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Harish Kumar
APJ Abdul Kalam Technological University, India

Sini V. Pillai
APJ Abdul Kalam Technological University, India

Vipin H
APJ Abdul Kalam Technological University, India

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IMPACT OF AGE AND SOCIAL DISTANCING ON COVID-19 EPIDEMIC IN INDIA

Harish Kumar*
Sini V. Pillai**
Vipin H***

ABSTRACT

Corona virus disease 2019 (COVID-19) is an infectious disease with Acute Intense Respiratory Syndrome Corona Virus 2 (SARS-CoV-2), and the World Health Organization (WHO) has proclaimed Covid-19 as a pandemic. The virus can spread quickly through close contact and via respiratory droplets induced when people cough or sneeze. The respective officials have promoted social Distancing, and governing bodies as a precautionary measure to prevent this novel disease as social contacts between people have a solid assortative structure in age. A mathematical model is used to predict the transmission of the disease, including age and social contact structure. In the research paper, a SIR Model of the spread of the corona virus that considers both the age and social contact structure has been explored. The bangs of Covid-19 on different age groups were highlighted for special attention to prevent the transmission of the disease.

INTRODUCTION

Corona virus disease 2019 (COVID-19) started in Wuhan, and China spread quickly worldwide. And thus, Social Distancing has been promoted by the authorities as a precautionary measure to prevent this novel disease. The goal of these social distancing interventions is to reduce the overall condition

Keywords: *Social distancing, Predictive modeling, Age structured impact, SIR model*

Student, CET School of Management, College of Engineering, Trivandrum, Affiliated to APJ Abdul Kalam Technological University

***** Assistant Professor, CET School of Management, College of Engineering, Trivandrum, Affiliated to APJ Abdul Kalam Technological University***

****** MBA Student, CET School of Management, College of Engineering, Trivandrum, Affiliated to APJ Abdul Kalam Technological University***

spread rates and the consequential excess mortality rates attributed to the pandemic, and further to delay and reduce the peak attack rate reducing pressure on health services and allowing time to distribute and administer antiviral drugs and, possibly, suitable vaccines. As these are geographically explicit, equivalent measures can have inconsistent results when applied to locales with fundamentally varying age and social contact structures. Quantitative evaluations of the effect of these measures in diminishing morbidity, top disease rates, and high mortality rates can be a helpful guide in public health planning.

Further, morbidity and mortality from the Covid-19 disease have critical contrasts across age-gatherings, with mortality expanding quickly in the elder people. The reality is that older age people are more vulnerable to the disease than others. It is evident from the WHO reports states that the senior citizens and underlying conditions increase the risk for severe infection. After falling sick, an asymptomatic carrier can transmit the disease for 7-10 days, called the infection period. Thus, new healthy people can only be infected by asymptomatic sick people who have fallen ill within the last 7-10 days, not those who have lost sick earlier (Vergu et al., 2010). Thus it is vital to estimate the total number of people affected by this virus and its distribution across different age groups. The mathematical model is taken into consideration for the appraisal of such age-organized effects of social distancing measures. The research paper follows predictive modeling, where the conclusions are made per the SIR model of disease transmission and graphical representation.

The novel Covid-19 pandemic has been rapidly increasing concerning the geographic location and how social measures are taken. The age factor plays an essential role in the transmission of this disease. The study gives an idea about the information of the condition concerning the age of the infected person. It is noted from various reports that Covid -19 is highly effective towards older people than teenagers and children. Also, Social Distancing is considered the most critical method in preventing the transmission of this disease. These statements have to be identified and analyzed. As this research undergoes predictive modeling, the results are assumptions based on the given data and may vary to actual products. The study's main objectives include data forecasting of infectious disease, modeling the impact of the disease over time and population, understanding age structural impact and influence of social distancing in controlling the spread of the virus. The various data sources for the same have been obtained from official state portals, government websites, journals, publications, and other related websites. Data Mining and Text Analytics are the two methods to which the data has been collected and transformed to the needed form or into an ordinary source defining the different relationship of variables to which the respective data collected. Predictive Modeling is used in this study. They are the type of analytics that uses data, statistics, algorithms, and programming to predict future outcomes. Secondary data is being used for the predictive modeling and analysis. From the simulated data, it can be observed that over 180 days (6 months approximately), about 1100 million in total are expected to get infected at the peak infection of 270 million in a span of one hundred days. It is also found that the possibility of catching the disease among the children is higher considering their contact mix.

