Using Tech & Math to Scale up Covid19 Tracking & Testing Capacity for India

Part 1 - Sample Pooling (or Group testing) with a mathematical approach to enable government to test more population with limited PCR machines - 3x capacity increment

The pooling strategy that we've described here could become extremely useful if a country moves to comprehensive, nation-wide or hotspot area wise testing of their population.

Pooling: Mixing is samples from different people together and conducting the test on the mixed sample.

We have presented a strategy for the pooling test that is backed by math to reduce the number of tests needed to identify positive samples. The strategy relies on the knowledge or good estimation of the probability of infection within the population or at least the tested sub-population. It also takes into consideration certain practical and logistical limits of the laboratory workers.

However, with some adjustments we believe it can be made simpler to implement.

Need of Pooling Test

- Mass Screening
- Limited Resources
- Limited manpower
- Economic Approach
- Time and speed of testing done compared to samples collected.
- To give positive assurance of negative reports is required to maximum mild or Asymptomatic person which will reduces the fearful thoughts, that's necessary for well being of mental health

Procedure of Pooling Test

We can use following steps to increase covid-19 testing capacity by pooling of samples:

1. When you collect samples, ask four questions from each user and tag them into one group as per their probability of being infected. The given chart divides the entire population based on their answers into 10 groups in order of their probability. The four questions asked take into account (a) combination primary v/s secondary contact tracing with travel history (b) severity of

symptoms (c) predicted immunity into weak v/s strong on the basis on age & historical pre-medical conditions. Each question has 2 possible answers - high probability v/s low probability. The total permutation & combination is 2^4 = 16. We used basic logics (HH into one, v/s HL LH LL into another) to reduce these to 10 groups. Refer to the chart below for better understanding.

2. Collect 3 swab samples per person or divide one sample into three parts while testing. Pool (or group) samples of all people in a group as one sample per group. Send these 10 group samples for a test keeping the other two samples of each patient aside.

3. Meanwhile conduct antibody tests off all patients individually and tag each patient with antibody test results as +ve and -ve. Since conductive antibody tests are relatively easier, assuming we can conduct them at scale. This step is optional and we can skip it in absence of its capacity.

4. The PCR test results of above 10 groups, will declare few groups as positive and few groups as negative. The entire population (every patient) under the groups with negative results are corona negative. Declare them corona negative and remove them from further steps.

5. For all positive corona groups we need to further identify which all patients are positive and which are negative. Divide the population into subgroups on the basis of antibody +ve and antibody -ve result of each patient. Name these sub groups as 1A+ve, 1-ve, 2A+, 2A-ve and so on. 1 represents the group number, A+ve or A -ve represents antibody test result.

6. Antibody negative subgroups have less probability of having a corona positive patient in comparison to antibody positive subgroups. Pool sample of all patients in negative subgroups. Re-conduct PCR test for them with the second swab sample of each patient.

7. Few subgroups would yield negative PCR results and others would be positive. Declare patients in corona negative sub-groups as corona negative and remove them from further steps.

8. For all antibody positive sub groups and antibody negative subgroups with second PCR result positive, go for individual testing. Final result will tell corona positive or negative at a patient level.

9. If the size of the population in step 8 is very large, divide the third sample into two parts. Use the first sample for pool testing into groups of 4 or 5 patients each. Remove corona negative

groups. Use the last part of the swab sample for individual testing of each patient of corona positive groups. Final result will tell corona positive or negative at a patient level

Table: Mathematical approach to increase Covid testing capacity using Pool testing on probability based groups

