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Operationalizing integrated needs-based workforce planning at Nova Scotia Health in response to the COVID-19 pandemic

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Abstract

This paper documents Nova Scotia Health's progress in operationalizing integrated needs-based workforce planning as part of its ongoing response to the pandemic. A multidisciplinary workforce planning team with representation spanning key portfolios was created to facilitate the organization's response to the pandemic. Analyses applied early in Wave 3 of the pandemic showed large projected shortages in several professions and identified which services would likely be scarcest among the available workforce relative to patient need. Based on these results, the workforce planning team recommended and supported operational teams in implementing a multi-faceted set of interventions aimed at increasing the availability of individuals with these competencies. These interventions collectively yielded an adequate supply of additional competent personnel to meet the needs of COVID-19 inpatients across the province through the third wave of the pandemic. Lessons learned are proving critical to maintaining core operations during Wave 4 of the pandemic.

Introduction

The ongoing COVID-19 pandemic has further demonstrated the critical dependence of healthcare systems on their respective health workforces, with mounting worldwide evidence of the tragic consequences of inadequate workforce planning.[1-7] This paper documents Nova Scotia Health's progress in operationalizing integrated needs-based workforce planning as part of its ongoing response to the pandemic.

Background: Waves 1 and 2

Nova Scotia Health is one of two regional health authorities in the Canadian province of Nova Scotia, with a population of just over 1 million. The other is Izaak Walton Killam (IWK) Health in Halifax, which serves as the main paediatric tertiary care facility for the Maritime provinces and also provides certain primary and secondary reproductive and paediatric health services to the residents of the Halifax Regional Municipality. Both Nova Scotia Health and the IWK also function as academic health centres working in partnerships with local universities as well as the Nova Scotia Community College.

As part of our initial COVID-19 workforce planning efforts at Nova Scotia Health, we applied COVID-19-specific staffing ratios developed in the United States[8] to the estimated numbers of inpatients at pre-specified "surge" levels within our organization. These calculations showed that, for higher surge levels, we would be short by hundreds and thousands of some professions, particularly pharmacists and respiratory therapists—an impossible deficit for a province our size (fewer than 1 million people at the time). These results prompted discussions at the highest levels of our organization to look beyond provider:patient ratios to questions of exactly what services would need to be provided for our COVID-19 patients and how to plan our staffing accordingly.

To address these questions we blended two related and previously published analytical frameworks for health workforce planning,[9,10] both of which focused on integrating health service and workforce planning and estimating service and workforce requirements as a function of measures of population health needs. While these are not the only such approaches to have been published,[11] we adopted them for the sake of expediency because several team members' familiarity with them.

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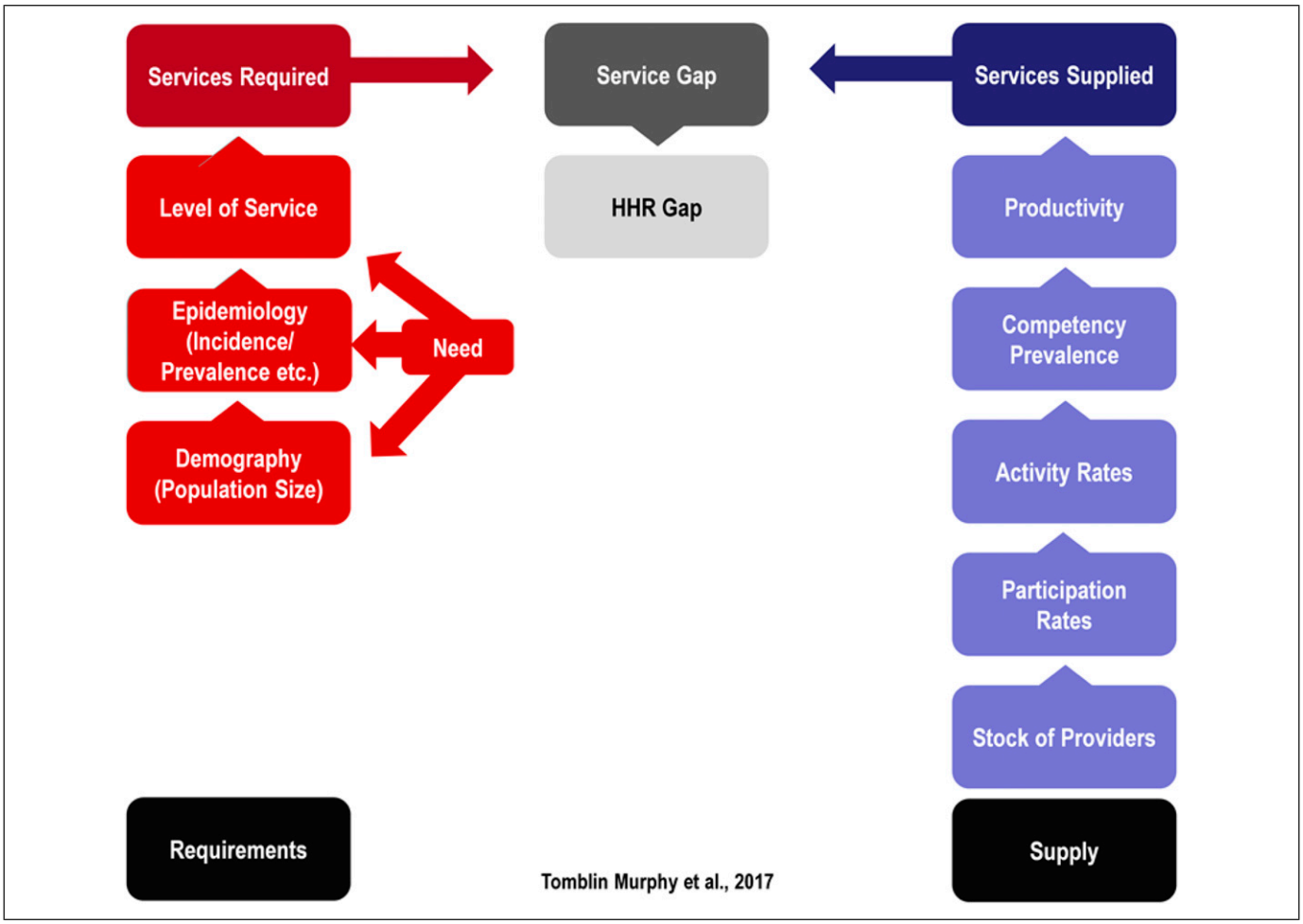

