ORIGINAL ARTICLE

CANADIAN COLLEGE OF HEALTH LEADERS
COLLÈGE CANADIEN DES LEADERS EN SANTÉ

Supply chain integration as a strategy to strengthen pandemic responsiveness in Nova Scotia

Anne W. Snowdon, PhD[1] and Michael J. Saunders, PhD[1]

Healthcare Management Forum
2022, Vol. 35(2) 62–70

DOI: 10.1177/08404704211061223
journals.sagepub.com/home/hmf
SAGE

Abstract

This provincial case study, one of seven conducted as part of a national research program on healthcare supply chain management during COVID-19, focuses on Nova Scotia. During the first wave of the pandemic, Nova Scotia faced the massive destabilization of its traditional supply channels and had to grapple with role clarity and communication in its emergency response structure. Nova Scotia was able to centralize its pandemic sourcing, procurement, and management efforts to its provincial health authority. Healthcare supply chain teams were able to rapidly modify their sourcing and procurement processes in order to compensate for the destabilization of their standard supply channels and assume responsibility for the province-wide management and distribution of pandemic supplies. The Nova Scotia case findings make clear both the value of a centralized and dedicated healthcare supply chain response—that integrates all provincial care delivery organizations—and the diversification of the healthcare supply chain.

Introduction and review of literature

Supply chain in health systems includes the sourcing and distribution of the products necessary to ensure that healthcare teams have access to the right products at the right time in order to deliver safe and effective patient care.[1] In health systems, supply chain teams source a complex and diverse array of products and equipment, from ventilators and intravenous pumps, to medications, vaccines, and Personal Protective Equipment (PPE). And yet, the strategic importance of the healthcare supply chain for health system capacity to deliver care is, for the most part, neither reflected in current research literature nor profiled relative to best practices aligned with the unique mandate of health systems. The recent global pandemic has clearly demonstrated the unique role of supply chain in enabling health systems to deliver care in a timely and safe manner.

There is a long history of supply chain disruptions that have occurred due to natural disasters and public health crises, resulting in severe consequences that have put health workers and patients at significant risk. One example was Hurricane Maria in 2017, where electrical grids were wiped out in Puerto Rico, which disrupted the production of intravenous therapy products, (e.g., IV bags) manufactured by Baxter.[2] The demand for IV bags skyrocketed globally, causing an increase in cost by 600%.[2] Similarly, a flood in 2012 impacted Sanofi Pasteur, the supplier of the cancer drug ImmuCyst. The result was significant delays in cancer treatment for patients as manufacturers could not increase production of the drug rapidly enough to meet the demand.[3] Public health crises, such as the SARS epidemic, also put extreme pressure on health system supply chains, due to an increase in demand for the critical products required to keep health workers and patients safe from transmission of the SARS virus. Not only do these crises put the physical health of essential workers at risk—three of the 44 Canadians who died from SARS were healthcare workers[4]—emerging evidence also identifies significant impact on the mental health of the workforce. In the current pandemic, the inadequate supply of PPE and the uncertainty these supply shortages created among Canada's healthcare workforce resulted in high rates of mental health issues, such as anxiety and depression.[5]

Healthcare supply chains involve a diversity of stakeholder groups, including patients, clinicians, suppliers, healthcare organizations, group purchasing organizations, distributors, and insurers, which adds to their complexity.[6,7] However, research and evidence of best practices for healthcare supply chain processes and management lags far behind other business sectors.[8-10] While research dedicated to understanding supply chain and logistics has been well established in the private sector, significant gaps in research remain in the healthcare sector.[11-14] Current research on supply chain and logistics has focused primarily on other business sectors and often attempts to apply non-healthcare supply chain–specific evidence and insights to healthcare supply chain challenges. However, the attempt to translate industrial or non-healthcare supply chain processes to healthcare supply chain management risks eliding the specificity of the healthcare supply chain, especially its unique end point in the care for, and protection of, human life. Practices that are relevant to industrial supply chain management (such as just-in-time logistics) may not be readily applicable to healthcare supply chain management because any destabilization of the healthcare supply chain may compromise the safety of care delivery for both patients

[1] University of Windsor, Windsor, Ontario, Canada.

Corresponding author:
Anne W. Snowdon, University of Windsor, Windsor, Ontario, Canada.
E-mail: anne.snowdon@uwindsor.ca

and the workforce. As Aldrighetti et al. note, given that the end of the health supply chain is human life, the standard by which health supply chain capacity is measured, is different from that of industrial supply chains:

> "In the context of HSCs [healthcare supply chains], such disastrous events [as disruptions] can potentially have devastating effects because human lives are on the table: these networks cannot afford to register missing drugs in the hospital, i.e. it should always perform with service level equal to 100%."[15]

This need for the capacity of a health supply chain to maintain a "service level equal to 100%" helps to contextualize the urgency of the development of strategies for healthcare supply chain resilience, and it is a key differentiator of the healthcare supply chain from industrial supply chains. When the healthcare supply chain breaks down, the result is a direct impact on human life.[15-17] The COVID-19 pandemic has led to unprecedented challenges for healthcare systems to meet the surge in demand for care of people suffering with COVID-19 infections. Research is needed to understand the unique features and outcomes of healthcare supply chain and to create evidence to inform the development of best practices.

