Barriers To and Strategies To Address COVID-19 Testing and Testing Hesitancy: A Rapid Scoping Review

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Abstract

Background: Testing is a foundational component of any COVID-19 management strategy; however, emerging evidence suggests that barriers and hesitancy to COVID-19 testing may affect uptake or participation and often these are multiple and intersecting factors that may vary across population groups. To this end, Health Canada's COVID-19 Testing and Screening Expert Advisory Panel commissioned this rapid review in January 2021 to explore the available evidence in this area. The aim of this rapid review was to identify barriers to COVID-19 testing and strategies used to mitigate these barriers.

Methods: Searches (completed January 8 2021) were conducted in MEDLINE, Scopus, medRxiv/bioRxiv, Cochrane and online grey literature sources to identify publications that described barriers and strategies related to COVID-19 testing.

Results: From 1294 academic and 97 grey literature search results, 31 academic and 31 grey literature sources were included. Data were extracted from the relevant papers. The most commonly cited barriers were: cost of testing; low health literacy; low trust in the healthcare system; availability and accessibility of testing sites; and stigma and consequences of testing positive. Strategies to mitigate barriers to COVID-19 testing included: free testing; promoting awareness of importance to testing; presenting various testing options and types of testing centres (i.e., drive-thru, walk-up, home testing); providing transportation to testing centres; and offering support for self-isolation (e.g., salary support or housing).

Conclusion: Various barriers to COVID-19 testing and strategies for mitigating these barriers were identified. Further research to test the efficacy of these strategies is needed to better support testing for COVID-19 by addressing testing hesitancy as part of the broader COVID-19 public health response.

Keywords: Covid-19, testing, testing hesitancy, health policy, social determinants of health, equity, coronavirus, scoping review

Background

COVID-19 is a disease caused by the SARS-CoV-2 virus that was first discovered in Wuhan, China in December 2019 and declared a global pandemic on March 11, 2020 (1). Since then, there have been over 170 million cases worldwide (2). COVID-19 is confirmed by testing, which plays an important role in the find-test-trace-isolate-support cycle to control the spread of COVID-19. Find-test-trace-isolate-support describes testing anyone with symptoms of COVID-19, tracing their contracts, and isolating these individuals until they are no longer contagious (3). While this process can prevent widespread outbreaks of the disease, there are other consequences of widespread testing such as separation from family members while waiting for test results.

In response to the rapidly growing body of evidence about COVID-19, and the understanding that an find-test-trace-isolate-support public health response is needed, the Canadian Minister of Health commissioned a COVID-19 Testing and Screening Expert Advisory Panel to provide evidence-informed advice to the federal government on science and policy related to to testing and screening(4). The panel consulted with over 80 health experts, public policy experts and members of industry to develop a robust testing approach across Canada. In late 2020, the authors of this review were approached to conduct a rapid scoping review of COVID-19 testing hesitancy to help the Panel develop guidance about COVID-19 testing.

COVID-19 Testing and Testing Hesitancy

99 In most jurisdictions, testing is managed by public health authorities. The gold
100 standard for COVID-19 diagnosis is reverse transcription polymerase chain
101 reaction (rRT-PCR) testing from a throat swab or nasopharyngeal swab (5).
102 Diagnosis of COVID-19 allows people and public health authorities to be aware of
103 infections and to take actions to limit the spread to others. Once a test is
104 confirmed positive, it is recommended that the individual and any close contacts
105 isolate for 14 days (6). Despite the population health benefits of COVID-19
106 testing, preliminary evidence shows that COVID-19 testing barriers exist along
107 multiple and intersecting dimensions. Limited access to testing may be the result
108 of testing centre hours, inaccessible environments, locations of testing centres,
109 communication strategies and decisions of how testing is allocated (4). There is
110 also hesitancy related to possible negative consequences of a positive test, such
111 as loss of income or employment or social stigma. The Canadian COVID-19 Expert
112 Panel on Testing and Screening recommends that all jurisdictions implement
113 context-specific strategies to increase testing uptake, such as testing centres in
114 disease hot spots and targeted communication strategies. As the COVID-19
115 pandemic continues to impact communities around the globe, empirical
116 evidence about the barriers to testing and strategies to mitigate barriers is
117 needed to fully implement the find-test-trace-isolate-support model.
118
119 *Conceptual Approach to Organizing Findings*
120 To better understand COVID-19 testing hesitancy, we reviewed evidence that
121 aimed to understand individual reasons for hesitating (delaying) to seek
122 healthcare when needed. The 'three delays' model is a prominent model that