Figure 1. Elements of the analytical framework for workforce planning.

Figure 1 shows the elements of the analytical framework previously described by Tomblin Murphy and colleagues.[9] As they explain in more depth, this framework estimates the volume and mix and services required to address a particular set of health issues (in this case COVID-19) as a function of:

1. The size and demographic characteristics of the population to be served;
2. The incidence and severity distribution of the issue(s); and
3. The volume and mix of services to be provided to individuals according to the degree to which they are affected by the issue(s) in question.

Simultaneously this approach estimates the volume and mix and services that can be provided by a workforce as a function of:

A. The number of providers in the workforce;
B. The proportion of the workforce available to work;
C. Among those available to work, the amount of time those providers are available;
D. The degree to which those providers have the competencies necessary to provide a given service; and
E. The rate at which providers can be reasonably expected to deliver those services over time at an acceptable standard of quality.

For each service, the estimate of the number of times it will be required is then compared with the estimate of number of times it can be provided.

Figure 2 provides an overview of our approach to operationalizing this framework in response to COVID-19. On the supply side, our first task was to determine the number and mix of Full-Time Equivalent (FTE) staff made available for COVID-19 response by slowing or shutting down other services (stock of providers and activity levels in Figure 1). We then articulated assumptions about how that availability would change in the future—for example, what proportion would be unavailable due to COVID-19 infection or exposure (participation rates). On the requirements side, we first needed to specify what services would need to be provided for COVID-19 patients and how often (level of service). Then for each of those services, we determined which of our professions, as a group, had the competencies to deliver it. In parallel, we determined which epidemiological

