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One year of COVID-19 pandemic: Case fatality ratio and infection fatality ratio. A systematic analysis of 219 countries and territories.

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ABSTRACT

Background. January 2021 marked one year since the start of COVID-19 pandemic: it is the time of intermediate conclusions.

Objective. To evaluate CFR and IFR due to COVID-19 in various countries and territories, and to study if parameters of a population age affect CFR and IFR.

Material and Methods. The databases of 219 countries were collected on the Worldometers, Index Mundi, Country Meters and World Bank websites. The processing of data was divided into two parts: the first part dealt with the calculation and analysis of CFR while the second, the calculation and analysis of IFR.

Results. The calculations revealed that in 74 out of 219 countries, CFR was less than 1.00 %, in 69 countries it varied between 1.00 % and 2.00 %, and in 76 countries it was more than 2.00 %. The calculation of IFR revealed that in 183 countries, IFR was less than 1.00 %, in 22 countries IFR was between 1.00 % and 2.00 %, and only in 14 out of 219 countries IFR was more than 2.00 %.

A correlation between IFR and parameters of a population age was found: the less median age and the percentage of 'aged' people – the less value of IFR, although, there was no correlation between parameters of a population age and CFR.

Conclusion. The global health care system has gone through a year of serious trial caused by COVID-19 and appeared to have emerged victorious. In the majority of countries analyzed, the parameters of mortality due to COVID-19 were at a low level. So, there seems to be an objective basis for optimism and hope for an early end to the pandemic.

Key words: COVID-19, Mortality rate, CFR, IFR, Case fatality ratio, Infection fatality ratio.

Abbreviations: Case fatality ratio (CFR); Infection fatality ratio (IFR); World Health Organization (WHO); The Coronavirus Disease 2019 (COVID-19).

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One year of COVID-19 pandemic: Case fatality ratio and Infection fatality ratio. A systematic analysis of 219 countries and territories.

Introduction

Fatality rate. There are two most important characteristics of infectious diseases: the first is a case fatality ratio (CFR) and the second, an infection fatality ratio (IFR). Case fatality ratio is the proportion between the number of patients who died from COVID-19 and the number of confirmed cases of COVID-19, while Infection fatality ratio is the proportion between the number of patients who died from COVID-19 and the number of estimated cases infected with SARS-CoV-19 [1].

Case fatality ratio. In the first report provided by a group of experts from Imperial College London, there were 41 confirmed cases of COVID-19 with 2 deaths (17.01.20) [2], so, the CFR was 4.88 %. In the second report provided by the same group of experts, there were 440 confirmed cases with 9 deaths (22.01.20) [3]. Thus, the CFR was 2.05 %. In a study done by L.Liang, et al, (2020) the authors discussed a strange phenomenon of the current pandemic - "Why the Covid-19 mortality rate varies so greatly across countries, from over 16 % in France and Belgium to less than 0.1 % in Singapore and Qatar" [4]. In a recent study conducted in Malaysia, the authors also noted a wide variation of CFR worldwide and highlighted the low CFR in their country [5].

Infection fatality ratio. To calculate an IFR one needs to know the number of deaths from COVID-19, the total number of confirmed cases of the disease and the number of people who could be infected with the SARS-CoV-2 virus, yet suffered the disease asymptomatically or with minimal symptoms that did not attract the attention of the patient and doctors [1]. To identify the total number of infection prevalence, tests were carried out for the presence of the viral genome (Polymerase chain reaction), or for specific antibodies against SARS-CoV-2 virus (IgM and IgG). Due to the fact that polymerase chain reaction provided positive results for a limited time after infection, and specific antibodies were produced and circulated in the blood of an infected person only for several months [6, 7], the percentage of seroprevalence would always be lower than the real one, and, therefore, IFR from COVID-19 would be always overestimated.

