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Panel Vector Auto-Regressive Model For COVID-19 Infected Cases and Deaths

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Abstract

This study aims to model the dynamic relationships between the number of COVID-19 infected cases and deaths in all the districts of Kerala state, India, from January 2021 to December 2021 based on the panel vector auto-regressive model. The random effect panel vector auto-regressive model of order two was found suitable to model dynamic relationships. This model explains 62 % variations in the endogenous variable, deaths (number of deaths). The exogenous variable deaths (-1) are highly significant, whereas the exogenous variable cases (-1) are significant at a 5% level. Both of these exogenous variables positively influence the endogenous variable. The other exogenous variables, viz., deaths (-2) and cases (-2), are non-significant. The Durbin-Watson test statistic value confirms the independence of the residuals, and the Wald test confirms the validity of the significance of the estimated regression coefficients.

JEL classification numbers: E18, HO, I1, J64, J88.
Keywords: Fixed and Random Effect Models, Panel VAR model, Cointegration test, Levin-Lin-Chu unit root test, Granger causality test, Hausan test, Wald test.

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1. Introduction

Vector auto-regression (VAR) is a statistical model used to study the dynamic relationship between multiple quantities as they change over time. VAR is a stochastic process model. VAR models generalize the single-variable (univariate) autoregressive model by allowing for multivariate time series. Sims (1980) developed the VAR model with p lags, VAR(p), for expressing a set of variables as weighted linear combinations of each variable's past values and the past values of the other variables in the set. The model does not depend on economic theory; instead, it constructs the autoregressive model regarding the lag phase as an independent variable to study the dynamic relationship between the variables. Therefore, if the intrinsic and exogenous properties do not discriminate the variables, they all are treated as endogenous variables. The panel vector autoregressive model (PVAR) is an extension of the VAR model. The VAR model can only be used to estimate the time series of variables rather than estimating the panel data variables. Later, Holtz-Eakin et al. (1988) combined the VAR model with the panel data to form the Panel VAR model. Mei et al. (2011) constructed a multi-factor dynamic system VAR forecast model of China's GDP, which considered six important economic indicators. Unlike to VAR model, the PVAR model introduces individual effects to reflect the individual differences in the variables. In addition, the PVAR model does not require longer spans like the VAR model and can be used to analyze comprehensive panel data with shorter pans. The PVAR model has been widely used after its improvement and perfection by Pesaran and Smith (1995), Love and Zicchino (2006), Binder et al. (2010), and others.

The present paper is aimed to estimate the dynamic relationships between COVID-19 infected cases and deaths in all 14 districts of Kerala state, India, from January 2021 to December 2021 based on a panel vector auto-regressive model.

2. Materials and Methods

2.1 Materials

The monthly data on COVID-19 infected cases and deaths dataset was collected from the official Kerala state government website (www.dashboard.kerala.gov.in) from January 2021 to December 2021. Various econometric tools related to panel data auto-regression modeling were employed to investigate the dynamic relationships between COVID-19 infected cases and the number of deaths due to COVID-19 in all 14 districts of Kerala state, India, from January 2021 to December 2021. EViews Ver. 11. was used to estimate the model and its parameters.

2.2 Methods

In analyses of time series data, the study variables must be stationary, which means that the means and variances of the variable data are the same. Accordingly, Levin-Lin-Chu unit root tests were performed to test the stationarity of the study variables, the number of COVID-19-infected cases (CASES), and deaths (DEATHS). To run

the PVAR model, the study variables should not be co-integrated. The Pedroni (2004) panel cointegration test was used to assess the co-integration relationships, allowing heterogeneity in the cointegrating equation's intercepts and slopes. To estimate the cointegration relationship between the number of deaths due to COVID-19 and the number of COVID-19 cases, the Pedroni Cointegration test (with no deterministic trend, with deterministic intercept and trend; and with no deterministic intercept or trend) was performed in addition to the Kao cointegration test (Kao and Chiang, 2000) and Johnson cointegration test (Johansen,1988). In the absence of Co-integration relationships between the study variables, the panel VAR model was employed to study the dynamic relationships between the variables.

2.2.1 Panel VAR model

The k-variate homogeneous panel VAR of order p with panel-specific fixed effects is represented by the following system of the linear equation:

$$Y_{it} = Y_{i,t-1}A_1 + Y_{i,t-2}A_2 + \ldots + Y_{i,t-p}A_p + X_{it}B + u_i + e_{it}$$

i=1,2,3,…,N and t = 1,2,3,…,Ti

where Y_{it} is a $(1xk)$ vector of dependent variables; X_{it} is a $(1x1)$ vector of exogenous covariates; u_i and e_{it} are $(1xk)$ vectors of dependent variable-specific panel fixed-effects and idiosyncratic errors, respectively. The $(k\ x\ k)$ matrices $A1, A2, \ldots, Ap$and the $(l\ x\ k)$ matrix B are parameters to be estimated. We assume that the innovations have the following characteristics:

$$E(e_{it}) = 0 \quad , \quad E(e_{it}^{'} e_{is}) = 0$$

$$for\ all\ t > s$$

The parameters in the above model may be estimated jointly with the fixed effects or independently of the fixed effects after some transformation using equation-by-equation ordinary least squares (OLS). The model is "auto-regressive" in the sense that it is explained (in part) by its lagged values of itself. However, it also has a "distributed lag" component in the form of successive lags of the "x" explanatory variable. Sometimes, the current value is excluded from the distributed lag part of the model's structure (Soharwardi et al.,2018).

3. Results and Discussion

3.1 District-Wise Summary statistics COVID-19 infected cases

District-wise total numbers of infected cases are presented in Table 1 and depicted in Figure 1. The result reveals that all over the Kerala state, 4479092 infected cases

were registered in 2021. The highest and lowest number of infected cases are reported in Eranakulam (561964) and Wayanad (118592) districts. All over the state, the pattern of COVID-19 infected cases is skew-symmetric since all the skewness values are positive. The distribution in Trivandrum and Alappuzha districts is highly skewed, and the distributions in the rest are moderately skewed. All the skewness values fall between the acceptable range (− 2 and + 2). Since all the kurtosis values are more significant than one, the distribution is too peaked and leptokurtic. For the rest of the districts, the dataset has lighter tails than a normal distribution (less in the tails). Since all the p-values of the Jarque-Bera (Jarque and Bera, 1987) test are non-significant, the infected cases are normally distributed in all the districts. Districts wise maximum number of total infected cases is depicted in Figure 2.

The maximum number of total infected cases has been reported in Malappuram (123987) district, followed by Eranakulam (116878), Trivandrum (103688), and Kozhikkode (90484). In the Kerala state total number of maximum infected cases was registered in all the districts in May. Districts wise minimum total number of infected cases is reported in Figure 3. The minimum number of COVID-19 infected cases has been registered in Kozhikkode (8871), Eranakulam (6639), Kannur (5986), etc.

In Kerala state total number of maximum infected cases have been registered in all the districts in March, except Kasargod district. The minimum number of total infections in this district is 1949, recorded in December.

