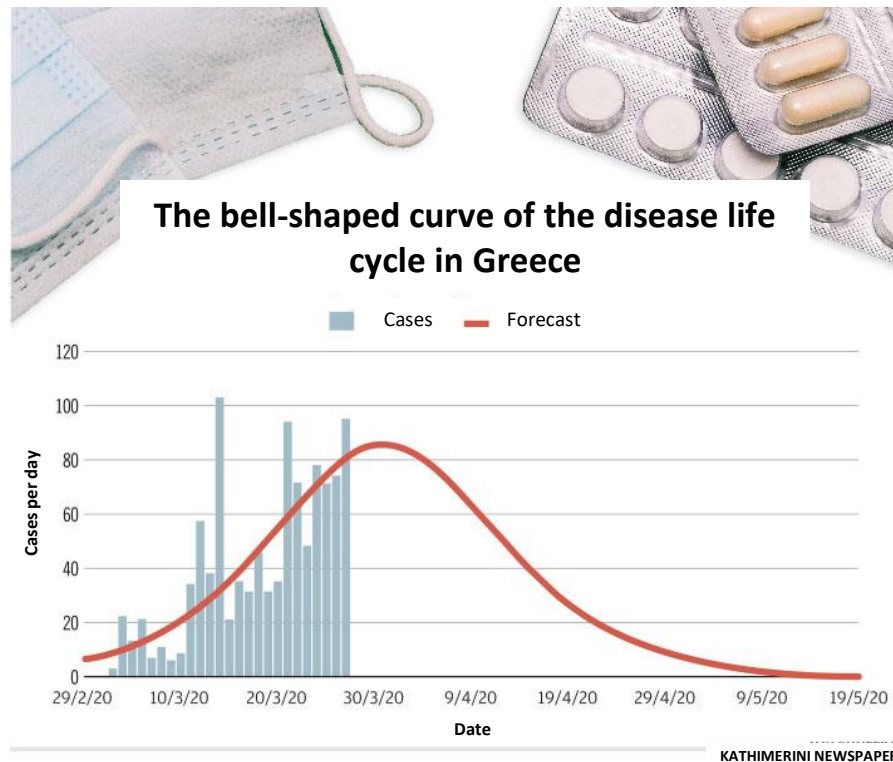


Forecast for the evolution of cases

Kathimerini Newspaper - 02.04.2020 • 22:34

GEORGIOS ATSALAKIS*, VASILEIOS TSOUMPRIS**



The growth of a phenomenon, such as a disease, quite often, according to scientific research, follows a sigmoid curve indicating normal progress. Conversely, if a phenomenon follows a sigmoid curve, then its growth process should be normal.

In both cases, the phenomenon will also be illustrated with the corresponding phenomenon life cycle under normal conditions.

The sigmoid and life-cycle curves are often used, for example, in the dissemination of new technologies. Similar use is made by biologists for the spread of diseases (see book by Th. Modis, "Predictions", Cretan Publications, 1996, in Greek).

Winning the battle against a disease, as shown by numerous scientific studies, is a stepwise process that follows a sigmoid (s-shaped) curve. Historical data for the first half of disease can help predict the second half. Moreover, the life cycle of the disease is symmetrical, so the second half of the disease cases can be predicted based on the first half.

A disease begins to subside long before the respective medication is perfected and disseminated. In the case of COVID-19, the key reasons why it should start to abate are the community's normal reaction by taking personal protection measures and the implementation of measures to prevent the spread of the virus. So the measures taken are part of a normal process that needed to be applied.

In Greece we have enough data for the period from the first recorded case on February 26, 2020 to March 28, 2020 to estimate when the virus will slow down and stop.

The period between February 26 and March 16 can be characterized as a virus incubation period for the country's population. On March 16, Greece entered a phase of sudden increase in reported cases, which will last until around the beginning of April, provided that Greek people comply with the virus response measures set by the state. After early April, the growth rate of daily cases will start to show signs of decline. After around the first half of April, the number of cases will enter the phase of steady development, i.e. the rate at which daily cases grow will decline. By mid-May, the recorded daily cases will have decreased considerably, and it is likely that the government will be able to proceed to a relative relaxation of the measures. Note that the chart describes the course of reported cases, which will total around 2,700 at the end of the epidemic. It is important that everyone observes the measures taken; for instance, if the newly recorded cases were about 70 instead of the 95 on the chart calculation day (28/3), we would all have gained 4-5 days in the above course and 25 fewer patients.

Therefore, we have enough data that enabled us to estimate when the spread of the virus will slow down and stop, because when the increase is exponential, the overall disease growth pattern is symmetrical. This symmetry is what enables s-curves to be predictive. When we reach the first half of the process, we know how the other half will turn out. The symmetry of the logistic function has been mathematically proven, but can also be intuitively understood.

We can, therefore, predict, with approximately 90% accuracy, that the spread of COVID-19 will be according to this chart. This, of course, is subject to the condition that there will be no irregularities over the next period of time (e.g. Massive numbers of people going on Easter holiday). In any case, however, this forecast serves as a timeline so that individuals, businessmen, government agencies, etc. can make better decisions. In our laboratory, Data Analysis and Forecasting, Technical University of Crete, we calculate this forecast daily (posted every few days on the fb account of Georgios Atsalakis). This forecast is a very good scenario for our country (Greece).

** G. Atsalakis is an Associate Professor at the Technical University of Crete.*

*** Vassilios Tsoumpris is a student of the School of Production Engineering and Management.*

Data Analysis and Forecasting Laboratory.

