COVID-19 Evidence Update

COVID-19 Update from SAHMRI, Health Translation SA
and the Commission on Excellence and Innovation in Health

23 July 2020

*Effectiveness of lockdowns**

recommend reading in conjunction with
'Responding to increased cases' (25 June 2020)

Executive Summary

Lockdowns control spread of a virus within the general community by restricting population movement, thereby significantly reducing contacts, aiming to reduce the effective reproduction number (Re) to below 1. Lockdowns vary in scope from partial (e.g. some public places are closed but people can move about freely), to progressive, to full or 'hard' lockdown (e.g. people cannot leave their homes). Lockdowns have been critical in breaking chains of transmission when there is community transmission with unknown sources and/or the numbers of incident cases are too great for contact tracing alone. A number of jurisdictions have effectively eliminated or supressed the virus and are not in lockdown. Primary strategies for sustained control of COVID-19 are: Test-Trace-Isolate; (international) border control and quarantine; physical distancing (1.5m distance in public and private settings, and controls on large gatherings), self-isolation (staying home when sick, when awaiting testing, and/or when a close contact of a known case) and hand hygiene.

State of evidence:

- There is a moderate volume of literature aiming to measure the effectiveness of lockdowns, and a good portion of it is peer-reviewed (a substantial amount of literature is still in pre-print).
- Evidence of lockdown effectiveness during COVID-19 is **heavily confounded** by factors, including: (i) the diversity of lockdown scope across jurisdictions, (ii) the stage of the local epidemic when lockdowns were implemented; and (iii) the effects from other strategies that were implemented simultaneously, which are difficult or impossible to disentangle.
- Furthermore, there are issues with the accuracy and comparability of measures of individual countries' policy measures which have been used in many of the studies.
- Longer term measurement is needed, as most analyses of COVID-19 report on lockdowns conducted during March and April 2020 when many countries implemented lockdowns in response to first surges in case numbers.

Effectiveness of lockdowns:

- Numerous studies indicate that **lockdowns that limit community mobility are effective**, especially when implemented during the **early rises in cases**. This is consistent with the effective suppression / elimination of COVID-19 in Australian states and territories and New Zealand, in response to lockdowns in late March 2020.

- **Late lockdowns** (e.g. following the peak in cases) **appear to be less effective** [1, 2]. There are also regional differences in the effectiveness of lockdowns.
- Studies reporting on the time taken to see a reduction in cases suggest that it requires **at least 7 days** [3] and possibly up to 54 days with only medium rates of compliance [4].
- International studies report that **regional lockdown strategies** can be effective but have risks and challenges with implementation. Containing the spread within a region can over-burden the health care system and increase the local epidemic size, but lowers the spread of infection outside of that region [5, 6].
- COVID-19 lockdowns have been implemented to varying degrees in different countries and at different stages of local epidemics, with varying degrees of community compliance and success.

<u>Other considerations</u>

- Community compliance with lockdowns is essential for them to be effective. Compliance with Australia and New Zealand's original lockdowns was sufficient for them to be highly effective (and more effective than predicted). There is concern that community fatigue may increase and compliance may fall, but such 'fatigue' has not been objectively observed or quantified.
- Lockdowns impact on employment, psycho-social wellbeing, health care provision and economic growth. Governments are faced with balancing such restrictions and preventing resurgence of transmission to unsustainable levels.
- The capacity to test-trace-isolate is critical in exiting lockdown.

Context

- Key points for risk management / control of COVID-19:
    - The presence and prevalence of transmissible virus in the whole community, or in a geographical area, drives risk.
    - Features of disease:
        - The virus will not circulate silently without cases presenting.
        - While the proportion of symptomatic cases is unknown, it is likely to be the majority. There is a lag between infection and onset of symptoms and symptoms present after an average of 5 days.
        - The majority of cases are mild to moderate and do no not require hospitalisation (~80% known cases). ~20% of cases will present requiring medical attention.
        - There are marked distributions of serious disease linked to: older age; obesity; and health comorbidities (chronic diseases); making specific cohorts more vulnerable.
    - Major transmission routes:
        - is via droplet spread between people in close proximity for a duration of time
        - Symptomatic transmission is more likely and common than transmission by those without symptoms (yet)
        - Virus may live on surfaces for hours to days
    - Test-trace-isolate strategies are fundamental to infection control, and a strength for Australia. Other countries implement these strategies with more "aggressive" isolation monitoring than Australia including surveillance via phone. These strategies are demonstrably effective and successful. There may be cultural differences between Australia and other countries in public tolerance for increased digital surveillance.
    - Different cases present different levels of risk for infection control:
        - Cases in well-supervised quarantine (e.g. overseas arrival) are very low risk
        - Cases among people in unsupervised self-isolation / quarantine are low risk (e.g. family members or close contacts of known cases; interstate arrivals where required)
        - Cases in people who are not self-isolation but who are linked to known cases are medium risk

