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PANDEMICS, LOCKDOWN AND ECONOMIC GROWTH: A REGION-SPECIFIC PERSPECTIVE ON COVID-19

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ABSTRACT

This study examines the impacts of COVID-19 induced factors and country specific health-care infrastructure and co-morbid factors on economic growth between January 1, 2021, to May 31, 2021 for 19 South and South-east Asian (SSEA) economies. Our findings indicate that COVID-19 related mortality negates growth, while vaccination and testing have no significant impact on growth during this period. We further quantify the effects by instrumenting government policy measures and vaccination drives in terms of testing, tracking and mortality. Our findings show a negative effect of lockdowns on growth, while vaccination has a positive impact on growth and controls fatality rate considerably.

Keywords: Pandemic; Economic growth; COVID-19, South asia; South-east asia.
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I. INTRODUCTION

The COVID-19 pandemic has severely jolted the economic activity and normal human livelihood across the globes. COVID-19's impact on the transitioning economies is found to be more severe (Mele and Magazzino, 2021; Konig and Winkler, 2020; Darjana *et al*., 2022; Jorda *et al*., 2020). These developing economies have experienced massive disruptions across various sectoral activities, right from shutdown of small-scale industries to the disruptions of tourism and aviation sectors (Gossling *et al*., 2020; Liu *et al*., 2021; Czerny *et al*., 2021). With the disruption of global interconnectedness, developing economies have been hard hit in terms of declining exports and a weakening tourism industry (Papanikos, 2020; Bodnar *et al*., 2020). Overall, economic hardship that has emerged from COVID-19 has resulted in the disproportionate fall in growth in low- and middle-income regions (Goldberg and Reed, 2021). The region of South and South-Eastern Asia is no exception to the pandemic induced challenges for growth. Almost all the economies in the region have been severely impacted by the COVID-19 pandemic (Babu *et al*., 2021; Rasul *et al*., 2021). Due to the high density of population in this region, community transmission has been more worrying from a recovery and containment points of view.

We, next, impart some preliminary evidence pertaining to the impact of COVID-19. Figure 1 shows the association between stringency measures (lockdown) and GDP from January 1, 2021, to May 31, 2021.This allows us to gauge the impact of government measures in terms of lockdown on GDP. From Figure I, we see that there exists a positive correlation between GDP and stringency measure in the region. Economies like Nepal, Laos, Afghanistan, Cambodia, Myanmar, the Philippines, Pakistan and Bangladesh experience marginal positive correlation between GDP and stringency measures. It indicates that imposing lockdown has impacted GDP to a certain extent. Arguably, this demonstrates the fact that lockdown measures impact GDP to a certain degree even after the first COVID wave weakened. However, economies like Singapore, Brunei, Thailand, and Malaysia experienced rising GDP growth despite imposing stricter lockdown measures. The study typically uses a trendline for COVID-19 related mortality and government measures in terms of stringent conditions to find out, how this mechanism works. We plot a trendline to find out the relative performance of these SSEA economies during first half of 2021

Figure 2 explains how the govt measures work in terms of controlling COVID-19 mortality. We find that a positive correlation between lockdowns and COVID-19 death. By using the average score of each economy, we find that countries like Laos, Singapore, Bhutan, Timor, Thailand, and Malaysia experience fewer mortality than the average death rate of the region as produced by the trendline. It is possible due to the high rate of testing, tracking, immediate isolation of the patients and robust health infrastructure in some of these economies. Our graphical evidence also demonstrates that economies with higher population density like India, Pakistan, Bangladesh, the Philippines, and Indonesia experience worsening COVID-19 situations, despite stringent measures. These five nations have experience higher mortality from COVID-19.

Figure 1.
GDP and Stringency (Jan 1, 2021, to May 31, 2021)

This diagram presents the association between GDP and stringency measures taken by all the SSEA economies. The red line states that there exists positive association between GDP and stringency measures. GDP is expressed in terms current dollars and is converted into natural log. Stringency is an index score with ranges from 0 to 100. Stringency measure is here being represented by the concerned government initiatives in initiating lockdown conditions.

Source: Author's own compilation.

