Emerging Evidence on COVID-19

Evidence Brief of SARS-CoV-2 Contact Tracing

Introduction

What evidence exists for the strategic use of effective and efficient COVID-19 contact tracing during the pandemic?

Contact tracing is one of several public health measures (PHMs) being used to control the spread of COVID-19. When a case is identified, contact tracing may be initiated by local public health authorities to identify individuals who have potentially been exposed to the case and assess their risk of exposure. Currently in Canada, close (i.e., high risk) contacts of COVID-19 cases are required to quarantine (i.e., self-isolate) away from others for 14 days (1). It is an important, but resource-intensive activity, and during periods of high COVID-19 transmission local public health has not always had the capacity for complete contact tracing. Thus, tools or strategies to improve efficiencies in contract tracing and tools to assess tipping points in the public health capacity to perform effective contact tracing are needed. This brief highlights studies and systematic reviews on strategies for effective and efficient contact tracing during COVID-19 available up to February 10, 2021. For the purpose of this evidence brief, contact tracing is defined as the identification of people recently exposed to an infected individual in order to quarantine them with or without testing to prevent further transmission. In this review isolation refers to confirmed cases isolating to prevent transmission within or outside of their household and quarantine refers to isolation of potentially exposed contacts from the community while they complete their incubation period.

Key Points

- The ability of public health to undertake comprehensive contact tracing depends on many factors including the transmission rate in the community, the capacity of public health to undertake contact tracing, and the ability to identify infected individuals and their contacts (2). Strategies to improve contact tracing in the context of the COVID-19 pandemic were summarized in seven rapid or systematic reviews with studies up to December 2020; and two empirical and fourteen modeling studies posted November 2020 through February 10, 2021.
- People who are infected with SARS-CoV-2 can transmit the virus before developing symptoms (presymptomatic) and when they are asymptomatic, which means that contact tracing will miss infected individuals if only symptomatic cases are targeted.
    - Contact tracing strategies that relied on identifying symptomatic cases for initiating contact tracing and quarantine of contacts were shown in included models to miss a proportion of cases and thus failed to control the COVID-19 epidemic (3).

  - Modeling studies showed that mass testing strategies to identify cases and conducting forward contact tracing were more effective in identifying cases and thus at controlling the spread of COVID-19 compared to contact tracing of symptomatic cases only (3-5); however, mass testing is very resource intensive in the short-term and has higher associated costs (6). For example mass testing of identified high risk populations (various healthcare workers, essential business employees, teachers and students) and contact tracing for cases in Canada was estimated to be up to $820 million per month in additional costs compared to the 70 million contact tracing activities were costing in July 2020 (7).
  - Contact tracing is effective at reducing transmission of variants of concern (8).

- Minimizing the time to identify a case and notify the high risk contacts of the case is an important factor in contact tracing to minimize the potential infectious days a person is not in quarantine or isolation.
  - Several included reviews and studies suggest that timely identification of cases (within 3 days of symptom onset) and quarantine of most of the high risk contacts (~60-90% contacts needed to be traced across studies) as quickly as possible was required for a test and contact-trace strategy to be effective (5, 9-11).
- Models show that the effectiveness of contact tracing in controlling the epidemic is reduced when the prevalence of cases (and number of potential contacts) in the community exceeds public health resources.
  - The local context will determine the maximum number of cases that can be handled per day. Exceeding that capacity will result in less effective contact tracing because some cases will not be traced or there will be delays in tracing cases leading to longer time to initiate quarantine or failure to quarantine of people exposed, which may lead to more transmission (2).
- Contact tracing is one of several PHMs used to control COVID-19 which work synergistically to control the epidemic. Studies have shown that as transmission decreases and restrictive PHMs (e.g., lockdowns, closures and restricted movement) are lifted, a strong contact tracing system with sufficient capacity is needed to avoid a resurgence (5% chance of resurgence vs. <50% chance if sufficient contact tracing capacity is not in place) (12).
- Increasing efficiency and effectiveness of contact tracing using new tools and strategies was evaluated in several reviews and studies.
  - Bidirectional contact tracing (contact tracing as early as 6 days prior to symptoms) more than doubles the reduction to R_e when compared with only forward tracing (contacts of the case from 1-2 days prior to symptoms until isolation). (8, 13). However the latter requires more public health capacity.

