

Factors Affecting Incidence and Fatality of Covid-19 Pandemic: A Cross-Country Analysis

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Abstract

This paper examines the factors affecting the incidence and the case fatality of Covid-19 at global level by using the cross sectional data from 79 countries. The data were collected from the websites of World Health Organization and World Bank. The data were analysed by applying the descriptive statistical methods, box plot and logistic regression. The analysis of data showed that there were wide inter-country variation in incidence and fatality of Covid-19. The regression results showed that incidence was positively associated with population density and human development index. However, fatality rate was negatively associated with population in younger age group and number of doctors. The study implies that there is a need to develop peripheral areas to decongest population and provide better access to healthcare facility to elderly people along with strengthening of healthcare workers to mitigate the impact of the pandemic.

Keywords: Covid-19, Global analysis, Incidence, Fatality, Logistic regression, Healthcare facility

Introduction

The pandemic of novel coronavirus (Covid-19) has created global health crisis and has threatened the human population in the entire world. The virus which causes a severe acute respiratory syndrome (SARS) disease in human being is considered to one of most dangerous threats to mankind as it is highly contagious and there is no specific medicine to cure from it. The Covid-19 was first discovered in a seafood market in Wuhan city of Hubei province, China in 2019. It is believed to have been transmitted to human being from animals (bat) but its zoonotic source is unknown (WHO, March 2020). In order to combat the spread of virus, China adopted the stringent measure of lockdown and quarantine of infected persons. However, it could not check the spread of virus to other countries (Yaylali, 2020). The virus spread rapidly to other countries through international air traffic (Suryawanshi, 2020). Since the global economy has a high degree of integration, the virus spread to almost all the countries of the world within a short span of time (Harilal, 2020). By the end of July, 2020, it had affected more than 200 countries as movement of

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people was not halted by many countries in a highly integrated world. The World Health Organization considered Covid-19 as the worst health crisis being faced by the human being and declared it as the global pandemic on 11 March, 2020 (Williamson *et al.*, 2020). In fact, it is the worst crisis being faced by mankind since World War-II and it can lead to instability and unrest in the world (The Economic Times, April 1, 2020). The world has been witnessing the pandemic after more than 100 years of the Great Influenza (popularly known as Spanish flu) of 1918 (Lama *et al.*, 2020). Though the infection of virus started in Asia, the worst affected countries are those in Europe and Americas. The total infected cases worldwide rose rapidly to 17.106 million as on 31st July, 2020. The virus has been highly fatal as it has killed 0.668 million people worldwide as on 31st July, 2020 (Situation Report-193, WHO). The global fatality rate of the covid-19 was 4.02 per cent. The virus is considered to be highly fatal to elderly people and those with comorbidities as most of the deceased were in the age group of above 64 years. As per the WHO report, the worst affected countries as on 31st July, 2020 are United States of America (4.388 million confirmed cases), Brazil (2.552 million cases), India (1.64 million cases), Russia (0.839 million cases) and South Africa (0.422 million cases). The elderly people are considered to be the most vulnerable population group (Daoust, 2020). The virus has been unfair to elderly people as over 90 per cent of deaths were accounted for by people of over 60 years of age with comorbidities such as cardiovascular disease, diabetes, or respiratory illness (Kluge, 2020). In addition, weaker immune system of older people makes it difficult for them to fight the virus infection.

