A Comprehensive Study on Mathematical Sampling before Testing For COVID-19 Infected Candidates

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Abstract— COVID-19 is a new infectious viral disease and it is great challenge to the entire globe. The corona virus COVID-19 is declared as pandemic and it will change the life style of human in our society. The number of infection cases related to COVID-19 is increasing almost exponentially like any other pandemic disease. Till date there is no vaccine or medicine which can prevent from infection of COVID-19. To combat infection from COVID-19 the Governments are trying to reduce the spread of the virus by doing some standard techniques such as lockdown and then testing, tracing, social distancing, quarantining and isolation of citizens. In the present paper the authors have tried to introduce explore the reference sampling to isolate COVID-19 infected patients. Reference sampling will be helpful to collect data and give a proper idea to testing for covid-19 patient.

Keywords— COVID-19, Pandemic, Sampling, Social

I.   INTRODUCTION

Corona virus disease (COVID-19) is an infectious disease caused by a newly discovered corona virus initially at Wuhan in China. It is not very clear till date whether the virus was created in the laboratory by some virologist or it came from Bat and then trough pangolin. We have to wait few more days to what was the actual source of COVID-19. Initially the scientists in China said that COVID-19 is transmitted from human to human. But within few days after that when it was found the people were also affected in different countries then the scientists agreed that the Novel Corona Virus can transmit from human to human primarily through droplets of saliva or discharge from the nose when an infected person coughs or sneezes. The evidence so far indicates that the virus is spread from person to person through small respiratory droplets. When a person coughs or sneezes, these droplets can also land on nearby surfaces. There is also evidence that the COVID-19 virus can last on surfaces – especially plastic or metal – for up to 24 hrs and even up to 3 days. This is why advice to avoid catching COVID-19 has focused on hand washing with soap, the use of alcohol-based hand sanitizing gels and keeping a distance from people who are symptomatic. Most people infected with the COVID-19 virus will experience mild to moderate respiratory illness and recover without requiring special treatment. Older people and those with underlying medical problems like cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop serious illness. [1]
The best way to prevent and slow down transmission is be well informed about the COVID-19 virus, the disease it causes and how it spreads. Protect yourself and others from infection by washing your hands or using an alcohol based rub frequently and not touching your face. At this time, there are no specific vaccines or treatments for COVID-19. However, there are many ongoing clinical trials evaluating potential treatments. World Health Organization(WHO) will continue to provide updated information as soon as clinical findings become available.[2]. In the present study the authors have explored the concept of sampling testing to identify COVIT-19 patients. Most of the countries are giving emphasis on testing and testing only. Testing will help to identify more patients related to Covid-19 infection. Therefore there is need to find out the list of patient on priority basis for whom first testing is required. There need to find the data from person and reference sampling will be helpful to prepare the list of person on priority basis.

II.   METHODS USED TO MINIMIZE THE TRANSMISSION PROCESS OF COVID-19

Let us now try to understand how we can split the members in a set to disjoint sets:

A.   Partition of Set into disjoint set

Let S be a set having collection of people and let it is partitioned into n disjoint set for a fixed period of time.
    Let disjoint set are represented as S_i for i=1,2,.......,n. Such that $\bigcap S_i = \emptyset$ for i=1,2,3,....,n for a fixed period of time.
The purpose of make disjoint set is to make minimum people are affected by spread of COVID-19

1)   Reason for partition of set

The World Health Organization (WHO) has declared COVID-19 to be a pandemic. The symptoms of COVID-19 appear within two to 14 days after exposure and include fever, cough, a runny nose and difficulty in breathing. It primarily spreads through the respiratory droplets of infected people. If a person touches a surface or object that has been infected by the virus and then touches his own mouth, nose, or eyes, he may get infected. [6]

Once a person is infected with a virus, their body becomes a reservoir of virus particles which can be released in bodily fluids – such as by coughing and sneezing – or by shedding skin or in some cases even touching surfaces. The virus particles may then either end up on a new potential host or an inanimate object. [6]

The transmission of virus can be reduced if the concept of Lockdown (i.e. in sense of mathematics partition of set) will be implemented. These will reduce the number of people infected from Covid-19. The main purpose is to keep the reproduction rate of virus (i. e. R < 1) and to reduce the rate of infection of people.