        - Cases of community (unknown source) transmission are highest risk
    - Effective control mechanisms:
        - **Physical distance** of <1.5m between people significantly reduces risk (Some activities will increase droplet reach: speaking; singing; coughing and sneezing; physical exertion).
        - Temporarily **separating suspected cases** (people with symptoms) from workplaces and the wider community. This involves encouraging people with symptoms to self-isolate and minimising social and financial disincentives for doing (such as loss of earnings).
        - **Hand washing** is protective against virus being picked up from surfaces
        - **14-day quarantine** time is sufficient to detect ~99% of symptomatic cases
        - Lockdowns (selective by geography or activity; and general)
    - Masks for general community:
        - Masks are of lesser effectiveness as a whole of population control strategy
        - When used properly, surgical masks are of benefit for source control, notably for symptomatic cases
        - Used and disposed of properly, masks may offer values in population settings where community transmission of the virus is occurring and physical distance cannot be achieved e.g. crowded public transport.

Perspectives on lockdowns:

- Community containment (e.g. lockdown) is an extension of social distancing to reduce intermixing of unidentified infected persons with non-infected community members and is particularly useful in settings where community transmission is substantial and when contact tracing is outpaced by the generation of new cases [7-9].

- An effective lockdown requires early intervention, clear rules, and strict enforcement [10].

- A piece in 'The Conversation' made the following points: A 'lockdown', whether implemented partially, progressively or fully, is a way of restricting movement of people in their communities and is often achieved through police presence and public health regulations. Easing of lockdown restrictions and a corresponding surge in cases has forced governments in many places across the world to order new lockdown restrictions (E.g. Segria, Spain; Leicester, UK; Beijing, China), however, these tend to be ring-fenced to high-risk areas rather than nationwide. Flawed public messaging and enforcement resulted in lockdown failures in Italy and India due to panic and people rushing home from across the country, spreading the disease with them. Repeated cycles of lockdowns and relaxing lockdowns may increase population fatigue and result in lower compliance.

- Karnon 2020 (Appl Health Econ Health Policy Editorial) [11]: Governments are grappling with the decision to either have an immediate lockdown or gradually step towards a lockdown. The gradual approach assesses the number of cases against the economic and social well-being of the population (due to isolation). The gradual approach may still result in lockdown, but whether it is better or worse than an immediate lockdown depends on the situation.

- There is an ongoing media and policy commentary in Australia about whether to follow a suppression or an elimination strategy, both of which have implications for lockdown. Suppression lockdowns are shorter, but as restrictions ease and cases rise, further lockdowns are likely. The uncertainty adds a substantial layer of complexity and risk to economic recovery. Elimination lockdowns are in place for an extended period, with suggestions of 2 weeks beyond the time when active cases in the community reach zero. There are also risks with the elimination strategy as cases can emerge after an area is determined COVID-free.

- Statement from the AHPPC (21 June 2020) [12]: The AHPPC recognised the importance of the measures taken by the Victorian Government which seek to reduce further spread and the development of new outbreaks. The AHPPC strongly discourages travel to and from affected areas until control of community transmission has been confirmed. The AHPPC supports the statements of the National Cabinet that the easing of restrictions is dependent in part on adherence to existing restrictions and our capacity to test and trace confirmed and possible cases.

Global lockdown policies and practices

- Lonergan 2020 (Eur Respir) [13]: "Lockdown" is one of the most stringent measures that has been adopted to control the spread of the virus, however, the forms of the restrictions and the exceptions allowed have varied between countries and regions.

- Oxford COVID-19 Government Response Tracker (OxCGRT) systematically collects information on several different common policy responses that governments have taken to respond to the pandemic on 17 indicators. Eight of the policy indicators (C1-C8) record information on containment and closure policies. Indexes are produced from the data to reflect Government action.
    - Our world in data (Policy Responses to the Coronavirus Pandemic) has visualisations of various policies (e.g. stay-at-home requirements) around the world and over time. [Note: these were not an accurate account of policies in place for Australia, at the time of writing]
    - The data also informs the "Lockdown rollback checklist" report, which summarises the extent that each country meets the WHO recommendations for relaxing physical distancing measures. The report shows that many countries are moving out of lockdown before meeting the WHO's recommended conditions.
    - The Stringency Index has been used to classify countries as having 'relaxed response' to the pandemic (scoring less than 70 out of 100); these countries are at increased risk of a second wave when exiting lockdown. On 25 June, the Guardian reported that 10 of the worst-affected countries were at risk as they eased restrictions due to rises in cases: US, Iran, Germany, Switzerland, Sweden, Bangladesh, France, Ukraine, Indonesia, and Saudi Arabia. Of note, there remained 9 countries that had tough lockdowns but were still reporting rising case numbers (Bolivia, Argentina, Colombia, Iraq, Philippines, Panama, Kuwait, China, and Oman).