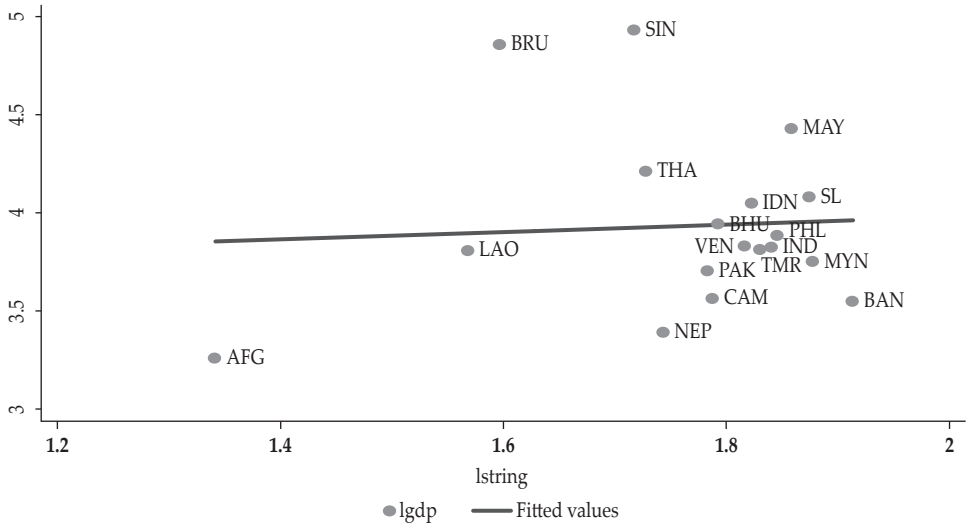
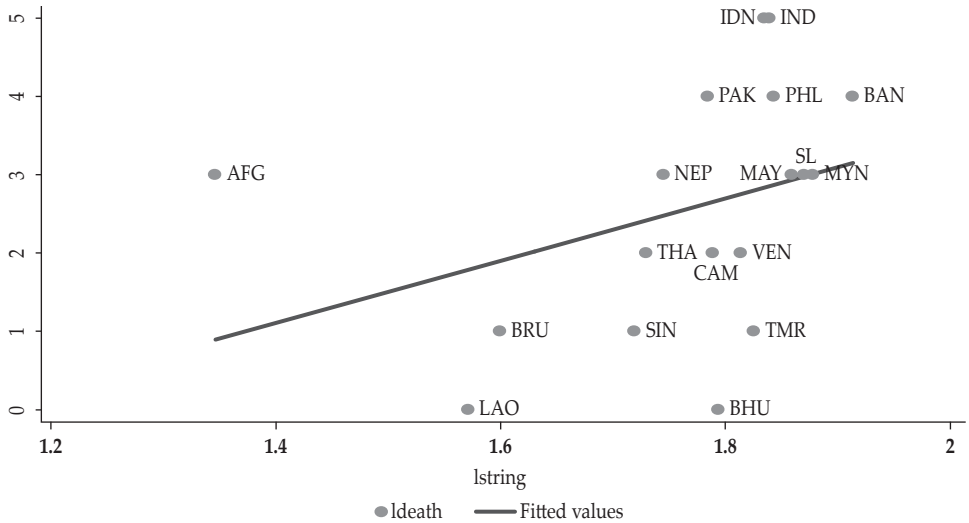


Figure 2.
Death and Stringency (Jan 1, 2021, to May 31, 2021)

This diagram presents the relation between COVID mortality and lockdown like stringent measures. As evident from red line, we notice that there exists positive correlation between lockdown and covid mortality. It shows that despite adopting stringent measures by the governments, death rate has not been brought down to a significant extent, instead it increases during the periods of high infection intensity. Number of deaths from COVID are given in pure numbers. Stringency is an index score with ranges from 0 to 100. Both variables are converted into natural logarithm.

Source: Author's own compilation.



In terms of the literature[1], we see several strands of literature pertaining to COVID from different economic, social, and institutional angles across the globe. Recent studies by Coccia (2021), Mele and Magazzino (2021) and Pedauga *et al.* (2021) have focused on the impacts of COVID-19 on economic growth and lockdown in the initial months of 2020. As of now previous studies (see our review in the ensuing section) rely more upon the analysis of impacts of COVID upon respective sectors from 2020 onwards. To the best of our knowledge, no study has systematically considered the aspects the effect of COVID-19 induced lockdown on economic growth.

Moreover, most of the earlier studies have considered mainly the impacts of COVID-19 on growth as well as various sectors due to the emergence of this pandemic. However, this study is different in terms of unraveling the impacts of COVID-19 induced factors and health infrastructures upon growth even after a year. This is relevant because it allows us to model the effects after a phase that has allowed economies to adjust to COVID-19. As a result, our study covers from 1 January 2021 to 31 May 2021. We have three objectives. First, how COVID-19 induced factors like testing, tracking of COVID cases along with loss of human life from COVID-19 impact growth. Second, we use govt measures (stringency index) to see how lockdown after a year impacted economic growth. Third, we seek to examine how the existence of lifestyle diseases and vulnerable healthcare facilities amidst the pandemic exert diminishing effects on growth.