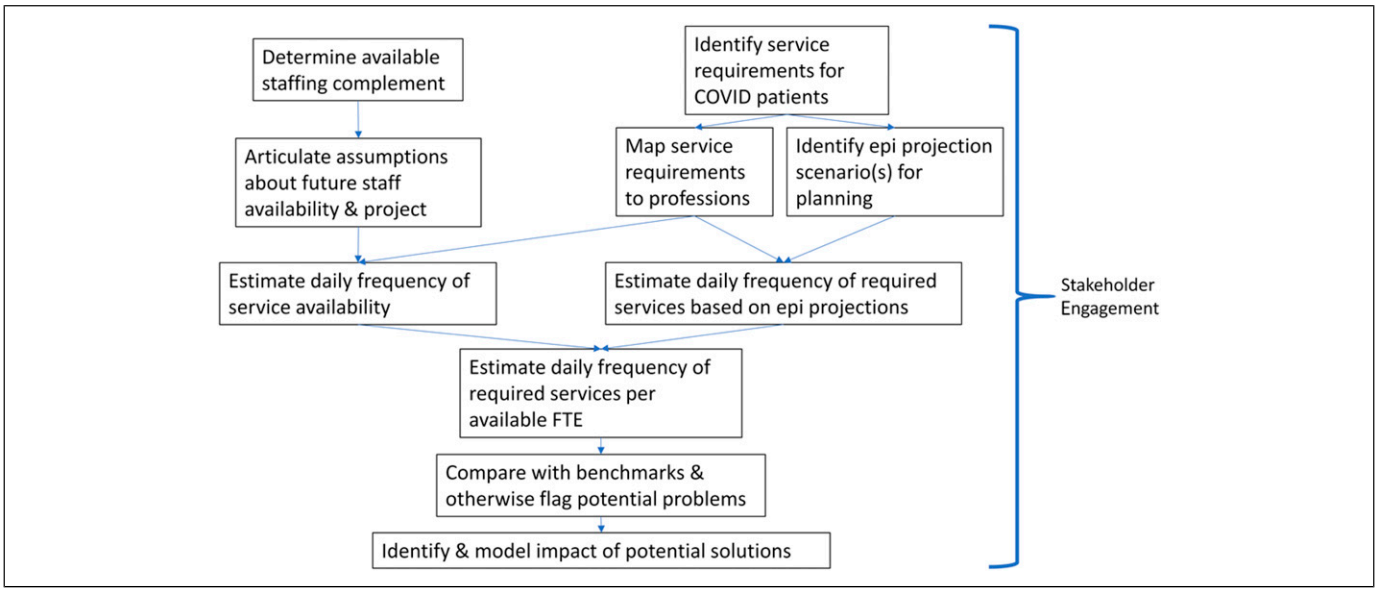

Figure 2. Operationalizing an integrated needs-based approach to COVID-19 workforce planning.

projection scenarios—that is, the number and severity of COVID-19 inpatients needing care—to include in our planning (epidemiology). Based on those, we estimated how many services we would need to provide on a given day and compared that against the capacity of the workforce we'd expect to have available on that day under different "what if" scenarios. We were then able to look for "problem" services—specifically those that looked like they would be needed more often than we could provide them (service gap)—and identify potential solutions. Achieving each of those steps depended on contributions of different key stakeholder groups, including the joint provincial epidemiological modelling group, infectious disease physicians within the organization, Nova Scotia Health's Interprofessional Practice and Learning (IPPL) and People Services teams, and industrial engineers from Nova Scotia Health's Performance Analytics team.

Results of this approach suggested that, given the size and professional mix of the workforce available for COVID-19 response and the projected peak and duration of what would later become known as the first wave, Nova Scotia Health would have enough staff with the competencies to deliver the services required of its COVID-19 inpatients. This conclusion held under several alternate scenarios run as sensitivity analyses—for example, a higher-than-anticipated portion of staff being unavailable.

Full application: Wave 3

In contrast to the first and second waves of COVID-19, the third placed unprecedented strain on Nova Scotia Health's staff and systems. Provincial projections early in the third wave suggested that, at its peak, up to 200 Nova Scotians would need to be hospitalized with COVID-19, about a third of whom would require intensive or critical care. While plans and beds existed to provide the inpatient and critical care spaces necessary to accommodate these patients, corresponding plans to staff these beds did not exist. Even if they had, they likely would have needed revising to reflect the impact of the pandemic, already more than a year in duration, on the province's health workforce and the need to also ensure adequate staff to maintain the province's crucial testing, contact tracing, and vaccination regimens. These additional, COVID-specific service streams posed their own workforce planning challenges due to the inherently variable need for them over time, the associated difficulties in recruitment and retention for these necessarily short-term roles, and competition with parallel recruitment and retention efforts in core service areas. It was in this context that an integrated workforce planning approach became essential to meet the surge in critical care that resulted from these infections.

To address this challenge, a multidisciplinary workforce planning team with representation spanning Nova Scotia Health's People Services, Performance Analytics, Medical Affairs, Research and Innovation, and IPPL portfolios was created. The team reported directly to members of Nova Scotia Health's Executive Leadership Team as well as to the provincial Emergency Operations Centre (EOC) established to coordinate the organization's COVID-19 response.

The team used two complementary approaches to inform workforce planning efforts for Wave 3. The simplest of these involved modifying the staffing ratios published in the United States to suit Nova Scotia Health's unique context based on local clinicians' accumulated experience during the first two COVID-19 waves. This yielded the estimates of the hours of care required from various health professions per inpatient day shown in Table 1.

Applying these ratios to the projected volume and acuity mix of COVID-19 inpatients for Wave 3 yielded profession-specific estimates of the gaps between numbers of available

Table 1. Estimated required hours of care per COVID-19 inpatient day by profession and patient acuity.

	RN	LPN	Pharmacist	Physiotherapist	Housekeeping	Physician
Required hours per patient day, inpatient	6.9	2.2	0.5	2.0	2.0	1.0
Required hours per patient day, ICU	23.5	0.0	2.0	2.5	1.0	4.0

	Unit clerk	Care team aide (CTA)	Unit aide	Respiratory therapist	Dietitian	Social worker	Occupational therapist
Required hours per patient day, inpatient	0.9	0.0	1.5	0.5	.25	.25	.25
Required hours per patient day, ICU	1.2	5.6	1.9	2.0	1.0	0.5	0.5

LFN: licensed practical nurse.