Link: <https://www.kathimerini.gr/society/1071879/provlepsi-exelixis-ton-kroysmaton/>

Opinion: Forecast for the evolution of the second wave of Covid-19 cases

Link: <https://www.kathimerini.gr/society/561069982/apopsi-provlepsi-tis-exelixis-toy-2oy-kymatos-ton-kroysmaton-toy-koronoioy/>

Kathimerini Newspaper 08.09.2020 • 20:08
GEORGIOS ATSALAKIS*, VASILEIOS TSOUMPRIS**

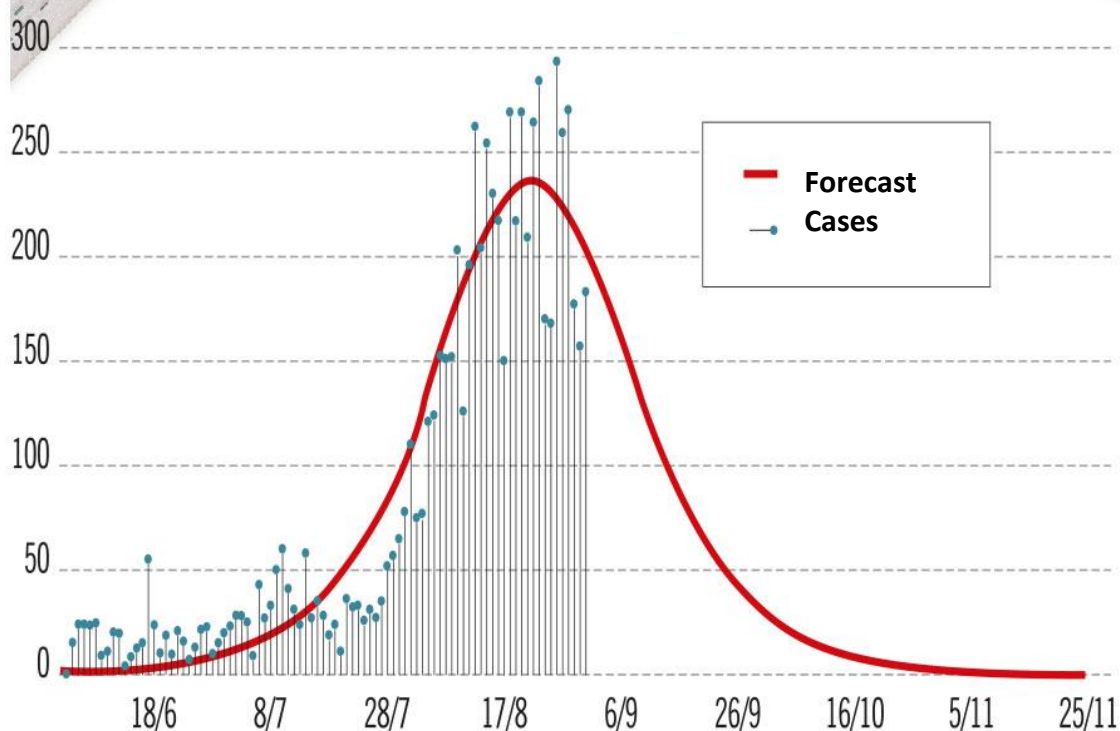
A disease begins to subside long before the respective medication or vaccine is perfected and disseminated. In the case of COVID-19, the key reasons why it should start to abate are the community's normal reaction by taking personal protection measures and the implementation of measures to prevent the spread of the virus. So the measures taken are part of a normal process that needs to be applied. This is how the first wave was managed. At the Technical University of Crete, we applied a sigmoid curve (s-curve) model, including the corresponding life-cycle curve, which predicted the spread of the first pandemic wave in a timely and successful manner. The peak of the first wave was observed in early April and its end in mid-May, as reported in the following link of the "Kathimerini"

newspaper: <https://www.kathimerini.gr/1071879/gallery/epikairothta/ellada/provleyh-e3eli3hs-twn-kroysmatwn>.

Winning the battle against a disease, as shown by numerous scientific studies, is a stepwise process that follows an s-curve or the corresponding bell-shaped (life cycle) curve. The s-curve represents the cumulative growth of cases while the bell-shaped curve shows the daily cases. Historical data for the first half of cases can help predict the second half. Moreover, the life cycle of the epidemic is symmetrical, so the second half of the epidemic cases can be predicted from the first half.



The peak and the decline



LINEAR AND
EXPONENTIAL
GROWTH
(SOURCE: Nigel
Hawtin)

Days	Linear	Exponentia
Day 2	3	3
Day 3	6	9
Day 4	9	27
Day 7	18	729
Day 14	39	1.594.323

The implementation of the predictive model for the 2nd wave of cases, based on data from the beginning of June until August 31, 2020, shows that the second wave reached its peak at the end of August and will come to an end at the end of November according to the chart. So we can predict, with approximately 90% accuracy, that the spread of the second COVID-19 wave will follow this chart. This is certainly subject to people's compliance with the protection measures for the remainder of the period. In any case, this forecast serves as a timeline so that individuals, businessmen, government agencies, etc. can make better decisions. It can also be used as a success indicator for the measures as long as the cases remain close to the curve.

Timely adoption of measures and, above all, people's full adherence to them prevented the exponential growth of cases in the first wave. As a result, Peru and Belgium are now at the forefront of Covid-19 deaths, with around 85 deaths per 100,000 inhabitants. Perhaps due to great publicity, one would expect to see Italy or the United States ranking place; yet Italy is in fifth place, with 58.68 deaths and the US in eighth place with 55.93. Spain (62.01) and the UK (61.05) come in the third and fourth places, respectively. They are followed by Chile in sixth place (58.16), Sweden in seventh place (57.58), Brazil in ninth place (55.79), France in tenth place (46.83), Russia in eleventh place (11.59), Denmark in twelfth place (10.77) and India in thirteenth place (4.53). Our country ranks very low with 2.49 deaths per 100,000 inhabitants due to the timely and successful implementation of measures.

