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1 **Title page**

2 **Full Title:** Using a Learning Health System Framework to Examine COVID-19 Pandemic Planning
3 and Response

4 **Short Title:** Learning Health System Framework and COVID-19 Response

5
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23 Abstract

24 **Background:** The COVID-19 pandemic has presented a unique opportunity to explore how health
25 systems adapt under rapid and constant change and develop a better understanding of health
26 system transformation. Learning health systems (LHS) have been proposed as an ideal structure
27 to inform a data-driven response to a public health emergency like COVID-19. The aim of this
28 study was to use a LHS lens to identify assets and gaps in health system pandemic planning and
29 response during wave one of the COVID-19 pandemic.

30 **Methods:** An integrated knowledge translation approach guided this concurrent triangulation
31 mixed methods study. We examined relevant organizational documents and system
32 performance data generated between January 1st, 2020 and August 31st, 2020 using directed
33 content analysis and descriptive statistics. Additionally, we conducted qualitative semi-
34 structured interviews with health care providers, patients and families, leadership and
35 management teams, and health centre support staff. Lastly, we used a triangulation matrix to
36 compare and contrast summaries of all quantitative and qualitative data and identify health-
37 system receptors and research-system supports relevant to the seven characteristics of the LHS.

38 **Results:** We identified six key priorities relevant to the pandemic response during wave one,
39 including access to health care, personal protective equipment, visitor restrictions, pandemic
40 assessment centre (PAC), working from home, and food services. We identified several health
41 system assets within the LHS characteristics, including appropriate decision supports and aligned
42 governance. Opportunities for improvement were identified in the LHS characteristics of
43 engaged patients and timely production and use of research evidence.

44 .

45 **Conclusion:** The LHS provided a useful framework to examine COVID-19 pandemic response
46 measures. We highlighted opportunities to strengthen the LHS infrastructure for rapid
47 integration of evidence and patient experience data into practice and policy for future pandemic
48 planning and response.
49

50 Introduction

51 The COVID-19 pandemic has been described as an extreme stress test of the health system and
52 society at large and has led to widespread societal changes.(1) In March 2020, Canadian health
53 systems implemented a range of policies and protocols to reduce the risk of transmission in
54 hospital and clinical settings. Telemedicine and virtual care options quickly filled the space across
55 a number of specialties for non-urgent care.(2,3) However, there was also a significant decrease
56 in the use of emergency departments for non-COVID-19 related urgent care.(4,5) COVID-19 and
57 pandemic measures have had a major impact on patients and families. For example, some
58 pregnant and parenting families experienced fear and significant psychological distress during
59 the perinatal and postnatal periods.(6) Adolescents with psychiatric disorders were at an
60 increased risk of a break or change in their care and management(7). These challenges have led
61 to careful consideration for the need to develop of sustainable healthcare system
62 adaptations.(8) This was also a stressful times for the health care workforce who were called to
63 adapt to rapid and constant change in their workplace and at home.(9)

64
65 COVID-19 has presented an unparalleled opportunity to explore how health systems adapt under
66 rapid and constant change and develop an understanding of the barriers and enablers to
67 transformation, to inform resilient and sustainable systems. Learning health systems (LHS) have
68 been proposed as an ideal structure to inform a data-driven response to a public-health
69 emergency like COVID-19.(10) A LHS is an environment in which *“science, informatics, incentives*
70 *and culture are aligned for continuous improvement and innovation, with best practices*
71 *seamlessly embedded in the delivery process and new knowledge captured as an integral by-*

72 *product of the delivery experience*".(11) A LHS is able to respond rapidly to changing evidence
73 and incorporate lessons learned from patient experiences on a continuous basis. There is
74 deliberate overlap between clinical practice, quality improvement, and research and
75 innovation.(12) This structure is critical to accelerate the most up-to-date research into real-
76 word practice. Lavis et al. define a rapid-learning health system as a combination of a health
77 system and a research system that is: 1) anchored in patient needs, perspectives and aspirations;
78 2) driven by timely data and evidence; 3) supported by appropriate decision supports and
79 aligned governance, financial and delivery arrangements; and 4) enabled with a culture of rapid
80 learning and improvement.(13) Learning cycles are the fundamental processes of LHS which seek
81 to strike a balance between patient and provider experiences and health system costs.(13)