separates the decision processes that may influence hesitancy into three decision stages. In other words, the recognition of symptoms and the decision to seek care (planning); finding and reaching an appropriate testing facility and deciding to go through the testing process (process); and receiving adequate care and determining what actions may need to be taken when an outcome is determined (outcomes). The model has primarily been used to understand barriers in access to care in low and middle-income countries by highlighting individual, organizational and system level barriers(7). For present our findings, we adapted the model to outline barriers that influence individuals to seek a COVID-19 test, including knowledge about access, symptoms, etc. (planning), the characteristics of the COVID-19 test itself (process) and consequences of the COVID-19 testing results (outcomes) (Table 1). Strategies to address these barriers were organized in the same manner (Table 2) (8).

Review questions

Given the importance of COVID-19 testing in the find-test-trace-isolate model, it is necessary to understand factors that prevent people from getting tested and approaches to improve testing uptake. The primary aim of this review is to describe barriers to COVID-19 testing. The secondary aim is to describe effective communication or testing strategies to aid in reducing barriers to COVID-19 testing or addressing COVID-19 testing hesitancy. The population, concept and context for this rapid scoping review is: 1) population – persons who are eligible to be tested for COVID-19; 2) concept – COVID-19 testing; and 3) context – testing in any setting.

147

Methods

We developed an a priori review protocol according to the research question. We drafted the protocol according to the updated methodological guidance for scoping reviews by Peters et al., adapted for a rapid review by the research team, members of Health Canada, and our teams' information specialist with expertise in designing searches on topics relating to health and economics(9). A rapid review methodology was chosen due to the time constraints upon which this request was needed to inform Health Canada's COVID-19 Expert Panel on Testing and Screening. This review is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews (PRISMA-ScR), and the search is reported according to the PRISMA extension for literature searches (Tricco et al., 2018).

Search strategy

An experienced information specialist designed comprehensive search strategies (see Appendix A for detailed information). No study registries were searched. All database searches were executed on January 8, 2021, and results were limited to January 2019-current. Grey literature was retrieved using a combination of targeted website searching and a series of Google queries. Due to the context of the rapid review process, citation searching, and expert consultation were not included in our search methods.

Screening & Data extraction

171 Covidence, an online tool for conducting various types of reviews
172 (www.covidence.org) was used to review the titles and abstracts for
173 inclusion/exclusion based on the criteria described in Appendix B. Due to the
174 rapid nature of this review, abstracts were reviewed by single reviewers. Next,
175 articles were single screened during full text using the same inclusion/exclusion
176 criteria. Data extraction was completed using the following end-points: (1)
177 country; (2) purpose or aim; (3) study design (if applicable); (4) subgroups and
178 populations of interest; (5) barriers to testing identified; (6) strategies to address
179 barriers or testing hesitancy – either implemented or suggested; and (7) lessons
180 learned, recommendations and outcomes of strategies implemented (if
181 available). The complete data extraction guidelines can be found in Appendix C.
182

Results

Overview of included studies

A total of 1294 unique published articles were identified from the database search. Another 97 grey literature sources were identified. After screening, 61 sources were included for data extraction (n=30 academic publications; n=31 grey literature sources; PRISMA diagram in Appendix C). The majority of studies were from the Unites States (n=36) and the remainder were from Canada (n=5), the United Kingdom or other countries (n=15).

