Spatial-Temporal Pattern of Novel Coronavirus Pneumonia (COVID-19) in Europe

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Abstract: Fighting the Novel Coronavirus Pneumonia (COVID-19) is an urgent task and major concern in the world. As the core of public health events, Epidemiology is most concerned with spatial-temporal pattern. Based on the statistical data, this paper discusses the impact range and spread trend of the epidemic in Europe. The significance and suggestions for multi-scale assessment of the epidemic severity are put forward.

1. Introduction
The outbreak of Novel Coronavirus Pneumonia (COVID-19) has occurred since the end of 2019, and has spread to many countries around the world by the end of February 2020. Combating the COVID-19 is the primary task facing all countries in the world. To make clear the spatial scope, temporal and spatial distribution of epidemic spread, the time of turning point and the severity of infection is the premise of making epidemic prevention plan; the evaluation of its severity is also an important content of releasing information to the public. This can not only promote the whole social science to recognize the new infectious diseases, but also improve the group rationality during the anti epidemic period, to avoid social panic and public opinion events caused by false speculation.

Based on the spatial attribute of epidemiology, the diseased population will have certain relevance in spatial location, while different spatial location, human environment and geographical environment will have different effects on the epidemic situation. With the help of geospatial information technology, the data of the number of people infected by the new crown epidemic in the main European countries from February 28 to March 8, 2020 were analyzed in time and space, and the causes of its spatial spread were discussed in depth.

2. Materials and methodology

2.1. Data
The administrative boundary shapefile of counties for Europe obtained using ArcGIS Desktop 10.5.
Figure 1. Figure of study area.

The world health organization (WHO) continue to monitor county-level data of novel Coronavirus disease-daily and across the world. For this study, the county-level counts of COVID-19 cases across the Europe from February 28, 2020, to March 8, 2020, were retrieved from WHO.

Table 1. Statistics on COVID-19 infections in major European countries (Number of infected)

| Date | Italy | France | Germany | Spain | UK | Switzerland | Norway | Sweden | Austria |
|------|-------|--------|---------|-------|----|-------------|--------|--------|---------|
| 2.28 | 650   | 38     | 26      | 25    | 16 | 6           | 4      | 7      | 4       |
| 2.29 | 888   | 57     | 57      | 32    | 20 | 10          | 6      | 12     | 5       |
| 3.1  | 1128  | 100    | 57      | 45    | 23 | 18          | 15     | 13     | 10      |
| 3.2  | 1689  | 100    | 129     | 45    | 24 | 19          | 14     | 10     | 10      |
| 3.3  | 2036  | 191    | 157     | 114   | 39 | 30          | 25     | 15     | 10      |
| 3.4  | 2502  | 212    | 196     | 151   | 51 | 37          | 32     | 24     | 24      |
| 3.5  | 3089  | 282    | 262     | 198   | 89 | 56          | 56     | 35     | 37      |
| 3.6  | 3858  | 420    | 534     | 257   | 118| 86          | 86     | 61     | 47      |
| 3.7  | 4636  | 613    | 639     | 374   | 167| 209         | 113    | 137    | 66      |
| 3.8  | 5883  | 706    | 795     | 430   | 210| 264         | 147    | 161    | 104     |

2.2. Method
Ordinary least square

The ordinary least squares model is a regression method that investigates the relationships between a set of explanatory or independent variables and a dependent variable and has the general form of (Word 2018):

\[ y_i = \beta_0 + x_i \beta + \varepsilon_i \]  

where at country \( i \),
- \( y_i \) is the COVID-19 incidence rates.
- \( \beta_0 \) is the intercept.
- \( x_i \) is the vector of selected explanatory variables.
\[ \beta \text{ is the vector of regression coefficients.} \]
\[ \epsilon \text{ is a random error term.} \]

2.3. Result and discussion
During this ten-day period, the number of COVID-19 infections in Europe showed an increasing trend, from 650 on the first day to 5,883 on the tenth day, an increase of 805%. And the rate of growth is increasing.

![Daily growth chart](image)

Figure 2. Growth chart of the number of infected persons

In terms of spatial and temporal distribution, COVID-19 infections in Europe are mainly concentrated in central Europe, namely Germany, Spain and Italy. The epidemic is spreading rapidly in these three countries. In Italy, in particular, the epidemic is moving very fast. In eastern Europe, the epidemic is moving more slowly than countries in the Mediterranean and Iberian islands, namely Italy and Spain. From this perspective, it can be seen that the western part of Europe has more frequent personnel exchanges and economic exchanges, while the eastern part of Europe has less contact with the western part of Europe. There are both historical reasons and geographical factors, which can be combined with the socio-economic data to make a deeper discussion.

(a) People infected on Feb.28
(b) People infected on Feb.29
3. Conclusion
The authors are using the GIS and statistical method to explain the spatial variability of COVID-19 rate across the Europe. Our results confirmed and extended the findings of the COVID-19 in Europe. The spatial variability of Spatial model in different counties can reflect different behavior of COVID-19 incidence rates in response to the selected explanatory variables. To the best of our knowledge, there is
a lack of nationwide researches on geographic modeling of COVID-19; thus, this study can be regarded as a basis for future geographic modeling of the diseases.

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