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Can innate immunity flatten the curve?

Covid-19 – A case study

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Abstract

We have proposed a model considering two equally sized population (group A and group B) with low and high levels of disease tolerance. We have argued that in the more tolerant group (group B) the progression of the disease with respect to time will be slow with lower number of infections at any given time. We attribute this effect to the innate immunity which advantageously, can also be one of the major contributing factors for flattening the curve. We have compared the growth of Covid-19 disease in various countries to understand this effect.

Keywords: Covid-19, Innate immunity, flattening the curve

Introduction:

Development of herd immunity at affected isolated geographical hotspots is key to control or eliminate communicable diseases that are air, droplet or fomite borne. Though herd immunity in these hotspots would be developed only after a given threshold value of the population is infected by the pathogen, the percentage of total affected individuals spanning the entire population would be considerably lower than projected. Additionally, if these regions are densely populated, herd immunity would be attained very rapidly as compared to regions with sparse populations.

To understand the present scenario of Covid-19, let us look back in history. The 1918 Spanish Flu Pandemic infected about half a billion people and killed about 50 million of them [1]. The 2009 Swine Flu outbreak was an influenza pandemic that lasted from January 2009 to August 2010. Some studies reported that over 1 billion people were infected and around 200,000 to 500,000 people succumbed to it [2]. This makes the Spanish Flu of 1918 substantially worse as compared to the 2009 Swine Flu pandemic even though it has to be noted that more people were infected by the latter. Some statistics even hint at the fact that Swine Flu Pandemic was no worse than seasonal flu [3], though the victims of both these pandemics were mainly from a younger age group [3].

Our immune system has two lines of defence. The innate immune response and the adaptive immune response. The innate immune response act as the first line of defence against pathogens even without previous exposure to them. The degree of its capabilities depends on the genetic constituent of the individual and might vary depending on the gene pool the individual belongs to [4]. The adaptive immune response mediated by antibodies produced against a specific antigen kicks into action only if the innate immune response is evaded by the pathogens. Thus, the innate immune response has a critical role in controlling the spread of an infection prior to the actions of the adaptive immunity [5]. This brings to

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light that different diseases have varying degrees of severity where the variation could arise due to demographic, geographic and genetic factors [6,7].

Model:

We propose a model schematically shown in Fig. 1. The number of infected (shown as solid lines) and susceptible (shown as dash lines) people of two equally sized populations comprised of individuals with two different levels of tolerance are shown in - Red: low tolerance ie., highly susceptible and Blue: high tolerance ie., low susceptible. Greater tolerance to the disease in a population will reduce the number of susceptible individuals as shown by the blue dash curve in fig.1. This high tolerance (i.e., low susceptible) would lengthen the time before which an individual will get infected by the disease as shown by a long tail in the distribution of the susceptible. The peak in the infectious curve will be close to the inflection point of the susceptible curve [8,9]. Thus, in Fig.1 we show that the curve is flattened due to a greater tolerance in the population and the maxima of the curve shifts to a later time as compared to the less tolerant (high susceptible – red) population as shown by a solid blue curve. Nevertheless, the required percentage of the population will get infected before the herd immunity is achieved. With this model, we now proceed to analyse results of Covid-19 data obtain from https://ourworldindata.org/coronavirus.

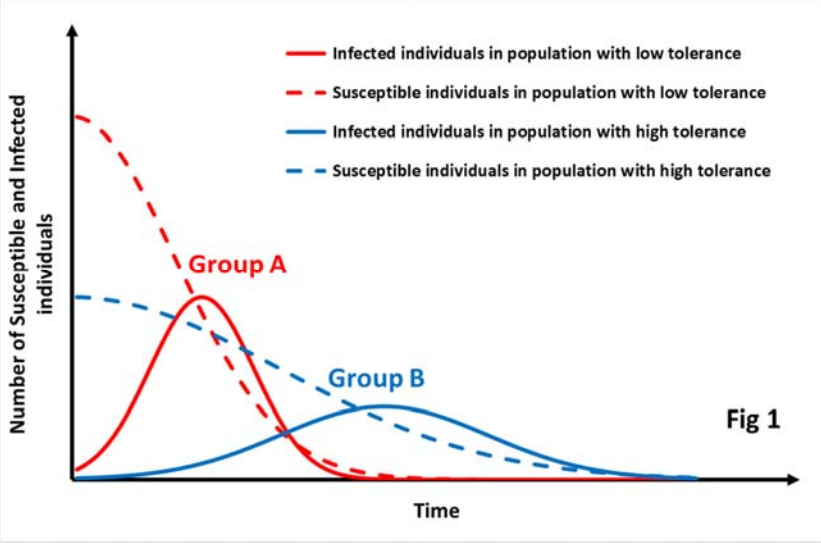

Fig 1: Representation of the number of infected and susceptible individuals of two equally sized populations with high (blue) and low (red) tolerance to a certain disease

Results and discussion:

In Fig. 2(a) we have plotted the daily new confirmed cases per million with a rolling 7-day average of different countries (i.e., taking sum of seven days per million and divide by seven to smoothen the curve), data acquired from https://ourworldindata.org/coronavirus till 18th April 2020. We see clear peaks for the countries that have been badly affected with high number of cases (termed as group A). A current downward trend in the disease progression in these countries (group A) is encouraging. The countries that show a lower number of cases are plotted again in an expanded scale in Fig. 2(b) (termed as group B). These countries (group B) have a significantly flatter curve (similar to solid blue curve in Fig. 1) as compared to countries that are more severely affected (see Fig. 2(a) which is similar to solid red curve in Fig. 1). These countries (group B) show lower number of cases and are yet to attain their peak (see Fig. 2(b)). This

