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Active case finding with case management: the key to tackling the COVID-19 pandemic

Zhongjie Li*, Qiulan Chen*, Luzhao Feng, Lance Rodewald, Yinyin Xia, Hailiang Yu, Ruochen Zhang, Zhijie An, Wenwu Yin, Wei Chen, Ying Qin, Zhibin Peng, Ting Zhang, Daxin Ni, Jinzhao Cui, Qing Wang, Xiaokun Yang, Muli Zhang, Xiang Ren, Dan Wu, Xiaojin Sun, Yuanqiu Li, Lei Zhou, Xiaopeng Qi, Tie Song, George F Gao†, Zijian Feng‡, and the China CDC COVID-19 Emergency Response Strategy Team

COVID-19 was declared a pandemic by WHO on March 11, 2020, the first non-influenza pandemic, affecting more than 200 countries and areas, with more than 5·9 million cases by May 31, 2020. Countries have developed strategies to deal with the COVID-19 pandemic that fit their epidemiological situations, capacities, and values. We describe China's strategies for prevention and control of COVID-19 (containment and suppression) and their application, from the perspective of the COVID-19 experience to date in China. Although China has contained severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and nearly stopped indigenous transmission, a strong suppression effort must continue to prevent re-establishment of community transmission from importation-related cases. We believe that case finding and management, with identification and quarantine of close contacts, are vitally important containment measures and are essential in China's pathway forward. We describe the next steps planned in China that follow the containment effort. We believe that sharing countries' experiences will help the global community manage the COVID-19 pandemic by identifying what works in the struggle against SARS-CoV-2.

Introduction

COVID-19 is an infectious disease caused by a recently emerged novel coronavirus (severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2]) that is different from the coronaviruses causing severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) and that has rapidly become a global health concern.¹⁻³ Since WHO characterised the COVID-19 epidemic as a pandemic on March 11, 2020,⁴ the situation has been worsening. By May 31, 2020, more than 200 countries and areas had been affected and the cumulative number of cases exceeded 5·9 million, with rapid daily increases in some countries.⁵

Here, we describe strategies and measures based on evidence and disease control practices in China, with the goal of promoting active case finding and case management in suppression and containment strategies, which we believe can reduce the health and socioeconomic damage caused by COVID-19 and allow for earlier safe resumption of more normal life. We describe risk-based lifting of restrictions, which were used to contain the coronavirus in China, and planned

pathways towards long-term prevention and control of COVID-19.

Severity and threat

Data show that COVID-19 is more severe an illness than is seasonal influenza (table 1), and SARS-CoV-2 is more contagious than are seasonal influenza viruses, having a basic reproduction number (R_0) nearly twice as high.^{8,15} Seasonal influenza is usually self-limited, with approximately 1·8% of cases needing hospitalisation.²⁰ By contrast, more than half of patients with COVID-19 in China develop pneumonia, usually needing inpatient care.^{21,22} The case-fatality ratio (CFR) of seasonal influenza is approximately 0·1%¹⁷ whereas the estimated CFR of COVID-19 was 5·9% in Hubei province, China, and 0·98% in all other regions of China.⁶ Because individuals with laboratory-confirmed infection must be hospitalised in China, regardless of disease severity, the crude estimates reflect a broader spectrum of disease than if only critically ill patients were hospitalised. The difference in CFR between Hubei province and all other regions of China probably reflects the later occurrence of

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*Joint first authors
‡Joint senior authors

Chinese Center for Disease Control and Prevention, Beijing, China (Prof Z Li PhD, Q Chen PhD, Prof L Feng PhD, L Rodewald MD, Y Xia PhD, H Yu MMed, R Zhang LLB, Prof Z An MPH, Prof W Yin MMed, Prof W Chen PhD, Y Qin PhD, Z Peng MMed, Prof D Ni MMed, J Cui BSMed, Q Wang BSMed, X Yang BSMed, M Zhang BSMed, X Ren PhD, D Wu MMed, X Sun MMed, Y Li PhD, Prof L Zhou MMed, X Qi PhD, Prof G F Gao DPhil, Prof Z Feng MMed); Weifang Medical University, Weifang, China (T Zhang MMed); and Guangdong Provincial Center for Disease Control and Prevention, Guangzhou, China (Prof T Song MMed)