In the second report submitted by the aforementioned group of experts from Imperial College London dated January 22, 2020, there were 9 deaths, 440 confirmed cases, and the estimated number of infected people reached 4,000 [3]. Thus, the IFR was 0.23 %. According to a research conducted by M. Neil et al. (2020), the IFR was most likely to be in the range of 0.30–0.50 %, and it should not exceed 1.00 % [8]. In yet another study by A. Rostami, et al. (2020), covering the time from the start of the pandemic to August 14, 2020, the estimated number of all infected persons reached 263,565,606 people [9]. On the same day, according to data presented on the Worldometers website [10], there were 777,073 deaths from COVID-19, thus, the IFR was equal to 0.29 %.

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In the article published by J. Ioannidis (2020), at the end of October 2020, worldwide, the number of infected people reached 10 %, and the IFR was between 0.15 % and 0.20 % [11].

Database. In this study, information on the number of reported deaths caused by COVID-19, reported cases of COVID-19, tests performed and population were collected on the Worldometers website. This site does not have investors, donors or grants that could influence the information published. The data published on the Worldometers website is compiled from over 5,000 sources, including official reports from the respective countries analyzed [10]. Information on the median age and percentage of the population aged 65 and above were obtained from the IndexMundi [12], Country Meters [13] and World Bank [14] websites.

The processing of data collected on January 22, 2021, was divided into two parts. The first involved calculating and analyzing CFR and the second, calculating and analyzing IFR. Based on the results obtained, corresponding graphs were prepared.

1. Case fatality ratio among COVID-19 patients in 219 countries

Objective. To study Case Fatality Ratio in 219 countries,[1] and to evaluate if parameters of a population age affect CFR.

1.1. Calculation of CFR among COVID-19 patients of 161 countries.

Material and Methods. To calculate the CFR worldwide, the databases of 219 countries with a total population of 7,801,382,128 people were collected on the Worldometers on January 22, 2021. To increase the homogeneity of the main group of study, countries with death numbers of fewer than 50 were excluded from further analysis.

The main study group included 161 countries, with a total population of 7,529,891,314 people. These countries had 97,225,719 confirmed cases of COVID-19 and 2,084,079 fatal cases due to the disease. For each country, the CFR was calculated by dividing the number of deaths by the number of confirmed cases.

Results. The overall case fatality ratio, derived by dividing the number of deaths (n=2,084,079) by the number of confirmed cases (n=97,225,719), was 2.14 %.

In the group of countries analyzed, the CFR ranged from 0.17 % in Qatar to 28.94 % in Yemen, and the average value of CFR was 2.20 ± 2.48 %. Due to the fact that the CFR values in Mexico (8.56 %) and Yemen (28.94 %) significantly exceeded the CFR values of other countries with high CFR values (China – 5.23 %; Egypt - 5.50 %; Sudan - 6.10 %; Ecuador - 6.16 %; Syria - 6.44 %), data from Mexico and Yemen were excluded from further calculation.

[1] Here and below 'Countries' means 'Countries and Territories'.

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1.2. Calculation of CFR among COVID-19 patients of 159 countries

Material and Methods. In the subsequent calculation, 159 countries (72.60% of 219) with a total population of 7,370,020,129 people (94.47% of 7.801.382.128), with 95,534,660 COVID-19 cases, and 1,939,096 fatal cases were included.

Results: In 159 countries, CFR ranged from 0.17% in Qatar to 6.45 % in Syria, with an average value of CFR = 1.99 ± 1.20 %. Based on the calculated CFR values, all countries were divided into 13 groups as shown in Figure 1.

