Research Article

Sampling Model on Surveillance of COVID-19 virus among Human Populations

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DOI: https://doi.org/10.24321/0019.5138.202016

I N F O

A B S T R A C T

India stands at 90,927 confirmed cases of Covid-19 infection with WHO classification of clusters of cases. The governments around the world including India are mostly testing only people showing symptoms of flu, which are underestimating the real numbers due to presence of asymptomatic humans under virus incubation period. Random surveillance testing should, therefore, start as soon as possible to establish the mortality rate and virality of the Coronavirus. Such surveillance for Covid-19 provides valuable early warning information about the spread of the virus and also reduces the uncertainty surrounding the true extent of the pandemic and its mortality rate. Considered one of the most reliable forms of data collection, surveillance testing is takes small number of demographically representative random people to use as an estimate for the whole population. Due to these reasons, attempt was made to develop a model for Covid-19 virus surveillance using rapid antibody testing method for screening the human populations on disease prevalence, which can be followed by rRT-PCR testing. This screening method was test checked in virtual situation in Qutbullapur Municipality of Medak district, Telangana state, wherein three different areas – High risk, Moderate risk and Low risk, each having 3 km area were identified in the Municipality with 2118 houses and projections were made for virtual sampling in 4 replicated unit areas. The projection of cost analysis came as Rs. 11,900 for first round rapid sample collection from randomly selected houses in entire Municipality, which appeared as a feasible financial projection for a disease like Covid-19. Major town/cities can consider to adopt this as surveillance method for covid-19 virus.

Keywords: Corona Virus Disease, Covid-19, Surveillance, Survey Model, Rapid Antibody Testing, Disease Prevalence, Medak District

Introduction

In humans, several corona viruses are known to cause respiratory infections ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome and Severe Acute Respiratory Syndrome.

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Coronavirus disease-19 is an infectious disease caused by a newly discovered coronavirus. It spreads fast from human to human primarily through droplets of saliva or discharge from the nose when an infected person coughs or sneezes and poses threat to public health[1]. The transmission rate (RO), although as per WHO is between 1.4 and 2,[2] other studies indicated it as between 1.5 and 3.5.[3] In view of this, the Ministry of Health and Family Welfare, Government of India issued guidelines COVID-19[4] on desired actions by all States and UTs for preventing this disease in the country. As a part of the guidelines, random surveys are being made by health care personnel to identify emerging COVID-19 hotspots by ramping up screening followed by confirmatory testing to contain the spread of the coronavirus. However, there exists the need to focus on more effective surveillance for contact tracing and early diagnosis to reduce the high fatality rate. COVID-19 surveillance goals are to (i) monitor spread and intensity of COVID-19 disease in the United States, (ii) understand disease severity and the spectrum of illness, (iii) understand risk factors for severe disease and transmission, (iv) monitor for changes in the virus that causes COVID-19, (v) estimate disease burden and (vi) produce data for forecasting COVID-19 spread and impact.

Efforts of Indian Council of Medical Research (ICMR)[5]

As per initial ICMR guidelines, patients from the hotspot areas are given the test with (i) those who are symptomatic and have come from abroad within the last 14 days, (ii) people who came in contact with a COVID-19 infected patient if they are symptomatic, (iii) all symptomatic health care workers, (iv) all patients with severe acute respiratory illness and (v) asymptomatic contacts of COVID-19 infected patient on their fifth and fourteenth day of contact. Further, people with Influenza like illness are also being tested for confirmatory rRT-PCR test. However, as per amended guidelines on 8th May, 2020, ICMR issued new testing strategy to track COVID-19 cases[5]. As per this, (i) asymptomatic direct and high-risk contacts of an infected person and who have undertaken international travel in the past 14 days, (ii) symptomatic health care workers, (iii) direct or high-risk contacts living in the same house and (iv) all patients hospitalized with Severe Acute Respiratory Infections (SARI) are tested between the fifth day and 14th day of coming into contact with the patient.

Post Lockdown Scenario

As India plans to exit the lockdowns, albeit in stages, the focus will be on states accounting for the most deaths and those which are not testing enough. Thus, the focus is moving from prevention to mitigation. Public health systems should be able to treat and bring down the human mortality. Wide spread screening and testing would only will protect the vulnerable ones and track the progress of the disease. This throws the need for rapid surveillance of this virus prevalence in a community for initiating further containment measures/medical management of the disease.