Background of the Epidemic

In late December 2019, from the reports of Huang et al. (2020), an outbreak of mysterious pneumonia-related cases characterized by fever, dry cough, and fatigue, symptoms were found in Wuhan, Hubei, China. According to World Health Organization reports, it has rapidly spread the entire provinces and suburbs (2020). As of February 6, 2020, a cumulative total of 28,276 confirmed cases of 2019-nCoV with 565 deaths were globally detected as documented by WHO (2020). Corona virus disease 2019 is renamed Severe Acute Respiratory Syndrome Corona virus 2 (SARS-CoV-2, formerly known as

2019-nCoV).On 30 January 2020, following the recommendations of the Emergency Committee, Tedros (2020) declared that the outbreak constitutes a Public Health Emergency of International Concern (PHEIC). On March 11, 2020, the WHO announced COVID-19 a global pandemic, considering it a significant outbreak since H1N1 influenza a pandemic in 2009, as John (2020) articulated. Ross (2003) proclaims that infectious diseases pose threats to the majority populace without any doubts or arguments. The simple management of health care facilities is inadequate to control the spread of contagious diseases. Public health has been developing a series of strategies over the past hundred years to apply at a population level to mediate or control the spread of infectious diseases. The transmission mode for most of these diseases is well known. Hence, population-based methods, such as social Distance, quarantine, and isolation, are frequently used for situations that intend to spread the virus at a community level. COVID-19 has spread to more than 200 countries, starting from China. Confirmed novel corona virus cases increased ten-fold in less than a month, from 100,000 in the first week of March to more than one million on 02 April and crossing 2 million by the second week of April, while more than 1lakh deaths have been reported across the world as on April 16,2020. The United States and European Countries are most affected by Covid-19. Europe has been slated as the most affected continent, where almost all European countries are worse affected by the Covid-19 outbreak.

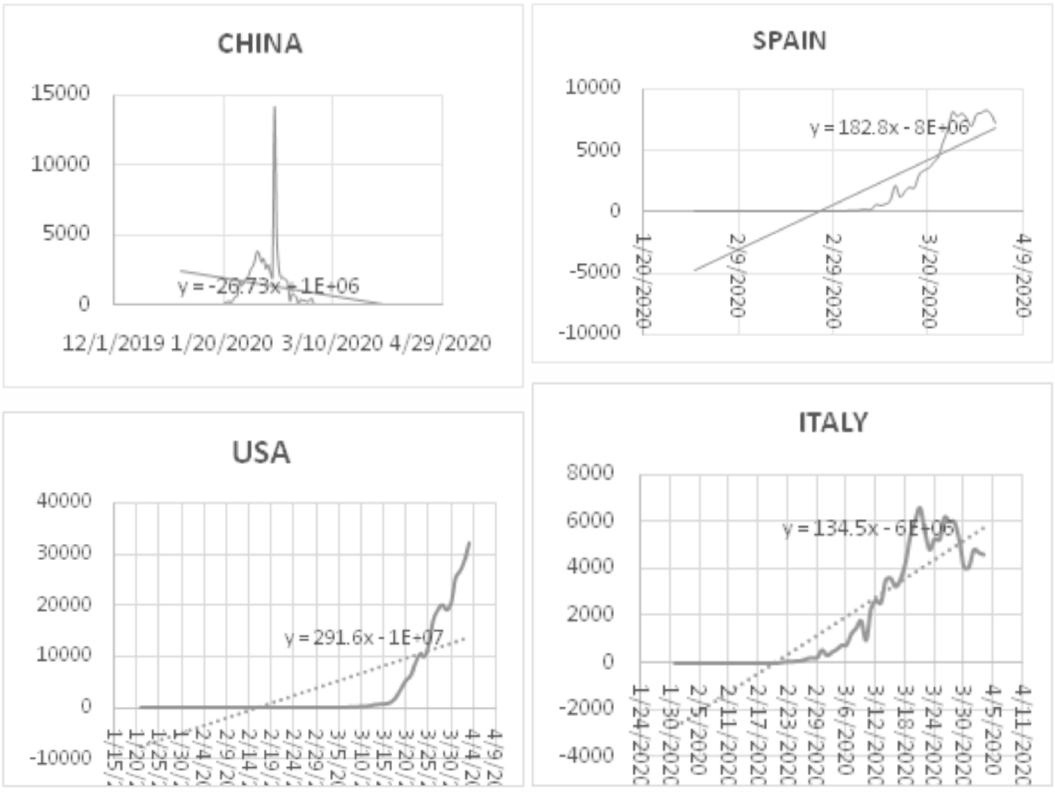
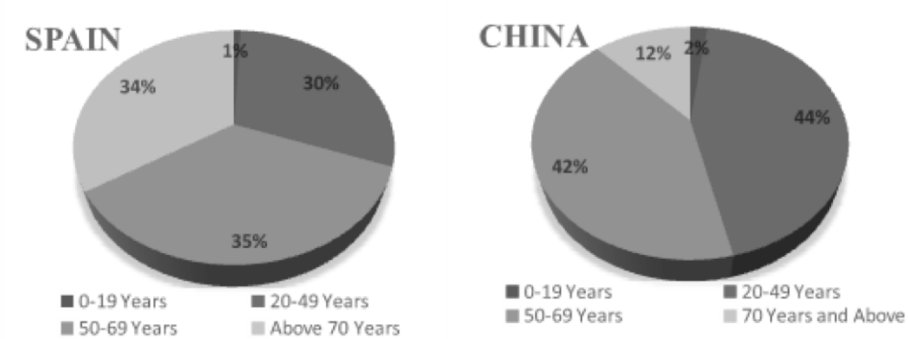


