Addressing global pandemic (COVID 19) – How much testing needed to control the disease effectively

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Abstract. Corona virus has so far infected more than 21 million people worldwide with a mortality rate of nearly 3-4%. In some countries, it given goes up as 10%. While lockdown has so far been the only practised measure to hold the spread of the virus, still rate of infection is steadily increasing. Vaccine and effective antidotes are still to come. In this scenario, effective testing only works as an eye opener and helps in strategizing further measures. However, the testing is still a concern especially in developing economies. How much testing required, what are the effective ways to test people and its associated cost are critical considerations for the authorities.

In this paper, we are going to analyse trend of positive cases detected in various countries, requirement of testing based on population density and how effective this had been in adapting containment measures. Based on reach and cost constraints, testing at a mass level is exceedingly difficult. So, testing must happen among the most representative sample of the population and the amount of testing in a representative population has a significant role in extrapolating data well on the entire population. So, we will look at what is the optimum amount of testing required per million population by various countries (which would depend on the population and population density). However, this would still not address the exact requirement of optimum sampling frame as data to do that is not available.

Keywords: COVID-19, infection rate, population density, trend analysis, testing requirement

1. Introduction

The ‘SARS-CoV-2’ originated from Wuhan, the capital of Hubei, situated in mainland China. This “Novel Severe Acute Respiratory Syndrome Coronavirus-2” first detected there on 27th December 2019 [1-3]. Within noticeably short duration it become worldwide pandemic affecting millions of people [4]. As reported by World Health Organisation (WHO) worldwide infections are 21,756,357 including 771,635 deaths, 2.16 p.m. CEST 18th August,2020 [5]. Among which nearly half of the deaths reported were in the four worst hit countries: The United States (168,999), Brazil (107,852), Mexico (56,757) and India (51,797) [5].
Almost all countries have taken the social distancing as only weapon to reduce the transmission of virus including lockdowns, quarantines, curfews, block of 7, 15, 21 days at stretch [6-16]. Government is persistently pushing everyone to wash hands, wear masks, social distancing, risk communication and awareness to flatten the curve of infection. This will give time to scientists to develop tools to fight virus and government to better testing infrastructure, health systems. It is found to be effective for most of the countries. To make the preventive action more effective testing has high importance. The countries having large populations mass testing is needed on this ground. This paper considers the data from worldometer [17]. As observed from data, few countries like Thailand, Slovakia, Germany, New Zealand, and South Korea kept track of the outbreak from the starting point. In due course these countries were able to bend the curve as confirmed cases reduced with increase of tests. Austria, Iceland, Slovenia, Tunisia, or Latvia also follows the same principle. On the contrary for other set of countries like the United States, Brazil, Mexico, India, Panama, Pakistan, Nigeria, and South Africa, tests manifest a little relevance to the size of confirmed cases and number of cases increasing rapidly [17]. However, in early phases of pandemic, no significant difference was observed in between two set of countries. But in due course the first set of countries managed to bend curve down while other set of countries yet to take time.

Cost of testing is borne by government for most of the countries, but long queue may have chance for infection. However private agencies charges between $30 to $50 in various countries. Bringing people for testing is an additional overhead for countries health department. Hereby, mass testing numbers may vary country wise based on populations, economic conditions, infection rate in last 3 months. Some of the country data, we see that despite increasing mass testing there is no significant impact on variation of infection rate. So, scientists, researchers should explore other factors as well to bring down curve for these highly infected counties.

Present study will focus on finding optimum number of tests/1Million population for individual country. Here we have taken few countries in our consideration.

2. Data and Methodology:

2.1. Current situation
Below table 1 depicts situation of few countries with higher to lower confirmed cases. The deaths also shown for the same set of countries in table 2. The data considered till 31st July 2020 [5]. Typically, transmission stages are divided into 4 categories. Most of the countries are at the stage of either community transmission or cluster of cases [5].

