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% mid-March to 9.07% mid-April, almost two times steeper; a rapid growth is observed within one month.

Usually in epidemiology, lethality is regarded as pathogen-specific constant, and in most case this well holds. 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, respirators and so on. 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.

In this article a parameter “lethal velocity” is defined as daily difference ratio of “cases and deaths”. Using this “lethal velocity”, we can analyze pandemic in different countries and regions in a single manner and can compare them. 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 change frequently according to 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 unknown, it clearly shows quasi-linear outline and lethality is obtained as gradient of the graph.

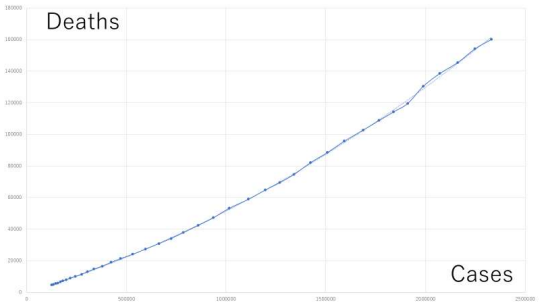

Fig.1 Global Lethality of COVID-19 ("X-plot")

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 changes, increases 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

A simple linear prediction shows us 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 impetuous conclusion shortly. However, even such simple analysis shows critical risks of the COVID-19 pandemic 2020.

Now we would treat lethality not constant, but clinical valuable or function of global / local medical care and other background. We would analyze various cases in more delicate manners.

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". The gradient of the trajectory shows a kind of "speed of death", so we call this steepness of the diagram "lethal velocity", and would analyze temporal changes of the global damage caused by the pandemic.

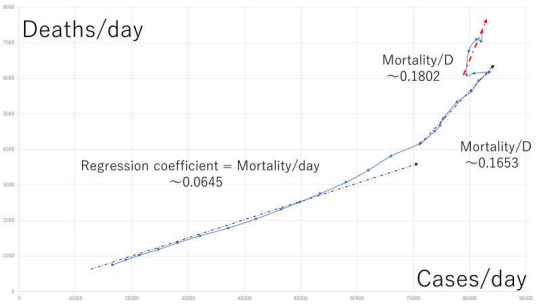

Fig.4 Global "Lethal velocity"
of COVID-19 ("Y-plot")

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 sum of each countries', and those data from countries base on different statistics. The sum must contain certain much error. Still, it could reflect general tendency and the increase of the lethality could be regarded as a symptom of global exhaustion of medical care.

3 Mean lethal velocity and path analysis

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

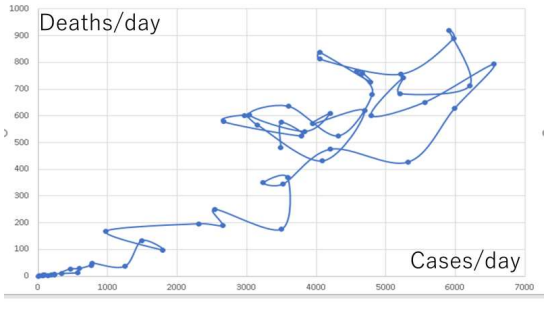

Fig.5 Path of daily lethal velocity
Italy, Mar.- Apr. 2020

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

Mean life time of COVID-19 is regarded as 8 days. 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.

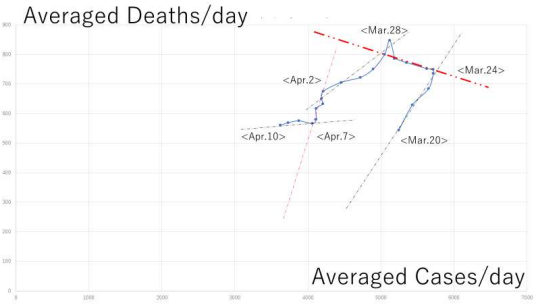

Fig.6 Path of mean lethal velocity
Italy, Mar.- Apr. 2020

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 is clarified.