Fig 1: *VIRUS OUTBREAK IN SELECT COUNTRIES*

As of April 18, 2020, the outbreak of the corona virus disease (COVID-19) had been confirmed in around 210 countries or territories. The virus had infected 2.5 million people worldwide, and the number of deaths had crossed over one hundred thousand. It is to be noted that among the ten major virus outbreaks in the last 50 years, the novel corona virus (2019-nCoV) ranked second in terms of the number of infected and the number of deaths. At the end of April 2020, the virus spread to 211 countries with almost 2.5 million confirmed cases. India witnessed an outbreak of the corona virus. The first case was reported in late January 2020 when three Indian students travelled to the southern state of Kerala from Wuhan in China. Three of them were tested positive for Covid-19, confirming a local contagion. At the same time, several other cases were confirmed in other parts of the country, where most of them linked to people having travel history to affected countries and through primary contacts.

Age Structural Impact

Age Dynamics plays a vital role in affecting the spread of the virus. Interferon's signaling proteins have shown to possess an essential part in the defense against this virus that characterizes the infectious rate based on age factor (Shahabi et al., 2020). For instance, Italy has number of deaths than China. There is a dramatically higher mortality burden in countries with older versus younger populations, adding that cultural practices such as the social connectedness of older and younger generations should be considered when governments make confinement policies (Lauren, 2020). The overall death rate from covid-19 has been estimated at 0.66%, rising sharply to 7.8% in people aged over 80 and declining to 0.0016% in children aged nine and under (Elizabeth, 2020). From the Imperial College COVID-19 Response Team (2020) reports, mathematical modeling of the effects of social distancing interventions can support decision-making based on the local contact patterns and known or assumed parameters of infectiousness, incubation time, and duration of immunity. Heterogeneities in contact networks can create a significant effect in identifying whether a pathogen can become epidemic or at pandemic levels (Kiesha et al., 2017). Communicable Disease transmission and recovery can be modelled using Susceptible-Infected-Recovered (SIR) model (Anderson R, 2020). The Covid19 is affected by the people who have the most undersized immune system. A stimulating correlation between the innate immune response threshold and the fatality rates in COVID-19 can be found. Differences in the dynamics of the interferon's-related innate immune responses in children, adults and the elderly reflect the reported fatality rates. The increased mortality rates in the elderly can be explained by the higher threshold of interferon-mediated immune responses. Earlier induction of interferons in children and their less developed immune system could be the reason behind their zero or near to zero fatality rate. Though the number varies, as a whole, the Covid-19 positive cases are most common for people aged above 20. Age Structure alone cannot act as substantial evidence for identifying the transmission but can provide a vital context for understanding and responding to the situation. The below graphs indicate how the pandemic has hit these countries according to their age pattern.