- Bidirectional contact tracing to identify the primary case of a cluster was found to be 2-3 times more effective against the spread of SARS-CoV-2 when compared to forward contact tracing alone (23).
- Efficiency of contact tracing is improved by the use of electronic data management tools which can double the number of contacts traced and is less prone to error and data loss (14).
- Contact tracing apps have been studied and evaluated in the context of COVID-19 quickly to reach more potentially exposed individuals. As these are a new technology, most models estimated a low uptake of the apps (e.g., 50%), which resulted in a reduced R_e by 18-26% compared to public health contact tracing that resulted in a 35-53% reduction in R_e (14). Higher proportions of population uptake of automated contact-tracing apps (estimates from 56% up to 100%) resulted in improved performance of contact tracing (13, 15, 16).
- A single empirical study reported a significant decrease in R_e (from 1.3 to 0.5) after regional testing of the United Kingdom's contact tracing app that had high uptake by the majority of the population. Version 1, reported in the study, was a Bluetooth enabled proximity contact tracing app which identified probable cases with self-reported symptomatic status (17).

Overview of the Evidence

Twenty-three articles were included in this evidence brief. Systematic and rapid reviews concerning contact tracing to mitigate spread of COVID-19 accounted for seven of the cited articles (three of them in pre-print status). In addition, 16 recent articles (published in Fall 2020/Winter 2021) presented evidence on effective contact tracing strategies, two with epidemiological evidence and 14 based on modelling studies (6 of the models are pre-prints).

AMSTAR-2 tool was used to evaluate the rapid and systematic reviews (n=7) in Table 1 (18). Overall quality of the review is categorized as high, medium, low or very low quality depending on how many AMSTAR criteria were not met.

The empirical evidence (n=2) is based on observational studies aimed to evaluate contact tracing strategies, or changes in current strategies. The observational studies were at risk of many biases. Caution should be used in the interpretation of the predictive models (n=13) as they may be sensitive to the assumptions of the model and are best used to compare different scenarios, as they may not reflect a real situation or be generalizable. Most of the evidence on this topic is from predictive models.

The limitations of the evidence include a lack of empirical evidence and high reliance on the findings of modelling studies or reviews based on pre-pandemic experience.

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REVIEWS OF CONTACT TRACING STUDIES

Table 1: Rapid and Systematic Reviews on Contact Tracing of COVID-19 Cases (n=7)

STUDY	METHOD	KEY OUTCOMES
Overall contact tracing strategies		
Mbwogge (2020) (4) Preprint Rapid Review United Kingdom Dec 2020 AMSTAR-moderate	A rapid review included 35 articles with evidence available up to December 22, 2020 on whether mass testing and tracing would be more effective than current testing and tracing in the UK. Results were synthesized by vote counting, considering the direction of effect and degree of bias in reported outcomes.	Across 13 of the studies mass testing was more effective than symptom-based testing in 76.9% (95% CI: 46.2-95.0) of the studies, thus would improve the suppression of COVID-19 beyond the current symptom based test and trace protocol in the UK. Mass testing improves detection of asymptomatic COVID-19 cases that are not detected in a symptom-based test scheme. Across 22 studies 40.7% (95%CI: 38.8-42.5%) of cases detected would be asymptomatic and would be expected to identify 28% (95%CI: 25.9-30.2%) of asymptomatic cases in the general population and 96.6% (95%CI: 82.2-99.9%) of asymptomatic cases among long term care staff.
Girum (2020) (19) Systematic Review Ethiopia Jun 2020 AMSTAR-moderate	The review identified 22 observational (n=9) and modelling (n=13) studies providing evidence of COVID-19 prevention through contact tracing, screening, quarantine and isolation. Studies up to June 2, 2020 were included in the review. 3 studies assessed all prevention strategies, and 5 specifically assessed contact tracing effects.	Contact tracing studies: • Isolating only symptomatic patients may not contain the epidemic. • Intimate contacts have transmission rates of 40-60%, indicating household contacts of cases should quarantine. • Outbreaks may not be contained, unless high levels of tracing and quarantine are introduced. • If R_o is 2.5, more than 70% of contacts must be traced for outbreak control (20). • Using a contact trace and quarantine strategy reduces transmission 50-60% compared to mass testing or self-isolation alone 2-30% (5) (listed in Table 2).

