A Short Note on Group Testing in Coronavirus Pandemic

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Abstract

Locking the city down with compulsory coronavirus tests is one of the approaches to control the spread of COVID-19. Rapid antigen tests can only be used as reference. A large number of complicated laboratory tests including polymerase chain reaction tests are still required. Group testing, which combines a number of individual samples into a single pool, is necessary, but the group size is difficult to decide. A simple mathematical approach proposed earlier is useful for group tests as pointed out in this short article.

1. Introduction

A workable disaster management [1] scheme for controlling COVID-19 outbreaks, particularly the very infectious Omicron variant, in dense urban areas is to pick out the infected patients and asymptomatic carriers quickly in the early stage. The city or parts of the city have to be locked down with territory-wide compulsory coronavirus testing on all citizens. All citizens are then not allowed to leave the building or estate, and mandatorily required to participate in detection tests. Taking the fifth wave outbreak [2] in early January in Hong Kong where there was no city-wide lockdown as an example, about 1.1 million citizens were reported to be infected in 2 months. On the other hand, early lockdown in Shenzhen for a week cut the transmission chain [3]. Several other cities in China have started or even completed lockdown, including Shanghai, Guangzhou, and others [4,5] in April 2022.

2. Current Situation

It appears that early lockdown with compulsory coronavirus testing is effective in controlling outbreak. However, it takes time to have more accurate tests [6-8]. Rapid antigen tests (RAT) [9-13] were developed. In using RAT [14,15], the kit instructions must be followed closely. Early exposure to COVID-19 might not get positive results. A false positive or negative result might be

obtained. Most of the people using them are not well-trained as medical technicians, leading to false results [16]. For example, users (particularly the elderly who do not even know how to use the consumption vouchers) are not aware that the tube containing the testing fluid has to be put in vertical position, and reading scale in horizontal for a particular brand. Positive RAT results have to be confirmed by more complicated tests again. Some coronavirus tests with RAT negative results were found to be positive by more accurate polymerase chain reaction (PCR) test [6-8] with high-cycle threshold (CT) value. Therefore, RAT results can only be taken as a reference value at the preliminary screening stage.

3. More Complicated Tests

A large number of more accurate but more time-consuming coronavirus detection tests in medical laboratories such as those by PCR [6-8] are still required in such controlling activities. The maximum daily number testing capacity in Hong Kong is around 500,000, with strong support by the central government. Samples have to be collected by skilled nurses or medical technologists in designated collection stations. Collected samples are then sent back to medical laboratories for testing by trained technicians using complicated instruments. The testing time for PCR is around a few hours. Further, the large number of testing kits required will be very expensive.

4. Group Tests

Group testing strategy [17-20] is a viable approach in places where the infection rate is low. More resources can be released to speed up mass screening under limited testing facilities. However, there are some criticisms against this strategy. But in places with high infection rates, group tests will waste resources. When group test is used, the optimal group size [18-20] should be determined to minimize the total number of tests required.

Pooling of samples in coronavirus tests is an effective and efficient strategy in screening carriers in big cities with a large population but low infection rate. A number of pooling methods are available, including two-round and three-round testing [17]. Two of the pooling methods are relatively simple, and minimization of the test number via using an optimal group size has been mathematically derived [20]. The most important parameter in such group tests is to decide is the pool or group size. The three-round testing method appears to be more efficient [20].

A pooling scheme [19,20] was proposed by cutting the population of the area concerned into divisions of size determined from the recent infection rate first. This is a transient parameter and should be updated frequently. Samples collected are then grouped into appropriate pooled size. The number of tests per person in that population is expressed as a function of these two variables with the minimum number determined by a mathematical scheme.

5. Conclusion

Group testing for a large population with a low infection rate is a feasible strategy for controlling disease spread when universal compulsory testing is adopted. Estimation of the minimum number of tests required in pool tests is important in planning resources.

In addition to picking up asymptomatic carriers, universal compulsory testing should also be useful for implementing health codes for free travelling involving millions of citizens.

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