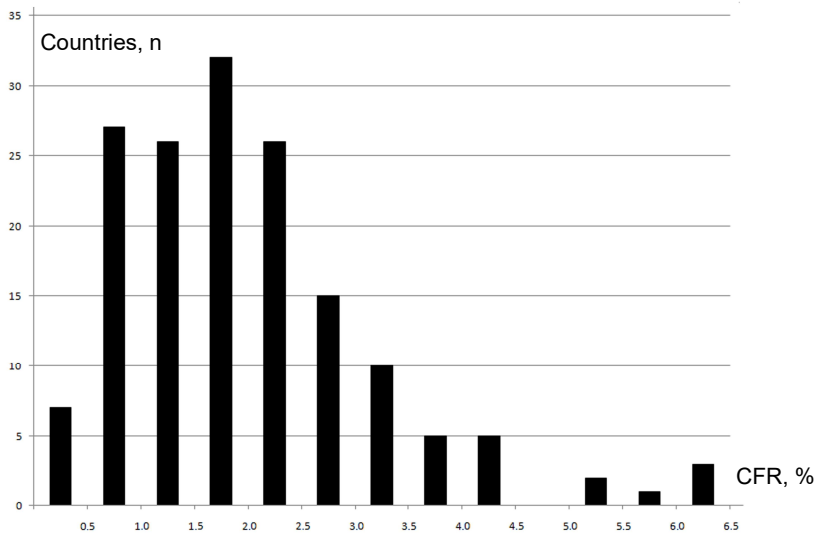

Figure 1: Distribution of 159 countries into 13 groups according to CFR value.
Group numbers: 1) CFR < 0.5%, n=7; 2) 0.5-1.0%, n=27; 3). 1.0-1.5%, n=26; 4). 1.5-2.0%, n=32; 5) 2.0-2.5%, n=26; 6) 2.5-3.0%, n=15; 7) 3.0-3.5%, n=10; 8) 3.5-4.0%, n=5; 9) 4.0-4.5%, n=5; 10) 4.5-5.0%, n=0; 11) 5.0-5.5%, n=2; 12) 5.5-6.0, n=1; 13) 6.0-6.5%, n=3.

The 1st group with the lowest CFR (<0.50 %) included 7 countries: Qatar (0.17 %), UAE (0.29 %), Bahrain (0.37 %), Malaysia (0.37 %), Botswana (0.47 %), French Guiana (0.50 %) and Sri Lanka (0.50 %).

The largest 4th group (CFR = 1.50-2.00 %) included 32 countries where the CFR varied from 1.50 % to 2.00 %: Bangladesh (1.50%), Malta (1.51%), Finland (1.54%), Libya (1.54%), Ireland (1.54%), Ethiopia (1.55%), Equatorial Guinea (1.60%), Panama (1.62%), Cameroon (1.62%), Portugal (1.63%), Czech Republic (1.63%), Slovakia (1.64%), Togo (1.66%), USA (1.66%), Kyrgyzstan (1.67%), Hong Kong (1.69%), South Sudan (1.70%), Guadeloupe (1.71%), Saudi Arabia (1.73%), Morocco (1.74%), Kenya (1.75%), Switzerland (1.77%), South Korea (1.78%), Latvia (1.79%), Trinidad and Tobago (1.79%), Austria (1.82%), Armenia (1.83%), Ukraine (1.83%), Russia (1.86%), Albania (1.86%), Suriname (1.88%), and the Philippines (1.99%).

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The groups # 9-13, where CFR exceeded 4.00 %, included 11 countries: Mali (4.03%), Bulgaria (4.05%), Iran (4.23%), Afghanistan (4.35%), Liberia (4.42%), Bolivia (5.04%), China (5.23%), Egypt (5.50%), Sudan (6.10%), Ecuador (6.16%), and Syria (6.44%).

Conclusion.

The calculations done in this section showed that in 34 out of 159 countries, the case fatality ratio was less than 1.00%, in 58 countries it varied between 1.00% and 2.00%, and in 67 countries it was more than 2.00%. In 7 out of 159 countries, the CFR was less than 0.50%.

1.3. Calculation of CFR among patients of 58 countries excluded from the main study

Material and Methods. The group of countries excluded from the main study consisted of 18 countries without fatal cases related to COVID-19, and 40 countries where the number of fatal cases due to COVID-19 was from 1 to 49. In these 58 countries with a total population of 271,490,814 people there were 132,846 cases of COVID-19 and 578 deaths caused by COVID-19. For each country, the CFR was calculated by dividing the number of deaths by the number of confirmed cases.

Results. Since there were no fatal cases due to COVID-19 in 18 out of the 58 countries, CFR was 0.00 % (<0.50%). In the remaining 40 countries, CFR ranged from 0.05 % in Singapore to 10.00 % in Western Sahara, with an average CFR value of 1.57±2.09 %. In 22 out of 40 countries CFR was less than 1.00 %, in 11 countries CFR was between 1.00 % and 2.00 %, and in the remaining 7 countries, CFR was more than 2.00 %. In 13 out of 40 countries CFR was less than 0.50 %.