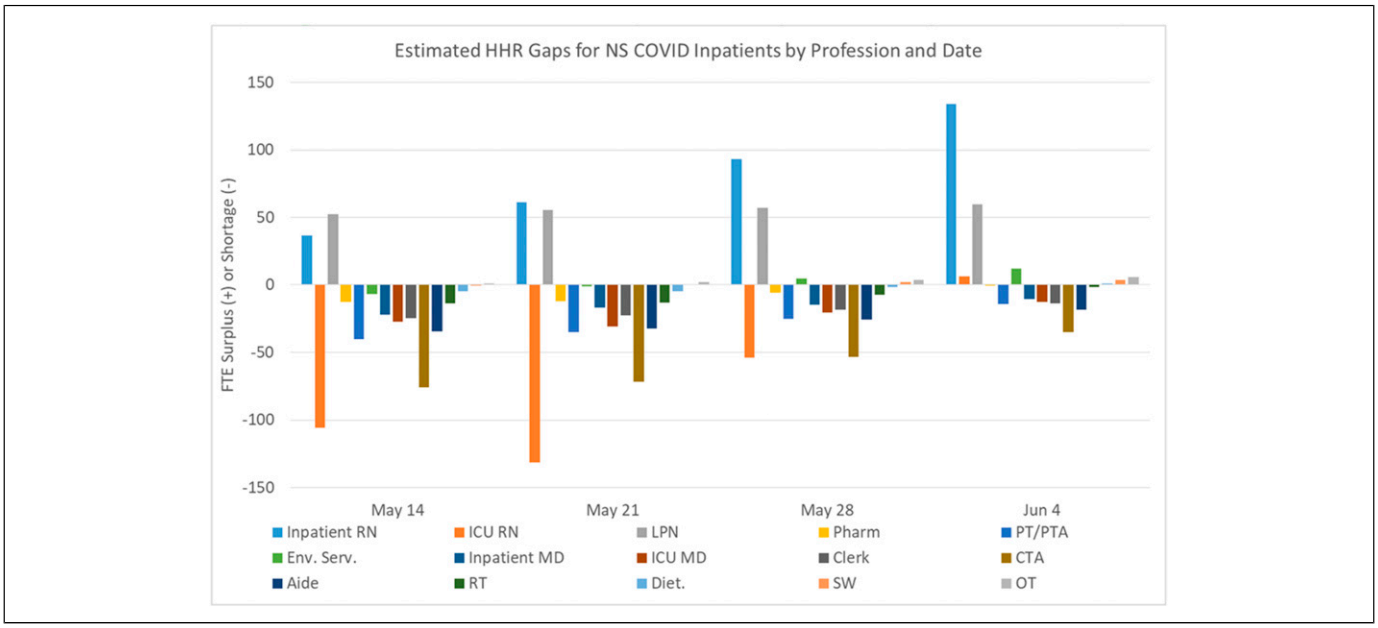

Figure 3. Estimated health workforce gaps for Nova Scotia COVID-19 inpatients by profession and date.

and required healthcare professionals through the expected peak of the wave as shown in Figure 3.

This analysis showed projected shortages in several professions, most notably over 100 FTE ICU RNs, at the peak of the wave.

To complement the above findings, the service-specific analyses conducted in Wave 1 were repeated. In updating the approach for Wave 3, several model parameters were changed.

Specifically:

- The projected number of cases and volume of hospitalizations—particularly those requiring intensive care—was much higher than in previous waves (epidemiology).
- The level of service component was updated based on the preceding months' published scientific evidence as well as the IPPL team's direct experience with previous COVID-19 waves.
- The future proportion of staff unavailable due to COVID-19 (participation rates) was estimated as a function of the projected volume of active COVID-19 cases in the province based on the correlation observed in Wave 2.

Table 2 provides initial results of updating the analytical approach for Wave 3. Specifically, it shows the 10 services estimated to be required most often relative to the workforce's estimated capacity to deliver them—calculated as the number of each service required per competent FTE per day.

The most "scarce" of these services, according to these results, were mainly those that, under normal circumstances, are provided only by either physicians and nurse practitioners (making a diagnosis), ICU-trained nurses, or respiratory therapists.

Based on these results, the workforce planning team recommended and supported Incident Management Teams in each of Nova Scotia Health's four geographic Management Zones, as well as other operational teams, in implementing a

Table 2. Services required most often relative to estimated workforce capacity, Wave 3.

Service	Services required per FTE per day			
	May 21	May 28	Jun 4	Jun 11
Interpret the results of history, physical exam, chest x-ray, and lab tests, leading to a diagnosis	17	27	25	18
Manage inotrope and vasopressor medications in ICUs	15	30	27	19
Monitor ventilation in patients on respiratory support	14	27	25	18
Check medication prescriptions for conflicts and dispense	13	19	17	13
Manage sedation of patients requiring critical care/ICU care	8	17	16	11
Order clinical diagnostic tests (eg, chest x-rays and CT scans)	7	11	11	8
Suction intubated/ventilated patients	6	11	10	7
Manage insulin infusions	6	10	10	7
Prepare total parenteral nutrition	6	7	6	5
Maintain an arterial line	5	11	11	7

multi-faceted set of interventions aimed at increasing the availability of individuals with these competencies. These included:

1. Reducing provision of lower-priority services (eg, elective surgeries) to free up personnel (including physicians) for reassignment to COVID-19 ICUs within collective agreement provisions;
2. Identifying and reassigning RNs with critical care experience currently working in other service areas back to critical care;
3. Identifying and reassigning RNs with recovery room experience to critical care, since much of the specialized equipment used in ICUs is also used in recovery rooms;
4. Recruiting recently retired RNs with critical care experience;
5. Optimizing the role of Licensed Practical Nurses (LPNs) by increasing their acute care competencies and/or deploying in Care Team Aide (CTA) or unit aide-type roles;
6. Reassigning anaesthesia assistants to supplement areas with shortages of RTs;
7. Accelerating hiring of recent graduates of local baccalaureate nursing, respiratory therapy, and critical care nursing programs;
8. Fully leveraging the newly created role of Emergency Support Aide (ESA), a support role with an initial focus on administering COVID-19 tests that has expanded to supporting patients' activities of daily living;
9. Requiring manager sign-off for staff seeking transfers to ensure staffing for core services such as emergency departments and ICUs were appropriately prioritized;
10. Designing alternate team-based service delivery models for critical care to free up and spread specialized critical care clinicians where the need was the greatest provincially (Figure 4);
11. Process improvements in critical care areas to reduce foot traffic of nurses; and
12. Mobilized Clinical Nurse Educators with critical care experiences in ICUs to support the daily developmental needs of the workforce.

These interventions collectively yielded an adequate supply of additional competent personnel to meet the needs of COVID-19 inpatients across the province through the third wave of the pandemic.

Key impacts included:

- 35 RNs with critical care experience working elsewhere in the organization were temporarily reassigned to ICUs.
- 77 RNs with recovery room experience with reassigned to ICUs.
- 107 recently retired RNs with critical care experience were identified and contacted; while none agreed to return to work in the ICU, many returned to work in vaccination clinics under conditional licenses provided by the provincial nursing regulator.
- 10 new RT graduates, 135 new BScN graduates, and 48 new graduates of the organization's critical care nursing program were recruited.
- An additional 21 RNs without previous experience were trained to work in the ICU.
- Hundreds of ESAs were hired to staff COVID-19 testing centres and vaccination clinics which, in addition to enabling the continuing of these essential services, freed up nurses and other regulated staff to work in critical care and other areas experiencing pronounced pressures.

Discussion and lessons learned

Several lessons learned from Nova Scotia's response to the H1N1 influenza pandemic[12] and an assessment by the Auditor General of provincial pandemic response plans[13]—coincidentally, initiated shortly before H1N1—were reflected in its response to COVID-19. These included:

- The likelihood of substantial portions of the provincial health workforce being unavailable to work during the

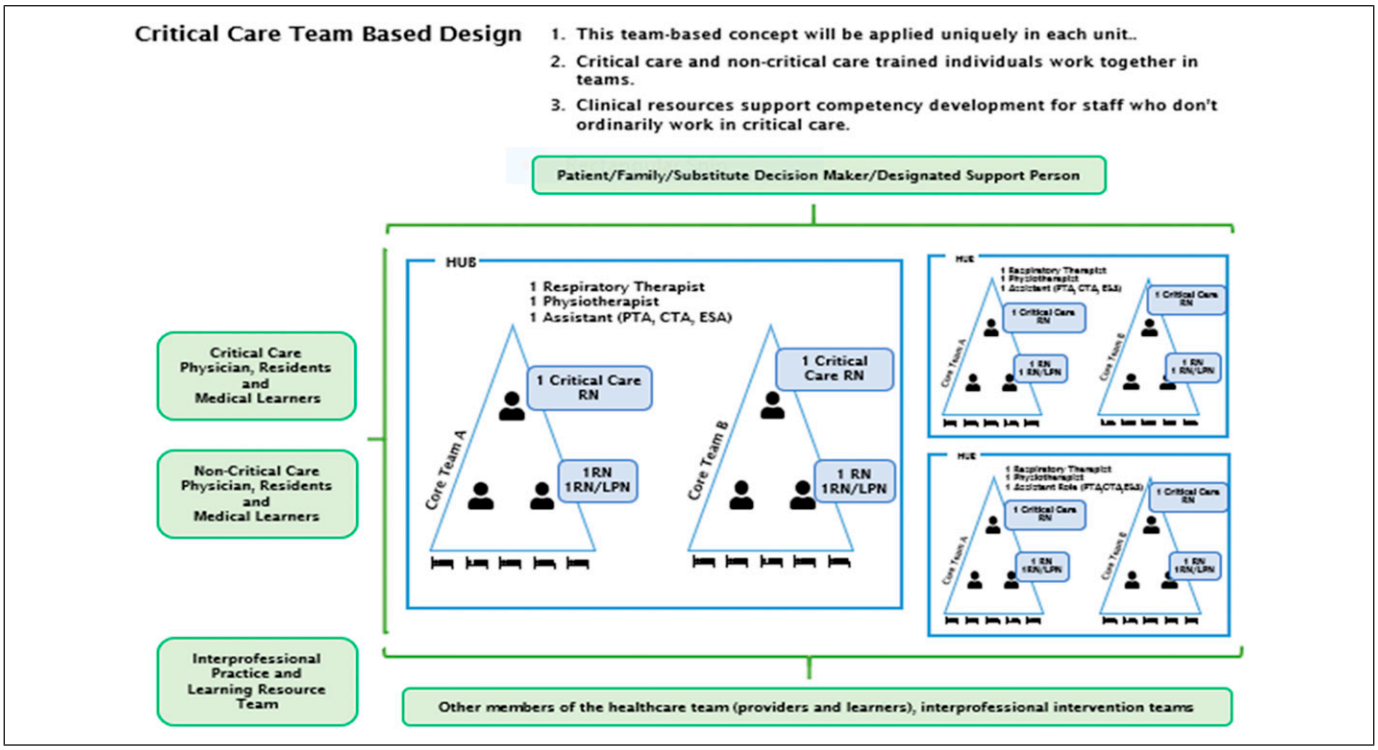

Figure 4. Alternate team-based service delivery models for critical care.

pandemic, which was factored into COVID-19 response planning as described above.