This paper reports on case study research of the province of Nova Scotia, revealing empirical evidence of supply chain processes and infrastructure within and across this provincial health system during the first two waves of the COVID-19 pandemic. This evidence is analyzed to document leadership approaches and strategies, supply chain capacity to respond to the pandemic, and articulate the implications and key lessons learned for leadership strategies. Together this analysis is offered to inform the design of effective, agile, and responsive pandemic supply management strategies for Canadian health systems. This case study is one of seven provincial case studies (British Columbia, Alberta, Manitoba, Ontario, Quebec, Newfoundland and Labrador, and Nova Scotia), funded by CIHR (Ref. # VR5 172669), that were conducted to examine health supply chain capacity and infrastructure across Canada. This research constituted the first national study of health supply chain. The case study was designed to respond to the following research questions:

- What are the supply chain processes and infrastructure required to optimize effective and timely health services delivery for the current and future phases of the COVID-19 pandemic?
- What procurement models, approaches, and policy frameworks offer secure sourcing of products to meet the surge in demand for care by COVID-19 patients?
- What is the digital maturity of supply chain infrastructure (and processes) in Nova Scotia, that, if strengthened, could optimize management of COVID-19?
- What are the data infrastructure and analytics strategies needed to strengthen the effectiveness of health system supply chain processes to support COVID-19 management?
- What is the influence of federal government initiatives, from the perspective of provincial stakeholders, on provincial health system capacity to manage COVID-19?

Methodology

This case examines the province of Nova Scotia's response to COVID-19, highlighting its unique challenges, opportunities, and experiences in healthcare supply chain management during this unprecedented pandemic. The University of Windsor's Research Ethics Board provided approval for this project. This case was one of seven, as part of a national CIHR Rapid Research program entitled "*Development of an Implementation Framework to Advance Provincial and National Health System Supply Chain Management of COVID-19*." A case study approach was designed to understand Nova Scotia's healthcare supply chain response during the COVID-19 pandemic. Case studies offer a way to explore and investigate real-life phenomenon through analyzing the context of events and the relationships between them.[18] The primary goal of this case study research was to understand the relationships between leadership strategies, key supply chain management strategies and capacity, and health system response across seven Canadian provinces. The primary data source for this empirical study came from 15 semi-structured interviews with 11 key informants. Of these 15 interviews, four were follow-up interviews with key informants. Theoretical sampling was used to identify participants that represented varied perspectives and expertise, including informants from government, healthcare organizations, healthcare supply chain experts, healthcare unions, and public health. Document analysis and previous research informed the conceptual framework and interview guide. Purposeful sampling was used to identify the participants who represented varied perspectives and expertise, including healthcare system leaders (n = 9), healthcare supply chain experts (n = 1), and union leaders (n = 1). Key informants were contacted by email and provided with a participation letter prior to the interview, identifying information about the study and their role and rights as a participant. Interviews were audio recorded using Microsoft Teams and transcribed by a professional transcriptionist. Key informant responses described experiences, perceptions and perspectives on supply chain capacity, processes, and health system responses and supply management during the first and second wave of the COVID-19 pandemic.

Anonymity was ensured through de-identification of participants and data (e.g., removal of any potential identifiers, such as individual or organization names), such that only the researchers conducting the interview were aware of participant identities. Coding of interviews proceeded as data was collected, whereby researchers were able to identify emerging themes and concepts to enable reflexivity as interview data were collected and analyzed. Data analysis software, N-Vivo (version 12) was used to assist with the organization and analysis of semi-structured interview data. The following sections describe the results of the analysis for this case study of Nova Scotia.

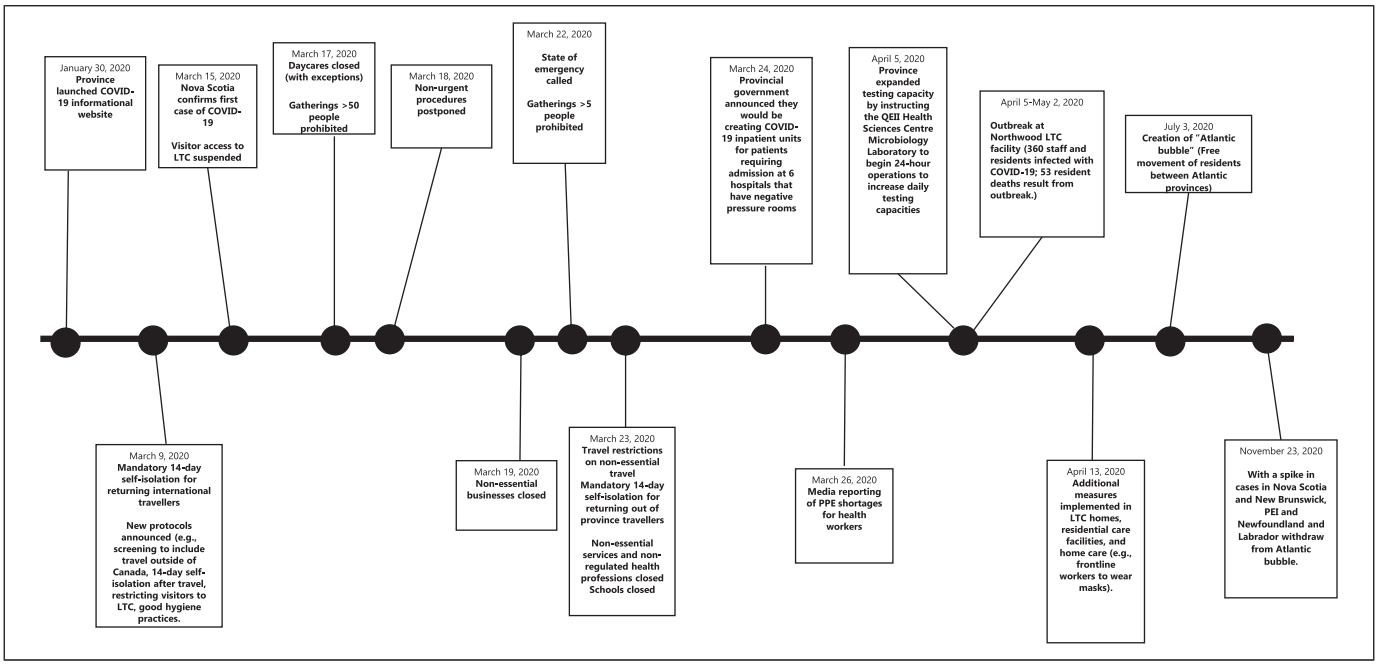

Figure 1. Timeline of Key COVID-19 pandemic milestones in NS.