Foreshadowing our main results, we find significant impacts of COVID-19 induced factors on economic growth of the region. Our empirical analysis shows that COVID-19 induced mortality significantly negates economic growth in the region. However, we also notice that a rise in COVID-19 cases accompanies economic growth. This effect is especially strong in the region where the lockdown is lenient but testing rates are high. Furthermore, our empirical estimates show that vaccination drive and testing are found to be insignificant and, in some models, mildly positive at 1 percent level of significance in impacting growth. This shows that vaccination drive and testing-tracking of COVID cases are not uniform across regions. For example, economies like Singapore and India are following rapid and mass scale vaccination drives, while economies like Bangladesh, Timor, Indonesia, Afghanistan, Nepal, and Bhutan are not having equal access to vaccination

[1] Several studies also show that COVID-19 induced factors have led to rising economic uncertainty over time (Iyke, 2020; Estrada *et al*., 2020; Yang and Deng, 2021; Haldar and Sethi, 2021; Baker *et al*., 2020; Bodnar *et al*., 2020). Economic uncertainty arising from COVID-19 and lockdown measures have also rattled the financial market (So *et al*, 2021; Wang and Wang, 2021; Zhang *et al*., 2020; Haldar and Sethi, 2020; Behera and Rath, 2021; Phan and Narayan, 2020; Das *et al*., 2020). Most of the studies found that the COVID-19 pandemic had a heterogeneous effect on sectoral returns like health, tourism, financial and manufacturing sectors (Sha *et al*., 2020; He *et al*., 2020; Narayan, 2021). Some studies found that the emergence of COVID-19 had a positive effect on the health industry and negative effects on the manufacturing and tourism industries (Shretta, 2020; Sha *et al*., 2020; He *et al*., 2020). Another bunch of research concluded that the COVID-19 outbreak has an adverse effect on the international trade market and global financial market, which deteriorates countries' economic growth and development (Vidya and Prabheesh, 2020; Liu *et al*., 2020; Ali *et al*., 2020; Zhang *et al*., 2020). Similarly, Yu *et al.* (2020) reported that continuous decline in labour-force participants during COVID outbreak deteriorates countries' economic growth particularly in low- and middle-income countries.

facilities. We also notice that the effect of stringency is found to be stronger in terms of its negative effect on growth, while some empirical models exhibit almost insignificant impacts of lockdown on growth.

The rest of the paper is organized as follows. Section II deals with data collected for the study and application of empirical methods. Empirical results are discussed in Section III. Finally, Section IV concludes with certain policy suggestions.

II. DATA DESCRIPTIONS AND METHODOLOGY

A. Data

The present study employed daily data covering the period January 1, 2021 to May 31, 2021. We mobilize several types of data to see, how COVID induced factors and country specific factors impact GDP in this SSEA region during the 1st half of 2021[2]. The countries considered in this study are selected based on the number of COVID-19 infections and mortality in the year 2020. According to the WHO (see their website for details), and the COVID-19 tracking database of John Hopkins University, South and South-East Asia had the 3rd highest number of COVID-19 infections and mortality rates after Europe and the USA. In fact, the region stands first in terms of COVID-19 infection rate among the developing and under developing blocs globally. Further, the region is having one of the highest COVID-19 infection rates per every 100,000 population in the year 2020. In 2021, this region has battled with the highest mortality cases despite some promising vaccination rates in few economies in the region (Zahid and Perna, 2021).[3] All the variables used in this study are collected in daily frequency form. The variables are further explained, both in terms of definitions measurements and sources, is presented in the Appendix, Table A1.

B. Methodology

We begin with the following empirical GDP function that includes variables discussed above:

$$GDP = f(CoVD, CoVC, CoVT, CoVV, String, HD, HB, HF, Diabe) \tag{1}$$

where, *CoVD, CoVC, CoVT, CoVV, String, HD, HB, HF, Diabe* indicate COVID-19 related mortality, cases, testing, vaccination, stringency measures, heart disease mortality, hospital bed facilities, handwashing facilities and diabetes cases. Equation (1) can be presented as an equation for a balanced panel data as follows:

$$GDP_{it} = \beta_1 CoVD_{it} + \beta_2 CoVC_{it} + \beta_3 CoVT_{it} + \beta_4 CoVV_{it} + \beta_5 String_{it} + \beta_6 HD_{it} + \beta_7 HB_{it} + \beta_8 HF_{it} + \beta_9 Diabe_{it} + \epsilon_{it} \tag{2}$$

[2] This study has only considered a region-specific analysis by looking into the COVID-19 mortality and positivity rates from the perspective of regions.

[3] Please See file:///C:/Users/hp/Downloads/ijerph-18-05350.pdf.

Here, t denotes time, i represents 19 SSEA economies, and ϵ_{it} represents the stochastic disturbance term of this empirical model. All the variables are converted into the natural logarithm form.