Table 1: District-wise summary statistics of COVID-19 infected cases

District	Sum	Maxi.	Mini	Std.Dev.	Skew.	Kurt.
Trivandrum	425467	103688	5385	26901.59	1.3048	4.4866
Kollam	347372	74984	5524	21120.34	0.8107	2.7369
Pathanamthitta	175817	28664	3746	7659.54	0.4203	2.3392
Alappuzha	268927	66151	3799	18547.13	1.0578	3.4795
Kottayam	293821	58727	5073	16144.39	0.8034	2.6360
Idukki	142083	27409	2161	7884.69	0.5965	2.3670
Eranakulam	561964	116878	6639	32400.03	0.7402	2.7654
Thrissur	475753	88047	5434	30455.94	0.4755	1.7677
Palakkad	336065	82906	2378	26444.23	0.7634	2.4507
Malappuram	487807	123987	4428	38455.23	0.9245	2.7984
Kozhikkode	473180	90484	8871	27666.71	0.5595	1.9231
Wayanad	118592	20372	1602	6436.95	0.4543	1.8772
Kannur	252699	51687	5986	15176.76	0.6553	2.2634
Kasargod	119545	24048	1949	8099.75	0.4890	1.7472

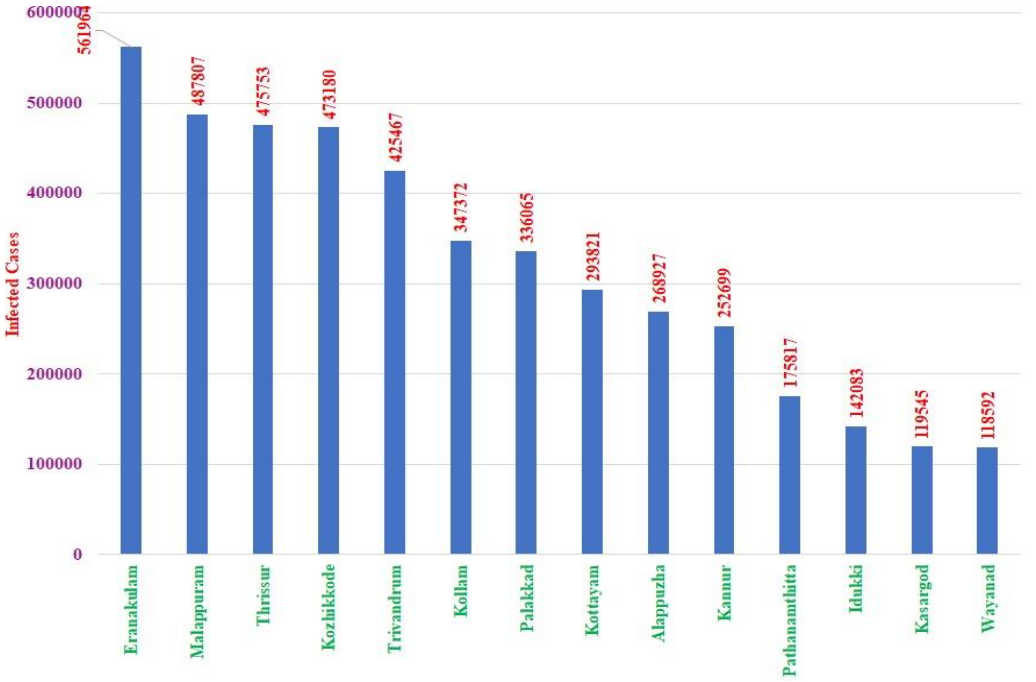

Figure 1: District-wise total number of COVID-19 infected cases

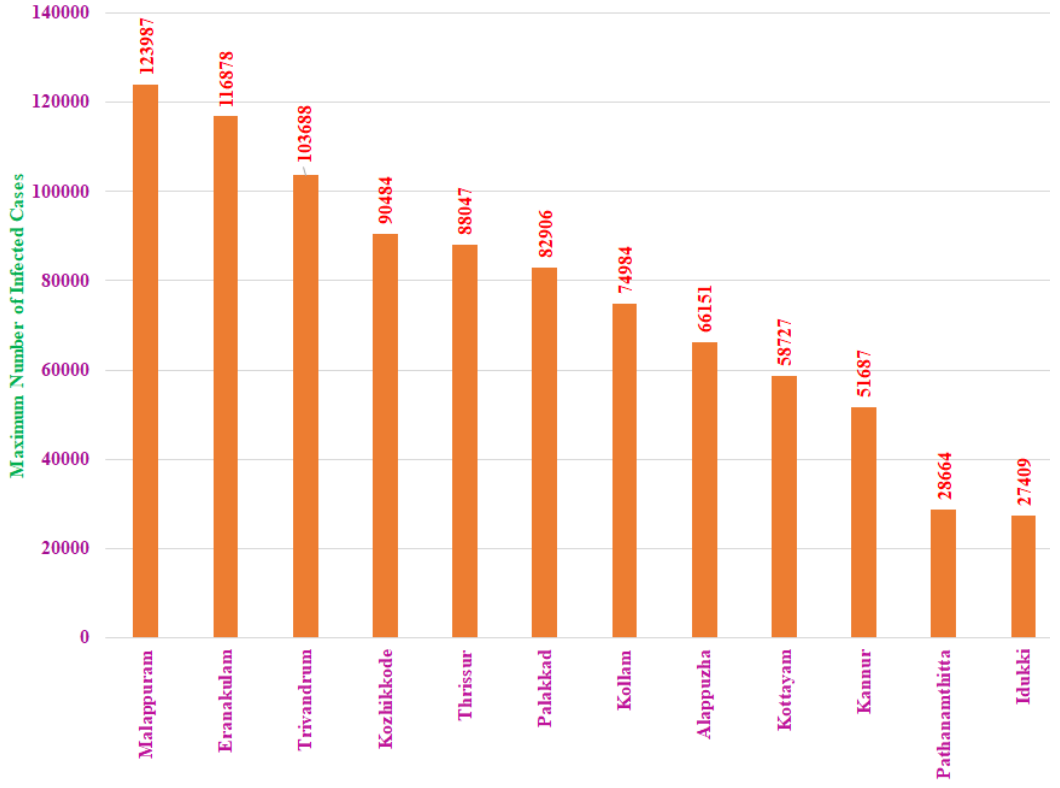

Figure 2: District-wise maximum number of COVID-19 infected Cases

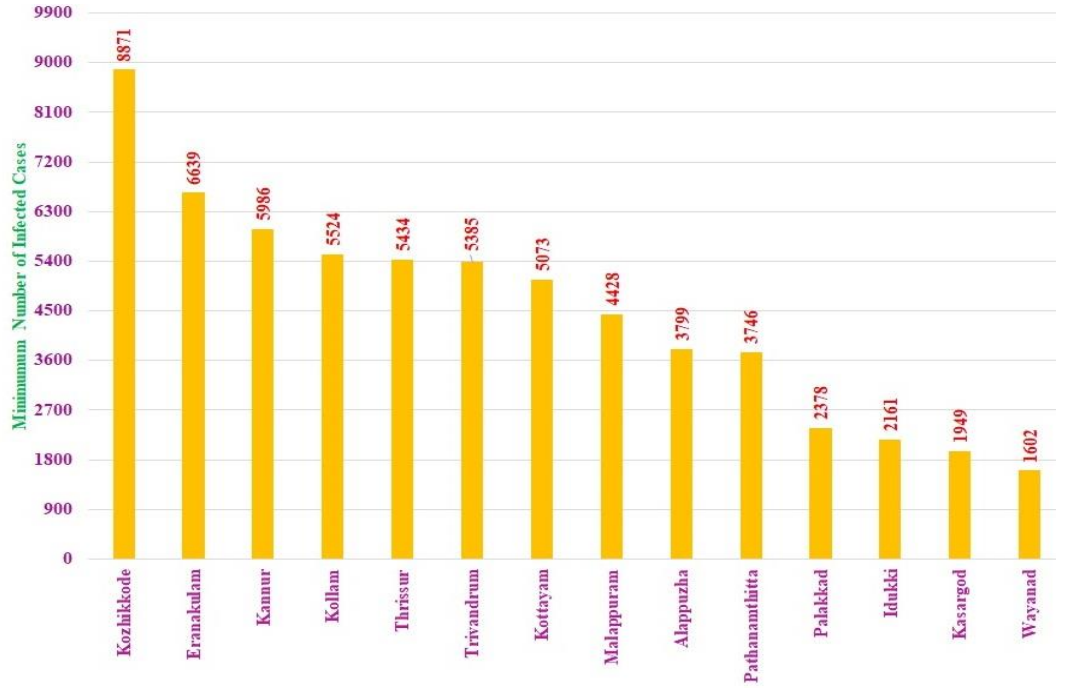

Figure 3: District-wise minimum number of COVID-19 infected cases.

District-wise total deaths due to COVID-19 infections are presented in Table 2 and depicted in Figure 4 to Figure 6. The result reveals that all over the Kerala state, 44722 deaths due to COVID-19 infections were registered in 2021. The highest number of deaths have been reported in Trivandrum (5631), and the lowest of 657 deaths have been recorded in Wayanad. In twelve districts, the number of deaths due to COVID-19 infections is positively skewed, whereas, in Palakkad and Wayanad, it is negative skew-symmetric (skewed left).