Provincial context

In Nova Scotia, there are two regional health authorities, Nova Scotia Health (NSH) and the IWK Health Centre (IWK), which are accountable for the delivery of health services across the province. These regional health authorities report to the Department of Health and Wellness (DHW). In 2015, nine district health authorities were consolidated, creating a single health authority (the Nova Scotia Health Authority, which was renamed as Nova Scotia Health) with four regional management zones (Western, Northern, Eastern, and Central).[19] The IWK Health Centre (the IWK), a women and children's hospital, was not included in this amalgamation process and remains a separate corporate entity with its own board of directors.[19]

An existing stockpile of pandemic supplies was in place prior to the COVID-19 pandemic, which was managed by the DHW. However, this pandemic stockpile was not adequate to meet the rapid surge in demand during the first two waves of the COVID-19 pandemic. This lack of adequate pandemic stockpile preparedness was attributed to two key factors: (1) the stockpile was primarily created for the H1N1 pandemic and was therefore insufficient for the scope and scale of the product demand created by the COVID-19 pandemic; and (2) there was no clear strategy to manage the stockpile inventory, resulting in expired and outdated products in the stockpile that were discarded. Accordingly, key informants stressed that this pre-pandemic supply preparedness strategy was not adequate to meet the demands of the COVID-19 pandemic.

Prior to the COVID-19 pandemic, NSH and the IWK had their own distinct supply chain management teams. If healthcare supply chain teams needed to procure a product, they would first engage their contracted vendors to source the product. If their existing vendors could not secure the required product or fulfill a particular supply volume requirement, they would then turn to a Group Purchasing Organization (GPO), which leveraged the aggregate buying power of multiple health organizations to secure the lowest possible product cost from vendors. Established vendor contracts were the cornerstone of their pre-pandemic sourcing of products to support care delivery. Group purchasing organizations were engaged only when supply could not be procured from existing vendor contracts in Nova Scotia. Once the COVID-19 pandemic unfolded, the established system of contracted vendors was destabilized and unable to supply sufficient quantities of products to meet the surge in demand for care.

COVID-19 in Nova Scotia

On March 15, 2020, the first three presumptive cases of COVID-19 were announced in NS.[20] On March 22, 2020, NS declared a provincial state of emergency, and anyone entering the province was required to self-isolate for 14 days.[21] A major outbreak of COVID-19 in the Northwood Long Term Care (LTC) facility occurred in April of 2020 and resulted in 360 people becoming infected (both residents and staff) and the deaths of 53 residents. The deaths in the Northwood outbreak account for just over half of the total deaths due to COVID-19 in Nova Scotia. From May to June of 2020, with a decrease in new cases, Nova Scotia began to relax public health restrictions. In June, its emergency response structure was stood down. On July 3, 2020, residents were free to travel within the Atlantic provinces (Prince Edward Island, New Brunswick, Nova Scotia, and Newfoundland and Labrador), creating what was called the "Atlantic bubble." However, on November 23, 2020, with

