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CASE REPORT

Asymptomatic Carrier State as a Measure of Information Uncertainty of the Novel Coronavirus Infection

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ABSTRACT

This case report describes entropy based on statistics of the novel coronavirus infection in the Russian Federation. Entropy (in bits) determined on the basis of the ratio of patients with clinical manifestations of the disease and asymptomatic carrier state, increased from 0.7219 by April 1, 2020, when the ratio of such patients was 4/5 to 1/5, to 0.8813 by April 14, 2020, when the ratio of the two groups of patients was 7/10 to 3/10. On May 3, 2020, the ratio of the two groups leveled off, reaching ½ to ½, so the entropy was 1.0000. An analysis of the data from April 19, 2020 to June 1, 2020 allowed us to clarify the average proportion between patients with and without symptoms, which is 14/25 to 11/25 with a certain bias towards patients with clinical manifestations of the novel coronavirus infection, and the entropy for this ratio is 0.9896. We found a transformation of entropy of the novel coronavirus infection which is explained by different proportions of patients with and without symptoms of the disease.

KEYWORDS: The novel coronavirus infection (COVID-19), Asymptomatic patients, Symptomatic patients, Information theory, Entropy analysis, Alternative signs, Health statistics.

INTRODUCTION

The novel coronavirus infection can often be asymptomatic, making testing for COVID-19 a key diagnostic method[1,2]. In Russia, statistics on asymptomatic patients has been regularly published since April 2020, when it became clear that the percentage of asymptomatic carriers of SARS-CoV-2 has a steadily increasing trend[3,4,5].

The purpose of this paper is to study the change in the ratio of COVID-infected patients in Russia with and without symptoms for the period from April 1 to June 1, 2020, as well as based on the ratios of entropy, which is a key parameter in the information theory indicating a measure of "disorder" of the phenomenon under study[6].

CASE REPORT

This case report contains an analysis of statistics on the novel coronavirus infection in the Russian Federation. A source for this work were reports containing information on the number of patients and the percentage of asymptomatic carriers of the novel coronavirus infection as of April 1 and 14, 2020[3,4], as well as regularly published statistics (from April 19 to June 1, 2020) for the novel coronavirus infection in the Russian Federation (Table I)[5].

TABLE I: INCIDENCE TRENDS FOR THE NOVEL CORONAVIRUS INFECTION, TAKING INTO ACCOUNT PATIENTS WITH CLINICAL MANIFESTATIONS OF THE DISEASE AND ASYMPTOMATIC PATIENTS IN THE RUSSIAN FEDERATION FROM APRIL 19 TO JUNE 1, 2020[5]

Date	Number of COVID patients, number of cases	Percentage of patients with symptoms (W_1), %	Percentage of asymptomatic patients (W_2),%
19.04.2020	6060	57.0	43.0
20.04.2020	4268	54.7	45.3
21.04.2020	5642	54.5	45.5
22.04.2020	5236	56.6	43.4
23.04.2020	4774	52.2	47.8
24.04.2020	5849	53.9	46.1
25.04.2020	5966	51.1	48.9
26.04.2020	6361	54.1	45.9
27.04.2020	6198	56.6	43.4
28.04.2020	6411	59.3	40.7
29.04.2020	5841	55.1	44.9
30.04.2020	7099	60.1	39.9
01.05.2020	7933	55.5	44.5
02.05.2020	9623	53.4	46.6
03.05.2020	10633	49.7	50.3
04.05.2020	10581	49.4	50.6
05.05.2020	10102	50.9	49.1
06.05.2020	10559	59.1	40.9
07.05.2020	11231	51.3	48.7
08.05.2020	10699	51.1	48.9
09.05.2020	10817	59.3	40.7
10.05.2020	11012	57.6	42.4
11.05.2020	11656	53.5	46.5

12.05.2020	10899	56.9	43.1
13.05.2020	10028	55.5	44.5
14.05.2020	9974	59.4	40.6
15.05.2020	10598	57.5	42.5
16.05.2020	9200	55.2	44.8
17.05.2020	9709	57.6	42.4
18.05.2020	8926	59.9	40.1
19.05.2020	9263	56.9	43.1
20.05.2020	8764	54.1	45.9
21.05.2020	8849	58.0	42.0
22.05.2020	8894	57.8	42.2
23.05.2020	9434	58.0	42.0
24.05.2020	8599	56.1	43.9
25.05.2020	8946	56.3	43.7
26.05.2020	8915	58.9	41.1
27.05.2020	8338	59.2	40.8
28.05.2020	8371	57.5	42.5
29.05.2020	8572	60.6	39.4
30.05.2020	8952	58.1	41.9
31.05.2020	9268	59.2	40.8
01.06.2020	9035	59.9	40.1
Mean	—	56.1	43.9

The daily percentages of patients with symptoms, as well as the mean percentages of patients with and without symptoms, were determined in Microsoft Excel. The calculation of entropy (in bits)[6] was performed according to the Shannon formula

$$H = -\sum_{i=1}^{n} P_i \log_2 P_i,$$

where P_i is the probability (occurrence) of the i-th option; n is the number of values that the system can take. In this study, $n = 2$.