- Assessment Capacities Project (ACAPS): lists, by date, the containment and mitigation measures used by governments around the world; it contains approximately 40 distinct strategies, grouped into 5 categories: social distancing, movement restrictions, public health measures, socio-economic measures and lockdown. As of 15 July 2020, the database which includes introduction and phase-out records, had 694 records of lockdown, of which 135 (19%) indicated full lockdown (spread across 40 countries). There were 559 partial lockdown records, 163 (29%) were targeted to specific locations or demographic groups.

Summary of Key Evidence

CEBM, University of Oxford: Evidence on measures to reduce community transmission of infectious diseases mostly come from studies on influenza and very few studies have evaluated interventions such as avoidance of mass gatherings and restricting movement. Emerging evidence in COVID-19 suggests that various forms of social distancing measures, including city-wide lockdowns, can slow transmission but timing and duration is crucial. As is combining social distancing with effective testing and quarantining of suspected cases.

Demonstrating the effectiveness of lockdown

Timing

- Figueiredo 2020 (Bull World Health Organ) [3]: An interrupted time series study evaluating the effectiveness of strict social distancing (i.e. lockdown; strict limits on activities outside the home) measures in 2 Chinese provinces showed that there was a **reduction in incidence 7-17 days post-implementation** and a **reduction in mortality 10 days post-implementation**.

- Effectiveness and the time required for changes were associated with the number of undiagnosed patients and post-lockdown home transmission.

- Sjödin 2020 (Euro Surveill) [4]: This modelling study estimated the disease burden and the time required until the quarantine could be lifted in a small town setting (n=5000), akin to Italy. Results: assuming 10% asymptomatic infections, for a 3-person household, **30 days** would be sufficient lockdown duration if there was **near-complete community adherence**. With only **medium compliance, 54 days would be necessary**. The larger the household size and amount of time in the public, the longer the lockdown period needed.

- Bonardi 2020 (Covid Economics) [14]: Analysed various lockdown strategies on growth rate in number of confirmed cases using a dataset comprising of 184 countries with data from 31 Jan to 4 May 2020. Results indicate that lockdowns are effective in stopping the growth of new cases. **On average, a decline in growth was observed after 25 days and was still lower 55 days later. Countries that reacted quicker saw a decline in growth rate sooner (23 days) than those that reacted slower (36 days).** The authors indicated that partial or regional lockdowns were as effective as stricter total lockdown measures, based on results indicating that blocking international borders was not as effective as inside-country measures. Lockdown worked better in developed rather than developing countries. However, timing of policy and data collection could have played a role in these findings.

- Amer 2020 (Disaster Medicine and Public Health Preparedness) [15]: Based on risk assessment applied to 6 countries, **results demonstrate that a spontaneous decrease after 10 days of lockdown can be noticed if the lockdown is effective**. The earlier announcement of lockdown and the stricter the adherence can lead to fewer infected total cases, fewer deaths, and faster to a plateau, a more precise estimation of cases, and fewer deaths. The authors note that it is meaningless to evaluate the lockdown timing according to the number of days since the appearance of the first case, rather it should be **evaluated by the number of cases per capita at the time of lockdown**. Increased testing also played a role in minimising cases and deaths and provided a better estimation of the true number of cases, which influences lockdown decisions.

- Cuadrado 2020 (medRxiv preprint) [16]: Evaluated the impact of small-area lockdowns in Chile based on a reduction in the effective reproductive number (Re) and 4 indicators of human mobility (public transport, retail and recreation, workplace, and residential). Data was collected up to 25 April 2020. Note that school and university closures and work from home interventions were already in place. Small-area lockdown produced a sizable reduction in human mobility, equivalent to an 11.4% reduction (95%CI -14.4% to -8.38%) in public transport and similar effects in other mobility indicators. **Ten days after implementation, the small-area lockdown produced a Re reduction of 0.86 (95%CI -1.70 to -0.02).** School and university closures, implemented earlier, led to a 40% reduction in urban mobility. Closure of educational institutions resulted in an even greater Re reduction compared with small-area lockdowns. Authors suggest that school closures accelerate the adoption of other voluntary confinement actions, such as working from home.