C. Presence of Interaction Variables

In addition to Equation (2), this study also seeks to explore the impacts of COVID-19 induced factors and health care factors on growth by introducing two interactive variables in the model. The model in this regard reads as follows:

$$GDP_{it} = \beta_1 CoVD_{it} + \beta_2 CoVC_{it} + \beta_3 CoVT_{it} + \beta_4 CoVV_{it} + \beta_5 String_{it} + \beta_6 (HD_{it} \times Diabe_{it}) + \beta_7 (HB_{it} \times HF_{it}) + \epsilon_{it} \quad (3)$$

In the above equation, we include two interaction terms. The interaction variable, $HD_{it} \times Diabe_{it}$, demonstrates the presence of existing co-morbid conditions like heart disease and diabetic cases. This variable will explain how the challenges of co-morbid conditions like heart disease and diabetes cases impact labor productivity and growth. The other interactive variable, $HB_{it} \times HF_{it}$ captures the presence of basic healthcare amenities like hospital bed facilities and handwash facilities. This variable explains how basic handwash facilities and hospital bed availability are essential during this pandemic time and help explain basic healthcare amenities in an economy.

III. EMPIRICAL RESULTS AND DISCUSSION

We use linear regression and quantile estimation methods to examine the effect of COVID-19 mortality and cases on economic growth. The linear model helps to find how changes in these above specified factors impact growth even in the year 2021, post-1-year of the COVID-19 pandemic. A possible problem in our empirical identification is that our main regressor could be endogenous due to reverse causality. In addition to this, we may face the potential issue of heterogeneity in growth dimensions in response to changes in the COVID-19 induced factors and lockdown. To account for these issues, we employ the quantile regression model as proposed by Koenker and Bassett (1978). We treat this as the benchmark non-linear model. The rationale for employing this model is to find out how best the heterogeneity and endogeneity issues are addressed.

Table 1 presents the correlation matrix for the variables identified above. The lockdown has a negative correlation with GDP, implying a possible negative impact on income growth. More importantly, we find a positive correlation between co-morbid conditions and COVID-19 death. We find a similar pattern between COVID-19 death and diabetes cases.

Table 1.
Correlation Matrix

This table shows the correlation among the variables along with their levels of significance. Standard errors are in parentheses. The symbols *, **, and *** imply $p<0.01$, $p<0.05$, and $p<0.1$, respectively.

	GDP	*CoVD*	*CoVC*	*CoVT*	*CoVV*	*String*	*HD*	*HB*	*HF*	*Diabe*
GDP	1.000									
CoVD	-0.300* (0.000)	1.000								
CoVC	-0.171* (0.000)	0.952* (0.000)	1.000							
CoVT	-0.061* (0.000)	0.612* (0.000)	0.674* (0.000)	1.000						
CoVV	0.019 (0.018)	0.250* (0.000)	0.310* (0.000)	0.301* (0.000)	1.000					
String	-0.074* (0.000)	0.192* (0.000)	0.184* (0.000)	0.065* (0.005)	-0.011 (0.010)	1.000				
HD	-0.684* (0.000)	0.301* (0.000)	0.102* (0.000)	-0.065* (0.005)	-0.066* (0.000)	0.106* (0.000)	1.000			
HB	0.438* (0.000)	-0.515* (0.000)	-0.486* (0.000)	-0.340* (0.000)	-0.159* (0.000)	0.431* (0.000)	-0.253* (0.000)	1.000		
HF	-0.682* (0.000)	0.165* (0.000)	0.079* (0.000)	0.121* (0.000)	0.031 (0.030)	-0.158* (0.000)	0.330* (0.000)	-0.504* (0.000)	1.000	
Diabe	0.513* (0.000)	0.162* (0.000)	0.251* (0.000)	0.276* (0.000)	0.107* (0.000)	-0.077* (0.000)	-0.193* (0.000)	0.128* (0.000)	-0.668* (0.000)	1.000

Table 2.
Factors Impacting GDP during Pandemics

This table shows the regression analysis of the effect on GDP controlled for several COVID-19 induced factors, namely vaccination, stringency, handwashing, hospital bed and co-morbid conditions in terms of heart diseases and diabetics. All variables are converted into natural log. Column I represents the regression analysis without time and country effects. Column II represents the regression analysis with only time specific heterogeneity. Column III presents the generalized least squares methods with homoscedastic panel approach. The last column (IV) shows the generalized least squares with heteroscedastic panel approach. Standard errors are reported in the parentheses under the values of coefficients. The symbols *, **, and *** imply $p<0.01$, $p<0.05$, and $p<0.1$, respectively.