S.No.	Q:1 X= If travel or contact, Y=no history & no contact	Q:2 Symptoms (1= severe, 0 = mild or no)	Q:3 Age (H=>50, L=<50)	Q:4 Pre medical history (Yes / No)	Step 1 Grouping for PCR Test	Hypothetical PCR test Results	Step 2 Antibody Test (A+ve, A-ve)	Step 3 Re-PCR for antibody negative subgroups	Hypothetical results of PCR test	Step 4 PCR test with third sample
1	X	1	H	Y			A+ve	Individual testing		
2	X	1	H	Y	1	PCR +ve	A-ve	Re-test pool	PCR +ve	Individual testing
3	X	1	H	N			A+ve	Individual testing		
4	X	1	H	N	2	PCR +ve	A-ve	Re-test pool	PCR +ve	Individual testing
5	X	1	L	Y			A+ve			
6	X	1	L	Y	3	PCR -ve	A-ve			
7	X	1	L	N			A+ve	Individual testing		
8	X	1	L	N	4	PCR +ve	A-ve	Re-test pool	PCR -ve	
9	X	0	H	Y			A+ve	individual testing		
10	X	0	H	Y	5	PCR +ve	A-ve	Re-test pool	PCR -ve	
11	X	0	H	N			A+ve			
12	X	0	H	N			A-ve			
13	X	0	L	Y			A+ve			
14	X	0	L	Y	6	PCR -ve	A-ve			
15	X	0	L	N			A+ve	Individual testing		
16	X	0	L	N	7	PCR +ve	A-ve	Re-test pool	PCR +ve	Individual testing
17	Y	1	H	Y			A+ve			
18	Y	1	H	Y			A-ve			
19	Y	1	H	N			A+ve			
20	Y	1	H	N			A-ve			
21	Y	1	L	Y			A+ve			
22	Y	1	L	Y	8	PCR -ve	A-ve			
23	Y	1	L	N			A+ve			
24	Y	1	L	N	9	PCR -ve	A-ve			
25	Y	0	H	Y			A+ve			
26	Y	0	H	Y			A-ve			
27	Y	0	H	N			A+ve			
28	Y	0	H	N			A-ve			
29	Y	0	L	Y			A+ve			
30	Y	0	L	Y			A-ve			
31	Y	0	L	N			A+ve			
32	Y	0	L	N	10	PCR -ve	A-ve			

Sample calculation using hypothetical data - Assuming a 1000 samples divided into 10 equal groups of 100 each. Say 50% groups came negative in Step 1 of PCR, we can say 500 are corona free and would be able to reduce the size of the population to be tested to 500 in just 10 tests. Now assuming further 50% of 500 are antibody negative, make five subgroups of these. Conduct PCR test again and say, out of 5 sub groups 3 came negative (150 people further eliminated as corona negative in five pool tests). Now conduct individual tests for these 350. This way it will take 365 tests for 1000 samples, ==a capacity increase by ~3x. Probability based grouping instead of random sampling is the key to eliminate more people in fewer results.== In real world group sizes won't be equal but would be on the basis of actual answers by population.

Disclaimer:- *This method of Pooling Test is under research and approval by scientists is still awaited. We are introducing this method based on our medical knowledge supported by mathematical calculations, strategic planning and logics to solve this pandemic outbreak.*

Merits of Pooling Test

- Community spread declines, it prevents entry into the community spread stage .
- Public health improves:- Mental health improved via getting positive assurance of knowing a big COVID free population. Mental Health proportional to physical, behavioral as well as social health states.
- Speed of testing increases upto 3-4 times.
- Focus of administration, political workers, medical workers get specified.
- Decreases time span of lockdown
- Helps to return in normal lifestyle as early as possible
- Provides mass screening in available resources
- Provides assurance of healthy areas, statistical differentiated need of quarantined and
- Isolated zone.