Now the epidemic spread can be divided into two parts (i) Mitigation and (ii) Suppression.:

a)   Mitigation

It is the process of "slowing but not necessarily stopping epidemic spread – reducing peak healthcare demand while protecting those most at risk of severe disease from infection." This is done by isolating suspected cases and their households, and social distancing the elderly and people at highest risk of serious illness.

b)   Suppression

Suppression, or basically, lockdown, which "aims to reverse epidemic growth, reducing case numbers to low levels" by social distancing the entire population "indefinitely" and closing schools and universities.
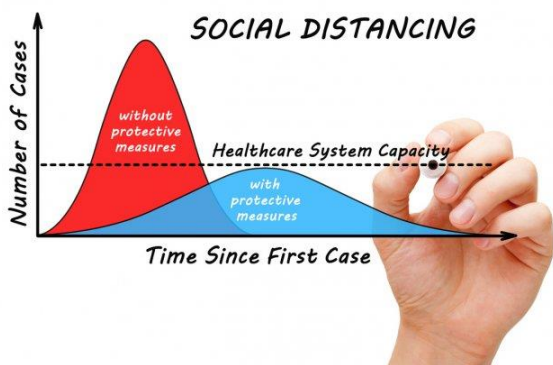

Figure 1:Advantage of Social Distancing

B.   Sampling and Testing Process

Now each member of Si should be tested using WHO recommended testing kit. But to test every member of each

Si will be complex. It may be possible of different types of problem as follows:

Table 1: case study of people and testing kit

Case 1	No of people need to be tested > No of testing kits available
Case 2	No of people need to be tested < No of testing kits available
Case 3	No of people need to be tested = No of testing kits available

Number of patient is unknown and not identified properly. So there is need to test whole population. But this situation will take more time and become complex

With passage of time, there is need to study the case of sampling. It is really a tough job to collect data from every person from a group of people. So, there is need to select some sample from a population when research is done to see the character of individuals.

a)   Population

Population is the collection of the elements which has some or the other characteristic in common. Number of elements in the population is the size of the population.

b)   Sample

Sample is the subset of the population. The process of selecting a sample is known as sampling. Number of elements in the sample is the sample size.
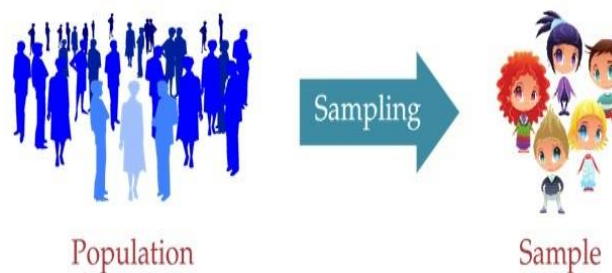

Figure2: Example to show sampling

Sampling will help to find the valid conclusion from the population and it will lead major role in the testing as per requirement. There are different types of sampling methods and it is categories as (i) Probability sampling and (ii)Non-probability sampling.

Probability sampling involves random selection, allowing you to make statistical inferences about the whole group.

On the other hand Non-probability sampling involves non-random selection based on convenience or other criteria, allowing us to easily collect initial data.[6]
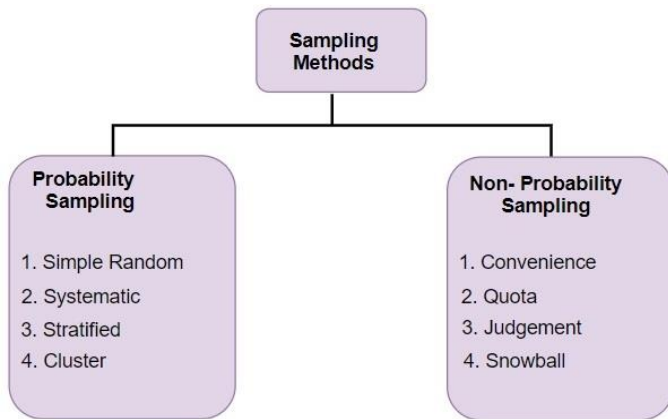
Figure 3:Some Important types of sampling