82

83 COVID-19 has changed the course of health care and has been identified as an excellent case for
84 highlighting the urgent need to develop learning health systems.(14,15) Given the rapidly
85 evolving response required for COVID-19, a LHS framework can offer a structure for examining
86 continuous learning and improvement during pandemic planning and response. Further,
87 implementation research has a crucial role to play in identifying important barriers and enablers
88 to the development of a LHS and tailoring interventions to support its use in practice.(15) As
89 such, the overall aim of this study was to examine the COVID-19 wave one pandemic planning
90 and preparedness work (up to August 2020) operationalized at a Canadian women and children's
91 tertiary health centre through a LHS lens. Our goal was to identify promising strategies for
92 pandemic planning and preparedness work for future waves.

93 Findings from previous phases of this larger program of research will be reported
94 elsewhere.(16,17) This paper aims to triangulate data using a LHS framework(13) and address
95 the following research questions:

- 96 i. What were the assets and gaps in the initial COVID-19 planning and preparedness work?
- 97 ii. What are the key resources and strategies that should be considered for planning and
98 preparedness for subsequent waves of COVID-19 and future pandemic planning?
- 99 iii. How can a LHS be used as a framework to inform pandemic response planning?

100

101 **Methods**

102 **Study design**

103 Guided by an integrated knowledge translation approach,(18) our concurrent triangulation
104 mixed methods design(19) examined qualitative and quantitative data from a range of sources
105 and involved iterative cycles of data collection, data confirmation and data analysis. Our team of
106 clinicians, managers, researchers and administrators met regularly throughout the project to
107 discuss project milestones, preliminary impressions, gaps in data collection and data analysis.
108 Project summaries were also distributed to all team members via email every two weeks. REB
109 approval (Institutional approval #1025812) was obtained prior to commencement of data
110 collection.

111

112 **Study setting**

113 This study was conducted at a tertiary pediatric and women’s health centre serving children and
114 families from the four Atlantic Canadian provinces (hereinafter referred to as the ‘Health
115 Centre’).

116

117 **Data sources**

118 **Administrative and textual data sources**

119 We examined relevant organizational documents and system performance data generated
120 between January 1st, 2020, and August 31st, 2020, including health administrative and human
121 resource data; policies and directives developed or adapted in response to the pandemic; health
122 centre communications; town hall meeting notes; and meeting notes from special committees
123 convened in response to COVID-19. Health Centre communication, and decision, directive and
124 policy documents were examined by one reviewer. Data were sorted and organized according to
125 date, target population (staff/patients or public), and type (e.g., social media communications,
126 newsletters, meeting minutes).

127

128 **Qualitative interviews**

129 We conducted semi-structured interviews with the following stakeholder groups: 1) health care
130 providers, 2) leadership and management team, 3) operations and support workers, and 4)
131 patients and families. Participants either received care or provided care/service in the health
132 centre during Wave 1. Interviews were guided by a semi-structured interview guide based on the
133 Theoretical Domains Framework(20) to explore participants’ beliefs and attitudes about the

134 pandemic planning and response processes. All interviews took place using Zoom
135 videoconferencing technology at a time that was convenient for the participant. Interviews were
136 audio-recorded and transcribed verbatim. Detailed methods and findings from this work are
137 reported elsewhere.(16,17)

138

139 **Data analysis**

140 **Administrative and textual data sources**

141 Patient census data for inpatient and ambulatory care areas for the period of January 1st to July
142 30th for 2019 and 2020 and human resource (HR) related to staff hiring, absence from work, sick
143 hours, unpaid leaves, terminations and redeployment for the period of March 1st to July 30th for
144 2019 and 2020 were examined using descriptive statistics (i.e., frequency counts). Key decisions,
145 directives and policies related to the pandemic response were categorized based on groups
146 developed from the pillars of infection prevention and control and the Federal COVID-19
147 Pandemic Guidance for the Health Care Sector document.(21,22) These groups included: 1)
148 Detection, which refers to any directive, decision or policy related to increasing and supporting
149 COVID-19 detection; 2) Prevention of Exposure, which refers to any directive, decision or policy
150 related to preventing exposure to COVID-19; and 3) Surge/Treatment, which refers to any
151 directive, decision or policy related to increasing hospital capacity to treat and manage high
152 COVID-19 patient volumes.

