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A Study on the Global Scenario of COVID-19 Related Case Fatality Rate, Recovery Rate and Prevalence Rate and Its Implications for India—A Record Based Retrospective Cohort Study

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Abstract

Importance: Corona virus disease 2019 (COVID-19) caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the pandemic claiming millions of lives since the first outbreak was reported in Wuhan, China during December 2019. It is thus important to make cross-country comparison of the relevant rates and understand the socio-demographic risk factors. **Methods:** This is a record based retrospective cohort study. Table 1 was extracted from https://www.worldometers.info/coronavirus/ and from the Corona virus resource center (Table 2, Figures 1-3), Johns Hopkins University. Data for Table 1 includes all countries which reported >1000 cases and Table 2 includes 20 countries reporting the largest number of deaths. The estimation of CFR, RR and PR of the infection, and disease pattern across geographical clusters in the world is presented. **Results:** From Table 1, we could infer that as on 4th May 2020, COVID-19 has rapidly spread world-wide with total infections of 3,566,423 and mortality of 248,291. The maximum morbidity is in USA with 1,188,122 cases and 68,598 deaths (CFR 5.77%, RR 15% and PR 16.51%), while Spain is at the second position with 247,122 cases and 25,264 deaths (CFR 13.71%, RR 38.75%, PR 9.78%). Table 2 depicts the scenario as on 8th October 2020, where-in the highest number of confirmed cases occurred in US followed by India and Brazil (cases per million population: 23,080, 5007 & 23,872 respectively). For deaths per million population: US recorded 647, while India and Brazil recorded 77 and 708 respectively. **Conclusion:** Studying the distribution of relevant rates across different geographical clusters plays a major role for measuring the disease burden, which in-turn enables implementation of appropriate public healthcare measures.

Keywords

Case Fatality Rate, COVID-19, Prevalence Rate, Recovery Rate, Statistical Analysis

1. Introduction

The present study concentrates on the current outbreak of the novel Corona virus disease 2019 (COVID-19) which originated in Wuhan, Hubei province, China, first reported during December 2019. The contagious severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) has subsequently spread to European and American countries, causing widespread morbidity and mortality. On 30th January 2020, WHO defined the outbreak as a Public health emergency of International concern [1]. WHO's Situation Report—106 released on 5th May 20 on the novel Corona virus (2019-nCoV), states that globally there are 3,517,345 confirmed cases and 243,401 deaths [2]. WHO declared COVID-19 as a pandemic on March 11, 2020 [3], and advised Governments to take urgent and aggressive action. So far, the pandemic has affected 210 countries across 6 continents [4].

The prevalence and incidence of a disease are among the most fundamental measures in epidemiology, which measure the burden of disease in a given population represented as the number of people affected [5]. Therefore, it is essential to know the counts of the number of people affected with a disease to plan for the health care needs.

2019-nCoV is spread via cough or respiratory droplets, contact with body fluids and from contaminated surfaces. Non-symptomatic individuals can also effectively transmit the infection, and face masks cannot limit the virus tropism to non-respiratory mucosal surfaces. Patients in remission can also transmit the virus. The mortality rate of novel corona virus could be between that of seasonal influenza and SARS (Severe acute respiratory syndrome).

R_0 or the basic reproduction number is the average number of cases in a susceptible population generated by one infected individual [6]. Human-to-human transmission of 2019-nCoV is confirmed with R_0 of 1.4 - 2.5. Incubation period is estimated between 2 to 10 days. Reports suggest that elderly and those with co-morbidities are at greatest risk of death. Acute respiratory distress syndrome is the likely cause of death. The biological cytokine storm in an individual is linked with the severity of the disease. There is no specific vaccine or anti-viral drug against this virus. Neither has the natural animal host been identified nor the presence of any intermediate host. However, 2019-nCoV is found to closely resemble the virus found in Chinese horseshoe bats [7].

Human pathogenic corona viruses (SARS-CoV) and SARS-CoV-2 bind to the epithelial cells of various organs through the protein receptor: angiotensin-converting enzyme 2 (ACE2). This is expressed on the target cells of the lung, intestine, kidney and blood vessels. However, in patients with hypertension and diabetes who are most often treated with ACE inhibitors or angiotensin II type-1 receptor blockers (ARBs), the expression of ACE2 is increased substantially. Even ibuprofen and thiazolidinediones can increase ACE2. This in-turn would facilitate COVID-19 infection. Increased expression of ACE2 is also found among the elderly age group. Among the Asian population, ACE2 polymorphisms have been linked with hypertension, diabetes mellitus and stroke. This could genetically predispose such individuals for SARS-CoV-2 infection. Hypertensives need to be substituted with calcium channel blockers which do not increase the expression of ACE2. Suitable alternative treatment needs to be initiated for diabetics and stroke patients [8].