Juneau (2020) (9) Preprint Systematic Review Quebec, Canada Jul 2020 AMSTAR- low	The review identified 32 observational (n=14) and modelling (n=18) studies concerning the effectiveness of contact tracing for COVID-19 control. All methods of contact tracing were included in the review (i.e. mobile apps, etc.). Studies were excluded if they did not consider community transmission settings or if they were not peer reviewed. The search dates are not provided in the preprint article.	Overall, the review asserts that a case must be isolated within 2-3 days of symptom onset; as well as at least 80% of their contacts quarantined, to result in no tertiary cases. Less efficient tracing and quarantine systems may slow the spread of SARS-CoV-2, but will be unable to stop the epidemic. Delays of ≥ 4 days or quarantine of less than 60% of contacts will be ineffective at controlling the epidemic.
Chung (2020) (16) Preprint Rapid Review United Kingdom May 2020 AMSTAR- very low	A rapid review of efficacy and policy of contact tracing, testing and isolation (TTI) for COVID-19 control identified 48 relevant studies. The search included publications as of May 28, 2020.	The evidence is synthesized into a suggested public health intervention strategy for Taiwan. • Public health interventions provide significant control in the absence of herd immunity for COVID-19, including contact tracing. • Test turn around of <24 hours is documented in multiple studies and is needed for quick case confirmation. • Mass testing of specific groups (i.e. healthcare workers) facilitates detection of additional cases and their contacts. • Digital tools to facilitate timely contact tracing are successfully utilized by many regions; including: cell phone based mobility, location, and apps for location, symptoms tracking and QR scans upon entry and exit of community locations. It is noted that 60-75% app usage is necessary for it to be effective against COVID-19 spread.
Digital Technology and Contact Tracing		
Anglemyer (2020) (14) Rapid review	This Cochrane rapid review conducted up to May 5, 2020 (pre-pandemic to early in pandemic) aimed to assess the benefits,	Gen pop apps: This review included 6 cohort and 6 modelling studies. Two modelling studies indicated compared to isolation alone, manual contact tracing resulted in a 35-53% reduction in R_e while digital contact tracing only reduced R_e by 18-26% across the models, the

New Zealand May 2020 AMSTAR- high	harms and acceptability of personal digital tracing solutions for identifying contacts of an identified positive case of an infectious disease.	latter assumed only 50% of the population used the app. Threats associated with privacy breaches, particularly from wearable devices were considered a possible threat. Public Health data collection apps: Having a data collection application for electronic contact tracing investigations identified 2x more contacts than paper forms during an Ebola outbreak. Another cohort reported reduced times to complete contact tracing with electronic data management system (plus they were less prone to error and data loss.) 2 cohorts reported digital systems save time and are simpler to use. Cost and internet access were barriers.
Braithwaite (2020) (15) Systematic Review United Kingdom Apr 2020 AMSTAR - medium	This systematic review on automated contact tracing, including by automating the processing of test results or symptom reports and by use of smartphone capabilities (eg, Bluetooth) to identify and notify contacts instantaneously who are at risk of infection, included articles published up to April 14-30, 2020 (pre-pandemic and early pandemic). 15 studies were included.	• No empirical evidence of the effectiveness of automated contact tracing (regarding contacts identified or transmission reduction) was identified. Four of seven included modelling studies suggested that controlling COVID-19 requires a high population uptake of automated contact-tracing apps (estimates from 56% to 95%), typically alongside other control measures. • Studies of partly automated contact tracing generally reported more complete contact identification and follow-up compared with manual systems. Automated contact tracing could potentially reduce transmission with sufficient population uptake. However, concerns regarding privacy and equity should be considered. • Automation of contact-tracing may improve the speed of quarantining contacts, which would lead to a bigger impact. Cohorts from Ebola demonstrated 69% contacts vs 39% contacts were visited and speed was reduced by 0.5- 5 hours across studies. • Resource requirements for test-based release from quarantine in the UK estimated 30-50 tests per positive case and 100000-200000 tests per day in the UK.
Qualitative Analysis of Knowledge, Attitudes and Behaviours		
Megnin-Viggars (2020) (21) Rapid review United Kingdom Jul 2020	This rapid systematic review on barriers and facilitators to engagement with contact tracing includes research up to July 15, 2020. Eleven studies were included, 6 on COVID-19, 5 on Ebola	Four themes were identified as facilitators to the uptake of, and engagement with, contact tracing: collective responsibility; personal benefit; co-production of contact tracing systems; and the perception of the system as efficient, rigorous and reliable. Participants reported that their intentions to use a contact tracing app was strongly influenced by a sense of collective responsibility (3 studies), and their desire to