Conclusion. If the previous calculations done in section 1.2, and the CFRs of Mexico and Yemen were to be taken into account, then in 74 out of 219 countries, CFR was less than 1.00 %, in 69 countries CFR varied between 1.00 and 2.00 %, and in 76 countries, CFR was more than 2.00 %. In 38 out of 219 countries, CFR was less than 0.50 %.

1.4. Analysis of the effect of population age on CFR among COVID-19 patients

Background. According to the databases which dealt with population age [14], only one out of 11 countries with CFR>4.00 % - Bulgaria, was included in the list of the top 50 countries with the largest percentage of old adults.

Material and Methods. To study the effect of age on CFR, two parameters were used – median age of a population, and the percentage of 'aged' people who were 65 years and above [12-14]. 218 countries were divided into two groups: the first group consisted of 109 countries where CFR was less than a median value (Libya, CFR=1.54 %), while the second group consisted of the remaining 109 countries where CFR was more than the median value.

There were also comparisons of the same parameters in the group of countries with low, medium and high case fatality rates.

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Results. In the first group of 109 countries, the average value of median age was 31.51±8.92 years, and aged people accounted for 9.84±6.57 % of the total population. In the second group of 109 countries, these parameters were 31.44±9.75 years and 10.14±6.68 %, respectively. There was no significant difference between analyzed parameters counted for both groups of countries ($p>0.05$).

In the group of 74 countries with CFR<1.00%, the average median age was 32.22±8.69 years, and aged people accounted for 9.85±6.29 % of the total population; in the group of 69 countries (CFR: 1.00-2.00%), the analyzed parameters were 31.80±9.54 years and 10.42±6.92 %; and in the group of 76 countries (CFR>2.00 %) the analyzed parameters were 30.38±9.76 years and 9.66±6.73 %, respectively. There was no significant difference between analyzed parameters counted for each of the three groups of countries.

Conclusion. The calculations done in this section revealed a wide variation of CFRs among different countries, but CFR value was not dependent on median age and percentage of aged people living in the analyzed countries.

1.5. Dynamics of CFR changes during 52 weeks (Mar 8, 2020 – Mar 6, 2021).

Objective. To study the dynamics of CFR after the announcement of the pandemic on March 11, 2020.

Material and Methods: To calculate the dynamics of CFR worldwide the databases of global daily new cases and daily deaths during 52 weeks (Mar 8, 2020 – Mar 6, 2021) were collected on the Worldometers website on March 11, 2021. During the analyzed time there were 116,959,185 new cases of COVID-19 and 2,596,118 deaths caused by COVID-19 [10].

Since a weekly cycle of mortality among patients with COVID-19 was discovered [15], every week was considered a separate unit. The sum of new cases and the sum of deaths were calculated for each of the 52 weeks. After that the 52 CFRs were calculated by dividing the number of weekly deaths by the number of weekly new cases. Daily CFR was calculated too.

Results. The overall global CFR value was 2.22 %. The highest weekly CFR = 8.51% was calculated for the 6th week (Apr 12-18, 2020), and the lowest weekly CFR = 1.31% was calculated for the 34th week (Oct 25-31, 2020). Dynamics of the weekly CFR is illustrated in Figure 2. The highest daily CFR = 9.51 % was on Apr 17, 2020, and the lowest daily CFR = 1.07 % was on Oct 25, 2020.

Conclusion. The highest global weekly and daily CFR was in April, 2020, when clinical trials on the use of medicines for the treatment of COVID-19 were in the initial phase [16]. The lowest weekly and daily CFR was in October, 2020, when the majority of clinical trials had already been completed, and effective therapeutic protocols had been designed and recommended for worldwide application [16, 17]. Further increase of the CFR globally and in some countries requires additional investigation.