In order to contain the spread of the virus, different countries implemented different measures and imposed lockdown at different times. The lockdown measures mainly included prohibition of large-scale gatherings, social distancing, complete close down of offices and business establishment, transport services etc. In fact, quarantine and self-isolation have become the dominant form of social life in several countries. In many countries, curfews were imposed, allowing people to access public space only for the most urgent needs (Low and Knoblauch, 2020). The measures were aimed to protect people from getting infected and break its chain of spread. Italy announced the national lockdown on 9th March, 2020, Spain on the 14th March, 2020, France on the 17th March 2020, Germany on the 22nd of March, 2020 (Yaylali, 2020). India imposed nationwide lockdown from mid night of 24th March, 2020 which continued up to 31st May, 2020. The other measures include strengthening of healthcare facilities, quarantine of infected persons, hand washing, social distancing and public awareness. These measures must have slowed down the rate of transmission, but the spread of the virus could be fully contained as the effectiveness of the measures depended on timing and their obey by the population. Further, the lockdown measures adopted to contain the virus had severe economic implications as it led to fall in consumption and obstructed supply chain processes and laying off of workers. It reduced business activities, increased unemployment and also reduced GDP. Many countries recorded negative growth of GDP. India has suffered GDP decline of 34 per cent in the first two quarters of 2020. According to International Monetary Fund, global economic growth is forecasted to be -3 per cent in 2020 (Gopinath, 2020). The

world trade in goods is projected to decline by 13 % to 32 % in 2020 (WTO, 2020). The pandemic has created economic crisis almost same magnitude of 2008-09 financial crisis (Fernandes, 2020) and caused economic hardship to poor, wage earners, migrant workers and contractual employees.

Since the cases and deaths from Covid-19 are increasing and the data show wide variation in incidence and fatality of Covid-19 across the countries, it is important to analyse the factors that affect the incidence and fatality rate of Covid-19 at global level. While some countries have recorded very high incidence of the pandemic, others have registered low incidence. Similarly, there is a wide disparity among the countries in terms of fatality of Covid-19. Further, it has been observed that there is a weak link between incidence and fatality as the countries with high incidence of the pandemic have relatively low fatality. Since, the incidence and fatality of the pandemic are increasing at the global level and most of the countries are finding it hard to tackle the menace of the pandemic, there is a need to identify the factors which are affecting the incidence and fatality of Covid-19 at the global level. There are some studies which have analysed the determinants of incidence and mortality of Covid-19. For instance, Yaylali (2020) assessed the factors affecting Covid-19 cases and death rate in German States. The study reported that sex ratio, population density and disposable income were crucial for the number of cases. The death rate was influenced by number of cases, sex ratio, disposable income, average age. Williamson *et al.* (2020) assessed the risk of severe outcomes of population from Covid-19 by creating a secure health analytical platform (OpenSAFELY). The study showed that Covid-19 related death was associated with being male, greater age, deprivation, diabetes, severe asthma. It also showed that Black and South Asian people were at higher risk as compared to white ethnicity. Jeet *et. al.* (2020) explored the role of important factors affecting incidence and mortality of Covid-19 using data from 97 countries. The study showed significant inter-country variation in incidence and mortality rates of Covid-19. The incidence was found to be associated with testing rate, elderly population, population below poverty line, UHC index and fatality rate was associated with testing rate, population density, and elderly population. Mukherji (2020) uncovered socio-economic and health/lifestyle factors that can explain the differential impact of the Covid-19 pandemic on different parts of the United States. The study developed vulnerability index for US counties and found that counties with high median income have a high incidence of the cases but reported lower deaths. International airports were found to be positively affecting the incidence. Health risks factors were found to be significant in explaining differences in mortality across counties. Countries with better health care were found to have lower deaths. But the countries with higher pollution were found to have higher deaths from the virus. Suryawanshi *et al.* (2020) examined the factors influencing Covid-19 cases and deaths by taking data from 48 districts of India. The study found positive association of Covid-19 case burden with population density and negative correlation of case fatality rate with health index, human development index, per capita expenditure on health. The study suggested for decongestion of cities and stricter

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measures in districts with international airports. Lama and Mitra (2021) examined the determinants of inter-State variation in incidence and fatality of Covid-19 in India by using the State level cross-sectional data. The ordinary least square method was applied to estimate the regression model and obtain the results.. The study showed that India had relatively low incidence of the disease. The Western region of the country was found to be worst affected by the pandemic. Among the States, incidence was the highest in Delhi and Maharashtra. But fatality was the highest in Maharashtra, Punjab and Madhya Pradesh. The results showed that incidence was positively affected by population density and international exposure and fatality was found to be negatively influenced by health care infrastructure.