Table 1. Cumulative confirmed cases till 31st July 2020

| Name of the Country | Cumulative confirmed cases | Graphical representation |
|---------------------|----------------------------|--------------------------|
| USA (United States of America) | 4.39M | |
| Brazil | 2.55M | |
| India | 1.64M | |
| Russian Federation | .84M | |
| South Africa | .48M | |
| Mexico | .41M | |
| Peru | .40M | |
Table 2. Cumulative deaths till 31st July 2020

| Name of the Country | Cumulative deaths | Graphical representation |
|---------------------|-------------------|--------------------------|
| USA (United States of America) | 150.1 k | ![Graphical representation of cumulative deaths](image) |
| Brazil | 90.1 k |
| Mexico | 45.4 k |
| UK | 41.2 k |
| India | 35.7 k |
| Spain | 28.6 k |
| Peru | 18.8 k |
| Iran | 16.6 k |
| Russian Federation | 14.0 k |
| Colombia | 9.5 k |
| Chile | 9.4 k |
| South Africa | 7.8 k |

2.2. Data Collection

Testing is most crucial factor in reduction of infection rate as it finds infected people and quarantine them to prevent from spread of virus. There are other strategies like physical distancing, washing hands, wearing masks and risk communication are less effective than testing.

In this study the researchers have collected data from Worldometer[17], every day starting 6th Apr to 31st Jul 2020 for all countries with daily cases, Total Cases/1M, New Cases/1M, #Tests /1M, Population Density (Population/Km²). Then Change in New Cases/1M has been calculated. A preview of the dataset given in table 3. This data preview shown for India and few days, but total data contains for all countries and Nearly 4 months (6th Apr to 31st Jul 2020).
Table 3. Preview of the data collected

| Date     | Country | New Cases | Total Cases/1M | Change in New Cases/1M | #Tests/1M | Population Density (M/square meter) |
|----------|---------|-----------|----------------|------------------------|-----------|------------------------------------|
| 06 Apr 2020 | India  | 489       | 3              | 0                      | 102       | 464                                |
| 07 Apr 2020 | India  | 573       | 4              | 1                      | 102       | 464                                |
| 08 Apr 2020 | India  | 565       | 4              | 0                      | 121       | 464                                |
| 09 Apr 2020 | India  | 809       | 5              | 1                      | 129       | 464                                |
| 10 Apr 2020 | India  | 875       | 6              | 1                      | 137       | 464                                |
| 11 Apr 2020 | India  | 846       | 6              | 0                      | 137       | 464                                |

2.3. Observations & Investigations
Below are few observations on the data set by doing curve fitting on the new cases.

- For few countries like Australia, Afghanistan the tests/M is extremely high comparative to new infected cases/M and % change in new cases has a decreasing trend day wise. E.g. Till 31st July the total tests/1M population done 166011 for 662 total cases/1M population in Australia.

- Country like Albania has done huge number of tests although the infection level is low, till 31st July, total cases/M is 1834 whereas total tests/M is 12506. This country has a decreasing trend % change in new cases on 31st July is -13%.

- In case of Andorra, till 31st July, the total cases/M is 11970 while tests/M is 48527. They have almost controlled the new infection.

- Country like Algeria very few tests have been done. No tests recorded after 19th May.

- For the countries Macao, Anguilla, Timor-Leste, French Polynesia, New Caledonia, Dominica, Falkland Islands, and Vatican City, all cases have recovered from infection and these countries have done more than enough tests. E.g. for Anguilla with 200 total cases/M population, the total tests/1 M population done 25,310 while the population is 15,014.

Based on different observations the researchers found that the testing may have a key role for isolation and prevention of transmission. So, there is a scope of investigation and finding a preventive measure to prevent world from a great downturn.

Based on population and cumulative confirmed cases the researchers have taken 24 countries from seven continents for observation and shown the trend of day wise new cases/1M population vs total tests/1M population in figure 1.
Figure 1. New cases vs Testing Trends.
From Figure 1, few observations are given below.