Methodology for Sampling

The principle of case management as identified in the report of ICMR NIE, Chennai[5], early identification with (i) identification of suspects and (ii) clinical lab testing are essential. Interim advisory for rapid antibody testing was provided by Government of India to ensure speedy detection cases of corona virus.[4] Sampling method for screening COVID-19 virus does not exist in the country although antibody testing is available. Further, no uniform criterion is followed for sample collection except as knee jerk reaction at places leading to confusion on real prevalence of the disease. Rapid testing could be undertaken by sampling for detection of antibodies (serological) using NIV developed anti-SARS-CoV-2 human IgG ELISA test kit for diagnosis and population surveillance among symptomatic as well as asymptomatic persons in possible/ suspected hot spots. Such sampling will bring out the invisible (asymptomatic) human subjects in short period, as these people transmit the infection without their knowledge into the community before symptoms surface. However, the positive persons are to be subjected to confirmatory reverse-transcription polymerase chain reaction (rRT-PCR) testing for the presence of the virus to take up treatment of affected persons. An attempt is made for arriving at acceptable uniform method for serological sampling for COVID-19 virus.

Sampling Strategy

Three parameters are needed for sampling purpose – i. identification of potential/ suspected areas with threat perception in each zone, ii. selecting randomly unit area for sampling and iii. age group of individuals. Once unit area is identified, houses and individuals with different age groups shall be identified for sampling, as indicated below. This activity should be performed before visiting the area of sampling.

Personnel on Duty and Stranded/ Migrants

Following types of humans need complete (100%) sampling:

i. All (Health care professionals) Health officers and nursing staff; ii. all sanitation personnel in public places; iii. security personnel and other essential staff in public places; iv. migrant workers; v. Stranded individuals/students/pavement dwellers etc.

Sampling Method in Human Habitations

For remaining human population in towns and cities, following sampling method can be adopted:

Materials Needed: Rapid antibody detection kits as approved by competent authority.

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No. of Samples per Person: Two samples per person for screening.

First sampling shall be taken on Day 1 and second sample for false negative persons on Day 14 since the disease could be in incubation period at first sampling period. The incubation period is reportedly between 2-14 days.[3]

- First sample may be taken from a subject on the day of visit.
- The second sample shall be taken from persons on the 14th day who get negative on first sampling. Normally, the antibodies will be developed from 2 to 14-day time. This time lag of 14 days makes individuals with un-detectable anti bodies (at the first day sampling) to develop detectable levels of the antibodies/disease in the person's body, in case he is infected. Hence catching these Invisibles will break the chain of transmission.

Zones and Areas for Sampling

Identify non-infected (Green) and Infected zones in a city or town. Low risk areas in an infected zone can be considered as non-infected zone only. Later, cluster sampling method could be adopted for statistical analysis. It is easy to be used from practical view point.[6]

- Non infected (Green) Zone: Sample collection can be taken from one randomly selected person in every 50th house. Convert the Non-Infected Unit into Infected Unit if new confirmed positive case is detected in the area.

- Infected (Red) Zone: In infected zones, identify three types of areas – (i) High Risk, (ii) Moderate Risk and (iii) Low Risk. 3 kilometers can be taken in each area since movement of individuals is allowed that much for making household purchases/purposes.

Unit Area Sampling

In each infected zone, areas with above 3 types of risk areas are to be identified. Random sampling is to be undertaken in 4 randomly selected units as given below:

- High Risk - Unit area taken should be 100-meter. Sample collection to be done from one randomly selected person in every household.

- Moderate Risk - Unit area should be 250 meters and-sample collection is to be from one randomly selected person in every 5th household.

- Low Risk - Unit area is to be 3000 meters and-sample collection should be from one randomly selected person in every 40th household.

Virtual Test Check of the Sampling Method

In order to test the feasibility of the screening method and its cost estimate, residential data were collected virtually in Qutbullapur Mandal of Medak district in Telangana State with (hypothetical) potential disease threat (Table 1). For this test checking the suggested method, Qutbullapur Municipality under Qutbullapur Mandal was selected.

Under this, Roda Mistrynagar with 270 houses was taken as High-Risk area, Papireddy-nagar with 368 houses as Moderate Risk area and Suraaram with 1480 houses as low risk area were selected. In each of these areas, 4 sampling units each with number of houses ranging from 12 to 14 were selected (Table 1) in high risk area (100 m), 7 to 10 houses in moderate risk area (250 m) and 9 to 10 in low risk area (3000 m) were identified. The percent area sampled in each risk area out of total area (3 km) were identified as 18.88, 8.42 and 2.5% respectively giving priority to high risk areas.

The cost analysis (Table 2) came as Rs. 5100 for first rapid screening for 31 samples in 31 houses in high risk area, Rs. 3100 in moderate risk areas for 31 samples in total 157 houses and Rs. 3700 for 37 samples in 1480 houses (Table 2). The total cost estimated for rapid screening of COVID-19 in the Municipality with 2118 houses comes to Rs. 23,800 for first sampling and the cost would depend on need for second sampling. This cost would be feasible for any local body to spend for public health screening.