- Pathak 2020 (medRxiv preprint) [1]: Simulation modelling of lockdown scenarios showed that **early lockdown substantially reduced the number of infections compared to no lockdown. A slightly delayed lockdown start (day 10) reduced infection during the lockdown period but there was an emergence of a peak post lockdown period. A late lockdown start (day 19) did not reduce infections during that wave.** The results indicated that lockdown efficacy was influenced by mobility, network topology and population size and recovery time.

- Mayorga 2020 (medRxiv preprint) [17]: Simulations of different scenarios relating to healthcare parameters (fatalities and ICU occupancy) suggest that a 45-day lockdown that starts and ends before a rise, or after the peak has minimal effectiveness on reducing healthcare parameters. **Lockdown is effective during the rise in ICU occupancy**. [Note: this pre-print provides very limited detail on methods and the focus is on healthcare parameters rather than cases.]

Strategies

- O'Sullivan 2020 (Transactions in GIS) [8]: Modelling of different scenarios based on **New Zealand** data and spatial features showed that **restricting movement** (based on New Zealand's four-level alert system) **within geographical regions rather than nationally leads to better outcomes for the population over time**, even though both strategies perform similarly for containment. This means applying triggers (e.g. positive test rate) at the local level and easing restrictions locally when thresholds are met for lower levels of lockdown. Authors suggest that to facilitate a geographical approach to lockdown, it is necessary to divide the affected area into regions, and then limit non-essential travel between them. This is more difficult to achieve in large metropolitan areas.

- Espinoza 2020 (PLoS One) [5]: Examines a model of disease transmission within and between economically heterogeneous locally connected communities. One community comprises a low-risk, low-density population with access to effective medical resources. The other comprises a high-risk, high-density population without access to effective medical resources. **Unrestricted mobility between a high and low risk community increases the number of secondary cases in the low-risk community but reduces the overall epidemic size. By contrast, mobility restrictions that isolate the high risk community reduces the number of secondary infections in the low-risk community but increases the overall epidemic size.**

- Zhang 2020 (medRxiv preprint) [18]: Simulation modeling applied to China (1-22 Jan 2020) showed that early intervention of social distancing can reduce the epidemic size significantly, especially when synchronising the intervention nationally at the earliest possible time. The effect of epicenter lockdown had different effects in Wuhan than non-Wuhan regions. **Early lockdown in Wuhan would deteriorate the situation in situ (due to pressure on local healthcare systems) but would largely lower the infection number outside of Wuhan (when social distancing policies were in place)**. Therefore there is a dilemma: to minimise epidemic size and death, the epicenter city should not be locked down, but to confine the epidemic distribution and mitigate the impact on nationwide socio-economics, the epicenter lockdown should be taken earlier.

- Ren 2020 (Eurasian Geography & Economics) [10]: Contrasts the 'relational' approach taken by Hong Kong, South Korea and Taiwan, where mass testing, contact tracing and quarantining infected individuals was prioritised, with 'territorial' lockdown where stay at home orders were issued but without adequate testing and targeted quarantine. The paper compares the approaches to lockdown taken by China, Italy and the US and the subsequent outcomes. China's lockdown was not nation-wide and implementation was targeted but largely uneven. There were also comprehensive methods of surveillance and enforcement. In contrast, Italy's lockdown was piecemeal and porous and was accompanied with mixed messages from Government. The US had the least coordinated effort at the national level, leaving the states and local authorities to fend for themselves, resulting in competition while bidding for critical medical supplies in the private market. Lockdowns, when implemented, were not enforced to the same extent as China and Italy, and is more akin to practicing social distancing when out in public.

- Kanga 2020 (Geocarto International) [19]: Zoned approach proposed for India so that hard lockdowns are only applied in high risk areas. No results reported.

Overall effectiveness

- Ghosal 2020 (Diabetes & Metabolic Syndrome) [2]: **A 61% and 43% reduction in infection rates 1-week post lockdown in the overall and India cohorts, respectively**. Countries with higher baseline infections and deaths (Spain, Germany, Italy, UK, and France-cluster 1) benefitted less than those who declared lockdown early on (Belgium, Austria, New Zealand, India, Hungary, Poland and Malaysia-cluster 2). Sweden and South Korea, countries without lock-down, fared as good as the countries in cluster 2.

- Atalan 2020 (Ann Med Surg) [20]: Demonstrates a **correlation with length of lockdown days and total number of cases**, based on 49 countries.

- Patel 2020 (Indian J Public Health) [21]: Case study of nonpharmacological interventions in **India**. **R_t began declining after the implementation of social distancing measures (e.g. mass gathering restrictions) and continued to decline during Phase 1 of lockdown (complete internal mobility restriction for 21 days).** R_t was steady during Phase 2 lockdown (conditional relaxation in mobility in areas not designated as COVID-19 hotspots) and then began rising again in Phase 3 lockdown (restrictions lifted according to 3 colour-coded zones). Easing of restrictions was coupled with increased testing, intensive case-based surveillance and containments efforts.