All the skewness values fall between the acceptable range (− 2 and + 2). Since all the kurtosis values are greater than one, the distribution is too peaked and leptokurtic. For the rest of the districts, the dataset has lighter tails than a normal distribution (less in the tails). All the p-values of the Jarque-Bera test are non-significant, indicating that the number of deaths due to COVID-19 infections is normally distributed in all the districts.

District-wise total number of maximum deaths is depicted in Figure 5. The total number of maximum deaths has been reported during October (Trivandrum, 1070); November (Eranakulam, 1321; Kollam, 1261; Thrissur, 981; Kozhikkode, 703; Kannur, 588, Pathanamthitta,496) and December (Alappuzha, 1032; Kottayam, 769; Palakkad,676; Malappuram, 659; Idukki, 234).

District-wise total number of minimum deaths is depicted in Figure 6. The total number of minimum deaths has been reported during February (Kozhikkode, 57; Thrissur,46; Malappuram, 30; Kannur, 29; Kottayam, 16; Kasargod,3 In); March (Trivandrum, 50; Alappuzha,49; Kollam, 33; Pathanamthitta,15; Wayanad, 8; Palakkad,8) and in April (Idukki,4).

Table 2: District-wise summary statistics of the number of deaths due to COVID-19 infection

District	Sum	Sum	Maxi.	Mini.	Std.Dev.	Skew.	Kurt.
Trivandrum	5631	1070	50	366.80	366.80	0.39	1.86
Kollam	4343	1261	34	372.48	372.48	1.28	3.89
Pathanamthitta	1759	496	15	138.22	138.22	1.34	4.38
Alappuzha	3359	1032	49	306.11	306.11	1.48	4.11
Kottayam	2532	769	16	230.49	230.49	1.47	4.07
Idukki	955	234	4	82.23	82.23	0.85	2.42
Eranakulam	5267	1321	33	417.34	417.34	0.99	2.94
Thrissur	5003	981	46	310.33	310.33	0.20	1.98
Palakkad	3776	676	2	237.61	237.61	-0.26	1.68
Malappuram	3319	659	30	209.20	209.20	0.18	1.95
Kozhikkode	3995	703	57	231.13	231.13	0.28	1.87
Wayanad	657	97	8	33.11	33.11	-0.24	1.61
Kannur	3289	588	29	214.56	214.56	0.43	1.79
Kasargod	837	154	3	55.56	55.56	0.17	1.62