GDP	**I**	**II**	**III**	**IV**
CoVD	0.082* (0.011)	0.084* (0.011)	0.080* (0.011)	0.029* (0.006)
CoVC	-0.097* (0.013)	-0.100* (0.013)	-0.092* (0.013)	-0.033* (0.007)
CoVT	-0.002*** (0.001)	-0.002 (0.001)	-0.002*** (0.001)	-0.001** (0.0006)
CoVV	0.003* (0.001)	0.003* (0.001)	0.003* (0.001)	0.001* (0.0004)
String	-0.118* (0.013)	-0.119* (0.014)	-0.114* (0.011)	-0.121* (0.004)
HD	-1.231* (0.031)	-1.235* (0.032)	-1.221* (0.041)	-1.186* (0.013)
HB	0.321* (0.035)	0.320* (0.036)	0.301* (0.039)	0.203* (0.016)
HF	-0.199* (0.009)	-0.199* (0.010)	-0.199* (0.017)	-0.241* (0.004)

Table 2.
Factors Impacting GDP during Pandemics (Continued)

GDP	I	II	III	IV
Diabe	0.557*	0.560*	0.543*	0.680*
	(0.049)	(0.060)	(0.045)	(0.017)
Constant	6.976*	6.992*	6.656*	6.696*
	(0.102)	(0.116)	(0.143)	(0.042)
Model	Regression	Regression with time effect	GLS with homoscedastic panels	GLS with heteroscedastic panels
F test/Wald test	916.92*	149.28*	8281.10*	2989.73*
No of obs	2869	2869	2869	2869

The basic linear regression results are reported in Table 2. The major rationale behind using various regression models is to see how GDP is impacted by COVID-19 induced factors in cases of the presence of time-specific heterogeneity and homoscedastic-heteroscedastic panels. Our empirical results convey that the coefficient of COVID-19 death exhibits marginal positive and significant association with the GDP growth. It states that COVID-19 related deaths have increased with growth marginally due to the lesser lockdown restrictions in the early part of 2021. Further, we see that while vaccinations aid growth the effect is marginal. Our empirical result suggests that for every 1% increase in the vaccination rate, GDP grows by 0.001% to 0.003%. Moreover, we notice that for every 1% increase in govt led stringent measure leads to a decline in GDP growth by 0.114% to 0.121% (see Columns I to IV). These estimates capture the marginal negative impact of lockdown on GDP. Next, we see the effects of heart diseases and diabetes (and health facilities) on GDP. Considering the effect of heart diseases and diabetes on GDP, we find that coefficients on heart diseases exhibit a negative and significant impact on growth, while diabetes cases show a positive and significant impact on growth. This illustrates that heart diseases result in higher loss of human capital, thus straining growth and diabetes cases grow up with the rising income and higher economic development, maybe due to the changes in lifestyle patterns. In previous estimates, we also examined the impact of health facilities on GDP. The empirical estimates show that rising hospital bed facilities in terms of curing not only COVID-19 cases but also other diseases impact growth positively.

Table 3 shows the impact of testing and deaths from COVID-19 on GDP in the presence of interaction effects. Both interaction terms have significant effects on GDP. On the one hand, HD**Diabe* positively influences GDP meaning that rising income and employment have positive impacts on GDP, thus resulting in more heart diseases and diabetes. On the other hand, *HB*HF* has a negative relationship with GDP, implying that all other variables display similar effects as in Table 2.

Table 3.
Examining the Impacts on GDP in Presence of Interaction Variables

This table shows the regression results on the effect on GDP controlled for several COVID induced factors, namely vaccination, stringency, handwashing, hospital bed and co-morbid conditions in terms of heart diseases and diabetics in presence of interaction variables. All variables are converted into natural log. Column I represents the regression analysis without time and country effects. Column II represents the regression analysis with only time-specific heterogeneity. Column III presents the generalized least squares methods with homoscedastic panel approach. Column no IV shows the generalized least squares with heteroscedastic panel approach. We have incorporated two interaction variables- for co-morbid conditions and basic health facilities. Standard errors are reported in the parentheses under the values of coefficients. The symbols *, **, and *** imply $p<0.01$, $p<0.05$, and $p<0.1$, respectively.

GDP	**I**	**II**	**III**	**IV**
CoVD	-0.419*	-0.422*	-0.419*	-0.397*
	(0.014)	(0.014)	(0.018)	(0.009)
CoVC	0.362*	0.367*	0.352*	0.334*
	(0.017)	(0.018)	(0.013)	(0.012)
CoVT	-0.001	-0.002	-0.001	0.004*
	(0.001)	(0.002)	(0.001)	(0.001)
CoVV	0.003	0.005**	0.003	0.001
	(0.002)	(0.002)	(0.002)	(0.001)
String	0.022	0.023	0.018	-0.003
	(0.016)	(0.017)	(0.012)	(0.003)
*HD*Diabe*	1.492*	1.496*	1.472*	0.923*
	(0.110)	(0.113)	(0.119)	(0.078)
*HB*HF*	-0.081*	-0.077*	-0.087*	-0.138*
	(0.028)	(0.029)	(0.022)	(0.014)
Constant	2.782*	2.790*	2.662*	3.092*
	(0.065)	(0.107)	(0.075)	(0.037)
Model	Regression	Regression with time effect	GLS with homoscedastic panels	GLS with heteroscedastic panels
F test/Wald test	169.34*	117.19*	1188.71*	1034.47*
No of obs	2869	2869	2869	2869

A. Quantile Regression Estimates

The quantile regression technique is used to find out how COVID-19 related complicacies, government measures in terms of stringency, health infrastructures and existing diseases impact growth at different quantiles. Our empirical estimates show that COVID-19 death has increased with growth at higher quantiles. Results show that every 1% increase in COVID-19 death has led to between 0.019% to 0.205% increase in growth (Table 4).