Correspondence to:
Prof George F Gao, Chinese Center for Disease Control and Prevention, Beijing 102206, China
gaofu@chinacdc.cn

	Case-fatality ratio	Infectious period	R_0	Serial interval	If containment is applicable or not
COVID-19	0·98-5·9% ^{6,7}	Highly infective at initial onset period, infectious before illness onset	2·2-4·7 ^{8,9}	4-6-7·5 days ^{8,10}	Successful in some countries at early epidemic stage
SARS	10% ^{11,12}	Highly infectious around 10 days from illness onset	2·2-3·6 ¹³	8-12 days ¹³	Successful worldwide
2009 H1N1 pandemic influenza	0·02-0·4% ¹⁴	Highly infectious from the end of incubation to initial onset	1·3-1·7 ¹⁵	2·8 days ¹⁶	Containment not implemented*; has become a seasonal epidemic after the pandemic
Seasonal influenza	0·1% ¹⁷	Highly infectious from the end of incubation to initial onset	1·2-1·4 ¹⁵	3 days ^{18,19}	Containment strategy is not applicable; continuous seasonal epidemics

R_0 =basic reproduction number. SARS=severe acute respiratory syndrome. *Based on the characteristics of the disease, national authorities adjusted the control and prevention strategy to mitigation.

Table 1: Comparison of basic characteristics of COVID-19, SARS, 2009 H1N1 pandemic influenza, and seasonal influenza

	Containment	Suppression	Mitigation
Aim	Stop virus transmission and spread	Decrease or stop community transmission	Lower and delay the epidemic surge to reduce health-care demand
Scenario	Early stage of epidemic in well defined areas	Ongoing community transmission in which containment is not feasible	Extensive community transmission, impossible to suppress
Case detection and management	Active case detection; managed isolation and care; quarantine of close contacts	Case detection; managed isolation and care; testing of close contacts	Detection of severe cases; managed isolation and care; limited contact tracing
Lockdown and intercity travel prohibition	Lockdown of endemic areas; restrict travel from those areas to other low epidemic areas	Few, based on risk	None
Other physical distancing*	Strict stay-at-home orders; school closure; cancellation of mass gatherings	Stay-at-home orders; school closure; cancellation of mass gatherings; adjustable to conditions	Cancellation of mass gatherings; school closure when and where necessary; ask vulnerable population to stay at home
Personal protection	Hand hygiene; respiratory etiquette; face mask use	Hand hygiene; respiratory etiquette; face mask use	Hand hygiene; respiratory etiquette; face mask use
Duration	Short term, followed by maintenance of elimination of transmission	Long term, adjusting suppression measures based on epidemic situation (relax or strengthen periodically)	Long term
Endpoint	Vaccine response to immunise the population to achieve community protection	Vaccine response to protect the vulnerable, stop community transmission, and achieve community protection	Vaccine response to protect the vulnerable, stop endemic transmission, and immunise the population to achieve community protection
Pros	Early, proactive, and strict implementation can be effective, largely preventing infection and death	Early, proactive, and strict implementation can be effective, largely preventing infection and death	Less short-term socioeconomic effect; necessary medical care able to be provided
Cons	Major short-term effect on daily life and social and economic costs; continued moderate socioeconomic effects during elimination period	Major short-term effect on daily life and social and economic costs; premature relaxing of interventions can lead to rebound of the epidemic	Medical system capacity can still be exceeded; substantial risk of high morbidity, mortality, and economic damage

*Physical distancing represents minimisation of physical contact between potentially infected individuals and healthy individuals, or between population groups with different levels of transmission, to decrease or interrupt transmission of COVID-19, by various means.^{28,29}

Table 2: Comparison between strategies

cases outside of Hubei province, because case-finding practices improved with experience. Scientists from Imperial College London (London, UK) estimated that the age-adjusted fatality ratio among all infected people in China was 0.66%.⁷