153 *Qualitative interviews:*

154 **Qualitative interviews**

155 All interviews were transcribed verbatim and de-identified before being imported to NVivo.
156 Transcripts were coded using a directed content analysis(23) followed by inductive thematic
157 analysis.(24) The Theoretical Domains Framework(20) (TDF) was used as a coding framework for
158 directed content analysis. Members of the coding team worked independently to identify
159 relevant themes for each of the TDF domains and met to discuss findings as a group. Themes
160 were then consolidated into major themes by two members of the coding team and again
161 reviewed and refined by the full coding team. Finally, the themes with accompanying quotes
162 were sent to interview participants and shared with the full research team for feedback and
163 verification. For this phase of the study, these qualitative findings were used to identify key
164 pandemic response priorities.

165

166 **Data triangulation**

167 Six members of the research team participated in data triangulation. We compared and
168 contrasted summaries of all qualitative and quantitative data through a series of individual and
169 group tasks. A matrix structure was developed to sort and organize data according to the Rapid-
170 learning Health System framework outlined by Lavis et al.(25) The team worked together to
171 identify a) key pandemic response priority areas, and b) health-system receptors and research-
172 system supports relevant to the seven characteristics of the LHS: 1) engaged patients, 2) digital
173 capture, linkage and time sharing of relevant data, 3) time production of research evidence, 4)
174 appropriate decision supports, 5) aligned governance, financial and delivery arrangements, 6)
175 culture of rapid learning and improvement, and 7) competencies for rapid learning and
176 improvement (Table 1). Initial findings were shared with the full research team during a virtual

177 meeting for verification and clarification. Next key findings were merged to reveal assets and
 178 gaps in the initial COVID-19 pandemic response during wave one.

179

180 **Table 1.** Learning Health System Characteristics(13)

<i>LHS Characteristic</i>	<i>Definition</i>
Engaged patients	Systems are anchored on patient needs, perspectives and aspirations (at all levels) and focused on improving their care experiences and health at manageable per capita costs and with positive provider experiences.
Digital capture, linkage and timely sharing of relevant data	Systems capture, link and share (with individuals at all levels) data (from real-life, not ideal conditions) about patient experiences (with services, transitions and longitudinally) and provider engagement alongside data about other process indicators (e.g., clinical encounters and costs) and outcome indicators (e.g., health status).
Timely production of research evidence	Systems produce, synthesize, curate and share (with individuals at all levels) research about problems, improvement options and implementation considerations.
Appropriate decision supports	Systems support informed decision-making at all levels with appropriate data, evidence, and decision-making frameworks.
Aligned governance, financial and delivery arrangements	Systems adjust who can make what decisions (e.g., about joint learning priorities), how money flows and how the systems are organized and aligned to support rapid learning and improvement at all levels.
Culture of rapid learning and improvement	Systems are stewarded at all levels by leaders committed to a culture of teamwork, collaboration and adaptability.
Competencies for rapid learning and improvement	Systems are rapidly improved by teams at all levels who have the competencies needed to identify and characterize problems, design data- and evidence-informed approaches (and learn from other comparable programs, organizations, regions, and sub-regional communities about proven approaches), implement these approaches, monitor their implementation, evaluate their impact, make further adjustments as needed, sustain proven approaches locally, and support their spread widely.

181

182

183 **Results**

184 Detailed results from the administrative and textual data and qualitative interviews will be
 185 published elsewhere.(16,17) Following data triangulation, we identified six key priorities as
 186 important assets and gaps relevant to the pandemic response during wave one and
 187 provide a summary of prominent issues related to the initial pandemic response. The
 188 six priorities are: 1) Access to Health Centre, 2) Personal protective equipment (PPE), 3) Visitor
 189 Restrictions, 4) Pandemic Assessment Centre (PAC), 5) Working from Home, and 6) Food Services
 190 (Table 2).