The high prevalence of COVID-19 infection among asian men when compared with women, and patients of other ethnicities could be due to their predominant expression of ACE2. This sex predisposition might be associated with much higher smoking rate in men than in women [9]. Other literature does not support the evidence for an association between smoking and prevalence or severity of COVID-19.

This study focused on computing the Case Fatality Rate (CFR), Recovery Rate (RR) and Prevalence Rate (PR) of COVID-19 infections across the geographical clusters. Prevalence is used to compare disease burden across locations or time periods, and provides the foundation for public policy which enables implementing appropriate healthcare measures.

Objectives: 1) To analyze the computed case fatality rate (CFR), recovery rate (RR) and prevalence rate (PR) of the infection for countries,

2) To draw inference of our findings for the population of India.

2. Methods

The data for the initial part of the study was extracted from https://www.worldometers.info/coronavirus/ owned by the data company "Dadax" [10]. This database includes 85 countries reporting >1000 COVID-19 cases as on 4th May 2020 [10].

This record based retrospective cohort study includes all countries which reported >1000 cases during the current COVID-19 pandemic. Measures such as total number of cases, total reported deaths, total recovered patients and total number of patients tested were extracted from the database and tabulated. Period prevalence provides a better measure since it includes all cases during a particular time period [11]. In our study, period prevalence has been computed from December 2019 till 4th May 2020. To calculate PR, CFR and RR in **Table 1**, we have categorised the study based on the six continents *viz.*, Asia, Africa, Europe, North America, Oceania and South America.

Data as of October 8th 20, for the second part of the study (**Table 2**, **Figures 1-3**) were derived from the Corona virus resource center, Johns Hopkins University of Medicine, USA [12].

The prevalence, mortality and recovery rate of individual countries were thus calculated:

As per the Dictionary of Epidemiology [13],

1) Mortality rate: estimate of the portion of a population that dies during a specified period,

2) Case fatality rate (CFR): the proportion of cases of a specified condition that are fatal within a specified time,

3) Prevalence rate: the proportion of the population that has health condition at a point in time,

4) Cumulative death rate [14]: the proportion of a group that dies over a specified time,

5) Recovery rate (RR) [15] from COVID-19: (No. of recovered cases/No. of closed cases) × 100,

6) Case fatality ratio (%): Number of recorded deaths/Number of cases × 100.

The denominator for computing the PR in our study is essentially not the population at risk, but the total number of individuals tested for 2019-nCoV. The numerator includes individuals who tested positive for this virus. Hence, ideally it is "Prevalence proportion".

3. Results

Data from **Table 1** depicts the initial stages of the epidemic, where-in the high CFR (>10%) in certain countries (Italy, Spain, France, UK, Belgium) could be due to poor social distancing measures along with co-morbid conditions among patients. The high CFR in Italy could also be explained by the fact that 23% of their population were >65 years old [16], and COVID-19 is more lethal in older patients. The denominator for computing CFR used in Italy and Spain is quantitatively less, as it includes screened individuals requiring hospital admission only [17]. In countries such as South Korea and Switzerland, massive screening measures have been implemented and the reported case fatality rate is <1% [18]. The denominator in this scenario may include many mild or asymptomatic cases. Differences in the definition of a COVID-19 related death could also explain the variation in CFR among different countries.

In **Table 1**, PR is not computed for China as information regarding the number of tests is not available. This could contribute to the high RR of 93.83% in China and could also be due to a milder strain of infection, and an equipped healthcare system enabling positive patients to effectively recover from the infection.

Table 2 sourced from daily Dashboard of the Center for Systems Science and Engineering (CSSE) [12], Johns Hopkins University of Medicine, USA, depicts the current morbidity of the COVID-19 pandemic for 30 countries reporting the highest case counts. The COVID-19 daily dashboard, confirmed cases: 36,234,307, deaths: 1,057,043 (2.9%) and recoveries: 25,276,017 (69.8%).

During an epidemic, cases could be defined as total cases (every confirmed case) or closed cases (recovered or died). In the initial phase of an epidemic,

Table 1. Shows the continent-wise distribution of COVID-19 CFR, RR and PR.