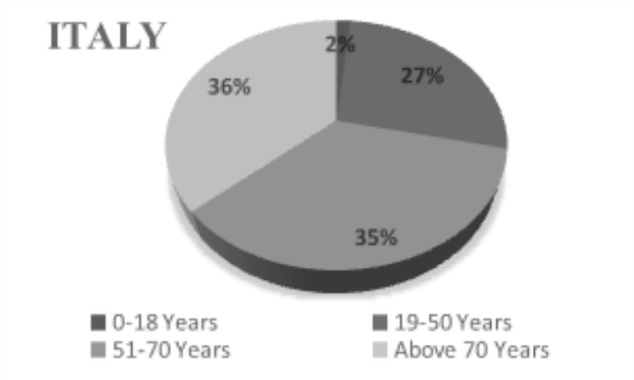


Figure2: *AGE PATTERN IN SELECT COUNTRIES*

From the data, it can be understood that Covid-19 is least affected among children or those aged below 20 years. Also, from the data, it can be observed that China's older age (above 70 years) positive cases are lesser, unlike Italy and Spain. This is because, from the given population density, Italy and Spain have more above 70 year aged people over China. In India, most Covid-19 cases are among the people aged between 20 and 60 years, and the least affected are children or teenagers aged below 20 years. The maximum percentage of corona virus-positive cases is 42% based on data published, comprising people aged between 21 to 40 years. The next most affected category of aged people between 41-60 years is 33%. The Senior citizens, who are aged above 60 years at 17%, are on par with the study of reported cases in China as India's Population density suggests that senior citizen are lesser when compared to the younger generation. However, the mortality rate among senior citizens stands high due to their underlying health conditions such as diabetes, cardiac issues, respiratory issues, hypertension etc. The least affected age group for the Covid-19 comprises those aged below 20 years, 8%. They are near similar to the trend line or pattern obtained from the studies of the most affected countries.

From the data reported by the researchers, it said that 0.04% of 10-19-year-olds would probably require hospital care, as would 1.0% of people in their 20s, 3.4% of people aged 30-39, 4.3% aged 40-49, and 8.2% aged 50-59, 11.8% in their 60s, 16.6% in their 70s, and 18.4% of those over 80. In the study, historical data of infected cases of Covid-19, population and their statistics are used to predict the possible outcome with the help of analytical tools such as Excel and programming language such as Python for analyzing and simulating the predictive models. The sample size for the study is the total number of Covid-19 infectious persons from the first date of reporting till the specified date used for the analysis. The research mainly focuses on Covid-19 Epidemic in India, and sample size data are taken from respective government portals. The Secondary data used for the data analysis includes quantitative data gained from various data sources. Data Mining and Text Analytics are the two methods to which the data has been collected and transformed to the needed form or into an ordinary source defining the different relationship of variables to which the respective data collected.

Data Analysis Technique

Predictive Analysis or Predictive Modeling is carried out for the analysis and the simulation of the resulted models. This analysis predicts the future outcome of India's spread of infectious disease based on the existing data or historical data. Forecasting and predictions are assumptions or likely to happen based on the inputs that have been provided involving mathematical constants and related

assumptions. Data Forecasting and SIR Model are mainly used for the analysis and the simulation of predictive models. The research and the simulation have been carried out with the help of Excel Stat and Python Programming. The mathematical differential equation for the same has been adjusted for the programming language for practical computation.

The Initial Values that are being set for forecasting the data using the Excel Function "FORECAST.ETS.CONFINT is the array of historical data of infected individuals from the date of reporting from 3 February 2020 (adjusting the previous data) till 3 July 2020. A Confidence Interval of 95 % is set under normal distribution towards the specific target date. Setting Confidence Interval will catch the accuracy of the predicted Model. The predicted or the forecasted values based on the initial values set are expected to fall within the speculated radius of the confidence interval implied.

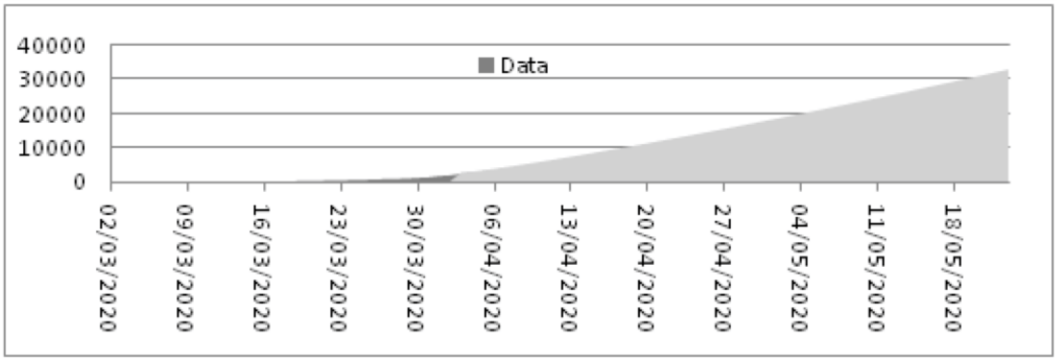


Figure 3: DATA FORECAST

A confidence level of 95% is set in forecasting this folded normal distribution of data. The predicted data signifies that under normal conditions, without countermeasures such as social distancing or contact tracing or increasing tests per million, more than 30,000 people get infected until the specified forecasted date. The results are purely assumptions under normal conditions without implying any mathematical conditions or biological constants such as primary reproductive ratio, transmission rate or doubling rate used to find the impact of the disease outbreak.