Severity of COVID-19 can be affected by availability of medical resources. The number of beds per 1000 people in Wuhan is 7.2,²³ which is high relative to many other countries.²⁴ In Wuhan in early February, 2020, the number of reported cases of COVID-19 was high, but the population prevalence of infection by that time was relatively low (probably <1%).²⁵ High caseloads stress medical systems and can lead to more deaths if health-care systems become overwhelmed. Should the COVID-19 pandemic worsen, its effect might approach that of the 1918 H1N1 influenza pandemic, which had a CFR of more than 2% and caused 50–100 million deaths worldwide.^{26,27}

Response strategies in China

Two overarching strategies, containment and suppression, have been used in China. Strategy decisions were based on factors including feasibility of interrupting virus transmission, estimates of disease severity, projected social and economic effects of strategy and disease, public acceptance and willingness, and government willpower

and capacity. These two strategies, and a third strategy of mitigation, which has not been implemented in China, include similar or overlapping measures. Comparison of the three basic strategies shows that all use non-pharmaceutical interventions (NPIs; table 2).

Containment

A containment strategy applies to an early-stage epidemic in a geographically limited area, taking measures that prevent person-to-person transmission of SARS-CoV-2 and importation and exportation of infection. The core measures of a containment strategy are proactive finding and managing cases, tracing and quarantining close contacts, and strict restriction or control of population movement when feasible and appropriate. Other measures are summarised in table 2.

In China, containment has been challenging for government and citizens. We have a command system in which the State Council coordinates a multisectoral joint response and can mobilise necessary resources. The command system in China promptly deployed medical resources. Three Fangcang shelter hospitals were made in Wuhan in less than 2 days, and 16 Fangcang shelter hospitals treated more than 12 000 patients in Wuhan.³⁰ Three mobile P3 laboratories (ie, level 3 laboratories for biosafety protection) were moved to

Wuhan from other cities, expanding nucleic acid testing capacity to 35 000 tests per day in February, 2020. These hospitals and laboratories helped ensure that every suspected case could be tested, treated, and isolated, and that their close contacts could be traced and isolated in a timely manner.^{31–33}

Citizen support has been essential. People not providing essential services had to remain at home as much as possible; everyone had to avoid gatherings and wear masks when going out. Wuhan suspended all transportation in and out of the city from Jan 23 to April 8, 2020. Varying degrees of intra-area and interarea transportation restrictions were applied throughout the entire country, from big cities to small villages, for at least 1 month. Many volunteers supported the community control policies. Timeliness was stressed, with hospitals required to report confirmed or suspected cases within 2 h, laboratories to report test results within 12 h, and local Centers for Disease Control and Prevention to complete case investigations within 24 h.

Modelling estimated that, had this containment effort not been done, the number of COVID-19 cases would have been an estimated 67-fold higher than they have been thus far.³⁴ According to this model, detection, isolation, and contact tracing with quarantine was the most effective part of the containment strategy, which was estimated to have prevented more infections than travel restriction and contact reductions.³⁴ Integration with NPIs served to strengthen and accelerate the effect of detection, isolation, tracing, and quarantine.³⁴ Suspending intracity public transport, closing entertainment venues, and prohibiting mass gatherings were also associated with reductions in case incidence.³⁵

Suppression

We use a suppression strategy for when an epidemic is in multiple areas with varying degrees of outbreak and community spread, when it is not possible or feasible to stop spreading by confining transmission to an isolatable geographical area. Core measures are similar to those for containment and are summarised in table 2. Suppression logically follows successful containment to prevent spread from imported cases and re-establishment of community transmission.

Suppression measures can keep transmission and prevalence low, decreasing the effective reproduction number (R_e).³⁶ Once R_e is below 1 in a community, spread in that community should eventually stop. However, maintenance of strict suppression measures, particularly physical distancing, brings a large socioeconomic burden. As shown by scientists at Imperial College London,³⁷ intermittent physical distancing triggered by trends in disease surveillance can allow interventions to be relaxed temporarily in short time windows, but measures will need to be reintroduced if or when case numbers begin to rebound. Therefore, a challenge for suppression is to balance the needs of epidemic control with restoration

and maintenance of social life, choosing epidemiologically appropriate times to relax or strengthen control. Importantly though, during times of more relaxed physical distancing efforts, proactive case detection and management with contact tracing and quarantine must be maintained, to avoid re-establishment of community transmission and a rebound of the epidemic.

