Math to explain the measures against the coronavirus

Starting from a low number of people infected with the new coronavirus, in a short time there may be a large number of people infected who cannot be assimilated by the health system. This is reflected in the mathematical curves of exponential growth, a reality that the population is accepting, and which has forced the Spanish government to adopt extraordinary measures to contain the pandemic.

Exponential growth curve of the infection with current data (as of 12 March 2020) provided by the Government of Spain, and predicted growth of the current trend without any measures (yellow line) and with the probable effect of the measures taken by the authorities (white line) / A. Galisteo/ IMDEA Networks

The purpose of the measures being taken by the authorities is to stop the spread of the virus. To understand these measures, it is essential to know how the spread works.

Suppose we are patient zero of a disease like this. The contagion we cause will depend on two factors. On the one hand, the number of people with whom we interact. If we were a hermit in the middle of the forest who did not interact with anyone, as soon as we were cured or died from the disease, it would not spread any more. On the other hand, there is the way the disease is transmitted. Some diseases, such as Ebola, are more difficult to spread because they are transmitted in large droplets, which requires greater proximity to the sick person. Others, such as tuberculosis, have a higher spreading factor because the bacteria are housed in the smaller droplets. The coronavirus is transmitted in medium-sized droplets, which means that beyond a certain distance from the infected person, they fall to the ground and do not reach the people around them.

Mathematics is used to determine how this contagion grows. If we want to know the number of infected people that will be there tomorrow, we must start from the number of infected people that there are today. We must take into account the number of people with whom those infected have interacted today, find the average probability of contagion and multiply the two numbers. Finally, we must subtract from the result those who have been cured. Since the disease is relatively long, the number of patients cured is much lower than those who are infected every day, although there is a high probability that they will be cured in the future.

This pattern of infection is exponential. This means that not only does the disease infect more people every day, but the speed of infection is also increasing. Let us assume that on average each infected person spreads the disease to one person per day. On the second day, two people will be infected, on the third day, four, on the 128th week, and twenty days later, more than a million people will be infected. This property is precisely what is so amazing and terrible about exponential behavior: it grows very quickly from relatively low numbers.

The public bodies that are taking action at European, national, regional and municipal level are working with models that can roughly predict how many cases there may be in a given area and how the epidemic is going to spread.
The average number of infections per patient per day varies from region to region. The reason for this difference is that many factors are involved: the culture of the country, for example if we are used to greater physical proximity as in Mediterranean countries or greater separation as in Nordic countries; the humidity of the environment, since with more humidity the droplets in which the virus spreads travel a shorter distance; the number of people with whom we are in contact daily, for example if the majority live in large agglomerations or in small populations, etc.

Like any illness, there will come a time when it will stabilize. This may happen because the right measures are taken and the number of patients does not increase, because a vaccine is created to help stop it, or because the majority of the population has been exposed and has been immunized.

**Health systems have limited capacity**

The question that is on many people's minds is: why are governments taking such drastic measures if in the end it is going to stabilize? It is because the important thing is not when the pandemic stabilizes, but how many people it has affected when it does because health systems have limited capacity. If we all get sick at the same time, the system will not be able to care for us. This is what governments are trying to prevent. And they are trying to control the variables involved in exponential growth.

The first is the number of interactions we have with other people, which we call R. If we go around a sparsely populated area, R will be close to 0. But if we go to a football match or are in a classroom at school the value of R increases a lot. Governments are encouraging teleworking, closing classes, postponing meetings and cancelling any activities involving many people so that interactions are as low as possible. And here another factor of Covid-19 intervenes, and that is that a large part of those infected are asymptomatic or have few symptoms. This means that there are many people infected who do not know it, but whose behavior is key to not spreading the pandemic.

On the other hand, not all the people who enter our 'contamination zone' will infect us, but there is a chance that they will, p. If we are at a party and talk in close proximity to other people, touch many surfaces and then put our hands to our face without washing, for example, the chances of getting infected are much higher. That's why awareness campaigns are being created, providing hand hygiene products in public places in the form of gels and asking us not to touch our faces with our hands.

To know how effective these measures are, we must understand that precisely because the virus exhibits exponential growth, reducing infections by every possible percentage at the base has a tremendous impact over time.

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Traducción al español:
/noticias/2020/matematicas-explicar-efecto-medidas-contra-coronavirus

Original source:
/news/2020/math-explain-measures-against-coronavirus

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Source(s): IMDEA Networks Institute
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