c)   Simple random Sampling method

Every element has an equal chance of getting selected to be the part sample. It is used when we don't have any kind of prior information about the target population.
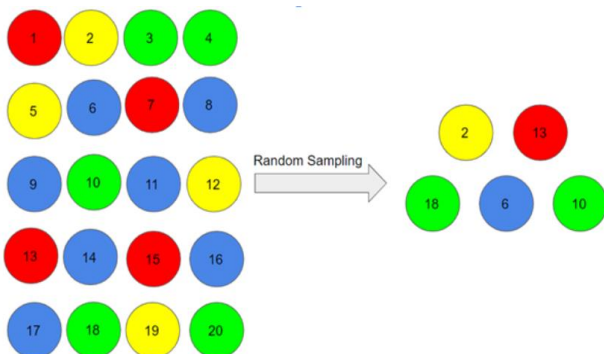

Figure 4 : Example to show random sampling

d)   Systematic Sampling method:

Systematic sampling is similar to simple random sampling, but it is usually slightly easier to conduct. Every member of the population is listed with a number, but instead of randomly generating numbers, individuals are chosen at regular intervals.
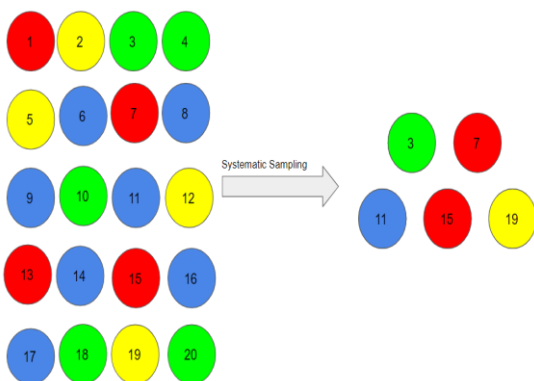

Figure 5 : Example to show systematic sampling

e)   Stratified sampling method

In this type of sampling, we divide the population into subgroups (called strata) based on different traits like gender, category, etc. And then we select the sample(s) from these subgroups
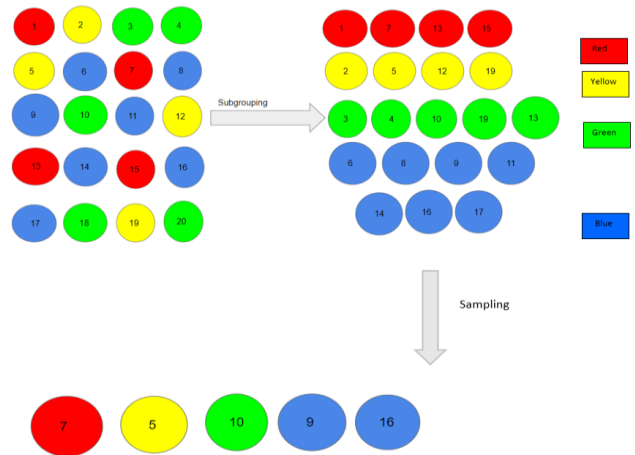

Figure 6 : Example to show Stratified sampling

f)   Cluster sampling method

Cluster sampling also involves dividing the population into subgroups, but each subgroup should have similar characteristics to the whole sample. Instead of sampling individuals from each subgroup, you randomly select entire subgroups. In a clustered sample, we use the subgroups of the population as the sampling unit rather than individuals. The population is divided into subgroups, known as clusters. Instead of sampling individuals from each subgroup, it is possible to randomly select entire subgroups.
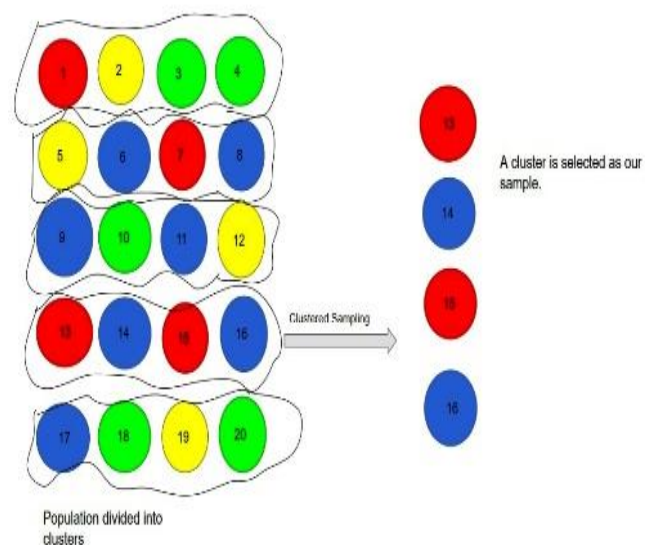

