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Analysis on the Transmission of COVID-19 and Countermeasures Based on Data Visualization

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***Abstract*— COVID-19 (Corona Virus Disease 2019) has been controlled largely in China, but it is still of great important to review the situation at the earliest stage, countermeasures and experience, as well as the problems. In this present paper, the spread and development of the epidemic situation are reviewed based on Baidu big data and the data released by health commissions, the phenomenon and correlation are studied, and the population migration, population base and economic development level of the provinces before and after Wuhan lockdown on January 23, 2020 are compared. It is concluded that the number of COVID-19 patients is correlated with the above three factors. Namely, there is generally a higher incidence rate in the regions with more migration population, larger population base and higher economic level. Using the epidemiological model, we carry out the evolutionary computation against the transmission of COVID-19, discuss the problems existing in the early prevention and control, and propose several measures and suggestions available for reference.**

***Index Terms*—COVID-19, Countermeasure, Data visualization, Data analysis**

I. INTRODUCTION

In Wuhan City, Hubei Province, lots of patients have been diagnosed with viral pneumonia since the end of December 2019. Finally, the etiology was confirmed as a novel coronavirus on January 8, 2020. This virus was called Corona Virus Disease 2019 (COVID-19) by National Health Commission of the People's Republic of China, suggesting a similar route of transmission to SARS-CoV-2[1]. With a stronger infectivity, it quickly spread to all regions of China from Wuhan during the Spring Festival, causing a serious panic to the public. The age of the patients susceptible to COVID-19 ranges from a few months to 90 years old. All people who have direct or indirect contact with the infected patients may be infected. More notably, there is a virus latency, which aggravates the workload of epidemic prevention and control. As of Wuhan lockdown on January 23, 2020, there have been many cases in Xiangyang, Yichang, Shiyan, etc. in Hubei Province. It was extremely urgent to take measures to prevent and control the epidemic situation. The Communist Party of China (CPC) and the Government provided substantial support and gave explicit directions, and the medical staff and the masses made atomic efforts and sacrifices, winning a victory in "Wuhan Defense" and "National Epidemic Prevention and Control". But internationally, the international epidemic prevention and control are still in grave difficulties. COVID-19 has evolved into a global health emergency. So far, more than forty million patients have been diagnosed with this virus, one million among whom have died unfortunately. This paper aims to investigate the transmission mechanism[2], evolution process**Error! Reference source not found.**, problems and countermeasures of COVID-19 at the early stage of epidemic prevention and control**Error! Reference source not found.**, so that experience and lessons are accumulated for the reference of the subsequent public health emergencies.

II. ANALYSIS ON THE TRANSMISSION TREND OF COVID-19 AT THE INITIAL STAGE BASED ON DATA VISUALIZATION

The cumulative diagnostic data (excluding Hong Kong, Macao, Taiwan regions) collected by National Health Commission of the People's Republic of China and provincial health commissions as of April 5, 2020 shows that Guangdong, Henan, Zhejiang, Hunan, Anhui, Jiangxi, Shandong, Jiangsu, Beijing, Chongqing rank the top ten in terms of severity apart from Hubei Province. Statistically, April 5 is finalized as the timeline of observation, because this interval between this timeline and national control time is much larger than the virus latency, the epidemic situation has been controlled basically around this day, and some schools restored the teaching order, resulting in the mobility of passenger. This distribution of cases diagnosed could reflect the periodic development of COVID-19.

In this regard, we regard the migrant population in the provinces during the Spring Festival transportation before January 23 as the main factor, and calculate the percentage of the population migrated from Wuhan in the provinces through the Baidu big data. Henan, as one of the destinations, occupies the largest proportion (17%) of the floating population from Wuhan. The linear correlation analysis on two sets of data indicates that the P value is 0.020<0.05, and there is a significant correlation; Pearson's correlation

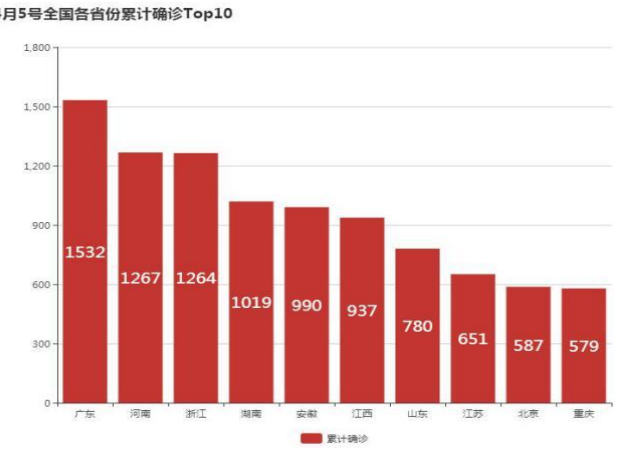

Fig.1 Cumulative confirmed cases in all provinces across the country on April 5

Fig.2 Confirmed case icon

coefficient is 0.591, and there is a moderately strong correlation, which suggests population migration is closely correlated with the number of confirmed cases in the provinces. In other words, population migration can be used to statistically explain 34% number of confirmed cases in the provinces.