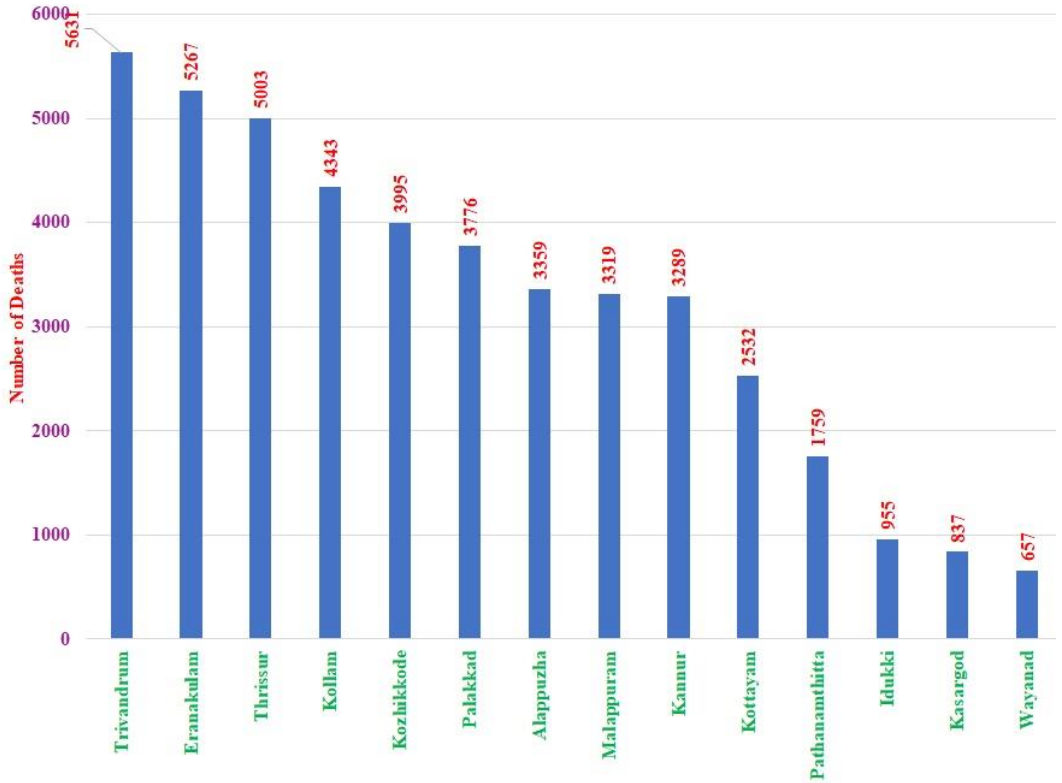

Figure 4: District-wise total number of deaths due to COVID-19 infection

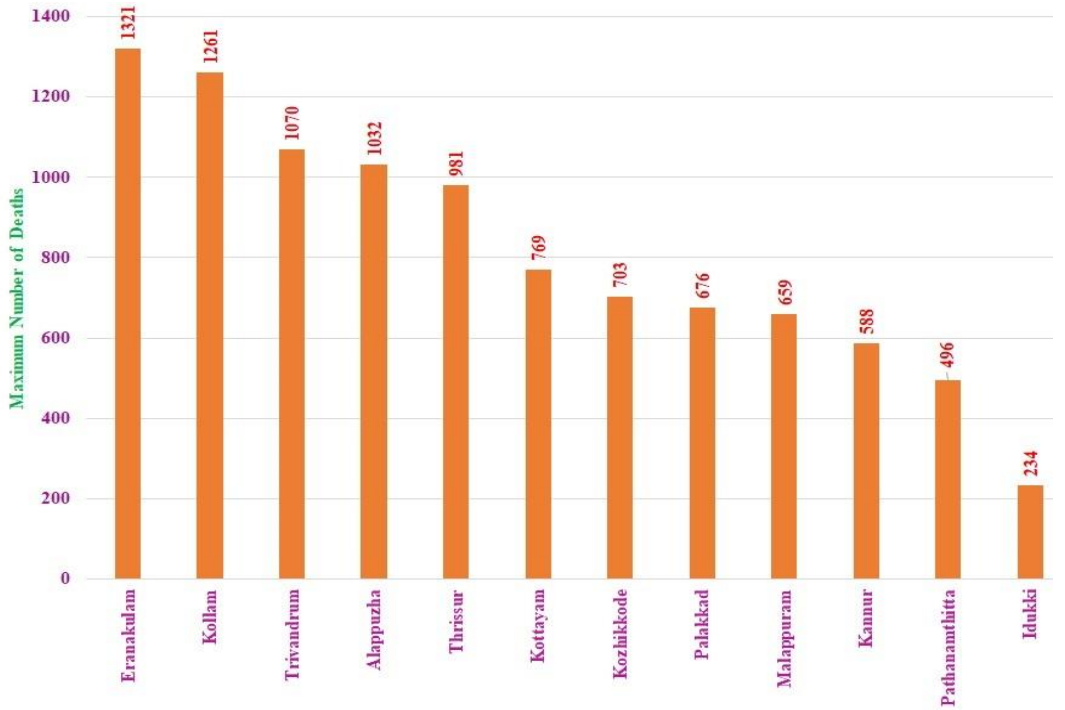

Figure 5: District-wise maximum number of deaths due to COVID-19 infection

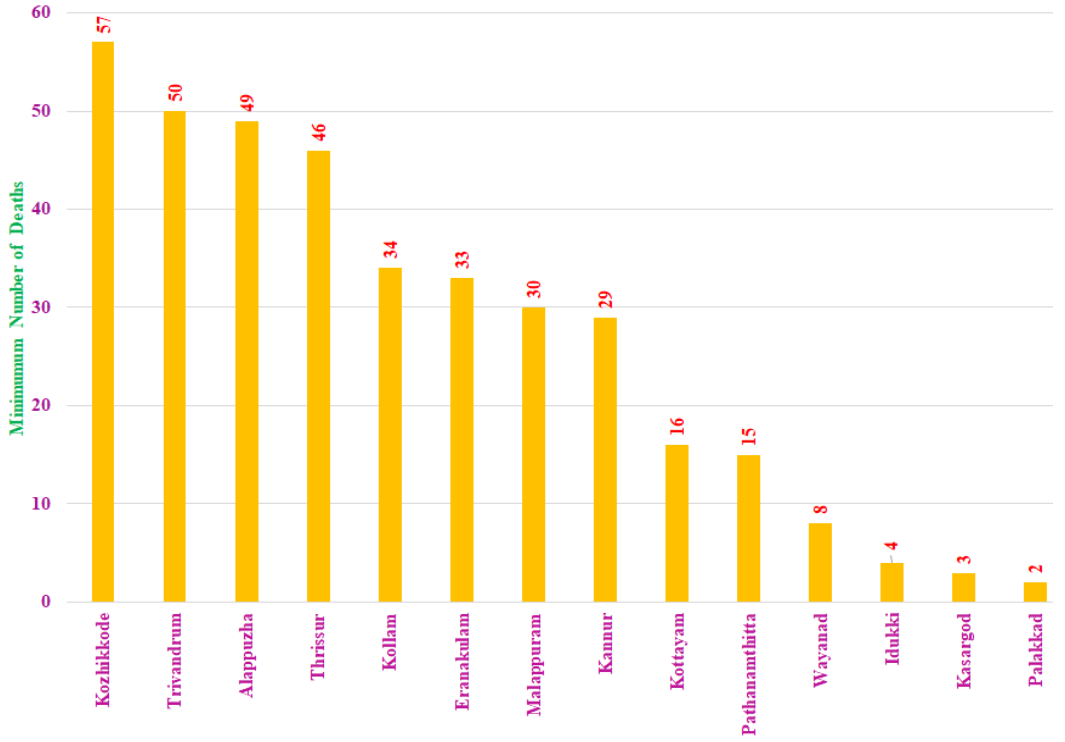

Figure 6: District-wise minimum number of deaths due to COVID-19 infection

3.2 Month-Wise Summary statistics COVID-19 infected cases

Month-wise total numbers of infected cases are presented in Table 3 and depicted in Figure 7. The result reveals that all over the Kerala state, 4479092 COVID-19 infected cases were registered in the year 2021. The highest number of COVID-19 infected cases were reported in May (955396) and the lowest in March (64881). All over the state, the death pattern due to COVID-19 infections is skew-symmetric since all the skewness values are positive. Since all the kurtosis values are greater than one, the distribution is too peaked and leptokurtic. Although the kurtosis value in December is greater than 3, the dataset has heavier tails than a normal distribution (more in the tails). For the rest of the districts, the dataset has lighter tails than a normal distribution (less in the tails). Since all the p-values of the Jarque-Bera test are non-significant, indicating that the COVID-19 infected cases are normally distributed in all months. The maximum number of COVID-19 infected cases was reported in May (123987) (Figure 8), and the minimum number of COVID-19 infections was reported in March (1602) (Figure 9).

Table 3: Month-wise summary statistics of the number of COVID-19 infection

MONTH	Sum.	Maxi.	Mini.	Std. Dev.	Skew.	Kurt.
January	168245	24482	2305	5780.85	0.3683	2.8243
February	130225	15803	2832	4373.71	0.2050	1.6798
March	64881	8871	1602	1982.85	0.2887	2.6793
April	446601	64263	11763	16876.17	0.6176	2.2829
May	955396	123987	17736	35064.24	0.5081	1.8038
June	397586	50764	6960	14834.06	0.0286	1.5001
July	466626	68664	9115	17764.94	0.4109	2.2102
August	660472	91811	16823	26016.30	0.4446	1.7699
September	623625	80612	9642	21124.73	0.1040	2.1709
October	286915	41829	4998	10555.85	0.6430	2.4960
November	173157	25588	2940	7310.53	0.6667	2.1555
December	105363	19129	1949	5321.86	1.0841	3.0260

