

1. Problem Overview

We are addressing the transmission of COVID-19 in densely populated settlements in developing countries, where social distancing is not viable. Usually, social distancing is very effective to reduce the transmission of this virus. However, in its current form, it is not a practical tool for such settlements due to crowded living conditions and economic constraints on the residents.

We believe that our problem is significant and urgent because roughly a billion people (Fig 1) live in these situations around the world and these settlements can quickly become an epicenter of pandemic in a metropolitan area. Our users are **low-income residents** of dense settlements in urban areas (generally impoverished daily wage workers), as well as **community health workers**. We arrived at the important questions that need to be addressed through extensive research and by interviewing key stakeholders from Mumbai (with 41% population living in slums), which is our focus for this project.

We have developed a roadmap of an alternative to social distancing as we know and practice today. Our solution essentially leverages the strength in numbers through developing economic solidarity among communities, and getting more out of limited testing resources through sampling and pooling tests. We have come up with several innovation targets.

Our central idea is to shift the focus from a single family to multiple neighboring families working together. In addition to mitigating financial stress in these low-income families, the multi-family setup can undergo pooled testing that will also help contain disease transmission across units.

Our solution is primarily targeted to highly dense localities but can be used in any setting facing lack of testing resources.

We strongly believe that enhancing cooperation amongst neighboring families and keeping them connected to the larger community, can urgently help them manage their lives amidst the COVID-19 crisis and also help foster a sense of belongingness in the long-term.

As the first reports of COVID-19 positive cases have already started rolling in from slums around the world, we believe that our solution, if timely implemented, can help stop the spread of the disease and lead to a better chance of well being for the residents as well as the general public that they form an integral part of.

2. Proposed Solution

Our proposed solution involves creation of units and super-units of these settlements which help in mitigation of disease transmission and economic hardship during the undergoing lockdowns around the world.

10-15 families in a settlement which are geographically and socially close, can be strengthened together into a **subunit**. This subunit can pool their finances, by working together in small-scale cottage industries (minimizing contact with the outside world) and buying groceries together (cheaper to buy in bulk).

All subunits in a small geographical division in a settlement can be strengthened together as a single cohesive '**unit**' of disease transmission. A unit can be formed on the basis of existing social or commercial ties within the community. The units should have shared infrastructure, like toilets and water sources, which are prime locations for interaction between residents. In absence of such amenities for the unit, temporary arrangements need to be made by the government so that most people are able to stay inside the unit. We will sample a small number of residents for testing every day to get an idea about if and how the disease is spreading through the unit.

Sampled and pooled testing is an efficient way to allocate the limited testing resources including kits and healthcare workers. Refer to the attached figure () and supplementary document **Team94_Model_COVID19JHU.pdf** detailing effectiveness of sampled testing. Essentially, in a unit as large as 500 people, with 20 people infected, testing only 30 people randomly picked will help you detect infection with 75% certainty. As up to 30 samples can be pooled together and used with a single test, we can effectively bring the number of tests needed per unit per day down to one.

The result of pool testing for the residents of a unit will determine the next step of the model. If we find any positive cases in a particular unit, we will go back to test every individual who we had taken samples from. We will isolate the COVID-19 positive individuals in local hospitals/ community halls/ schools turned into isolation wards. As time passes, if health care resources are dwindling, there is a possibility of isolating the units as they are, so that the resources can be brought to the community instead of displacing a large number of people.

Our secondary aim is to create trading opportunities across cottage-scale industries with a dual objective of maintaining the cash flow and collaboration between units. We propose to set up simple businesses like that of soap papers, that can be traded with other units and made available to the healthcare workers. We identify that cottage industries may not be enough and if no external help is forthcoming, a subset of the residents of a unit might have to go out of the unit for work. We propose the use of two-day workweek in such circumstances to minimize the risk of exposure.

As expected, we will require a large group of healthcare workers and volunteers working on the field to collect samples and monitor symptoms. To aid the field workers we have developed a web based data collection and dissemination portal where health workers and volunteers can get the list of individuals to be tested randomly that day and anonymized test results will then be used to create a heatmap of infection spread in the settlement. This data can be used by the healthcare workers as well as by the residents of the settlements to keep themselves informed about the situation, providing transparency to the proceedings.