However, the above analysis only takes population immigrating from Wuhan into consideration. Actually, both population base and economic development level shall be considered (the population mobility is larger in the regions with higher economic level). Therefore, we carry out the linear correlation analysis by regarding the population and GDP level in the provinces in 2019 as the reference indexes. It is found that Pearson's correlation coefficient between the population and number of confirmed cases is 0.546, P value is 0.035<0.05, and there is a moderate correlation; Pearson's correlation coefficient between the GDP level and number of confirmed cases is 0.53, P value is 0.042<0.05, and there is also a moderate correlation, both of which can be used to statistically explain 29.8% and 28.1% number of confirmed cases, respectively. Practically, we carry out a partial correlation analysis on population migration, trying to eliminate the interference of population and economic level. The findings show that the Pearson's correlation coefficient ascends to 0.610, resulting in a stronger correlation. It is concluded that in the provinces which accept more population from Wuhan, the larger the province's population base and the higher the economic development level, the greater the number of confirmed cases.

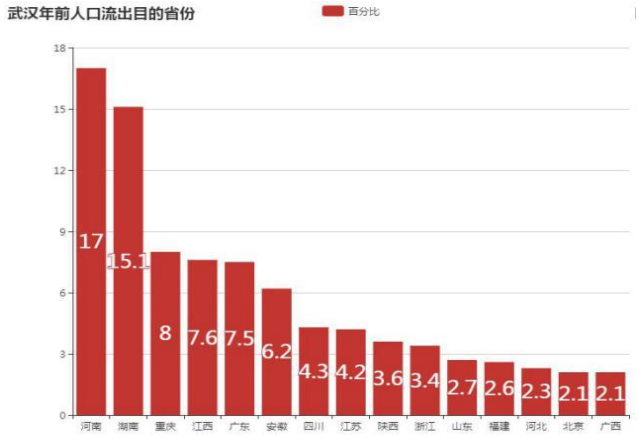

Fig.3 Population outflow percentage diagram

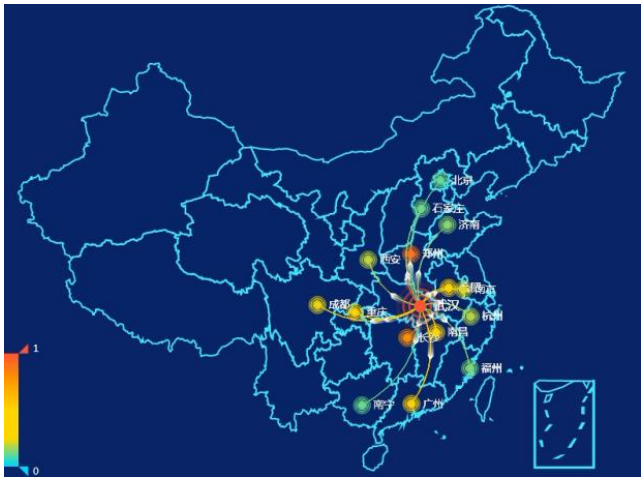

Fig.4 Migration icon

III. MODEL EVOLUTION

Starting from the simple epidemiological model SIRS, we carry out the analysis. S means the susceptible population who are healthy, I means the infected population who are patients, and R means the cured population who are convalescent patients. It is obvious that the total population in the region (N=S+I+R) remains unchanged. Assuming that the daily number of exposed population is r, the infection rate is B, and the daily cure rate of patients is y[4], then

$$\begin{cases} dS/dt = -rBIS/N \\ dI/dt = rBIS/N - yI \\ dR/dt = yI \\ N = S + I + R \end{cases} \quad (1)$$

In addition, we also need to consider mortality for the transmission of COVID-19. It does not mean that the patients who suffer from COVID-19 will be immune all their life after being cured. There is a virus latency after the infection. Hence, we evolve the model into a more complicated Q-SEIRS. Namely, the dead population Q and virus latency E. Assuming that the daily mortality is q, it is found that the relationship between S and I is essentially unchanged, except that the intermediate process E is added, the rate at which E is transformed into I every day is o, and the detection result of R still may be positive[8]. Assuming that the probability of the patients among R who would not be immune all their life[5],.

$$\begin{cases} dS/dt = -rBIS/N + aR \\ dE/dt = rBIS/N - oE \\ dI/dt = oE - yI - qI \\ dR/dt = yI - aR \\ dQ/dt = qI \end{cases} \quad (2)$$