SIR Model

The aim is to fit the mathematical model to predict or estimate the probable infectious people at the end of the specified time interval on contact β. The model includes considering symptomatic and asymptomatic infective uncertainty, hence considering all cases to be symptomatic. This model tends to underestimate the possible severity of the Covid-19 outbreak. The standard equation for the analysis of the SIR Model are given below:

β (beta) = Infection/Transmission Rate

γ (gamma) = Recovery Rate

$$\frac{ds}{dt} = -\beta SI$$

$$\frac{dI}{dt} = \beta SI - \gamma I \qquad \frac{dR}{dt} = \gamma I$$

Table 1

India Data (3 APR)	
Total Infected	2549
Total Recovered + Removed	264
Population	1,380,004,385

Where, S=Susceptible; I= Infected; R= Recovered

Basic Reproductive Ratio, $Ro = \frac{\beta}{\gamma}$

The mathematical modeling, in Python Programming used for analysis and simulation of models, the equations are adjusted as:

S, I, R = N

dSdt = -beta * S * I / N

dIdt = beta * S * I / N - gamma * I

dRdt = gamma * I

Essential Reproductive Ratio been adjusted as,R0 = effective contact rate / recovery rate.

The model assumes all the cases as symptomatic, and the model fits the parameters as effective contact rate at 0.345 and recovery rate at 1/7. The forecasted data considers the impact of the Covid-19 outbreak in India without any biological constants used to predict the possible outcome of the epidemic. They are indicated under normal conditions and are considered assumptions. The SIR model computes the outbreak of the disease practically and theoretically for an open or closed population over time.

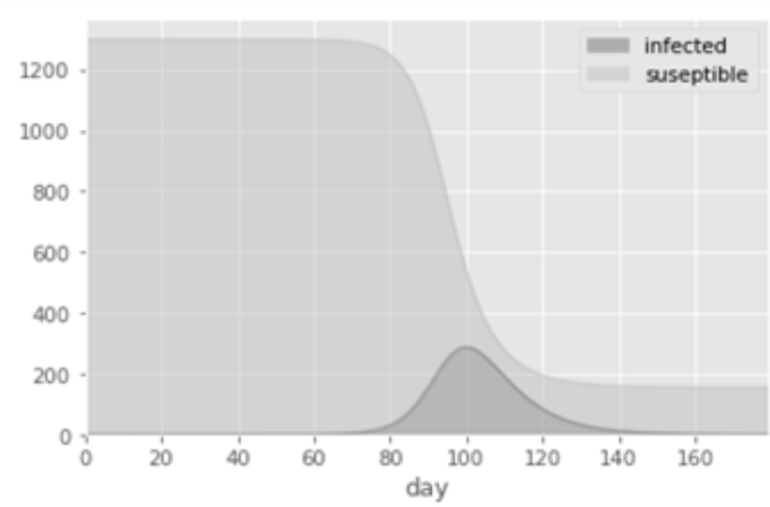


Figure 4: SIR Model

The SIR Model extends the predictive model of the possible outcome of the epidemic to a six-month forecast exhibiting the potential number of infected people in the orange and the possible number of susceptible people for the infectious disease in blue. The modeling is based on mathematical computation using biological constants with existing data simulated through a computer programming language. From the simulated data, it can be observed that over 180 days, about 1100 million in total are expected to get infected at the peak. The derivation is based on the existing data and is predicted by assuming any countermeasures such as social distancing or other related measures. The interpretation is optimistic towards the best-case scenario of the possible outcome of the epidemic without mitigation, closure of public gathering.