Findings were categorized in the following two sections: 1) barriers or factors that influence COVID-19 testing and/or testing hesitancy; and 2) strategies to mitigate COVID-19 testing barriers or hesitancy. Each section is then subdivided into sections focusing on the planning, process, and outcomes using the 'three delays' model conceptual framework (7).

Planning barriers

The planning stage in the *three delays model* focuses on factors that influence the decision to seek appropriate medical care once symptoms are noticed or risk of infection is severe enough. In this case, barriers that influence decisions to seek COVID-19 testing found in the literature include the cost of testing, health literacy, trust in the health system, and health status.

Cost of testing

Cost, often associated with lack of health insurance, was identified as a barrier to seeking COVID-19 testing by eight sources(10–16). Fernando et al. (2020)

207 described the prohibitive cost of testing, the cost of missing work and
208 transportation costs associated with traveling to and from testing sites as
209 reasons why people did not seek testing. Thunström et al (2020) found that
210 personal financial situations did not affect an individual's willingness to take a
211 free test.
212
213 *Health literacy*
214 Health literacy was cited as a barrier to COVID-19by nine sources (10,17–24),
215 Health literacy may refer to limited knowledge of testing, misinformation
216 regarding testing and COVID-19, and/or poor recognition of symptoms.
217 According to the COVID-19 Unified Command Report (2020), low health literacy
218 is associated with risky health behaviours, lower likelihood of seeking treatments
219 and care, and reduced compliance with health-related instructions/guidance,
220 including seeking COVID-19 testing. Misinformation and mixed facts regarding
221 protective measures, transmission, and testing protocols were cited as a reason
222 people do not seek COVID-19 testing(20,23,24). In a longitudinal survey of
223 Australian citizens (n=1369 participants), Bonner et al. (2020) found that not
224 knowing how or where to get tested was a common barrier to testing. Different
225 social groups may be prone to low health literacy preventing testing for various
226 reasons. Undocumented immigrants and foreign workers are often disconnected
227 from the healthcare system and social services, resulting in this group not
228 seeking testing or care when needed (21).
229
230 *Trust in the health system*

231 Low trust in the health system was cited as a barrier to seeking COVID-19 testing
232 by six sources(15,25–29). Due to the nature of the sources, there is limited
233 validated evidence that trust in the health system impacts the likelihood that an
234 individual will or will not seek COVID-19 testing. Distrust in the health system
235 combined with minority status results in decreased access to testing and overall
236 disparities in access to COVID-19 care. Histories of systemic abuse and
237 exploitation of minorities by the medical and research communities, such as the
238 Tuskegee syphilis experiment, were cited by two sources(25,28) as a cause of
239 distrust in the healthcare system.
240
241 *Health status*
242 There were two sources that identified current health status as a barrier to
243 testing(30,31). Both sources describe the challenges of encouraging individuals
244 who feel healthy (e.g., asymptomatic) to take COVID-19 tests. Levitt (2020)
245 indicates that refusal for testing among people with self-perceived good health
246 status is one of the greatest barriers to controlling COVID-19; the article further
247 describes the societal costs of healthy individuals not getting tested and suggests
248 ways to incentivize regular testing in this group. Kernberg (2020) determined
249 that among individuals who declined COVID-19 testing, the second most popular
250 reason was confidence that they were not infected with the virus.
251
252 ***Process barriers***
253 The process stage in the *three delays model* focuses on factors that influence
254 reaching of appropriate medical services, including uncertainty about the

