SHORT ARTICLE

COVID 19 Dawn from Wuhan: "The Number Game"

Harinder Singh[1], Sumit Chawla[2], Bharti Chawla[3]

[1]Professor & HoD, Department of Community Medicine, Pt. Jawahar Lal Nehru Government Medical College and Hospital, Chamba, Himachal Pradesh; [2]Associate Professor, Department of Community Medicine, Pt. Jawahar Lal Nehru Government Medical College and Hospital, Chamba, Himachal Pradesh; [3]Assistant Professor, Department of Community Medicine, Pt. Jawahar Lal Nehru Government Medical College and Hospital, Chamba, Himachal Pradesh

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Corresponding Author

Dr Sumit Chawla; Associate Professor, Department of Community Medicine, Pt. Jawahar Lal Nehru Government Medical College and Hospital, Chamba, Himachal Pradesh - 176310
E Mail ID: drschawla86@gmail.com

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Abstract

On 31st December 2019, China informed local WHO office of "cases of pneumonia of unknown etiology detected in Wuhan. As of 6th May 2020, there are nearly 3.6 million cases of corona virus infection and approximately 0.25 million deaths worldwide. The real-time data regarding the actual number of cases, as it originates from the epicenter is the key to the estimation of the case fatality rate, hospitalization rates, expected timeline of arrival of contagion, and other epidemiological data. The novel virus has no available literature pertaining to its epidemiological parameters, on which experts can base their estimates and hence the challenge in planning for epidemic management. Bolstering this challenge are the reports alleging under-reporting by Chinese authorities. Alleged toned down numbers could have led to erroneously low estimates contributing to inadequate public health response globally. We conducted a simulation on epidemiological model of COVID-19 to find out expected time off arrival of infections and mortality in different countries and compared this to actual data.

Keywords

COVID-19; Computer Simulation; Pandemics (As per MSeH)

Introduction

In December 2019 an epidemic of acute respiratory tract infection of unknown etiology broke out in Wuhan, China and on 31st December 2019 local WHO office was informed of the same. The outbreak was declared a Public Health Emergency of International Concern on 30th January 2020 by WHO(1).

As of 6th May 2020, there are nearly 3.6 million cases of corona virus infection and approximately 0.25 million deaths worldwide(2). The real-time data on actual number of cases, as it originates from epicenter is the key to the estimation of parameters such as the case fatality rate, hospitalization rates, expected timeline of arrival of contagion, and other disease-related epidemiological data. Bolstering this challenge are the reports alleging gross under-reporting by Chinese authorities as to the morbidity, mortality and timeline of the affected population at epicenter, the Wuhan in China. The alleged toned down numbers lead to erroneously low estimates of the affected number of persons by other Nations and that could have contributed to inadequate public health response globally.

Aims & Objectives

1. To find out expected time off arrival of infections in different countries
2. To find out mortality in different countries.
3. To compare the projections on time of arrival of infection and mortality to actual data.

Material & Methods

We, the authors from Community Medicine, Pt. JLNGMCH, Chamba, H.P., India planned to delve deeper on the issue of under-reporting by making projections using epidemiological modeling and computer simulations to make quantitative estimate of epidemic along-with the timelines. To make simulations in silico-environment we base it on epidemiological SIR model. It allows us to describe the number of people in compartments (susceptible, infected and removed/recovered/deceased) with ordinary differential equation, where β is a parameter controlling how much the disease can be transmitted through exposure and γ is a parameter expressing how much the people get removed/recovered/deceased/ in a specific period. The density dependence assumption often appears not to hold, an alternative "frequency dependent" formulation of the SIR model(3) is used as follows and is depicted in [Table -1].

As per the Report of the WHO-China Joint Mission on Coronavirus Disease 2019(1), we have used value of R_o = 2.5 and assumed once the people recover, they get immunity and are no longer susceptible again to the virus . Additionally, we assume the incubation and latent periods coincide and that, there is no pre-symptomatic infectious period which is likely not an accurate assumption, given reports of pre-symptomatic transmission, but unfortunately no data is available on the length of the latent period itself. For majority of patients the median time from onset of symptoms to clinical recovery for mild cases is approximately 2 weeks(1) therefore we assume the mean infectious time to be 2 weeks (14 days). Hence value of γ i.e. inverse of mean infectious time is .07. S, I, and R compartments in the epidemiological model are connected by transitions that define how individuals may pass from one state to another (e.g., from susceptible to infected); while the associated parameters determine the likelihood that such transitions take place.

The WHO China joint report(1) mentions the number of cases of Pneumonia of unknown origin as reported on 31st December to be 44. Using the value of β, we can calculate that to have 44 successful transitions to infective compartment there ought to have been 251 infected persons coming in contact with susceptible ones. Also amongst 95% of such effective transitions, the earliest ought to have occurred two times the incubation period i.e. 28 days back i.e. around 3rd December 2019. We used this information to simulate the spread of COVID-19 from the epicenter of the outbreak at Wuhan in China.

