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Dynamics of Infections and Number of Vaccines Needed to Avoid Covid-19 in Europe

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Abstract

The work analyzes the dynamics of transmission of infections by the new coronavirus in twelve European countries, including France, Germany, Italy, Spain, UK, Austria, Croatia, Denmark, Greece, Romania, Czech Republic, and Portugal, whose data from contagion were obtained by Johns Hopkins University until September 24, 2020. The study confirmed that this new coronavirus (SARS-CoV-2) surprised all the countries of the world that had to improve their public health policies to confront this disease according to the results obtained from the calculation of the mantissa. Although the countries were able to improve their policies after the first wave of contagion, Spain and France have the highest proportion of cases that stand out significantly with the rest of the countries in the second wave of infections that the world faces again. Likewise, the beginning of the epidemic outbreak was determined, which could help to track the spread of the disease through European countries (not the first case registered in each country), from which it can be inferred that the outbreak begins in Italy and later the rebound begins in Germany, France, and Spain. Within days, it significantly affects Greece and Austria, reaching Denmark, the Czech Republic, Romania, and Croatia. Finally, the number of people who must be vaccinated to counteract the advance of Covid-19 in these European countries was determined based on the calculation of the Effective Reproductive Number, R_t. The number of people that would have to be vaccinated in all these countries to counteract this disease sums up to 206.830.361.

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Introduction

The world is facing a pandemic caused by a new coronavirus (SARS-CoV-2) that has generated more than 30 million people infected and nine hundred thousand deaths distributed in more than 180 countries, according to data recorded by Johns Hopkins University on September 24th, 2020.

Thanks to the systematic registration of the information, the scientific community is continually creating models to monitor and predict the dynamics of Covid-19 infections, allowing, for example, designing and improving public health policies in a given country as well as preventing the spread of this disease in the future for example [1-3].

After the experience obtained by the different countries in the first wave of the pandemic, it was to be expected that the following waves of infections should not have a significant impact as the first, as a result of the measures necessary to avoid further contagions, such as monitoring compliance with distancing social, case tracking, early detection of asymptomatic cases by PCR, etc.

In parallel, it has been observed that in record time, there are efforts at international level to develop a vaccine to help counteract this epidemic. For this reason, we here propose to study the dynamics of infections in twelve European countries selected in the first wave of infections, and finely calculate how many people should be vaccinated in each country to stop the advance of the epidemic in each country.

Methodology

The data on infections by Covid-19 corresponding to France, Germany, Italy, Spain, UK, Austria, Croatia, Denmark, Greece, Romania, Czech Republic, and Portugal have been obtained from Johns Hopkins University, from December 31st, 2019 to September 24th, 2020. Subsequently, the ratio between the number of cases of contagion and the population density per Km^2 has been determined to visualize their impact. Surprisingly, this type of representation is not used in the scientific literature to the author's knowledge.

Likewise, the elapsed time from the first case of Covid-19 detected in each country until the beginning of the epidemic outbreak (characterized by an exponential growth) was determined. This time indirectly indicates how effective the measures adopted by each country have been to avoid contagion by Covid-19.

In parallel, the mantissa value of the total accumulated cases was calculated according to the methodology proposed by Isea [4-6], which allows visualizing the rhythm of the "infection rate" as a function of time, according to the following equation:

$$\text{Mantissa (Cases)} = \text{Log}_{10}(\text{Cases}) - \text{Integer}[\ (\text{Log}_{10}(\text{Cases}))\ ]$$

where $\text{Log}_{10}(\text{cases})$ is the base 10 logarithm of the cases recorded daily, and 'Integer' is the integer part of the value obtained.

Finally, the value of the Effective Reproduction Number (R_t) is estimated according to the Wallinga and Lipsitch methodology [7], which has been validated in several scientific articles [4,5]. This basically consists of determining a function called the generation time (mGT), which is the lag time between infection in a primary case and a secondary case. Thus, the population needed to be vaccinated will simply be [8]:

$$(1-1/R_t)N$$

where N is the population per country, where there is no immunity in the population.