AMSTAR - high	and 1 on other infectious diseases.	help reduce the deaths of others, particularly those who are vulnerable (2 studies). Many indicated it was a means to ending the pandemic and embraced their role (2 studies) even when participants had some concerns over using a contact tracing app they viewed it as the "only way out" and this collective responsibility was prioritised over personal doubts (1 study). Five themes were identified as barriers to the uptake of, and engagement with, contact tracing: privacy concerns; mistrust and/or apprehension; unmet need for more information and support; fear of stigmatization; and mode-specific challenges.

EFFECTIVENESS OF CONTACT TRACING

Table 2: Epidemiological and Modeling Studies Published Fall 2020/Winter2021 on Effective Contact Tracing Strategies (n=16)

STUDY	METHOD	KEY OUTCOMES
Epidemiological Evidence (n=2)		
Carroll (2020) (3) Contact Tracing Evaluation Ireland May – Aug 2020	The study monitors and evaluates the testing and contact tracing system in Ireland. Contacts of laboratory confirmed COVID-19 cases identified May 19 – August 2, 2020 were included (n=7272).	4586 of the 7272 contacts were tested at least once during the study period. • The attack rate of contacts was 7% (95% CI: 6.3 – 7.8%). • Symptomatic contacts testing positive on 'Day 0' was 14.6% • Asymptomatic contacts testing positive on 'Day 0' was 5.2% Symptom based criteria for contact testing at the time of identification misses >66% of secondary cases and their contacts.
Kendall (2020) (17) Contact Tracing Evaluation United Kingdom May – Jun 2020	The study assesses the impact of the test and trace system applied on the Isle of Wight, England as of May 2020. The system was introduced to Isle of Wight before being expanded to the entire UK. Version 1 of the NHS contact tracing app was implemented, which used Bluetooth to detect physically close contacts and allowed users to input cough or fever symptoms if	A significant decrease in R_e was observed after implementation of the system (from 1.3 to 0.5).

	experienced. Once symptoms were indicated, historical contacts would be notified of potential exposure and provided infection control guidance (this did not include direction to isolate or quarantine at the time).	
Modeling Analyses (n=13)		
Aleman (2021) (22) Preprint Model Canada May 2020	An agent-based model is employed to evaluate PHMs, including contact tracing, in Newfoundland on COVID-19 prevention. The model is age-stratified and considers spatial movement and comorbidities of individuals. Travel volumes of low, medium and high are modeled for comparison.	Stringent contact tracing minimized transmission of COVID-19 by 4-74x compared to no contact tracing. The model also shows that cases of COVID-19 would have overwhelmed with the contact tracing capabilities in Newfoundland without additional PHMs to control the epidemic.
Campbell (2020) (7) Economic Model Canada July 2020	5 populations were identified for strategic testing within Canada: • contacts of COVID-19 cases • acute care hospital employees • community health care workers; and both staff and residents of long-term care homes; • essential business employees with high levels of interpersonal or public contact (excluding healthcare); and • students and staff in primary and secondary schools. The testing rates of July 8-17, 2020 were used as a baseline, to compare the increased testing necessary for scenarios of strategically testing the populations identified. Testing costs considered: • direct test costs; • laboratory capacity; and • human resources for sampling, administrative scheduling/recording and contact tracing.	5 strategies were modelled and compared to the baseline (which had a monthly cost of $69.8 million): 1. Systematic tracing and testing of contacts – all provinces have lab capacity, administrative requirements increase 1.2 times and cost increase of $11.1 million per month above baseline. 2. Acute care hospital employee testing – cost of $29 million per month. 3. CHW and LTC testing – cost of $12.8 million per month. 4. Essential employees with high contacts - $321.7 million per month. 5. Students and school staff testing - $816 million per month. Lab capacity and staffing increases were all necessary in strategies 2-5. Epidemiological impacts of contact tracing were not directly modelled, and no cost-benefit analysis provided. It is hypothesized these testing costs and associated contact tracing will