191
 192 **Table 2.** Six key identified priority areas with corresponding definition

<i>Key Priority Identified</i>	<i>Description of Key Priority</i>
1. Access to health care	Encompasses any relevant data related to access to the health care which arose because of the pandemic response. This includes cancellations and closures, restrictions to labs and diagnostic imaging, the creation of the Pandemic Response Unit (PRU), and virtual care.
2. Personal protective equipment (PPE)	Encompasses any relevant data related to PPE which arose during the pandemic response. This includes directives pertaining to the usage of masks and scrubs, the sourcing and storing of PPE, and the PPE-related educational efforts targeted at the staff.
3. Visitor restrictions	Encompasses any relevant data related to visitor restrictions due to the pandemic response.
4. Pandemic Assessment Centre (PAC)	Encompasses any relevant data pertaining to the creation, operation and changes of the PAC.
5. Working from home	Encompasses any relevant data related to the transition and process of working from home. As well, it includes the IT infrastructure and changes which took place to ease the transition and process of working from home.
6. Food services	Refers to any relevant data related to the closure and cancellation of Food Services and any additional food supports that were developed during the initial pandemic response (wave one).

193
 194

195 The following results represent the data triangulation findings mapped onto the LHS
196 characteristics.

197 **Engaged patients**

198 During the Health Centre’s COVID-19 response, patients were passively engaged through the
199 dissemination of rapidly changing information to patients and families through various channels.
200 Social media platforms (Facebook, Twitter, and Instagram) and the Health Centre’s website were
201 the main avenues of communication with public regarding cancellations, closures, reopening of
202 services and visitor restrictions. Despite these efforts, study findings highlight a shift from
203 patient-centered care during the first wave of the pandemic response. For example, critical
204 policies related to strict visitor restrictions and access to the health centre were developed and
205 implemented by the leadership team as part of the rapid response to managing the impact of
206 the pandemic; however, patient and family partners were not involved in this in this process. The
207 Health Centre did launch the COVID-19 Patient Survey in August 2020 to gather feedback from
208 patients and families about their experience throughout wave one of the pandemic response.

209 **Digital capture, linkage and timely sharing of relevant data**

210 From the outset of the pandemic, teams worked quickly to *capture, link, and share* relevant
211 COVID-19 data. The Health Centre developed a new structure to collect administrative data
212 related to PAC, including volumes of patients and number of registrations. The Health Centre’s
213 Incident Management Committee (IMC) tracked and used PAC administrative data to inform
214 decisions regarding redeployment to PAC, required capacity and changes in service hours. To
215 keep all staff and physicians informed, the COVID-19 subsite on the Health Centre’s intranet was

216 instrumental in linking staff to up-to-date and relevant information regarding the evolution of
217 the pandemic.

218

219 Several teams also gathered department-specific data to inform their decision-making and
220 information dissemination. These teams included the Airway Management Group (intubation for
221 COVID-19 patients), Mental Health and Addictions (service changes and usage), human resources
222 (changes in staffing), and Strategy & Organizational Performance team (weekly PPE reports).
223 Additionally, efforts were made to link data provincially, with the Health Authorities' System
224 Performance and Analytics Teams collaborating to develop the COVID-19 Dashboards.

225

226 **Timely production of research evidence**

227 In response to the pandemic, the health centre participated in a provincial funding initiative to
228 support efforts to generate evidence to address a range of research questions relevant to
229 COVID-19. Seven COVID-19-related studies were launched as part of the province's COVID-19
230 Health Research Coalition in the areas of Discovery Science, Health System Improvements and
231 Social Sciences. The health centre's Research Services Office collaborated with other pediatric
232 and women's centres across Canada to develop a protocol to quickly close non-COVID related
233 research, employing a work from home strategy for health service researchers and modifying the
234 Research Ethics Board approval process to expedite COVID-19 related studies. While the studies
235 funded through the provincial initiative addressed key issues related to COVID-19, our findings
236 identified limited formal linkages between and within the healthcare community and research
237 community for timely sharing of research evidence to support policy and practice change.

238 Informal communication with trusted sources was identified as the most prevalent strategy for
239 knowledge exchange during wave one.

240

241 **Appropriate decision supports**

242 The Health Centre relied on new and existing *decision-support systems* in their pandemic
243 response. Provincially, the Health Centre is a member of key working groups set up by the
244 Department of Health and Wellness through Public Health with the office of the Medical Officer
245 of Health which guided provincial health system readiness. Locally, PPE tracking systems and
246 work from home guidelines were developed to guide decision-making in these areas. Although
247 the existing, pre-COVID-19 Pandemic Response plan provided some logistical information related
248 to system response, it was not used to guide the specific organization-level COVID-19 response
249 as it contained high level suggestions which did not cover the full breadth of the required
250 response.