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indicates a slow progress of the disease in these (group B) countries. The group B are yet to achieve the peak and the very low numbers of infection progression with time clearly indicates that some other factor may be influencing their disease progression. We can attribute the cause for this slow progression of the disease with such delayed low number of infections to innate immunity ie., the first line of our immune defence system. The low number of hospitalizations per million rules out the adaptive immunity stage being reached by majority of the group B population. From the above discussion we can clearly see the differences in the disease progression among these two groups. The trends observed in Fig.2 (a and b) supports our proposed model.

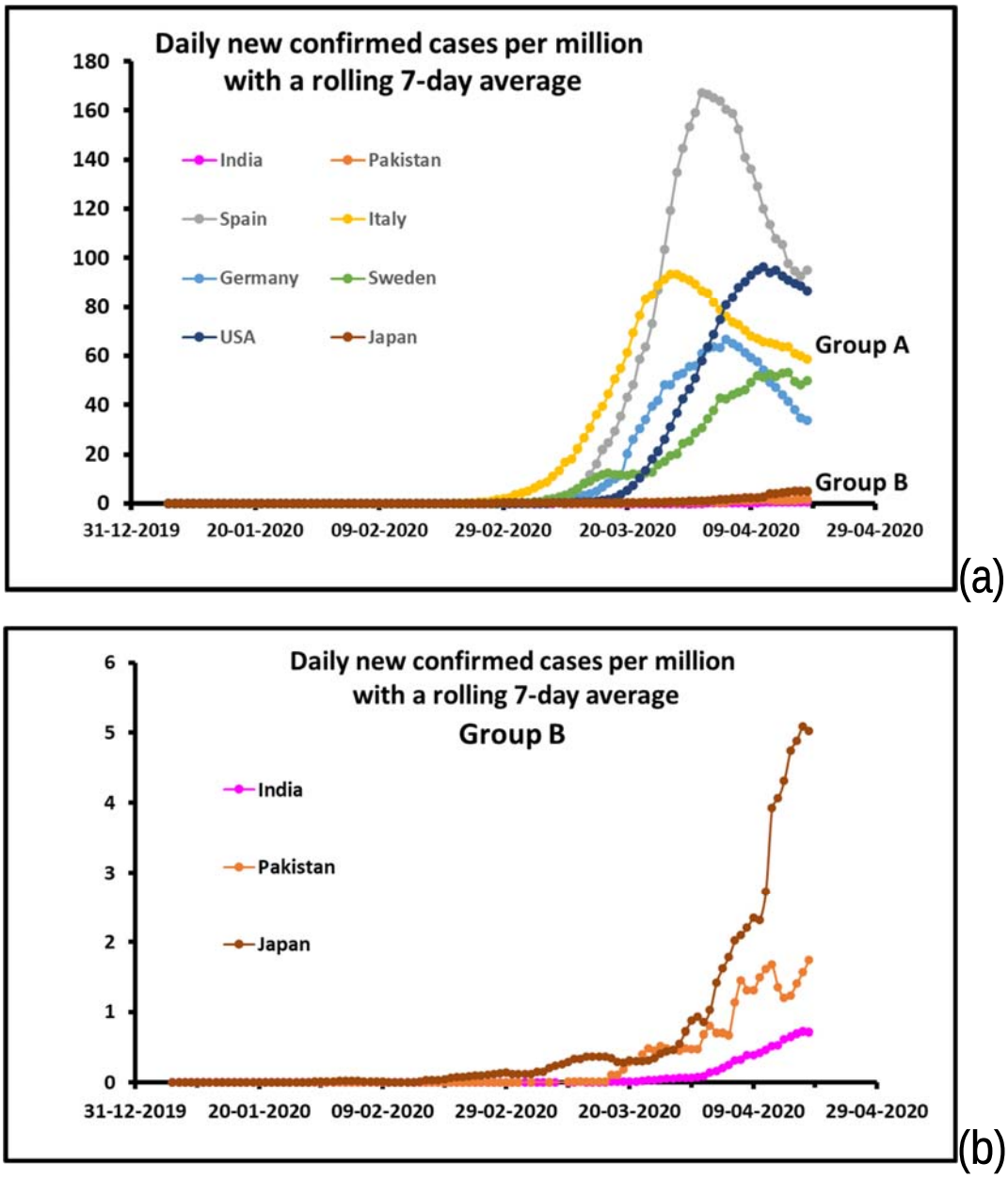

Fig 2(a) and (b): Daily new confirmed cases per million with a rolling 7-day average of different countries with data acquired from https://ourworldindata.org/coronavirus up to 13th April 2020.

Conclusion:

Hence, we can conclude from our proposed model that, the countries where the population has high tolerance (low susceptibility to a disease ie., group B countries; shown as Blue in Fig 1) will show slow progression of disease which can be attributed to the presence of better innate immunity. This results in flattening the curve along with shifting of the peak to later time, where the flattening and delay in the peak will depend on the strength of innate immunity of the population.

Ethical approval: This study did not require ethical approval

Conflict of interest: None

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