The COVID-19 Omicron wave in the framework of a new mathematical modeling in few European countriesand the right time for lifting restrictions

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Abstract

The COVID-19 Omicron wave in Romania, Bulgaria and Germany is considered within a new approach [6] for modeling Epidemics and a short comparison is made of similar application to few strongly affected countries in the beginning of 2022: the USA, the UK and France. The main novelty of that approach is the tracking of successive generations of infected people instead of treating in time the evolution of several large compartments within which the total population is partitioned (susceptible, infected, recovered,...). Because of the much strongest transmission of Omicron, its wave starts to dominate the Pandemic after some moment in time, and then the simplest version of the model [6] can be employed (without consecutive waves, no incoming from outside infected individuals e.t.c.) The daily observed new infection cases are described in a reasonable way after normalization. The position of the calculated Pandemic peaks in time in Romania and Bulgaria indicates a transition from the second to to the third generation of infected people. For comparison, in the USA, UK and France the transition is from the third to the fourth generation. The parameters derived by reproducing the data in the three countries considered are consistent with those derived earlier for the USA, the UK and France (i.e. infection and recovery rates). Due to the high contagiousness of Omicron, a very large part of the population will be gone through a contact with the virus in a relatively small period of time (3-4 months). This part is comparable to the total number of infections which occurred for two years, since the beginning of the Pandemic by end of 2019. Therefore, one may hope that some temporary acquired immunity will be reached. Adding the effects of vaccination, one may hope with moderate optimism that it will be possible to control/stop the COVID-19 Pandemic soon. However, lifting restrictions should be done carefully and country specifically, and of course at the right time, as illustrated by the examples of the UK and Germany.

The present work represents exclusively a mathematical modeling of the Pandemic and does not deal with any other aspect of health, social or economic character as well with throwing away any possibility for unexpected developments. Yet we hope that the present results will be of some help.

1 Introduction

In the beginning of 2022, the importance of the COVID-19 Pandemic's issue does not need any argumentation[2]. Since the first signals for the seriousness of that Pandemic worldwide in the beginning of 2020 [1], much has been learned about the SARS-CoV-2 virus itself, though this process is not finished because new virus variants/mutations appear with time, with different properties, including much increased contagiousness in some cases. This is the case with the Omicron variant identified in late November 2021 [3]. The present work is concerned with some mathematical aspects of addressing and modeling the Omicron-stage of the Pandemic which is now dominating or will be soon dominating in most countries of the world [4]. However, one should never forget that dealing with the development of Epidemics is a multidisciplinary subject. Epidemiologists, specialists in infections, virologists, medics with different specializations, pharmaceutics, immunologists, molecular biologists etc. naturally participate by addressing the issues relevant to them. Thus, the modeling remains just a more or less reliable quest for mathematical apparatus able for short and/or long term forecasting. In this way, it is possible to address more efficiently the issue of the health, social and economic price that societies have to pay to stop/control the Pandemic.

In particular, when in the beginning of March 2022 the Omicron wave has reached in many countries its maximum and decreasing trends are observed, the question of lifting different restrictions arises again. This time, there are objective and real preconditions which are met and which make reasonable such a program of “return to the normal”. However, this general trend cannot be a basis for automatism in dealing with the problem, within about the same nature and tempo of lifting restrictions everywhere. On the contrary, this should be done with taking into account the specific features of the situation at every place (country or even region, may be). The present work illustrates that latter need by showing the necessity of more precise modeling and observed effects of (fortunately small) changes in the decreasing trends, which are obviously related to lifting restrictions, in few European countries. The concrete cases investigated are the developments related to the Omicron wave in Romania, Bulgaria and Germany in the period 30.11.2021 (shortly after the first identification of that variant) till beginning of March 2022. Thereby, some text and illustrations from two previous publications of ours [6, 10] are widely used for support.

2 The method employed for the calculations

In general, it is highly desirable to dispose with description of the Epidemics in the full time range till its disappearing (falling in the background). However, this may be difficult for cases where an Epidemics can become endemic, pathogens undergo evolution or immunity (acquired by recovering from illness or given by vaccination) has a limited duration. To solve such problems, if possible, a class of involved Epidemics models, based so far mainly on Ref.[5], are applied, also with many further developments. These models are denoted usually as compartmental models since their idea is to partition the entire population into compartments (groups) with some transition rates describing the speed of the displacement of individuals from one compartment to another one. The simplest version is the so-called SIR model where the three compartments are those of the people susceptible to infection (S), the infected people (I) and the number of recovered people (R), all of them being functions of the time t. Other variants upgrading SIR contain more compartments including people with other, different status in the propagation of the infection and the corresponding transition rates. Thereby, in some cases an immunity with limited duration is also considered. This seems to be the case of the Covid-19 Pandemic, at least for a part of the population.