Country	Total Cases	Total Deaths	Total Recovered	Total Tests	Case Fatality Rate (%)	Recovery Rate (%)	Prevalence Rate (%)
Asia							
Turkey	126,045	3397	63,151	1,135,367	2.70	50.10	11.10
Iran	97,424	6203	78,422	496,273	6.37	80.50	19.63
China	82,880	4633	77,766	N/A	5.59	93.83	N/A
India	**42,533**	**1391**	**11,775**	**1,107,233**	**3.27**	**27.68**	**3.84**
Saudi Arabia	27,011	184	4134	352,555	0.68	15.30	7.66
Pakistan	20,186	462	5590	212,511	2.29	27.69	9.50
Singapore	18,205	18	1408	143,919	0.10	7.73	12.65
Israel	16,208	232	9749	397,046	1.43	60.15	4.08
Qatar	15,551	12	1664	104,435	0.08	10.70	14.89
Japan	14,877	487	3981	183,251	3.27	26.76	8.12
UAE	14,163	126	2763	1,200,000	0.89	19.51	1.18
Indonesia	11,192	845	1876	112,965	7.55	16.76	9.91
S. Korea	10,801	252	9217	633,921	2.33	85.33	1.70
Bangladesh	9455	177	1063	81,434	1.87	11.24	11.61
Philippines	9223	607	1214	120,736	6.58	13.16	7.64
Malaysia	6298	105	4413	195,833	1.67	70.07	3.22
Kuwait	4983	38	1776	196,397	0.76	35.64	2.54
Kazakhstan	3920	27	1084	296,136	0.69	27.65	1.32
Bahrain	3383	8	1718	144,155	0.24	50.78	2.35
Thailand	2969	54	2739	178,083	1.82	92.25	1.67
Afghanistan	2704	85	345	11,068	3.14	12.76	24.43
Oman	2568	12	750	40,459	0.47	29.21	6.35
Armenia	2386	35	1035	24,177	1.47	43.38	9.87
Iraq	2296	97	1490	103,262	4.22	64.90	2.22
Uzbekistan	2149	10	1319	242,536	0.47	61.38	0.89
Azerbaijan	1932	25	1441	157,932	1.29	74.59	1.22
Sum:	**551,342**	**19,522**	**291,883**	**Average:**	**2.28**	**44.21**	**6.93**
Europe							
Spain	247,122	25,264	148,558	1,932,455	10.22	60.12	12.79
Italy	210,717	28,884	81,654	2,153,772	13.71	38.75	9.78
UK	186,599	28,446	N/A	1,206,405	15.24	N/A	15.47
France	168,693	24,895	50,784	1,100,228	14.76	30.10	15.33
Germany	165,664	6866	130,600	2,547,052	4.14	78.83	6.50

Continued

Russia	134,687	1280	16,639	4,100,000	0.95	12.35	3.29
Belgium	49,906	7844	12,309	423,971	15.72	24.66	11.77
Netherlands	40,571	5056	N/A	225,899	12.46	N/A	17.96
Switzerland	29,905	1762	24,500	280,220	5.89	81.93	10.67
Portugal	25,282	1043	1689	426,836	4.13	6.68	5.92
Sweden	22,317	2679	1005	119,500	12.00	4.50	18.68
Ireland	21,506	1303	13,386	169,377	6.06	62.24	12.70
Belarus	16,705	99	3196	204,239	0.59	19.13	8.18
Austria	15,597	598	13,228	274,355	3.83	84.81	5.68
Poland	13,693	678	3945	375,948	4.95	28.81	3.64
Romania	13,163	790	4869	195,508	6.00	36.99	6.73
Ukraine	11,913	288	1548	129,723	2.42	12.99	9.18
Denmark	9523	484	6987	233,799	5.08	73.37	4.07
Serbia	9464	193	1551	101,911	2.04	16.39	9.29
Norway	7847	211	32	172,586	2.69	0.41	4.55
Czechia	7781	248	3587	257,678	3.19	46.10	3.02
Finland	5254	230	3000	102,300	4.38	57.10	5.14
Moldova	4121	125	1382	20,447	3.03	33.54	20.15
Luxembourg	3824	96	3379	48,118	2.51	88.36	7.95
Hungary	2998	340	629	82,010	11.34	20.98	3.66
Greece	2626	144	1374	79,332	5.48	52.32	3.31
Croatia	2096	79	1489	38,084	3.77	71.04	5.50
Bosnia and Herzegovina	1857	77	825	33,928	4.15	44.43	5.47
Iceland	1799	10	1717	50,406	0.56	95.44	3.57
Estonia	1700	55	259	55,206	3.24	15.24	3.08
Bulgaria	1618	73	308	47,636	4.51	19.04	3.40
North Macedonia	1511	84	945	17,246	5.56	62.54	8.76
Slovenia	1439	96	241	55,520	6.67	16.75	2.59
Lithuania	1410	46	635	141,678	3.26	45.04	1.00
Slovakia	1408	24	619	96,220	1.70	43.96	1.46
Sum:	**1,442,316**	**140,390**	**536,869**	**Average:**	**5.89**	**41.97**	**7.72**
North America							
USA	1,188,122	68,598	178,263	7,196,740	5.77	15.00	16.51
Canada	59,474	3682	24,908	897,444	6.19	41.88	6.63
Mexico	23,471	2154	13,447	93,791	9.18	57.29	25.02
Dominican Republic	7954	333	1606	30,102	4.19	20.19	26.42
Panama	7197	200	641	34,459	2.78	8.91	20.89