255 services. In this case, barriers in this delay include the availability and
256 infrastructure of COVID-19 testing sites, including the perceived fear of the
257 testing process.
258
259 *Availability of testing sites*
260 Thirteen sources described the availability of testing sites as a process barrier for
261 testing, both in general(10,25,27,32) and in specific communities
262 (18,24,27,29,33). Transportation barriers and access to testing centres play a role
263 in accessing COVID-19 testing sites. Among adults surveyed in the United States
264 (cross-sectional, n=3058 participants), 15% reported not being aware of where to
265 get tested or did not have means to travel to get tested (24). In New York City,
266 clusters analysis demonstrated that a lack of availability of testing sites in lower
267 SES communities where there were a higher proportion of positive cases and
268 more severe cases than higher socieoeconomic communities[34]. In comparison,
269 testing sites in Texas were often located in what was described as "whiter"
270 communities[21] while testing was limited in Black communities, and this was
271 attributed to the inequitable distribution of resources(33). Further, Maxmen et
272 al. (2020) explained that the lack of access to testing was exacerbated in rural
273 and remote communities. Similarly, distance to testing sites increased in rural
274 areas, resulting in a reduction of testing access. Rader and colleagues concluded
275 that geographic barriers to testing exacerbated health inequalities in rural
276 counties. They recommended that geographic accessibility be considered when
277 planning the location of testing sites. Similarly, in remote communities in

278 Australia, testing availability and timeliness were identified as barriers to testing
279 (34).
280
281 *Infrastructure*
282 Two articles identified physical limitations including limited mobility, blindness,
283 low vision, difficulty hearing, communication or understanding information and
284 sensory challenges as barriers to testing (21,35). Further, long wait times for
285 testing and test results were identified as barriers to testing in five studies
286 (24,36–39), where Clipman et al. (2020) reported that 53% of survey respondents
287 (n=3058) in the United Stated waited eight or more days for test results, while a
288 drive-through testing in Phoenix had a thirteen hour wait for testing. Thappa et
289 al. (2020) highlighted the discomfort associated with waiting at a facility for
290 results.
291
292 Discomfort, worry, and distrust were also identified as barriers to testing.
293 Kernberg et al. (2020) found that when offered a monosymptomatic test, 17% (of
294 270 patients) declined, most frequently citing concern for test discomfort.
295 Further, an Australian national survey of 1359 citizens found that pain during
296 testing (11%) was the most common barrier (Bonner et al., 2020). Four studies
297 reported that the safety of testing sites and worry about infection were barriers
298 to seeking testing(40–43). More specifically, the fears of the safety of test sites
299 were related to physical distancing, isolation, and cleaning practices. Among
300 racialized Americans, Egelko et al. (2020) noted that distrust in the healthcare
301 system and the state was present due to racist treatment that had and continued

302 to exist within them, and the ongoing role these institutions had in perpetuating
303 health inequities. Similarly, immigrants lacking legal status were also hesitant to
304 receive a test, as there was a fear that the government may use personal
305 information to ensure immigration enforcement (44).
306
307 ***Outcome barriers***
308 The outcomes stage in the *three delays model* focuses on the consequences once
309 care is received. In this case, the consequences of a positive COVID-19 test.
310 Barriers in this delay include the stigma associated with a positive test and the
311 personal and health costs of a positive test.
312
313 *Stigma*
314 Social stigma was identified as a barrier to being tested for COVID-19, as testing
315 may suggest people did not follow public health recommendations (e.g., use of
316 personal protective equipment, physical distancing (23,45,46). Among racialized
317 Americans, there may have been fear of testing due to possible repercussions of
318 testing positive, such as substandard or stigmatized healthcare. One source
319 identified that sex workers in Africa faced stigma and discrimination, and this
320 may have limited their access to contact tracing and COVID-19 testing.
321
322 *Personal and health costs of testing positive*
323 Several personal costs were identified as barriers to testing across populations:
324 loss of work and income (21,32,38,47,48), need to quarantine following a
325 positive test (two sources), and fears of deportation among immigrants.

