Five common misconceptions regarding flattening-the-curve of COVID-19

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Abstract
In the fight against COVID-19 pandemic, the phrase “Flattening the curve” (FTC) has become a rallying cry, popularized by government leaders and journalist in the news and on the social media. FTC is a succinct way of communicating an important public health message that physical distancing, mask-wearing and other public health measures will decrease the peak number of cases and prevent the healthcare system from being overwhelmed. However, while the message of FTC is right in the sense that limiting transmission will reduce the peak number of cases, some visualizations used to illustrate its effect are incorrect from an infectious disease modelling point of view. The misconceptions are misinterpretations of flattened curves, the effect of FTC on the duration of the pandemic, the dynamics of the curve to be flattened, and the overestimation of the importance of FTC.

Keywords Flattening the curve · Pandemic duration · Bell-shape curve · Farr’s Law

Flattening-the-curve (FTC) refers to a strategy adopted to slow down and spread out the outbreak dynamics. FTC is a succinct way of communicating an important public health message that physical distancing and other public health measures will reduce the peak number of cases. Its roots trace back to a guidance issued by the Centers for Disease Control and Prevention (2007), which contained an image which was possibly the original FTC graph. During this pandemic, it seems to have first appeared on 29 February 2020, in The Economist (“Covid-19 Is Now in 50 Countries, and Things Will Get Worse,” 2020). Today, FTC has become a global watchword, popularized by politicians and journalists, to prevent the healthcare system from being overwhelmed.
overwhelmed. During the pandemic, there are various COVID-related graphs in the news and on social media, depicting the number of new daily cases, active cases, and cumulative cases. The often-cited FTC graph is shown in Fig. 1.

It is claimed that FTC will buy us time to formulate effective measures, improve healthcare infrastructure and develop a vaccine (Kennedy, 2020). While the message of FTC is right that limiting transmission will reduce the peak number of cases, some of its visualizations have shortcomings from a mathematical modelling perspective. In a recently published paper in this journal (Mat Daud, 2021), the author provided comment on another article about one common misconception regarding FTC (Debecker & Modis, 2021). To complement the paper, in this paper, the author provides a brief review of and addresses another five common misconceptions among the general public, journalists, politicians, science communicators, and physicians (Jozaghi, 2020).

1 Misconception 1: misinterpretation of flattened curves

The phrase FTC is often used without specifying what “the curve” actually is. The curve (or epidemic curve) being flattened is the number of active cases over time. The $x$-axis represents a measure of time (in days) since the first case was reported, while the $y$-axis represents the number of currently infectious, or active cases at one time (some graphs use log-scale axis or plot numbers as fractions of the total population). Sometimes the axes are not well-labeled, so identify carefully which graph you are viewing. Since an individual is usually infectious for more than one day this curve is not equivalent to the number of new daily cases. The width represents the duration of the pandemic, and the area under the curve (the epidemic size) represents the cumulative number of cases. A recent study found that most people have a poor understanding of the definition of flattened curves, which then influence their attitude toward public health measures (Fansher et al., 2020; Lalwani et al., 2020). Understanding
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the concept of FTC requires an understanding of which curve needs to be flattened. Not every flattened curve indicates that conditions are improving. FTC often refers to reducing the number of active cases to avoid overwhelming the healthcare system, but FTC can also refer to decreasing the number of cumulative cases by substantially reducing the number of new cases. To defeat the pandemic, the graph of new cases versus time should not be flat. It should be a downward-sloping curve, decreasing towards zero. While a constant rate of new cases is better than an increasing rate, FTC of new daily cases is not sufficient to ensure that the healthcare system is not overwhelmed or the pandemic will end. A cumulative curve that increases slowly and flattens out indicates the disease spread has slowed down. Figure 2 shows the cumulative curve start to flatten only when the daily cases steadily approach zero does. For more details, see Debecker & Modis (2021) and Wicklin (2020).

2 Misconception 2: FTC will prolong the duration of the pandemic

It is often claimed that FTC will prolong duration of pandemic (Bergquist, 2020; Roberts, 2020). However, Cooper et al., (2020) used a Susceptible-Infected-Removed (SIR) model to argue that the claim is scientifically incorrect. They found that the decrease in the peak number of cases will eventually reduce the duration of the epidemic. This means that, while aggressive and dramatic measures need to be implemented as early as possible (because the epidemic growth is exponential, not linear), the duration of the measures which comes with massive economic and social consequences, should not be prolonged as often claimed. Churches & Jorm (2020) simulated stochastic individual compartmental model to examine the effect of intervention measures on the local epidemic spread of COVID-19. They argue that there is no empirical basis to the claim that FTC approximately doubles the duration of the epidemic. They suggested that the intervention measures, particularly intensive case-finding and strict enforcement of isolation and quarantine, may substantially reduce the total number of cases and deaths, with minimal or no extension to the duration of the epidemic. In other words, public health measures may potentially shrink the curve, rather than just flatten it. Their findings were consistent with the study by the Imperial College (Ferguson et al., 2020).
3 Misconception 3: FTC is sufficient to defeat COVID-19 pandemic

Mathematically speaking, FTC is a necessary condition, not a sufficient condition in defeating the virus. Firstly, a study found that reducing the number of infected people is more important than simply keeping hospitals from becoming overwhelmed. Even if hospitals are not overwhelmed, an increase in COVID-19 admissions may still lead to more number of deaths than we would expect from only the hospitalized patients (Karaca-Mandic et al., 2020). The study found that a 1% increase in non-ICU bed use (130 beds on average) was associated with 17.84 more COVID-19 deaths.