Age Structured Transmission of Disease

The aim is to highlight the age differences emphasizing their effect on the spread of the Covid-19 outbreak. The partitioning of the population has been differentiated into two age groups, age below 25 and age above 25 and is labeled by the index, ι = 1,2. The age below 25 is presumed to be children, and young adults above 25 are supposed to be adult and old aged people. Aged below 25 can catch the infection from the subordinates, and Aged above 25, so is vice versa. Their infection rate has been implied as λ^1 (t) and λ^2(t), respectively. The Cij contact matrix quantifies how much age group interacts with each other.

$$\Lambda^1(\mathrm{t}) = \beta\left(\mathrm{C}^{11}\frac{I^1}{N^1} + C^{12}\frac{I^2}{N^2}\right) S1$$

$$\Lambda^2(\mathrm{t}) = \beta\left(\mathrm{C}^{21}\frac{I^1}{N^1} + C^{22}\frac{I^2}{N^2}\right) S2$$

The differential equation for the same and the Age Structured Differential equation are as follows

$$S_\mathrm{i} = -\Lambda_\mathrm{i}(t)S_\mathrm{i}$$

$$I_\mathrm{i} = \Lambda_\mathrm{i}(t)_\mathrm{i}\, I_\mathrm{i} - \gamma I_\mathrm{i}$$

$R_i = \gamma I_i$ And $S_i + I_i + R_i = N_i$

The age group with a higher rate is likely to quickly catch the disease that depends on the matrix implied or provided. The model assumes all cases as symptomatic, and the model fits the parameter as a beta at 0.345 and recovery rate set at 1/7. This section highlights the population's age structure and emphasizes the spread of infectious disease to different age groups. Most pandemics follow an Exponential curve during the initial spread and eventually flatten out (Ma et al., 2014)

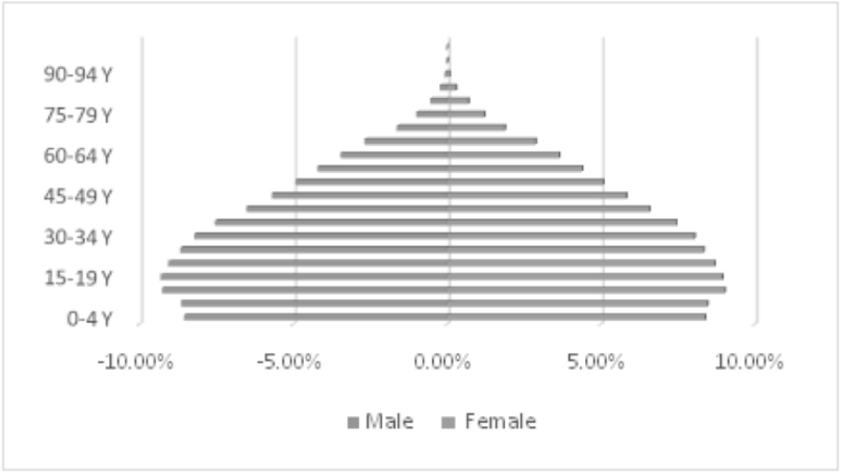


Figure5: *POPULATION PYRAMID*

Fig shows the population pyramid of India differentiated by their age and gender. This population pyramid showcases the depth of population determined by their age. The fraction of the entire population based on their age is fitted into the SIR Model to predict the results below. The epidemic Curve for the two aged groups (Aged above 25 and Age Below 25) are illustrated

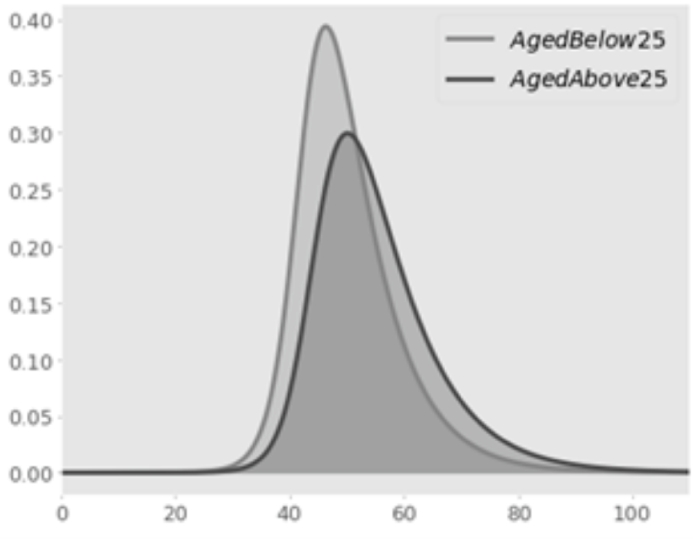


Figure6: *AGE STRUCTURED EPIDEMIC CURVE*

As it is observed from the population pyramid and the resulted data, the population for the age below 25 (Orange) are relatively higher than the age group "age above 25" (blue) as so is their possibility of catching the disease is higher considering their contact mix. Larger populations of the age group "aged below 25" are students and the contact mix is very much higher in response, which then results in a higher transmission peak. The depth of the infectious population aged above 25 are higher as the total susceptible population is relatively higher than the latter as depicted in the population pyramid. Another notable finding is that the population Aged below 25 in the graph gets deviated initially, passed through "Aged above 25". This indicates a higher possibility of disease transmission from the Children or Young Adults to Adults as their contact mix is higher. This is one of the significant reasons the closure of schools and colleges is given the highest priority as Aged below 25 primarily belongs to those groups to restrict the lower reproductive ratio and effective contact rate.