The importance of understanding the exponential growth of cases is paramount in order to accept the need for immediate action, hence the table showing the linear and exponential growth of cases.

In linear growth, a value which equals 3 on the second day will be 6 on the third day, 9 on the fourth day, 18 on the seventh day and 39 on the fourteenth day. In the exponential growth, 3 on the second day cases will reach 9 on the third day, 27 on the fourth day, 729 on the seventh day and 1,594,323 cases on the fourteenth day. This example illustrates that even a day's delay in taking measures can have devastating effects on the spread of the pandemic.

Another way to understand exponential growth is the example of the chess board. If we place 1 grain of rice on the bottom right square of the board and then twice as many grains on each subsequent square, the total number of grains on the board will reach the astronomical figure of 18,446,744,073,709,551,615 (or 18,446 trillion!).

The second wave started to grow exponentially towards the end of July, but immediate action contained the exponential growth. Therefore, strict observance of the measures is key for both the containment and elimination of the second wave.

*** G. Atsalakis is an Associate Professor at the Technical University of Crete.**

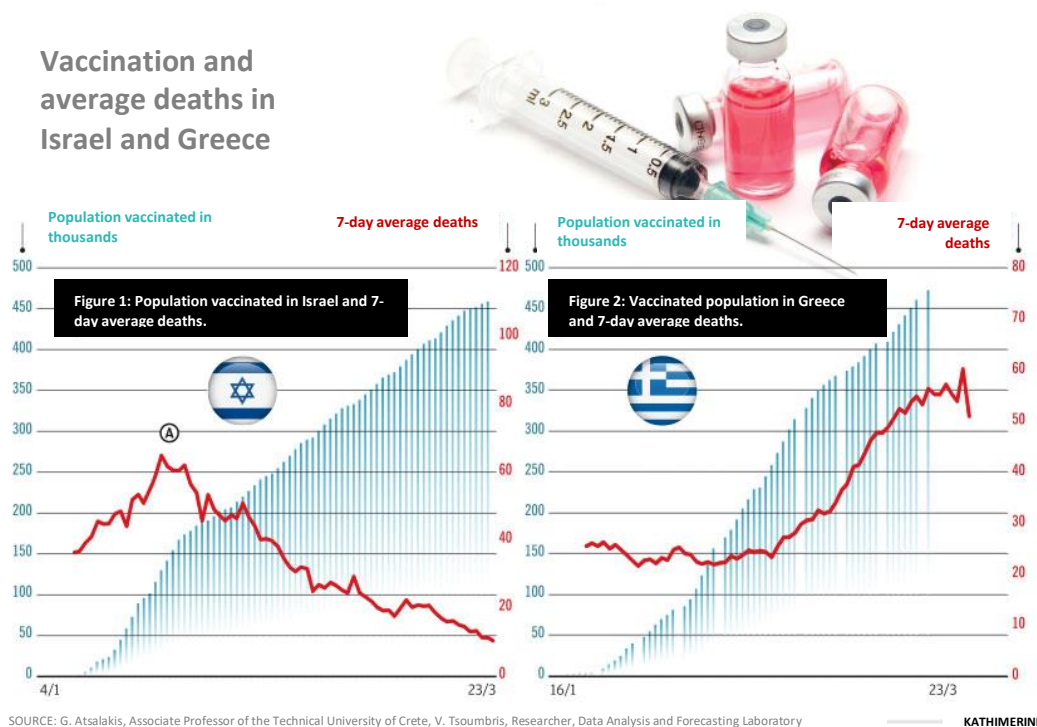
**** Vasileios Tsoumpris is a student of the Technical University of Crete.**

Vaccinations: How we can quickly become Israel

G. ATSALAKIS, V. TSOUMPRIS*

RESEARCH OF THE TECHNICAL UNIVERSITY OF CRETE

Vaccination and average deaths in Israel and Greece



Analyzing actual data of other countries with higher vaccination rates, we can draw useful conclusions on the progress of the pandemic and, especially, on the rate of deaths, which are the most important impact of the pandemic. The growth of cases detected via increased testing is an important parameter, as the identification of more cases in the community can, if properly traced, significantly mitigate the impact of the pandemic spread. Eastern countries managed to control the spread of the pandemic through high testing rates. However, the hope of halting the pandemic, especially for the countries of the West, lies in vaccination programmes.

The impact of a vaccination programme depends not only on the effectiveness of the vaccine itself, but also on other factors such as national vaccination coverage rate, high-risk group vaccination as a priority, and vaccination of groups with frequent social contacts.

Israel is a country which has currently fully vaccinated about 50% of its population, hence we have enough and reliable data to analyse. An interesting conclusion is after which population vaccination rate we can observe a decline in daily deaths, looking at the 7-day average deaths.

In Figure 1, based on Israeli data, the blue vertical lines show the cumulative number of people in the community who have been vaccinated with the 2nd dose. The red line illustrates the 7-day rolling average of deaths. Initially, deaths rose along with vaccinations. The death toll peaked at point A, around the middle of the last ten days of January, when approximately 14% of the population had been vaccinated.

In Figure 2, based on Greek data, the blue vertical lines represent the cumulative number of the population vaccinated with the 2nd dose, while the red line represents the 7-day average deaths.

In our country (Greece), by March 27 when cases stood at 3,133 approximately 5% of the population had been vaccinated with two doses and 10% with one. The 7-day rolling average of deaths was initially increasing along with number of vaccinations, just as in Israel. In the last few days, it showed a stabilization trend.