		reduce downstream healthcare costs, due to transmission prevention.
Bradshaw (2021) (13) Model United States Jan 2021	A Bayesian model is used to demonstrate the effects on the COVID-19 pandemic when implementing bidirectional contact tracing, as opposed to the more common forward tracing being used in most strategies. 'Forward tracing' is informing recently exposed individuals; while bidirectional tracing additionally identifies the potential infector to allow for notification to them and their others that were potentially exposed.	Implementing bidirectional contact tracing in the model scenarios more than doubles the reduction to R_e when compared with only forward tracing. Increasing the window of contacts to be notified from 2 days presymptomatic to 6 days provided the greatest decrease in R_e. This can be replaced by smartphone exposure notification applications, but only if uptake of the app is near 100%.
Endo (2020) (23) Model United Kingdom 2021	A branching process model is used to simulate the effect of combining backward and forward contact tracing in the PHMs for COVID-19. Index cases are identified though symptom-based surveillance in both scenarios. With forward tracing subsequent exposures since the index may have been infectious are identified and quarantined. Backwards tracing identifies the primary case (infector of the index) and traces all of the primary case's exposures forwards for quarantine. The model is intended to simulate potential case detections and compare the effect on the COVID-19 cases in a community. The probability of identifying the primary case with backward tracking was set at 50 and 80% for different scenarios. The probability of identifying descendant cases from a confirmed case was varied from 0-100%; and the probability of an index case being identified by symptom surveillance was explored at 10%, 20% and 50%.	Backward tracing identifies a much larger proportion of cases, and therefore creates greater control over the spread of COVID-19 when implemented. The model found that the addition of backward tracing to the PHMs was 2-3 times more effective than forward tracing alone. The model assumes that secondary cases (from the index) were quarantined prior to becoming infectious and therefore did not result in any tertiary cases. This may under estimate the effects of backward contact tracing measures.
Bracis (2020) (24) Model	An age stratified model projects COVID-19 cases and deaths during and after a reopening period for King County, WA. Various scenarios of public	Lockdown fit a rate pC_PI of ~35% and maintaining <45% pC_PI was necessary to have reasonable control

USA Mar-Nov 2020	health interventions are presented, including variations of pre-COVID physical interaction (pC_PI) rates, testing practices, isolation and contact tracing.	of the epidemic with the testing practices as of May, 2020. The model indicated that increased testing, isolation and tracing would permit 60% pC_PI while still maintaining reasonable control. • Enhanced testing is more than 50% of symptomatic infections identified. • Contact tracing of at least 50% of contacts identifies at least 5% of asymptomatic and pre-symptomatic cases. • Random mass testing will increase identified rates of all cases 0.5 percentage points (assumes 4.5% of population tested daily).
Aleta (2020) (11) Model United States Aug 2020	Agent based model of SARS-CoV-2 transmission in Boston, MA. The model is used to analyze unmitigated spread of SARS-CoV-2, as well as with two different lockdown and release strategies; both with various levels of case detection and tracing effectiveness. Only testing, tracing and quarantine are considered, all other public health interventions are excluded from the main analyses.	The study compares scenarios that range from i) only household contacts of cases are quarantined to ii) 40% of case contacts are traced and quarantined, as well as the contacts' household members. Quarantine of the contact and their household provides a reduction in transmission sufficient to flatten the epidemic curve and prevent a second wave. The model shows that enhanced testing and contact tracing can control the COVID-19 epidemic to within healthcare capacity, even while relaxing physical distancing interventions.
Kucharski (2020) (5) Model United Kingdom Oct 2020	A quantitative model of individual-level transmission was used to simulate the effects of testing, isolation, tracing and contact reduction in household, work, school and other settings. Social contacts were modelled with data from 40,162 participants in the UK via a contact tracing app on smartphones.	In general, a large proportion of cases need to be isolated and their contacts quarantined to control the COVID-19 epidemic in the simulations. A combination of case isolation and contract tracing was found to be more effective than mass testing. Mean transmission reductions are presented for scenarios of various interventions:

		• 2% - mass testing of 5% of a population per week. • 29% - isolation of cases within their household. • 35% - isolation of cases outside of their household. • 64% - isolation of cases with quarantine of their household and manual tracing of all contacts. • 47% - isolation of cases with quarantine of their household and app-based contact tracing (assumes app use of 53%).
Ashcroft (2020) (25) Preprint Model Switzerland Dec 2020	A theoretical model is created to analyze the effectiveness of test-trace-isolate-quarantine (TTIQ) strategies to control COVID-19. Empirical distributions are used to study how the probability of detecting cases, fraction of contacts quarantined and the delay of these events effect the timing of SARS-CoV-2 transmission. The model predicts the number of secondary cases and if necessary tertiary cases that result from the index case given the circumstances.	Introducing contact tracing and contact quarantine to the mitigations is analyzed and it is found that the fraction of index cases identified and isolated has the largest effect on controlling the epidemic: • R_e = 1.5 cannot be controlled with 30% of index cases isolated, even if 100% of their contacts quarantine. Most to least effective efforts within the TTIQ Strategies: • Increase fraction of index cases identified and isolated. • Reduce time from symptom onset to isolation of index case. • Reduce time to quarantine secondary cases. • Increase the fraction of secondary cases identified and quarantined. • Extending the lookback window to identify contacts. As the R_e of the epidemic increases, it becomes increasingly difficult to flatten the epidemic curve with testing and isolation.
Bradshaw (2021) (8) Preprint	A Bayesian model presented in an earlier publication (13) is used to assess the effectiveness of various strategies of	The model R_e estimated at 1.2 to 2.0 for variant transmission, accounting for interventions already in place to reduce COVID-19 spread.

Model Germany Jan 2021	contact tracing against the B.1.1.7, P.1 and B.1.351 variants of SARS-CoV-2.	• Isolation of symptomatic cases at low compliance rates, with no contact tracing reduces R_e by 0.2-0.3; and if R_e is then ≥ 1.4, even 50% of exposures being identified successfully could move R_e below 1. • Contact tracing of 60-70% of the exposed, up to 2 days before index symptom onset produces a R_e reduction of 0.1 above isolation alone; and implementing bidirectional tracing of up to 6 days before symptom onset with 45-55% contacts successfully traced provides a similar level of mitigation. • A reduction of 0.1 or 0.2 to R_e results in case reductions over 2 months of 37-43% and 61-66%, respectively.

Stuart (2021) (10)
Preprint
 	
Model
 	
South Wales, Australia
Oct – Dec 2020
	A stochastic model is created to analyze various levels of testing, tracing and mask utilization and the resulting vulnerability to resurgences of COVID-19 in a low transmission community.	• Testing and tracing rates have a larger relative impact, particularly when there is inconsistency in community mask wearing.
		• Testing 90% of symptomatic individuals and 90% of their contacts controlled the epidemic.
		• Reducing testing rates of symptomatic individuals resulted in many times more infections (numbers for Oct 1 – Dec 31, and reflect scenario of high mask use):
		  • 90% -> ~180 cases
		  • 80% -> 2-3x increase
		  • 65% -> 8-12x increase
		  • 50% -> 30-50x increase

Amaku (2021) (26) Preprint Model Brazil Feb 2021	This quantitative model aims to evaluate the impact of contact tracing symptomatic (assumed) cases, in the absence of testing, in Sao Paulo, Brazil. Symptomatic individuals are not confirmed by testing, but isolated and traced contacts are also isolated.	The model baseline assumes no contact tracing strategy. A scenario of 5000 symptomatic individuals isolated per day, and 80% of isolated contacts are COVID-19 infections, reduces cases and deaths in the population by 80% after 60 days.

