Quantitative Analysis of Medical Collapse based on COVID-19 Lethality

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Abstract

Global lethality of COVID-19, calculated as the ratio of total infected cases and total deaths, increases from 4.69% in mid-March to 9.07% in mid-April, almost two times as large within one month.

Usually in epidemiology, lethality is regarded as pathogen-specific constant value and in most case this holds generally. However, COVID-19 is new corona virus and antibody therapy is not yet established (Apr. 2020). At least one more year is expected to establish vaccine, and to spread it globally. In such condition, clinical lethality has much relation to local medical care in quality and quantity. Lethality could be interpreted as an indicator of regional medical collapse and medical reestablishment. In advanced countries, medical collapse is discussed in relation to the number of surplus hospital beds or respirators. However, in regard to further spread of pandemic to developing countries and post-conflict areas, we should define different phenomenological parameter to evaluate the degree of regional medical collapse quantitatively.

The author defined "lethal velocity" from daily difference ratio of cases and that of deaths. Using this lethal velocity, we analyze pandemic in different countries and regions. Further correlation function analysis between pandemic and social, economic and medical disparity are in preparation.

Key words: COVID-19, pandemic, medical collapse, lethality, disparity

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1 Introduction:

Global COVID-19 lethality rapidly increases.

Lethality of pathogen is regarded as constant value. Usually, case fatality of pandemic is evaluated according to the intrinsic toxicity of the microbe or virus

However, from clinical point of view, lethality can float from value to value, after the difference in medical care, social condition, economic disparity and other background.

Fig. 1 shows global clinical lethality of COVID-19 pandemic from February to April 2020. Though the confidential level of the original data is uncertain, it clearly shows quasi-linear outline and lethality is obtained as gradient of the graph.

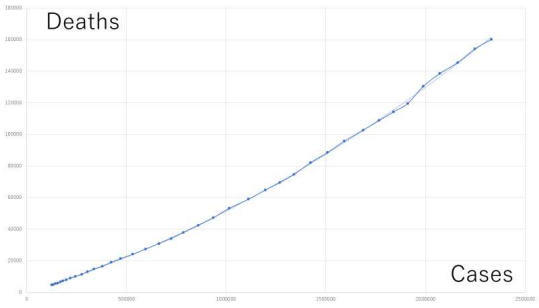

Fig.1 Global Lethality of COVID-19 ("X-plot")

In this article we call this kind of data plot "X-plot". Through ordinal regression analysis we can get mean gradient of the plot 0,0682. i.e. the mean global lethality of COVID-19 pandemic COULD be regarded 6.82%.

Now let us observe the plot more carefully. The gradient of the line shows slight change, increase in steepness. Through sectional regression analysis we obtain 4.69% (mid-March), 5.23%(late March), 7.40%(early April) and 9.07% (mid-April) lethality respectively. Fig.2 clearly shows monotonic increasing tendency of global clinical lethality.

Fig.2 Increasing global lethality

Through a simple linear prediction, we obtain more than 20% lethality in June 2020

Fig.3 Linear prediction of lethality

As we have little information in accuracy of the original data, we should not draw conclusion shortly. However, even such most simple analysis shows critical risks of the COVID-19 pandemic 2020.

Now we would like to regard lethality not constant, bat clinical valuable, or function of global / local medical or and other background and analyze various cases in more delicate manner.

2 Lethal velocity:

Daily ratio of deaths to cases

To get detailed time-dependent characteristics of the COVID-19 pandemic, let us plot daily cases to daily deaths. As the gradient of the trajectory shows a "speed of death", we call the steepness of this diagram "lethal velocity" and analyze temporal changes of the global damage caused by the pandemic.

Fig. 4 shows changes in global "lethal velocity" from March to April 2020. Here again, the gradient of the slope is steepening; During mid-March the lethal velocity, or differential lethality is round 6.45% where in early April it increases to 16% and in mid-April 19%. Monotonical increase of lethal velocity is observed. In this article we call this type of diagram "Y-plot".

The global cases-deaths data is calculated as simple summation of each country and those data from countries base on different statistics. The sum must contain certain amount of error. Still it could hold general global tendency and the increase of the lethality can reflect global exhaustion of medical care caused by the sudden pandemic without critical solution.

3 Mean lethal velocity and path analysis

Fig.5 shows Italian data of daily cases and daily deaths caused by COVID-19 [2].