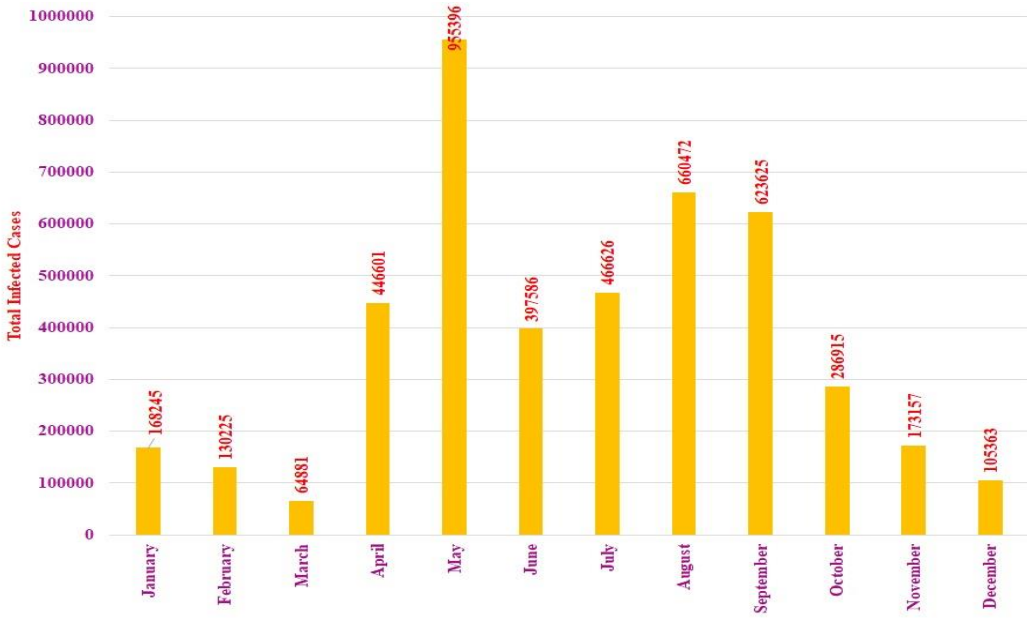

Figure 7: Month-wise total numbers of COVID-19 infected cases

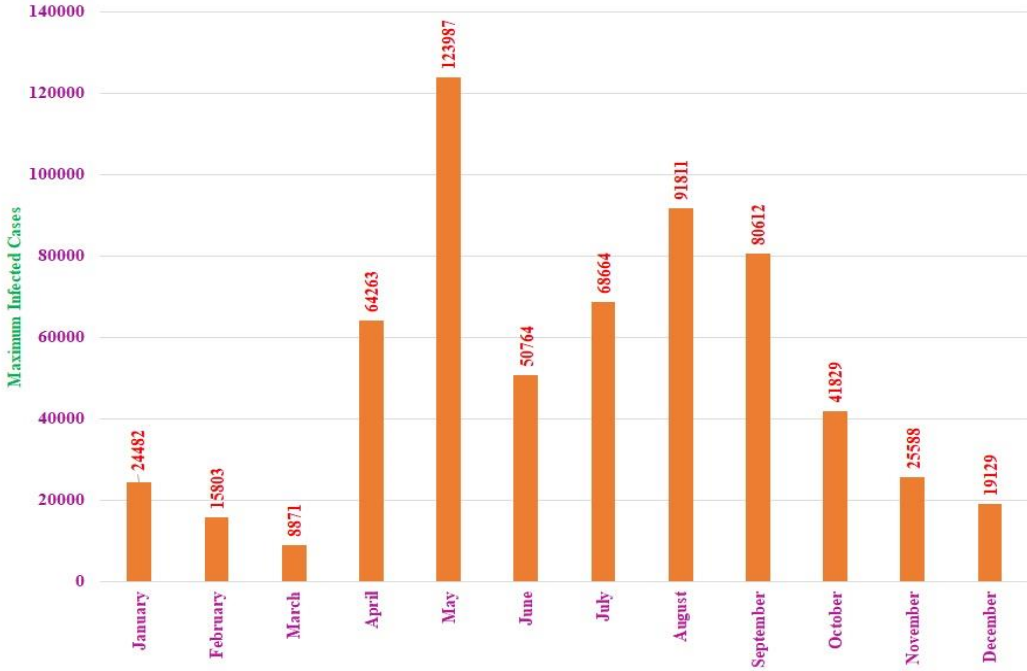

Figure 8: Month-wise maximum numbers of COVID-19-infected cases

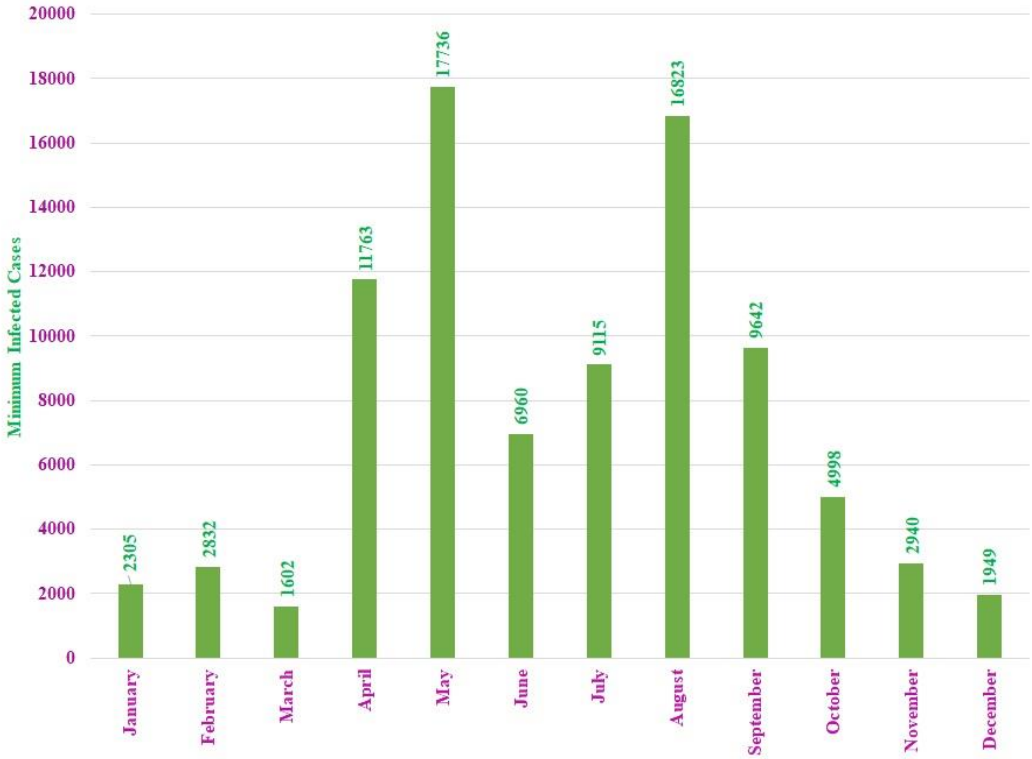

Figure 9: Month-wise minimum numbers of COVID-19 infected cases

Month-wise total deaths due to COVID-19 infections are presented in Table 4 and depicted in Figure 10. The highest number of deaths due to COVID-19 infections was registered in November (8451) and then decreased to 7662 in December. From February onwards, the number of deaths increased every month. Since all the p-values of the Jarque-Bera test are non-significant, indicating that the COVID-19 infected cases are normally distributed in all months. The month-wise maximum and minimum deaths are depicted in Figures 11 and 12, respectively.