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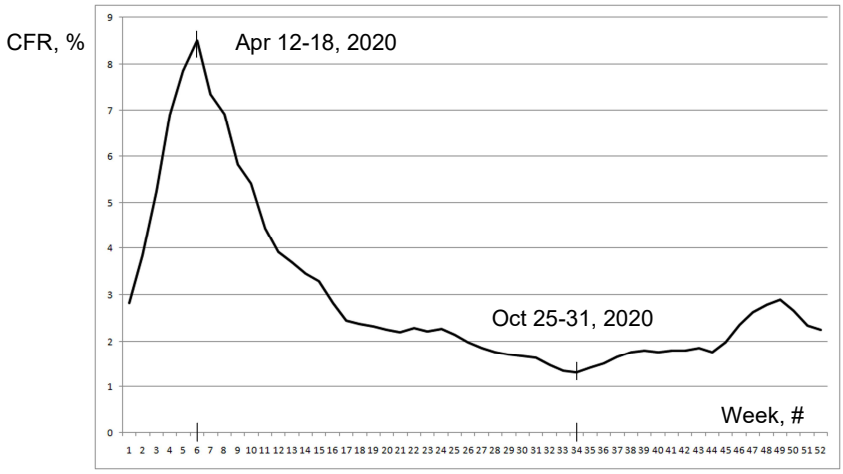

Figure 2. Dynamics of the global CFR during 52 weeks (Mar 8, 2020 – Mar 6, 2021).
In the above graph, the X axis shows the number of each week, while the Y axis shows CFR (%).

2. Infection fatality ratio among COVID-19 patients in 219 countries

Objective. To study Infection Fatality Ratio in 219 countries and to evaluate if parameters of a population age affect IFR.

2.1. *Material and Methods*. After collecting the databases, countries with fewer than 50 reported cases of deaths, countries without information on the number of tests on SARS-CoV-2 performed, and countries where the number of tests performed exceeded the total population, were excluded from the IFR study group.

The remaining 141 countries (64.38 % of 219) had a total population of 7,225,048,939 people (92.61 % of 7,801,382,128), 95,806,806 confirmed COVID-19 cases, 2,069,176 COVID-19-related deaths and 1,298,969,684 COVID-19 tests conducted.

Before estimation of an IFR, it was assumed that each person was tested only once, and the distribution of infected people among the entire population was equal. Therefore, the number of infected people was expected to increase in direct proportion to the increase in the number of new tests performed. So, to calculate the estimated number of infected people, the following formula was applied: the total number of infected individuals was derived from the number of total confirmed cases divided by the total number of tests performed and multiplied by the total population.

First, the estimated number of infected people was calculated based on the number of confirmed cases of COVID-19, the number of tests performed and the population of the country. Then, IFR was calculated by dividing the number of deaths due to COVID-19 by the estimated number of people infected with the SARS-CoV-2 virus.

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Results.

Since 95,806,806 COVID-19 cases were detected after 1,298,969,684 tests, it can be expected that if the number of tests would reach the total population (n=7,225,048,939), the total number of infected people would increase to 532,890,698. Thus, the overall IFR for 141 countries would be 0.388 %.

Among 141 countries analyzed, the IFR ranged from 0.005 % in Guinea (the minimal value) to 2.575 % in the United Kingdom (the maximal value).

Based on the estimated IFR values, all the countries analyzed were divided into 13 groups, as illustrated in Figure 3.

The first and largest group with the lowest value of IFR (< 0.20%) included 67 countries. Some of the countries had quite large populations, for example, India with a total population of 1,387,530,727 people had an IFR of 0.197 %; Indonesia (275,127,290; 0.089%), Pakistan (223,256,147; 0.071%), Nigeria (208,944,590; 0.007%), Bangladesh (165,599,479; 0.032%), Japan (126,259,973; 0.066%), Ethiopia (116,527,002; 0.025%), the Philippines (110,388,276; 0.134%), etc. But other countries in this group had small populations, for example, Mayotte (276,431; 0.151%), French Polynesia (281,811; 0.067%), Cabo Verde (559,335; 0.181%), Suriname (589,549; 0.106%), Guyana (788,664; 0.139%), etc.