251

252 **Aligned governance, financial and delivery arrangements**

253 Throughout the pandemic response, *systems shifted to align* with national, provincial and local
254 decisions and directives. To ensure success of these changes, teams adapted directives to meet
255 the specific needs of the organization and its patient population. The People and Technology
256 committee worked with unions to facilitate rapid staffing changes and redeployment brought
257 about by the pandemic response and supported staff who shifted to working from home. To

258 support financial arrangements and delivery, business continuity planning was initiated for all
259 departments in order to further adjust to the rapid changes brought about by the pandemic.

260

261 **Culture of rapid learning and improvement**

262 The COVID-19 pandemic created a *culture of rapid learning and improvement* in order to
263 respond to the fast-paced changes needed to curb the spread of the virus. The Health Centre
264 worked closely with provincial organizations and governing bodies to share pandemic-related
265 evidence, develop actions and implement key decisions. Rapid changes were made to the
266 delivery of virtual care, with Mental Health and Addictions Services being recognized as a leader
267 in this area. Staff and patient feedback were brought to the IMC, facilitating open discussion and
268 helping to maintain an awareness of patient needs among staff.

269

270 **Competencies for rapid learning and improvement**

271 Fear and uncertainty of the pandemic facilitated organizational *capacity for rapid learning and*
272 *improvement*. The pandemic response created a unified objective for the Health Centre which
273 was enacted by all staff at all levels of the organization. To address unprecedented challenges,
274 the Leadership Team coordinated the pandemic response by: a) collaborating with provincial
275 organizations and governing bodies; b) creating new committees (i.e., COVID-19 response
276 committee); and c) leveraging existing teams (People & Organization Development, Logistics and
277 Resources Committee, Clinical Program Operation Committees, etc.). Looking ahead, the
278 Leadership Team developed the *Reimagining and Resuming Services Plan*, which is a

279 commitment to shift operations back to pre-pandemic functioning while remaining agile to re-
280 implement COVID-19 restrictions across the organization during subsequent waves of the
281 pandemic.

282

283 **Discussion**

284 This study used a LHS framework to identify assets and gaps in the implementation of the COVID-
285 19 pandemic measures at a Canadian women and children’s tertiary health centre during wave
286 one (up to August 31st, 2020). A LHS includes cycles of continuous learning and offers a valuable
287 framework to organize a systematic and data-driven response to health system crises like COVID-
288 19.(10) Our study examined data from multiple sources and identified several opportunities to
289 improve the learning health system infrastructure.

290

291 **Engaging patients in rapid decision-making**

292 LHS are anchored on patient needs, perspectives and aspirations.(13) Engaging patients in health
293 research and health care delivery has seen exponential growth in recent years.(26) Aligning
294 communication strategies with the principles of patient engagement and patient- and family-
295 centered care has been identified as critically important during the COVID-19 pandemic.(27) The
296 Health Centre in this study had well-established structures and mechanisms for engaging
297 patients and families such as a Family Leadership Council, a Youth Advisory Council, as well as an
298 established practice of including parent and youth in research. Engaging patients and families in
299 co-creating care is also outlined in the health centre mission statement. However, due to

300 uncertainty related to scarce and evolving evidence related to COVID-19 and the rapid pace of
301 decision-making required to managed wave one, many of the usual ways of working based upon
302 patient and family-centred care principles were limited during the first phase of pandemic
303 planning and response.(28,29) As in many health care organizations, non-essential services and
304 personnel were moved to work-from-home or furloughed. In our study, communicating changes
305 to patients and families regarding how to access care was a key priority for the Health Centre.
306 However, balancing communication of general access policies with tailored messages for special
307 circumstances proved challenging. Patients and families need to be involved in designing care in
308 complex situations such as a pandemic response to ensure care is patient centered.(30) The
309 visitor restrictions and physical distancing measures that were implemented proved challenging
310 for some parents and patients who felt isolated from their support network and struggled to
311 build trusting relationships with their care providers. This can have significant impact on patient
312 and health outcomes; the inability to see, touch and talk to loved ones during a hospital stay can
313 increase the burden of illness.(31)