The review of literatures showed that there are a lack of studies which have comprehensively analysed the factors determining the incidence and fatality rate of Covid-19 at the global level. In this background, the paper is an attempt to analyse the factors which are playing crucial role in determining incidence and fatality rate of Covid-19 at the global level. The findings of the study can serve as a useful guide for the policy makers of various countries to deal with the pandemic and take appropriate measures reorganize the institutions to reduce both incidence and fatality of the pandemic.

Data Source

The study is solely based on secondary sources of data. It is based on cross sectional data collected for 79 countries which had ten thousand and more confirmed cases of Covid-19 as on July 31, 2020. The data on confirmed cases and deaths from Covid-19 were collected from the website of World Health Organization (WHO). The data on population density, per capita income, human development index, age composition of population, international tourist arrivals, health workers, health infrastructure and healthcare expenditure were collected from the website of World Bank. The data were analysed by using the descriptive statistical methods, box plots and regression analysis.

Analytical Framework

The incidence of Covid-19 was calculated as the number of confirmed cases per million population. On the other hand, the fatality of Covid-19 was calculated as the number of deceased per 1000 confirmed cases. In order to examine the factors influencing the incidence and the fatality of Covid-19 at global level, regression analysis was applied. The incidence of Covid-19 was taken to be a function of population density, per capita income, international tourist arrivals, human development index. While fatality was taken to be a function of per capita income, age group, health workers (doctors), health infrastructure (hospital beds) and healthcare expenditure.

Since the dependent variables (incidence and fatality) are in ratios and their values range between 0 and 1, a linear regression model would not be suitable as it would give spurious results. In such a case, logistic regression model is the suitable one. Hence, logistic regression model was applied to examine the incidence of Covid-19 across the countries.

Results and Discussion

Incidence and Fatality of Covid-19 at Global Level

The analysis of incidence of Covid-19 across the countries shows that as on July 31, 2020, incidence of the pandemic was the highest in Qatar (39,003 cases per million population) followed by Bahrain, Chile, Oman and Kuwait. Table 1 presents the top ten countries in terms of cases per million population. The United States which had the highest number of confirmed cases (4.388 million cases as on July 31, 2020) and was listed at number seven in terms of incidence of the pandemic. Interestingly, China, where the pandemic started the first, recorded the lowest incidence of Covid-19 (63 per million population) among the 79 countries. It implied that China's strategy of strict lockdown and quarantine had been quite fruitful in combating the pandemic. This indicates that the governance also matters a lot in dealing with the emergency situation like pandemic.

Table 1: Top Ten Countries in terms of Incidence of Covid-19 Cases (As on 31st July 2020)

Countries	Population 2019	Confirmed cases	Incidence (cases per million population)
Qatar	2832067	110460	39003
Bahrain	1641172	40755	24833
Chile	18952038	353536	18654
Oman	4974986	79159	15911
Kuwait	4207083	66529	15814
Panama	4246439	63269	14899
United States	328239523	4388566	13370
Armenia	2957731	38550	13034
Peru	32510453	400683	12325
Brazil	211049527	2552265	12093

