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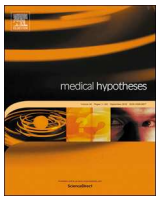

Household representative sample strategy for COVID-19 large-scale population screening

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ABSTRACT

In the advent of COVID-19 pandemic, testing is highly essential to be able to identify, isolate, treat infected persons, and finally curb transmission of this infectious respiratory disease. Group testing has been used previously for various infectious diseases and recently reported for large-scale population testing of COVID-19. However, possible sample dilution as a result of large pool sizes has been reported, limiting testing methods' detection sensitivity. Moreover, the need to sample all individuals prior to pooling overburden the limited resources such as test kits. An alternative proposed strategy where test is performed on pooled samples from individuals representing different households is presented here. This strategy intends to improve group testing method through the reduction in the number of samples collected and pooled during large-scale population testing. Moreover, it introduces database system which enables continuous monitoring of the population's virus exposure for better decision making.

Introduction

The emergence of COVID-19 pandemic, caused by the virus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has devastated economies and lives worldwide [1]. Testing is paramount in order to identify and isolate infected people, and be able to curb transmission of this infectious disease. To date, large-scale population testing has not been carried out in most countries, particularly those in third world, mainly due to the shortage of test kits, financial and logistical challenges, which has limited the efforts to identify and isolate infected persons. In some situations, the test kits (e.g. polymerase chain reaction (PCR) reagents, swabs) are reserved for only frontline workers or those showing clinical symptoms, although, this virus can also be transmitted by asymptomatic carriers with recent data indicating that these group of individuals may be a major source of transmission [1,2].

One way to overcome this limitation is the adoption of group testing, where samples are not individually tested but multiple samples from different people are combined and tests are then performed on these groups or pooled samples. Any group that tests negative are eliminated and no further individual tests is conducted whilst for groups that test positive, further tests are conducted to determine the infected samples [3]. A recent report involving the pooling of up to 10 samples has been demonstrated for SARS-CoV-2 PCR [4]. Moreover, group testing approach was recently utilized for large-scale population testing in Chinese cities of Wuhan and Mudanjiang [5,6]. However, in group testing, the large pool size has been reported to cause sample dilution, exceeding the sensitivity for the current SARS-CoV-2 testing methods [7]. Furthermore, each individual is sampled prior to pooling, increasing the demand of test kits.

Hypothesis

An alternative strategy is therefore suggested, where samples of representative individuals from different households are pooled and tested. The idea is borne from the fact that, occupants in a house rarely observe social distancing or wear face masks and therefore, physically interact with each other regularly. Transmission of SARS-CoV-2 among individual to individual through droplets, contaminated surfaces and hands have been reported [8,9]. Hence, in case of an infected occupant, there is a likelihood of a cross-sectional virus transmission among the occupants in the house. Therefore, the result from the representative sample of a household would indicate the virus exposure of the occupants of the house.

Evaluation of hypothesis

In order to test this idea for COVID-19 large-scale population screening, the people within a residential neighborhood in a city would be organized into groups, where each group would comprise the household (Fig. 1). The unique identification of these households would be their postal addresses or the use of Global Positioning System (GPS). The occupants in the house characterize the samples and only one representative sample (one person) would be collected for each household irrespective of the number of occupants in the house (Fig. 1). It is expected that the occupants of the house must have stayed together for an extended period (e.g. 3 weeks to 1 month) to be considered as a

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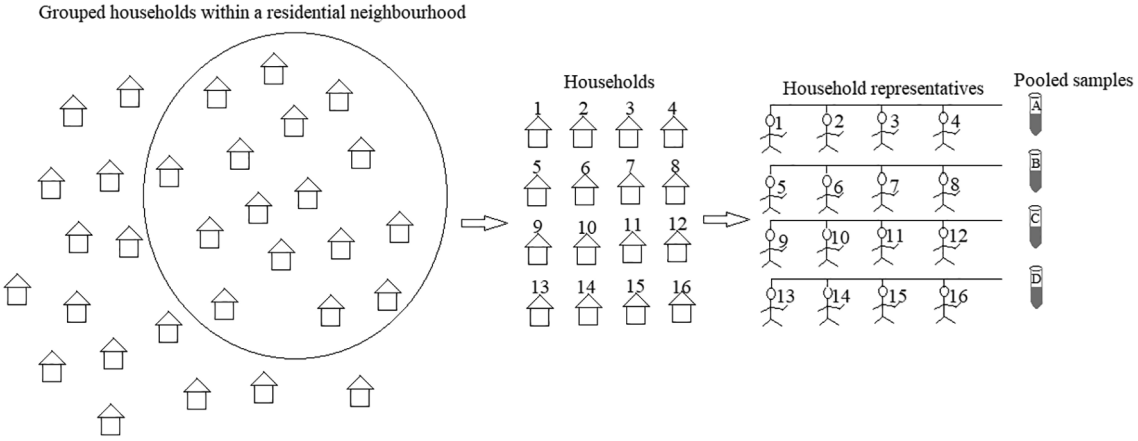

Fig. 1. Households within a residential neighborhood in a city divided into groups. The samples of selected representatives per households are pooled for COVID-19 testing. Four samples of selected representatives (1 – 16) are pooled for testing (A – D). The numbers (1 – 16) signifies the unique identifiers (postal address or global positioning system) of the households, which is computed in a database for continuous monitoring of virus exposure.

group. The selection of the group's representative and the number of households to be put in a group would be done randomly. The example indicated in Fig. 1 comprise sixteen groups of households with their selected representatives. The samples of four selected household representatives are then collected and pooled for testing. If any pooled sample (labeled as A, B, C and D, Fig. 1) tests negative, it can be concluded that all members in groups (house occupants) are negative and no individual tests would be required. Whereas, if any pooled sample tests positive, further tests would be performed on the samples of the selected household representatives to identify the infected sample and subsequently isolate and test all occupants in the household/group from which that individual represents.

Overall, the results of the pooled samples (designated A to D, Fig. 1) would provide virus exposure information of many individuals from different households within the residential neighborhood by using small pool sizes and relatively few sample collection. For instance, in this method, if each household or group (e.g. designated 1 – 4, Fig. 1) has minimum of three occupants, then one pooled sample (e.g. labeled as A, Fig. 1) would give virus exposure information of twelve people from different households as compared with traditional group testing method, where samples of all twelve individuals would have been collected and pooled prior to testing, resulting in enormous required resources.

Periodic rotational group testing

Periodic rotational group testing would also be carried out in order to gather adequate data on COVID-19 infection for better decision making. Hence, the selected representative from each household for testing could be rotated randomly among the occupants in the house and the results computed in a database. This holistic approach is more effective because, if infection is missed among the occupants in Period 1 testing, it is likely to be detected in Period 2 testing. It is recommended to conduct testing within 3 weeks or one month intervals, which correspond with the reported incubation period of the SARS-CoV-2 [10].

Database build-up

Prior to testing, the selected representatives would schedule an appointment with the testing center (hospitals, clinics or designated places) or health personnel (in case of home visit). During testing, the unique identifier (postal address or GPS) for each selected representative sample would be computed in a database for fast-tracking the testing and contact tracing process. For instance, in situation of infection, the information in the database can enable identification of people contacted by the infected person's group members, and thereby quickly trace, test and isolate infected individuals.

Potential and relevance

The implementation of the proposed household representative sample strategy for group testing has the potential to reduce the pool size and required test kits/resources, leading to economical conduct of COVID-19 large-scale population screening for efficient control of the spread of SARS-CoV-2.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mehy.2020.110200.

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