Results

Figure 1 shows the result of the ratio between the number of accumulated infections and the population density per Km^2 as a function of time. This result reveals that Spain (represented in green) presents a contagion dynamic much higher than the rest of the countries, followed by France in yellow. To a lower extent, there are the cases observed in Italy, UK, Portugal, and Germany. The cases reported in Romania and the Czech Republic are beginning to increase, but very slowly compared to all the previous ones. Based on this result, Spain is the country that has been able to control this disease the worst since it began.

Figure 2 shows the number of infections by Covid-19 in France (red color) and Germany (blue) as a function of time. This figure reveals that the epidemic outbreak (not the first case recorded in each country) began in a similar period of time, which is indicated by the number 1. After overcoming the first wave of infections, France presents a new significant increase (indicated with the number 2) not detected in Germany.

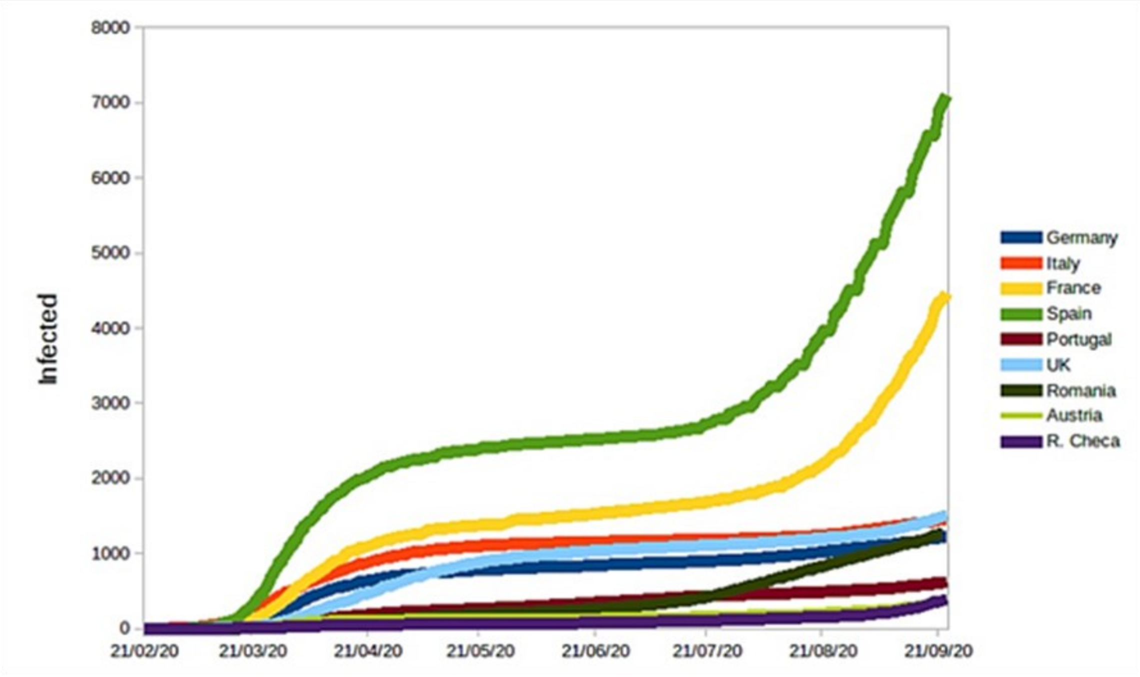

Figure 1. The ratio of nine European countries obtained from the accumulated cases of Covid-19 between the population density as a function of time.