Very recently, we published [6] a new and simple method for describing Epidemics including consecutive ways. This method uses also a kind of compartmentalization, where one of the main structures is the group of infected people whose different generations are tracked. The other main structure are the generations of recovered people. This compartmentalization naturally appears in the chain of the "human to human to human ..." transmission and represents one of the novelties of the model. In the model, linear differential equations are solved [6] while e.g the SIR-like models require the solving of non-linear differential equations. Only two rates λ_R (rate of recovery) and λ_C (rate of infection or spreading rate) are employed which are assumed to be constant in time. The idea is that one is dealing with large enough population among which the process of Epidemics spreading is governed by statistical laws. Thus, the time for recovery is a random variable when many infected people are considered. As most of the models describing Epidemics, we use for the distribution of the recovery times an exponential distribution with mean recovery rate $\lambda_R = 1/\tau_R$ (with τ_R being the mean time needed for recovery). Concerning the rate of spreading the infection λ_C, comments similar to those made above about λ_R can be done with the important distinction that the former rate may be very largely influenced by measures as confinement, reduction of social contacts, reconfinement, appearance of new virus variants etc. Detailed studies on the epidemics-transmission mechanism and the possibility to control it represent for example Refs. [7, 8, 9] and references therein.

As already mentioned in Sec.1, the Omicron variant of SARS-CoV-2 is characterized by higher contagiousness than the other dominant previous variants (in different time periods), the δ-one "possessing" the previous record. Although in some countries mixing of the δ and Omicron waves is observed by mid January 2022, in others a very strong effect of increase of the daily new cases indicates the forthcoming dominance of Omicron. The very simple mathematics in Ref.[6] opens the possibility to forecast the development of Epidemics in time for different infection and recovery rates. This is quite relevant for getting a fast idea for cases related to the appearance of strongly contagious infection pathogens as Omicron. The main point is, as it is in many scientific disciplines, that when one factor dominates all other factors which influence somehow a phenomenon, scientists consider such a case as a testing ground for checking a particular model and simultaneously learn more about the overwhelmingly dominant factor. Simply the picture at an early stage is quite pure and not obscured by later developments which are likely to occur because of some desynchronizations in the otherwise globalized world.

The relevant data sets of points for Romania, Bulgaria and Germany were taken from the site [11] and is displayed in Figs. 1,2,3c with open diamonds. They cover the time range from 30.11.2021 to about 05.03.2022. As discussed in Ref.[6], it is clear that the total population is not tested every day nor the number of people tested each day is the same. Therefore it is necessary to perform a normalization of the raw data for following better in time the absolute number of new daily cases of infections. In this way, fully comparable numbers are directly considered. Of course, one has to keep in mind that they are related to some constant fraction of the total population. There are factors, however, which may bias the normalization as e.g. possible concentration of tests in regions of the country with higher number of new cases or within clusters of enhanced transmission, several tests for one individual in the period considered e.t.c., and these factors may vary with time.

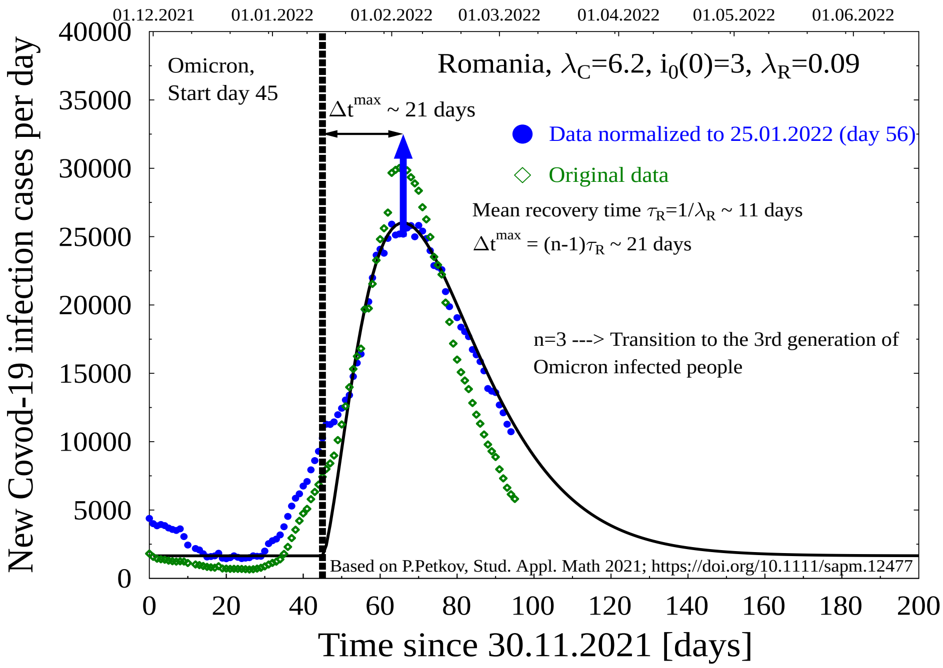

Figure 1: Development of the COVID-19 Pandemics in Romania represented by normalized newly registered cases per day (filled circles). The number of tests per day used for a day by day normalization (correction) were taken from the site [11]. The original raw data without normalization are represented by open diamonds. The plateau-like part of the data before the effect of increase is considered as a constant (averaged) background and reflecting the previous stage of the Pandemic. The calculations (fits) according to Eq.6 are represented by a continuous line. A maximum of the peak is predicted about February 4^{th}. The derived parameters are also indicated. The infection and recovery rates are in days^{-1}. See also text.