Figure 7 : Example to show Cluster sampling

g) Referral /Snowball Sampling Methods

This technique is used in the situations where the population is completely unknown and rare.

Therefore we will take the help from the first element which we select for the population and ask him to recommend other elements who will fit the description of the sample needed. So this referral technique goes on, increasing the size of population like a snowball.
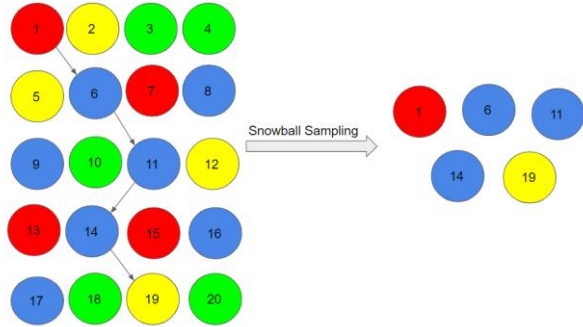

Figure 8 : Example to show Referral sampling

C.   Which sampling method may be used for COVID-19?

Sampling and testing is major concern to overcome the fight against COVID-19. Proper sampling will help to tackle the case of COVID-19. General approach of sampling is shown in the following flow chart.
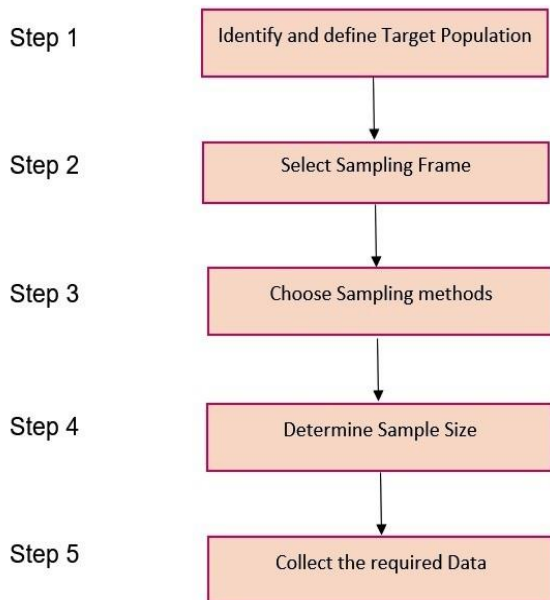

Figure 9 : Example to show methods of sampling

Snowball sampling or referral sampling may be helpful to fight against Covid-19.Generally people do not want to discuss or reveal their problem in public due to fear of behaviour of different types of people. COVID-19 is highly sensitive topic for some people. People do want to discuss or share information openly: So referral sampling will help to deal with those people who do not openly discuss and participate in surveys to share information about COVID-19.   Susceptible people will respond the researchers and also refer the people who were in contact with them to collect information. Here the process of reference will occur where each susceptible will refer to other. Snowball sampling will be helpful in the situations where it is complex or tough to access information from relevant person. It starts with finding people to study.
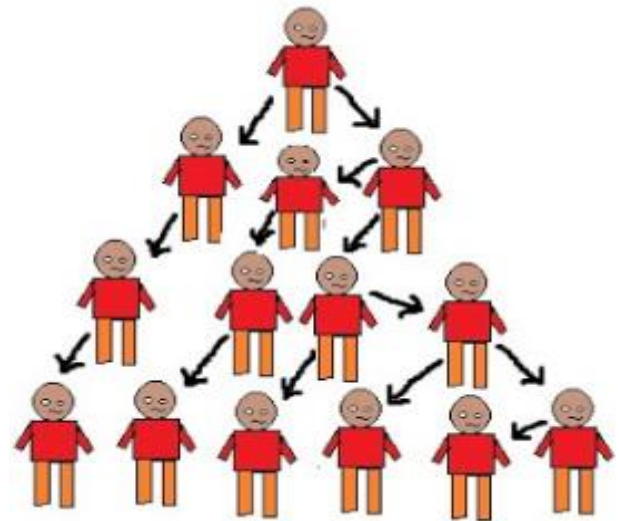