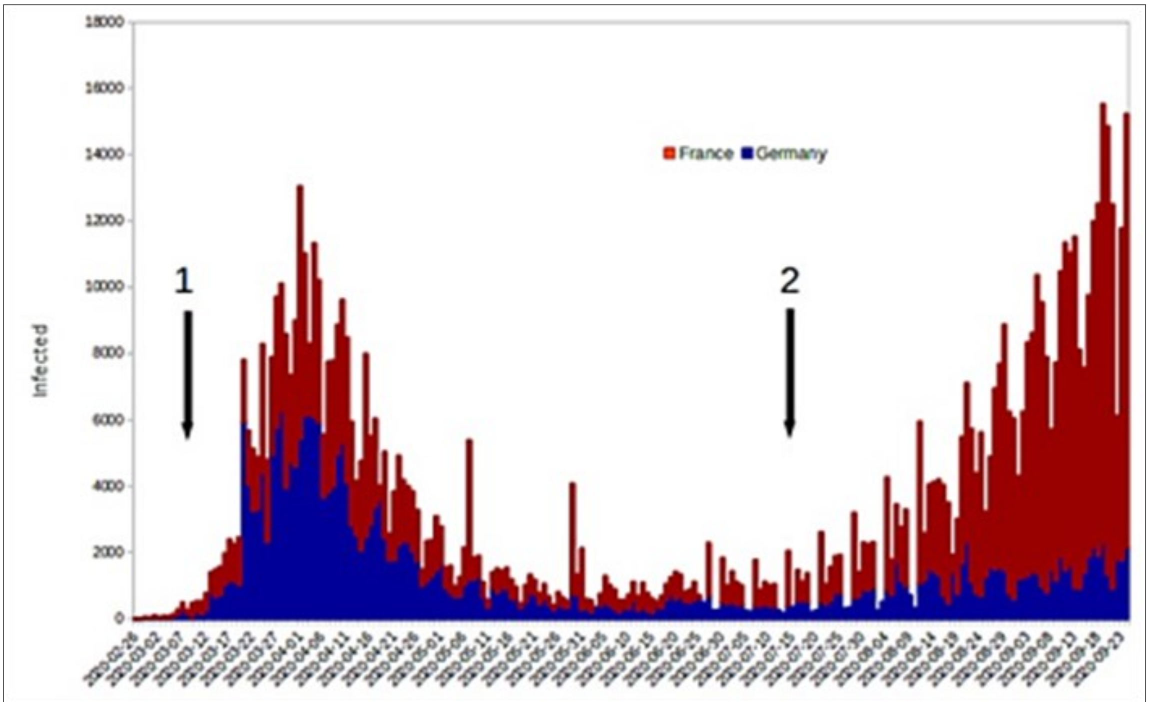

Figure 2. Total cases of contagion by Covid-19 in France (red color) and Germany (blue). The epidemic outbreak is indicated by the number 1, while the number 2 shows the start of the second wave only in France.

The behavior of the cases observed in Germany is precisely what should be observed in all the countries studied in this work, *i.e*. a reflection of the experience obtained in the first wave of infections that originated in the Wuhan market in China.

To understand how the transmission dynamics of Covid-19 infections has been in the twelve European countries, the calculation of the mantissa was determined in Figure 3. In the twelve countries, it is observed that initially they present high changes at the beginning of the epidemic, due to the fact that the curve was restarted several times, revealing the high rate of initial infections. The expected result is that this curve will be maintained or decreased over time, reflecting that these countries have controlled the disease. However, Spain and France present a high growth rate with respect to the rest of the countries, in view of the slope of the calculation of the mantissa. Likewise, Croatia, Czech Republic, Greece, and Romania show a somewhat similar growth of infections by Covid-19 compared to Germany. However, Italy is the only country whose value decreases over time, that is, they are controlling contagions with respect to the other eleven countries.

Finally, Table 1 shows the values required to obtain the value of R_t, and thus be able to determine the number of people needed to control this pandemic. When observing the values in Table 1, the fact is that there is no correlation between the number of infections and the population of each country, which refutes the idea that the more people in a country, the greater contagion.

On the other hand, Table 1 also indicates the first case reported by Covid-19 and the beginning of the epidemic outbreak calculated in the present work. It is interesting to note that the first episode recorded in each country is not a reflection of the beginning of the epidemic outbreak. In fact, based on the onset of the epidemic in each of the twelve selected countries, one could infer that the epidemic began to spread in Italy, and then, Germany, France, and Spain. Within days it reached Greece and Austria, finally reaching Denmark, the Czech Republic, Romania, and Croatia.

Likewise, when looking at the time that elapsed between the initial outbreak and the start of the epidemic in each of the countries, curiously France is the country that delayed the start of the outbreak after 34 days, followed by Germany (29 days), UK (28), and Spain (27), which can be associated with the measures adopted by these countries to contain the registered cases. Unfortunately, as indicated above, France and Spain are the ones that have least controlled the epidemic over time, while the countries with the shortest response time have managed to minimize their negative impact.