326

327 ***Planning Strategies***

328 *Eliminate cost of testing/ Incentivize testing*

329 Eighteen sources described strategies intended to address planning barriers.
330 Seven articles overviewed strategies to eliminate the cost of testing, rather than
331 improving convenience of testing(31), although no evidence was provided that
332 these strategies would be effective. Several authors(19,36,47,49), mostly from
333 the United States, proposed improving uptake by eliminating the costs of COVID-
334 19 tests, providing incentives to taking tests, including cash benefits, especially
335 for low income or undocumented citizens who may have been afraid to take a
336 test due to immigration status.

337

338 *Promote awareness*

339 Doyle et al., (2020) proposed a public information campaign to inform uninsured
340 people in the US that care was available at no charge[27]. They suggested that this
341 would help address misconceptions about the consequences of testing. Capps et
342 al. (2020) recommended that the federal government provide funding to local
343 testing sites to increase uptake of symptomatic individuals[28]. Earnshaw (2020)
344 conducted a cross-sectional survey of 845 adults in the US to examine individual
345 characteristics such as COVID-19 stigma variables (e.g., anticipated stigma and
346 stereotypes), COVID-19 control variables (e.g., knowledge and fear), and
347 sociodemographic characteristics to determine behaviour towards testing[49].
348 Page et al (2020) suggested funding community and religious organizations to
349 promote awareness around testing and testing sites[18].

Scientific communication strategy aimed at improving health literacy

Two sources suggested that scientists, academics and other experts were able to counteract misinformation about the pandemic, testing and consequences of a positive test to help improve public trust(22,48). Additionally, they suggested building a multi-disciplinary network of academic, community, public, and other partners to understand and address those most impacted by structural inequities, with a focus on testing and tracing. Khaldi et al. (2020) recommended a strategy whereby government bodies provide leadership through initiatives that address misconceptions about the pandemic, testing, outcomes, and other issues that inhibit individuals from testing.

Targeted communication strategies aimed at vulnerable populations to improve inequities

In a commentary, Thappa et al. (2020) suggested that the Indian government target specific information and education materials that reflected the unconcerned attitude many Indian residents have toward testing. This would require regular updating of information and content. Similarly, in an editorial, Sotgiu et al. (2020) recommended that the government provide a consistent stream of communication that addresses misinformation and provided honest, direct, simple communication from leaders about testing.

Egelko et al (2020) proposed that unidirectional messaging was ineffective and would potentially turn individuals away. Instead, they suggested that community

374 trust needed to be fostered with the aim of making testing an attractive option
375 for all individuals through targeted approaches. Specifically, the authors
376 suggested framing testing as a surveillance method which allows for anonymity
377 instead of as a case-finding method which could be infringing.
378
379 *Various strategies*
380 The community council of Tower Hamlet in the U.K. designed a protocol that
381 addressed a local outbreak of COVID-19(50), including strategies for planning,
382 process and outcomes. For planning, they designed a survey and community
383 mapping exercise to gather in-depth insight on support needs. Additionally, a
384 Community Engagement Sub-group had been established to support residents
385 taking part in the national test and trace programme. Initial findings were that
386 community members were more likely to engage in the plan if they were
387 approached by trusted community faith leaders. This helped build trust to
388 convey messages regarding the benefits of testing and contact tracing and
389 responding to data about hotspots or areas of low uptake.
390
391 ***Process strategies***
392
393 *Availability of testing sites*
394 Four articles suggested ways to improve the availability of testing
395 sites(18,29,51,52). Murphy et al., (2020) reported on the implementation of a
396 free testing initiative for Southeastern Pennsylvania Transportation Authority
397 employees offered by the Black Doctors COVID-19 Consortium, as a way to