Source: WHO

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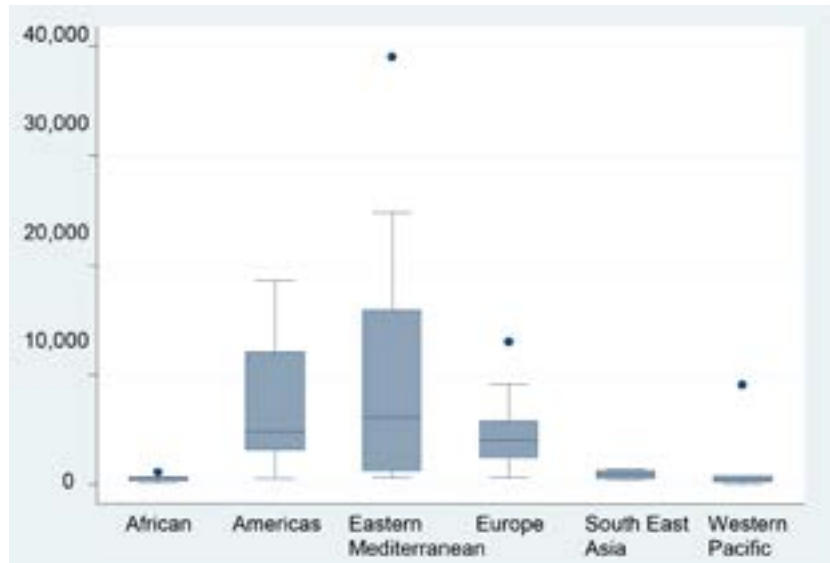
Table 2 and Figure 1 depict a great extent of variation in the incidence of Covid-19 across regions of the world. The regional analysis of the incidence of Covid-19 revealed that Eastern Mediterranean region had the highest incidence of Covid-19 with mean incidence of 9272 per million population (Table 2).

Table 2: Descriptive Statistics of Region wise Incidence of Covid-19 (As on 31st July, 2020)

Regions	Min.	Max	Mean	Std. Deviation
Eastern Medi- terranean	269	39003	9272	11734.01
Americas	602	18654	6955.06	5235.54
Europe	702	13034	4387.42	2648.17
Western Pa- cific	63	9084	1861	3549.4
African	148	8234	1312.6	2448.74
South East Asia	393	1441	929	477.09

Source: WHO

However, the region also had the highest standard deviation of incidence, which implied that there was a wide variation within the region. It was followed by Americas (with mean incidence of 6955 per million population) with standard deviation of 5235.54. Among the various regions, the incidence of Covid-19 was the lowest in South East Asia (929 cases per million population) and African region (1312.60 per million population). These regions also had the lowest standard deviation of incidence of the pandemic. It implied that relatively underdeveloped regions of the world were least affected by the pandemic. This could be attributed to poor transport and communication networks and scattered distribution of population in remote villages in the countries of these two regions.



Source: WHO

Figure 1: Region-wise Incidence of Covid-19 (Per million population)

The analysis of data on fatality of Covid-19 across the countries showed that France had the highest fatality (172.55 deceased per 1000 cases) followed by the United Kingdom, Belgium and Italy. Among the 179 countries, fatality was the lowest in Singapore (0.52 deceased per 1000 cases) Qatar (1.55 deceased per 1000 cases), Ukraine (2.42 deceased per 1000 cases and Nepal (2.66 deceased per 1000 cases). The fatality of Covid-19 in top ten countries is presented in Table 3.

Table 3: Top Ten Countries in terms of Fatality of Covid-19 (As on 31st July 2020)

Countries	Confirmed cases	Total deceased	Fatality rate (per 1000 cases)
France	174648	30136	172.55
The United Kingdom	302305	45999	152.16
Belgium	67913	9840	144.89
Italy	247158	35132	142.14
Netherlands	53963	6147	113.91
Mexico	408449	45361	111.06
Spain	285430	28443	99.65
Canada	115470	8917	77.22
Sweden	80100	5739	71.65
Ireland	26027	1763	67.74