Continued

Cuba	1649	67	827	53,545	4.06	50.15	3.08
Honduras	1055	82	118	4810	7.77	11.18	21.93
Sum:	**1,288,922**	**75,116**	**219,810**	**Average:**	**5.71**	**29.23**	**17.21**
South America							
Brazil	101,826	7051	42,991	339,552	6.92	42.22	29.99
Peru	45,928	1286	13,550	375,096	2.80	29.50	12.24
Ecuador	29,538	1564	3300	78,659	5.29	11.17	37.55
Chile	19,663	260	10,041	206,218	1.32	51.07	9.54
Colombia	7668	340	1722	114,602	4.43	22.46	6.69
Argentina	4783	246	1354	65,813	5.14	28.31	7.27
Bolivia	1594	76	166	7651	4.77	10.41	20.83
Sum:	**211,000**	**10,823**	**73,124**	**Average:**	**4.38**	**27.88**	**17.73**
Africa							
South Africa	6783	131	2549	245,747	1.93	37.58	2.76
Algeria	4474	463	1936	6500	10.35	43.27	68.83
Egypt	6465	429	1562	90,000	6.64	24.16	7.18
Morocco	4903	174	1438	42,112	3.55	29.33	11.64
Cameroon	2077	64	953	N/A	3.08	45.88	N/A
Djibouti	1112	2	686	13,856	0.18	61.69	8.03
Ivory Coast	1398	17	653	10,778	1.22	46.71	12.97
Sum:	**27,212**	**1280**	**9777**	**Average:**	**3.85**	**41.23**	**18.57**
Oceania							
Australia	6822	95	5849	633,107	1.39	85.74	1.08
New Zealand	1487	20	1276	152,696	1.34	85.81	0.97
Sum:	**8309**	**115**	**7125**	**Average:**	**1.37**	**85.77**	**1.03**

N/A: indicates data not available.

Table 2. List of 30 Countries with high case counts as of 8th October 20.

Country	Total confirmed cases	Total deaths	Total recovered	Confirmed cases per million population	Deaths per million population
US	7,554,434	211,905	2,999,895	23,080	647
India	6,835,655	105,526	5,827,704	5007	77
Brazil	5,000,694	148,228	4,457,172	23,872	708
Russia	1,253,603	21,939	998,197	8605	151
Colombia	877,684	27,180	773,973	17,676	547
Argentina	840,915	22,226	670,725	18,898	500
Spain	835,901	32,562	150,376	17,890	697

Continued

Peru	835,662	33,009	723,606	26,048	1029
Mexico	799,188	82,726	679,693	6334	656
France	693,603	32,463	102,061	10,354	485
South Africa	685,155	17,248	618,127	11,858	298
United Kingdom	546,959	42,605	2435	8227	641
Iran	488,236	27,888	399,300	5919	338
Chile	474,440	13,090	447,053	25,331	699
Iraq	394,566	9683	323,815	10,183	250
Bangladesh	374,592	5460	288,316	2312	34
Saudi Arabia	338,132	4972	323,769	9983	147
Italy	333,940	36,061	235,303	5526	597
Philippines	331,869	6069	274,318	3040	56
Turkey	329,138	8609	288,954	3999	105
Indonesia	320,564	11,580	244,060	1188	43
Pakistan	316,934	6544	302,375	1492	31
Germany	312,956	9583	269,771	3772	116
Israel	283,532	1846	220,046	31,533	205
Ukraine	251,243	4807	112,365	5514	106
Canada	175,610	9594	148,105	4739	259
Netherlands	161,287	6587	4607	9341	382
Romania	145,700	5247	113,112	7420	267
Ecuador	143,531	11,743	120,511	8402	687
Morocco	140,024	2439	118,142	3887	68

Reference: https://coronavirus.jhu.edu/map.html. Source: Johns Hopkins University CSSE.

since the number of closed cases is relatively small, the CFR thus calculated is an over estimate. By contrast, when CFR is calculated for total cases it becomes an underestimate (as the numerator is underestimated) [14]. There is a time-lag associated with diagnosing and reporting cases. CFR calculated per total cases is least affected by the reporting biases. Although CFR per total cases underestimates the figure in the initial phase of outbreak, it remains the best tool to express the fatality of the disease [14].