Though no fixed correlation to medical exhaustion / medical collapse is observed, combined correlation function analysis could reveal basic characteristics of local pandemic and medical care. In this Italian case, the counterclockwise rotation, at large numbers of patients / victims, well agrees with the medical collapse of the country.

We would perform similar analysis to those data in 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 large patients / victims number. In both countries serious medical collapse had observed and the trajectory of lethal velocity matches to them.

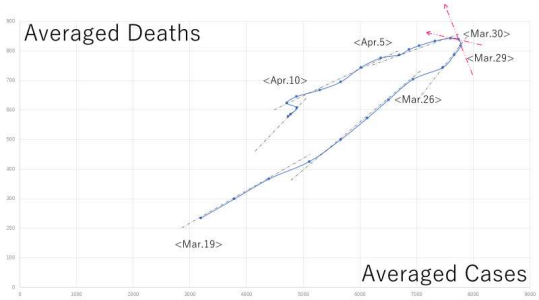

Fig.7 Path of mean lethal velocity
Spain, Mar.- Apr. 2020

The French trajectory of lethal velocity shown in Fig.8, meanders and shows a loop-behavior, within a counterclockwise rotating envelope.

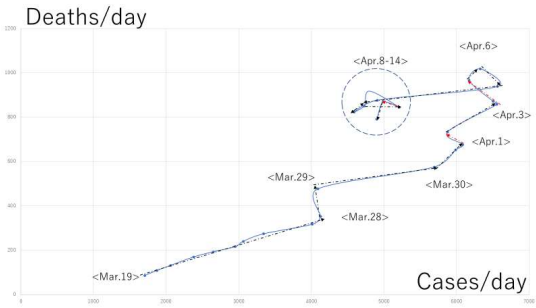

Fig.8 Path of mean lethal velocity
France, Mar.- Apr. 2020

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

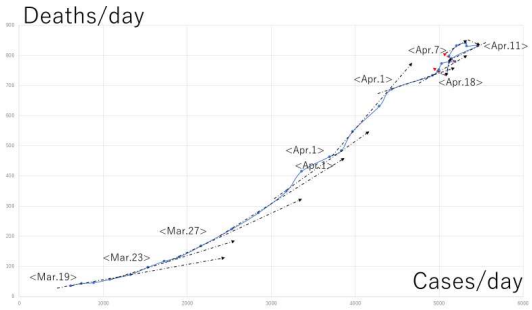

Fig.9 Path of mean lethal velocity
UK, Mar.- Apr. 2020

Although gradients of lethal velocities 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.

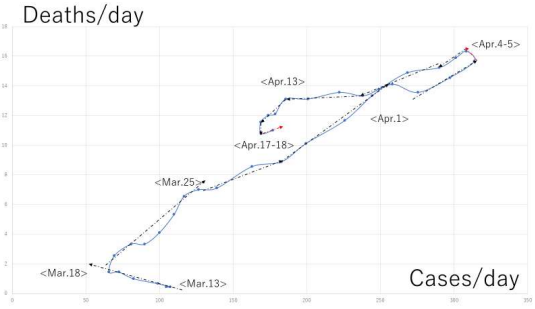

Fig.10 Path of mean lethal velocity
Denmark, Mar.- Apr. 2020

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

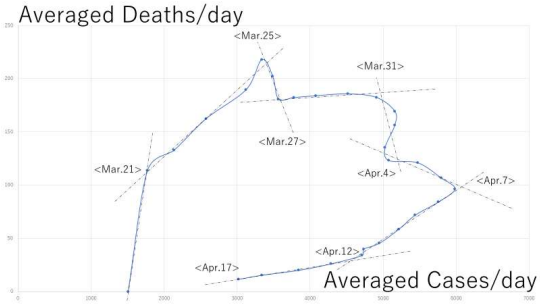

Fig.11 Path of mean lethal velocity
Germany, Mar.- Apr. 2020

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 epidemic.