In Israel, the corresponding vaccination rate of 5% had been reached on January 18 with 9,970 cases. Exactly one week later, deaths started to decline (25/01/2021). On that day the country was still in general lockdown and had the second highest number of serious cases during the pandemic. The lockdown was lifted in the second ten-day period of February. Economy opened up almost entirely in the second ten-day period of March.

The Israeli pandemic pattern has been also reflected in the UK data. Based on the assumption that the pandemic in our country (Greece) follows the Israeli pattern, it is expected that deaths will decrease approximately one week after 5% of the population has been vaccinated (on 27/3), just as in Israel. In Figure 2, the red line of the 7-day rolling average shows that the deaths will decline in early April, when we will have reached the equivalent of Israel's point A, which was recorded when vaccination was 14%.

Greece will not have to attain the corresponding vaccination rate of Israel (14%) to see a reduction in deaths. The reasons are the effectiveness of the vaccination programme in high-risk groups and the lower incidence by 2/3 compared to Israel. It is also worth noting that the deaths during this wave have been about 40% fewer than during last November's wave.

The advent of rapid self-tests, if accompanied by effective tracing, will yield even more positive results. Of course, observing personal protection measures (social distancing, proper use of face mask, avoiding crowded areas, etc.) is deemed crucial for the above scenario to come true.

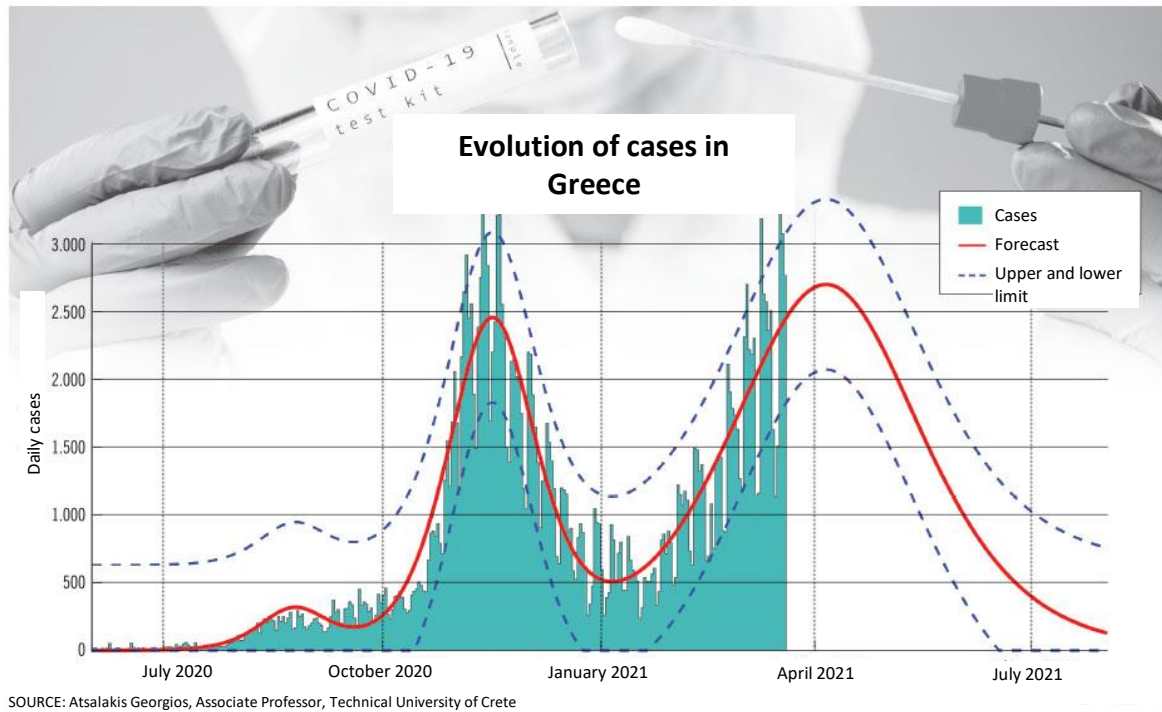
**G. Atsalakis, Associate Professor, Technical University of Crete and V. Tsoumbris, Researcher, Data Analysis and Forecasting Laboratory.*

Link: <https://www.kathimerini.gr/society/561311005/emvoliasmoi-pos-mporoyme-na-ginoyme-grigora-israil/>

The end of the COVID-19 waves

Kathimerini Newspaper 24.03.2021 • 10:58

GEORGIOS ATSALAKIS*, VASILEIOS TSOUMPRIS**



Usually a wave of cases is eliminated after appropriate community protection measures have been taken, and provided that such measures are universally complied with. In the case of COVID-19, the key reasons why it should start to abate are the community's normal reaction by taking personal protection measures and the implementation of measures to prevent the spread of the virus. Therefore, the measures taken are part of a normal process that needed to be implemented. The first wave, in March 2020, was completed following a smooth bell-shaped curve. The appropriateness of the measures coupled with their universal observance led to the elimination of the first pandemic wave.

Last August's 2nd wave, as shown by the chart, was not eliminated. Shortly before reaching the end, **came the 3rd wave**, which grew exponentially and peaked in mid-November. The downward trend of cases started in mid-November but was never completed, because the measures either were not appropriate, or they were not properly and universally respected by the community.

As a result a 4th wave emerged in mid-January, which reached the same height as the previous wave, although cases did not grow exponentially as in the previous wave.