Source: WHO

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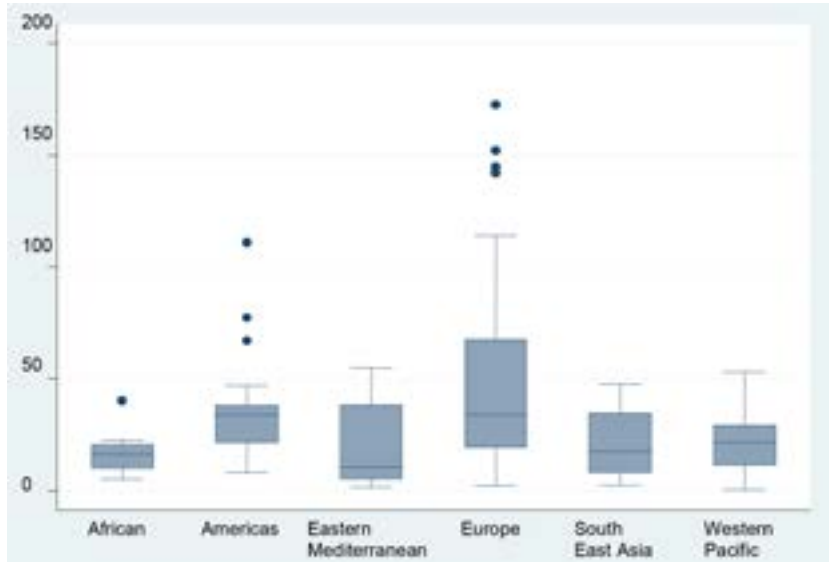
The region wise fatality of Covid-19 is presented in table 4 and figure 2¹. The table 4 shows that Europe region had the highest fatality of Covid-19 with mean of 51.09 deceased per 1000 cases. It was followed by Americas with mean fatality of 37.69 deceased per 1000 cases. The high fatality of Covid-19 in Europe and Americas, despite having superior healthcare facilities and high per capita income, could be attributed to their ageing population and comorbidities. Covid-19 was reported to be biased towards old people as most of the deceased were in the age group of 65 and above. The fatality of Covid-19 was the lowest in African (17.30 deceased per 1000 cases) and South East Asian (21.29 deceased per 1000 cases) regions. The low fatality of Covid-19 in African and South East Asia, despite having relatively inadequate healthcare facilities and low per capita income, could be attributed to large proportion of younger population who usually have better immunity, low level of pollution and organic food habit of the people. The standard deviation of fatality of Covid-19 was the highest in Europe and the lowest in African region.

Table 4: Descriptive Statistics of Region wise Fatality of Covid-19 (As on 31st July, 2020)

Regions	Min.	Max	Mean	Std. Deviation
Europe	2.42	172.55	51.09	47.33
Americas	7.92	111.06	37.69	26.19
Eastern Mediterranean	1.55	63.07	23.99	21.81
Western Pacific	0.52	53.05	22.94	17.79
South East Asia	2.66	47.57	21.29	19.19
African	4.98	40.23	17.3	10.04

¹ Includes 78 sample countries.

Source: WHO



Source: WHO

Figure 2: Region-wise Fatality of Covid-19 (Per 1000 cases)

Determinants of Incidence and Fatality of Covid-19 Pandemic

In order to examine the factors influencing incidence and fatality of Covid-19 across the countries, the incidence of Covid-19 (IOC) was defined and calculated as the ratio of confirmed cases to the total population of the country. The fatality of Covid-19 (FOC) was calculated as the ratio of deceased to the confirmed cases. The value of both the dependent variables – IOC and FOC – lies between 0 and 1. Hence, logistic specification of the model will be suitable over the simple linear regression model. Accordingly logistic specification of regression for both the dependent variables has been formulated. The baseline regression models for IOC and FOC are:

$$IOC = \frac{1}{1 + e^{-Z}} \dots \dots \dots (1)$$

Where, $Z = \beta_0 + \beta_1 PD + \beta_2 PG + \beta_3 TA + \beta_4 HDI + \beta_5 R_1 + \beta_6 R_1 + \beta_7 R_1 + \beta_8 R_1 + \beta_9 R_1 + U$ and

$$FOC = \frac{1}{1 + e^{-Z}} \dots \dots \dots (2)$$

Where, $Z = \beta_1 PG + \beta_2 AG + \beta_3 AD + \beta_4 AB + \beta_5 HE + \beta_7 R_1 + \beta_8 R_1 + \beta_9 R_1 + \beta_{10} R_1 + \beta_{11} R_1 + U$ and