- In USA, there is no significant decrement occurs in the new cases. On 6th April, the new cases/1M population 91.70, on 8th June it is 57.55, it varies and got peak value of 235.58 on 24th July, sharply decreased to 169.50 on 26th July and again increases. The test data increases systematically.
- Brazil has of sharp ups and down in new cases/1M population. On 6th April it is 4.37, on 19th June it increased to 259.79; on 21st June decreased 79.29. Tests/1M population is also not done uniformly. It sharply increased on 27th July to 59252. On 27th July new cases/1M population decreased to 110.87, but again increased to 333.22 on 29th July.
- India has consistent increase in new cases/1M population with slight variation. The tests/1M population also increasing very consistently.
- In Russia new cases/1M population on 6th April is 6.53, It reaches to its peak 79.87 on 11th May and it shows a decreasing trend
- In case of South Africa, the new cases/1M population is 0.52 on 6th April, it reached 234.92 on 24th July and decreased to 119.53 on 27th July. But it does not show any consistent trend. The tests/1M population is consistent throughout.

2.4. Data Processing
Data has been categorised as below by keeping these broad conditions
- Independent variables - #Tests/1M, Population density, Country
- Dependent variable - %Change in new cases day wise (0 - %Change is less than 10%, 1 - %Change is greater than or equal to 10%)
- Country data is categorical variable, hence transformed for the modelling purpose into one hot coded variable
- Independent variables had been normalised by standard scalar transformation

2.5. Data Modeling for predicted number of test cases / Million
Building any model is dependent on underlying relationship between the independent and dependent variables. The dependent variable i.e. “%Change in new cases day wise” has been chosen carefully to analyse when this change becomes stable or there is no significant change number of new cases in one day over the previous day. That point would be assumed as optimum number of tests / million required for respective countries.

As had been shown above in Table-1, as ‘#Tests/1M’ increases, we see %Change in new cases start to become more stable (except a few countries, which seem to be still having insufficient data to draw a conclusion). Hence, we tried to understand what optimum number of tests for each country could be that would give us a realistic picture for new cases.

We have also included population density of each country as we anticipate new infection and tests required would be very much dependent on this parameter. E.g. If we are testing in a geography with sparsely populated locality, rate of infection will not be same vis-à-vis a densely populated geography. This will also affect number of tests need to be conducted in these two different geographies.
As we have also seen in table1, the main independent and dependent variable manifest non-linear relationship in nature, hence, we tried to work around a non-linear model. For this purpose, we chose a Sigmoid Neuron, as our dependent variable has two classes (0,1). Here Sigmoid Function is the right choice while we predict probability as output in range of 0 and 1.
The relationship of Sigmoid Function can be expressed as

\[ f(x) = \frac{1}{1 + e^{-(wx - b)}} \]

We have used mean squared loss = sum \((Y_i - Y_{\text{predi}})^2\) for gradient descent. The loss function is optimised for both weights i.e. ‘w’ and bias i.e. ‘b’. Our aim is to calculate ‘w’ and ‘b’ so that the loss is minimised between predicted class and actual class. \([\text{Class 0} = \text{change in new case less than 10\%}, 1 = \text{change in new case 10\% or more}]\) \([\text{Here } Y_i \text{ stands for actual value and } Y_{\text{predi}} \text{ stands for predicted value i.e. } f(x)]\)

Using chain rule of partial derivatives, we get the actual loss function for ‘w’ as –

\[ \nabla w = [(f(x) - y) * f(x) * (1 - f(x))] \] and the same for ‘b’ as \( \nabla b = [(f(x) - y) * f(x) * (1 - f(x))] \)

Weight \( w \) is initialised to a random number between 1 and length of the data. Bias \( b \) is initialised to zero. The gradient descent through partial derivative to calculate change is \( w \) & \( b \). The actual values of \( w \) and \( b \) are updated as \( w - \nabla w \) and \( b - \nabla b \) for each epoch and multiplied by the learning rate till we reach the minimum loss. The main objective of the loss function is to achieve minimum loss in training set as well as lower variance i.e. low difference of accuracy between Train and Test set of data.