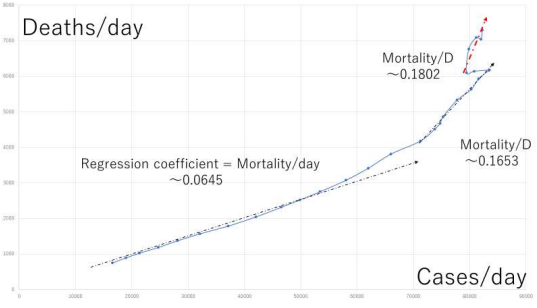

Fig.4 Global "Lethal velocity" of COVID-19 ("Y-plot")

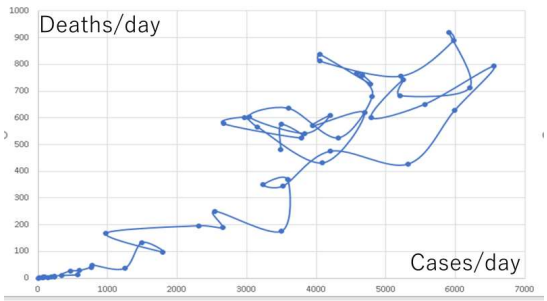

Fig.5 Path of daily lethal velocity Japan, Mar.- Apr. 2020

High volatility of the changes of cases and deaths make the path of the diagram complicated. Thus, we would like to extract fundamental characteristics of the trajectory.

Mean life time of COVID-19 is regarded as 8 days. So, let us take average values $< V_n >$ of 9 days both for the values V_n of the cases and deaths.

$$< V_n > = \frac{1}{9} \sum_{k=n-4}^{n+4} V_k$$

From the view point of signal processing, this average means “low-pass filtering” and high frequency components would vanish; rapid changes of daily cases and deaths are leveled and fundamental feature of the trajectory would make its appearance.

Fig. 6 shows “mean lethal velocity” observed in Italy from 20 Mar. to 10 Apr.

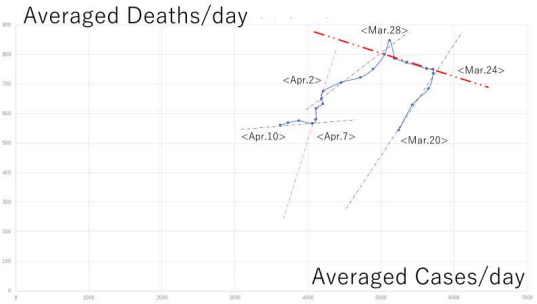

Fig.6 Path of mean lethal velocity
Italy, Mar.- Apr. 2020

With filtering calculation, the path clearly shows five different period of lethality.

During the first period, from 20 Mar. to 24, lethal velocity shows stable gradient, going up to the right. However, it suddenly turns to the left with counterclockwise manner.

During the second period, from 24th to 28th Mar. though the cases decrease in number, deaths increase monotonically with constant steepness.

Then, from 28th Mar, to 2nd Apr. the regression line goes down to the left. From 2nd to 7th Apr. the regression line steepens. In this case, counterclockwise rotation, this steepness means rapid decrease of death.

However, after 7th Apr. the gradient of regression line flattens again and little decrease of lethal velocity is observed.

With averaging operation, or low-pass filtering, mid-term behavior of the lethal velocity could be clarified.

Though they have little steadfast correlation to medical exhaustion / medical collapse, combined correlation function analysis would reveal basic characteristics of local pandemic and medical care. In this Italian case the counterclockwise rotation matches to the medical collapse of the country and the recovering process of the medical care.

We can make similar analysis to those data of various countries in different period of epidemics and pandemics.

4 Results and discussion

Fig. 7 shows behavior of lethal velocity in Spain. The path of the diagram shows similar feature to the case of Italy: counterclockwise rotation. In both countries serious medical collapse had occurred and the trajectory of lethal velocity matches to the tragic phenomenon.

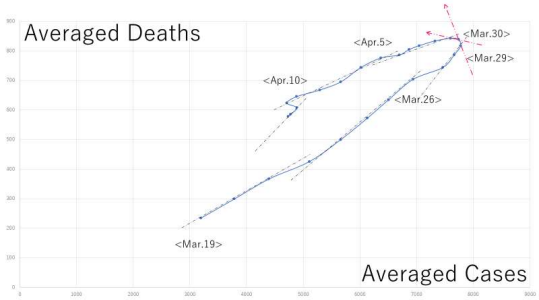

Fig.7 Path of mean lethal velocity
Spain, Mar.- Apr. 2020

The French trajectory of lethal velocity shown in Fig.8 meanders and even makes loop behavior in early April, but generally shows counterclockwise rotation.