Impact of Social Distancing

For structuring the impact of social distancing, the SIR Model should be extended to the SEIR Model, including additional parameters. The standard differential equation for the SEIR Model are:

$$\frac{ds}{dt} = -\beta SI$$

$$\frac{dE}{dt} = \beta SI - \alpha E$$

$$\frac{dI}{dt} = \alpha E - \gamma I \qquad \frac{dR}{dt} = \gamma I$$

And S + I + R = N

An additional parameter for social mixing, ρ is included in the equation,

$$\frac{dE}{dt} = \rho \,.\, \beta \,.\, SI - \alpha \,.\, E$$

The higher ρ value, the lower is the social distancing factor. Assuming all cases as symptomatic and fitting the data resulted in the predicted SIR Model to this model, additional parameters are set to the program adjusting the equation and plot. The social distancing factor always lies between 0 and 1. The value of 0 indicates that everyone is maintaining social distancing, and a value of 1 indicates the least amount of social distancing measure taken. The aim is to emphasize the influence and impact of social distancing in restricting infectious disease transmission. The data is connected with the resulted SIR Model, including the addition parameter ρ, the social contact mix. A higher value in Social Contact Mix means a lower level of social distancing.

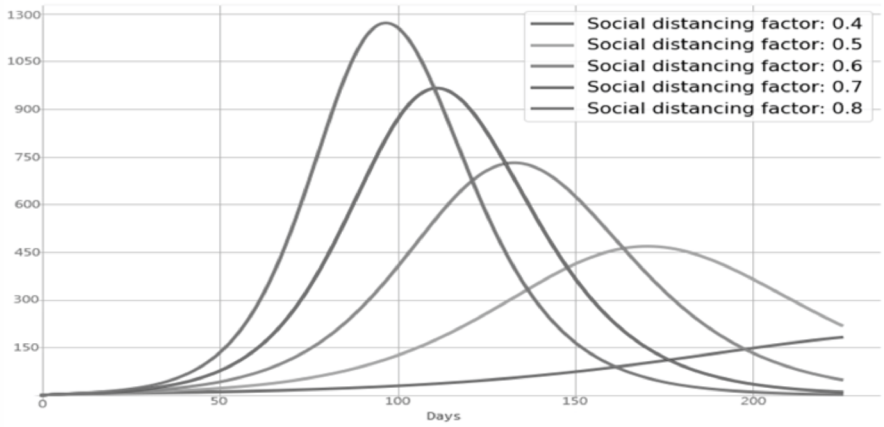


Figure7: *SOCIAL DISTANCING FACTORS*

The impact of social distancing can be observed reducing the transmission of infectious disease. As explained before, the increase in the social distancing factor (SDF) value means there is lower social distancing measure is taken, so is lower social distancing factor means the highest form of social distancing measures are taken. It can be observed from the Figure that the p-value provided 0.8 peaks with the most, which indicates that, if their most minuscule amount of social distancing measures been taken, the probability of infectious population will become substantially higher. Likewise, the curve's flattening with the minor infectious population occurs when a complete social distancing measure is taken where the social distancing factor value is given as 0.4. It should be noted that with just social distancing, the susceptibility for Covid-19 was brought down from 1100 million to less than 300 million people. The flattening of Curve for SDF = 0.4 takes a longer time interval, but it can be assured that infectious disease transmission could be controlled without infecting more population.