Though the change of clinical lethality and medical collapse could have correlation, there is no fixed relationship. However, observation of clinical lethality can make prediction against possible potential hazard and medical collapse.

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

Although mean lethal velocity of 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 varieties of "cases and deaths" (Fig.12).

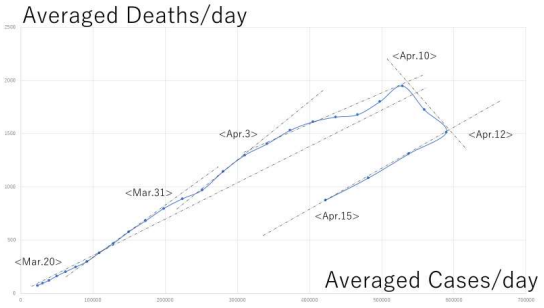

Fig.12 Path of mean lethal velocity
US, Mar.- Apr. 2020

We have not yet got sufficient domestic data of US COVID-19 pandemic local "cases and deaths". In further analysis we would reveal possible background of the differences, increasing and convergence of lethality, in various socio-economic contexts.

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 strange behaviors.

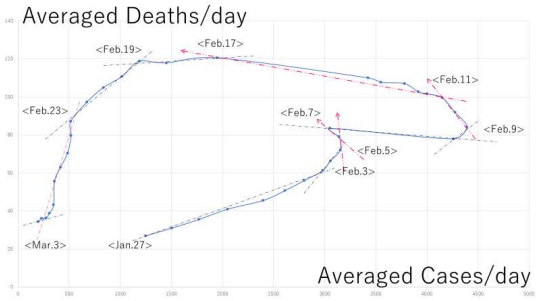

Fig.13 Path of mean lethal velocity
Mainland China, Jan.-Mar. 2020

Especially, in comparison to European countries, the rapid and steep convergence of death in mid-March could be regarded "exceptional". "Y-plot" can reflect "artifact" more sensitively than "X-plot".

Similar strange behaviors of lethal velocity are observed in that of Japan.

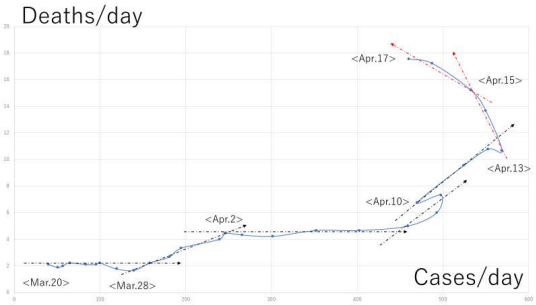

Fig.14 Path of mean lethal velocity
Japan, Mar.- Apr. 2020

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

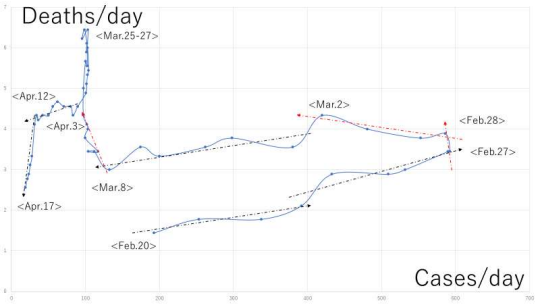

Fig.15 Path of mean lethal velocity
Korea, Feb.-Apr. 2020

The counterclockwise rotation, however, 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 / deaths is small and the national level of medical care keeps ordinal high standard. We shall scrutinize each case and analyze them independently and carefully.

Australian strategy against COVID is most successful. Here again the trajectory of Australia shows COUNTERCLOCKWISE rotation but in low number (Fig.16). The tail of a pandemic wave is fluctuating; much different from that of Mainland China.

Fig.16 Path of mean lethal velocity
Australia, Mar.- Apr. 2020

Strategy of Singapore is also most successful, but the trajectory is different from that of Australia and rather similar to that of Germany, though the number of patients is much smaller.