- Deo 2020 (medRxiv preprint) [22]: modelled four scenarios for containment of COVID-19 in **India**. Estimates of R_0 for the phases no-intervention, partial-lockdown and lockdown were 4.46 (7.1), 1.47 (2.33), and 0.817 (1.29) respectively, assuming 14-day (24-day) infectious period, supporting the effectiveness of lockdown measures.

- Umer 2020 (arXiv preprint) [23]: **Pakistan** had regional differences in whether a complete or partial lockdown policy was implemented. There were also regional differences in whether complete and partial lockdowns were effective at containing the virus. **Complete and partial lockdown appeared to be effective in 4 regions, but not in the 3 largest provinces.** Authors conclude that divided political leadership, weak public will, and lockdown enforcement mechanisms, socio-economic constraints, and epidemic stage have collectively influenced the ineffectiveness of lockdown policies.

- Hyunjung 2020 (Research Square preprint) [24]: Used machine learning to evaluate the timing and intensity of lockdown (none, restricted public social gathering, nationwide lockdown) and travel restriction (none, flight suspension, border closures) policies based on data from 183 countries collected between 21 Jan and 7 Apr 2020. **Results showed that lockdown and travel restrictions are effective in reducing transmission of COVID-19, and when compared to actual government implementation, the model mostly recommended earlier and higher intensity of lockdown and travel ban.**

- Alfano 2020 (Appl Health Econ Health Policy) [25]: Results show that **lockdown is effective in reducing the number of new cases in the countries that implement it, compared with those countries that do not**. This is especially true around 10 days after the implementation of the policy. Its efficacy continues to grow up to 20 days after implementation.

- Fang 2020 (Working paper) [26]: The lockdown of Wuhan reduced inflow by 76.64%, outflows by 56.35%, and within-Wuhan movements by 54.15%. Using simulations with these estimates, **the lockdown of the city of Wuhan on January 23, 2020 contributed significantly to reducing the total infection cases outside of Wuhan**, even with the social distancing measures later imposed by other cities. COVID-19 cases would be 64.81% higher in the 347 Chinese cities outside Hubei province, and 52.64% higher in the 16 non-Wuhan cities inside Hubei, in the counterfactual world in which the city of Wuhan were not locked down from January 23, 2020.

- Ji 2020 (Clinical Infectious Diseases) [27]: Data from China suggest that a **2-month lockdown helped to flatten the curve in Huangshi city**.

- Lavezzo 2020 (medRxiv preprint) [28]: **Transmission in Vo, Italy, substantially reduced following the lockdown**, with the weekly effective reproduction number declining from 3.0 to 0.14 by the end of the 14-day lockdown.

Lockdown exit strategies

- Gupta 2020 (medRxiv preprint) [9]: Modelled strategies to exit nation-wide lockdown in India (one of the strictest lockdowns in the world) based on 140 confirmed COVID-19 patients; assumptions based on incidence data from 4 Mar to 25 Apr. Results indicated that **extending lockdown past the peak of active cases is beneficial, and that increased testing is needed once restrictions are lifted**.

- Lee 2020 (medRxiv preprint) [29]: Modelled various scenarios of COVID-19 incidence in a US city (King County, WA). The initial scenarios were 1) case isolation at home; 2) school closure, and 3) social distancing (no workplace or neighbourhood contact) at low, medium and high rates of compliance, and the exiting lockdown strategies were a combination of 8 different levels of social distancing over a 4-month period (case isolation and school closure was the same throughout). Results: **the most restrictive scenario for exiting lockdown was the most effective in reducing transmission, however, all 8 scenarios yielded a second wave once social distancing strategies were relaxed and schools reopened**.

- Lonergan 2020 (Eur Respir) [13]: Data from 89 countries up to 21 May 2020 were analysed to model when 'lockdown' measures could be lifted. These data suggest that **few countries could have even one week per month unrestricted without seeing resurgence of the epidemic**. Similarly, restoring 20% of the activity that has been prevented by the lockdowns looks difficult to reconcile with preventing the resurgence of the disease in most countries.

- Goscé 2020 (J Infection) [30]: Modelled a range of scenarios to predict the epidemiological impact of lifting the lockdown in London, UK. The scenarios were 1) city-wide continuation and removal of lockdown; 2) less stringent social distancing and universal testing; 3) shielding those over 60 years; 4) universal testing and use of face masks without lockdown; and 5) universal testing, contract tracing and mask use after prolonged lockdown. Results indicate that lockdown is a highly effective strategy in reducing infections and mortality. **Lifting lockdown would likely lead to a resurgence of cases**. Of the scenarios tested, only one had potential for higher effectiveness in reducing infections compared to ongoing lockdown with no additional interventions: combine continued lockdown with universal testing, case isolation, contact tracing and isolation, and facemask use by the general population. This strategy could eliminate the infection from London over an interval of 4-6 months, after which release of lockdown may be possible.