Secondly, a study shows that even if the curve is successfully flattened by reducing mobility, population crowding is an independent factor to the shape of the curve. The shape is more closely related to population layout and social structures than population size and density (Rader et al., 2020). Traditional epidemic models are based on a single population, but in reality, large populations have many linked communities. This allows an outbreak to travel through populations community-by-community and causing a prolonged epidemic. Therefore, the shape of the curve will be different between cities, or even neighbourhoods. Mathematical models developed to forecast the dynamics of COVID-19 agree that FTC without controlling the epidemic completely is not sufficient. A study which used a simple compartmental deterministic model of COVID-19 transmission in Australia found that the strategy to defeat COVID-19 must go beyond FTC and include other tools such as testing and contact tracing (McBryde et al., 2020).

4 Misconception 4: the curve has a single peak (Bergstrom, 2020)

As illustrated in Fig. 1, the flattened curve shows what happens if the spread of the virus slows down; the virus that initially grow exponentially to reach a peak and then decline. An inevitable feature of realistic epidemic models is typically not shown in the FTC graph. That is, viruses may come back after they subside. For example, the narrative appears in a model developed by a group of researchers and published in New York Times (Roberts, 2020). As lockdowns are easing in many countries, such narrative may mislead public into assuming that the pandemic is ending, and the normal life will return once the FTC time-frame ends. Using the same model to illustrate the idea of FTC, it can be shown that the curve may look like a sine function or a series of waves (not necessarily a single peak). A study suggested that intermittent physical distancing may be required into 2022 unless healthcare system capacity is improved substantially or a vaccine becomes available and fully deployed (Kissler et al., 2020). Therefore, reaching the steady-state where the number of active cases has declined to a very low level, and stay very low, is essential before measures can be gradually lifted. For example, New Zealand waited until it had “crushed the curve” (World Health Organisation, 2020) before cautiously relaxing restrictions. Taking signs of “flattening” as a signal to lift mitigation measures too soon, may lead to serious cases and deaths to another outbreak just as bad as, or even worse than, without the mitigations in place at all, as happened during the 1918 influenza pandemic (Markel et al., 2007). Therefore, any study on the effects of mitigation measures
should consider longer time-frame. That is, until a steady-state is reached, or at least until a vaccine is expected to be available (even a viable vaccine will require time to be fully deployed).

5 Misconception 5: the curve is bell-shaped and obeys Farr’s Law

The FTC graph in Fig. 1 consists of a tall, narrow curve and a short, flatter curve. The tall curve is created by a steep increase and followed by a quick decrease. The short curve is created by a more gradual increase and a more gradual decrease. The shape of the curve to be flattened is eerily similar to a normal distribution and often resembles a symmetrical bell-shaped curve, implicitly suggesting that the pathogen’s spread is subject to natural laws (Boumans, 2021) and obey the Farr’s Law of Epidemics which states that epidemics rise and fall in approximately a bell-shaped curve. However, the assumption that COVID-19 would just die down as depicted by a normal distribution is not necessarily true, as shown by a study (Bregman & Langmuir, 1990) which employed the law and wrongly predicted when the AIDS outbreak in 1990 would end.

Misconceptions 4 and 5 may mislead the public into assuming that the pandemic is almost over, and the old norm will return once they see the number of cases decreases. They may be complacent and thus relaxing their precaution measures, causing another spike in the number of new cases. The epidemic may grow exponentially again, unless a significant proportion of the population has developed immunity or the virus has been eradicated. The duration of preventive measures may not matter, if the transmission rate return to normal when the preventive measures lifted, and mortality rate remain the same. Lifting the mitigation measures, the epidemic will grow exponentially again, unless a significant proportion of the population has developed immunity or the virus has been totally eliminated, without risk of reemergence.

6 Conclusion

Public health depends on public understanding and behaviour. Regardless of what measures will be implemented in the fight against COVID-19, their success will largely depend on the level of public compliance. However, maintaining extreme measures on a timescale of months or even years, is economically expensive and would require a great sacrifice from the public. A correct understanding of FTC will assist to determine the best time to implement and lift any mitigation measures, to achieve a perfect balance between economy, wellness and wellbeing.

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