Table 4: Month-wise summary statistics of the number of deaths due to COVID-19 infection

MONTH	Sum.	Maxi.	Mini.	Std. Dev.	Skew.	Kurt.
January	671	98	9	26.79	0.3377	2.2143
February	454	88	3	24.10	0.7064	3.0002
March	424	58	2	19.12	0.0640	1.5980
April	687	110	4	35.36	0.4191	1.9982
May	3507	760	10	204.11	1.0407	3.7167
June	4420	1043	57	256.48	1.6027	5.6607
July	3546	464	56	151.79	-0.0421	1.3257
August	4007	548	72	171.75	0.1481	1.5746
September	4299	596	70	169.17	-0.0523	1.7992
October	6594	1106	93	322.99	0.7719	2.6696
November	8451	1321	97	374.97	0.6150	2.5433
December	7662	1032	91	299.84	-0.2329	1.7269

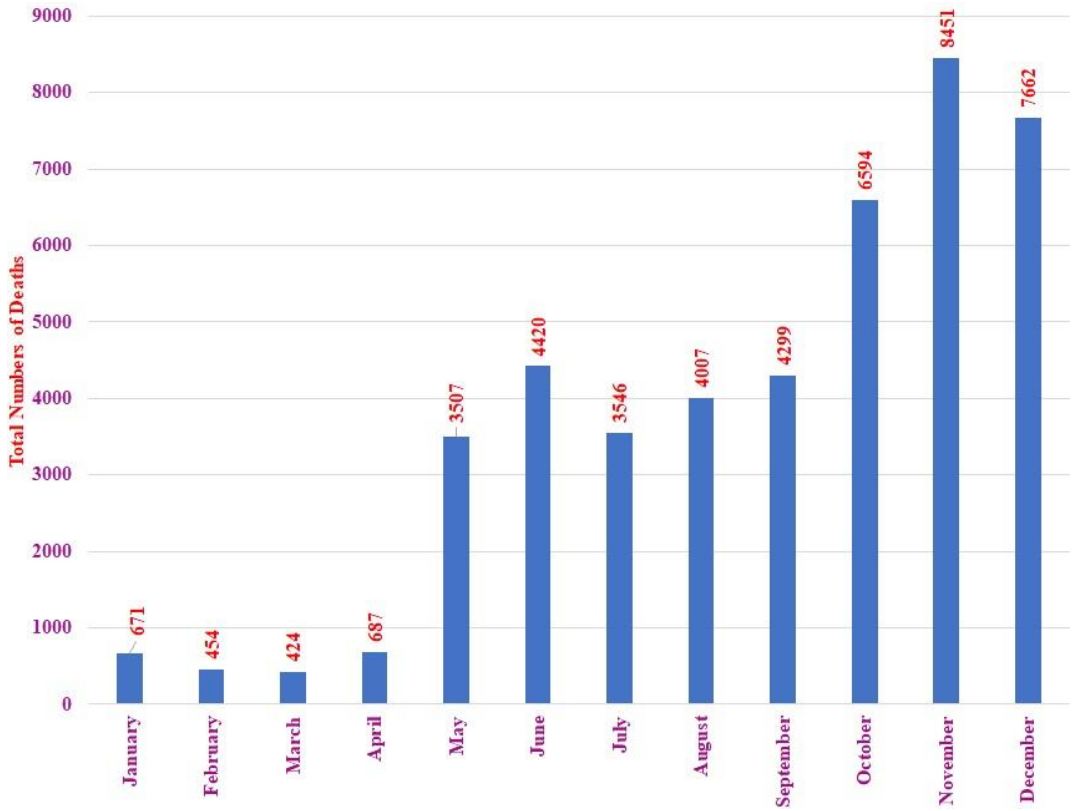

Figure 10: Month-wise total number of deaths due to COVID-19 infections

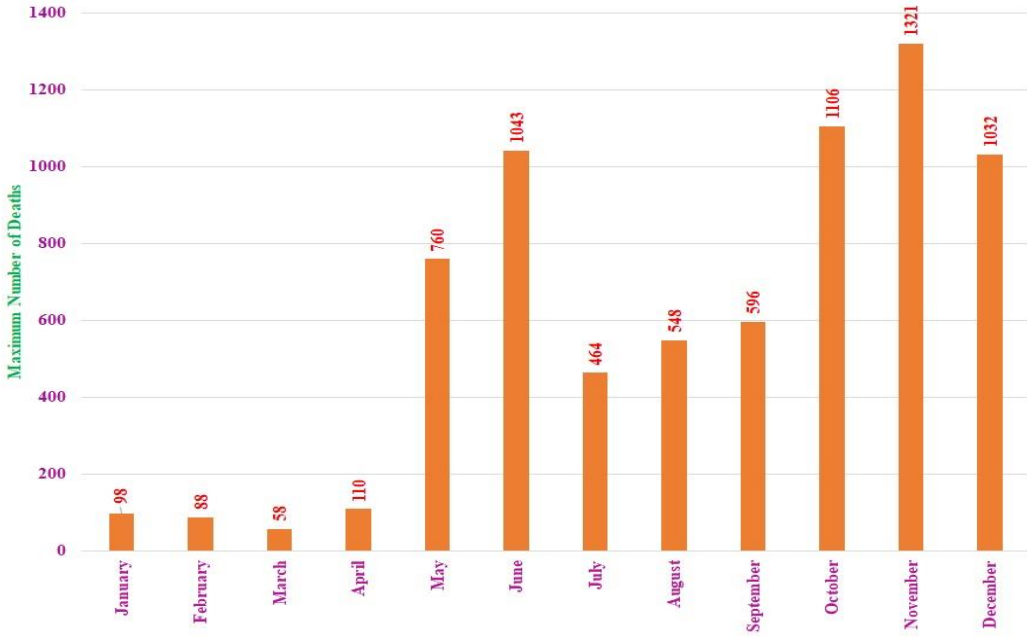

Figure 11: Month-wise maximum number of deaths due to COVID-19 infections

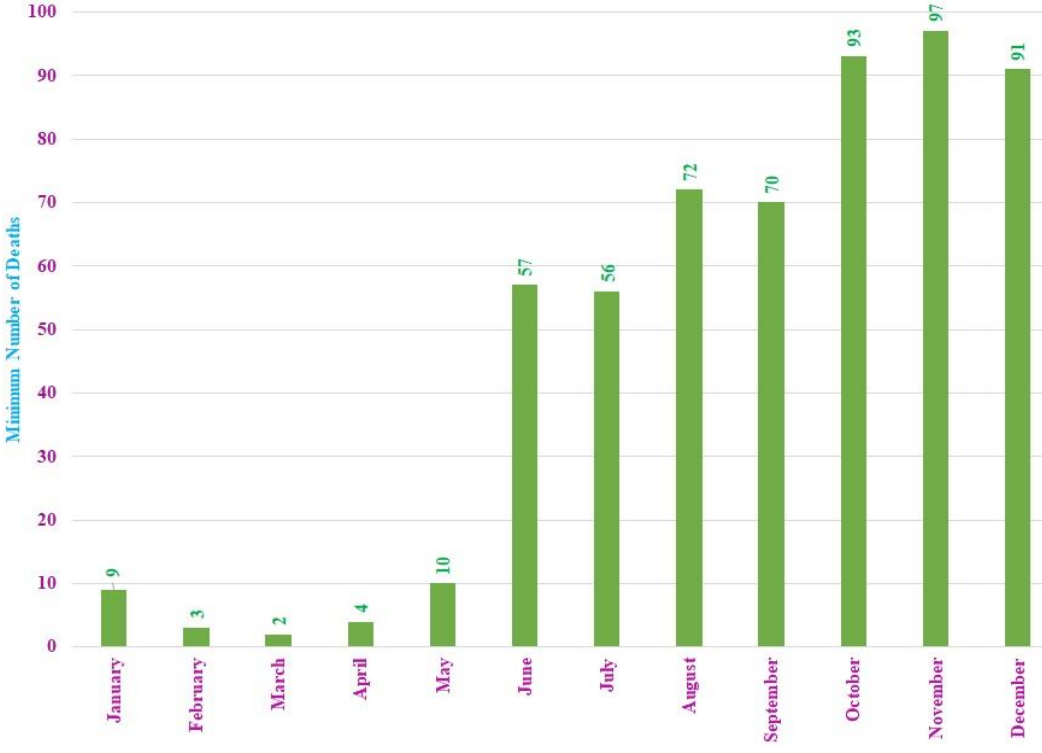

Figure 12: Month-wise minimum number of deaths due to COVID-19 infections

3.3 Unit root tests

In analyses of time series data, the study variables must be stationary, whose statistical properties, such as mean, variance, autocorrelation, etc., are all constant over time. Accordingly, Levin et al.(2002) unit root tests were performed to test the stationarity of the study variables, viz., the number of infected cases and deaths. The results are reported in Table 5. The test results reveal that the two variables under study are stationary since the Levin, Lin, and Chu t-statistics are highly significant ($p<0.0000$). Hence, the variables under study are stationary.

Table 5: Unit root test results for the variable Cases and Deaths

Method	Cases		Deaths	
	Statistic	Prob**	Statistic	Prob**
Levin, Lin & Chu t*	-4.2807	0.0000	-4.9468	0.0000

** Probabilities are computed assuming asymptotic normality

3.4 Panel Cointegration test

To estimate the cointegration relationship between death due to COVID-19 infections and the number of COVID-19 infected cases, the Pedroni Cointegration test (with no deterministic trend, with deterministic intercept and trend; and with no deterministic intercept or trend) was performed in addition to the Kao Cointegration test (Kao and Chiang, 2000). The results of the Pedroni and Kao Cointegration tests are presented in Tables 6 through 9.

Table 6: Characteristics of Pedroni Cointegration test (No deterministic trend)

Name of Test Statistic	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-1.361338	0.9133	-1.513637	0.9349
Panel rho-Statistic	1.732908	0.9584	2.203370	0.9862
Panel PP-Statistic	1.827337	0.9662	2.597631	0.9953
Panel ADF-Statistic	1.574986	0.9424	2.410286	0.9920
Group rho-Statistic	4.077287	1.0000		
Group PP-Statistic	5.098787	1.0000		
Group ADF-Statistic	4.799022	1.0000		

Table 7: Characteristics of Pedroni Cointegration Test (Deterministic Intercept and Trend)

Name of Test Statistic	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	0.611097	0.2706	1.766901	0.0386
Panel rho-Statistic	1.571157	0.9419	1.573164	0.9422
Panel PP-Statistic	-6.412785	0.0000	-5.935624	0.0000
Panel ADF-Statistic	-9.289025	0.0000	-8.438939	0.0000
Group rho-Statistic	3.038982	0.9988		
Group PP-Statistic	-6.250494	0.0000		
Group ADF-Statistic	-8.045632	0.0000		

Table 8: Characteristics of Pedroni Cointegration test (No Deterministic Intercept or Trend)