314

315 However, as Hart et al.,(32) recommend, restrictions on family presence does not need to
316 replace the principles of family-centred care. Moving forward, public and patient engagement
317 will be critical for decision-making about removing COVID-19 restrictions.(33) Similar to how
318 workplace communications have shifted drastically to online communications, patients and
319 families can be engaged via teleconference and videoconference methods in both planning and
320 care delivery. These strategies are needed to support continued pandemic response, as well as
321 planning for post-pandemic health care delivery.(34) Engaging patients and families in this way

322 will address the ethical imperatives and economic and social benefits from patient
323 engagement(35,36) and strengthen a LHS structure for future rapid-learning and health system
324 change. For subsequent waves of the pandemic and as we move forward post-pandemic, efforts
325 are needed to format feedback channels to better facilitate management and leadership
326 response to pertinent issues and develop a mechanism to support tailored communication to
327 patients and families.

328

329 **Ethical framework for learning health systems**

330 Participants revealed tensions as patients, families, and health care providers experienced the
331 impact of policies and practices deployed throughout the first wave of the pandemic. For
332 instance, health care provider participants identified the ethical and moral dilemmas that were
333 experienced when enforcing visitor restrictions to prevent transmission of the virus. Other
334 research has identified the need to examine the ethical implications of restrictive public health
335 and physical distancing measures, use of technology and data for contact tracing, and the impact
336 of guidelines on equity-seeking populations.(37) Ethical considerations are not included as a
337 main characteristic of Lavis et al.'s LHS framework.(13) Comparatively, Menear et al.(38)
338 developed a framework for value-creating LHS in which an ethical component is described as a
339 main LHS pillar. Given the ethical implications of many COVID-19 responses, and ethical
340 component seems like a timely addition to LHS frameworks to support challenging decision-
341 making.

342

343 **Improved digital capture, linkage and timely sharing of relevant data**

344 A key component of a LHS is digital capture, linkage, and timely sharing of data (patient
345 experiences, provider outcomes, and other process and outcome indicators), to make timely,
346 evidence-informed decisions.(13) In this study, administrators and care providers worked quickly
347 to capture, link and share local contextual data related to COVID-19. Several working groups and
348 new teams were organized. However, there was limited interdepartmental sharing of these data
349 and integration of patient experience data into decision-making. There was a stronger focus on
350 broader-level systems data (i.e., PPE use, volume of patients in pandemic assessment centre,
351 human resources re-deployment etc.). A lack of an existing data capture system and the pace of
352 new knowledge led to more reactive initiatives in response to the pandemic and lack of capacity
353 for sharing data, whereas having a comprehensive decision support system, including an
354 electronic health record (EHR), could have supported a proactive response to the pandemic.
355

356 Previous research demonstrates the ability of EHRs to capture, link and share data. EHRs with
357 decision support system capabilities have shown to improve patient safety, preventative care,
358 implementation of evidence-based care guidelines, and communication and management of
359 clinical information for providers and patients.(39) EHRs allow for predictive models to be
360 embedded within clinical decision supports to allow for real-time risk prediction and support
361 decision-making.(40) In addition to EHR and decision support systems, a LHS will not be realized
362 without adequate digital capture of the care experience. This includes infrastructure that allows
363 for collection and integration of patient reported experience measures and patient reported
364 outcome measures.(41)

365

366 Our findings suggest that during wave one, limited real-time health outcomes and experience
367 data were collected to inform rapid decision-making. Further, limitations with provincial
368 information technology support systems meant that significant manual work from decision
369 support services was required during the first wave to generate reports to guide decision-
370 making. In a priority setting exercise to inform Canada’s response to the COVID-19 pandemic,
371 McMahon et al. (37) identified the need for timely access to data for researchers, decision-
372 makers, and front-line care providers to inform policy and care delivery decisions, including the
373 rapid analysis of effective and evidence-informed response strategies. COVID-19 has highlighted
374 critical gaps in data capture across Canada, including a lack of ability to link data and collection of
375 race and ethnicity data, which risks further impacts of pandemic policies on existing health and
376 social inequities.(37) Efforts are urgently needed to build a digital infrastructure that includes
377 care experience data, process and outcome indicators, to inform rapid cycles of policy and care
378 delivery decisions.