Equation (1) and (2) can be linearised as:

$$L_{IOC} = \ln\left(\frac{IOC}{1-IOC}\right) = \beta_0 + \beta_1 PD + \beta_2 PG + \beta_3 TA + \beta_4 HDI + \beta_5 R_1 + \beta_6 R_1 + \beta_7 R_1 + \beta_8 R_1 + \beta_9 R_1 + U \dots \dots \dots (3)$$

And,

$$L_{FOC} = \ln\left(\frac{FOC}{1-FOC}\right) = \beta_0 + \beta_1 PG + \beta_2 AG + \beta_3 AD + \beta_4 AB + \beta_5 HE + \beta_7 R_1 + \beta_8 R_1 + \beta_9 R_1 + \beta_{10} R_1 + \beta_{11} R_1 + U \dots \dots \dots (4)$$

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As the data set was cross section in nature, Breusch-Pagan test was carried out; results confirmed the absence of the problem of heteroscedasticity with respect to both the formulations. The average and maximum values of VIF in both regression models were also found to be less than 10, and hence, multicollinearity was also not a serious issue. The details of explanatory variables with expected sign are presented in Table 5.

Table 5: Details of explanatory variables

Variable	Notation	Definition	Expected impact	
			IOC	FOC
Population density	PD	People per sq. km of land area	+	NA
Per capita GDP	PG	GDP per capita is gross domestic product divided by midyear population	+	+
Tourist arrival	TA	Arrival of international tourist per thousand	+	NA
Human development index	HDI	Value of HDI	+	NA
Age Group	AG	Percentage of population in age 15-64 years	NA	-
Availability of doctors	AD	Physicians per 1,000 people	NA	-
Availability of beds in hospital	AB	Hospital beds per 1,000 people	NA	-
Health expenditure	HE	Current health expenditure as a per cent of GDP	NA	-
Regional dummy	Five dummies have been used	R1 = 1 if Africa, 0 otherwise	+/-	+/-
		R2 = 1 if Americas, 0 otherwise		
		R3 = 1 if Eastern Mediterranean, 0 otherwise		
		R4 = 1 if Europe , 0 otherwise		
		R5 = 1 if South East Asia , 0 otherwise & Western Pacific is the reference region		

The results of the regression analysis² for the determinants of the incidence and fatality of Covid-19 are presented in Table 6.

² Based on the availability of data, 78 countries are considered for the regression analysis.

Table 6: Regression Results for Incidence and Fatality of Covid-19

Variable	Incidence			Fatality		
	Coef.	Std. Err.	P>t	Coef.	Std. Err.	P>t
Population density (PD)	0.00043***	0.00011	0.00000	-	-	-
Per capita GDP (PG)	0.00000	0.00001	0.95200	-0.000001	0.000006	0.879000
Tourist arrival (TA)	-0.00005	0.00020	0.79200	-	-	-
Human development index (HDI)	3.23968**	1.33794	0.01800	-	-	-
Age group (AG)	-	-	-	-0.0781***	0.026055	0.004000
Availability of doctors (AD)	-	-	-	-0.110308	0.114073	0.337000
Availability of beds in hospital (AB)	-	-	-	0.013407	0.046131	0.772000
Health expenditure (HE)	-	-	-	0.156084***	0.055021	0.006000
R1	1.43699***	0.53764	0.00900	-0.551781	0.680146	0.420000
R2	3.34565***	0.42811	0.00000	0.593790	0.548183	0.283000
R3	3.20671***	0.43870	0.00000	0.474948	0.518571	0.363000
R4	2.65616***	0.38867	0.00000	0.807524*	0.477005	0.095000
R5	1.67262***	0.57929	0.00500	0.330340	0.705742	0.641000
Constant	-11.05644***	1.11785	0.00000	0.089755	1.914044	0.963000
F			14.55(9,68)***			4.73 (10, 69)***
R-squared			0.6582			0.4138
Adjusted R-squared			0.613			0.3263