With these results, the number of people that would have to be vaccinated in all these countries to counteract this disease sums up to 206.830.361. To the authors' knowledge, this is the first time that such estimation is published.

Conclusions

The work analyzes the dynamics of Covid-19 infections in France, Germany, Italy, Spain, UK, Austria, Croatia, Denmark, Greece, Romania, Czech Republic, and Portugal. It is shown how Spain and France are the countries that present a significant increase in cases as a result of the second wave of infections by Covid-19 with respect to the other countries considered in the work. On the other hand, it is highlighted that the first case reported by Covid-19 in the country does not represent the beginning of the epidemic outbreak, so this last date should be recorded for future studies of this pandemic. In fact, the beginning of the epidemic outbreak can help to trace the spread of the disease through European countries. Thus, the outbreaks began in Italy, later in Germany, France and Spain. Within a few days, it significantly affected Greece and Austria, finally reaching Denmark, the Czech Republic, and Romania until it reaches Croatia. These results agree roughly with the calculations obtained from the value of the mantissa, such that Italy is the only country where the epidemic is being controlled by reducing the rate of infections with respect to other countries.

Finally, the number of people necessary to be vaccinated to avoid another wave of infections by Covid-19 according to the data obtained until September 24th, 2020 is obtained, but a greater number of vaccines are probably necessary in France and Spain for the sustained increase in cases that are being registered at the time of writing this paper.