The corresponding values of \( w \) and \( b \) for the minimum loss are stored for the model function.

**Figure 2.** Sigmoid Neuron curve.

A Typical Sigmoid Function takes the shape as in Figure 2, where the lowest possible value is 0 and the highest value is 1 as any probability value lies between 0 and 1. When the model is being trained using gradient descent of bias ‘b’ and weight ‘w’, as the gradients saturate gradually, i.e. no change in the accuracy, the learning stops. Table 4 has the list of epochs and learning rate for various countries where our model has saturated from further learning, we have used those model parameters for respective countries for further prediction on optimum number of test cases.
This model was built through Python code. Below are steps preview to create model and dump the mode for prediction.

2.5.1. Import and data load and data correction

```python
import pandas as pd
import numpy as np
import os
import matplotlib.pyplot as plt

os.chdir('C:\DATA\Trina\Research\Y2020\IOCER-JISC\ExperimentByPython')
# Change directory to working directory

# Read the excel data in a Pandas dataframe
data = pd.read_excel('Data-April-06th to July 31st.xlsx', sheet_name='Final with formula')

# Raw data cleaning and preprocessing
data.dropna(subset=['Country'], inplace=True)  # Drop blank rows not having any country name

data = data[data['Population Density']!="N/A"]  # Drop rows where Population density is N/A

data = data[data['% change in new cases daywise']!="START"]
# Not including filtering out the starting row of each country

data['#Tests /IM'].fillna(0, inplace = True)  # Fill blank rows with 0

C:\ProgramData\Anaconda3\lib\site-packages\pandas\core\ops\array_ops.py:253: FutureWarning: elementwise comparison failed; returning scalar instead, but in the future will perform elementwise comparison res_values - method(rvalues)

data.describe()
data.head()
```

2.5.2. Variation graph

```python
# gca stands for 'get current axis'
ax = plt.gca()
countryVar = "India"
# data.plot(kind='Line',x='Date',y='Total Cases/IM',color='green', ax=ax)
data.plot(kind='Line',x='Date',y='#Tests /IM', color='red', ax=ax)
data = data[countryVar][countryVar]  # Change the name of the country here to check the graph

data.plot(kind='line',x='#Tests /IM',y='% change in new cases daywise',color='green',
title=countryVar,ax=ax)

plt.xlim(-1.5, 1.5)
plt.show()
plt.savefig('output.png')
```

2.5.3. Split Data into Train and Test

```python
# from statsmodels.tsa.arima_model import ARIMA

print (data.columns)
data.fillna(0, inplace=True)

Index(['Date', 'Country', 'New Cases', '% change in new cases daywise', 'Total Cases/IM', 'Change in New Cases/IM', '#Tests /IM', 'Population Density', 'Total Population'],
dtype='object')

df_model = data["#Tests /IM"]
# Where test number is zero, is filtered out for the modeling purpose
df_model.shape[0]
```
2.5.4. Model Training and Dumping when stabilized: Key programming steps are given below.

```python
In [16]: X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, random_state=42)
#Splitting the data into training and testing set

In [17]: X_train.columns

In [18]: #Convert the variables into Numpy arrays
X_train_arr = X_train.values
X_test_arr = X_test.values
y_train_arr = y_train.values
y_test_arr = y_test.values

In [20]: from sklearn.preprocessing import StandardScaler, MinMaxScaler
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, mean_squared_error
scaler = StandardScaler()
X_scaled_train = scaler.fit_transform(X_train_arr)
X_scaled_test = scaler.transform(X_test_arr)

In [21]: #Replace NaN or infinite values with Finite values
X_scaled_trainT = np.nan_to_num(X_scaled_train)
X_scaled_testT = np.nan_to_num(X_scaled_test)

In [22]: SigmoidNeuron()

In [23]: #Measure train/test accuracy
def c_accuracy(y_data, y_pred, t_type, epoch, learning_rate):
    print(X_scaled_trainT.shape[0])
    c=0
    f=0
    for a, p in zip(y_train, y_pred):
        if ((a==0 and p<0.5) or (a==1 and p>=0.5)):
            c=c+1
        else:
            f=f+1
    print("Accuracy", "Training/Testing", "epoch", "learning_rate")
    print(c/n*100, t_type, epoch, learning_rate)
```
3. Results and Discussion