Figure 1 [12] shows the number of deaths per 100 confirmed cases (observed case-fatality ratio). Countries at the top of this figure have the most number of deaths proportional to their COVID-19 cases, not necessarily the most deaths overall. Differences in mortality numbers can be caused due to the difference in number of people tested, demography of the population (age distribution), characteristics of the healthcare system and other unknown factors.

Figure 2 [12] plots the daily confirmed new cases (7-day moving average). Flattening the curve means the number of new COVID-19 cases has reduced when compared with the count of previous day. The flattened curve in the plot will show a downward trend in the number of daily new cases. This analysis using a 7-day moving average prevents skewing of data, which could happen as a result of change in reporting methods. This is calculated by averaging the values of that day, two days before and the next two days.

Figure 3 [12] charts the day-to-day outbreak in 20 Countries (with highest

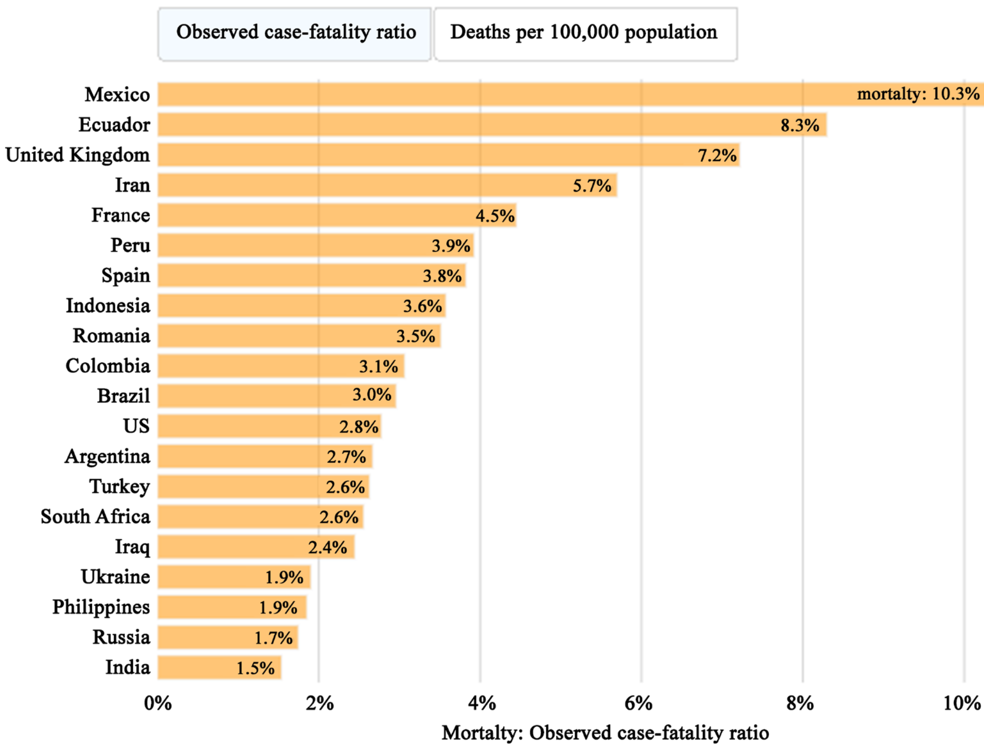

Figure 1. Case Fatality Rate of COVID-19 in infected countries. (X axis: Case fatality ratio; Y axis: Country).

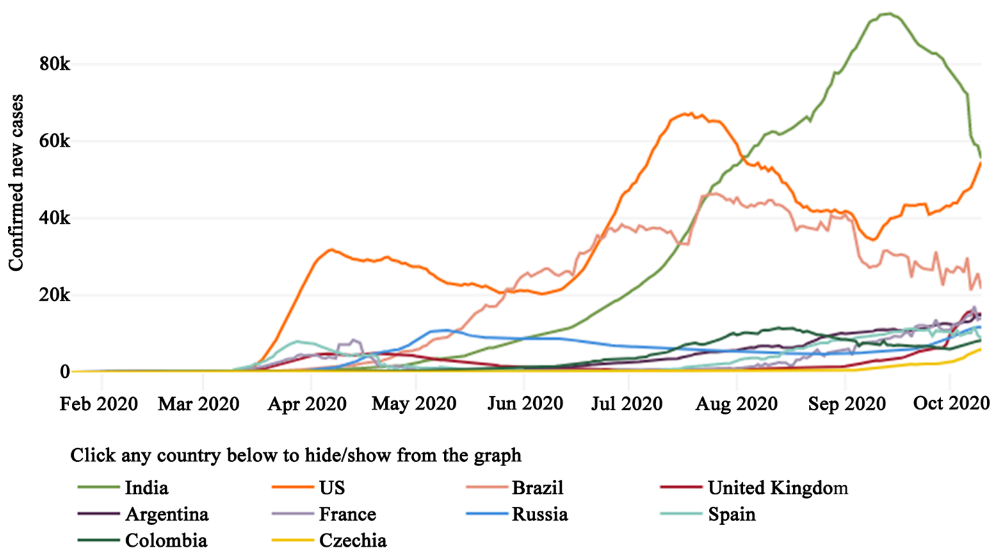

Figure 2. Outbreak evolution for the current 10 most affected countries. (X axis: Month and Year; Y axis: Confirmed new cases in thousands).