Table 4.
Examining the Impacts of COVID-19 Induced Factors on GDP at Various Quantiles

This table shows the quantile estimates for GDP controlled for several COVID induced factors and other factors considered for the analysis. Columns I to IV contain the quantile estimates for GDP from 25th to 90th All variables are converted into natural log. Standard errors are in parentheses. The symbols *, **, and *** imply $p<0.01$, $p<0.05$, and $p<0.1$, respectively.

GDP	I	II	III	IV
CoVD	-0.052*	0.019*	0.131*	0.205*
	(0.015)	(0.007)	(0.020)	(0.008)
CoVC	0.050*	-0.017*	-0.147*	-0.206*
	(0.017)	(0.008)	(0.023)	(0.009)
CoVT	-0.009*	-0.001	0.001	-0.001
	(0.002)	(0.001)	(0.001)	(0.001)
CoVV	0.001	0.001	0.001	0.005*
	(0.001)	(0.001)	(0.001)	(0.001)
String	-0.158*	-0.134*	-0.101*	-0.026*
	(0.018)	(0.009)	(0.024)	(0.010)
HD	-1.304*	-1.192*	-1.110*	-1.183*
	(0.041)	(0.020)	(0.056)	(0.023)
HB	0.452*	0.262*	0.087	-0.102*
	(0.046)	(0.023)	(0.064)	(0.026)
HF	-0.016	-0.222*	-0.353*	-0.372*
	(0.012)	(0.006)	(0.017)	(0.007)
Diabe	0.647*	0.723*	0.390*	-0.221*
	(0.064)	(0.032)	(0.088)	(0.036)
Constant	6.335*	6.189*	6.335*	6.282*
	(0.347)	(0.067)	(0.183)	(0.076)
Quantiles	25th	50th	75th	90th
Pseudo R^2	0.486	0.506	0.602	0.713

Next, we find that the coefficient of COVID-19 cases exhibits a negative and significant association with growth at the 1% level of significance. At a higher quantile 90th, we notice that every 1% increase in COVID-19 cases leads to a 0.202% decline in GDP growth. Furthermore, we find that tests and vaccination rate are statistically insignificant in terms of their effects on GDP growth. The possible reason could be the under-reporting of cases and lower vaccination rates in many economies.

Table 5.
Interaction Effects at Various Quantiles

This table presents the quantile estimates for GDP controlled for several COVID induced, basic health facilities, co-morbid and lockdown measures from 25th to 90th quantiles. Columns I to IV shows the 25th to 90th quantiles respectively in presence of interaction variables like basic health facilities and existing co-morbid conditions. All variables are converted into natural log. Standard errors are in parentheses. *, **, and *** present $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively. Source: Author's own compilation.

GDP	I	II	III	IV
CoVD	-0.188*	-0.536*	-0.615*	-0.223*
	(0.011)	(0.032)	(0.036)	(0.009)
CoVC	0.260*	0.538*	0.594*	0.047*
	(0.014)	(0.040)	(0.045)	(0.031)
CoVT	0.032*	0.004	-0.010	-0.004
	(0.002)	(0.004)	(0.007)	(0.004)
CoVV	0.004*	-0.006	-0.001	0.003*
	(0.001)	(0.005)	(0.001)	(0.000)
String	-0.267*	-0.016	0.122*	0.346*
	(0.013)	(0.014)	(0.043)	(0.002)
*HD*Diabe*	-0.472*	-0.109	0.777*	-1.457*
	(0.089)	(0.108)	(0.282)	(0.019)
*HB*HF*	0.672*	0.055	-0.174*	-1.081*
	(0.023)	(0.052)	(0.073)	(0.005)
Constant	3.299*	2.818*	2.538*	4.890*
	(0.052)	(0.149)	(0.167)	(0.011)
Quantiles	25th	50th	75th	90th
Pseudo R^2	0.277	0.157	0.281	0.466
No of obs	2869	2869	2869	2869

From Table 5, we find that COVID-19 death has impacted growth negatively at various percentiles. We also find that vaccination and testing have exhibited no significant impact on growth, which implies, possibly, an unequal distribution of vaccination and under-reporting of COVID-19 cases. Our study further demonstrates that stricter government measures reflect higher GDP at higher quantiles, while there is no such significant relation between GDP and government measures at lower quantiles. Increasing co-morbid conditions during the pandemic time has resulted in a higher public health costs and greater human capital loss, thus impacting growth at all quantiles (see Columns I to IV, Table-5).