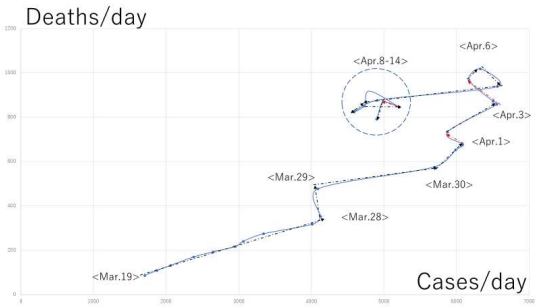

Fig.8 Path of mean lethal velocity
France, Mar.- Apr. 2020

In contrast to those trajectories, lethal velocity curve of UK at the same period shows remarkable contrast to that of Latin countries (Fig.9).

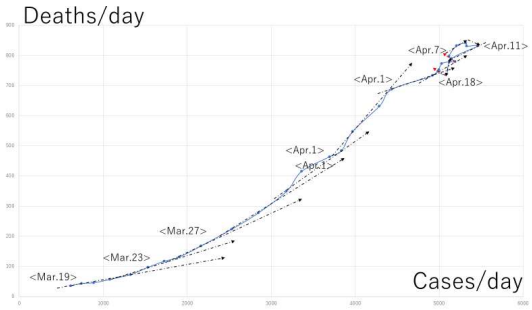

Fig.9 Path of mean lethal velocity
UK, Mar.- Apr. 2020

Although those gradients of lethal velocity monotonically increase up to the end of March, the path never turns counterclockwise and medical care in UK well endured the hardship. In early and mid-April, the path shows small triggers to the counterclockwise rotation, but barely endures from the reverse rotation.

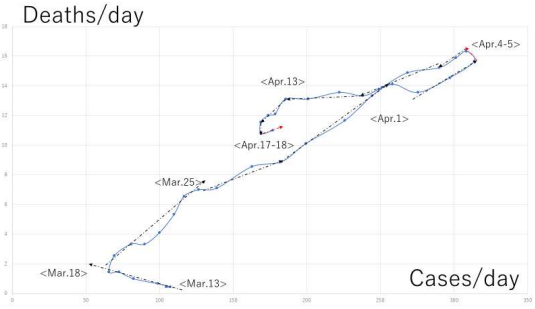

Fig.10 Path of mean lethal velocity
Denmark, Mar.- Apr. 2020

The lethal velocity trajectory of Denmark shows similar trajectory to UK in longer time scale. Although the path shows small trigger to the counterclockwise rotation, it keeps original gradient and decreases the number of deaths constantly.

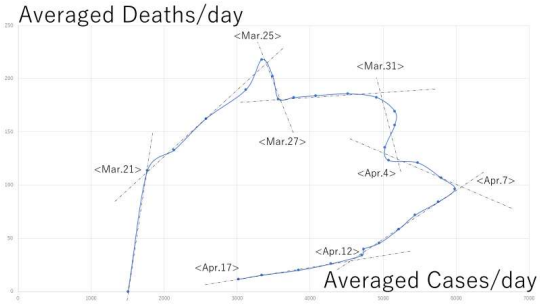

Fig.11 Path of mean lethal velocity
Germany, Mar.- Apr. 2020

In comparison to those countries, the German trajectory shows much different behavior (Fig.9). In German diagram, lethal velocity, or daily differential lethality, had been suppressed two times (late March and beginning of April) and the gradient goes down to the right (up to 7 Apr.), then turns CLOCKWISE to the left and now the first wave is about to converging.

In this COVID-19 pandemic, Germany had never generated medical collapse and the trajectory of lethal velocity shows strong effort of suppression against the epidemics.

Though the change of clinical lethality and medical collapse could have correlation, there is no fixed relationship. However, observation of lethality is useful to predict possible potential hazard and medical collapse.

It is also meaningful to observe divergence of lethality and lethal velocity within single country. It can reflect difference of society, economic situation and medical disparity.

Although mean lethal velocity of The United States shows strong linearity and definite CLOCKWISE turn to the convergence of the first wave, it only shows statistic average and the sum consists of awful variety of cases and deaths(Fig.12).