The fitting procedure to reproduce the normalized data is described in details in Ref.[6]. The best results obtained are presented in Figs. 1,2 and 3 with a continuous line. The parameters derived are also indicated. Before discussing the results, we remind the basic features of the new, tracking method employed. The first step is the determination of the evolution in time of the number of infected individuals $i_n(t)$ in the different generations enumerated by n. The first generation (or the group of the so-called zero patients) $i_1(t)$ obeys a differential equation similar to the well known radioactivity decay law of Rutherford-Soddy:

$$\frac{di_1(t)}{dt} = -\lambda_R i_1(t) \tag{1}$$

with the solution $i_1(t) = \lambda_R i_1(0)e^{-\lambda_R t}$. For the next generations, the linear differential equation for the derivative of $i_n(t)$ contains on the r.h.s. the decrease of $i_n(t)$ and the increase due to infections from the previous generation i_{n-1}, always with the same rates. The final result for the n^{th} generation reads:

$$i_n(t) = \frac{{\lambda_C}^{n-1} i_1(0) t^{n-1} e^{-\lambda_R t}}{(n-1)!}. \tag{2}$$

By summing up the number of infected people from different generations one obtains for their total number as function of time the expression

$$i(t) = \sum_{k=1,2,..N_{max}} \frac{(\frac{\lambda_C}{\lambda_R})^{k-1} n_1(0) x^{k-1} e^{-x}}{(k-1)!}. \tag{3}$$

where N_{max} is the last generation and $x = \lambda_R t$. This expression represents a sum of Poisson distributions weighted by the factors $(\frac{\lambda_C}{\lambda_R})^{k-1}$. The quantity defined as $R_0 = \lambda_C/\lambda_R$ is the so-called basic reproductive number in the framework of the present model. This reproductive number is somewhat model-dependent and is discussed in detail in [12, 13, 14, 15]. Roughly, this is the number of people who will be infected by one contagious individual till the moment when this individual completely recovers. Then, Eq.2 can be rewritten as

$$i_n(t) = (R_0)^{n-1} \frac{i_1(0)(\lambda_R t)^{n-1} e^{-\lambda_R t}}{(n-1)!}. \tag{4}$$

It is to be noted that in the formalism presented the dependence on R_0 is very strong, changes with the generation number n and is different from that in the other models designed so far to describe Epidemics in time. Then, the peak value of f $i_{N_{max}}(t)$ dominates the sum of all generations of infected people $i(t)$ of the whole epidemics. The function $i_n(t)$ has one maximum which occurs at

$$t_{max} = (n-1)/\lambda_R = (n-1)\tau_R. \tag{5}$$

If one considers $i_n(t)$ as a distribution over time, its expectation (mean) value M1= nτ_R is positioned in time after the maximum of $i_n(t)$, the difference being just τ_R. This means that the Epidemics cannot be considered by far as finished even after t_{max} +τ_R. The precise range of the epidemics depends on τ_R and n, and increases with n.

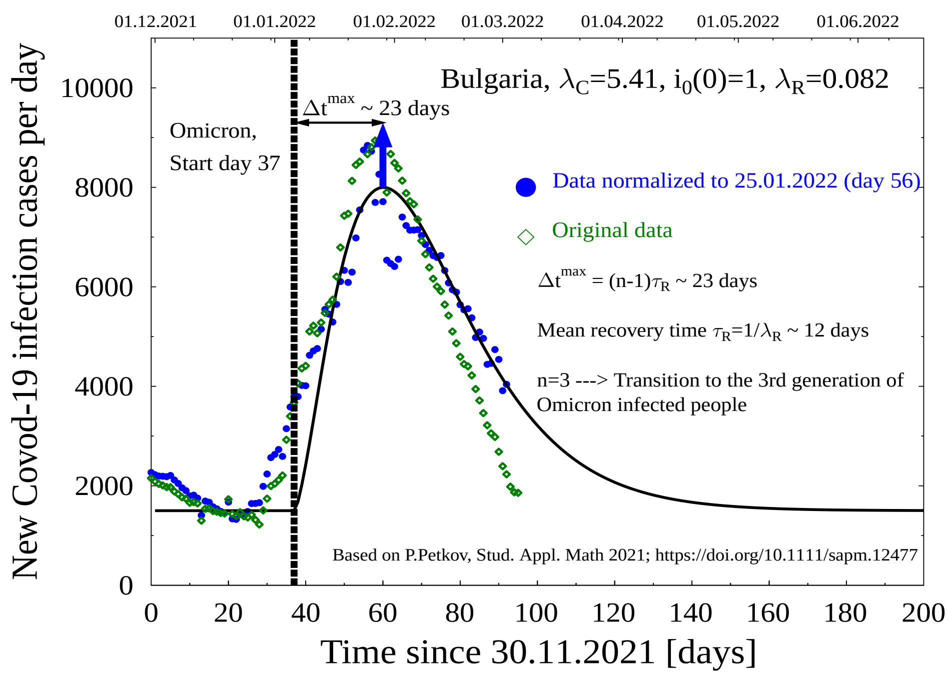

Figure 2: The same as in Fig.2 but for Bulgaria. Here, the maximum of the peak is predicted about January 29^{th}. See also text.

Concerning the daily behavior of newly infected people (i.e. the new infections per day) used to monitor the epidemics, it can be calculated as

$$C(t) = \lambda_C \sum_{n=2}^{K_{max}} i_{n-1}(t). \tag{6}$$

where K_{max} sets a limit in the generation number depending on the actual status of the epidemics at time t. K_{max} is also considered as fitting parameter [6]. The function $C(t)$ can be directly compared to the normalized data on the new cases per day in the epidemics and was used to fit the data in Figs.1,2 and 3.