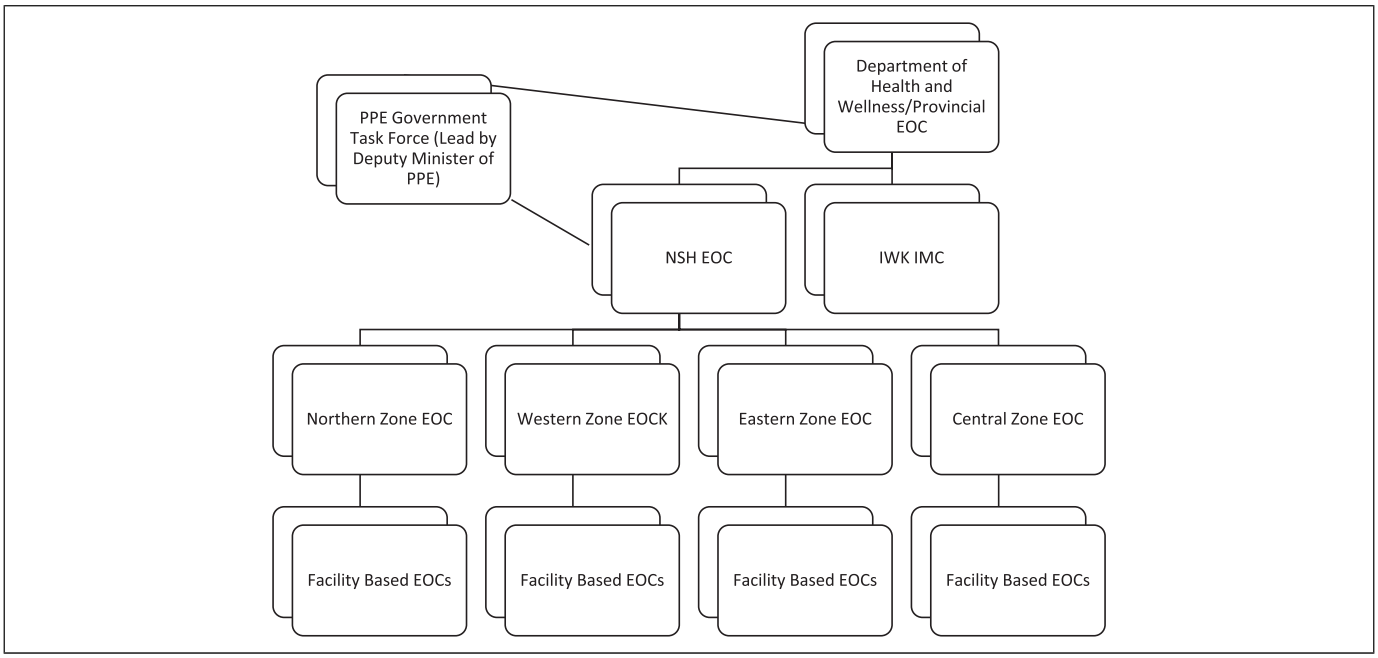

Figure 2. NS COVID-19 pandemic response governance structure.

rising COVID-19 cases in New Brunswick and NS, Newfoundland and Labrador and Prince Edward Island announced their withdrawal from the Atlantic bubble.[22] To date, Nova Scotia has had 6038 cases and 94 deaths due to COVID-19.[23] The key milestones for COVID-19 in Nova Scotia are illustrated in Figure 1.

Emergency governance structures, decision-making, and role clarity in the NS pandemic response

In January of 2020—before the appearance of the first case of COVID-19 in the province—an NSH incident management team began to monitor and prepare for potential cases of COVID-19. To respond to the early waves of the pandemic, Nova Scotia implemented an Emergency Operations Centre structure for both the provincial government (Department of Health and Wellness) and NSH. The IWK engaged its Incident Management Committee (IMC) in mid-February (Figure 2).

The provincial EOC structure was led by the Chief Medical Officer of Nova Scotia. Each of the health authority zones (Western, Northern, Eastern and Central) had their own EOCs that reported into Nova Scotia Health EOC. In mid-February, with the realization that the pandemic would be of significant scope and scale, the IWK mobilized its IMC to manage its pandemic response, which was fully mobilized by March 2020, when the state of emergency was declared in Nova Scotia.

The NS leadership structure was multi-layered and was viewed by some informants to be complex and challenged by communication and lack of role clarity, described in the following:

> *"Role clarity [was an issue from] top to bottom, like between individuals, between departments, between government. In some areas department of health, what's your role here? You know, NSHA, what's your role here? And we had enormous challenges with role clarity right from the frontline all the way through to the top."* (Clinician Leader)

Specifically, communication and decision-making between public health and the health authorities was not well established. Public Health decisions were perceived to be influenced by the perception that PPE was in short supply:

> *"In some situations, I still think Public Health did not implement some protocols as soon as they could because there was still this concern that if we did have an outbreak, that some of those supplies would be eventually needed by the core health system. And it did take us, or there has been a lot of convincing, to say: we're good, we're good, we can consider all of that. We have enough for the doctors and the frontline staff—please go ahead and give out these masks to the public."* (Supply Chain Leader)

Given the cruciality of PPE and the capacity of health supply chain to support responsiveness to the pandemic, a multi-organizational PPE task force was created in early April of 2020, which included members from both the DHW and NSH EOC. This task force was mandated to make decisions on how PPE supplies would be used in clinical settings, assess requests for PPE from care settings, and approve pandemic procurement decisions. Significantly, it was able to provide a provincial lens on health supply chain and PPE issues. A sub-committee of this task force was a PPE assessment group. This PPE assessment group was responsible for assessing the claims for PPE requests from all sectors; they were also responsible for the development of the allocation models necessary to guide decisions on how

PPE and critical products were distributed to the various organizations across the province. The deputy minister leading the PPE government task force was able to support, approve, and take responsibility for the purchasing decisions of NSH healthcare supply chain teams in order to hasten procurement of critical supplies. NSH healthcare supply chain teams were ultimately responsible for all of the pandemic sourcing and procurement efforts across the province.

Following the first wave of the COVID-19 pandemic, a "COVID network" was established to formalize the NS pandemic management and governance response. The COVID network designated clear roles and responsibilities for staff teams who were assigned dedicated duties aligned with managing COVID-19, as described by a supply chain leader in NS:

> *"…with the COVID network it's a persistent, constantly pulsing structure that is already organized and focused on the types of issues needed… So, we've kind of created a more persistent focused network through the COVID network structure, if that makes sense, with people having designated roles and responsibilities."* (Supply Chain Leader)

The leadership structure shifted from a multi-layered EOC structure to a network strategy as the demands of the pandemic shifted and changed over time.

Supply chain centralization and strategy to support pandemic response

During the first wave of the pandemic, the sourcing, procurement, and management of pandemic supply chain needs were *centralized* to the NSH supply chain team. However, this centralization was not immediate. The NSH healthcare supply chain mandate did not initially encompass managing and supporting LTC facilities. Instead, LTC had to access and obtain supplies provisioned by, the provincial stockpile of pandemic supplies, described in the following:

> *"I think when we started, in Nova Scotia, the Department of Health, the government arm … still is the operator and the deliverer of homecare and nursing home services predominantly. They had their own separate stockpile, their own decision-making process, their own supply chain logistics process, separate to NSH."* (Supply Chain Leader)

According to a PPE task force member, there was a gap of three weeks between the implementation of the same policies (including masking protocols) and distribution of the same protective supplies to LTC facilities as were provided to acute care hospitals.