Achievability and feasibility of containment and suppression

SARS-CoV-2 is mainly transmitted by symptomatic cases. Analysis of nucleic acid tests in a cohort with 2147 close contacts showed that only 17% (22 of 132) of cases were asymptomatic among all nucleic acid test-positive cases.³⁸ Similarly, in the Diamond Princess cruise ship outbreak, approximately 18% of nucleic acid test-positive cases were asymptomatic.³⁹ Based on national surveillance data from China, clinical manifestations of COVID-19 are readily identifiable in most patients, with more than half developing pneumonia, which facilitates early case finding.^{21,22,40,41} Although presymptomatic and even asymptomatic infected individuals can transmit the virus, their ability to transmit is much lower than that of symptomatic infected individuals.^{42–44} By actively identifying symptomatic patients and expanding testing of their close contacts, a large burden of asymptomatic infection can be detected, and with infected individuals appropriately isolated at an early stage, risk of transmission will be reduced. Low transmissibility of asymptomatic cases, and the ease with which symptomatic cases can be diagnosed using readily available, sensitive, and specific diagnostic tests, support the notion that transmission can be interrupted by finding and managing cases and tracing and quarantining their close contacts.

The core containment and suppression strategies are worthwhile, not only in an early stage of the epidemic but also during a later community transmission stage. With limited community transmission, as was seen in provinces outside Hubei in China, containment was achieved within a month. Widespread community transmission of SARS-CoV-2 in Hubei (population 59 million) was stopped in less than 2 months (figure).

The most urgent and important measure of the containment and suppression strategies is scaling up testing of each suspected case and all close contacts of those infected.^{45,46} With the increase in PCR testing capacity in China as an example, the median time from illness onset to diagnosis was shortened from an initial average of 12 days in early January to only 3 days in early February.⁴⁷

After containment in China

The current situation of COVID-19

The containment strategy has largely been successful in China. From April 1 to May 31, 2020, there have been, on average, 54 infections reported daily by China's National Health Commission, which were almost all