3 Discussion of the results for the daily new cases of infections

The data points in Figs.1,2 and 3 display a quite complicated behavior with time, especially for the normalized points in the beginning of December 2021 and for the raw data by beginning of January. The simplest version of the model presented in Ref.[6], i.e without considering consecutive waves and infected people entering into the investigated system from outside, cannot describe all the data set. Therefore, we decided to take into account the contribution of the Pandemic before Omicron by subtracting a constant background determined by averaging over a subset of points with similar behavior with time. In this way, in the beginning of January 2022 an effect of increase is definitely observed. However, a more pure Omicron effect is observed later, preceded by a period where there is some mixed role of earlier variants (δ on top, of course) and the incoming Omicron wave. Thus, the time position of the start of the latter wave was treated as an adjustable parameter allowing a reproduction of the fast increase accompanied by a change of the slope of splines passing through a set of successive data points toward higher value. After that, calculations using Eq. 6 were performed in order to reproduce the data. In the next sections, we consider specifically the data for the three countries considered.

3.1 Romania

All data are normalized to the point at 25.01.2022 (both earlier or later registered). At this date, 77161 tests were performed in Romania [11]. The expected peak position of the fitted curve is about February 4^{th} (day 66). This corresponds roughly to 21 days after the "start" of the Omicron wave and according to the relation Δt_{max} = (n-1) τ_R (cf. Eq.5), with $\tau_R = 1/\lambda_R \approx 11$ days, indicates n=3 i.e. this is the moment when the third generation of infected people is dominant. But one should not forget that this generation provokes infections in the 4^{th} generation and without some other effects on the Pandemic's development one should arrive to even higher numbers. This does not happen and will be discussed a bit later below. Also, far beyond the maximum the raw data indicate a much faster decrease of the new infection case per day than the calculated curve and the normalized points. This deviation deserves attention when a program for gradually lifting the restrictions has to be made.

3.2 Bulgaria

The analysis presented in Fig.2 is similar to the analysis for Romania in Fig. 1, with small differences in the derived parameters. The normalization is made with respect to the data point at 25.01.2022 when 30627 test were performed. A somewhat unexpected is the behavior of the normalized point in the vicinity of the maximum which display large fluctuations. They are due to irregularities in the otherwise smooth behavior of the number of tests per day according to the site [11]. Namely, the four points around February 1st which drop down are characterized by number of tests around 40000, i.e. are larger by minimum 15% than the neighboring ones, although also obtained by a 7-day rolled procedure. The opposite effect is observed a bit earlier, just before the maximum of the calculated curve. It should be noticed that the latter is very close to the position of the maximum indicated by the raw data as well as the normalized points lie in a nearly perfect way on the calculated curve on the decreasing side. They were not used for fitting. The raw data indicate also here a much faster decrease.

3.3 Germany

The analysis presented in Fig.3 is in general similar to what has been shown in Figs.1,2 for Romania and Bulgaria, respectively. However, there are features and differences in the derived parameters which need some comments. First, the countries under comparison are very different with Germany on the single one side, indeed. For example, the population of Germany is much larger (about 80 millions) against about 6 millions for Bulgaria and 19 millions for Bulgaria, the infection rate $\lambda_C = 4.96$ days^{-1} is the smallest, the actual generation of infected people is the n=4 one. The normalization in Fig.3 for Germany was made with respect to the data point at 30.01.2022 when 364841 tests were performed. The most significant and may be important effect is the tendency for increase shortly after the maximum on February 12^{th}. In Fig.3. A vertical line indicates the date 14.02.2022 when a three-step relaxing restriction did start and few days later the expected