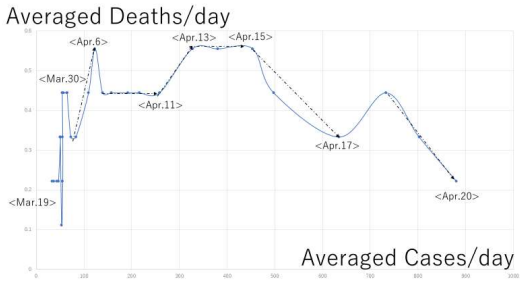

Fig.17 Path of mean lethal velocity
Singapore, Mar.- Apr. 2020

At last I would like to show the best example where my analysis is totally powerless: the trajectory of Vietnam (Fig.18). I could not calculate cases/deaths clinical ratio, for there is no victim by COVID-19 up to 23rd Apr. in this country. This is the ideal case of convergence in a pandemic wave. We shall learn much from Vietnamese strategy in detail.

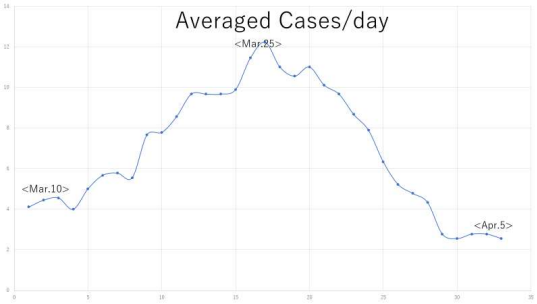

Fig.18 Averaged daily cases, no death.
Vietnam, Mar.- Apr. 2020

Trajectory of Taiwan shows realistic case next to Vietnamese ideal. The tail also shows rather long residue and it is not clear whether this tells convergence or seedling to the next second wave of epidemic.

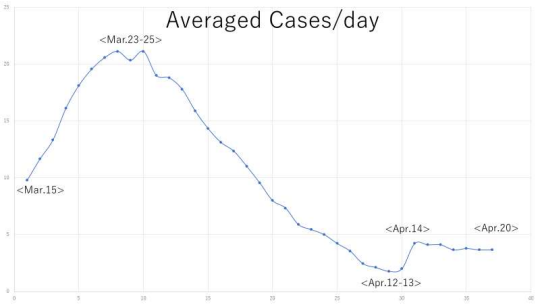

Fig.19 Averaged daily cases, no death.
Taiwan, Mar.- Apr. 2020

Unfortunately, Taiwan has 6 Victims. With those martyrs statistics, mean lethal velocity shows following trajectory.

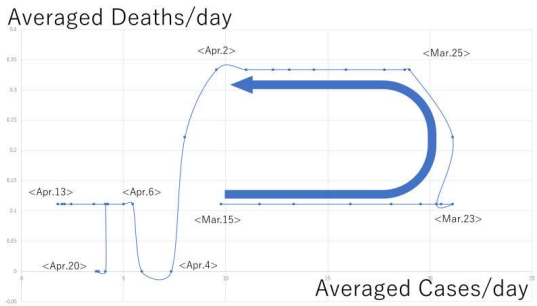

Fig.20 Path of mean lethal velocity
Taiwan, Mar.- Apr. 2020

Taiwan's strategy is regarded as one of the best counter measure against COVID-19, and in this case, the lethal velocity trajectory shows counterclockwise rotation at small number of victims.

5 Remarks

Bengal famine is one of the worst complex of natural disaster and artificial calamity throughout human history. Amartya Sen had revealed fundamental mechanism behind this tragedy and had contributed immensely for the possible relapse prevention [3].

The ideal 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 community, such as New York or Tokyo.

In this short article I simply show principles of lethality analysis, ground prescription and formula, classification of diagrams according to their paths, forms and topology.

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

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References

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[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)