Analysing 2nd and 3rd wave data from the beginning of June 2020, we are able to estimate when the current 4th wave is going to peak and, then, slow down in order for cases to drop to low, manageable levels. The blue dashed curves in the figure show the range within which daily cases can move in the coming period. The continuous red curve shows the COVID-19 case development, as calculated by an algorithm that processes the number of daily cases. Data were processed and plotted as a bell-shaped curves generated by data compiled by March 20, 2021.

The peak of the current wave will be reached in early April and minimisation of cases will occur in July. Whether cases will be minimised before or after July will depend on the course of vaccinations and compliance with the rudimentary measures until they are completed.

Social distancing, avoiding overcrowding and proper use of face mask will be the key factors after the lockdown has been lifted in order to minimize cases and prevent a subsequent wave.

It is important to recall the exemplary management of the virus by Japan, which did not impose any lockdown or shut down theatres and cinemas or restaurants and bars. It did so by mainly focusing on the proper use of the face mask, social distancing and avoiding overcrowding. Of course, people's vaccination is paramount, so that the sum of people who have been vaccinated and those who have recovered from the virus accounts for 70%-75% of the population so as to achieve herd immunity by November.

Failure of part of the community to be vaccinated in some geographical areas may sustain daily cases at high levels. Moreover, the virus may reappear even in areas where it has been eliminated.

The downward course of the red curve illustrates the reward for the community's efforts to halt the spread of the virus. It serves as a 'path' or 'guide' that can be used to assess the efficiency of pandemic response measures and the effectiveness of the community's effort.

** Associate Professor, Technical University of Crete.*

*** Researcher in the Data Analysis and Forecasting Laboratory.*

Link: <https://www.kathimerini.gr/society/561303655/to-telos-ton-kymaton-toy-koronoioy/>

G. Atsalakis, V. Tsoumpris: The Next 3 Months of the Pandemic Based on Israel's Experience

Kathimerini Newspaper - 21.04.2021 • 08:07
G. ATSALAKIS, V. TSOUMPRIS*

Data on the **vaccination progress** and its impact on the pandemic in **Israel** are still studied by many researchers, as they are the only real data we currently have for analyses and comparisons. Previously made predictions can for the first time be compared with actual data of Israel's complete control over the pandemic.

Israel managed to lift the lockdown on February 15, i.e. 30 days after the peak of **cases** and 20 days after the peak of deaths, and proceed to almost total market opening on March 15, i.e. 60 days after the peak of cases and 50 days after the peak of deaths. Yesterday, 3 months after the peak of cases, the mandatory use of the face mask (except for public areas) was lifted and all schools opened.

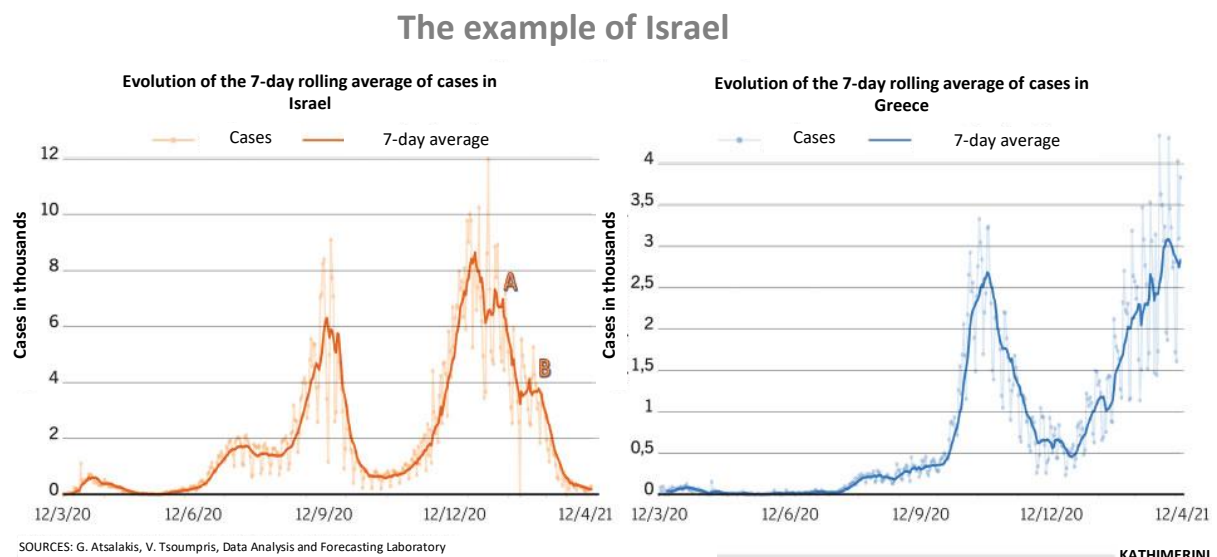


Figure 1 shows the development of the pandemic in Israel. The effect of vaccinations resulted in the peak of the last wave in mid-January 2021. Ten days after the peak of cases came the peak of deaths. It took 3 months to gain complete control over the pandemic. During the quarter, outbreaks occurred on two occasions. In point A of Figure 1, the sharp rise of cases resulted from the gradual opening of the economy. In point B of the figure a second sharp increase is observed due to the lifting of the lockdown.

Currently, 3 months after the peak of cases and 80 days after the peak of daily deaths, Israel has achieved immunity due to either vaccination, or infection of 85% of the population over the age of 16. In addition, since their peak, there has been a decrease in:

- a) cases by 98%;
- b) deaths by 87%;
- c) mechanically ventilated patients by 78%; and
- d) new admissions by 93%.

In our country (Greece), figure 2 shows the peak of the 7-day rolling average of the last wave cases, which was confirmed in the first 10 days of April.