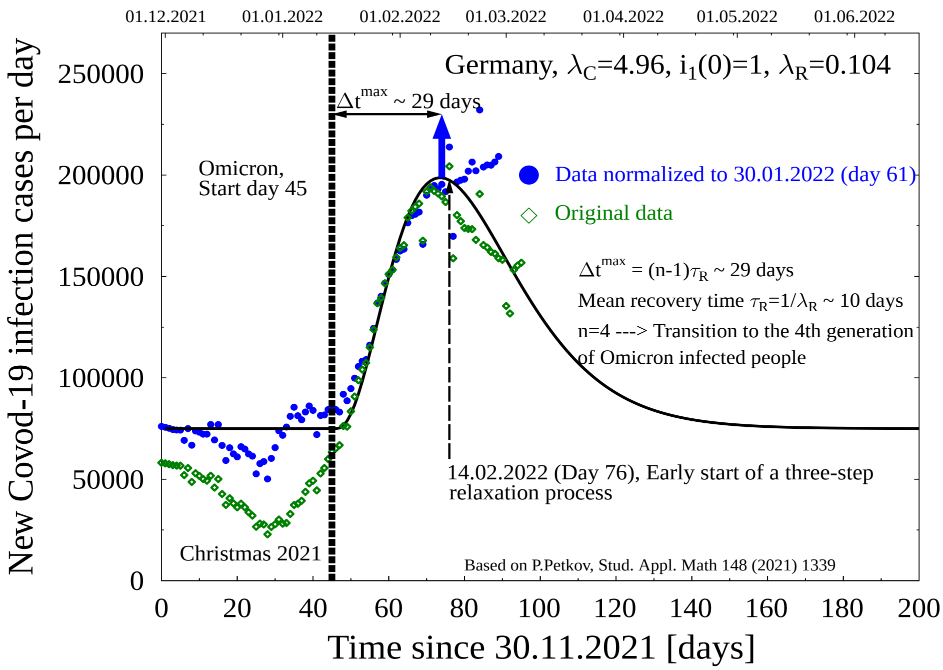

Figure 3: The same as in Fig. 1 but for Germany. Here, the maximum of the peak is predicted about February 12^{th}. A vertical line indicates the date 14.02.2022 when a three-step relaxing restriction did start and few days later the expected decreasing trend was suddenly transformed in an opposite, increasing one. See also text.

decreasing trend was suddenly transformed in an opposite, increasing one. Another difference is the drop of the new daily infection cases around Christmas 2021 which cannot be completely corrected even by the normalization on a day per day basis. This may be an indication that for the specific case of Germany the proposed way of normalization is biased by some factors which remain to be investigated. Also, large fluctuations in the behavior of the normalized points are observed in the vicinity of the maximum. Different from the case of Bulgaria (Fig.2), they cannot be associated with deviations from the smooth behavior of the time evolution of the number of tests per day. In this way, the behavior of the data in Fig.3 appears as the most complicated one among the considered in this work. It may also suggest that the process of lifting restrictions began a bit too early.

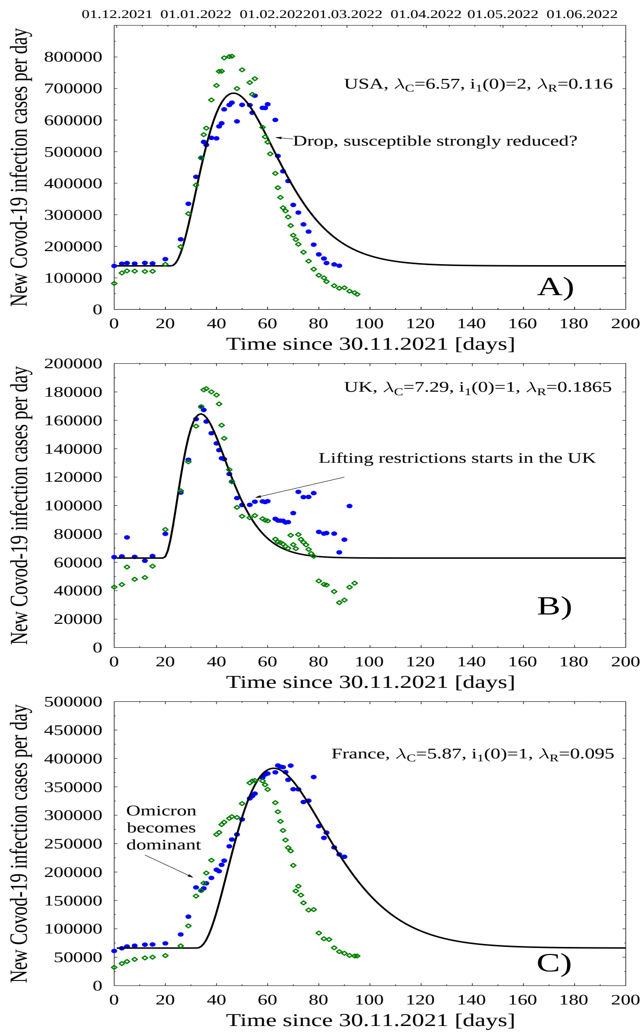

Figure 4: Part A (top):Development of the COVID-19 Pandemics in the USA represented by normalized newly registered cases per day (filled circles). The number of tests per day used for a day by day normalization (correction) were taken from the site [11]. The original raw data without normalization are represented by open diamonds. The plateau-like part of the data before the effect of increase is considered as a constant (averaged) background which reflects the previous stage of the Pandemic related developments in the future. The most successful calculation (fit) according to Eq.6 is represented by a continuous line. The derived parameters are also indicated, with the infection and recovery rates in days^{-1} The effect of the normalization is clearly seen and is rather large. An inspection of the data on the number of tests made daily show an non-interrupted reduction trend after reaching the maximum which correlates partly with the very fast decrease of the raw new daily cases. A reduction of the latter cases is predicted also by the calculation but it has a much slower character. Parts B,C: The same as in part A, but for the UK and France, respectively. For discussion of specific features seen in each of the three panels (some of them shortly indicated in the figure) see text.

An investigation of the effects of vaccination level and acquired temporary immunity, which are discussed below for some other countries, may clarify the situation.

3.4 Comparison with data from other countries

The parameters of the fitted curves in Figs. 1,2 and 3 require some comments. First of all, the infection rates λ_C= 5$\div$ 6.2 days^{-1} are very large. They can be compared to the value of 0.71 days^{-1} derived in Ref.[6] for the first wave in the USA and Europe in spring of 2020 related to the original Wuhan virus. In Table 3 of the latter work, the rates of transmission are compared in relative units with respect to contagiousness (i.e. for the Wuhan virus one has 1.0, for α : 1.4$\div$1.9, for δ: $\geq$ 3). In addition, in calculations according to the model of Ref. [6] the ratio R_0=λ_C/λ_R participates with ever increasing effect, at the power of $(n-1)$ for every next generation number n. Therefore is no wonder that the Omicron wave becomes so fast the dominant one (at present). For larger τ_R (smaller λ_R) the effect is complementary enhanced.