Figure 8 : Example to show Referral sampling from a sample

Role of sampling may be helpful in testing. It may be helpful to prepare the list of priority of the person. By using iteration process of this sampling it may be useful to generate priority of the person whose testing will be done first. Snowball sampling may be helpful to identify which person should be in isolation and which person should be in quarantine .Isolation and quarantine are public health practices used to protect the public by preventing exposure to people who have or may have a contagious disease.

Isolation separates sick people with an infectious disease from people who are not sick.

Quarantine separates and restricts the movement of people who were exposed to a contagious   disease to see if they become sick. These people may have been exposed to a disease and do not know it, or they may have the disease but do not show symptoms.

General algorithm process for people in COVID-19
Step1: start
Step2: take a sample from the population
Step3: Select the susceptible person
Step4: Find the persons related with susceptible person.
Step 5 makes quarantine to all of them
Step 6: make testing. If result is positive go to
step 7 otherwise got step10

Step7: Find all the infected persons
Step8: give proper treatment to infected person by isolating them
Step9: find the result .if they recovered got step 10 and if not recovered goto step 11
Step10: Send home
Step11: End

Mathematically, prepare a reference set for testing

$R_i = \{a_{i1} \rightarrow a_{i2} \rightarrow \ldots\ldots \rightarrow a_{im}\}$ for arbitrary variable and $i=1,2,\ldots,n.$

Here one variable will refer another variable on the basis of priority. And finally find $\bigcup R_i$ to calculate the numbers of COVID-19 patient.

Process of referencing will help to identify and isolate that person who has COVID-19 will reduce the expansion of problems in new patient. So there exist chances of slowing the rate of new infection and it will help to reduce the overall number of cases. Effective testing and quarantine measures may be helpful to make easy the pressure on health services.[11]

Study and reference of cases on the basis of age, sex and premedical condition and location may make testing easy and will give fruitful result. Referencing may be from one person to single person or multiple people. So, during testing it is needed to check the priority in testing.
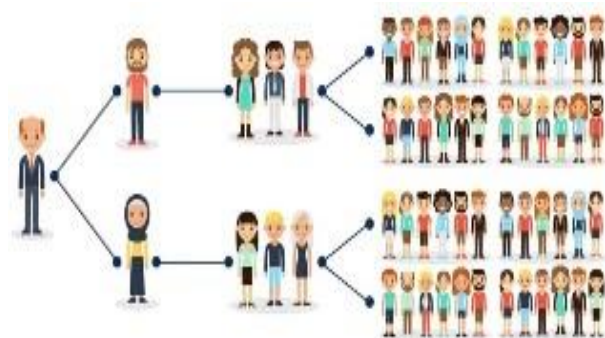

Figure 8 : To show Referance of people from one to multiple person

III.   ADVANTAGE

a)   Cost effective
Referral system of techniques will be cost effective as the referrals are obtained from a primary data source. It's is convenient and not so expensive method. It will help to find the quicker results. The system should follow good co-operation otherwise there will be problem to find actual data regarding person.

b)   Decreased lead time
Referral sampling and testing based on it will help to decrease the searching time of COVID-19 patient.

c)   Improved Patient access

There are different types of sampling and based on the situation it may be possible to used probability or non-probability based sampling. For example cluster based sampling will help to categories sample on the basis of age, sex and premedical condition of the people.

d)   )Enhanced Provider/ health System Communication
Reference system will enhance the communication level among health worker.