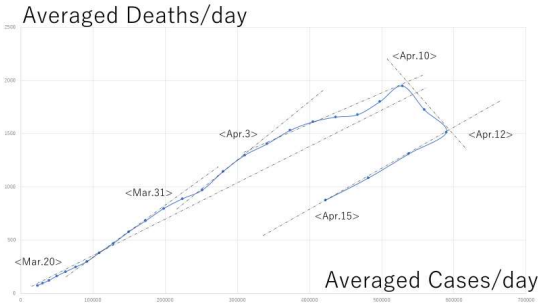

Fig.12 Path of mean lethal velocity
US, Mar.- Apr. 2020

We have not yet got sufficient domestic data of US COVID-19 pandemic cases and deaths. With further analysis we would reveal possible background mechanism of the difference, increasing and convergence of lethality in various socio-economic context.

The first outburst of COVID-19 pandemic was observed in Wuhan, China.

Fig. 13 shows lethal velocity of whole Mainland China. Though typical counterclockwise turn is observed, Chinese trajectory shows several unnatural features.

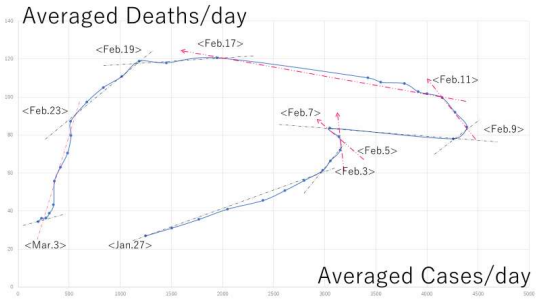

Fig.13 Path of mean lethal velocity
Mainland China, Jan.-Mar. 2020

Especially, in comparison to European countries, the rapid and steep convergence of death in mid-March is totally unnatural. "Y-plot" can much more sensitively reflect any kind of artifact than "X-plot".

Similar unnatural behavior of lethal velocity trajectory is observed in that of Japan.

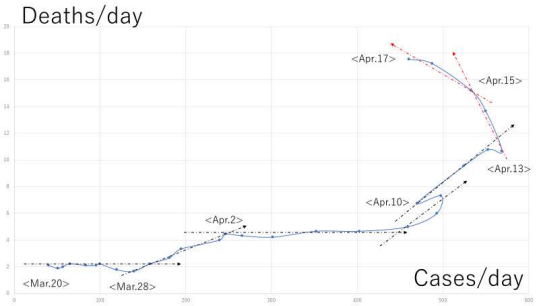

Fig.14 Path of mean lethal velocity
Japan, Mar.- Apr. 2020

In Mid-April, Japanese trajectory begins to show counterclockwise rotation and the domestic medical care is about to exhausting.

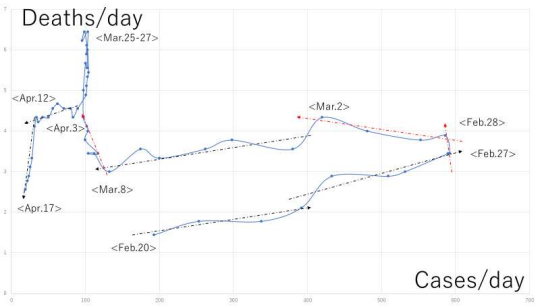

Fig.15 Path of mean lethal velocity
Korea, Feb.-Apr. 2020

However, the counterclockwise rotation does not always mean medical exhausting or collapse. A good example is that of South Korea.

Korean trajectory also shows counterclockwise rotation. But the absolute number of the infected cases / deaths is very small and the national level of medical care keeps ordinal high level.

We shall scrutinize each case and analyze them independently and carefully.

5 Remarks

Bengal famine is one of the worst complex of natural and artificial disaster throughout human history. Amartya Sen had revealed fundamental background mechanism and

had contributed immensely for the relapse prevention [3].

The will of my research group toward the COVID-19 pandemic is parallel to the ethical direction of Sen's welfare economics. Cross correlation analysis between lethality, social and economic disparity and other parameter would explain the difference and changes of lethality, even within a state or in a city, such as New York or Tokyo.

In this short article I would show simple principle of lethality analysis, ground prescription, formula and classification of diagrams according to their paths and forms.

From the view point of big-data ELSI and AI analysis we would analyze dynamical characteristics of medical care, collapse prediction and prevention, and instant recovery from the critical situation.

The author would like to show best thanks to Christoph, Luetge and the members of Global AI Ethics Consortium, Masashi Yanagisawa and Junji Nakamura for their fruitful discussion.

References

[1]https://www.worldometers.info/coronavirus/

[2]https://www.worldometers.info/coronavirus/country/italy/

We used similar database for the analysis of pandemic in other countries.

[3] Sen, A. "Poverty and Famines: An Essay on Entitlement and Deprivation" Oxford New York: Clarendon Press Oxford University Press. (1982)