For comparison, we present in Fig.2 data for three other countries where the Omicron wave had a strong effect on the Pandemic in the beginning of 2022: the USA, the UK and France. The figure is taken from the investigation performed in Ref. [10] and modified for the present work by adding more data points closer to present. The reproduction of the data by the calculations in Fig.4 is reasonable in the region of increase and in the vicinity of the maximum in all three cases. The role of the normalization is also clearly seen, and in the cases of the UK and France is quite dramatic..

There are indications that the decreasing part of the data after the peak maximum can be also well described after normalization by the calculations (as it is clearly seen in the cases of the UK and France). After the maxima, the raw data for the USA and France decrease much faster than the calculated curves. This difference is related to a gradual decrease of the daily tests once the peak value has been reached. In general, after the maximum only a decrease may be expected in principle. However, a realistic estimate of its actual speed and state (i.e. when a sufficiently low level will be reached) is of importance for the control of the Pandemic and eventually lifting restrictions, for example. This is strongly suggested by the development in the UK after the initialization of such lifting measures about 21.01.2022 (Fig.4B). Large fluctuations of the new infection cases per day are observed both in raw and normalized data although in average the decreasing trend is conserved and that lifting of restrictions finally seems to be made not too early. It has also to be mentioned that the Omicron wave has started a bit earlier in the

Table 1: Summary of parameters derived by fitting the data on the new daily infection cases for the countries considered in the present work. The initial date of the Omicron wave, which is treated as an adjustable parameter, is displayed in the second column. The next three columns present the parameters of the wave used to calculate the different generations of infected people $i_n(t)$ (λ_C, $i_1(0)$ and λ_R) which best the data. All rates are in days^{-1}. The mean recovery time τ_R is shown in column 6 (in days). The next column 7 present the time t_{max} (in days) when the calculated maximum of the Omicron peak is found. The corresponding generation number "n" and the basic reproductive number R_0 are displayed in columns 8 and 9, respectively. See also text.

Country	O-start day	λ_C	$i_1(0)$	λ_R	τ_R	t_{max}	Number n	R_0
USA	25 25.01.2021	6.57	2	0.116	8.6	47 16.01.2022	4	57
UK	19 19.01.2021	7.29	1	0.1865	5.4	34 03.01.2022	4	39
France	32 05.01.2022	5.87	1	0.095	10.5	62 30.01.2022	4	62
Romania	45 14.01.2022	6.2	3	0.09	11	66 04.02.2022	3	69
Bulgaria	37 06.01.2022	5.41	1	0.082	12.2	61 29.01.2022	3	66
Germany	45 14.01.2022	4.96	1	0.104	10	64 02.02.2022	4	48

UK. In the case of the Omicron wave, the evolution downwards is related to the existence of a very large fraction of the population possessing protection against Covid-19 due to vaccination and natural (temporary) immunity acquired after recovery from being infected. The case of the USA (Fig.4A probably is a very good illustration of these circumstances with both raw and even normalized data lying below the calculated curve after the mid February. The role of the acquired immunity within the Omicron wave is supported by estimates that in 3-4 months about the same number of people are (or will be) infected as for the nearly 2 previous years of the Pandemic. The UK was the first country where such effects have been discussed and intentions of lifting gradually all restriction measures were declared, followed soon by others.

The fitted infection rates λ_C in Romania, Bulgaria and Germany are compatible with the range of values derived for the USA, the UK and France. The adjustable “start days” of the first group of countries are about 20 days later than those of the second group (with the exception of France to some extent). It may seem unexpected, but from the present perspective lifting restrictions in Romania and Bulgaria looks much more timely and reasonably than in the case of Germany. In this context, the example and the experience of the development in the UK may be very useful. It is not our intention to formulate rules for lifting restrictions, but a criterion on how much the data and fits are above the acceptable "background” at a given planed time may be also useful. Thereby, mathematical modeling has still to be employed along other guiding lines of social, health and economics character, in general.

4 Conclusions

The COVID-19 Omicron wave in Romania, Bulgaria and Germany is considered within a new approach [6] for modeling Epidemics and a short comparison is made of similar application to few strongly affected countries in the beginning of 2022: the USA, the UK and France. Because of the much larger contagiousness of Omicron, its wave starts to dominate the Pandemic at some time moment , after which the simplest version of the model [6] is employed (without consecutive waves and incoming infected from outside the system). The daily observed new infection cases are described in a reasonable way after normalization. The position of the calculated Pandemic peaks in time in Romania and Bulgaria indicates a transition from the second to to the third generation of infected people. For comparison, in the USA, UK and France the transition is from the third to the fourth generation. The parameters derived by reproducing the data in the three countries considered are consistent with those derived earlier for the USA, the UK and France (i.e. infection and recovery rates). Due to the high contagiousness of Omicron, a large part of the population goes through a contact with the virus in a relatively small period of time (3-4 months), and the resulting number of infected people is comparable with the cumulative effect of nearly two years of Pandemic. Therefore, one may hope that some temporary acquired immunity will be reached. Adding the very serious effects of vaccination, one may issue with moderate optimism a forecast for controlling/stopping the COVID-19 Pandemic soon. However, lifting restrictions should be done carefully and country specific, and at the right time, as illustrated by the examples of the UK and Germany

The present work represents only a mathematical modeling of the Pandemic and does not deal with any other aspect of health, social or economic character as well with throwing away any possibility for unexpected developments.