The initial approach of the NSH EOC was to prioritize the distribution of critical supplies to hospitals, a strategy that was motivated, at least in part, by media reports from Italy of hospital systems being overwhelmed by patients with COVID-19 and unable to mobilize products to support care delivery. However, the largest COVID-19 outbreak in Nova Scotia took place in the Northwood LTC facility. A review of the COVID-19 outbreak at the Northwood LTC facility—led by government appointed infectious disease consultants—suggested critical staff shortages, difficulty isolating COVID-19 positive patients to mitigate the risk of transmission of the virus, and a lack of access to Infection Prevention and Control specialists, were contributing factors to this major outbreak.[24] All pandemic supply management was eventually centralized to the NSH healthcare supply chain, resulting in a more proactive and equitable supply management strategy that worked to support all healthcare facilities in the province. The integration of LTC into supply chain management was a critical lesson learned from experience during the first wave of the pandemic:

> *"Business, industry, healthcare, LTC, everybody gets their PPE from one group. And it's a group that advise and oversee this one giant stockpile. So, and what that resulted in, in wave 1, is that the nursing homes and LTC, we were late deciding to mask them, deciding on policies to protect them, the things you put in place in hospital, we were 3 weeks getting the same policy and procedures and gear out to the nursing homes and that killed us. That was the biggest problem. So, wave 2 starts, we've got fit testing in nursing homes, on the same day we've got fit testing in endoscopy and departments we're worried about in acute care."* (Clinician Leader)

Sourcing strategies. Supply shortages were a challenge well before the first case of COVID-19 was confirmed in Nova Scotia. However, as the pandemic unfolded globally, supply chain teams set out to source and procure critical supplies in order to build capacity to respond to anticipated cases of COVID-19. In February, NSH supply chain leaders sent out what they called "pulse buys"—like a radar pulse—doubling their orders with their traditional vendors to determine which products would be the most difficult to source and procure. Through these pulse buys, it became immediately apparent to healthcare supply chain leaders that the contracted providers or vendors would not be able to meet the surge in demand across the health system for some critical products. Alongside the destabilization of the traditional health supply chain, a source of uncertainty for NS health leadership was the Federal health supply chain. A clinician leader described how two factors compromised the reliability of the Federal health supply chain during the first wave of the pandemic: (1) a lack of product; and (2) a lack of visibility to the Federal supply:

> *"So [they were] useless at first because they [the Federal government] didn't have much to give. Really hard to nail them down on what they might be able to source and supply, so they were not on our radar at all, like they were, we rank our orders, they never became a low risk order. They were always like we don't know, we can't count on it."* (Clinician Leader)

> *"From a procurement and supply [perspective], we did not use the feds supply very much at all. Definitely not at all early because they didn't, we had no visibility and no ability to figure out how we might get it [supplies], when we might get it, etc."* (Clinician Leader)

Accordingly, NSH health supply chain teams quickly realized that additional strategies to procure critical supplies would be required in order to have the capacity to supply critical products to healthcare organizations. The limited supply available to meet the surge in demand for critical products forced NSH health supply chain teams to rapidly modify their procurement processes to be more responsive and agile in sourcing products, a process described in the following:

> *"During COVID, we agreed that during the emergency measures period that we were in, and the need to react quickly and leverage non-traditional channels, we still in principle followed [our traditional operational design], so first we would try to get everything we need off a [GPO] contract, which we did try to do, but then ... we found that most of the vendors that we were dealing with through contracts were the traditional mainline vendors and they didn't have a lot of extra capacity to provide supply. So, then, rather than sending the requirement to Nova Scotia government procurement, we [the healthcare supply chain team] executed whatever dollar amount was necessary [to purchase large volumes of products], because we had the most intimate understanding of what the requirements were and were able to be agile and make those arrangements quickly."* (Supply Chain Leader)

When seeking out alternative sources of products, vendors with a physical presence in NS, or NS-based importers were prioritized by healthcare supply chain teams in order to more directly engage with the new vendor to ensure product delivery. To mitigate the risk of further supply chain destabilization, health supply chain teams also placed multiple orders to multiple vendors for the same product, and attempted to identify product sources in multiple geographic regions. Instead of "putting all of their eggs in one basket," as a supply chain leader put it, they placed orders with multiple vendors, to ensure that multiple vendors would be working on their behalf to secure products from suppliers. They also attempted to identify product sources in multiple geographic regions, under the assumption that the diversification of geographic sources of products would help to mitigate the risk of further supply chain destabilization (in the event, for example, that a region closed its borders). In this diversified procurement strategy, if three of their familiar vendors—vendors that they had done business with before—could fulfill an order for a product, then the fourth vendor "slot" would be filled by an "unfamiliar" vendor. They would solicit samples from four or five of these unfamiliar vendors; the first vendor to provide a sample would be awarded the contract.

This rapidly diversified sourcing strategy successful for Nova Scotia. A supply chain leader described Nova Scotia as a "Goldilocks province," one ideally suited for the cultivation of a domestic manufacturing capacity:

> *"Nova Scotia is a Goldilocks province because we're just barely big enough to try to do things in an organized way, but we're not too big that trying to do things in an organized way creates impossible problems to solve and too many stakeholders to corral. So, for example, on gowns, we were able to convert a factory that existed for t-shirts to make gowns, and we only had to convert one because we're not too big, and that one factory was able to produce as many gowns as we needed. We were able to get all of the hand sanitizer we needed from regional production from distilleries and private sector, and we were able to do that again because we're not too big. The capacity that already existed was willing to shift."* (Supply Chain Leader)

However, in order to alleviate pressures on especially scarce critical products, like N95 respirators, Nova Scotia also implemented allocation and conservation strategies to conserve product inventories as much as possible.