3. Use Case

Our solution is focused on reducing infection spread in the dense informal settlements where most of the dwelling population depends on daily wage jobs and is from lower economic stratum. Specifically, we have chosen the Dharavi Slums of Mumbai as a model to implement

our plan. To efficiently use our model, the local population will have to adjust to the work routine devised for them which will grant them limited freedom over a complete lockdown currently in place. It will be expected of the residents to confine themselves to the specific unit as they pool their financial resources to work together. Fitting this solution into their routine should be done by a lot of awareness through the help of on-ground front-line healthcare workers, and police who are monitoring their physical status and their boundaries.

4. Evidence for Functionality/Efficacy.

We have devised several key steps to curb the spread of COVID-19 in slums. First of them is to divide the entire area into small units'. As published in a local news journal on 31st March 2020, the local governing bodies have already started dividing one of the slums of Mumbai- Worli- into smaller units for quarantine measures(fig). Our solution is a generalized one that can be applied to other areas as well. We have also suggested to use pool testing for single unit dwellers. We know this approach has been used previously in West Africa for the Ebola outbreak during 2014-2016. (ref). Besides we have primary results from literature that we can pool as many as 32 samples for qt-PCR based COVID-19 testing. (ref from MedrXiv). We are also developing a web based database to collect and disseminate information for each of the units.

5. Further Design / Testing Work Required

To implement this plan into a working product for a dense settlement, attention needs to be paid to an effective mapping of units and super-units. Resources and utilities (like toilets and water sources) need to be made accessible for every unit.

Some risks/unknowns that we need to take into account:

1. Intra and Inter-unit competition- if an illusion of lack of resources presents like how to be respectful of their boundaries and yet reduce inter-unit tension; One idea is to have a super-unit with trading enabled inside, and a community enforcement measure to ensure residents abide by the rules.
2. We need the residents to realise the fact that– all the regions are going to become RED (Figure 3A); It's just a matter of time. So if people adhere to the boundaries, the number of red patches at a given time will be manageable and the government can help better to cope. Better communication and bringing community leaders on board to help should do the trick.
3. We need more detailed information about the number of toilets to be able to predict how many extra toilets do we need and the trajectories of water supply tanks to suggest additional stops? Our design requires approval and feedback from the local government to be implemented.

6. Implementation Plan

Once the design is finalized, we are planning to work with the experts to implement the plan. Our primary players would be front-line healthcare workers, community leaders, and local government. For our test case Dhravi, Mumbai, we are currently working on identifying our

possible NGO partners (for example, SNEHA, Rahat Covid 19, RAHI) and commercial partners (for example, MyLab testing kit CEO) on-ground, but expert suggestions would be highly helpful. Our team's projected timeline, from the end of this event to launch our solution, can be divided into 4 phases :- expert suggestions on design and software development (7 days), local government, local NGO partnership structure (7 days), On ground discussion and advertisement campaign with local leaders (7 days), On ground deployment and distribution of health workers (7days). Therefore, the design plan can be launched within 30 days from the end of this event.

7. Resources Needed for Completion

For our use case (Dharavi, Mumbai slums) in this challenge, We have designed a web based platform and heat map of case progress in Units based on local commercial units and public toilet locations for this challenge. Our heatmaps are currently based on old data published in literature. In order to provide a more accurate solution, we need the most up to date toilet, water supply and commercial unit maps which are available only in the government database. Our platform also has a reporting system for health care workers which pulls data for individuals to be tested on a particular day. We require mediators to government authorities who can help us get access to that database. We plan to use Google Cloud Platform (GCP) because of its cost effectiveness and scalability to host our web services. We need financial help for this hosting service to deliver the solution in a timely manner. This design plan requires a strong team of government officials, local community leaders, healthcare workers, volunteers. Therefore, we need mentorship in public health researchers who have experience in working with dense settlements and have experience with behavioral aspects of this design. We hope to get mentorships from CBID global immersion team and get financial help from the Covid-19 launchpad grant from JHU.