Source: WHO & World Bank

Note: ***, ** & * represents significance at 1 per cent, 5 per cent and 10 per cent respectively

In () degrees of freedom

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The results of regression for incidence of Covid-19 indicated that population density (PD) had a positive impact on incidence of Covid-19 cases and the coefficient of this variable was significant at 1 per cent level of significance. It shows that the incidence of Covid-19 was significantly more in the countries with higher density of population. Hence, there is a need to strictly implementation of social distancing measures in the countries with high population density. The variable human development index (HDI) was also found to be positively affecting the incidence of Covid-19 cases which coefficient was significant at 5 per cent level of significance. It indicates that the incidence of Covid-19 is high among the countries with higher development. This could be due to the fact that most of the countries which are suffering the worst from Covid-19 are the developed countries of Europe and Americas. Since the Covid-19 is highly contagious, greater mobility of people due to higher level of development might have increased the incidence of Covid-19 cases in those countries. The region wise analysis of incidence of Covid-19 showed that Eastern Mediterranean, Americas and Europe had the higher incidence as compared to Western Pacific, African and Asian regions. The variable like per capita GDP and tourist arrivals (TA) were not found to be significant factors. All the regional dummies were also found to be significant which confirmed the significant variation in the incidence of Covid-19 across regions.

Regarding the factors determining fatality of Covid-19, it was found that the coefficient of variable age group was negative and significant at 1 per cent level of significance. It implies that countries which are having higher proportion of population in age group of 15-64 years have lower fatality rate of Covid-19. This was expected as the Covid-19 was reported to be biased and fatal to older people. The coefficient of variable health expenditure (HE) was positive and significant at 1 per cent level of significance which was opposed to our expectation. This could be due to the fact that most of the countries with higher per capita health expenditure are the countries of Europe and Americas. These are also the countries witnessing higher fatality of Covid-19. The variables doctors (per 1000 population), hospital beds (per 1000 population) were also not significant revealing the absence of any impact on the fatality of Covid-19. The coefficient of regional dummy R_4 (Europe region) was found to be positive and significant. It implies that as compared to other regions, fatality was significantly higher in Europe region.

Conclusion

The entire world has been deeply affected by Covid-19 pandemic. The pandemic has paralysed the normal life across the globe and has created one of the worst global health crisis. It has infected millions of people and has been highly fatal to elderly people and to those with comorbidities. The incidence of Covid-19 was found to vary widely across the countries. The incidence was higher in Eastern Mediterranean, Americas and Europe. The fatality of Covid-19 was found to be higher in Europe and Americas. Both incidence and fatality of Covid-19 were lower in African and South East Asian regions. This implies that

relatively less developed parts of the world are least affected by the pandemic. This could be due to inadequate availability of transport infrastructure as studies have showed that incidence of the pandemic was positively affected by international airports and number of travelers. The relatively low fatality rate of Covid-19 in countries of African and South Asian regions can be attributed to organic food habits of the people and relatively lower level of air pollution. The regression analysis which was carried out to identify the factors affecting incidence and fatality of Covid-19 at global level showed that incidence was positively affected by population density and human development index (HDI) indicating that densely populated countries and countries with high HDI are likely to suffer higher incidence of the pandemic. On the other hand, case fatality of Covid-19 was negatively affected by proportion of population in the age group of 15-64 years and number of doctors per thousand population. However, it was positively affected by health expenditure as percentage of gross domestic product. Further, fatality was found to be positively associated with Europe region which indicated that this region had the higher fatality as compared to other regions. The findings of the study showed that there is a need for strict implementation of social distancing measures in areas with high concentration of population. At the same time, measures must be adopted to develop peripheral areas to decongest population in urban centres. It indicates that there is a need to adopt measures to reduce population growth as a long term strategy. The study shows that to reduce case fatality rate, elderly people should be given proper attention and access to better healthcare facilities. Further, health infrastructure, particularly, health workers must be strengthened to minimise the fatality rate.

Declaration of Conflict of Interest

The author(s) declared no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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