398 increase testing for frontline non-hospital workers. Murphy (2021) reported on
399 the same Consortium, where female black doctors provided free tests to
400 underserved communities. The COVID-19 Testing and Contact Tracing Health
401 Equity Guidebook suggested addressing barriers such as transportation by using
402 a mixed approach, including drive-through sites, walk-up sites, mobile screening,
403 and door-to-door screening. Similarly, Maxmen et al., (2020) described a multi-
404 pronged approach to augment access to testing, including testing at physical
405 clinics, youth shelters and by deploying a street medicine team (using a mobile
406 RV) - which was indicated to be useful for contact tracing among individuals
407 experiencing unstable housing.
408
409 Adeniji et al., (2020) suggested allowing self-administered tests and education on
410 how to use them and two others proposed establishing test sites in pharmacies
411 (53,54)[61]. Another article described an initiative that used drones to deliver
412 testing kits to remote communities, such as Stoney Nakoda First Nations, Eden
413 Valley, and Big Horn (satellite reserves)(55). Kissam et al., (2020) argued that
414 COVID-19 testing in local areas should shift towards being a component of a
415 comprehensive public health strategy along with contact tracing for those who
416 test positive and additional supports for those required to quarantine/self-
417 isolate.
418
419 *Accessibility*
420 The COVID-19 Testing and Contact Tracing Health Equity Guidebook proposed
421 offering bilingual, culturally tailored testing and contact tracing services in

422 communities with elevated risk. Authors suggested the consideration of
423 processes that include individuals who lack permanent contact information or
424 have unstable housing, and using recognizable locations that are familiar to the
425 community. Maxmen et al., (2020) proposed multiple, accessible testing facilities
426 with providers that reflect community characteristics. Similarly, the Minnesota
427 Department of Health proposed improving accessibility of testing sites for those
428 with physical disabilities by providing signage that is clear, visible, and easy to
429 understand. One article recommended that trusted community leaders and
430 organizations help develop and coordinate testing strategies (56). Similarly,
431 Mitchell et al., (2020) emphasized the need for collaboration and coalitions
432 between academics, laboratories, public health and local healthcare to target
433 vulnerable populations and increase access to tests. Another proposed making
434 testing sites more convenient by providing drive-through testing, which could
435 help to address the fear of infection (57). Galavix et al. (2020) proposed ongoing
436 monitoring and evaluation of testing interventions and their impact on access,
437 where factors such as culture, history, values and needs of minority communities
438 are considered.
439
440 A media article described how Oregon Health & Science University (OHSU)
441 allotted the first two hours of the testing day for first responders, OHSU health
442 patients, and household members of OHSU health employees (58). To help
443 people understand the process of testing, two healthcare professionals in
444 Saskatchewan agreed to take a COVID-19 test despite being asymptomatic, then

share their lived experience with their patients to decrease stigma and increase education about the discomfort of the test (59).

Outcome Strategies

Accommodations for self-isolation & Support for tracking and tracing

One article proposed various strategies to increase testing among minority populations such as increasing the availability of testing sites in minority neighbourhoods and providing cost-free temporary accommodations for self-isolation (60)[65]. Tower Hamlets Council in the United Kingdom linked those isolating to existing supports in the community, such as faith and mutual aid groups and used locally trained and embedded volunteers to support individual residents at every stage of the national test and trace process.

Discussion

This review identified a variety of planning, process, and outcome barriers to testing. Strategies to address testing hesitancy were often well aligned with the testing barriers. For example, the cost of tests was a barrier to accessing testing. Thus, strategies included reducing or eliminating testing costs and/or providing cash incentives for testing, especially for low-income and marginalized groups. To address low health literacy as a barrier to testing, it has been suggested to use scientists, academics, influencers, and other experts to counteract misinformation about testing. Planning barriers to COVID-19 testing included issues with the availability and accessibility of test sites. Appropriate strategies focused on improving the accessibility of testing centres for people with disabilities and multisectoral collaboration within communities while developing the testing centres. Outcome barriers and strategies were least frequently reported on. Outcome barriers that were identified included the social stigma of a positive test if the individual did not follow restrictions, fear of stigmatized healthcare for racialized Americans, and loss of work or income if a positive test was received. The proposed strategy for these barriers was to focus on increasing the availability of testing sites in minority neighbourhoods and the provision of free accommodation for self-isolation.