We have not taken into account any lock –down or social distancing measures, for the reasons

1) that since the start of pandemic countries have applied the mentioned interventions quite late and also the different countries have defined lockdowns by different grades
2) By resorting to different interventions we are only trying to lower the peak of epidemic curve but the area under the curve i.e. total affected persons would remain the same. Flattening the curve would reduce the number of affected individuals reporting to health facilities on peak days without altering cumulative number of affected individuals, though the period of epidemic would be stretched for a little longer duration in time.

Software: We used The Global Epidemic and Mobility (GLEAMviz) computational tool, publicly available software to explore realistic epidemic spreading scenarios at the global scale. The GLEAMviz computational framework is based on a meta-population approach in which the population of the world is spatially structured into geo-localized patches/cells or subpopulations (e.g., cities) where individuals mix. The GLEAMviz framework integrates three data layers while giving simulations:

- An individual-based stochastic mathematical model of the infection dynamics, (SIR model in the instant case).
- Real-world data on the mobility of this population (Air and road travel)
- Real-world data on the global population

Satellite and census sources are used to calculate the population density in each of these cells, which are then clustered into subpopulations centered on their nearest transportation hub. Generally, an infectious disease is transmitted among new population clusters when people commute to work or school or travel longer distances on national and international flights. Stochastic simulations were made to generate the statistical output of potential epidemic evolutions and analytics for quantities such as newly generated cases, seeding events, number of new infections per day, and time of arrival of the infection. It is important to note that the forecast ensemble and the statistical quantities depend on the key parameters of COVID-19 and the initial condition, the date, and the place of Wuhan outbreak. In publicly available GLEAMviz software that we have used, only 20 runs of simulations are possible. [Figure 1]

To provide understanding and intelligence on the unfolding of the pandemic, this stochastic forecast output was aggregated and explored.

Results

Actual reported deaths, time of arrival of infection and simulated data on the same parameters are as reported in [Table 1] in respect of different countries.[Figure 2]

Discussion

We observed that the actual arrival of infection in countries(2) is earlier than the date given as per simulation and preceding by 4 to 48 days. Such a scenario does explain the increased mortality than was expected. The early unexpected arrival of the infection caught the emergency public health authorities unawares and relatively underprepared for the challenge. Similar projections might have also been obtained by public health authorities of other countries and the early arrival of infection caught them also unawares and raised mortality. Compare the lives saved (98 & 99%) in South Korea and Taiwan respectively where infection arrived by 20 & 4 days earlier, with US and Spain where lives saved are in negative (-472% & -2764%) i.e. more lives are lost as given by projections and infection arrived 37 and 33 days earlier than projection.

Case fatality rates of COVID-19(5) is taken as 4·03% and is used by us for calculation of estimated mortality. In Europe and North America, there are more number of cases and mortality than the projections as given by the simulation, possible reason for this in our opinion could be under-reporting of the no. of cases from Wuhan, the epicenter of this pandemic. Compare this to Asian region countries wherein actual mortality and cases are lesser than projections, i.e. there are gains or protection of 68% to 99.9% lives. The arrival of the infection in Asian countries like S. Korea, Taiwan, and Japan is also earlier as compared to projections made though relatively to a small extent when compared to western countries. These countries are also geographically close to China from where the outbreak started and for this reason, these countries were supposed to be affected with more force of infection. But still, these Asian countries have managed to keep their numbers down, credit to the strict lockdown measures, social distancing and use of masks and other preventive steps that helped in saving health and lives of their people as compared to western countries.

Possible reasons for their lesser affected numbers could be:

1) Asian countries' proximity to China may have helped in raising the alarm when the disease was in a more controllable phase.
2) These countries do have some built-in advantages, such as a culture where handshakes and hugs are less common than in western countries.
3) Previous experience with SARS, a coronavirus outbreak in 2003, has taught these Asian countries how to act quickly and effectively.
4) These countries enacted early travel restrictions, large-scale testing, contact tracing for confirmed cases, and aggressive quarantine rules.
5) Additionally, the MERS coronavirus outbreak in 201(4) exposed the problems that a lack of test kits will cause. Western countries haven't had this experience with SARS and MERS, which has hampered the effectiveness of their responses.

A team of researchers from Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) an autonomous institute under the Department of Science &Technology (DST), Government of India along with a collaborator from IISc Bengaluru have developed a heuristic predictive model for COVID-19 that provides short-term predictions about the evolution of the disease and they have given projections of 38220 deaths and 535,000 cases by mid-May 2020(5). Our simulations give the projected deaths in India at 17933 and cases as (2)44,989 by mid May 2020.

Ortiz JL(6) predicts USA will reach 100,000 deaths in the latter part of May 2020. That's the case for the model produced by the Los Alamos National Laboratory, which features detailed state-by-state information that includes one-week and six-week forecasts as well as situational updates. Youyang Gu, a data scientist whose model is one of seven listed by the CDC website, concurs with the late-May estimate for reaching six figures. Gu's COVID-19 Projections, which relies on data from Johns Hopkins to forecast future deaths through a combination of artificial intelligence and a classic infectious-disease model, factors in the expected loosening of stay-at-home orders. Our simulations give projections for USA to cross 6 figures (deaths) on 22nd May 2020.

