1919A	ORF1a	L552I	Not found in literature				
	C2232T	ORF1a	A656V	Found in high concentration in SARS-CoV-2 genetic material from sewage water but nothing found on its functional effect				
	A2712G	ORF1a	K816R	Not found in literature				
	G3340T	ORF1a		Not found in literature				
	T4273/4G	ORF1a	Y1337N	Not found in literature				
	G4289T	ORF1a	A1342S	Not found in literature				
	C4320T	ORF1a	A1352V	Is a prevalent mutation especially in samples from Brazil but nothing found on its functional effect				
	C5167T	ORF1a		Not found in literature				
	C5467T	ORF1a		Not found in literature				
	A6497G	ORF1a	K2078E	Not found in literature				
	G6532T	ORF1a		Not found in literature				
	G12167T	ORF1a	V3968F	Not found in literature				
	T12535C	ORF1a		Not found in literature				
	G14829T	ORF1b	M454I	Not found in literature				
	T6511C	ORF1a		Not found in literature				
	C6539T,Y	ORF1a	H2092Y	Predominantly found in Delta strains and has been associated with asymptomatic infections				
	T12181C	ORF1a		Not found in literature				
	G13843A	ORF1b	D126N	Not found in literature				
	T15096C	ORF1b		Not found in literature				

Table S 19. Significant mutations

State	Mutation	Region	Amino acid substitution	Functional effect	State	Mutation	Region	Amino acid substitution	Functional effect
Karnataka	C106T	5'UTR		Not found in literature	Punjab	G210T	5'UTR		
	G425A	ORF1a	V54I	Not found in literature		G374A	ORF1a	E37K	decreases susceptibility to covid19 as it destabilizes ACE2 and lessens its affinity to Spike protein
	A548G	ORF1a	I95V	Not found in literature		C934T	ORF1a		Not found in literature
	C629T	ORF1a	L122F	Not found in literature		C1076T	ORF1a	P271S	Not found in literature
	C835T	ORF1a		Not found in literature		C1385T	ORF1a	H374Y	Not found in literature
	C853T	ORF1a		Not found in literature		C2644T	ORF1a		Not found in literature
	C1060T	ORF1a		Not found in literature		A3064G	ORF1a		Not found in literature
	A1119T	ORF1a	Q285L	Not found in literature		A3951G	ORF1a	D1229G	Not found in literature
	C1267T,Y	ORF1a		Not found in literature	Uttar Pradesh	G713R	ORF1a		Not found in literature
	C1912T	ORF1a		Not found in literature		C1267T	ORF1a		Not found in literature
	T2019C	ORF1a	M585T	Not found in literature		G7996A	ORF1a		Not found in literature
	C3157T	ORF1a		Not found in literature		C8664T	ORF1a	T2800I	Not found in literature
	C3177T	ORF1a	P971L	Not found in literature		G13850A	ORF1b	G128D	Not found in literature
	A3314G	ORF1a	T1017A	Not found in literature		C24784T	S		Not found in literature
	A3652G	ORF1a		Not found in literature		G24914C,S	S	D118H	Leads to reduction in infectivity
	C3990T	ORF1a	T1242I	Not found in literature	Tamil Nadu	C100T,M			Not found in literature
	G4444A	ORF1a		Not found in literature		G210T	5'UTR		Not found in literature
	A4659G	ORF1a	Y1465C	Not found in literature		G1048T	ORF1a	K261N	Was prevalent in samples from International travelers but nothing found on its biological effect
	A5608G	ORF1a		Not found in literature		G1161K	ORF1a		Not found in literature
	C9559T	ORF1a		Not found in literature		G2095A	ORF1a		Not found in literature
	C10336T	ORF1a		Not found in literature		G28712A	N	G147S	Not found in literature
	C10702T	ORF1a	A88V	Responsible for within host adaptation	Gujarat	C1403A	ORF1a	P380T	Not found in literature
	C11344T	ORF1a		Not found in literature		G8102T	ORF1a	V2613F	A neutral mutation associated with asymptomatic infections
	A12121T	ORF1a		Not found in literature		G12718A	ORF1a		Not found in literature
	T15096C,Y	ORF1b		Not found in literature	West Bengal	C6285T	ORF1a	T2007I	Not found in literature
	T15163C	ORF1b		Not found in literature		G284T	ORF1a		Not found in literature
	C16349T	ORF1b	S961L	Not found in literature		C799T	ORF1a		Not found in literature
	T17385G	ORF1b	D1306E	Not found in literature		C835T	ORF1a		Not found in literature
Kerala	Pos C28A,*	5'UTR		Not found in literature		G839A	ORF1a	G192S	Not found in literature
	Pos C222T	5'UTR		Not found in literature		C1170T	ORF1a	S302F	Not found in literature
	Pos A513G	ORF1a	H83R	Not found in literature		A1622G	ORF1a	I453V	Not found in literature
	Pos G521T	ORF1a	V86F	Signature mutation of the Pango lineage A.28.It was widely reported in France and Egypt		G1681T	ORF1a	E472D	Not found in literature
	Pos G862A	ORF1a		Not found in literature		T3793C	ORF1a		Not found in literature
	C1059T	ORF1a	T265I	Responsible for increase in virulence and transmission		A5533G	ORF1a		Not found in literature
	C1498T	ORF1a		Not found in literature		G5558T	ORF1a	V1765L	Not found in literature
	C1758T	ORF1a	A498V	Widely present in Malaysian and Tunisian samples, its impact has not been investigated		C5869T	ORF1a		Not found in literature
	G1855A	ORF1a		Not found in literature					
	C3225T	ORF1a	T987I	Not found in literature					
	G3403T	ORF1a		Not found in literature					
	C6706T	ORF1a		Not found in literature					
	G9494A	ORF1a	V3077I	Not found in literature					