Supply conservation. Nova Scotia implemented allocation frameworks to control access to critical supplies by limiting the use of PPE to specific clinical situations. The PPE subcommittee of the PPE government task force was responsible for the development of these allocation models. The scarcity of N95s and a lack of up-to-date fit-testing among the healthcare workforce required supply inventory of multiple different sizes of N95s to fit test each staff member. Each employee in health organizations were required to be fitted for the appropriate N95 mask. Once a mask was used for fit testing, it had to be discarded. Accordingly, supply chain teams had to source N95s for fit testing as well as sufficient inventories to support infection control protocols. This was explained by a supply chain leader:

> *"For the first month I'd say and that was a challenging dynamic because you're trying to acquire N95s and you always have to factor in the fit testing you know, time it takes to fit test, the quantity it would take to fit test, it doesn't help to get a small quantity of N95s. You really have to get enough that you have enough to fit test and then consume for a reasonable period. So that was more the pressure on N95s at the outset."* (Supply Chain Leader)

> *"The testing wasn't up to date for a lot of staff, staff weren't fit tested across the board always to the kinds of models that we could provide, and so we actually used more N95s for fit testing than we did for COVID-19."* (Supply Chain Leader)

To limit access for N95 masks, supply chain teams removed them from clinical areas that were determined to not require the use of these masks based on the care procedures required in each setting. By sequestering the N95s (and other critical supplies) to a centralized warehouse, Nova Scotia supply chain teams were then able to allocate and monitor product usage. The implementation of conservation strategies had a tremendous impact on the mental wellbeing of frontline healthcare workers due to perceived lack of safety in the workplace, which was a source of anxiety and uncertainty for the frontline workforce. A Nurse leader described nurses' concerns about access to PPE:

> *"We had hundreds and hundreds of calls from nurses, mostly concerned about PPE. We had a lot of calls from nurses that maybe are immunosuppressed or they were caring for a senior in their home or they had young children and so there was a loss of, a great deal of anxiety and fear in the first I'd say two months because of the unknown, right. And there was so many changes, like we didn't wear masks, then we did wear masks and you had shields, so there was changes almost every other day in what the PPE*

requirements would be. So that created a lot of angst as well." (Clinician Leader)

Nursing unions advocated for nurses to have access to N95s when caring for all COVID-positive patients. They also advised their nurses to request N95s if warranted, following a point-of-care risk assessment. PPE usage guidelines, however, restricted the usage of N95s to aerosol generating medical procedures, which primarily take place in acute care settings. Allocation measures therefore limited the ability of nurses to exercise their clinical judgement in the use of protective products. To redress this diminishment of professional autonomy, nurses' unions advocated for a memorandum of understanding with the government to allow nurses to make decisions to determine the use of protective products in clinical settings. However, this strategy was unsuccessful. According to one supply chain leader, a supply "conservation mindset" extended well into the second wave of the pandemic and continued to shape the pandemic supply management response, even as supplies stabilized:

"What's really interesting now though is, we have an abundance of N95s now, but we're still holding firm on those same principles as we did back at the very beginning, so we're still behaving in a conservation mindset." (Supply Chain Leader)

Despite the success of the team's sourcing strategies, conservation of PPE supplies remained in place long after supply inventories were restored and were able to respond to the demand surge in supply utilization. A conservation mindset towards supply distribution continued throughout the early waves of the pandemic across Nova Scotia.

Domestic sourcing. Another supply chain strategy that NS employed to help to stabilize its supply inventories was sourcing from local manufacturers. A notable example was the retooling of a local garment manufacturing company, which pivoted to manufacturing medical gowns. Local manufacturers quickly established a local manufacturing capacity focused on protective products or equipment to support the Nova Scotia health system. The capacity for local manufacturing to support the demand for domestic sources of protective products is described in the following by a healthcare supply chain leader:

"I could tell you for hand sanitizer over 90 % was domestic. For gowns I'd say about 50% was domestic. For shields probably 60% was domestic. For gloves zero. And for face masks zero. And on the whole that probably means about 30-40% was domestic." (Supply Chain Leader)

Local production of protective equipment became an important source of supplies offering a buffer against the challenges of sourcing, evaluating, and securing globally manufactured products.

Data infrastructure and modelling

At the onset of the pandemic, Nova Scotia lacked a robust data infrastructure, which resulted in decision-makers and supply chain teams having to estimate the rate of utilization of protective products such as PPE, the locations (e.g., clinical settings and health organizations) where products were most needed, and the degree of urgency of product demand. To overcome this lack of data visibility, the manual counting of products in each health organization was required to understand utilization rates. To overcome the inaccuracies of manual counting, the supply chain team elected to monitor and track daily orders for products as a surrogate for product utilization rates. Tableau software was used to create a dashboard of daily orders of supply volumes as an estimate of supply demand and utilization rates across the province. The limitations of supply volume estimates in inventory and utilization rates across the province remained a challenge throughout the pandemic.