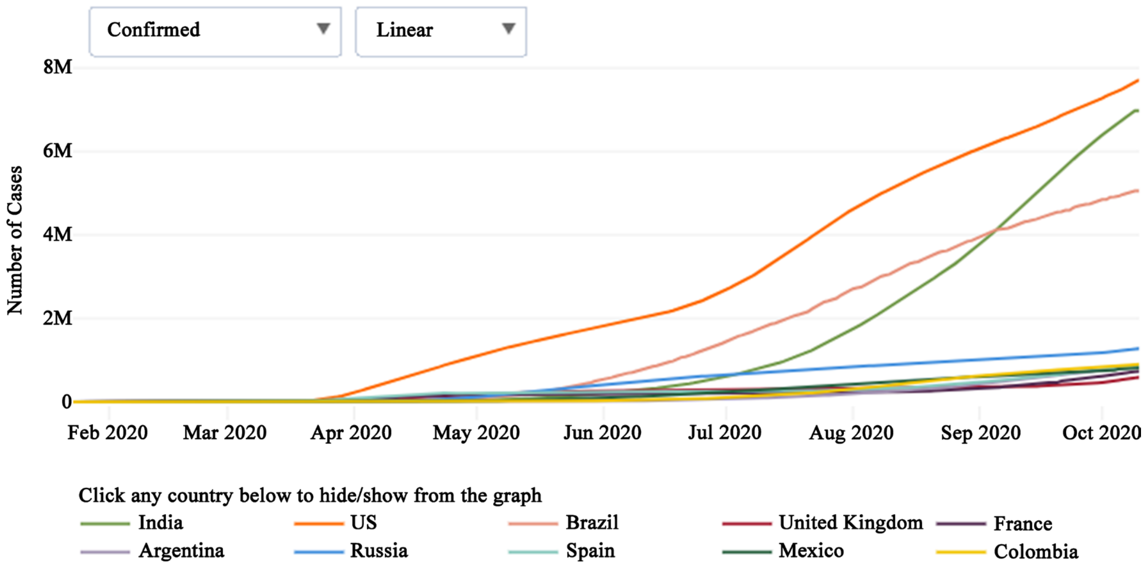

Figure 3. Day-to-day outbreak in 20 Countries. (X axis: Month and Year; Y axis: Number of cases in millions).

absolute daily number of deaths), for visualizing the succession of events. The trend lines follow the total number of cases over time, on a country-by-country basis and illustrate how the pandemic is expanding. This includes the number of people who have ever tested positive for corona virus in a given Country. An upward bend in the curve indicates either a time of explosive growth of cases or a change in how cases are defined or counted.

In India, we have low test positivity rate (ratio of positives to total persons tested: TPR), low testing rate (ratio of total persons tested to the total population) and low prevalence (number of COVID-19 cases per million population at risk). Low testing does not account for the low prevalence of COVID-19. As on 24^{th} Apr 20, the TPR was 4.76, which means for every 21 persons tested in India, 1 person was found infected. The epidemic has past its peak in South Korea, where the TPR has stabilized to ~2%. To reach this situation, South Korea has tested 1.2% of its population. Until the cut-off date of 24^{th} Apr 20, 525,667 persons were tested in India which needs further testing of 15.71 million persons (to reach 1.2% mark) [19].

4. Discussion

Using country-level data, our study aims to analyze the PR, CFR & RR of different countries during the on-going COVID-19 pandemic. Such comparisons enable assessing the indicators of disease characteristics and recognizing the performance of health systems. Undetected cases or delayed case reporting can significantly impact these indicators, which mandates for limiting their denominator from open cases to closed cases (outcome is recovered/discharged or dead).

CFR although has a significant role in epidemiology, tends to provide crude information with regard to the current COVID-19 epidemic. It is a measure of disease severity and is often used for predicting disease course or outcome [20].

While estimating the CFR from country-level data, we need to factor the delay between reporting of COVID-19 cases and related deaths from the country. This could be compounded by the under-reporting of deaths.

Screening and diagnosis is by RT-PCR and rapid antigen test (RAT) in India, with antibody testing used for epidemiological purpose only. While computing the test positivity rate, some Countries report the percentage of people who test positive, some report the percentage of tests that come back positive and some report the percentage of tests that were performed on first-time recipients who indeed had COVID-19 (people over people, people over tests or tests over tests).