- Brethouwer 2020 (arXiv preprint) [31]: Proposes that long-distance connections will drive second-wave disease propagation. Close-range ties connect infected individuals with others who are higher risk for infection whereas long-range ties expose people who would otherwise not be at risk. Therefore, interventions should be targeted at reductions in non-local transmission. The model simulation results indicate that close monitoring and checking of long-distance ties allows overall policy to be more permissible (but social distancing still required) and still control a second wave. The authors suggest that risk of long-range transmission mostly occurs in relation to transport, travel and delivery sectors.

- Van Bunnik 2020 (medRxiv preprint) [32]: Authors propose **segmenting and shielding (S&S)** as an option for exiting lockdown. Segmenting is dividing the population into relatively homogenous groups in terms of healthcare needs and shielding is minimising all interaction with vulnerable people. Modelling of a range of scenarios showed that a combination of increased protection of the vulnerable population and relaxation of restrictions (lockdown) on the non-vulnerable population can prevent an overwhelming second wave in the UK. However, there are many caveats with the approach.

- Friedman 2020 (Front Public Health) [33]: Authors propose organising people into zones, with more interactions inside their zone than across zones, which may deliver lower infection rates with less social distancing, particularly if combined with simple quarantine rules and contact tracing. An 'inter-zonal reproduction number', based on R_0, can be computed to track and manage disease progression.

- Mahase 2020 (BMJ; narrative briefings [34, 35]): UK case study: As national restrictions began to ease, Leicester was placed under local lockdown (stay at home except for essential needs) for at least an

additional 2 weeks, after it was found to have 3 times more COVID-19 cases than the next highest city (141 per 100K popn vs 46 in next highest location). The situation was described as predictable and avoidable given that the virus was still widely circulating, and there was no functional system of test-trace-isolate, when restrictions began easing. Leicester has high levels of disadvantage and poverty. The briefing also cited the situation in Padova, Italy, where a local lockdown had worked in conjunction with comprehensive test-trace-isolate strategies.

- Block 2020 (Nature Human Behaviour) [36]: Authors propose behavioural network-based strategies for selective contact reduction that every individual and organisation can easily understand, control and adopt: contact with similar people, strengthening contact in communities, and repeatedly interacting with the same people in bubbles. The figure below shows how the virus can spread through networks that vary in terms of path lengths (despite having the same number of individuals and social interactions:

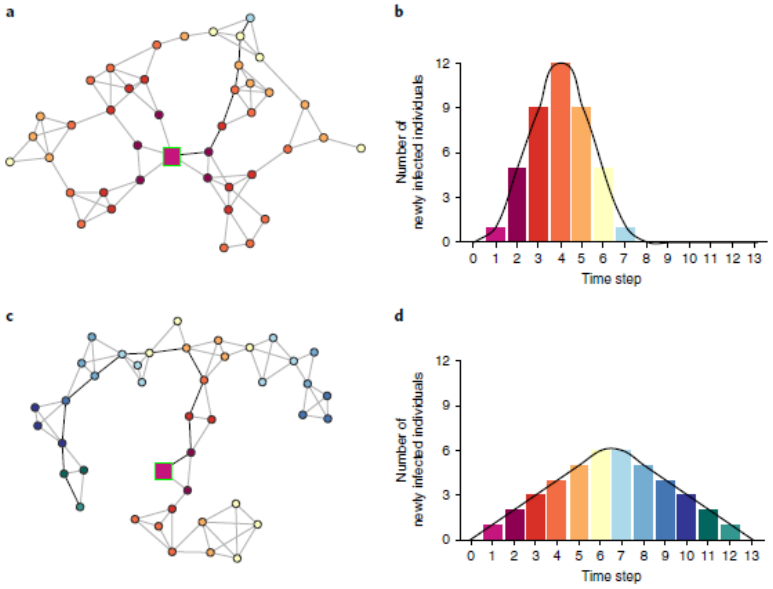

Fig. 1 | Two example networks. a–d, Two example networks (**a** and **c**) have the same number of nodes (individuals) and ties (social interactions) but different structures (shorter path lengths in **a** and longer path lengths in **c**), which imply different infection curves (**b** and **d**, respectively). Bold ties highlight the shortest infection path from the infection source to the last infected individual in the respective networks. Network node colour indicates at which step a node is infected and maps onto the colours of the histogram bars.