It is expected that deaths will peak at the current levels and that cases will continue to drop based on Israeli pandemic case decline shown in Figure 1. Special care needs to be taken during the gradual lifting of the lockdown and opening of the market when we reach the respective points A and B, around Easter.

On **March 24, 2021 we published another analysis** where we predicted that the pandemic would reach its peak in the first 10 days of April and would be controlled in July.

The peaks of cases and deaths have already been confirmed. What remains now is to maintain the measures and intensify vaccinations so as to confirm the forecast that the pandemic will be under control in July, i.e. 3 months after the peak of cases, just as in Israel. If the vaccination program continues smoothly and people rush to get vaccinated, it will be possible to gain full control over the pandemic in July.

The above predictions give a vision - a path - which is worth striving for. However, it will take considerable individual effort from all of us to achieve this favourable development. It is very important that all of us individually contribute to social distancing, use face masks properly and avoid overcrowding at least for the next three months.

We can envision a case development similar to that of Israel and make yet another considerable effort to protect our health, and ensure the opening of tourism and the recovery of the economy.

**Mr. G. Atsalakis is Associate Professor at the Technical University of Crete and Mr. V. Tsoumpris is a Researcher at the Data Analysis and Forecasting Laboratory.*

Link: <https://www.kathimerini.gr/society/561337444/g-atsalakis-v-tsoympris-oi-epomenoi-3-mines-tis-pandimias-vasei-tis-empeirias-toy-israil/>

The effectiveness of vaccinations in Greece

Analysing actual data of **Israel**, which is the world leader in the number of **vaccinations**, and reviewing the important dates when critical decisions were made, we can draw useful conclusions on the roll out of the pandemic in our country (Greece) and the effectiveness of vaccinations.

The figure shows that the peak of the 7-day average of cases in Israel was reached on January 15, 2021 when 5% of the population had been fully vaccinated and the number of cases stood at 8,395. In Greece, the peak was noted on April 5, 2021 with 6.2% of the population fully vaccinated and 3,075 cases. The death toll for Israel peaked on January 25, 2021 with 6,874 cases and 14% of the population vaccinated 10 days after the peak of the cases.

Comparison with Israel

Major events	Days since the peak of cases (Israeli in brackets)			
	Percentage of fully vaccinated population (Israeli in brackets)		Dates for Greece (cases in brackets)	
	Dates for Israel (cases in brackets)			
Peak of cases	15/1/21 (8.395)	5/4/21 (3.075)	6,2% (5%)	—
Peak of deaths	25/1/21 (6.874)	21/4/21 (2.780)	7,3% (14%)	16 (10)
Opening of a large part of the market	15/2/21 (4.823)	4/5/21 (1.745)	9,2% (27%)	29 (30)
Almost total opening of the market	15/3/21 (2.332)	31/5/21 (≈1.400)	≈19% (44%)	55 (60)

KATHIMERINI
NEWSPAPER

The death toll in our country (Greece) peaked on April 21, 2021 -16 days after the peak of the cases- with 2,780 cases and 7.3% of the population vaccinated. A large part of the market in Israel opened on February 5, 2021 -30 days after cases reached a peak- with 4,823 cases and 27% of the population vaccinated. In Greece, it occurred on May 4, 2021 -

29 days after the cases peaked- with 1,745 cases and 9.2% of the population vaccinated. The market opened almost totally in Israel on March 15, 2021 with 44% of the population vaccinated, 60 days after the peak of the cases; in our country it will occur on May 31 with an estimate of 1,400 cases and about 19% of the population vaccinated, 55 days after the peak of the cases.

As we had predicted **in our previous analysis on April 17, 2021**, the dates of crucial events in our country were achieved with lower vaccination rates than in Israel. Deaths were reduced by almost half of Israel's total vaccination rate, i.e. 6.7% less vaccinated population ($14-7.3=6.7\%$). The largest part of the market was opened with 9.2% of the population vaccinated, i.e. 2/3 (17.8%) less vaccinated people than in Israel ($27-9.2=17.8\%$). Our country on May 21, 2021, i.e. one and a half months after the peak of the cases and having vaccinated 29% of the population with one dose and 16% with two doses, managed to reduce the 7-day average of the following parameters:

- a) Cases by -50% since their peak.
- b) Mechanically ventilated patients by -22% since their peak.
- c) Deaths by -35% since their peak.

The effectiveness of vaccinations is now evident. Accelerating vaccinations will further reduce the above rates.

For Israel the corresponding figures today, 130 days after the peak of the cases, are -99% (five per million inhabitants), -98% (0.4 per million) and -98% (0.2 per million).

The pandemic in Greece has started moving in the direction of the Israeli impressive results and may continue provided that vaccinations will be pursued normally, the community will observe the necessary measures (proper use of face mask, social distancing and avoiding crowded areas) and at least 75% of the population will be vaccinated. Proper observance of the measures will guarantee the start of the tourist season and earlier recovery of the economy. Special care should be taken for the vaccination of the most vulnerable groups, which have been vaccinated by only 65%-70% on average. The above confirm **our analysis on March 24, 2021** where we predicted the peak of the cases in the first 10 days of April and the control of the current wave of the pandemic in July.

The efforts of the government and the community should be oriented towards adherence to the measures and a fast vaccination rate as parameters will occasionally spike on the way to total opening of activities. We are approaching the victory over the pandemic. Victory shows that we are capable! Defeat shows what we deserve!