Appendix (Figures/Data/Tables):

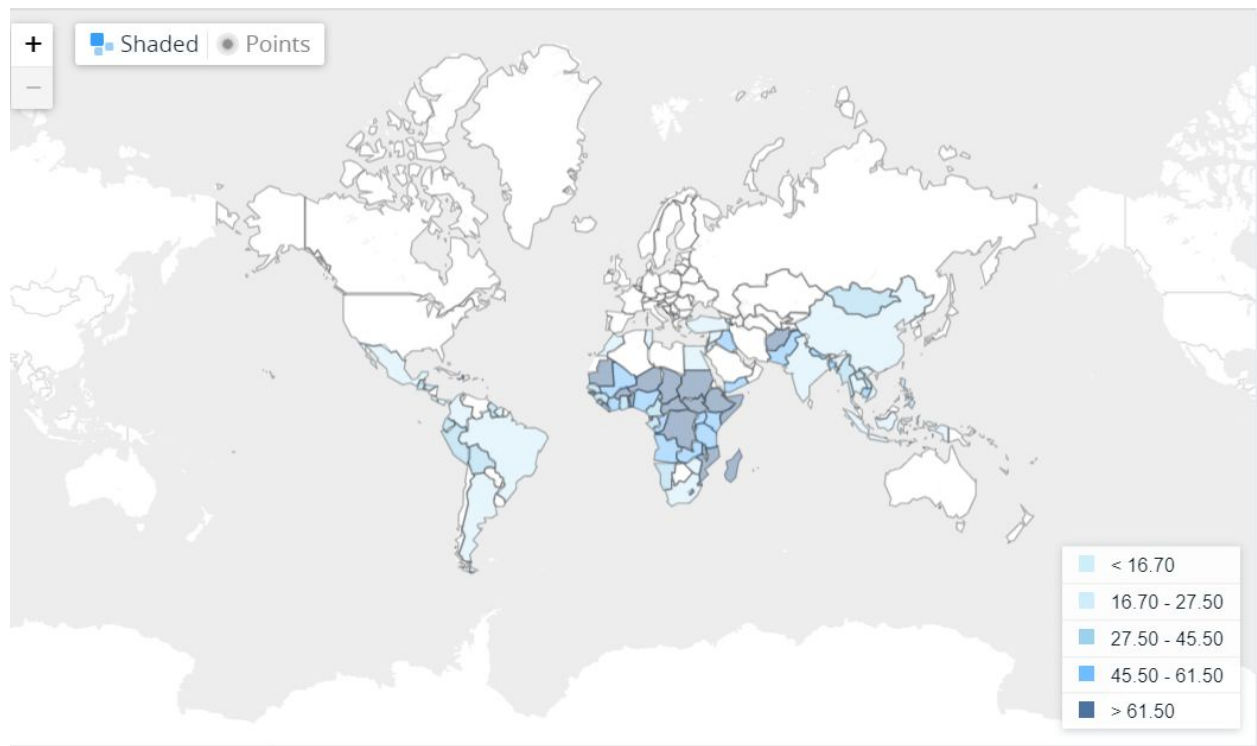


Figure: Map showing percentage urban population living in slums all over the world.

List of figures: - In a file attached called 'Figures.pdf'

- 1) Figure about dense settlement population
- 2) Flow chart for slum dwellers and health workers daily routine
- 3) Map of toilets, water resources and industry of Dharvi
- 4) Our map (add green red, some places, super cell) and worli map side by side
- 5) Screenshot of web interface, google map,
- 6) Probability calculation maps

Supplementary material

- 7) Team94_Model_COVID19JHU.pdf
- 8) Website directory, webapp
- 9) Presentation

Reference list

Web platform files :-

<https://github.com/sourabhsc/dharavicovid>

Ques 1

Why social distancing not possible?

<https://www.cnn.com/2020/03/30/india/india-coronavirus-social-distancing-intl-hnk/index.html>

<https://www.fastcompany.com/90483973/what-will-coronavirus-do-to-one-of-africas-large-st-slums>

Mumbai slum numbers

https://censusindia.gov.in/maps/Town_maps/Mum_slum_pop.aspx

<https://worldpopulationreview.com/world-cities/mumbai-population/>

Why urgent?

<https://economictimes.indiatimes.com/news/politics-and-nation/asias-largest-slum-dhara-vi-reports-first-case-of-coronavirus/articleshow/74937159.cms>

Dividing Slums into units?

<https://scroll.in/article/957843/not-much-we-can-do-to-keep-ourselves-safe-fear-grips-mumbai-slums-as-covid-19-cases-rise>

Pool testing

<https://www.medrxiv.org/content/10.1101/2020.03.26.20039438v1>

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6405069/pdf/pone.0212113.pdf>