  - The proposed aim is to devise interaction strategies that are more like 1c than like 1a
  - Results show that a mix of strategies provide comparable benefits to single strategies, and all work considerably better than simply releasing a floodgate of full non-strategic contact; however, further modelling is needed to assess the implications across a variety of contexts.

- Fadlallah 2020 (report) [37]: Guidance on exiting lockdown across 3 phases: readiness, initiation, implementation.
  - Readiness: there is no consensus for threshold level, but consideration given to epidemiological control (e.g. beyond peak of infections and trajectory of decreasing positive cases), health care capacity, appropriate testing and tracing capacity (including isolation of confirmed cases), and sustained preventive measures at scale.
  - Initiation: establish task force, improve infrastructure and capability for testing, develop strategy with all key stakeholders (governments, private sector, businesses, general public), put in place a clearly coordinated system to implement and monitor the exit strategy, and develop a well-coordinated communication strategy.
  - Implementation: Use step-wise, phased approach to ease restrictions on movement, travel and work, using experimentation and re-assessment in approximately monthly cycles. Real-time surveillance will be essential to identify any increases in cases.

- Other recommendations include: progressively replace general measures by more targeted ones; general physical distancing precautions should still be the norm; re-open gradually the most important services and businesses first; explore different work modalities/schedules to control spread of infection; re-introduce transport services gradually; scale-up diagnostic and monitoring for detection of virus and identification of immune people; progressively authorise public gatherings; enforce and sustain public health and preventive measures to prevent the spread of the virus; ensure continuous (and real-time) monitoring; educate, empower, build public trust and manage public expectations in the new reality; provide support to vulnerable populations and struggling businesses to enhance compliance with the lockdown exit strategy.
- Triggers to re-instate stricter measures: a substantial number of cases cannot be traced back to known cases; a sustained rise in new cases for five days; hospitals are no longer able to safely treat all patients requiring hospitalisation.

Studies suggesting that lockdown is insufficient or unnecessary

- Haug 2020 (medRxiv preprint) [38]: conducted an extensive analysis on the impact of 4,579 individual non-pharmaceutical interventions (NPIs) on the effective reproduction number R_t of COVID-19 in 76 territories worldwide. The findings suggest that **there is no silver bullet and no single intervention would be enough to stop the epidemic**, but there are some interventions that contribute to reducing R_t to below one. At the global level, i) social distancing, ii) travel restrictions, and iii) healthcare and public health capacity (e.g., reduce the burden on the healthcare system by encouraging self-initiated isolation of people symptoms) have a particularly strong effect on the reduction of R_t. **There was a strong correlation between the effectiveness of the national/state lockdown and the epidemic age of its implementation.**
  - Importantly, the efficacy of individual **NPIs strongly varied across countries and world regions, and in relation to human and economic development as well as different dimensions of governance.** This indicates high heterogeneity across countries and a non-independence among the different NPIs. Furthermore, the effectiveness of each NPI depends on the epidemic age of its adoption - the same NPI in the same country can have a drastically different impact if taken early or later on.
  - The authors conclude that there are NPIs considerably less intrusive and less costly than lockdowns that could be highly effective, such as specific risk communication strategies and voluntary measures that strengthen the healthcare system. Note that analysis is based on data collected during March and April 2020.

- Chen 2020 (arXiv preprint) [39]: By constructing scenarios with different combinations of NPIs, empirical findings suggest that the **combination of mask wearing, lockdown, school closures and centralised quarantine is the most effective, and was the strategy used by China.** However, it is the most economically costly method. **Countries may avoid the lockdown policy by imposing school closure, mask wearing and centralized quarantine to reach similar, albeit slightly delayed outcomes on controlling the COVID-19 infection.** This was the approach taken by South Korea. Modelling based on 9 countries: Italy, Spain, Germany, France, UK, Singapore, South Korea, China and the US for the time period 22 Jan to 3 Mar 2020. In this study, social distancing was non-significant, potentially due to the overlap with lockdowns (more comprehensive) and school closures (less comprehensive).

- Nader 2020 (SSRN preprint) [40]: Machine learning modelling approach applied to cumulative cases compared to government interventions in 95 countries. The outcome metric was growth rate (daily increase rate of cumulative confirmed cases). The dataset included the daily growth rate for 3800 total days from 95 countries (noteworthy exclusions: The Netherlands, UK, cruise ships Diamond Princess and Grand Princess) up to 22 April, 2020.
  - Results indicated that for the general population school closures, limiting public gatherings and public services closures had the most impact on growth rates.

- In most countries, school closures were implemented early when the growth rate was still very high and showed a noticeable effect about 7 days after implementation. [Note: that this measure was always implemented in combination with other measures.]
- A similar trend was observed for limiting public gatherings but a noticeable effect was observed about 10 days after implementation.
- The decrease in growth rate was more steady following public services closures.
- Note that the effects of measures introduced later, that were targeted, or had short timeframes (e.g. curfews or lockdowns) may be diluted by other measures.