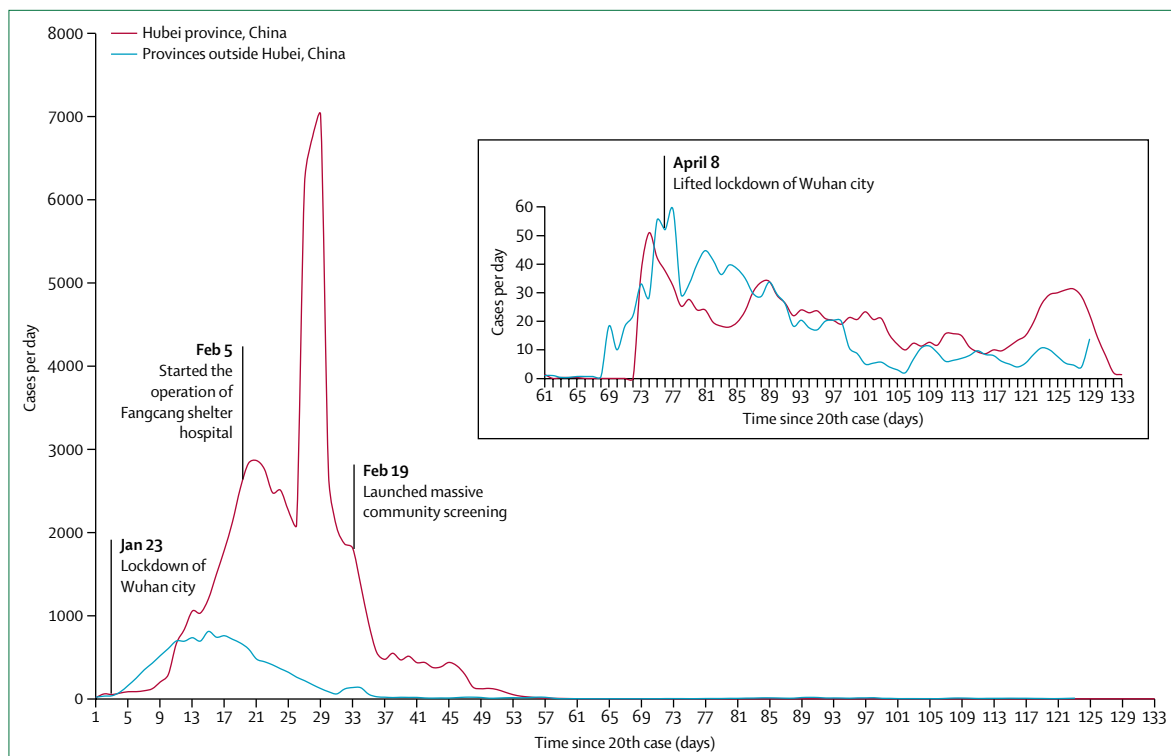


Figure: COVID-19 cases in China, as of May 31, 2020

Data obtained from the National Health Commission of the People's Republic of China (May 31, 2020). The main plot shows the number of cases per day by the number of days since the cumulative case count exceeded 20. The inset box shows a scaled up plot of cases since day 61. Since April 1, 2020 (the 73rd day in Hubei's curve and the 69th day in the curve for the other provinces), the number included both symptomatic and asymptomatic cases. All data were smoothed over for each day by adopting the latest 3-day window (the day and 2 days before).

importation cases or second-generation cases from importations, and an average of 0.6 new deaths have been reported each day, with the most recent death reported on April 14, 2020.⁴⁸ There is no known ongoing community transmission, but the risk of local transmission introduced by internationally imported cases remains a major concern. Almost the entire population of China remains susceptible to SARS-CoV-2 and, therefore, is at risk of a COVID-19 epidemic.

The long-term goal of the COVID-19 response and high-level pathway to achieve it

Although China is in a position in which there is little ongoing morbidity and mortality from COVID-19, the socioeconomic costs to maintain such a situation are very high and unsustainable in the long term, particularly in view of the high population susceptibility.⁴⁹ This situation raises two questions. First, what is the strategic goal of COVID-19 management in China? Second, what is a pathway for achieving that goal?

The current strategic goal is to maintain no or minimal indigenous transmission of SARS-CoV-2 until the population is protected through immunisation with safe and effective COVID-19 vaccines, at which time the risk of COVID-19 from any source should be at a minimum. This strategy buys time for urgent development of

vaccines and treatments in an environment with little ongoing morbidity and mortality. A vaccine response is almost certain to be a global necessity in the COVID-19 pandemic response, preventing infection among those at risk of exposure or medical risk and, ultimately, immunising the population to stop virus importation and transmission.

Vaccines, as they emerge from regulatory authorities and WHO prequalification, can be used as appropriate for their indications and as allocated equitably through global collaborative partnerships.⁵⁰ Depending on evidence yet to emerge about COVID-19, vaccines might need to become integrated into routine immunisation programmes.⁵¹ Uncertainties exist about immunogenicity, efficacy assessment, safety profiles, production capacities, and availability timelines of COVID-19 vaccines, necessitating much research and time before this goal can be achieved. Specific issues related to coronavirus vaccines include concerns about antibody-dependent enhancement and vaccine-associated enhancement of respiratory disease.^{52,53} As vaccines are developed and licensed, ensuring supply and strategic and equitable use will be vitally important in China and globally.

The planned pathway to safely achieve the goal of an immune population is to substitute the containment strategy with a suppression strategy and to maintain

suppression with the minimum number of physical distancing restrictions necessary, as adjusted based on local epidemiological risk.⁵⁴ The containment and suppression core measures of case detection and isolated case management with contact tracing will be maintained, while COVID-19 surveillance is integrated into the National Notifiable Diseases Surveillance System as a level 2 notifiable disease. Early detection and response are central strategies to interrupt transmission in even the smallest areas, ultimately minimising socioeconomic effects. In mid-May, China expanded the capacity of nucleic acid testing to more than 1·5 million specimens per day, and specific groups—including suspected cases and close contacts, outpatients in fever clinics, overseas travellers, health-care workers, and staff in closed environments (eg, nursing homes and prisons)—were prioritised for testing.⁵⁵

Further research and action are needed to ensure a sufficiently sensitive surveillance system and strong response mechanism, including establishment of a highly accessible laboratory network, maintenance of awareness of both primary health-care providers and the public, and regular training and exercise of local Centers for Disease Control and Prevention and communities. One example of research to strengthen surveillance relates to development of efficient methods to identify asymptomatic cases, who pose a threat to elimination of community transmission and are now included in the disease surveillance system. The sixth edition of the National Health Commission's guidelines³³ for control and prevention of COVID-19 will be updated as new evidence emerges about how best to protect people from this disease.