379

380 **Role of embedded research for timely production of evidence**

381 Our study identified a gap in the Health Centre’s ability to rapidly generate and incorporate
382 research evidence to support policy and practice decisions related to COVID-19. The Research
383 Services Office quickly focused on the critical administrative tasks of halting non-COVID-19
384 related research studies and streamlining Research Ethics Board processes to rapidly support
385 projects related to the treatment of COVID-19. While the early focus of research
386 production was on the treatment of COVID-19, members of the Executive Leadership also
387 recognized the impact that the pandemic measures could have on patients, families, health

388 centre staff and providers. Consequently, they collaborated with a provincial funding initiative to
389 commission work to study the impact.

390

391 Several factors contribute to the gap in generating and incorporating research evidence into
392 policy and practice decisions. First, this was an unprecedented event with limited published
393 research evidence available to guide policy and practice change, particularly in the early phases
394 of the pandemic. Second, the existing health system-research structures and partnerships that
395 support the timely inclusion of evidence into decision-making were not well established. To be
396 most effective in supporting a LHS, *“researchers must be fully integrated into their internal
397 environments where health problems are articulated, priorities and plans set, new initiatives
398 developed and launched, and resultant changes managed”*.⁽¹²⁾ Translation of research into
399 practice can be challenging but having researchers and research programs embedded in health
400 system operations promote direct implementation of evidence-based practices.⁽⁴²⁾ Moving
401 forward, there is a need to build and strengthen partnerships with health service researchers
402 and implementation scientists internal and external to the health centre to allow for ready
403 access to best available evidence and support the design and evaluation of policy and practice
404 change strategies. Implementation researchers working in collaboration with health system
405 partners can rapidly scale up and spread promising practices to address the changing needs of
406 patients, health care providers, and the health system. To actualize a LHS moving forward, there
407 is an opportunity for novel integrated systems where embedded researchers inform decision-
408 making processes through timely production of evidence.

409

410 Use of LHS as a framework to study implementation

411 A LHS framework provides an opportunity to enhance health systems, such as the participating
412 Health Centre, to achieve optimal patient outcomes.(13) While LHS are a relatively novel
413 approach to health care, early evidence indicates its effectiveness in supporting health care
414 providers to reduce diagnostic errors(43) and improve patient safety by enhancing
415 interprofessional collaboration to reduce medication errors.(44) Overall, the literature primarily
416 focuses on LHS theory rather than its applicability in practice.(41) To address this limitation, Lavis
417 et al.(13) utilized a LHS framework to map assets and gaps in provincial health systems across
418 their ability to meet the care needs of patients, providers, etc.

419

420 Building on Lavis' approach, we used their LHS characteristics as a framework for mapping the
421 assets and gaps, through quantitative and qualitative data sources, in the Health Centre's
422 response to the COVID-19 pandemic. Our evidence suggests that the organization was already
423 implementing many features of a LHS pre-pandemic and has the capacity and infrastructure to
424 further develop as a LHS without radically altering the way it functions (i.e., leveraging existing
425 assets). Moreover, the COVID-19 pandemic has helped accelerate the Health Centre as a
426 functioning LHS. Our study provides an example of applying a LHS lens to analyzing health system
427 decision-making and identifying key components needed to achieve desired patient and health
428 system outcomes. To move the science forward on LHS, efforts are needed to build on existing
429 theories and schematic frameworks and provide practical guidance to researchers and health
430 system decision-makers on how to actualize a LHS in practice. More specifically, research is

431 needed to develop measurement tools, implementation strategies for LHS adoption, and LHS
432 indicators in practice and policy.

433

434 Conclusion

435 The COVID-19 pandemic has highlighted the urgent need to develop a LHS informed data-driven
436 response to a public-health crisis and complex health system challenges. This study used a LHS
437 framework to examine the COVID-19 pandemic planning and preparedness work conducted at a
438 Canadian women’s and children’s health centre. We identified key assets and gaps related to
439 engaging patients in decision-making, improving digital capture, linkage and sharing of relevant
440 data, and timely production of evidence. Overall, this study identified promising strategies for
441 future pandemic planning and preparedness work. Further, we outlined opportunities to
442 strengthen the LHS infrastructure to promote the rapid integration of evidence and lessons
443 learned from patient experiences into decision-making.

444

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446

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