During the peak of the epidemic in South Korea during March 2020, 10,000 tests were conducted daily by simultaneously involving the private sector. These tests identified the infected individuals, who were later isolated and treated to break the chain of transmission. Along with other control measures, the epidemic situation was brought under control. Death rate in South Korea is <1% when compared to 3.7% globally. In contrast, it is reported that the US Government failed to provide testing facility at multiple points. It initially did not accept the WHO approved tests, the nucleic acid testing kits sent to individual States did not test the specific genes, and the private sector was not involved in testing for infection. Death rate in US is 2.4%, with many undiagnosed infections due to shortage of test kits. Before discharging a confirmed COVID-19 patient, hospital authorities need to wait for two negative results (24 hours apart). However, after the first week of infection, the nasopharyngeal swab may not provide adequate yield as the virus would have travelled lower along the respiratory tract. Testing criteria during the initial stages of the pandemic include those with respiratory symptoms and pertinent travel history, and close contacts of lab confirmed cases. Such criteria should accommodate the clinical discretion of healthcare Providers for testing their patients. Surrogate testing of samples from other influenza like illness for COVID-19, will enable understanding the unknown chains of transmission [21].

The exotic nature of this disease explains the reason for a few countries not reporting any cases of COVID-19, as no infected individual might have entered them. True prevalence of COVID-19 cases in India remains unknown, as we lack in extensive testing for SARS-CoV-2. To study the spread of COVID-19 initially, ICMR has tested for SARS-CoV-2 in samples from patients admitted with severe acute respiratory illness (SARI) in multiple centres across India during the period 15th Feb 20 to 2nd Apr 20 [22]. Such sentinel surveillance activities could yield false negatives. Hence the nucleic acid amplification test: real time reverse transcriptase polymerase chain reaction (RT-PCR) should be supplemented with antibody testing. In India, E (envelope protein) and RdRp (RNA dependent RNA polymerase) genes of SARS-CoV-2 were tested in the RT-PCR technique.

During the initial stages, UK paid the price for strategizing herd immunity as a policy and exposing the population. Dr. Peravali [23] clarifies that herd immunity could be used as a strategy only if the mortality rate is in the range of 1% -

2%. Dr. Muliyil [23] clarifies that 60% of the population should have developed immunity against the virus for the onset of herd immunity. Presently on account of unknown modes of transmission, the focus should shift from not just isolating infected individuals but towards protecting the vulnerable individuals as well as responsible self-quarantine of contacts. Contact tracing involves locating all contacts of a positive patient, listing them and regularly following up on the specific symptoms and testing for infection. It can prevent transmission in both containment (breaking all chains of transmission) and mitigation (flatten the curve) phases of the pandemic response.

In COVID-19, the main cause of death is recognized to be respiratory failure and subsequent hypoxaemia. This needs to be supported by invasive mechanical ventilation in an intensive care unit (ICU), until the lungs recover. In case of further deterioration, ECMO (Extracorporeal membrane oxygenation) systems can control gas exchanges for weeks. This can be complicated with other causes such as shock and multiple organ failure. The biochemical profile of non-survivors shows low lymphocyte counts, high C-reactive protein and D-dimer levels, which may not succinctly provide the actual process of death. Due to the stretched health care systems, it becomes difficult to interpret the cause of death as specifically due to COVID-19 or as a result of treatment limitations. In addition, we need to factor the age-group of many hospitalized patients who are elderly and frail where-in COVID-19 infection could be an epiphenomenon [17]. Many patients in middle-care units will end up receiving non-invasive ventilation and vasopressor support, for whom the chances of survival might be assessed as low. Apart from the viral infection, we need to assess the patient's underlying condition while determining the cause of death. Lack of resources such as medical facilities, beds, personnel or equipment could compound the situation.

The preparedness plan for tackling COVID-19 as evidenced from UK [3], comprises of four phases: containment, delay, mitigation and research. Containment (prevention) comprises of hand washing, detection, isolation, care of infected people, contact tracing and screening of contacts. Delay includes social distancing measures such as school closure, cancellation of gatherings and avoiding non-essential use of public transport. Mitigation (control) for established infection was implemented in China, Italy, Iran, and South Korea during April-May 20, to enable optimum patient care, maintenance of essential hospital services and provision of community support for infected individuals [3]. Such mitigation plans should be tailored to the local demographics, as was evident in Italy which shows a high rate of severe or fatal cases due to the older population in its affected regions [3].