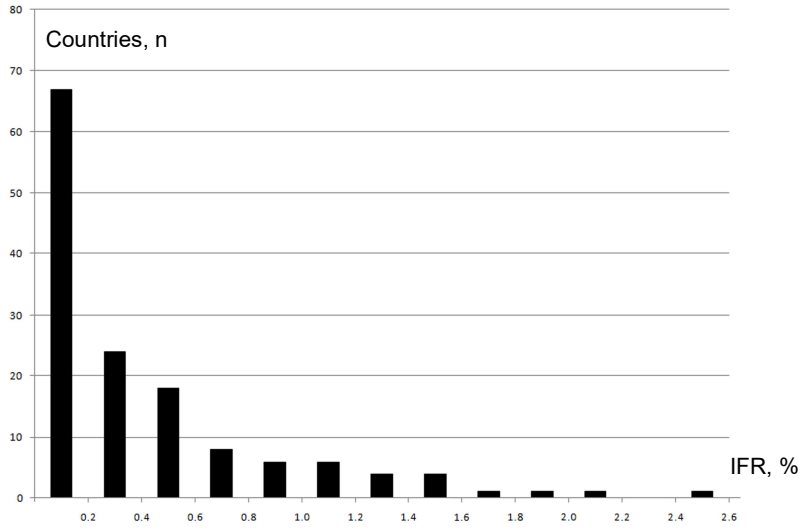

Figure 3: Distribution of 141 countries into 13 groups according to IFR value.
In the graph above, the X axis shows IFR value (%), while the Y axis shows the number of countries in the group. Group numbers: 1) IFR < 0.2%, n=67; 2) 0.2-0.4%, n=24; 3) 0.4-0.6%, n=18; 4) 0.6-0.8%, n=8; 5) 0.8-1.0%, n=6; 6) 1.0-1.2%, n=6; 7) 1.2-1.4%, n=4; 8) 1.4-1.6%, n=4; 9) 1.6-1.8%, n=1; 10) 1.8-2.0%, n=1; 11) 2.0-2.2%, n=1; 12) 2.2-2.4%, n=0; 12) IFR: 2.4-2.6%, n=1.

The groups with high values of IFR (>1.00 %) included Lithuania (1.001%), Latvia (1.016%), Hungary (1.024%), Portugal (1,050%), Germany (1.074%), Canada (1.126%), Russia (1.246%),

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Liechtenstein (1.247%), Greece (1.376%), Hong Kong (1.386%), the United States (1.461%), Spain (1.461%), France (1.497%), Australia (1.552%), Italy (1.716%), Belgium (1.998%), San Marino (2.128%), and the United Kingdom (2.575%).

Conclusion.

The calculations done in this section showed that in 123 out of 141 countries, the IFR was below 1.00 %, in 16 countries IFR was between 1.00 and 2.00 %, and only in 2 countries IFR was above 2.00 %. In 101 out of 141 countries IFR was less than 0.50 %.

2.2. Estimation of IFR in the 78 countries excluded from the main study

As mentioned above, countries with fewer than 50 reported cases of deaths, countries without information on the number of tests performed, and countries where the number of tests performed exceeded the total population, were excluded from the IFR study group.

Methods and Results.

Considering that IFR is always less than CFR, we can estimate the highest possible value of IFR for the countries without information on the number of tests performed (n=13), and countries where the number of tests performed exceeded the total population (n=14). In 10 out of the 27 countries of this group, both CFR and IFR were less than 1.00%, in 5 countries, CFR and IFR were between 1.00% and 2.00%, and in 12 countries, both CFR and IFR were more than 2.00%. In 5 countries of this group CFR and IFR were less than 0.50%.

In 18 out of the 78 countries, there were no reported deaths due to COVID-19, so both CFR and IFR were 0.00%.

In the remaining 33 countries with fewer than 50 reported cases of deaths, IFR was calculated in a similar manner described in section 2.2. In 32 out of 33 countries IFR was less 1.00%, and in 1 country IFR was between 1.00% and 2.00%. In 30 out of 33 countries IFR was less than 0.50%.

Conclusion.