It is possible, although unlikely, that safe and effective COVID-19 vaccines cannot be developed or will take many years to develop. In such a situation, China will rely on innovations in COVID-19 treatment and technology-assisted strategies to suppress the disease, reducing it to a more manageable public health problem. To help policy makers identify the most effective, least intrusive, and most socioeconomically acceptable measures to prevent and control COVID-19, we need innovation in identification of effective drugs and treatment strategies through research with the international scientific community, innovation in communication technologies supporting management of cases and identification of close contacts at risk of having been infected, evaluation of the effectiveness of COVID-19 transmission control measures, and public engagement in assessment of societal acceptability of specific control measures.

Which specific measures are continuing nationwide and which are being relaxed?

Containment measures have been partly relaxed throughout China. Widespread domestic travel restrictions, coupled with quarantine at the destination, have stopped, except in high-risk areas (ie, areas with cluster-related

cases). Wuhan was the last city to stop travel restrictions. International travel is greatly curtailed; anyone entering China is required to be in quarantine for 2 weeks. Physical distancing measures, such as bans on gatherings and online-only schooling, continue throughout China, although many high school and college students have returned to their schools for graduation. Restaurants in most areas have reopened, requiring a distance of 1 m between patrons. Wearing of masks is still required in health-care facilities, indoor public areas, and public transportation vehicles.

How the relaxation is based on epidemiological risk and high technology

China will relax physical distancing measures based on county-level epidemiological risk assessments, which will allow prompt recovery of socioeconomic activity in low-risk areas and timely recovery in areas of intermediate and higher risk. For precise support of people's movements across areas at different risk levels, we use individual-level health codes implemented in the 5G network as an electronic pass system.⁵⁶ Health codes are shared within and among provinces and eventually will be available nationwide. People apply online or through a widely available mobile phone application. The health code application supports an environment of unrestricted movement while facilitating identification of close contacts of cases by public health professionals.⁵⁷

For most areas of China, the risk of COVID-19 is regarded as low; work has resumed, and restaurants and other shops and businesses are open. In areas of intermediate and higher risk, alternative work schedules, flexible work mechanisms, and home offices are used as physical distancing measures. Public places operate normally but with routine prevention measures (eg, mask wearing), and enclosed entertainment and leisure places are open to visit by reservation, with visitor numbers limited.^{58,59} Schools are being reopened for classroom teaching. Control measures continue to focus on vulnerable groups (eg, elderly people, children, pregnant women, students, and medical staff) and high-risk places (eg, nursing homes, prisons, and hospitals).

How the community acts on precise prevention and control

China continues to rely on community networks to promote precise prevention and control.⁵⁷ In low-risk areas and communities without cases, people entering from higher risk areas (or overseas) are subject to quarantine for 14 days. In areas of intermediate risk and communities with sporadic cases or outbreaks, management measures in communities will be strengthened but will allow entry and exit for work. Management of close contacts of cases and people discharged from hospitals will continue. When necessary, high-risk areas or communities with virus transmission will undergo lockdown until there are no new cases for 14 days after confirmation

of the last case. Community service agencies and volunteers ensure supplies for normal living for people under lockdown. Employers are required to take routine prevention measures, such as ventilation, fever screening, hand hygiene, and environment disinfection. If cases are found, precise containment measures are to be taken at the smallest work-unit level, such as an office or a workshop.