Demerits of Pooling Test

- Limited trained sample collectors
- Human error during testing procedure.
- More test kits or handling of multiple parts of samples required

Medical Aspects of Pooling Test

- **Biotechnology of Pooling Test -** Mixing of more than 1 sample of nasopharyngeal/ oropharyngeal swabs is possible in RT-PCR machine. *For this refer www.cdc.gov*

- **Microbiology Of Pooling Test** - Viral content remains stable for 72 hours at 2 to 8‹C. After 72 hours the virus gets extracted. *For this refer www.cdc.gov*

- **Analytical data of RT-PCR machine -** 1 ma*chine can test 20-180 samples at a time, it varies depending on brand and size of machine. Time required in testing a single sample 90min to 240min. Depends on manpower availability, machine quality and efficiency of both machine and Technician. For This refer website of [FDA](FDA)*

*For to know basics about COVID 19 i.e. anatomy, pathology, hematology, epidemiology, medicinal aspects, prevention strategies refer www.icmr.nic.in , www.who.in, www.mohfw.gov.in or mail us on **aditisinghal1997@gmail.com** for detailed PDF.*

Part 2. Using Tech to Trace Corona Carriers - Telecom Operators

Based on roaming recharges, inter-state carrier change, last active location, GPS, wifi & IP addresses, telecom providers can trace and tag users with travel history to a high accuracy. Enforce mobile service providers / operators such as Jio, Airtel, Vodafone, BSNL to provide the following user lists-

1. Users with international travel history
2. Users with inter state travel history
3. Users with interstate travel history to Delhi during 14th - 16th March, jamaat incident, which may have returned to natives later
4. Users with interstate travel history to hotspots

Reach out to each of them through IVR telecalling, Whatsapp, Google Android notification, OEM manufacturer device, short code SMS etc. to take the mandatory Q&A every week updating their symptoms and lockdown status. Classify these people into high risks v/s low risks based on Q&A. Put this data into AarogyaSetu app.

Restrict movements of the high risk people. Use telecom operators to -

1. Generate alert if last active pincode location is changed (from last tower history)
2. Send an automated call with a warning and request to return to their home.
3. Report to the nearest police about such unauthorized movements.
4. Send a SMS to all family members (phonebook contact history) about his movement.
5. Disable outgoing / incoming calls except emergency govt numbers until user self reports or fills another pre designed survey for such cases.

Part 3. Using traced data in Aaorgyasetu while relaxing lockdown

Post relaxation of lockdown how this data can be used. Classify users into red, green, yellow. If green comes in the vicinity of yellow, it turns yellow. If yellow turns in the vicinity of red it turns orange recommended for testing. If a red is getting in touch with too many people, tag him as a super spreader and isolate him. This is already in progress in China with apps like wechat, alipay etc supporting chinese government.

Android can ring a buzzer around any yellow marked people warning others to maintain distance using Bluetooth. Put red in self isolation. Greens can walk free with necessary precautions.

At Least 300 MN people with smartphones can interact and identify each other. People with smartphones might need to avoid poor people without smartphones in a conservative approach. Since the disease has travelled internationally, if the rich can protect themselves, it won't go till poor (where collecting data may not be possible). What are your thoughts?

भारत से COVID19 की निकासी! कैसे?
स्वस्थ आबादी को संक्रमित होने से रोककर,
संक्रमित आबादी का तेजी से पता लगाने और उसका इलाज करने और आगे प्रसार को नियंत्रित करने से।

कोरोना रोकने के लिए प्रदेश सहित संपूर्ण देश में लागू हो पूल टेस्टिंग

पूल टेस्ट के द्वारा कम समय में ज्यादा से ज्यादा लोगों का परीक्षण किया जा सकता है इस बात को समझते हुए उत्तर प्रदेश एवं अंडमान निकोबार में इसे प्रयोग में लाते हुए **कम संसाधनों में बड़ी सफलता की ओर छलांग** लगाई है। एक समाचार रिपोर्ट के अनुसार इसे इंडियन काउंसिल फॉर मेडिकल रिसर्च आईसीएमआर द्वारा भी अनुमति दे दी गई है।