Role of the environment: Heat or humidity might have a modifying effect on the virus, as in cold weather, droplets that carry the strain stay stable for longer, so it is spreads much more in colder nations.

Country response: Highlighting the success of the ongoing lockdown, Sh. Narender Modi (Hon. PM, India) said(7), "Lockdown has yielded positive results, the country has managed to save thousands of lives in the past 1.5 months." Agreement for a nation-wide lockdown with success demonstrates collective leadership government and society at large. Strong leadership and political commitment are responsible for substantial lives saved (68%) in India as per our projected data but preserving these gains would be a challenge. Lockdowns do have to be supplemented with other measures like testing, contact tracing, improving resources at hospitals, capacity building of health workers and an exit strategy for lockdowns as otherwise it would have bearing on community participation, economy of country, mental and social health of communities and thus promoting public fatigue.

In the end we would like to close by saying that India is on track to limit the spread and mortality while USA and European countries seem right as per our simulations to suggest both numbers and timelines from Wuhan in China are widely understated. But lesson to be learnt from Taiwan, S. Korea and Japan is that, despite being geographically close, their exemplary actions have throttled the spread of virus in their countries keeping them virtually untouched by the pandemic. Last but none least our calculations are based on assumptions of various values/parameters regarding the novel corona virus, these values might keep changing with arrival of more data and research on this new virus.

Conclusion

Simulations done in the study concluded that countries where date of arrival of infections preceded the projections, suffered more as compared to the countries in which infection arrived later or around projected timelines.

Recommendation

Such simulations with correct and timely input of data can fairly estimate not only the time of arrival of infections in different parts of the world but also the expected mortality, which are quite useful in planning and management of such pandemics.

Limitation of the study

We used the free of cost version of the software which allows only 20 runs, but if purchased the software allows hundreds of runs, this improves the accuracy of projections even further.

Relevance of the study

Study demonstrates that with already available tools we can fairly make projections for a novel virus pandemic thus has the potential to immensely help in management of pandemics.

Authors Contribution

All authors have contributed equally.

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Tables

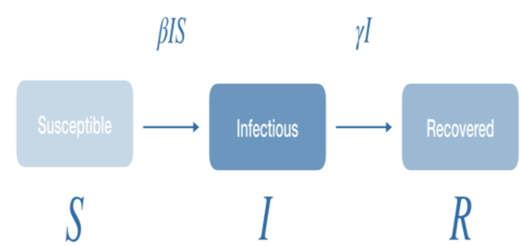
TABLE 1 ACTUAL DATA AND SIMULATED DATA (FOR APRIL-MAY, 2020) AS COMPUTED BY GLEAMVIZ SOFTWARE. (DEPICTED IN FIGURE 1)

S.No.	Country	Deaths 29th Apr 2020 (simulation)	Actual deaths (worldmeter) as on 29th Apr 2020	Deaths prevented till date as on 29th Apr 2020	Percent Deaths prevented on projections	Projected Cumulative Cases as on 15th May 2020 (simulation)	Projected Cumulative deaths as on 15th May 2020 (simulation)	Simulated date of arrival of infection	Actual date of arrival of infection	Precedence in days of arrival of infection
1	India	3221.22	1008	2213.22	68.71	444989	17933.06	18-Mar	30-Jan	48
2	US	10355.49	59266	-48910.51	-472.31	1346880	54279.26	26-Feb	20-Jan	37
3	Italy	1606.96	27359	-25752.04	-1602.53	224620	9052.19	03-Mar	31-Jan	32
4	Spain	831.55	23822	-22990.45	-2764.77	119890	4831.57	04-Mar	31-Jan	33
5	France	3109.75	23660	-20550.25	-660.83	391559	15779.83	22-Feb	24-Jan	29
6	UK	3426.31	21678	-18251.69	-532.69	433440	17467.63	19-Feb	31-Jan	19
7	Canada	1940.2	2859	-918.8	-47.36	251702	10143.59	23-Feb	27-Jan	27
8	China	4132554.4	4633	4127921.4	99.89	251203900	10123517	??	31-Dec	??
9	Taiwan	34457.47	6	34451.47	99.98	1435000	57830.5	25-Jan	21-Jan	4
10	South Korea	19859.84	246	19613.84	98.76	3444000	138793.2	09-Feb	20-Jan	20
11	Japan	20861.38	394	20467.38	98.11	2584069	104137.98	11-Feb	30-Jan	12

Figures

FIGURE 1 GLEAMVIZ SOFTWARE WITH AIR CONNECTIVITY AND EPICENTER OF COVID 19 AT WUHAN, CHINA

FIGURE 2 SIR MODEL USED BY THE AUTHORS



$dS/dt = -\beta SI/N$

$dI/dt = \beta SI/N - \gamma I$

$dR/dt = \gamma I$

also $S+I+R = N$ (remain constant)

$R_o = 2.5$

Also[3] $R_o = \beta/\gamma$

$\beta = R_o \gamma = 0.175$