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Figures

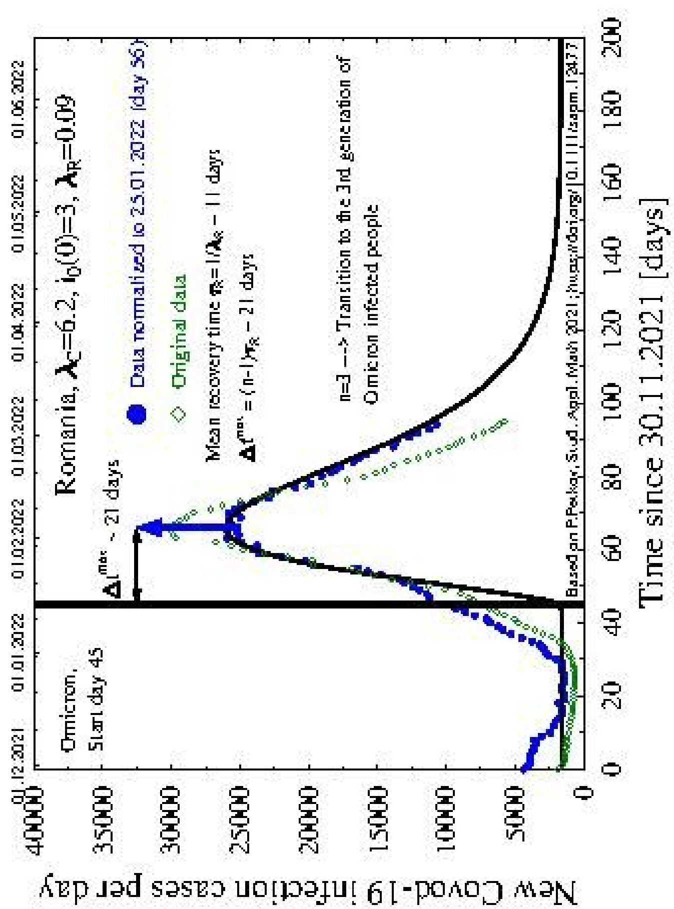

Figure 1

Development of the COVID-19 Pandemics in Romania represented by normalized newly registered cases per day (filled circles). The number of tests per day used for a day by day normalization (correction) were taken from the site [11]. The original raw data without normalization are represented by open diamonds. The plateau-like part of the data before the effect of increase is considered as a constant (averaged) background and reflecting the previous stage of the Pandemic. The calculations (fits) according to Eq.6 tare represented by a continuous line. A maximum of the peak is predicted about February 4th The derived parameters are also indicated. The infection and recovery rates are in days^{-1}

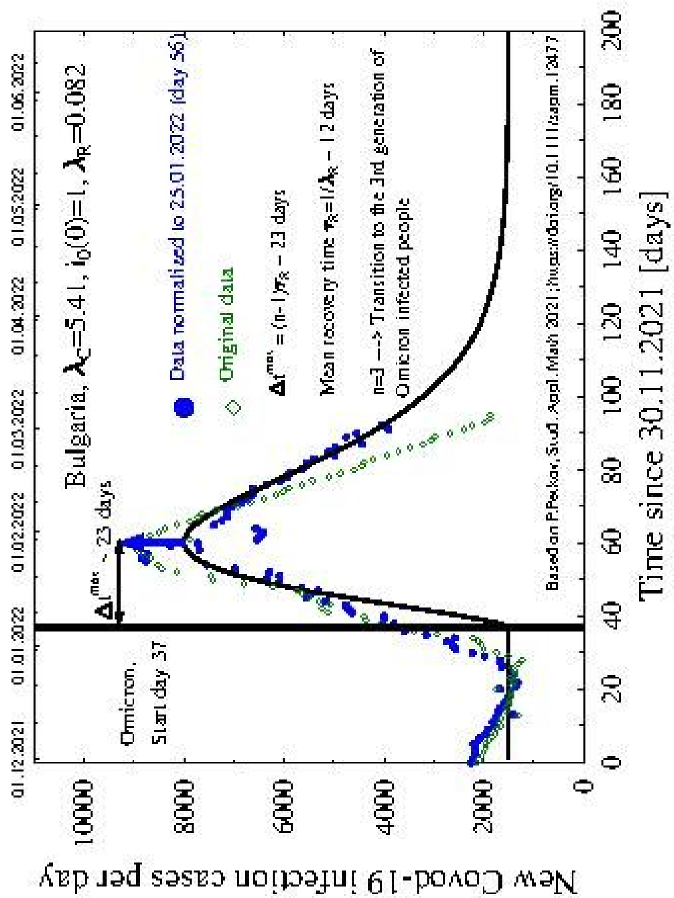

Figure 2

The same as in Fig.1but for Bulgaria. Here, the maximum of the peak is predicted about January 29th