इंदौर के विशेषज्ञों द्वारा तैयार एक रिसर्च पेपर के अनुसार अगर जन समूह पर प्रश्नावली जो कि **आरोग्य सेतु** जैसी ऐप द्वारा एकत्रित की जा रही है तथा **टेलीकॉम सर्विस प्रोवाइडर** की सहायता से **अंतरराष्ट्रीय एवं अंतरराज्यीय ट्रैवल हिस्ट्री** की सूची प्राप्त कर सैंपल एकत्रित किए जा सकते हैं। इन सैंपलो को पूल टेस्टिंग द्वारा **कम समय तथा कम टेस्टिंग किटों** का उपयोग करते हुए संक्रमित तथा गैर संक्रमित व्यक्तियों की सूची प्राप्त कर ली जाती है तो यह हमें जल्द से जल्द **संक्रमित व्यक्तियों को उपचार करने, लॉक डाउन को खोलने** के लिए जोन को **परिसीमित करने** तथा **संक्रमित जोन के परिसीमन** के लिए उपयोगी होगा।

विशेषज्ञ टीम की सदस्य **अदिति सिंगल** के अनुसार यह पूल टेस्ट जल्द से जल्द **प्रदेश सहित संपूर्ण देश** में लागू करना चाहिए जिससे हम संक्रमित व्यक्तियों को जल्द उपचार प्रदान कर सकें तथा देश की **अर्थव्यवस्था को शीघ्रातिशीघ्र पटरी** पर ला सकें। साथ ही यह टेस्ट व्यक्ति को **अतिशीघ्र उसके नमूने की जांच का रिजल्ट उपलब्ध** कराता है जिससे वह **मानसिक स्थिरता** रखते हुए अपनी बीमारी के **सही इलाज की ओर अग्रसर होता** है। इस टेस्ट के द्वारा हमारी **टेस्टिंग कैपेसिटी** को **कई गुना बढ़ाया जा सकता** है तथा उस पर **आने वाले खर्च को भी कई गुना कम किया जा सकता है।**

टोल नाका पर **इंटरसिटी थर्मल स्क्रीनिंग सेंटर** और नमूना संग्रह केंद्र बना सकते हैं। लॉकडाउन खुलने के बाद शहर में **असामान्य संक्रमित व्यक्ति** के प्रवेश का पता लगाने के लिए।
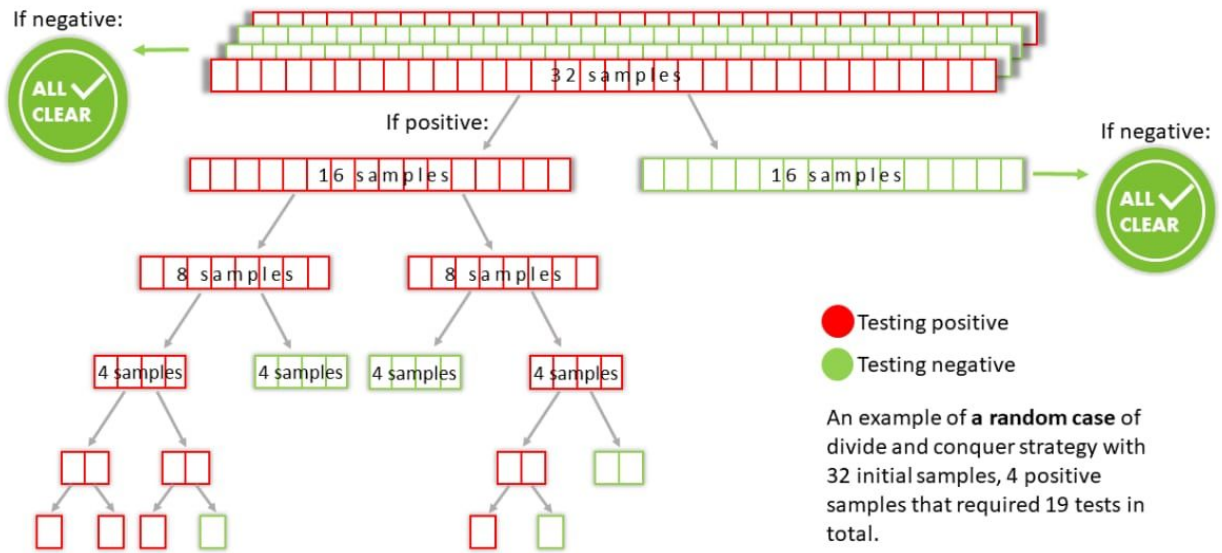
क्या है पूल टेस्ट