Table S 20. Significant mutations

State	Mutation ID	α-Value without mutation	α-Value with mutation	State	Mutation ID	α-Value without mutation	α-Value with mutation
Gujrat	Market	0.0048	0.0051	Tamil Nadu	Market	0.0066	0.0072
	Interstate	0.0069	0.0067		Interstate	0.0008	0.0009
	Intrastate	0.0113	0.0118		Intrastate	0.0007	0.0007
	C1403A		0.0009		C100T		0.001
	G8102T		0.0018		G210T		0.001
	G12718A		0.0007		G1048T		0.0022
					G2095A		0.0012
					G28712A		0.0019
Kerala	Market	0.2090	0.2183	Punjab	Market	0.0209	0.0765
	Interstate	0.0492	0.0457		Interstate	0.0013	0.0015
	Intrastate	0.0278	0.0276		Intrastate	0.0007	0.0008
	C28A		0.0071		G210T		0.5115
	C222T		0.1113		G374A		0.5014
	A513G		0.0067		C934T		0.499
	G521T		0.0097		C1076T		0.0132
	G862A		0.0235		C1385T		0.0613
	C1059T		0.0059		C2644T		0.0274
	C1498T		0.0069		A3064T		0.0377
	C1758T		0.0106		A3951G		0.0429
	G1855A		0.1105				
	C3225T		0.0067				
	G3403T		0.0073				
	C6706T		0.0088				
	G9494A		0.1112				
West Bengal	Market	0.0011	0.0012	Uttarpradesh	Market	0.0006	0.0005
	Interstate	0.0008	0.0009		Interstate	0.0007	0.0005
	Intrastate	0.0012	0.0013		Intrastate	0.0008	0.0006
	G284T		0.0034		G713R		0.0065
	C799T		0.0038		C1267T		0.0037
	C835T		0.0025		G7996A		0.0115
	G839A		0.0027		C8664T		0.1249
	C1170T		0.0023		G13850A		0.007
	A1622G		0.0028		C24784T		0.007
	G1681T		0.0023		G24914C		0.0043
	T3793C		0.0025				
	A5533G		0.0019				
	G5558T		0.0026				
	C5869T		0.0027				
	C6285T		0.0057				
Karnataka	Market	0.0012	0.0014	Maharashtra	Market	0.0004	0.3876
	Interstate	0.0011	0.0013		Interstate	0.0004	0.1227
	Intrastate	0.0014	0.0014		Intrastate	0.0005	0.0192
	C106T		0.0019		G124T		0.0480
	G425A		0.0029		C147T		0.0636
	A548G		0.0022		G252T		0.0092
	C629T		0.0039		C364T		0.1269
	C835T		0.0026		C981T		0.0322
	C853T		0.0018		C1613T		0.0625
	C1060T		0.0018		T1626G		0.0118
	A1119T		0.0052		G1681T		0.0089
	C1267T		0.0020		C1919A		0.0182
	C1912T		0.0019		C2232T		0.0560
	T2019C		0.0023		A2712G		0.0100
	C3157T		0.0019		G3340T		0.0095
	C3177T		0.0043		T4273G		0.0252
	A3314G		0.0018		G4289T		0.0103
	A3652C		0.0020		C4320T		0.0093
	C3990T		0.0019		C5167T		1.2369
	G4444A		0.0019		C5467T		0.0092
	A4659G		0.0022		G5578T		0.0109
	A5608G		0.0038		A6497G		0.0615
	C9559T		0.0019		T6511C		0.0093
	C10336T		0.0034		G6532T		0.0096
	C10702T		0.0019		C6539T		0.0090
	C11344T		0.0020		G12167T		0.0104
	A12121T		0.0073		T12181C		0.0093
	T15096C,Y		0.0019		T12535C		0.0266
	T15163C		0.1311		G13843A		0.0666
	C16349T		0.0038		G14829T		0.6450
	T17385G		0.0042		T15096C		0.0270
					G15406T		0.0579
					C15656T		0.0098
					C15895T		0.0116
					G15982T		0.0107
					C16134T		0.0760

Table S 21. the α-values for All 8 State with respect to mutation and other interventions.