Given that some population who are in virus latency may be infectious in the actual viral transmission, the probability of which is low, we need to modify the model[6]. E itself can infect E. As the population in virus latency, they contact more exposed population. Assuming such population is r2, and the infection rate is lower, assuming such rate is B2, then change the equation of S and E[7].Obviously,N=S+E+I+R+Q

$$\begin{cases} dS/dt = -rBIS/N - r_2B_2ES/N + aR \\ dE/dt = rBIS/N + r_2B_2ES/N - oE \end{cases} \quad (3)$$

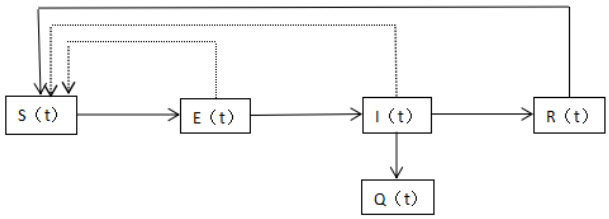

Fig.5 Final model

The data released officially at the initial outbreak of COVID-19 is used to calculate, showing that nearly all of regions in China begun to be blocked several days after January 23, 2020. The strict measures effectively contained the mobility of population, significantly reduced the number of exposed population and avoided the further epidemic diffusion, making remarkable achievements in the epidemic prevention and control, and contributing to the epidemic prevention and control worldwide. Simultaneously, supplies, experts and medical staff were assigned successively, Huoshenshan Hospital and Leishenshan Hospital in Wuhan were built quickly, and the mobile cabin hospitals were put into use one after the other in different regions, which significantly increased the rehabilitation rate and decreased the mortality rate. Macroscopically, the fatality rate of COVID-19 dropped but its infectiousness increased continuously. However, lots of patients and population in virus latency received appreciate appropriate treatment and arrangement under the joints efforts and quick response. Few exposed population were infected in spite of stronger infectivity, which effectively avoided the spread of the epidemic and controlled it within a short time.

IV. Problems Existing at the Early Stage of Epidemic Prevention and Control

It can be found that, Wuhan and the surrounding cities became severely afflicted areas due to the failure to respond to COVID-19 at the early stage of epidemic prevention and control. On one hand, the governments did not take effective measures timely, resulting in a large population mobility and grave consequences. On the other hand, the Chinese epidemic prevention and control system has not been sound nor perfect yet. The officials could not propose countermeasures, but reported the issues to the superior staff, wasting the precious time of epidemic prevention and control. At the same times, the material supply and personnel allocation were not reasonable enough, and the limited manpower and material resources could not be fully utilized, which boosted pressure on prevention and control work. Furthermore, the masses felt jittery and questioned the official information, forming communication barriers, because they did not trust some government personnel and researchers. What's more, the official information was distorted and shamed maliciously by some individuals and we-media for their own illegitimate demands and page views. The foreign media and political groups also deliberately exaggerated embellishment to the situation and maliciously spread rumors, which played an extremely negative role in the public opinion environment.

V. Related Suggestions and Measures

The governments should make efforts to carry out overall coordination, implement the unified allocation and deployment of people from all walks of life and the relevant departments like hospitals and Red Cross, and establish and improve the emergency response mechanism for public health emergencies. The management departments and health committee systems at all levels, including disease control centers, hospitals, and other functional departments, should establish and improve the stable and sound coordination mechanism as early as possible, thus playing the role of prevention and control resources effectively and reasonably.

The relevant authorities must shoulder the responsibilities, instead of evade the problems blindly, thus avoiding a greater social crisis. Researchers must propose the issues boldly and cautiously, not only provide the public with correct guidance, but also consider social solidarity and stability, eliminating unfavorable factors.

The direction of public opinion shall be guided timely. The official media shall provide authoritative, forceful and scientific value judgments, which are not "windy" or "insinuating", and wield the authority of public opinion, and to believe that rumors end with sage. The competent departments should severely punish and suppress the self-media that deliberately exaggerate terrorism, creating a harmonious public opinion environment.

Appendix

area	Confirmed cases	Migration percentage	Population	GDP
Guangdong	1532	7.5	11521.0	107671.07
Henan	1267	17.0	9640.0	54259.20
Zhejiang	1264	3.4	5850.0	62352.00
Hunan	1019	15.1	6918.4	39752.12
Anhui	990	6.2	6365.9	37114.00
Jiangxi	937	7.6	4666.1	24757.50
Shandong	780	2.7	10070.0	71067.50
Jiangsu	651	4.2	8070.0	99631.52
Beijing	587	2.1	2153.6	35371.30
Chongqing	579	8.0	3124.3	23605.77
Sichaun	559	4.3	8375.0	46615.82
Shanghai	536	0.8	2428.1	38155.32
Heilongjiang	504	1.1	3751.3	13612.70
Fujian	350	2.6	3973.0	32395.00
Hebei	327	2.3	7592.0	35104.50

Fig.6 Provincial data

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