3.1 Training and Testing

Finalized model was taken by varying epoch values and learning rate for the data set chosen for each country. Below results created by stabilizing accuracy and then model was saved in each case.

Table 4. Epochs, learning rate and Change in new case variation plot for various countries

| Country | Epoch | Learning rate | Train set accuracy | Test set accuracy | Change in new case variation plot |
|---------|-------|---------------|--------------------|------------------|----------------------------------|
| India   | 100   | 0.0001        | 44.15              | 44.15            | ![Image](image_url)               |
|         | 100   | 0.005         | 72.72              | 72.72            | ![Image](image_url)               |
| Country     | Epoch | Learning rate | Train set accuracy | Test set accuracy | Change in new case variation plot |
|-------------|-------|---------------|--------------------|-------------------|----------------------------------|
| USA         | 100   | 0.0001        | 41.55              | 41.55             | ![USA change in new case variation plot](image) |
|             | 100   | 0.01          | 72.72              | 72.72             | ![USA change in new case variation plot](image) |
| Russia      | 100   | 0.0001        | 63.63              | 63.63             | ![Russia change in new case variation plot](image) |
|             | 500   | 0.01          | 89.61              | 89.61             | ![Russia change in new case variation plot](image) |
| South Africa| 100   | 0.0001        | 46.75              | 46.75             | ![South Africa change in new case variation plot](image) |
|             | 100   | 0.015         | 59.74              | 59.74             | ![South Africa change in new case variation plot](image) |
| Peru        | 100   | 0.0001        | 62.33              | 62.33             | ![Peru change in new case variation plot](image) |
|             | 100   | 0.015         | 68.83              | 68.83             | ![Peru change in new case variation plot](image) |
| Australia   | 100   | 0.00015       | 58.44              | 58.44             | ![Australia change in new case variation plot](image) |
| Country | Epoch | Learning rate | Train set accuracy | Test set accuracy | Change in new case variation plot |
|---------|-------|---------------|--------------------|------------------|----------------------------------|
| Chile   | 100   | 0.0001        | 62.33              | 62.33            | ![Chile](image)                  |
|         | 100   | 0.005         | 67.53              | 67.53            | ![Chile](image)                  |
| UK      | 100   | 0.0001        | 44.15              | 44.15            | ![UK](image)                     |
|         | 100   | 0.005         | 70.12              | 70.12            | ![UK](image)                     |
| Canada  | 100   | 0.0001        | 62.33              | 62.33            | ![Canada](image)                 |
|         | 100   | 0.005         | 71.42              | 71.42            | ![Canada](image)                 |
| Argentina| 100  | 0.0001        | 51.94              | 51.94            | ![Argentina](image)              |
|         | 100   | 0.005         | 54.54              | 54.54            | ![Argentina](image)              |
| Mexico  | 100   | 0.0001        | 48.05              | 48.05            | ![Mexico](image)                 |
|         | 100   | 0.005         | 59.74              | 59.74            | ![Mexico](image)                 |
| Country       | Epoch | Learning rate | Train set accuracy | Test set accuracy | Change in new case variation plot |
|--------------|-------|---------------|--------------------|-------------------|-----------------------------------|
| Qatar       | 100   | 0.0001        | 38.96              | 38.96             | ![Qatar](image1)                  |
|             | 100   | 0.005         | 67.53              | 67.53             | ![Qatar](image2)                  |
| Saudi Arabia| 100   | 0.0001        | 52.63              | 52.63             | ![Saudi Arabia](image3)           |