B. Robustness Checks

To avoid the issue of endogeneity, we adopt the instrumental variable (IV) model. In the regression analyses, there exists a higher probability that the explanatory variables might be correlated with the error terms, resulting in biased estimates. Factors like government measures and healthcare facilities can also be subject to a lot of extraneous factors like inequality, political ballgame, corruption, and several invisible factors. IV estimates account for these challenges, where an instrumental variable is strongly correlated with the explanatory variable, not with stochastic disturbance terms.

Table 6.
IV Regression Estimates with GDP as Outcome Variable (by Considering Various Instruments Using Stringency, COVID-19 Cases, COVID-19 Death and COVID-19 Test)

This table presents the instrumental variable regression results for GDP controlled for variables considered for the analysis. In Column I, lockdown like measures is instrumented for three different conditions like co-morbid conditions and mortality rate. In ColumnII2, this study instruments COVID-19 cases with testing rates, vaccination and availability of hospital beds. Column III again indicates the instruments of COVID-19 mortality for co-morbid conditions and availability of hospital beds. Column IV finally instruments COVID-19 testing for cases, mortality rate and hospital bed facilities. For this IV, we model various instruments to see how GDP responds to various factors as considered for the analysis. Further, our post-estimation results are found to be robust for all analyses. All variables are converted into natural log. Standard errors are in parentheses. The symbols *, **, and *** imply $p < 0.01$, $p < 0.05$, and $p < 0.1$, respectively.

GDP	I	II	III	IV
CoVD		0.265*	-0.685*	
		(0.035)	(0.023)	
CoVC	0.152*		0.697*	
	(0.015)		(0.026)	
CoVT	0.006*		0.001	-0.031*
	(0.003)		(0.001)	(0.002)
CoVV	0.001		-0.005*	0.005*
	(0.001)		(0.002)	(0.001)
String	-1.095*	-0.022**	-0.082*	-0.024*
	(0.047)	(0.011)	(0.015)	(0.011)
HD		-1.586*		-1.238*
		(0.084)		(0.026)
HB	2.061*			
	(0.099)			
HF	-0.237*	-0.207*	-0.263*	-0.169*
	(0.013)	(0.009)	(0.010)	(0.012)
Diabe		0.773*		0.830*
		(0.059)		(0.064)
Constant	4.611*	6.215*	2.983*	6.528*
	(0.049)	(0.213)	(0.076)	(0.080)
Instruments	*Stringency = Heart Disease Diabetes Death*	*Case = Test Vaccines Hospital Bed*	*Death = Heart Disease Diabetes Hospital Bed*	*Test = Case Hospital Bed Death*
Durbin endogeneity test	573.80*	133.22*	1051.02*	169.12*
First stage *F* test	226.73*	114.54*	596.73*	406.13*
Wald chi-square	2279.33*	722.16*	3106.67*	717.63*

Table 6 reports our results from the IV models. Notice that columns I to IV report the impacts of COVID-19 induced factors upon GDP by using various instruments. Our main results are as follows. First, the stringency and GDP are negatively related, while being instrumented by heart disease, death, and diabetes (Columns I to IV, Table-6).

Table 7.
IV Regression Estimates with Interaction Variables

This table presents the instrumental variable regression models in presence of two interaction variables of co-morbid conditions and basic health facilities. In Column I, co-morbid conditions are instrumented for COVID-19 mortality. In Column II, lockdown like stringency is instrumented for COVID-19 testing rates and the COVID-19 infection cases. In last column, the vaccination rate is instrumented for co-morbid conditions and the COVID-19 mortality cases. All variables are converted into natural log. Standard errors are in parentheses. The symbols *, **, and *** imply $p < 0.01$, $p < 0.05$, and $p < 0.1$ respectively.

GDP	**I**	**II**	**III**
CoVD	-2.202* (0.555)	-0.291* (0.027)	
CoVC			-0.365* (0.053)
CoVT	0.074* (0.015)		-0.057* (0.016)
CoVV	-0.007 (0.006)	0.029* (0.005)	0.524* (0.081)
String	0.085 (0.074)	1.603* (0.240)	0.282* (0.083)
*HD*Diabe*		1.293* (0.222)	
*HB*HF*	-2.080* (0.320)	-1.408* (0.140)	-0.474* (0.121)
Constant	1.490* (0.241)	1.704* (0.322)	1.280* (0.532)
Instruments	*Heart Disease*Diabetes = Death Case*	String = Test Case	*Total Vaccination = heart disease*Diabetes Death*
Wald chi-square	148.45*	208.42*	152.79*
Durbin Endogeneity test	747.30*	151.03*	514.50*
First stage *F* test	27.44*	29.45*	21.62*

In the presence of interaction variables, we find that COVID-19 related mortality has impacted growth negatively, while interaction variables are instrumented for COVID-19 death and cases. It shows that COVID-19 related mortality along with rising co-morbid conditions impact growth negatively. Lastly, we notice that vaccination rates boost growth while being instrumented for comorbid conditions and death. It indicates that efficient and quick vaccination efforts across economies averts mortality and reduces hospitalization rates significantly in the region (See Column III, Table-7).