Table 1.Virtual screening for COVID-19 virus in qutbullapur mandal of medak district in telangana state

S. No.	Parameter	
1	Name of the Mandal	Qutbullapur
2	Name of the Zone	Infected
2.1.	Name of the area	Qutbullapur Municipality
2.1.2	Risk perception	High risk/Moderate risk/Low risk
2.1.3	No of Units	4 in each area
	No of Houses (Mean) in each unit HIGH RISK AREA - Rodamistri nagar No of houses in 100 m in 1st Unit	12 14

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2.1.3	2nd Unit	
	3rd Unit	13
	4th Unit	12
	No of houses in all 4 sampling units	51
	Total no of houses in 3 km	270
	MODERATE RISK AREA - Papireddy nagar - Jagadgirigutta	
	No of houses in 250 m in	35
	1st Unit	31
	2nd Unit	43
	3rd Unit	48
	4th Unit	157
	No of houses in all 4 sampling units	368
	Total no of houses in 3 km	
	LOW RISK AREA - Suraaram	
	No. of houses in3000 m in	360
	1st Unit	400
	2nd Unit	370
	3rd Unit	350
	4th Unit	1480
	Total no of houses in 3 km	
3.	No of houses for sampling*	
	HIGH RISK AREA	
	i. @ 1 /house in high risk area in	12
	1st Unit	14
	2nd Unit	13
	3rd Unit	12
	4th Unit	51
	Ii. Total no. of houses for sampling	51/270 = 18.88
	iii. Proportion of houses for sampling in total area (%)	
	MODERATE RISK AREA	
	i. @ 1/every 5th house in moderate risk area in	7
	1st Unit	5
	2nd Unit	9
	3rd Unit	10
	4th Unit	31
	ii. Total no. of houses for sampling	31/368 = 8.42
	iii. Proportion of houses for sampling in total area (%)	
	LOW RISK AREA	
	i. @1/40th house in low risk units in in	9
	1st Unit	10
	2nd Unit	9
	3rd Unit	9
	4th Unit	37
	ii. Total no. of houses for sampling	37/1480 = 2.5
	iii. Proportion of houses for sampling in total area (%)	

*One sample per house is to be taken for covid-19 screening.

Different Age Groups in Each Sampling Area

Samples should represent different age groups because:

- The age group from 10 to 50 move outside their residential premises during the lockdown/normal period for various activities and hence are likely act as "time ticking bombs" ready to explode as they don't show any of the symptoms (Asymptomatic Carriers).

- Most of the infected elderly age group subjects would be normally symptomatic and will present to the hospital with symptoms from 4th day onwards once infected. Otherwise, they may need less priority due

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to reduced movement in the Lockdown period.

- The lockdown can be removed once no positive case is detected in non-infected area.

Proportion of Sampling among Different Age Groups

- 90% of samples from the age group 10-50 years
- 10% of samples from the extreme age groups i.e., less than 10 years age and above 50 years age plus others with compromised immunity.

- There exists another segment of persons viz., (i) migrants locked up due to lockdown, (ii) health care persons notified by the Government including the security, health and sanitation personnel and (iii) pavement dwellers. Hence, consider 100% sampling among Healthcare workers, security personnel, essential services workers of local bodies, and other individuals who might come into accidental contact with a confirmative case.

Table 2.Cost Analysis Projection for Screening of Covid-19 in Qutbullapur Mandal in 3 Different Risk Areas

Type of Risk	No. of Houses	Unit No.	No. of Houses Sampled/Total no. of houses/ unit	Cost for screening** (Rs.) @100/sample (First time)	#Cost for screening** (Rs.) @100/sample (Second time)	Total cost (Rs.) @100/ sample for both samples
Roda Mistri Nagar - High Risk area	270	1	12/12*	1200	1200	2400
		2	14/14	1400	1400	2800
		3	13/13	1300	1300	2600
		4	12/12	1200	1200	2400
			51/51	5100	5100	10200
Papireddy Nagar, Jagatgirigutta	368	1	7/35**	700	700	1400
		2	5/31	500	500	1000
		3	9/43	900	900	1800
		4	10/48	1000	1000	2000
			31/157	3100	3100	6200
Suraaram	1480	1	9/360***	900	900	1800
		2	10/400	1000	1000	2000
		3	9/370	900	900	1800
		4	9/350	900	900	1800
			37/1480	3700	3700	7400
Qutbullapur Municipality	2118			11900	11900	23800

*1 sample/house in all houses of 100 m area; **1 sample/5th house; ***1 sample/40th house.

#Second sampling is subjected to false negative (covid incubation period) in the first sampling.

The cost for a Municipality of 2118 houses comes to Rs. 11900 for single time sampling and for second time sampling the cost depends on need for it.

Mapping and Tabulation

Plot the sampling unit area/map with number of households with residents (age category wise) and workout the number of samples to be collected beforehand based on above criteria and model. This will not only save time, but also indicate input and infrastructure requirements to carry with each team. It may be tabulated as follows. This can be amended based on the need:

Name of village/ town/ city:

Name of person surveyed:

Date of survey:

Town/City/Ward with District	Ward/Unit area	No. of houses	No. of houses to be sampled	No. Individuals category-wise		
				Less than 10 years age	10 to 50 years	Above 50 years and vulnerable patients

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Conflict of Interest: None

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