State	Interstate Transport			Intrastate Transport			Markets, malls and shopping complexes		
	Partial	Complete	No	Partial	Complete	No	Partial	Complete	No
Uttar Pradesh	23.03.20, 24.03.20	25.03.20 - 13.05.20	10.09.20 - 29.04.21	23.03.20, 24.03.20	25.03.20 - 07.06.20	07.09.20 - 29.04.21	17.03.20 - 24.03.20	25.03.20 - 06.06.20	07.06.20 - 29.04.21
	14.05.20 - 09.09.20			08.06.20 - 04.09.20			08.06.21 - 21.06.21	30.04.21 - 07.06.21	
	30.04.21 - 09.06.20			01.06.21 - 09.06.21	30-04-21 - 31.05.21				
Kerala	14.03.20 - 24.03.20	25.03.20 - 09.06.20	01.08.20- 07.05.21	20.05.20 - 07.09.20	23.03.20 - 19.05.20	08.09.20 - 07.05.21	14.03.20 - 22.03.20	23.03.20 - 30.05.20	14.06.20 - 26.04.21
	09.06.20 - 01.08.20			02.06.21 - 01.07.21	08.05.21 - 01.06.21		31.05.20 - 13.06.20	01.05.21 - 30.05.21	
	08.05.21 - 12.07.21						27.04.21 - 30.04.21		
							31.05.21 - 10.08.21		
Maharashtra	23.03.20, 24.03.20	25.05.20 - 17.05.20	17.06.20 - 26.04.21	03.05.20 - 06.09.20	23.03.20 - 02.05.20	07-09.20 - 26.04.21	15.03.20 - 22.03.20	23.03.20 - 24.04.20	08.06.20 - 26.04.21
	18.05.20 - 16.06.20			24.05.21 - 15.08.21	27.04.21 - 23.05.21		25.04.20 - 07.06.20	27.04.21 - 04.06.21	
	27.04.21 - 26.06.21						05.06.21- 14.08.21		
Gujarat	22.03.20 - 24.03.20	25.03.20 - 11.05.20	31.05.20 - 26.04.21	19.05.21 - 31.05.20	23.03.20 - 31.05.20	01.06.20 - 26.04.21	15.03.20 - 20.03.20	21.03.20 - 07.06.20	08.06.20 - 26.04.21
	12.05.20 - 31.05.20				27.04.21 - 18.05.21		19.05.21 - 04.06.21	27.04.21 - 18.05.21	
	27.04.21 - 31.05.21								
Punjab	22.03.20 - 24.03.20	25.03.20 - 30.04.20	01.06.20 - 27.04.21	04.05.20 - 19.05.20	22.03.20 - 03.05.20	20.05.20 - 19.04.21	01.06.20 - 07.06.20	22.03.20 - 31.05.20	08.06.20 - 19.04.21
	01.05.21 - 31.05.21			20.04.21 - 27.04.21	28.04.21 - 09.05.21		20.04.21 - 27.04.21	28.4.21 - 18.05.21	
							19.05.21 - 08.07.21		
West Bengal	21.03.20, 22.03.20	23.03.20 - 11.05.20	25.05.20 - 15.05.21	21.03.20, 22.03.20	23.03.20 - 03.05.20	11.11.20 - 05.05.21	21.03.20 , 22.03.20	23.03.20 - 30.03.20	08.06.20 - 30.04.21
	12.05.20 - 24.05.20			06.05.21 - 15.05.21	16.05.2021- 29.06.21		31.03.20 - 07.06.20		
	16.05.21 - 15.07.21			04.05.20 - 10.11.20			01.05.21 - 16.06.21		
Karnataka	18.05.20 - 16.06.20	24.03.20 - 17.05.20	17.06.20 - 26.04.21	19.05.20 - 06.09.20	24.03.20 - 18.05.20	07.09.20 - 26.04.21	14.03.20 - 23.03.20	24.03.20 - 17.05.20	08.06.20 - 20.04.21
	27.04.21 - 21.06.21			25.06.21 - 20.06.21	27.04.21 - 24.05.21		18.05.20 - 07.06.20	27.04.21 - 20.06.21	
							21.04.21 - 26.04.21		
							21.06.21 - 05.07.21		
Tamil Nadu	25.05.20 - 11.11.20	24.03.20 - 24.05.20	12.11.20 - 09.05.21	19.05.20 - 06.09.20	24.03.20 - 18.05.20	07.09.20 - 08.05.21	15.03.20 - 23.03.20	24.03.20 - 04.05.20	29.06.20 - 24.04.21
	10.05.21 - 22.08.21			21.06.20 - 05.07.21	09.05.21 - 20.06.21		05.05.20 - 28.06.20	09.05.21 - 13.06.21	
							26.04.20 - 08.05.20		
							14.06.21 - 27.06.21		

4 Supplementary Materials

The supplimentary material like the Code, Dataset is available in the given link: https://github.com/Prithwish-ghosh/Biostatistics