Exponential virus growth and increasing the capacity of a healthcare system

Exponential growth in a nutshell. How can the new coronavirus spread so fast? Every infected person will on average infect about three other persons [current estimates of the coronavirus infection rate are between 2 and 3]. Let us look at how the number of new infections grows over time. The first infected person infects three others. Together, these three people infect nine other people. Together, they infect 27 new people. What do we observe? The increase in cases actually gets faster over time! After the first step, there is an increase of two infected people. In the next step, this number is already six, which then becomes 18. Numbers that grow in this way are said to follow exponential growth. Going only 16 steps forward, more than 60 Million people are already infected. Once the virus infects the majority of the population, the spread will slow down, – but we want this deceleration to happen much earlier, when our healthcare system is not overburdened yet. Exponential growth very well describes the initial propagation of the virus in the population. This is shown in the following figure for Italy and for Germany.
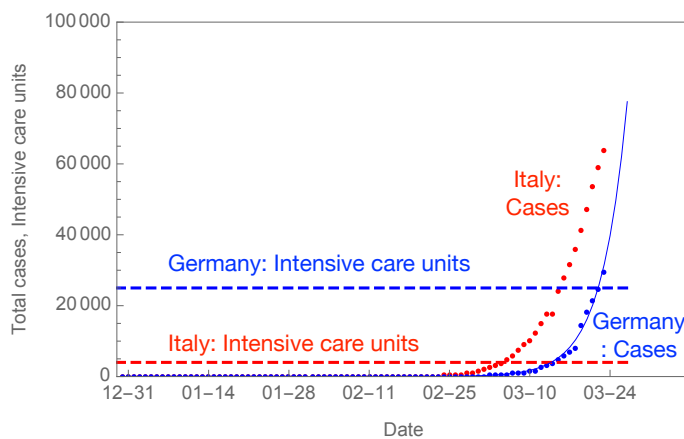

Fig1 - **Exponential growth speeds up with time.** Number of total cases and the number of intensive care unit beds for Germany and Italy. Each bed will be needed for many days, but not every patient will need a bed.

A different perspective brings clarity. This looks scary. Even if there are some limitations to this representation. For example, it is not easy to compare the spread of the virus in different countries. Moreover, information like the change in the infection rate, which is important to assess effectiveness of preventive measures in place, is not directly visible. In this respect, one gets a much clearer idea by counting, instead, how long it takes for the number of infections to be multiplied by a factor of 10 – see the numbers of cases in the next figure on a so called logarithmic scale. Without preventive measures, the number of patients always increases by a factor of 10 in the same time. Thus, the growth in number of cases grows follows a straight line in this plot.
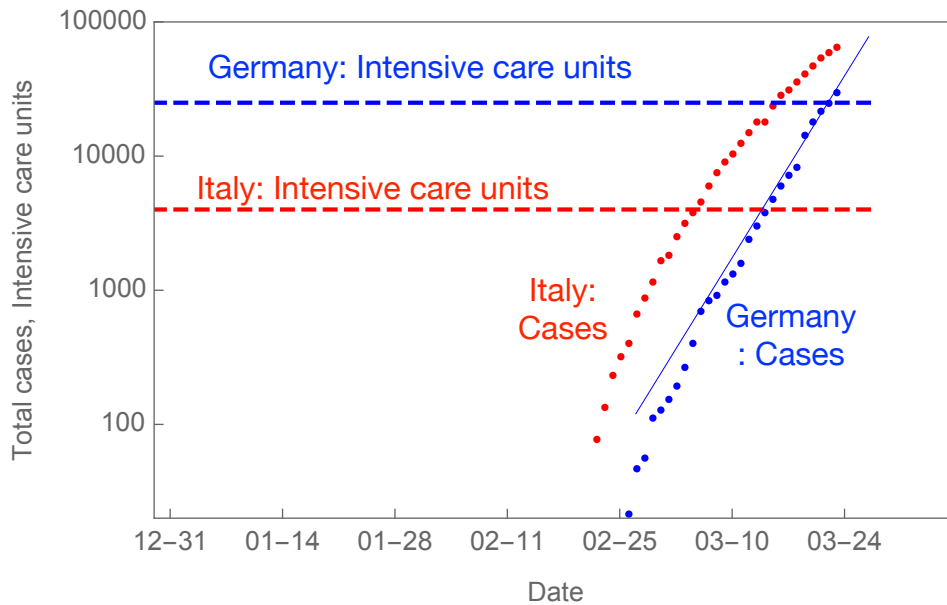
Fig2 - **A new scaling of the number of cases.** A logarithmic y-axis shows that the disease dynamics is not fundamentally different in Germany and Italy.