|             | 100   | 0.005         | 80.26              | 80.26             | ![Saudi Arabia](image4)           |
| Italy       | 100   | 0.0001        | 54.54              | 54.54             | ![Italy](image5)                  |
|             | 100   | 0.005         | 67.53              | 67.53             | ![Italy](image6)                  |
| Germany     | 100   | 0.0001        | 44.15              | 44.15             | ![Germany](image7)                |
|             | 100   | 0.00015       | 55.84              | 55.84             | ![Germany](image8)                |
| France      | 100   | 0.0001        | 51.94              | 51.94             | ![France](image9)                 |
|             | 100   | 0.002         | 48.05              | 48.05             | ![France](image10)                |
|             | 100   | 0.005         | 51.94              | 51.94             | ![France](image11)                |
| Country | Epoch | Learning rate | Train set accuracy | Test set accuracy | Change in new case variation plot |
|---------|-------|---------------|--------------------|-------------------|----------------------------------|
| Brazil  | 100   | 0.0001        | 46.75              | 46.75             | ![Brazil change in new case variation plot](image1) |
|         | 100   | 0.005         | 58.44              | 58.44             | ![Brazil change in new case variation plot](image2) |
| Iran    | 100   | 0.0001        | 66.23              | 66.23             | ![Iran change in new case variation plot](image3) |
|         | 100   | 0.005         | 80.51              | 80.51             | ![Iran change in new case variation plot](image4) |
| Colombia| 100   | 0.0001        | 46.75              | 46.75             | ![Colombia change in new case variation plot](image5) |
|         | 100   | 0.01          | 54.54              | 54.54             | ![Colombia change in new case variation plot](image6) |
| Spain   | 100   | 0.0001        | 54.54              | 54.54             | ![Spain change in new case variation plot](image7) |
|         | 100   | 0.005         | 55.84              | 55.84             | ![Spain change in new case variation plot](image8) |
| Nigeria | 100   | 0.0001        | 55.84              | 55.84             | ![Nigeria change in new case variation plot](image9) |
|         | **100** | **0.015**     | **58.44**           | **58.44**         | ![Nigeria change in new case variation plot](image10) |
| Country  | Epoch | Learning rate | Train set accuracy | Test set accuracy | Change in new case variation plot |
|----------|-------|---------------|--------------------|------------------|----------------------------------|
| Indonesia | 100   | 0.0001        | 54.54              | 54.54            | ![Indonesia](Indonesia.png)      |
|          | 100   | 0.00015       | 46.75              | 46.75            | ![Indonesia](Indonesia.png)      |
|          | 100   | 0.0002        | 54.54              | 54.54            | ![Indonesia](Indonesia.png)      |
| Bangladesh | 100   | 0.0001        | 33.76              | 33.76            | ![Bangladesh](Bangladesh.png)    |
|          | 100   | 0.005         | 64.93              | 64.93            | ![Bangladesh](Bangladesh.png)    |
| China    | 100   | 0.0001        | 58.33              | 58.33            | ![China](China.png)              |
|          | 900   | 0.015         | 58.33              | 58.33            | ![China](China.png)              |
| Japan    | 100   | 0.0001        | 46.75              | 46.75            | ![Japan](Japan.png)              |
|          | 100   | 0.01          | 48.05              | 48.05            | ![Japan](Japan.png)              |
3.2 Results and Prediction

Building any model is dependent on underlying relationship between the independent and dependent variables. The dependent variable i.e. “%Change in new cases day wise” has been chosen carefully to analyse when this change becomes stable or there is no significant change in number of new cases.