The incidence of patients with symptoms ($P_1 = W_1/100$) and the incidence of patients without symptoms ($P_2 = W_2/100$), which can be interpreted as alternative signs, are taken into account as variants for the measure of disorder being evaluated. Entropy parameters for two groups of patients were calculated by an online calculator (https://planetcalc.ru/2476/).

Obviously, the entropy of the novel coronavirus infection changed following a change in the ratio of patients with and without symptoms. That is, if on April 1, 2020, only every fifth patient had no clinical manifestations of the novel coronavirus infection, then by April 14, 2020, the incidence of asymptomatic carriers of the virus has increased, and every third patient had no characteristic symptoms[3,4]. On May 3, 2020, a parity ratio of patients with and without symptoms was recorded[5]. This shows that every second patient was characterized by asymptomatic carrier state (Table II). In terms of information theory, the most clinically informative and stable stage is April 1, 2020, since the entropy value is minimum, so the disease diagnosis is supported by typical symptoms. With the increasing incidence of asymptomatic patients by April 14, 2020 the entropy value increases, which introduces informational uncertainty at the level of visual manifestations of the disease. On May 3, 2020, an almost equilibrium situation for patients with and without symptoms was established, which ensured the maximum level of entropy, showing a significant informational uncertainty of the infection (Table II).

TABLE II: ENTROPY VARIABILITY TREND BASED ON THE RATIO OF PATIENTS WITH AND WITHOUT CLINICAL MANIFESTATIONS OF THE NOVEL CORONAVIRUS INFECTION[3,4,5]

Date	COVID patients, number of cases	Percentage of COVID patients with symptoms (W_1), %	Percentage of COVID patients without symptoms (W_2), %	Visual ratio of symptomatic (black squares) and asymptomatic (white squares) cases	Entropy (H), bits
01.04.2020	440	80	20	■■■■□■■■■□	0.7219
14.04.2020	2774	70	30	■■□■■□■■□■	0.8813
03.05.2020	10633	50	50	■□■□■□■□■□	1.0000

In this regard, laboratory diagnosis is becoming a decisive factor in the identification of this nosology, which is characterized by the increasing trend of asymptomatic carriers of the novel coronavirus infection. In the absence of laboratory diagnostics or untimely testing, asymptomatic carriers present a real hazard for the further spread of the disease due to their social activity.

This is due to the fact that doctors, due to the lack of clinical presentation, cannot identify the nosology by external manifestations[7], and those infected do not perceive themselves as diseased, since the infection is asymptomatic.

A more detailed analysis of the trend series of percentages of patients with and without symptoms was performed for the period from April 19 to June 1, 2020 (Table I)[5]. It was found that the average percentage of patients with COVID-19 symptoms is more than 56%, while the percentage of patients without symptoms is about 44%, which gives the basis for the following approximate proportion: 14/25■ to 11/25□. Such ratio shows some dominance of patients with clinical manifestations of the infectious disease. Entropy for this ratio is at the level of 0.9896.

DISCUSSION

When discussing the results obtained, it is important to specify that blurring or complete absence of symptoms is one of the factors for the further spread of the novel coronavirus infection, since the carrier of the coronavirus, firstly, does not identify him/herself as a patient, and secondly, puts at risk of infection people communicating with them. In a pandemic, a socially active population should have a high level of responsibility in terms of public health, which is manifested in independent measurement of the risk of infection[8]. This requires regular testing for COVID-19 in case of predicted risk, which is associated with real social activity of the population, initiated, for example, by necessary labor relations.

Obviously, the current information uncertainty due to the parity or almost equilibrium ratio of patients with and without symptoms in this sense is hazardous from an epidemiological point of view.

Thus, the use of information theory allows us to understand the dependence of entropy on the ratio of patients with and without symptoms, which indicates a transformation of the clinical information content of the novel coronavirus infection, which is more stable the less is the number of patients with the asymptomatic nature of the disease. At the same time, the informational instability of the infectious disease increases as the percentage of asymptomatic carriers of SARS-CoV-2 increases.

DEDICATION: This case report study is dedicated "To the memory of my mother Valentina Andreevna Morozova (1951-2020)"

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