Pandemic stockpile strategy. A decision—approved by the government—was made by healthcare supply chain leaders in Nova Scotia to create the warehousing capacity and pandemic supply stockpile necessary to address province-wide supply needs. As a supply chain leader explained, this pandemic stockpile required the digital infrastructure to incorporate non-HA customers:

"We got [the] infrastructure and IT technology so that we could serve any customer regardless of whether they were private sector or public sector through a common technology platform, which would have been previously impossible with our normal ERP system. So, we built all the underlying enablement." (Supply Chain Leader)

The creation of digital tools enabled a more data-driven supply chain strategy, which included data modelling to examine various scenarios or "what if" situations. Data and digital infrastructure made it possible for the team to take a more proactive approach to planning for a variety of possible events, such as surge in demand for critical products. This was described by the same supply chain leader:

"When we model our requirements, we model them under circumstances where protocols that don't even exist could possibly exist. So, we are trying to foresee demand from places that we, I guess looking at what other jurisdictions have done around the world, we ask ourselves a question: what if we did that here, even if it's not potentially on the radar here, just in case at some point our leadership decides they would like to do that too? And so, we are still scanning the environment. We are still including demand in our modelling which then feeds our procurement strategy for things that are currently not taking place here to try to anticipate and be ready. And for N95s as the example, we continue to and have been procuring well above the quantity that our current conditions or any you know, reasonably foreseeable set of circumstances would predict we'd require. So, we are still trying to always not be, I guess, a challenge from an implementation perspective." (Supply Chain Leader)

Although digital infrastructure in Nova Scotia was not well developed prior to the onset of the pandemic, supply chain teams created the dashboard tools and data analytics capacity necessary to mobilize existing data. This enabled proactive

modelling to anticipate demands for products and ensure that their healthcare supply chain could readily respond to and adequately support public health directives.

Conclusions and implications for health leaders

The COVID-19 pandemic has revealed the critical strategic importance of healthcare supply chain management and processes for supporting care delivery. Healthcare supply chain destabilization can greatly compromise the ability of healthcare systems to deliver care. At the same time, measures to prioritize the allocation of critical products and conserve product inventories during supply shortages, can result in the inequitable distribution of supplies, negative outcomes for the health workforce, and put at risk vulnerable populations, such as residents of LTC facilities. Drawing on the LEADS in a Caring Environment framework (LEADS),[25] the Nova Scotia case study makes clear two key implications for health leaders:

1. The importance of integrating healthcare supply chain expertise into leadership decision-making

Although healthcare supply chain teams in Nova Scotia felt supported by health leadership, a lack of communication between senior decision makers and healthcare supply chain teams led to a delay in the implementation of critical public health policies, due to the perception of supply shortages. That is, decisions on public health measures to mitigate the risk of transmission of the virus were viewed as being influenced by supply capacity. In this case, the assumption made by health leaders of an absence or limitation of supply—at times influenced leadership decision-making and extended the use of conservation measures long after supply shortages were overcome and inventories were replenished. The establishment of clear lines of communication between senior health leadership and healthcare supply chain teams support greater collaboration in decision-making, informed by supply chain data and capacity to respond to support implementation of leadership decisions.

2. Systems transformation: Provincial supply chain connectivity for supply equity

If supply chain management is a critical enabler of a health system's capacity to deliver care, then healthcare supply chain processes must be equitable and inclusive to ensure all care delivery organizations are supported to deliver care effectively and safely. A lack of digitally enabled supply chain infrastructure in Nova Scotia led to a delay in providing critical products to LTC. Health leadership prioritized hospitals, with only manually collected data on supply inventory to inform decisions. A sufficiently connected and engaged healthcare supply chain strategy, which is inclusive of all care delivery organizations, would allow for the equitable distribution of critical products. In Nova Scotia, after this initial delay, a more comprehensive and inclusive supply chain strategy was augmented by digital tools, which were able to estimate supply utilization patterns to inform decisions on product distribution. Data and digital tools transformed supply chain processes and informed leadership decisions to enable a proactive supply management approach for LTC and the integration of all care delivery organizations into a centralized healthcare supply chain strategy across the province. Healthcare leaders are uniquely positioned to mobilize resources to advance digitally enabled supply chain processes to manage and ensure the equitable distribution of critical products necessary to protect Canadians and the health workforce. The Nova Scotia case clearly demonstrates the value of a digitally enabled supply chain strategy that offers health systems the capacity to respond proactively to critical shortages and ensure the safe and effective care delivery for every citizen. Health leaders should consider the ways in which care delivery depends upon healthcare supply chain resilience and connectivity—upon a supply chain that can provide equitable and comprehensive access to essential supplies.

The COVID-19 pandemic has exposed the cruciality of a connected and digitally enabled healthcare supply chain that is supported and informed by data to accurately track utilization and supply chain capacity to meet demands for health services. Nova Scotia diversified its sourcing and procurement of critical medical products by placing multiple orders with multiple vendors, and balanced its procurement strategy with a domestic supplier strategy to offset global shortages. At the same time, the Nova Scotia healthcare supply chain experience during COVID-19 makes clear the necessity of a supply chain that encompasses and equitably distributes products to all care delivery organizations within a province. These key features of the Nova Scotia strategy offer important evidence to inform strategies to advance supply chain resilience in the post-pandemic future.

Funding

This article is financially supported by Canadian Institutes of Health Research (VR5 172669).