How elimination of community transmission allows resumption of routine services

Successful containment, followed by the more flexible suppression strategy, has brought important benefits. Elimination of community transmission of SARS-CoV-2, in which effective disease surveillance consistently finds no cases with unknown source, and risk-adjusted lifting of travel and physical distancing measures have offered the opportunity to resume suspended routine work in China, including work on other infectious diseases. For example, China's 110 000 immunisation clinics have resumed routine work and are completing a 2-month catch-up campaign to recall children who missed routine vaccination services because of COVID-19; the school entry vaccination record check programme will be able to operate in August and September, 2020, ensuring high vaccination coverage for children entering kindergarten at age 3 years and primary school at age 6 years.

Discussion

China's containment effort has strikingly curtailed morbidity and mortality from COVID-19 and stopped community transmission of SARS-CoV-2. At the same time, almost the entire Chinese population remains susceptible to SARS-CoV-2 and is dependent on public health measures for protection, while vaccines, treatments, and minimally intrusive suppression measures are being developed for long-term prevention and control. The successful containment effort builds confidence in China, based on experience and knowledge gained, that future waves of COVID-19 can be stopped, if not prevented. Case identification and management, coupled with identification and quarantine of close contacts, is a strategy that works.

Other countries that successfully contained COVID-19 with case and close-contact identification and management include Iceland, Mongolia, Singapore, South Korea, and Vietnam. Singapore maximised detection of suspected patients through a public prevention clinic network and tightly implemented, legally supported home quarantine orders for patients with mild illness.⁶⁰ South Korea greatly expanded the scope of testing to detect cases as early as possible.⁶¹ More than 600 screening sites capable of taking SARS-CoV-2 nucleic acid tests were established, including public health-care clinics, drive-through centres, and walk-in screening sites. Across South Korea, more than 15 000 screening tests could be done in a day. Based on the triage system, patients with mild COVID-19,

particularly those younger than 50 years, were instructed to stay in designated places or remain home instead of hospitals. Additional measures included suspension of classes, lockdowns of serious outbreak areas, and banning of gatherings.⁶¹ The core intervention in these countries has been timely detection and management of suspected and confirmed cases and identification and management of their close contacts.

An alternative to containment and suppression is mitigation, which seeks to reduce health effects and decrease the epidemic peak by protecting vulnerable populations and avoiding overwhelming the health-care system, thereby slowing and reducing transmission. Core interventions are focused on treatment of severe cases and implementing NPIs, rather than optimising detection and management of every case and close contact. With mitigation, mild cases can go undetected and serve as sources of infection, supporting community transmission. Mitigation might allow development of herd immunity over a long time, but at a great cost in terms of number of cases, morbidity, and mortality.³⁷ Experience with influenza A is that NPIs (without case finding, isolation, and contact tracing) can reduce spread by up to 50%,⁶² which is potentially insufficient to alleviate critical medical needs caused by the COVID-19 epidemic.³⁷ With ongoing virus transmission, the COVID-19 pandemic might continue indefinitely until relieved by an effective vaccine response.

In summary, we are now facing a totally new, extraordinarily complex, and highly damaging virus. Countries are in different phases of the epidemic: early stage, plateau phase, or having just gained first-phase victory but facing additional waves from imported cases. Countries need to implement measures tailored to epidemiological circumstances and system capacities, but successful practices in several countries, including China, Singapore, and South Korea, show that—at the individual level—identification and management of infected people and their close contacts are practices that work.^{37,60,61}

WHO is committed to providing technical leadership supporting Member State implementation of the International Health Regulations and innovation to refine evidence-based prevention and control strategies for COVID-19. We have a firm belief that through international collaboration, sharing, and innovation, and with UN leadership, the trajectory of this pandemic can be changed for the better.

Contributors

GFG and ZF had the idea for this report, with input from ZL, QC, LF, WY, ZA, YX, WC, and TZ. QC, YX, HY, LR, RZ, ZL, and DN reviewed published literature and wrote the first draft. YQ, TZ, QC, XY, MZ, YX, and QW made the tables. JC and XR drew the figure. GFG, ZF, ZL, QC, YX, HY, RZ, LR, YQ, DN, WC, TZ, LZ, ZP, ZA, DW, XS, YL, XQ, and TS reviewed and revised the report. All authors approved the final version.

Declaration of interests

We declare no competing interests.

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