Conclusion and future research

A mathematical model for the spread of Covid-19 is computed and simulated, predicting the possible outcome. The paper highlights the age structural contact mix for the spread of the infectious disease, resolving the various aspects of the population generalizing the impact and influence of social

combination and social distancing in the space of this contagious disease. The predictive modeling was undertaken using Data Forecasting and SIR Model based on the historical data collected. The model forecasts the spread of illness during different time intervals without countermeasures such as vaccines or social distancing. Also, the impact of Covid-19 towards other age groups were highlighted that needs special attention. The Age group and their contact structure have an essential role in the transmission of disease. It is observed that Age grouped below has peak stage in transmitting the disease considering their social mix with the subordinates. The school and workplace closure should be promoted to restrict a consistent sizeable social gathering that helps transmit illness and increases the primary reproductive ratio. From the predictive modeling, it is evident that social distancing is the key to controlling disease transmission. The significance of social distancing was spotlighted in flattening the curve and preventing the spread of disease into a larger population. Thus it is the best way to practice social distancing for some time, considering the nature of the infectious disease. As there were uncertainties in data, the cases were regarded as symptomatic. The detailed and accurate estimates can only be obtained when included several factors such as asymptomatic cases, herd immunity, etc. The resulted models are based on the historical data excluding several factors, and they are primarily assumptions and predictions, and the actual may vary. The model can be used as a frame of reference and understand pandemic the situation and does not acknowledge other social, economic, medical and ethical characteristics.

REFERENCES

Anderson, R.; Heesterbeek, H.; Klinkenberg, D. and Hollingswort, T. (2020), How will country-based mitigation measures influence the course of the COVID-19 epidemic. The Lancet. Available at: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30567-5/fulltext

Elisabeth, Mahase (2020), Covid-19: death rate is 0.066% and increases with age, study estimates. BMJ 2020. Doi.org/10.1136/bmj.m1327

Huang, C.; Wang, Y.; Li, X.; Ren, L.; Zhao, J. and Hu, Y. (2020), "Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China". Lancet 2020. DOI: 10.1016/S0140-6736(20)30183-5.

Imperial College COVID-19 Response Team (2020), Impact of non-pharmaceutical interventions (NPIs) to reduce COVID19 mortality and healthcare demand, 1st ed. London: Imperial College.https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf [Accessed 29 Mar,2020].

John,

Elflein (2020), Infections and deaths of major virus outbreaks in the last 50 years as of 2020.Statista. Available at:https://www.statista.com/1095192/worldwide infections-and-deaths-of-major-virus-outbreaks-in-the-last-50-years/

Kiesha, Prem; Alex, R.; Cook, Mark Jit (2017) Projecting social contact matrices in 152 countries using contact surveys and demographic data [online]. PLoS Comput Biol 13(9): e1005697. Available at: https://doi.org/10.1371/journal.pcbi.1005697

Lauren Chadwick (2020),Social distancing working in Italy but epidemic could be determined by population demographics [online]. Euro News. Available at :https://www.euronews.com/2020/03/18/social-distancing-working-in-italy-but-epidemic-could-be-determined-by-population-demograp

Ma, J., Dushoff, J., Bolker, B.M. et al. Estimating Initial Epidemic Growth Rates. Bull Math Biol 76, 245–260 (2014). https://doi.org/10.1007/s11538-013-9918-2

Ross, Upshur (2003), The Ethics of Quarantine [online]. AMA Journal of Ethics. Available at: https://journalofethics.ama-assn.org/article/ethics-quarantine/2003-11

Shahabi nezhad F.; Mosaddeghi P.; Negahdaripour M.; Deghani Z.; Farahmandnejad M.; Moghadami M.; Nezafat and Masoompour S. M. (2020), Therapeutic Approaches for Covid-19 Based on the Dynamics of Interferon-mediated Immune Responses.Preprints 2020, 2020030206. doi:10.20944/preprints202003.0206.v1

Tedros, Adhanom (2020), COVID 19:Public Health Emergency of International Concern (PHEIC) Global research and innovation forum: towards a research roadmap, Global Research Collaboration For Infectious Disease Preparedness. Geneva: WHO, p. 2.

Vergu E, Busson H, Ezanno P (2010) Impact of the Infection Period Distribution on the Epidemic Spread in a Metapopulation Model. PLoS ONE 5(2): e9371. https://doi.org/10.1371/journal.pone.0009371

Centre For Disease Control (2020), Self Isolation [online]. CDC, BC Centre for Disease Control. Available at: http://www.bccdc.ca/health-info/diseases-conditions/covid-19/self-isolation

European Centre for Disease Prevention and Control,. (2020). Resource estimation for contact tracing, quarantine and monitoring activities for COVID-19 cases in the EU/EEA.[online]. European Centre For Disease and Control. Available at https://www.ecdc.europa.eu/en/publications-data/resource-estimation-contact-tracing-quarantine-and-monitoring-activities-covid-19

World Health Organization. Novel Coronavirus (2019-nCoV). Available at https://www.who.int/emergencies/diseases/novel-coronavirus-2019. Accessed April 7, 2020.

World Health Organization. 2019-nCoV Situation Report. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situationreports/