IV.   CONCLUSION AND FUTURE SCOPE

Today the greatest challenge is fighting against COVID-19. There exist challenges to find the people who are affected by COVID-19. The sampling techniques which describe in this paper will help to find the person whose testing is needed to get information about COVID-19 infection. Also sampling will help to increase the awareness among people to find against COVID-19. As there is no Vaccine and no suitable anti-viral medicine is available so therefore, the most challenging issue how to detect the infected persons and then isolate them. In the present paper the authors have mentioned few sampling methods which may be used to apply testing for COVID-19. Time is an important factor to overcome the epidemic Covid-19.At present situation Corona virus Covid-19 is spreading in unpredictable way .There is need to break the chain of COVID-19. So there need more testing and testing. Referencing sampling is based non-probability methods and there may exist chance to find out the people whose testing is required immediately to overcome the COVID-19 problem. However, there exists future scope to study different types of sampling methods which will allow us to test people more accurately even if the people are asymptomatic.

REFERENCES

[1]   R.Prasad , " The Pandemic NoteBook , A handy guide from the Hindu on understanding the corona virus pandemic and staying protected against COVID-19", The Hindu, 2020 page 1-21.

[2]   S..Nadeem, " Coronavirus COVID-19 : Available fee literature Provided by various Companies , Journal and organization around the world" Journal of ongoing Chemical research, vol 5, issue 1, 2020, page- 7-13,

[3]   F. Zhang , L Li , H Y Xuan, "Overview of infectious disease transmission models [J].", Theory and Practice of Systems Engineering, 2011, 31(9):1736-1744.

[4]   B. Yang , H.Pei , H .Chen., ". Characterizing and discovering spatiotemporal social contact patterns forhealthcare[J]. "IEEE Transactions on Pattern Analysis & Machine Intelligence, 2016, 39(8): 1532-1546.

[5]   Yichi Li, Bowen Wang, Ruiyang Peng, Chen Zhou, Yonglong Zhan, Zhuoxun Liu, Xia Jiang *and Bin Zhao1* " Mathematical Modeling and Epidemic Prediction of COVID-19 and Its Significance to Epidemic Prevention and Control Measures" Remedy Publications LLC. 2020 | Volume 5 | Issue 1 | Article 1052-1061

[6]   World health organization ,"Surface sampling of coronavirus disease (COVID-19): A practical "how to" protocol for health care and public health professionals" Version: 1.1 Date: 18 February 2020 , page 1-26

[7]   TR Julian, FJ Tamayo, JO Leckie, AB Boehm. (2011), "Comparison of Surface Sampling Methods for Virus Recovery from Fomites. Appl Environ Microbiol." 77(19): 6918-6925.

[8] H. Taherdoost , "Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research" International Journal of Academic Research in Management (IJARM) Vol. 5, No. 2, 2016, Page: 18-27, ISSN: 2296-1747

[9] S.C. Gupta, V.K.Kapoor "Fundamentals of Mathematical Statistics"Sultan Chand & Sons 2001,India, page 13.1-13.72

[10] A.P.Bainab,M.Jas "Elements of Probability and Statistics, Tata McGraw –Hill Publishing Company Limited, India,Page 279-309

[11] S.K.Mapa, "Introduction to Real Analysis" Sarat book Distributors, india,2000 page 1-20

[12] J.N Sharma, A.R.Vasishtha, "Mathematical Analysis –II "Krishna Prakashan Media (p)Ltd.2007 page 40-60

[13] B.K.Pal, K.Das , "Engineering Mathematics volume-4",U.N.Dhar & Sons private Ltd. India page 2-42 to 2-73.

[14] Victor Alexander Okhuese, "Mathematical Modeling and Epidemic Prediction of COVID-19 and Its Significance to Epidemic Prevention and Control Measures" Annals of Infectious Diseases & Epidemiology 2020, vol 5 issue 1, article 1052

[15] Parimal Mukhopadhyay, Theory and methods of Survey Sampling , Second Edition , PHI learning.

[16] A. S. Mandloi and V. Choudhary, " An Efficient Clustering Technique for Deterministically Deployed Wireless Sensor Networks ", International Journal of Scientific Research in Network Security and Communication (ISSN: 2321-3256) , Volume-1, Issue-1, April- 2013 . Page 6-10

[17] S.Dubey, R. Jhaggar , N. Jhariya, A. Thakur, "System for Providing News Associated with Location" , International Journal of Scientific Research in Computer Sciences and Engineering (ISSN: 2320-7639), Vol.5, Issue.3, pp.25-29, June (2017) E-ISSN: 2320-7639

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