ORCID iD

Anne W. Snowdon https://orcid.org/0000-0003-4640-6842

References

1. Snowdon A, Alessi C. *Visibility: The new value proposition for health systems*. World Health Innovation Network; 2016. Available at: https://scanhealth.ca/explore-projects-resources/view-all-articles/89-visibility-the-new-value-proposition-for-health-systems-condensed-version
2. Wong JC. Hospitals face critical shortage of IV bags due to Puerto Rico hurricane. *The Guardian*. 2018. Available at: https://www.theguardian.com/usnews/2018/jan/10/hurricane-maria-puerto-rico-iv-bag-shortage-hospitals
3. Mostafid AH, Palou Redorta J, Sylvester R, Witjes JA. Therapeutic options in high-risk non-muscle-invasive bladder cancer during the current worldwide shortage of bacille Calmette-Guérin. *Eur Urol*. 2014;67(3):359-360. doi:10.1016/j.eururo.2014.11.031

4. Low DE. SARS: Lessons from Toronto. In: Knobler S, Mahmoud A, Lemon S, Mack A, Sivitz L, Oberholtzer K, eds. *Learning from SARS: Preparing for the Next Disease Outbreak: Workshop Summary*. Washington: National Academies Press; 2004:63-83.
5. Smith PM, Oudyk J, Potter G, Mustard C. The association between the perceived adequacy of workplace infection control procedures and personal protective equipment with mental health symptoms: a cross-sectional survey of Canadian health-care workers during the COVID-19 pandemic: L'association entre le caractère adéquat perçu des procédures de contrôle des infections au travail et de l'équipement de protection personnel pour les symptômes de santé mentale. Un sondage transversal des travailleurs de la santé canadiens durant la pandémie COVID-19. *Can J Psychiatry*. 2021;66(1):17-24. doi:10.1177/0706743720961729
6. Abdulsalam Y, Gopalakrishnan M, Maltz A, Schneller E. Health care matters: supply chains in and of the health sector. *J Bus Logist*. 2015;36(4):335-339. doi:10.1111/jbl.12111
7. Landry S, Beaulieu M. The challenges of hospital supply chain management, from central stores to nursing units. In: Denton B, ed. *Handbook of Healthcare Operations Management*, Vol. 184. New York: Springer; 2013:465-482. doi:10.1007/978-1-4614-5885-2_18
8. Rickles H. The mysterious case of healthcare logistics. Paper presented at: AHRMM Annual Conference, Setting the Standard. 1999; San Francisco.
9. Ebel T, George K, Larsen E, Shah K, Ungerman D. *Building a New Strength in the Healthcare Supply Chain*. McKinsey & Company; 2013. Available from: https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/pharma%20and%20medical%20products/pmp%20new/pdfs/mckinsey%20white%20paper%20-%20building%20new%20strenghts%20in%20healthcare%20supply%20chain%20vf.pdf. Accessed September 1, 2021.
10. Kwon I-WG, Kim S-H, Martin DG. Healthcare supply chain management; strategic areas for quality and financial improvement. *Technol Forecast Soc Change*. 2016;113(part B):422-428.
11. Dixit A, Routroy S, Dubey SK. A systematic literature review of healthcare supply chain and implications of future research. *Int J Pharm Healthc Mark*. 2019;13(4):405-435. doi:10.1108/IJPHM-05-2018-0028
12. Gendy AWA, Lahmar A. Review on healthcare supply chain [conference paper]. Paper presented at: IEEE/ACS 16th International Conference on Computer Systems and Applications (AICCSA). November 3-7, 2019; Abu Dhabi:1-10. doi:10.1109/AICCSA47632.2019.9035234
13. Kumar S, Blair JT. U.S. healthcare fix: leveraging the lessons from the food supply chain. *Technol Health Care*. 2013;21(2):125-141. doi:10.3233/THC-130715
14. Arshoff L, Henshall C, Juzwishin D, Racette R. Procurement change in Canada: an opportunity for improving system performance. *Healthc Manage Forum*. 2012;25(2):66-69. doi:10.1016/j.hcmf.2012.03.002.
15. Aldrighetti R, Zennaro I, Finco S, Battini D. Healthcare supply chain simulation with disruption considerations: a case study from Northern Italy. *Glob J Flex Syst Manag*. 2019;20(1):81-102. doi:10.1007/s40171-019-00223-8
16. Mandal S. The influence of organizational culture on healthcare supply chain resilience: moderating role of technology orientation. *J Bus Ind Mark*. 2017;32(8):1021-1037.
17. Snowdon A, Saunders M. COVID-19, workforce autonomy and the health supply chain. *Healthc Q*. 2021;24(2):16-26.
18. Yin RK. *Case study research: Design and methods*. 4th ed. Thousand Oaks, CA: Sage; 2009.
19. Fierlbeck K. *Nova Scotia: A Health System Profile*. Toronto: University of Toronto Press; 2018:31-33.
20. *News release: First Presumptive Cases of COVID-19 in Nova Scotia; New Prevention Measures*. Nova Scotia. Published March 15, 2020. Available at: https://novascotia.ca/news/release/?id=20200315002. Accessed September 1, 2021.
21. *News release: State of Emergency Declared in Response to COVID-19, Seven New Cases*. Nova Scotia. Published March 22, 2020. Available at: https://novascotia.ca/news/release/?id=20200322001 Accessed September 1, 2021.
22. Grant T. As COVID-19 Cases RISE, N.L. and P.E.I. Exit Atlantic Bubble for at Least 2 Weeks. *CBC News*. Updated November 24, 2020. Available at: https://www.cbc.ca/news/canada/nova-scotia/atlantic-bubble-burst-1.5812454. Accessed September 1, 2021.
23. *Nova Scotia COVID-19 Dashboard*. Government of Nova Scotia. Updated September 1, 2021. Available at: https://experience.arcgis.com/experience/204d6ed723244dfbb763ca3f913c5cad. Accessed September 1, 2021.
24. Eggertson L. *Review Uncovers Fatal Flaws in Long-Term Care Infection Control*. CMAJ News. Published September 22, 2020. Available at: https://cmajnews.com/2020/09/22/covid-northwood-1095899/. Accessed September 1, 2021.
25. Dickson G, Tholl B. *Bringing Leadership to Life in Health: LEADS in a Caring Environment Putting LEADS to Work*. 2nd ed. Cham: Springer; 2020. doi:10.1007/978-3-030-38536-1