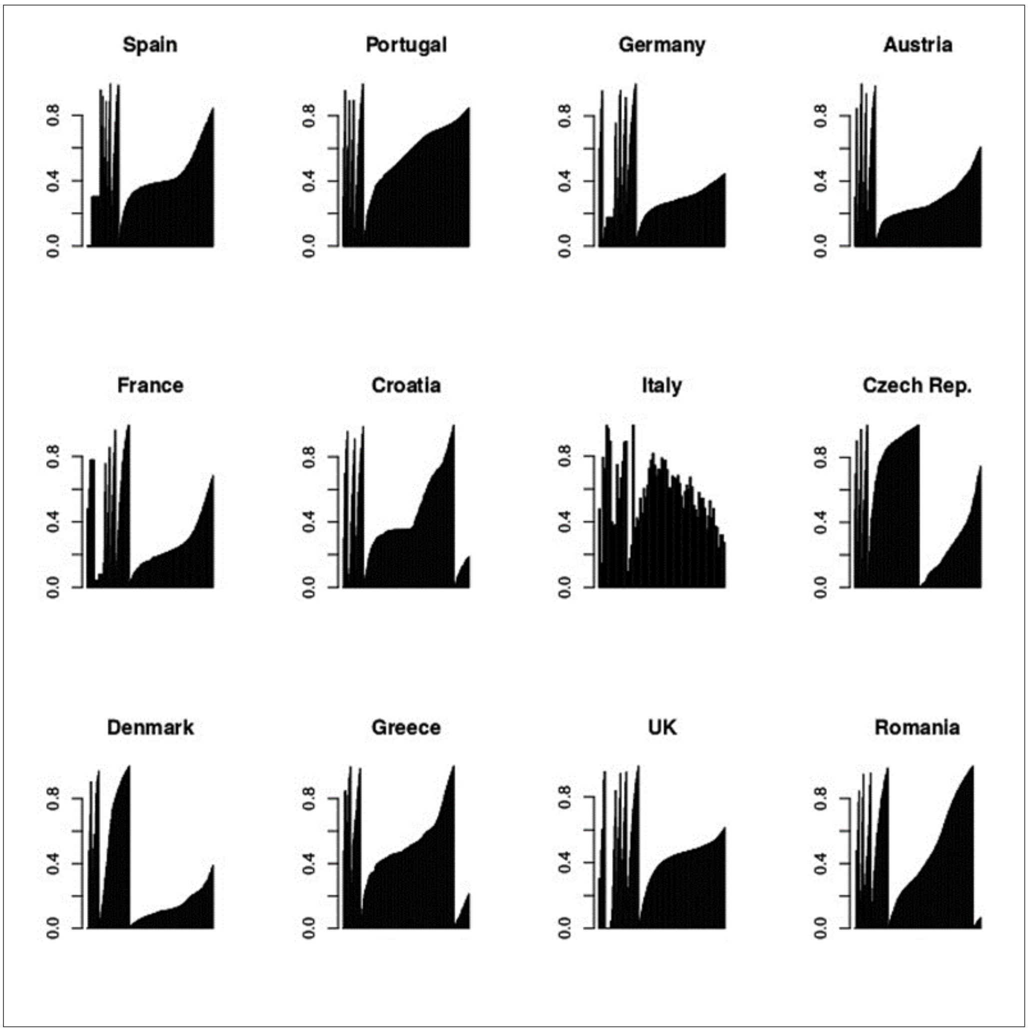

Figure 3. The results of the mantissa values in the following countries: France, Germany, Italy, Spain, UK, Austria, Croatia, Denmark, Greece, Romania, Czech Republic, and Portugal.

Table 1. The total population, the population density per Km^2, the first reported case, and the beginning of the epidemic outbreak calculated in this work. Also, the time elapsed between both events and the R_t. Ho is simply the result of calculating $(1-1/R_t)$. Finally, the numbers of people who must be vaccinated to avoid this epidemic in these countries are shown in the last column.

Country	Population	Dens. Pop. Km^2	1st reported case	epidemic outbreak	Time	R_t	Ho	People to be vaccinated
France	65,273,512	104.64	25/01/20	28/02/20	34	2.25 ± 0.02	0.56	36,263,062
Germany	83,783,945	225.36	28/01/20	26/02/20	29	3.06 ± 0.38	0.67	56,403,571
Italy	60,461,828	206.57	31/01/20	22/02/20	22	2.43 ± 0.12	0.59	35,580,417
Spain	46,754,783	97.61	01/02/20	28/02/20	27	2.34± 0.02	0.57	26,774,107
UK	67,886,004	267.25	01/02/20	29/02/20	28	1.50 ± 0.03	0.33	22,628,668
Austria	9,006,400	104.84	26/02/20	06/03/20	9	2.98 ± 0.29	0.66	5,984,118
Croatia	4,105,268	75.46	26/02/20	16/03/20	19	1.31±0.02	0.24	971,476
Denmark	5,792,203	134.81	27/02/20	09/03/20	11	1.53 ± 0.02	0.35	2,006,449
Greece	10,423,056	81.55	27/02/20	06/03/20	8	2.05 ± 0.03	0.51	5,363,320
Romania	19,237,682	90.01	27/02/20	12/03/20	14	1.83 ± 0.05	0.45	8,725,287
Czech Rep.	10,708,982	135.5	02/03/20	11/03/20	9	1.41 ± 0.23	0.29	3,113,959
Portugal	10,196,707	112.45	03/03/20	12/03/20	9	1.42 ± 0.30	0.30	3,015,927

References

1. Isea, R. (2020) La dinámica de transmisión del Covid-2019 desde una perspectiva matemática. RevistaObservadordelConocimiento, Vol. 5(1): 15.
2. Isea, R. (2020) A preliminary model to describe the transmission dynamics of Covid-19 between two neighboring cities or countries. MedRxiv ID: 20156695.
3. Kissler, AJ.,Tedijanto, C., Goldstein, E., Grad, YH., y Lipsitch, M. (2020). Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic 3period. Science, Vol. 368: 860.
4. Isea, R., y Lonngren, KE. (2020). A quick look at the registered cases of Covid-19 throughout the world. International Journal of Coronavirus, Vol. 1(3): 15.
5. Isea, R.,yLonngren, KE. (2018). Toward an early warning system for Dengue, Malaria and Zika in Venezuela. Acta Scientific Microbiology, Vol. 1(3): 30.
6. Isea, R., y Lonngren, KE. (2017). Proposal For An Early Warning System Against An AH1N1 Influenza Pandemic In America. Adv. Research Journal of Medicine and Medical Science, 1(2): 1.
7. Wallinga, J. y Lipsith, M. (2007). How generation intervals shape the relationship between growth rates and reproductive numbers. Proceedings of the Royal Society B: Biological Science. 274: 599.
8. Neal, P., y Theparod, T. (2019). The basic reproduction number, R0, in structured populations. arXiv ID: 1903.10353.