IV. CONCLUSION AND POLICY IMPLICATIONS

We study the impact of COVID-19 induced factors, government measures and healthcare facilities on economic growth rate. Our study shows that COVID-19 death and COVID-19 cases have impacted growth negatively. When it comes to the vaccination rate, we do not notice any significant improvement in GDP.

These finding have several policy implications. First, there is a need to boost the vaccine distribution, supply and accessibility in such a way that people in the remote are get vaccinated. Second, the availability of basic medical needs like

hospital bed, doctor consultation, and availability of medicines for all types of diseases and basic handwashing facilities are critical to reducing the negative effects of COVID-19 on economic growth.

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APPENDIX

The following tables A1 and A2 provide the detailed overview of the names of indicators/variables along with the definition, measurements and sources and samples of countries considered for the analysis. Data regarding the indicators are considered from the January 1, 2021 to May 31, 2021.

Table A1.
Definition of Indicators Used in this Study

Indicator's name	Definition, measurement, and sources of the indicators
Gross Domestic Product Percapita (GDP)	GDP is defined as the market value of all final goods and services produced inside the geographical territory in an accounting year. GDP per capita is derived by dividing total GDP values by total population. We have collected this data from our world in data database. GDP per capita is measured in terms of 2011 US$ Constant Price.
Total COVID Cases (CoVC)	COVID case is defined as the no of people getting infected by COVID in the time considered for the study.
Total COVID Deaths (CoVD)	The COVID related mortality data are extracted from Our world in data platform. COVID death is defined as the no of persons, who succumb to the COVID infection during the time period considered. Here, we carry out the extraction of daily data of COVID death of all 19 economies in the region. However, in the initial months of 2021, some economies have not reported the data, for which zero value is assigned.
Total COVID Tests (CoVT)	Total COVID tests include the people being tested for COVID infection. It includes both infected and non-infected persons being tested for COVID infection. Daily data w.r.t COVID tests are being collected for all 19 SSEA economies.
Total COVID Vaccines (CoVV)	This indicates the number of people being vaccinated against COVID-19 infection. Data frequencies for vaccination in this study are available on a daily frequency. Total COVID vaccines include both strands of people, who are fully and partially vaccinated
Cardiovascular Disease (HD)	Data regarding cardiovascular disease actually refer to the death rate from chronic heart disease. Data regarding this are extracted on a daily basis for all 19 SSEA economies. Mostly, it shows the mortality rate from the chronic disease. The reason behind putting this variable as a control variable is to see, how human capital loss from this co-morbidity impacts of growth during pandemic time.
Stringency Measure (String)	Stringency measure corroborates nine different measures in terms of strict government intervention including school closures, travel bans, workplace closures and others. This is the composite index with having the range from zero to 100. Zero score indicates no strictness. Score of 100 shows very strict government measures in terms of lockdowns. Data regarding stringency measures in this study are being fixed on a daily basis. Data on daily stringency score are from our world in data database. However, originally this index has been proposed by Hale *et al* (2021) through a study, "A Global Panel Database of Pandemic Policies".
Hospital Beds (HB)	This variable indicates the hospital bed availability for inpatients across public, private, general and specialized hospitals along with the rehabilitation centers. Data regarding this are available for the study on a daily frequency on per 1000 people basis. It is considered as one of the indicators of basic health infrastructures in terms of impacting economic growth
Hand wash Facilities (HF)	Hand washing facilities refer to the accessibility of hand wash facilities overall at public, private places including housing and hospital facilities in terms of share of population. Data w.r.t hand washing facilities are originally considered from our world in data source.
Diabetes Mellitus (Diabe)	Diabetes prevalence mostly indicates the percentage of share of total population aged between 20 and 79 suffering from both type 1 and type 2 diabetes. Data in this regard are collected on a daily frequency in terms of percentage of population.

Table A2.
Sample Countries Considered for the Study

Countries from South Asia (SA) (8 Countries)	Countries from South-East Asia (S-E Asia)	SSEA Region (South and South-East Asian Region)
India, Bangladesh, Pakistan, Sri Lanka, Nepal, Maldives, Bhutan, Afghanistan	Myanmar, Thailand, Malaysia, Singapore, Indonesia, Laos, Cambodia, Vietnam, Timor, Brunei, Philippines	Total 19 Countries in the analysis