	The proportion of isolated contacts with this strategy who are actual COVID-19 infections is varied through scenarios.	A scenario of 5000 symptomatic individuals isolated per day, and 20% of isolated contacts are COVID-19 infections, reduces cases and deaths in the population by 40% and 50%, respectively after 60 days. In areas with high transmission between contacts and low availability of tests, the symptomatic contact tracing strategy can significantly impact COVID-19 spread.
Amaku (2020) (6) Model Brazil Nov 2020	A modified SEIR model is used to simulate the COVID-19 epidemic in Sao Paulo, Brazil from March through December 2020. Epidemiological data through July 18, 2020 was used to fit the model. Public health interventions reached at most a 59% reduction in contacts per individual in late March, and by August this was only 41%. Sao Paulo attempted to control the epidemic primarily through high testing rates.	Model scenarios with start dates of April, May, June, July or August 1 were run to the end of Dec 2020 to assess the effect of 1) mass testing of individuals; and 2) testing symptomatic individuals and if positive, testing of their contacts. • Mass testing (1) and strategic testing (2) were predicted to reduce cases by 90% compared to predicted case levels at the end of 2020. Mass testing would have an estimated cost of 2.25 billion USD; while strategic testing costs would be 150 million USD.
Contreras (2021) (27) Model Chile Jan 2021	A model of COVID-19 transmission in a community is used to study a test-trace-and-isolate (TTI) strategy.	The model identifies 2 tipping points between controlled and uncontrolled COVID-19 in the population: • 'Hidden' infection chains due to asymptomatic, presymptomatic, avoiders and undetected cases becomes too high; or • New infections exceed the capacity for tracing. A scenario of the hidden R_e run at 1.8 provides a stable system, but instability is introduced with an increase of the hidden R_e to 2.0. When the workload of tracing causes delays to exceed the generation time (4 days in this model) contact tracing is no longer effective.

		TTI alone cannot contain the COVID-19 epidemic due to these tipping points, and in the absence of herd immunity additional public health interventions must also be employed.
Yin (2021) (12) Preprint Model China Jan – May 2020	A quantitative model of individual-level transmission simulates the effects of testing delays, tracing and mask use in megacity populations. Spread of COVID-19 was simulated in a population of 11.2 million in Shenzhen City, China using mobile phone tracking data. The likelihood of a sporadic cases causing a COVID-19 resurgence once the city reopens, applying various public health intervention scenarios.	If the city reopens in the absence of a contact tracing system, there is less than a 50% chance of mitigating resurgence due to sporadic cases. Reopening with household contact tracing, 100% masking compliance and testing within 28 hours of symptom onset reduced the probability of a resurgence of cases to 5%. The same level of mitigation (5% resurgence) is achieved with mask compliance of 80% and testing of 40%, if tracing is expanded to include work/school contacts. This relationship holds for equivalent mitigation with decreased masking and testing, as long as contact tracing efforts are increased accordingly.

Methods:

A daily scan of the literature (published and pre-published) is conducted by the Emerging Science Group, PHAC. The scan has compiled COVID-19 literature since the beginning of the outbreak and is updated daily. Searches to retrieve relevant COVID-19 literature are conducted in Pubmed, Scopus, BioRxiv, MedRxiv, ArXiv, SSRN, Research Square and cross-referenced with the COVID-19 information centers run by Lancet, BMJ, Elsevier, Nature and Wiley. The daily summary and full scan results are maintained in a Refworks database and an excel list that can be searched. Targeted keyword searching was conducted within these databases to identify relevant citations on COVID-19 and SARS-COV-2. Search terms used included: [(test AND (trace OR tracing OR contact)) OR (contact tracing AND review) OR mass testing OR active test] [TITLE]. Each potentially relevant reference was examined to confirm it had relevant data and relevant data was extracted into the review. Relevant systematic reviews and rapid reviews were identified and summarized and new research from Fall 2020 and Winter 2021 were also identified to update the review results. A cross analysis of studies in the reviews was not conducted. This review contains research published up to February 10, 2021.

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