- Shortages of laboratory staff as a limiting factor in a future pandemic response. Considerable investment in medical laboratory technology as well as improvements in lab staffing at Nova Scotia Health in the intervening years resulted in greatly expanded lab capacity for COVID-19 response.
- The potential for a temporary licensure pathway to allow for more health professionals (eg, retirees) to help with pandemic response, and this has been implemented by key regulatory bodies such as the Nursing[14] and Medical Laboratory Technologist colleges during COVID-19.
- The "Good Neighbour Protocol"—an agreement between healthcare unions and the provincial government that specified how health human resources are to be shared across the province and how healthcare providers are to be compensated and protected while responding to an emergency that impacts the healthcare system. Implemented during the H1N1 pandemic, the protocol applies to workers from within the province, from other jurisdictions and to volunteers.[15] During COVID-19, this protocol informed how healthcare professionals were reassigned within Nova Scotia Health and between Nova Scotia Health and other employers (eg, long-term care facilities) in response to the pandemic.
- The leveraging of a wide range of health professionals from in a variety of settings as part of mass vaccination campaigns was crucial to both H1N1 and COVID-19 responses in the province. The problem of long queues for vaccines during H1N1 was averted during COVID-19 by the use of on-line and phone scheduling for appointments.

Learnings from experience with Severe Acute Respiratory Syndrome (SARS) in other jurisdictions in 2003 foreshadowed several workforce challenges experienced by Nova Scotia Health in its COVID-19 response.

- A commissioned analysis of Ontario's SARS response[16] noted specific workforce shortages in contact tracing and lab testing that had been exacerbated by recent layoffs. Like other jurisdictions, Nova Scotia was similarly dealing with a shortage of medical laboratory technologists prior to the COVID-19 pandemic.
- Another Ontario study of the impact of SARS on the nursing workforce highlighted the high proportion of nurses working multiple part-time and casual roles in multiple facilities (resulting from previous government cuts to full-time positions) as exacerbating risk of outbreaks, and identified the lack of nursing workforce surge capacity as putting the entire provincial healthcare system at risk. [17] Ontario later increased the availability of full-time employment for nurses in the province, [18] which Nova Scotia Health has also done.
- A policy analysis of British Columbia and Ontario's approaches to their public health workforces post-SARS noted that workforce and process issues were only beginning to be addressed even 8 years later;[19] in a similar vein, Nova Scotia Health's COVID-19 response

has been constrained by the number of contact tracing staff available relative to case volumes during waves 3 and 4.

The COVID-19 pandemic has underscored the critical importance of planning for the health workforce in ways that anticipate and account for changes in population health needs and integrate planning across professions. Despite repeated calls spanning decades from major stakeholder groups for health workforce planning to be conducted in this way,[20-29] there has been relatively little uptake of these methods.[30,31] Importantly, this is not primarily a problem of either inadequate data or analytical tools to support such planning.[32]

Beyond the recommended staffing ratios published by UCSF as noted above, there is minimal public information on the inner workings of other jurisdictions' pandemic responses in terms of workforce planning. The Canadian Institute for Health Information estimates that nearly 6,000 nurses, pharmacists, physiotherapists, and occupational therapists returned to work to help with the COVID-19 response after having left the profession, and that 83% of physicians in the country provided at least one virtual visit.[33] They also reported that multiple provinces authorized additional professions to administer COVID-19 testing—for example, in Quebec, these included midwives, chiropractors, occupational therapists, optometrists, ambulance technicians, and those practising within a health and social services institution. In Manitoba, these included medical laboratory technologists, occupational therapists, pharmacists, physiotherapists, and healthcare students under specific conditions.

Other jurisdictions have identified some of the same workforce interventions as Nova Scotia Health as part of their pandemic response. Alberta Health Services, for example, reassigned staff from lower to higher priority areas, used alternate models of care, and prioritized testing for health workers to maximize workforce availability.[34] British Columbia's Ministry of Health identified service reductions (including postponing surgeries and rescheduling home support visits), redeployment of staff, and use of virtual health technology as strategies for its response to the Omicron wave.[35] Ontario's Ministry of Health has announced work with sector partners to implement a retention and recruitment strategy for health professionals to address chronic shortages exacerbated by the pandemic.[36] The degree to which the development of these other jurisdictions' development of these strategies has been informed by the type of workforce planning used at Nova Scotia Health is not clear from any published material we have found.