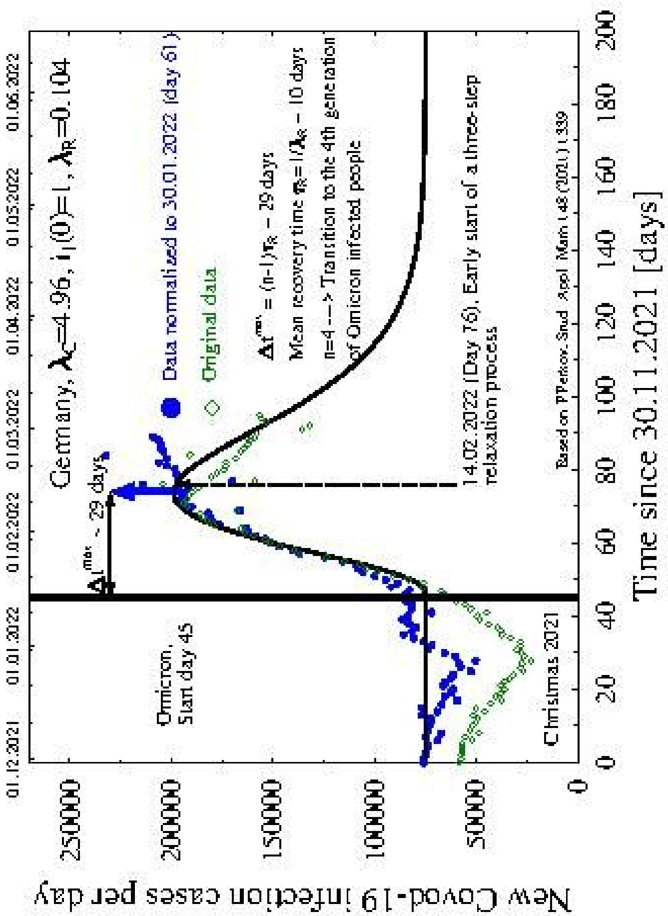

Figure 3

The same as in Fig.1but for Germany. Here, the maximum of the peak is predicted about February 12th. A vertical line indicates the date 14.02.2022 when a three-step relaxing restriction did start and few days later the expected decreasing trend was suddenly transformed in an opposite, increasing one.

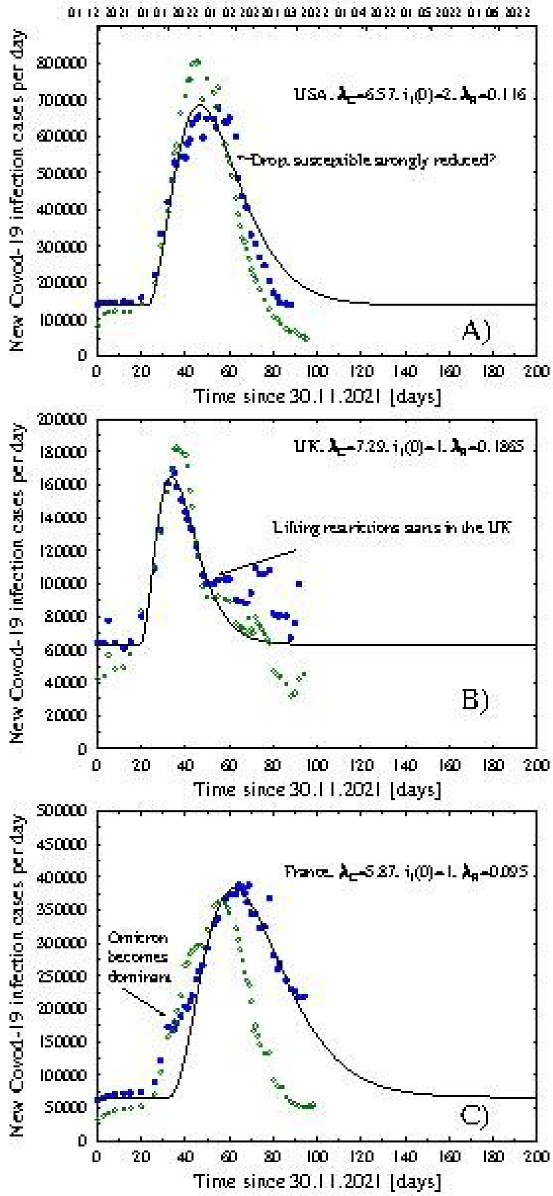

Figure 4

Part A (top):Development of the COVID-19 Pandemics in the USA represented by normalized newly registered cases per day (filled circles). The number of tests per day used for a day by day normalization (correction) were taken from the site[11] The original raw data without normalization are represented by open diamonds. The plateau-like part of the data before the effect of increase is considered as a constant (averaged) background which reflects the previous stage of the Pandemic related developments in the future. The most successful calculation (fit) according to Eq.6is represented by a continuous line. The derived parameters are also indicated, with the infection and recovery rates in days^{-1} The effect of the normalization is clearly seen and is rather large. An inspection of the data on the number of tests made daily show an non-interrupted reduction trend

after reaching the maximum which correlates partly with the very fast decrease of the raw new daily cases. A reduction of the latter cases is predicted also by the calculation but it has a much slower character.

Parts B,C: The same as in part A, but for the UK and France, respectively.

For discussion of specific features seen in each of the three panels

(some of them shortly indicated in the figure) see text.