Occasionally, strategies did not align with barriers, presenting gaps in the literature. For instance, the distrust in the healthcare system, experienced especially by racialized Americans, though identified as a planning, process, and outcome barrier in a variety of capacities, was not directly addressed by any

483 strategy. Although process strategies did include culturally tailored testing
484 services and interventions that considered culture, history, and values of
485 minority communities, strategies were vague or localised geographically and
486 therefore not directly designed to target healthcare system distrust. More
487 research should be conducted to understand and implement tactical solutions
488 that address the root causes of healthcare system distrust.
489
490 Mukattash et al. (2020) indicated that pharmacists could provide testing in their
491 communities in Jordan with appropriate training. Further studies found in the
492 broader literature discussed the crucial role that pharmacists played in
493 community health and the response to COVID-19 (61,62). Moreover, a pilot
494 study in Alberta, where COVID-19 testing was made available in 20 pharmacies,
495 quickly expanded to 168 pharmacies and counting (63), though Canada had yet
496 to see widespread testing in pharmacies compared to that in the United States
497 (64,65). Testing in pharmacies could be an important consideration for
498 policymakers in Canada.
499
500 *Strengths and Limitations*
501 Strengths of this review include our comprehensive search strategy and inclusion
502 of grey literature. As the COVID-19 pandemic continues to evolve, it was
503 necessary to include the most up-to-date, current information. A number of
504 limitations of this review were identified. First, the majority of sources (39) were
505 opinion pieces (i.e., commentaries, perspectives, media articles). Two sources
506 were guidelines to prevent stigma and carrying out contact tracing, and twenty-

one articles collected or analyzed primary or secondary data. These findings demonstrate a lack of experimental and observational designs to better understand the development of barriers to COVID-19 testing and to direct the impact of strategies. There is a need for both types of studies to determine the extent to which a barrier inhibits COVID-19 test seeking behaviour and the effectiveness of strategies to improve the uptake of COVID-19 testing or address testing hesitancy. Further, the majority of publications were from the United States, which limits our understanding of testing barriers in other areas of the world.

Conclusion

This review intended to identify and summarize the best available evidence to inform Canada's COVID-19 Expert Panel on Testing. The impact or effectiveness of strategies to address COVID-19 testing barriers or testing hesitancy is largely unknown. The information found within this review provides an evidentiary basis to suggest that multi-pronged approaches to addressing barriers are being both suggested and implemented. The use of implementation science frameworks may be a means of developing, evaluating, and refining approaches to addressing COVID-19 testing barriers and hesitancy.

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Authors' Contributions

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825 **Table 1.** Examples of barriers to COVID-19 testing organized by type of delay.

Planning barriers	Process barriers	Outcomes barriers

• Cost of Testing
• Health literacy
  • Misinformation
  • Testing criteria (changes in testing criteria)
• Health status
• Trust in health system
	• Availability of testing sites
	  • Waiting times (availability of human resources, testing supplies)
	• Infrastructure features of testing sites
	  • Time delay in results (including laboratory capacity)
	  • Test properties (including pain, length of test)
	  • Test accuracy/sensitivity (false positives)
	  • Safety of test site (chance of infection)
	  • Trust in the process
		• Stigma
		• Personal cost (cost of isolation, positive test results: work, cost related to care etc.)
		  • Consequences on employment
		  • Health consequences

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829 **Table 2.** Strategies to address COVID-19 testing barriers and/or COVID-19 testing

830 hesitancy

Planning strategies	Process Strategies	Outcomes Strategies
• Eliminate costs of testing • Incentivize testing with rewards • Promote awareness and testing locations • Scientific communication strategy aimed to improve health literacy • Targeted communication strategies aimed at vulnerable populations to improve inequities.	• More variability in type of testing sites (drive thru, walk up, at home, drone delivery etc.) • Transportation support • Culturally tailored testing sites for communities • Have community champions • Informative signage	• Housing for self-isolation • Support for tracking and tracing

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