**Mr. G. Atsalakis is an Associate Professor at the Technical University of Crete. Mr. V. Tsoumbris is a Researcher in the Data Analysis and Forecasting Laboratory.*

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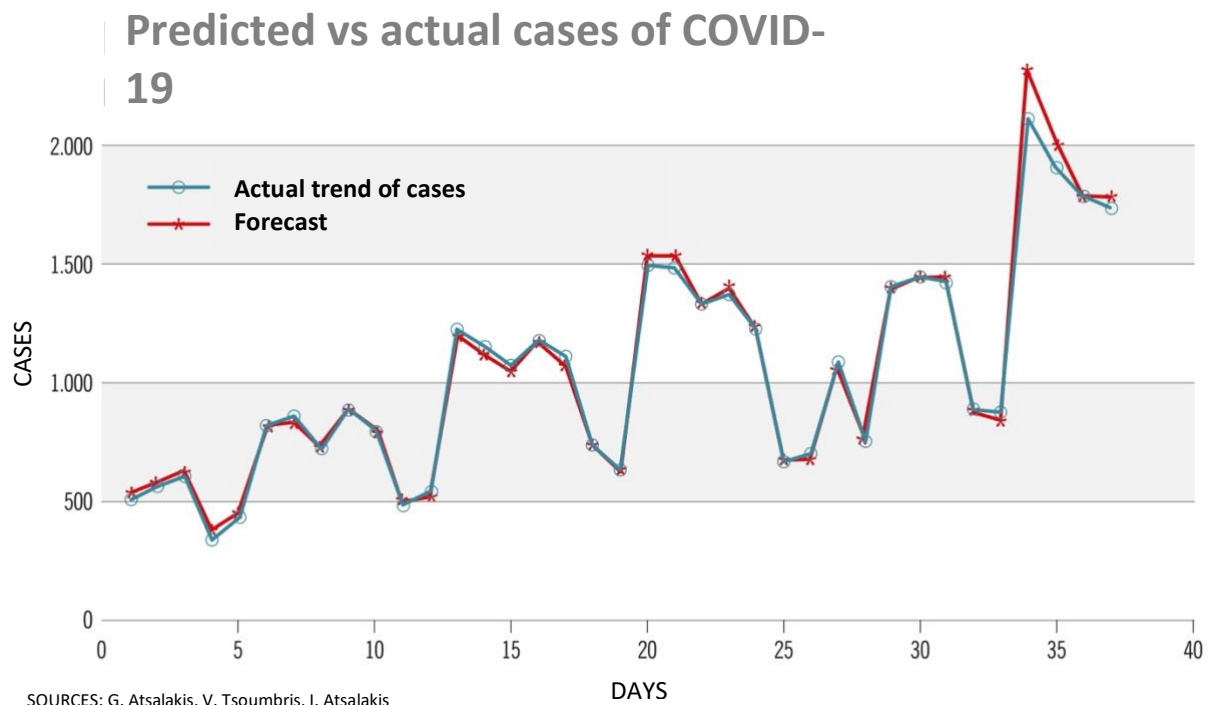
Neuro-fuzzy system to forecast the trend of daily coronavirus cases

GIORGOS ATSALAKIS, VASILEIOS TSOUMPRIS, IOANNA ATSALAKIS*

Artificial intelligence coupled with soft computing is an emerging approach in computing, which incorporates the ability of the human brain to explain and learn in an environment of uncertainty and ambiguity. It resulted from the premise that real problem solving requires the use of intelligent systems that combine knowledge, techniques and methodologies from different sectors. These intelligent systems must incorporate expert human knowledge, adapt and learn in a changing environment, and explain how they make decisions or act.

Neuro-fuzzy models as soft-computing and artificial intelligence techniques with learning capability, representing human reasoning, are applied to real-world problems that present complexity and uncertainty, such as decision-making, predictions, control problems, etc. Neuro-fuzzy models, because of their ability to integrate human knowledge and adapt it using optimization methods, play an key role in designing hybrid intelligent forecasting systems.

Developing a forecasting system which predicts the number of cases continues to be the subject of extensive research. Various strategies, models and methodologies have been developed for the prediction of daily cases, but with a limited accuracy rate. On the other hand, no models have been developed to forecast the next-day trend, namely whether the number of cases will move upward or downward. In developing the proposed model account is taken of the people's compliance, based on the principle that ultimately it is people's behaviour with regard to pandemic response measures and containment rules that determines the number of daily cases.



The proposed neuro-fuzzy model was developed using pandemic data of Greece. It consists of four input variables: a) the daily pandemic cases; b) the number of deaths; c) the number of hospital admissions; and d) the daily test index, calculated dividing the number of daily cases by the number daily tests. The model output is the next-day up- or downward trend of cases.

Training the proposed hybrid model with 328 past real-world data yielded 24 fuzzy rules, which forecast whether the cases will move upward or downward on the next day based on the inputs. The training and forecasting processes are conducted daily to take account of the new daily data.

The model was used to forecast daily cases over a period of 37 days in January-February 2021. The trend of next-day cases was predicted with an accuracy rate of 94.45%.

The chart shows the forecast based on data that had been used in the model training. The blue curve with empty dots represents the actual trend of cases. The red line with asterisks represents the forecast based on data that had been used for the model training (excluded from the sample) and shows the prediction of daily cases over 37 days.

The main benefits of the proposed system are: 1) The proposed neuro-fuzzy forecasting methodology is applied for the first time to predict the trend of cases and its performance is evaluated by applying in case trend forecasting. 2) The system is easy and user-friendly as it does not require any expert knowledge. 3) Due to the type of data and inputs used by the system, data collection and processing only take

a few minutes for the system to make the forecast. This advantage enables the user to apply the system and receive the forecast values as soon as the daily data are announced by the Authorities. 4) The system may be immediately re-trained at any time to improve its predictive capability based on the new data.

**Mr. Georgios Atsalakis is an Associate Professor at the Technical University of Crete.*

Mr. Vassilios Tsoumpris is a Researcher, graduate of the Technical University of Crete.