The National lockdown in India from 25th March 20 till 31st May 20 will enable reducing the rate of COVID-19 transmission. In countries such as Italy, Spain, USA (especially New York) social distancing was not maintained during the initial stages of epidemic which lead to the spread of the disease in an expeditious manner. During the early stages of infection in the first fortnight of March 20, the Indian Government screened incoming travellers for symptoms of fever at airports and seaports. It advised quarantine at Government facilities for those in-bound from COVID-19 epicenters (China, Italy, South Korea, Iran, Japan) and home quarantine for others. However, the advisory should have insisted quarantine at state run facility for passengers in-bound from new hotspots as well.

R_t, the real-time effective reproductive number depicts the number of people a COVID-19 patient can infect on average at a given time "*t*". This is an effective version of the basic R_0, which is the virus actual transmission rate at "*t*". The Institute of Mathematical Sciences at Chennai [24], estimates that R_t had declined to 1.55 during the second week of April 20 indicating a slight flattening of the curve. Post-relaxation of the lockdown in India from 1st June 20, there is a risk of R_t increasing or the doubling rate of infection decreasing. Overdispersion means that a minority of infected individuals are responsible for an unexpectedly high percentage of transmission, depending on the pattern of social contact. Simulation models need to account for the heterogeneity of the Indian population including the urban-rural disparity, requirement of the healthcare personnel, PPE kits for them, availability of medical infrastructure including ventilators.

High income countries like US, Italy and France have struggled to contain this epidemic, and other countries like Singapore, South Korea are finding it hard to mitigate the initial gains in containment. This reflects the highly contagious nature of the SARS CoV-2 virus. Communities need to actively participate in social distancing measures for atleast one year, before which we can relax on the engagement. Civic responsibility is important during the protracted nature of the response. Over the course of one year by which time a vaccine will be hopefully developed, the target for doubling time (doubling of the total number of cases) should be 45 days and for R_t it is <1.12. The ideal R_0 to target is <1, which is an indicator of stoppage of transmission. The Kerala model of reverse isolation post-lock down, which focus on containing elderly and those with co-morbidities will buy us more time [25].

As on the third week of October 20, US is reporting a second wave of the pandemic. Dr.Nuzzo J. from John's Hopkins University opines that the wave is a description of the visible peak in the number of cases or deaths. It is difficult to count the number of waves until the pandemic is over. The COVID-19 pandemic may not pan out like the 1918 influenza pandemic which had three peaks in deaths. More than the virus, the contribution to the rise and fall of the epidemic depends on the behaviour of the community. Since incidence is driven by inaction, targeted public health measures need to be implemented to stop the transmission of corona virus. This includes testing, case isolation, contact tracing and infection prevention practices like physical distance and masks.

It is imperative to ensure healthcare workers are provided protective gear (N95 masks, goggles, protective gowns) similar for Group A infections such as

Cholera and Plague [26]. Survival rate of COVID-19 patients on ventilator care is low, varying from 14% to 34% [27].

5. Conclusions

Contact tracing is an important tool to break the chain of transmission of infectious disease. While addressing the current epidemic in India, we need to build a pool of trained contract tracers as part of the Integrated Disease surveillance system. Such activities supported by good quality, accessible testing will play a critical role in preventing the present and second wave of the COVID-19 epidemic. Training such tracers is more practical when compared with providers being trained in intensive care. For sick cases, the ventilator facilities and its functionalities are located in the urban areas, which is a detriment for continued response efforts. The crucial performance indicators in the Indian context include the role of tests (screening vs diagnosis), daily capacity for testing and turn-around time for lab results.

Scoring of Prevalence and CFR along with RR will highlight the high risk areas and enable the development of point-of-care tools. When comparing the COVID-19 CFR and mortality rates between different countries and regions, we need to ensure transparency in the reporting policies of laboratory tests, clarity of the denominator measure used to calculate CFR, and appropriate retrieval of demographics such as age, sex and clinical co-morbid status of affected patients.

For improving the chances of survival following an infection, it is vital to access medical care at an early stage. Unique strategies need to be employed for high-risk groups such as elderly and those with co-morbidities such as hypertension, diabetes and cancer. Public health communication about the epidemic needs to be coherent and scientific. Travel restrictions imposed by ~100 countries [28] during the period April-May 20 (2 months) need to consider the implications for trade, supply chains for food and resources including medical equipment.

Key Points

Question: Estimating the COVID-19 case fatality rate (CFR), recovery rate (RR) and prevalence rate (PR) of the infection across countries.

Findings: This record based retrospective cohort study was conducted to compute the COVID-19 morbidity and case fatality rates across countries. Although variations exist in computing the case fatality rate across countries, it remains the best tool to express the fatality of the disease.

Meaning: Measures such as PR, RR and CFR will highlight the high risk areas, and enable the development of point-of-care tools.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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