Name of Test Statistic	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	0.491295	0.3116	0.321542	0.3739
Panel rho-Statistic	0.148871	0.5592	0.656965	0.7444
Panel PP-Statistic	0.591498	0.7229	1.233710	0.8913
Panel ADF-Statistic	-0.200313	0.4206	0.879375	0.8104
Group rho-Statistic	3.999541	1.0000		
Group PP-Statistic	4.329492	1.0000		
Group ADF-Statistic	3.348038	0.9996		

The test results reveal that in eleven tests, the null hypothesis of no cointegration is accepted since most of the test statistics p values are > 0.5000, indicating that no cointegration exists; i.e., there is no long-term relationship between the number of deaths due to COVID-19 and the number of COVID-19 infection cases.

Table 9: Characteristics of the Kao Cointegration test

Test Name	t-Statistic	Prob.
ADF	0.323838	0.3730

From Table 10, the hypotheses of no cointegration were accepted for both the trace and maximum eigenvalue tests since their respective p-values are more significant than the 5% chosen significance level. Therefore, since the variables under study are stationary at the level and are not cointegrated, the PVAR(p) model is appropriate for analyzing the panel data (Rubinfeld, 1991).

Table 10: Characteristics of Johansen Fisher Panel Cointegration test

Hypothesized	Fisher Stat.*			
No. of CE(s)	**(Trace test)**	**Prob.**	**(Max-Eigen test)**	**Prob.**
None	31.52	0.2944	26.94	0.5215
At most 1	38.56	0.0882	38.56	0.0882

3.5 Panel VAR model

The interpretation of the estimated coefficients of the PVAR, VAR, and VECM models are done in terms of the influence on nature (positive or negative effect) dynamic (short term and long term) between the endogenous variables taken together and especially with their own. The number of lags to be included in the VAR model using the lag selection criteria is illustrated in Table 11. The selection criteria result reveals that lag 2 is the appropriate model.

Table 11: PVAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-483.3978	NA	3.91e+12	34.67127	34.76643	34.70036
1	-441.7260	74.41386	2.66e+11	31.98043	32.26590	32.06770
2	-434.6338	11.65153	2.14e+11	31.75955	32.23534*	31.90501
3	-431.8936	4.110180	2.38e+11	31.84955	32.51565	32.05318
4	-428.6113	4.454608	2.57e+11	31.90081	32.75722	32.16262

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level) ;
FPE: Final prediction error; AIC: Akaike information criterion ;
SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion

The fixed and random effect (PVAR (2)) models have been estimated and presented in Tables 12 and 13. To decide whether to consider the fixed effect model or the random effect model, Hasman's test has been carried out, and the results are presented in Table 14. Since Hasman's test statistic value is non-significant, the random effect model is appropriate.

The random effect model reveals both the lag variables (exogenous variables) explain 62 % of variations in deaths. The exogenous variables DEATHS (-1) and CASES(-1) are highly significant. Both of these exogenous variables positively influence the endogenous variable (DEATHS). The other independent exogenous variables, viz., DEATHS(-2) and CASES (-2) (second lag), are non-significant. Also, since the estimated Durbin-Watson stat value is 2.02, the errors due to the estimated model are uncorrelated, which is preparable.