पूल टेस्ट में प्रत्येक नमूने की जांच नहीं करते हुए टेस्टिंग मशीन की क्षमता अनुसार कुछ नमूनों को मिला लिया जाता है। अगर नमूनों के मिश्रण का टेस्ट नेगेटिव आता है तो सभी को नेगेटिव मान लिया जाता है और अगर पॉजिटिव आता है तो रिसर्च पेपर की टेबल अनुसार उसके वरीयता क्रम के अनुसार उन सभी नमूनों की जांच की जाती है। इससे समय की बहुत बचत होती है तथा जांच किट भी कम उपयोग करते हुए बड़ी संख्या में टेस्ट किए जा सकते हैं। यह टेस्ट उन क्षेत्रों के लिए बहुत ही कारगर साबित हो सकता है जहां या तो संक्रमण की संभावना बहुत कम है अथवा अधिक संक्रमित क्षेत्र हैं।

पूलिंग टेस्ट की प्रक्रिया

एक काल्पनिक उदाहरण लेकर पूलिंग टेस्ट की व्याख्या की गई प्रक्रियाः-

If negative: ALL CLEAR

32 samples

If positive: 16 samples

16 samples — If negative: ALL CLEAR

8 samples | 8 samples

4 samples | 4 samples | 4 samples | 4 samples

● Testing positive
● Testing negative

An example of **a random case** of divide and conquer strategy with 32 initial samples, 4 positive samples that required 19 tests in total.

एक **प्रतिगमन क्षेत्र** से **संगरोधित जनसंख्या** (Quanratined Population) के 500-600 नमूने लें उन्हें विभिन्न समूहों जैसे **आयु, लक्षण, व्यसनों, जीवन शैली की बीमारियों के आधार** पर 10 समूहों में विभाजित करें वर्गीकरण के अनुसार एकल टेस्ट ट्यूब में संबंधित श्रेणी के नमूने जोड़ें और **मिश्रित नमूने पर आरटी-पीसीआर परीक्षण लागू करें,** जिसके परिणामस्वरूप आपको 3-4 समूह सकारात्मक और 6-7 समूह नकारात्मक मिलते हैं, बाद में नकारात्मक नमूने त्यागें और 3-4 नमूने विभाजित करें आगे के 5-10 समूहों में लक्षणों, लिंग आदि की गंभीरता के आधार पर उन्हें टेस्ट करें और उन्हें व्यक्तिगत परीक्षण के लिए भेजें।

इससे **आपको संक्रमित व्यक्ति का तथ्यात्मक डेटा, असंक्रमित समुदाय के तथ्यात्मक आंकड़ों के साथ मिलता** है।

उनके **अलगाव और आवश्यक उपचार** के लिए ध्यान केंद्रित करने से ।

यह COVID19 की मास स्क्रीनिंग के लिए गणितीय अवधारणा के आधार पर समझाया गया पूलिंग टेस्ट का तरीका है जो 3-4 बार परीक्षण क्षमता बढ़ाता है।

I, Aditi Singhal MBBS student of Index Medical College emphasizing and seeking the attention of Govt. For " pooling test" strategy to be applied on national,state or district level especially in Hotspot towns.In this article medical content is supported by Dr.Neha Chadda (BHMS & Sr. Zoology faculty),Dr.Shankul Dwivedi (MBBS,president IMA-MSN MP state) Rtd. Major Gen.Dr.S.K.Nema(HOD,pathology IMHRC) and analytical aspect is by Raghav Singhal(IIT KGP/Phonepe) and hindi translation is done by Shrikant goyal.

Dated: 14/04/2020

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