We now see an almost straight line for Germany and a slightly curved one for Italy that are almost parallel at times: the virus spreads at roughly the same speed in both countries, but Italy is about 10 days ahead. If we manage to slow down the spread of the virus in Germany, i.e. reduce the number of people that an infected patient infects, the straight line becomes curved – as in the case of Italy. This can be achieved through social distancing: if we only meet very few people, we can only infect very few people.

Exponential growth vs. linear countermeasures. Why do we need to achieve this? Unlike the virus, intensive care beds and medical staff do not grow exponentially. Even if we can provide 5000 new intensive care beds with ventilation every month, every week, or every day – and we must hard work to do so – such an increase cannot keep up with exponential growth.
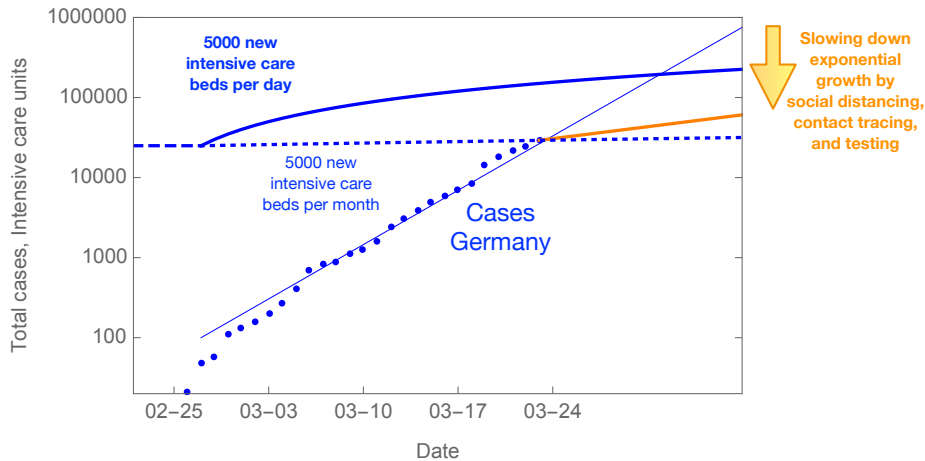
Fig3 - **Even an increase of our healthcare capacities will not suffice.**
As even increasing the number of beds by 5000 per day (which is clearly
not feasible) will only help in the short run, it is crucial to slow down
exponential growth.

We aim to avoid overburdening our healthcare system. In this way, we can avert
many additional deaths due to diseases that under normal circumstance would not
be life-threatening. To achieve this, we must start by reducing not only the number of
cases, but importantly the increase in the number of cases.
This is possible via social distancing. Different countries have taken different
measures to achieve this goal. For example, South Korea via extensive tracking and
testing of people has managed to stabilize the total number of cases providing a
buffer for the healthcare system, which had the chance to fight the virus and give
time for infected people to recover. The increase in the number of infected people in
South Korea has now plummeted, and total infections are no longer exponentially
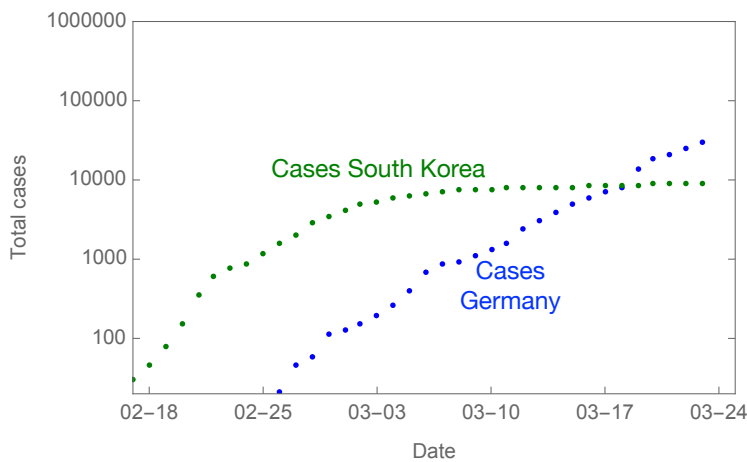expanding.

Fig4 - **South Korea managed to slow down the disease.** South Korea
shows that the combination of social distancing, tracing and testing can
work.

Even if the economic sacrifices are high and the restrictions seem threatening, we
will be able to achieve the goal via strict adherence to social distancing.

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