- Wong 2020 (J Infect) [41]: Used the Oxford COVID-19 Government Response Tracker's Stringency Index to determine whether containment measures reduced the number of confirmed infections. The Stringency Index consists of school closure (C1); workplace closure (C2); public event cancelation (C3); restrictions on gathering size (C4); public transport closure (C5); staying at home requirements (C6); restrictions on internal movement (C7); restrictions on international travel (C8); and public information campaigns (H1). Results showed that, based on data from 15 to 30 April, a higher stringency index was associated with a lower incidence increase. Three indicators were statistically significant: school closing, workplace closing and public information campaign. [Note: authors do not elaborate on how they assess the measures for each country, only that they "Computed the average of all stringency indices for each nation on or before 31 March 2020"]

- Bausch 2020 (Am J Trop Med Hyg; commentary) [42]: Proposes 'Precision physical distancing' (i.e. tailored and optimised to specific settings) as an alternative to lockdown. Examples include:

Restaurant
Seating capacity restricted based on specific assessment of sufficient distancing based on configuration of the establishment
All customers seated until given permission to circulate by management (e.g., to exit or use toilet facilities)
Controlled entry and exit to ensure spacing
Tables must be at least 2 m apart, with tape or chalk lines on the floor to mark out spacing and pathways to exits and toilet facilities
Maximum of two people per table, not seated face-to-face (to avoid droplet deposition on mucous membranes during speaking, coughing or sneezing)
No touching between clients or staff
Hand sanitizer and public health message on precision physical distancing and healthy practices to avoid COVID-19 placed on each table
Servers must wear masks at all times
Tables and chairs are decontaminated between customers
Local food market
Controlled entry and exit to ensure spacing
Entry restricted based on specific assessment of sufficient distancing based on configuration of the market
Every other stall left empty, with monitors to reinforce and control flow (e.g., movement between stalls)
No more than two people at a time per stall
Hand sanitizer or sanitation station with soap and water placed in front of each stall
Surfaces where client–seller interface occurs decontaminated after each client interaction, with complete decontamination of market at the end of each day
Sporting event*
Controlled entry and exit to ensure spacing
Seating capacity restricted based on specific assessment of sufficient distancing based on the configuration of the venue and section of stands
Every other seat left empty, with monitors in each section to reinforce and control movement and flow (e.g., to exit or use toilet facilities)
Hand sanitizer or sanitation station with soap and water placed at entrance to each section of stands
No food or drink sold
Stadium decontaminated after each game

Behavioural response to lockdowns

- Rieger 2020 (Review of Behavioural Economics) [43]: Measured activity patterns in France, Germany, UK and US during lockdown using multiple data sources that collected data during March and April 2020. Found that in most cases, after a steep decline in activity due to the COVID-19 outbreak and the various lockdown measures, a small but steady increase in activity sets in.

- Brzezinski 2020 (INET Oxford working paper) [44]: Using US data from 1 Feb to 31 Mar 2020 from various sources, the study shows that outbreaks of COVID19 are significantly associated with uptakes in physical distancing. At the state-level, the downward trends in traffic were observed in the presence and

in the absence of policy interventions. In highly urbanised areas that are less distrustful of science, more highly educated, have higher incomes or have stronger institutions, people react more strongly to an outbreak even in the absence of lockdown policies. The authors suggest that less restrictive containment policies targeted along socio-economic lines are likely to be more effective at containing an outbreak than total lockdowns.

- Engel 2020 (SSRN preprint) [45]: Based on US GPS data, rise in local infection rate corresponds with a reduction in mobility by 2.31%. An official stay-at-home restriction order corresponds to reducing mobility by 7.87%. Counties with larger population over 65 years, Democratic voters, higher population density more responsive to disease prevention and restriction orders.

- Pullano 2020 (medRxiv preprint) [46]: Analysed mobile phone data in France. Nationwide mobility went from 60m trips per day to 20m trips per day after lockdown came into effect and stabilised in the second week. Long-range traffic (>100 km) was disrupted more severely than average (85% reduction). Short-range trips also reduced, resulting in an overall decrease of 65% in mobility. Movements during rush hours were among the most disrupted, indicating that the combined effect of school closure and telework led to a ~75% reduction. Daytime movements during weekends also exhibited a higher-than-average decrease, hinting at a successful reduction of recreational activities. Larger reductions were measured in regions more severely hit by the epidemic, with an estimated 1% decrease in regional mobility every 10 additional hospitalizations (per 100,000 inhabitants).

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