Ms. Ioanna Atsalaki is a PhD candidate at the Technical University of Crete.

Link: <https://www.kathimerini.gr/society/561326545/neyro-asafes-systima-provleptis-tis-taxis-ton-imerision-kroysmaton-koronoioy/>

The forecast for the 4th Covid-19 wave

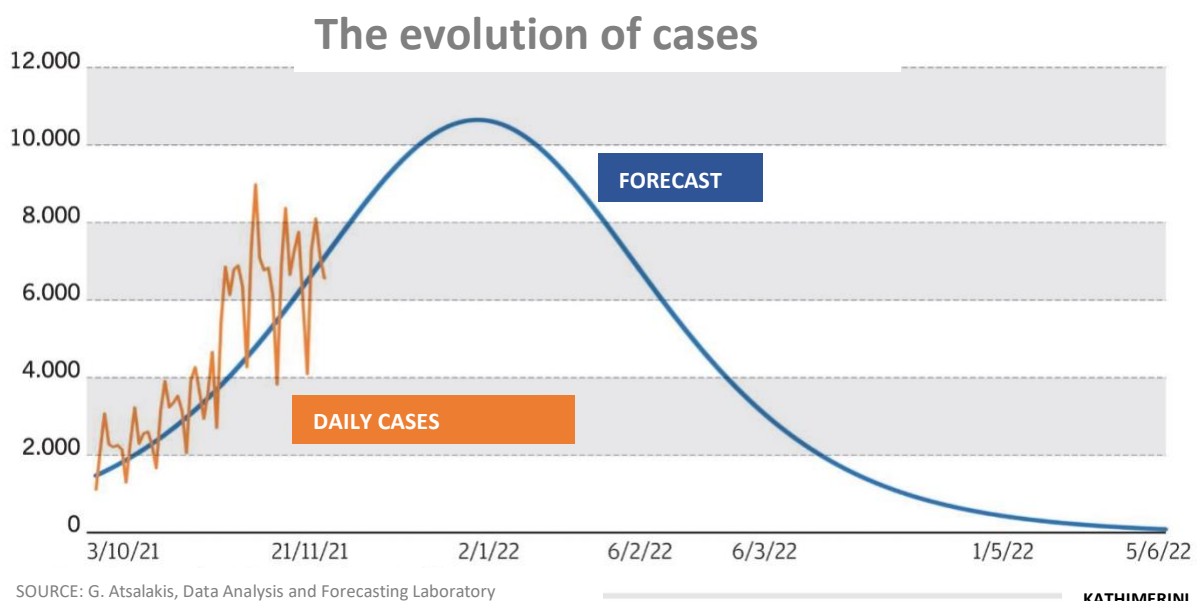
Kathimerini Newspaper - 02.12.2021 • 21:11

GEORGIOS ATSALAKIS*, VASILEIOS TSOUMPRIS**

Winning the battle against a **pandemic**, as shown by previous waves, is a stepwise process that follows a bell-shaped curve. Historical data for the first half of the wave can help predict the second half.

The key reason why **COVID-19** should start to subside is the community's normal reaction by taking personal protection measures, avoiding crowding, keeping distances, using face masks, being vaccinated, etc., in order to prevent the spread of the virus. Therefore, both vaccinations and other measures taken are part of a normal process and need to be enforced in order to deal with the pandemic.

There is enough data for the current wave, so it is possible to estimate when the wave will reach its peak and then start to decline down to a few cases. The chart shows the bell-shaped curve of the current wave where daily cases, illustrated in amber, oscillate around the bell-shaped curve.



At the beginning of October, the pandemic entered a phase of sudden increase in reported cases, which we predict will culminate around the beginning of January 2022, provided that the introduced measures against COVID-19 perform and the vaccinations go on to reach 70% of the population. After early January, the rate of increase in daily cases will start to show a downward trend. However, unless vaccinations continue at a satisfactory rate, we may have a temporary drop in the number of cases but then observe a new peak or new peaks during the winter. The

objective is to see the number of cases entering the phase of steady reduction, namely the daily case increase rate should decline steadily over a long period of time. By mid-May, the recorded daily cases will have decreased sufficiently, and by June case levels will be low enough to be manageable. In the chart, the bell-shaped curve shows the ideal course that cases should follow by June for the current wave to be effectively curbed.

It is important that all people implement the measures, new vaccinations increase and booster dose be administered to those who have completed six months since the second dose, so as to maintain the immunity of the vaccinated population. A major increase in the vaccinated population by 10 percentage points, currently 61%, could de-escalate the cases earlier. What is more, if vaccinations increase by 20 percentage points, we will see a considerable curbing of the cases and a significant drop in deaths much earlier.

We may therefore predict with approximately 90% accuracy that the spread of the current pandemic wave will follow the above bell-shaped curve, peaking in early January and troughing in June. This, of course, is subject to the condition that there will be no irregularities meanwhile (e.g. failure to observe personal protection measures over Christmas, vaccination slow-down, failure to administer the booster dose to those who have completed six months, emergence of a new mutation, etc.).

The curve, if cases follow its course, will reflect the reward for community's efforts to halt the spread of the virus. Moreover, the curve serves also as a 'guide' that can be used to assess the effectiveness of pandemic response measures: the closer the number of daily cases follows the course of the bell-shaped curve, the more successful the management of the current pandemic wave will be.

* *G. Atsalakis, Associate Professor, Technical University of Crete.

** V. Tsoumpris, Researcher, Data Analysis and Forecasting Laboratory.

Link: <https://www.kathimerini.gr/society/561611098/i-provlepsi-toy-4oy-kymatos-toy-koronoioy/>