The calculations done in the section 2.1. and 2.2. revealed that in 183 countries (83.56 % of 219) with a total population of 6,551,338,310 people (83.98 % of 7.801.382.128), IFR was less than 1.00 %, in 22 countries IFR was between 1.00% and 2.00 %, and only in 14 out of 219 countries IFR was more than 2.00 %.

In 154 out of 219 countries (70.32 % of 219) with a total population of 4,844,054,092 people (62.09% of 7.801.382.128) IFR was less than 0.50 %.

Since some of the patients were tested more than once, the real IFR values could be lower than presented in the study.

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2.3. Analysis of the effect of age on IFR among COVID-19 patients

Background. According to the database which dealt with population age, 17 out of 36 countries with IFR>1.00 % were included in the list of top 50 countries with the largest percentage of old adults [14].

Objective. To evaluate if parameters of a population age affect IFR.

Material and Methods. To study the effect of age on IFR, two parameters were used - median age and the percentage of 'aged' people [12-14]. 218 countries were divided into two groups: the first group consisted of 109 countries where IFR was less than a median value (Tunisia, IFR=0.208 %), and the second group consisted of the other 109 countries, where IFR value was more than the median value.

Results. In the first group of countries, the average value of median age was 27.06±8.05 years, and aged people were 7.00±4.88 % of the total population. In the second group, these parameters were 35.82±8.45 years and 12.93±6.82 %, respectively. There was a highly significant difference between analyzed parameters counted for both groups of countries: for median age $p<0.05E-11$ and for percent of aged people $p<0.05E-10$.

Conclusion. The calculations and analysis done in this section has revealed a correlation between IFR value and median age and percentage of aged people living in the analyzed countries: the younger population – the less value of IFR.

Discussion

In this study two main parameters of mortality from COVID-19 were estimated. As a result of the CFR calculation, countries were distributed from a minimum value of 0.17% in Qatar to a maximum value of 28.94% in Yemen. Likewise, based on IFR calculations, countries were distributed from a minimum value of 0.005% in Guinea to a maximum value of 2.575% in the United Kingdom.

For some countries, their position between minimal and maximal values of CFR and between minimal and maximal values of IFR were different. For example, Mexico (CFR=8.56%) and Yemen (CFR=28.94%) had the highest values of CFR. However, when calculating the infection fatality ratio, their IFRs (0.017% for Yemen and 0.280% for Mexico) were lower than the overall IFR for 141 countries (0.388%).

Nevertheless, other countries had low values for both IFR and CFR: in 74 out of 219 countries both parameters of mortality were less than 1.00 %, and in 38 countries they were less than 0.50 %. The latter group of countries included Malaysia with a population of 32,595,582 people, Sri Lanka (21,463,233 people), Cambodia (16,846,976 people), Burundi (12,084,506 people), UAE (9,956,592 people), Laos (7,333,942 people), Singapore (5,875,898 people), etc. 13 out of 38 countries were in Asia, 8 in North America, 7 in Oceania, 5 in Africa, 2 in Europe and 2 were in South America.

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A correlation between the percentage of aged population and mortality was revealed only for IFR, but not for CFR. According to earlier publications, mortality due to COVID-19 depended on continents, countries, regions, patients' age, comorbidities, money spent on health care, therapeutic protocols used, etc. [4-5, 18-20].

Conclusion

More than a year has passed since the COVID-19 pandemic was announced. The global health care system has gone through serious trials and seemed to have emerged victorious. Under the leadership of WHO, hundreds of clinical trials have been carried out [16], which have led to the development of effective therapeutic protocols with the application of well-known medicines used successfully for many years [17].

Current estimations of both CFR and IFR have led to the conclusion that the danger of the disease caused by the new SARS-CoV-2 virus was significantly less than expected at the time of its emergence [21]. About a third of the countries analyzed have emerged as leaders in the fight against COVID-19, as they have successfully brought the fatality rate to a minimal level. In these countries, every fatal case caused by the SARS-CoV-2 was treated as a tragic exception rather than a typical outcome of a new disease. Countries which have been successful in fighting this new disease should be emulated, especially by those countries where the fight against COVID-19 has not been so successful.

Thus, this study provides an objective basis for optimism and inspires a hope for an early end to the pandemic.

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