Table 5. Prediction stabilisation and optimisation for different countries

| Country      | Epoch | Learning rate | Train set accuracy | Test set accuracy | #Tests /M 31st Jul 2020 | Population Density (M/square meter) | Predicted Probability |
|--------------|-------|---------------|--------------------|-------------------|--------------------------|-------------------------------------|-----------------------|
| India        | 100   | 0.005         | 72.72              | 72.72             | 13636                    | 464                                 | 0.62934               |
| USA          | 100   | 0.010         | 72.72              | 72.72             | 150000                   | 36                                  | 0.26574               |
| South Africa | 100   | 0.015         | 59.74              | 59.74             | 49850                    | 49                                  | 0.22704               |
| Peru         | 100   | 0.015         | 68.83              | 68.83             | 70234                    | 26                                  | 0.14463               |
| Australia    | 100   | 0.000         | 70.09              | 69.67             | 166011                   | 3                                   | 0.65185               |
| Chile        | 100   | 0.005         | 67.53              | 67.53             | 48493                    | 26                                  | 0.16506               |
| Canada       | 100   | 0.005         | 71.42              | 71.42             | 107239                   | 4                                   | 0.44754               |
| Argentina    | 100   | 0.005         | 54.54              | 54.54             | 15642                    | 17                                  | 0.40160               |
| Mexico       | 100   | 0.005         | 59.74              | 59.74             | 7505                     | 66                                  | 0.30882               |
| Qatar        | 100   | 0.005         | 67.53              | 67.53             | 150000                   | 248                                 | 0.16975               |
| Saudi Arabia | 100   | 0.005         | 80.26              | 80.26             | 96122                    | 16                                  | 0.01816               |
| Italy        | 100   | 0.005         | 67.53              | 67.53             | 112823                   | 206                                 | 0.39902               |
| Germany      | 100   | 0.000         | 55.84              | 55.84             | 95351                    | 240                                 | 0.60953               |
| France       | 100   | 0.005         | 51.94              | 51.94             | 45681                    | 119                                 | 0.54245               |
| Brazil       | 100   | 0.005         | 58.44              | 58.44             | 59247                    | 25                                  | 0.18534               |
| Iran         | 100   | 0.005         | 80.51              | 80.51             | 29221                    | 52                                  | 0.05482               |
| Colombia     | 100   | 0.010         | 54.54              | 54.54             | 30900                    | 46                                  | 0.36298               |
| Spain        | 100   | 0.005         | 55.84              | 55.84             | 142834                   | 94                                  | 0.54011               |
| Nigeria      | 100   | 0.015         | 58.44              | 58.44             | 1321                     | 226                                 | 0.33164               |
| Indonesia    | 100   | 0.0002        | 54.54              | 54.54             | 5502                     | 151                                 | 0.3582                |
| Bangladesh   | 100   | 0.005         | 64.93              | 64.93             | 7140                     | 1265                                | 0.1096                |
| China        | 100   | 0.0001        | 58.33              | 58.33             | 62814                    | 153                                 | 0.5833                |
| Japan        | 100   | 0.010         | 48.05              | 48.05             | 6375                     | 347                                 | 0.5396                |

For few countries (like Russia, UK.), as data is still not matured for any conclusion, we have excluded them from the above table 5.

4. Conclusions

This paper aims to stabilize the model to get higher accuracy on test numbers / million which was received based on the data set captured. As seen, data variation is wide enough to create a common model for all countries. However, initial study depicts few countries can continue to do their test same way and some countries like US is already good and they can have 150,000 as optimum tests/M. Russia data is decaying, Russia should increase number of tests. This study considers only population and last 4 months data on changes in new cases but there are various other parameters like community acceptance, testing correctness, awareness to the countrymen plays bigger role to find greater accuracy.
5. References

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