Integrated, needs-based workforce planning approaches like that being used by Nova Scotia Health can and have been applied in a growing variety of other contexts—a recent systematic review found these were most common in Australia, Canada, England, and New Zealand.[11] At the national level, these approaches have been applied to planning, for example, for the oral health workforce in Ireland,[37] the maternal health workforce in Guinea,[38] and the eye care workforce in Singapore.[39] They have also been applied in large sub-national jurisdictions such as for the primary care workforce in the Toronto region.[40] As such, we are confident the approach described above could also be applied in larger jurisdictions with supportive contexts as described below.

In addition to executive-level leadership support as detailed elsewhere,[31] implementation of such an approach at Nova Scotia Health has been facilitated by the multidisciplinary nature of the team, leveraging key portfolios across the organization. This has allowed for a comprehensive and integrated assessment of workforce challenges as well as the identification and enactment of potential solutions. To help populate the analytical frameworks referenced above, implementation of this approach has also benefited from technical tools developed for workforce planning before the pandemic[41] by the organization's People Services and Performance Analytics portfolios, including a Tableau dashboard that integrates and summarizes workforce data from a range of administrative databases across Nova Scotia Health in a readily accessible manner. Crucially, the approach used by the team also coordinated efforts to plan for physicians with those planning for all other professions. The combined technical and political expertise of the workforce planning team was a critical enabler to create rapid identification and implementation of the strategies outlined above in Wave 3. Finally, execution of each of the strategies that enabled Nova Scotia Health to weather Wave 3 of the pandemic depended heavily on the contributions of the IPPL team in preparing healthcare providers with widely varying experience levels to practice safely and effectively in unfamiliar environments as their patients' needs required.

Ongoing work and broader application

At the time of this writing in March 2022, Nova Scotia is currently emerging from the fourth wave of the COVID-19 pandemic, having again leveraging its integrated, needs-based health workforce planning capacity to help mitigate the impacts of unprecedented burdens on the provincial healthcare system. Lessons learned from previous waves—particularly the importance of integrating planning across professions and organizational portfolios, and the essential nature of IPPL leadership—are continuing to prove critical to maintaining core operations in the face of extraordinary pressures on the provincial healthcare system. Other healthcare organizations encountering workforce challenges—associated with the pandemic or otherwise—may wish to consider adopting an integrated, needs-based approach to planning such as that described above. The analytical components of this approach have been previously published and are among a wide and growing range of tools available for use by health system and workforce planners worldwide.