Table 12: Characteristics of estimated fixed effect PVAR model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	88.60644	32.82038	2.699738	0.0079
DEATHS(-1)	0.700019	0.101784	6.877476	0.0000
DEATHS(-2)	-0.014646	0.127208	-0.115137	0.9085
CASES(-1)	0.001857	0.000799	2.325198	0.0217
CASES(-2)	-0.000398	0.000891	-0.446828	0.6558
Root MSE	171.8097	R-squared		0.635422
Mean dependent var	311.4071	Adjusted R-squared		0.584620
S.D. dependent var	285.5676	S.E. of regression		184.0483
Akaike info criterion	13.38780	Sum squared resid		4132602.
Schwarz criterion	13.76601	Log-likelihood		-919.1457
Hannan-Quinn criteria.	13.54149	F-statistic		12.50783
Durbin-Watson stat	2.027458	Prob(F-statistic)		0.000000

Table 13: Characteristics of estimated random effect PVAR model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	56.73332	26.81084	2.116059	0.0362
DEATHS(-1)	0.728427	0.100089	7.277823	0.0000
DEATHS(-2)	0.039264	0.120517	0.325794	0.7451
CASES(-1)	0.002348	0.000734	3.198802	0.0017
CASES(-2)	-0.000440	0.000862	-0.510533	0.6105
Effects Specification			S.D.	Rho
Cross-section random			0.000000	0.0000
Idiosyncratic random			184.0483	1.0000
Weighted Statistics				
Root MSE	176.5320	R-squared		0.615105
Mean dependent var	311.4071	Adjusted R-squared		0.603701
S.D. dependent var	285.5676	S.E. of regression		179.7714
Sum squared resid	4362896.	F-statistic		53.93627
Durbin-Watson stat	2.004464	Prob(F-statistic)		0.000000

Table 14: Characteristics of estimated Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	5.014515	4	0.2858

3.6 Wald test

According to the Wald test (Wald, 1943) results presented in Table 15, the hypothesis that all coefficients are zero is rejected at a 1% significance level; thus, the validity of the significance of coefficients is confirmed, meaning that they add explanatory power to the model.

Table 15: Characteristics of Wald test

Test Statistic	Value	df	Probability
F-statistic	70.86904	(4, 135)	0.0000
Chi-square	283.4761	4	0.0000

3.7 Causality test

The Granger test (Granger, 1969) of causality was employed to assess whether causal relationships exist among the variables and determine the direction of the causality. The results are presented in Table 16. The test results reveal that the null hypothesis of no causality between the independent and dependent variables running in either direction is rejected. Hence, bidirectional causality exists between the study variables.

Table 16: Characteristics of Pairwise Granger Causality test

Null - Hypothesis	Obs.	F- Statistic	Prob.
CASES does not Granger Cause DEATHS	140	5.97657	0.0033
DEATHS does not Granger Cause CASES		3.67312	0.0280

3.8 Impulse Response Function

The sensitivity responses of the two variables using impulse response graphs are presented in Figure 12. It can be deduced that number of COVID-19 deaths (DEATHS) is sensitive to COVID-19 infected cases (CASES), as evident from the graph labeled "Response of DEATHS to CASES" at the top right of Figure 12. Furthermore, it can be deduced that CASES is sensitive to DEATHS, as evident from the graph labeled "Response of CASES to DEATHS" at the bottom left of Figure 12. This further buttressed the findings on Granger causality earlier discussed.

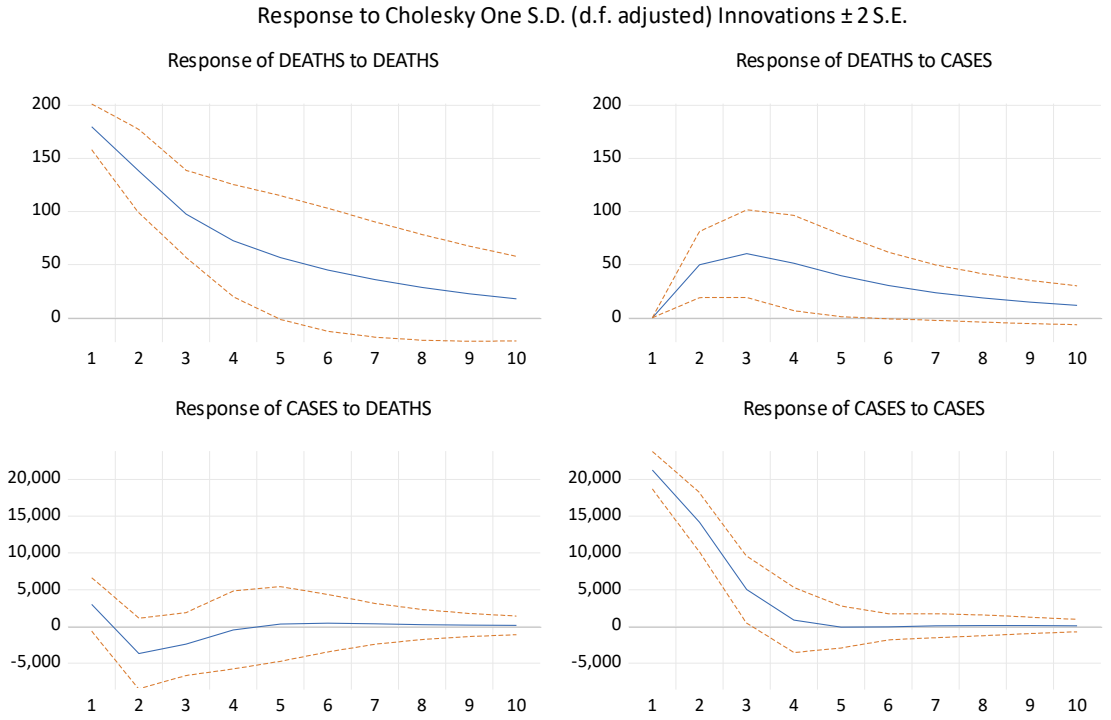

Figure 12: Impulse Response Function

4. Conclusions

The result reveals that all over the Kerala state, 4479092 infected cases were registered in 2021. The maximum number of total infected cases has been reported in Malappuram (123987) district, followed by Eranakulam (116878), Trivandrum (103688), and Kozhikkode (90484). In the Kerala state total number of maximum

infected cases was registered in all the districts in May. The minimum total number of infected cases has been reported in Kozhikkode (8871), Eranakulam (6639), Kannur (5986), etc. The total number of maximum infected cases have been registered in all the districts in March, except Kasargod district. The minimum number of total infections in this district is 1949, recorded in December. The total number of maximum deaths has been reported during October (Trivandrum, 1070); November (Eranakulam, 1321; Kollam, 1261; Thrissur, 981; Kozhikkode, 703; Kannur, 588, Pathanamthitta, 496) and December (Alappuzha, 1032; Kottayam, 769; Palakkad,676; Malappuram, 659; Idukki, 234). The total number of minimum deaths has been reported during February (Kozhikkode,57; Thrissur,46; Malappuram, 30; Kannur, 29; Kottayam, 16; Kasargod,3); March (Trivandrum, 50; Alappuzha,49; Kollam, 33; Pathanamthitta,15; Wayanad, 8; Palakkad,8) and in April (Idukki,4). The random effect model reveals that both the lag variables (exogenous variables) explain 62 % of variations in the endogenous variable, deaths. The exogenous variables DEATHS (-1) and CASES(-1) are highly significant. Both of these exogenous variables positively influence the endogenous variable (DEATH). The other independent exogenous variables, viz., DEATHS(-2) and CASES-2) (second lag), are non-significant. Also, since the estimated Durbin-Watson stat value is 2.02, the errors due to the estimated model are uncorrelated, which is preparable. Wald test confirms the validity of the significance of coefficients.

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