

1 **Title:** Comprehensive large-scale nucleic acid testing strategies support China's sustained  
2 containment of COVID-19

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23 To the Editor – Following identification and initial characterization of COVID-19 in late  
24 December 2019 and early January 2020, China’s containment goal has been complete  
25 interruption of local transmission of SARS-COV-2<sup>1</sup>. The nationwide epidemic wave centered  
26 on Wuhan was contained by April 2020 with non-pharmaceutical interventions (NPIs) alone,  
27 but was associated with economic loss – China’s first-quarter gross domestic product (GDP) fell  
28 6.8% compared with first-quarter 2019<sup>2</sup>. Since containment, there have been numerous  
29 outbreaks in China caused by imported viruses with local spread, varying in size from seven to  
30 1,200 cases, all stopped with NPIs alone<sup>3</sup>. Sustained containment has high socioeconomic value  
31 - economic activities recovered rapidly with a GDP increase of 3.2% during April-June 2020  
32 and 4.9% during July-September<sup>2</sup>; government’s response to the pandemic was perceived  
33 positively by the Chinese public<sup>4</sup>. In this letter, we describe two large-scale PCR-based testing  
34 strategies which played critically important roles in sustaining containment since last April in  
35 mainland China - routine active PCR-based screening, and mass PCR testing during outbreak  
36 response.

37 With virtually all of China’s population susceptible to SARS-CoV-2 prior to induction of  
38 any vaccine-induced population immunity<sup>5</sup>, imported viruses pose an enormous threat to  
39 containment. All incoming international travelers, workers handling imported goods, medical  
40 center outpatients with fever or respiratory symptoms, and medical staff caring for patients  
41 with fever or infectious diseases are actively screened with PCR to determine if they are  
42 infected. Incoming travelers have been required to quarantine at designated hotels for 14 days  
43 following entry into China, during which time they are tested at least twice. As of 30  
44 November 2020, 3,866 SARS-CoV-2-infected travelers were diagnosed, preventing seeding of  
45 virus in susceptible communities (Figure).

46 Outbreak investigations in Beijing and Dalian found that food contamination could  
47 potentially transmit SARS-COV-2<sup>6,7</sup>. Isolation of viable virus in outer packages of imported  
48 seafood in Qingdao strengthened the evidence for such transmission. Workers handling  
49 imported goods are now required to be tested weekly for SARS-COV-2, preventing several

50 importation-related outbreaks: for example, four dockworkers were found to have become  
51 infected in December in Dalian, and an outbreak investigation in Kashgar, Xinjiang found  
52 SARS-COV-2 importation via a contaminated cross-border truck.

53 Fever clinics have long been established in secondary and tertiary hospitals. Anyone with  
54 fever seeking healthcare is screened by PCR. Medical facilities admit anyone with suspected  
55 COVID-19, unexplained pneumonia, or severe acute respiratory tract infection and test the  
56 patients and accompanying persons with PCR. This screening strategy has identified index  
57 cases of several outbreaks - Xinfadi market in Beijing, Dalian, Pudong airport<sup>8</sup>, Qingdao<sup>9</sup>, and  
58 Manchuria.

59 Routine testing requires many PCR tests. Laboratories combine five or ten specimens and  
60 test the combination for SARS-CoV- 2 RNA as an efficiency and cost-saving measure. If the  
61 combination tests positive, individuals whose samples were combined are tested separately to  
62 identify the infected individual(s). With a 10:1 pooled sampling approach, the average cost  
63 per person tested is approximately 9 RMB yuan (\$1.50 USD) in China.

64 Routine PCR testing is augmented with testing of all close contacts of an infected  
65 person. Since September 2020, all close contacts of infected individuals have been required to  
66 be tested three times during a 14-day centralized quarantine period - day 1 or 2, one day later,  
67 and day 14.

68 Mass, community-wide PCR testing during or following outbreak response has proven to  
69 be a useful strategy to identify infected individuals, including those with no symptoms, and to  
70 determine whether a community is free of SARS-CoV-2. Once a local outbreak is identified,  
71 geographic jurisdictions are classified by epidemiologists into regions at low, moderate, or  
72 high-risk of virus transmission. Persons in high-risk settings are tested individually. In  
73 moderate-risk areas, a 5:1 or 10:1 pooled sampling approach is used to reduce the number of  
74 tests.

75 The first citywide mass screening was performed between May 14 and June 1, 2020 in  
76 Wuhan city, testing nearly 10 million people with PCR and identifying 300 asymptotically-

77 infected individuals for quarantine. The testing results were used to support full reopening of  
78 local socioeconomic activities<sup>10</sup>. Large screening programs have been implemented following  
79 local case reports that indicated possible community transmission. For instance, during the  
80 Beijing Xinfadi outbreak, 11.9 million persons were tested between 11 June and 14 July 2020;  
81 in Dalian, 4.5 million persons were tested between 26 and 31 July; and in Qingdao, 10.9  
82 million persons were tested between 11 and 16 October<sup>9</sup>. These large-scale, population-wide  
83 screenings contributed to case finding and rapid control of epidemics and provided evidence for  
84 government to reopen economic activities.

85         Timeliness of PCR test results varies by testing purpose and epidemiologic situation.  
86 For members of the public who request PCR testing but have no symptoms or exposure history,  
87 results are to be reported within 24 hours. Results from outpatients, inpatients, caregivers,  
88 close contacts of confirmed cases, and persons residing in high-risk areas in a local outbreak  
89 setting are to be reported within 12 hours. Results for patients in fever clinics and emergency  
90 departments are to be reported within 6 hours.

91         In China’s new-normal situation, comprehensive, active, and innovative PCR-testing  
92 strategies are performed for targeted groups and in outbreak settings, ensuring timeliness of  
93 early case detection and interruption of local outbreaks - essential ingredients in the prevention  
94 and control strategy. Maintenance of containment has greatly reduced the impact of COVID-  
95 19 in terms of suffering, lives lost, and socioeconomic progress.

96         The introduction of COVID-19 vaccines globally and in China will undoubtedly improve  
97 epidemiological situations. PCR testing strategies will be adjusted to fit the changing  
98 epidemiological situations in China – likely one in which few or fewer NPIs will be needed for  
99 effective epidemic control. Inexpensive, readily available, and rapid PCR testing will continue  
100 to be essential for sensitive SARS-CoV-2 virus surveillance well into the future. Throughout  
101 2020, PCR testing served the public well, helping to make and keep China nearly free of SARS-  
102 CoV-2, and providing socioeconomic space and time for vaccine development and long-term  
103 prevention and control of COVID-19.

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107 **Author contributions**

108 Zhongjie Li, Zijian Feng and George F. Gao designed and supervised the study. Zhongjie Li and  
109 Fengfeng Liu wrote the manuscript; Jinzhao Cui designed and draw the figure. Zhibin Peng,  
110 Zhaorui Chang, Qiulan Chen, Liping Wang participated in literature review and data collection.  
111 Shengjie Lai, George F. Gao commented on and revised drafts of the manuscript.

112 **Competing interests**

113 The authors declare no competing interests.

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**Figure legend**

Local and imported COVID-19 cases from 1 April 2020 to 30 November 2020, with outbreaks and mass PCR test strategies indicated.

# No. of reported cases