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References

1. Bourgeault IL, Maier CB, Dieleman M, et al. The COVID-19 pandemic presents an opportunity to develop more sustainable health workforces. *Human Res Health*. 2020;18:83.
2. Canadian Institute for Health Information. *Pandemic experience in the Long-Term Care Sector: How Does Canada Compare With Other Countries?* Ottawa, ON: CIHI; 2020.
3. Anderson M, O'Neill C, MacLeod Clark J, et al. Securing a sustainable and fit-for-purpose UK health and care workforce. *The Lancet*. 2021;397(10288):1992-2011.
4. Sharp A, Jain V, Alimi Y, Bausch DG. Policy and planning for large epidemics and pandemics - challenges and lessons learned from COVID-19. *Current Opinion Infec Dis*. 2021;34(5): 393-400.
5. Yang BK, Carter MW, Nelson HW. Trends in COVID-19 cases, deaths, and staffing shortages in US nursing homes by rural and urban status. *Geriatric Nursing*. 2021;42(6):1356-1361.
6. World Health Organization. *The Impact of COVID-19 on health and care workers: A closer look at deaths*. Geneva, Switzerland: WHO; 2021.
7. Clarke J. *Impacts of the COVID-19 Pandemic in Nursing and Residential Care Facilities in Canada*. Ottawa, ON: Statistics Canada; 2021.
8. HealthForce Center. *Health Workforce Baseline and Surge Ratio*. San Francisco, CA: University of California; 2020.
9. Tomblin Murphy G, Birch S, MacKenzie A, Rigby J, Langley J. An integrated needs-based approach to health service and health workforce planning: applications for pandemic influenza. *Healthcare Policy | Politiques de Santé*. 2017;13(1):28-42.
10. MacKenzie A, Tomblin Murphy G, Audas R. A dynamic, multi-professional, needs-based simulation model to inform human resources for health planning. *Human Res Health*. 2019;17:42.
11. Asamani JA, Christmals CD, Reitsma GM. The needs-based health workforce planning method: a systematic scoping review of analytical applications. *Health Policy Planning*. 2021;36(8): 1325-1343.
12. Province of Nova Scotia. *Nova Scotia's Response to H1N1 Summary Report*. Halifax, NS: Province of Nova Scotia; 2009.
13. Office of the Auditor General of Nova Scotia. *Special Report - Pandemic Preparedness*. Halifax, NS: Province of Nova Scotia; 2009.
14. College of Nursing. Rapid Re-Licensing for COVID-19. Available at: https://www.nscn.ca/explore-nscn/news-and-media/news/2020/rapid-re-licensing-covid-19-temporarily-closed. Acce ssed January 9, 2022.
15. Province of Nova Scotia. *Good Neighbor Protocol to be Signed*. Halifax, NS: Province of Nova Scotia; 2009.
16. Campbell A. The SARS commission interim report: SARS and public health in Ontario. *Biosecurity Bioterrorism: Biodefense Strategy, Pract Sci*. 2004;2(2):118-126.
17. Baumann AO, Blythe JM, Underwood JM. Surge capacity and casualization. *Canadian J Public Health*. 2006;97(3):230-232.
18. Baumann A, Hunsberger M, Crea-Arsenio M. Workforce integration of new graduate nurses: evaluation of a health human resources employment policy. *Healthcare Policy | Politiques de Santé*. 2011;7(2):47-59.
19. Regan S, MacDonald M, Allan DE, Martin C, Peroff-Johnston N. Public health human resources: a comparative analysis of policy documents in two Canadian provinces. *Human Res Health*. 2014; 12:13.
20. Lomas J, Stoddart GL, Barer ML. Supply projections as planning: a critical review of forecasting net physician requirements in Canada. *Soc Sci Med*. 1985;20(4):411-424.
21. Hall TL. Guidelines for health workforce planners. *World Health Forum*. 1988;9(3):409-413.
22. Maynard A, Walker A. Managing the medical workforce: time for improvements? *Health Policy*. 1995;31(1):1-16.
23. Lavis JN, Birch S. The answer is ....., now what was the question? Applying alternative approaches to estimating nurse requirements. *Canadian j Nursing Admin*. 1997;10(1):24-44.
24. Birch S, O'Brien-Pallas L, Alksnis C, Tomblin Murphy G, Thomson D. Beyond demographic change in human resources planning: an extended framework and application to nursing. *J Health Services Res Policy*. 2003;8(4):225-229.
25. Canadian Nurses Association, Canadian Medical Association. *Toward a Pan-Canadian Framework for Health Human Resources: A Green Paper*. Ottawa, ON: CMA; 2005.
26. Pan American Health Organization. *Toronto Call to Action 2006-2015. Towards a Decade of Human Resources in Health for the Americas*. Washington, DC: PAHO; 2005.
27. Health Action Lobby. *Core Principles and Strategic Directions for a Pan-Canadian Health Human Resources Plan*. Ottawa, ON: Health Action Lobby; 2006.
28. Federal/Provincial/Territorial Advisory Committee on Health Delivery and Human Resources. *A Framework for Collaborative Pan-Canadian Health Human Resources Planning*. Ottawa, ON: Health Canada; 2007.
29. Global Health Workforce Alliance, World Health Organization. *A Universal Truth: No Health Without a Health Workforce*. Geneva, Switzerland: WHO; 2013.
30. Tomblin Murphy G, Birch S, MacKenzie A, Bradish S, Elliott Rose A. A synthesis of recent analyses of human resources for health requirements and labour market dynamics in high-income OECD countries. *Human Res Health*. 2016;14:59.
31. Tomblin G, MacKenzie A, MacQuarrie C, Sampalli T, Rigby J. Evidence to care: learning from a case study of health workforce planning and COVID-19 response in Nova Scotia. *Canadian J Nursing Leadership*. 2021;34(4):19-30.
32. Tomblin Murphy G, Birch S, MacKenzie A, et al. The drive towards sustainable health systems needs an alignment: where are the innovations in health systems planning? *Healthc Pap*. 2017; 16(3):40-46.
33. Canadian Institute for Health Information. *Health Workforce in Canada: Highlights of the Impact of COVID-19*. Ottawa, ON: CIHI; 2021.

34. Lee J. Rapid spread of Omicron, staffing shortages could threaten patient care, say Alberta doctors, nurses. CBC News. Accessed March 5, 2022.
35. Nesbit B Health authorities take drastic action to offset staffing shortages. CTV News. Accessed March 5, 2022.
36. Tsekouras P. Ontario's nursing shortage has been an issue for years. Why weren't we prepared for the COVID-19 pandemic? CTV News. Accessed March 5, 2022.
37. Ahern S, Woods N, Kalmus O, Birch S, Listl S. Needs-based planning for the oral health workforce - development and application of a simulation model. *Human Res Health*. 2019;17:55.
38. Jansen C, Codjia L, Dieleman M, Lamine Y, Cometto G. Realizing universal health coverage for maternal health services in the Republic of Guinea: the use of workforce projections to design health labor market interventions. *Risk Manage Healthcare Policy*. 2014;7:219-232.
39. Ansah JP, Koh V, De KOrne D, Jayabaskar T, Matchar DB, Quek D. Modeling manpower requirement for a changing population health needs: The case of ophthalmic nurses and allied health ophthalmic professionals. *Health Policy Tech*. 2019;8(3): 282-295.
40. Simkin S, Chamberland-Rowe C, Bourgeault IL. An integrated primary care workforce planning toolkit at the regional level (part 2): quantitative tools compiled for decision-makers in Toronto, Canada. *Human Res Health*. 2021;19:86.
41. Piers G. *Workforce Planning in the Nova Scotia Health Authority*. Victoria, BC: University of Victoria; 2017.