Digitalization Initiatives of Home Care Medical Supply Chain: A Case-Study-Based Approach

Martin Beaulieu, Omar Bentahar, Smail Benzidia, and Angappa Gunasekaran

***Abstract*—The exceptional COVID-19 crisis has shown the fragility of the health supply chain and the need for its digital transformation. However, digitization initiatives for healthcare supply chain have focused mainly on the hospital as a central point of consumption as well as on the relationship between the hospital and its suppliers. Thus, unlike previous studies that have focused on the digitalization of the internal supply chain of hospitals, this article is centered on the digitalization of external trajectories, particularly, the home care medical supply chain. This perspective complements the hospital-centric model, in which logistics activities are analyzed only from the point of view of the focal actor, which is the hospital. In order to understand this contemporary phenomenon embedded in a local context, we have conducted an in-depth case study. Based on an enriched model of the digital supply chain developed by Queiroz et al. (2021), this article offers for the first time a deep understanding and digitalization initiatives of the home care medical supply chain. The research proposals can guide logistics managers and nurses on their initiatives of digitalization of the home care medical supply chain, and further strengthen the healthcare development. This article draws the attention of healthcare stakeholders to the importance of efforts in the digitalization of external trajectories, thus allowing the healthcare system to adapt to the growing needs of elderly people and people with physical or mental disabilities.**

***Index Terms*—Digitalization, healthcare, home care, medical supply chain, technology.**

I. Introduction

THE COVID-19 pandemic has brought the importance of home care activities in the effective delivery of health organizations to the forefront. In many countries, these services compensated for the lack of hospital resources that were then monopolized to provide care to the population with severe symptoms of COVID-19 [1]. Also, in many countries, such as the United States, Canada, France, Spain, and Belgium, a significant proportion of deaths attributable to COVID-19 consisted of residents of seniors' centers [2]. This finding has led to a reconsideration of this care organization. Thus, these two phenomena are combined:

1) to prevent the patient's recovery phase following a medical intervention from being systematically carried out in a hospital center;
2) to be able to assist the elderly so that they can remain in their environment as long as possible [3].

Under these conditions, the demand for home care services will increase in the coming years [4], [5].

Based on the aforementioned, home care can involve a variety of activities [6]. Some of these activities may require medical supplies to accompany the provision of patient care. Over the past 40 years, the healthcare sector medical supply chain has been modeled or compared to what has been done in the mass distribution sector such as food or retail [7], [8]. However, the needs of home care introduce a new distribution model that could be guided by developments in e-commerce, which is characterized by the atomization of deliveries, as opposed to bulk-based chain [9]. Precisely, Whitehead and Frazier [10] recommended that healthcare supply chain managers draw inspiration from e-commerce practices to improve the performance of their supply chain. Along the same lines, healthcare supply chain experts recognize the challenges of this adaptation [11].

E-commerce relies on information technology, which is also a foundation for supply chain management [12], [13]. In recent years, a series of innovations in the field of information technology (blockchain, big data, Internet of Thing, artificial intelligence, cloud computing, etc.) have been embodied under the term digitalization. Du et al. [14], Queiroz et al. [15], Teubner and Stockhinger [16], and Zekhnini et al. [17] point out that the concept of the digital supply chain is emerging, and in this sense, there are developments of framework for its implementation. This study pursues the following research question: how can the medical supply chain of home care activities be digitalized? By selecting the healthcare sector, this study diversifies the research in the field of supply chain digitalization that is often focused on the manufacturing sector [18], [19]. Kim and Lee [20] produced a study on the impacts of the digitalization of the healthcare supply chain, but focused only on its manufacturers, and not on the downstream activities surrounding care delivery. Studies of the supply chain in the healthcare sector have increased since the mid-1990s [69]. Often, this research centers on hospital logistics [21], [87]. The recent literature review by Ali and Kannan [70], which does not mention home care as a research area, confirms this trend. There is, therefore, a theoretical gap to be filled by a better understanding of the home care medical supply chain based on an enriched conceptual model of supply chain digitalization.

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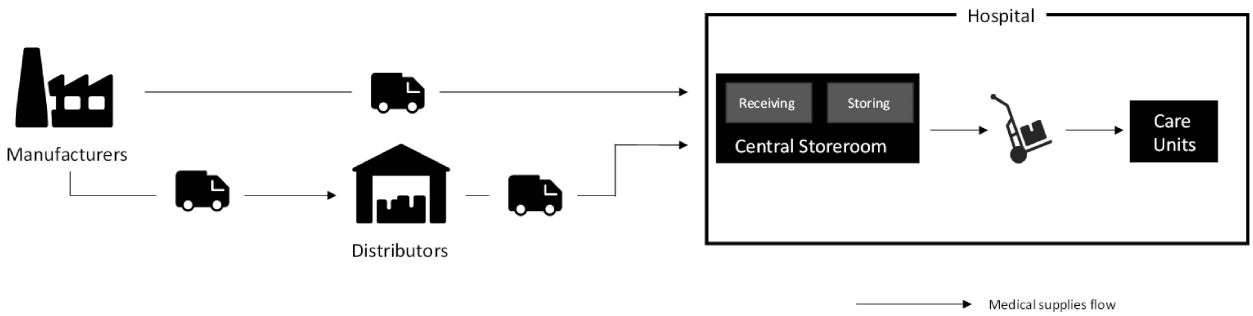

Fig. 1. Healthcare supply chain.

In the literature review, we will specify the characteristics of the healthcare supply chain as well as the parameters of the analysis model of digitalization initiatives. The second part will present the details of the chosen methodology. The case study will be privileged given the emerging nature of the research topic [22]. This is a coherent choice given the early stage of theoretical developments in the topic of supply chain digitalization [17]. We then present our case study. The discussion will allow us to offer digitalization propositions in light of the studied experience. Finally, the conclusion will be an opportunity to formulate future research directions.

II. Literature Review

The literature review is divided into two parts. The first part presents the characteristics of the health care supply chain. Care delivery requires a diversity of products where medical supply (glove, needles, syringes, swabs, etc.) is a critical input [23]. This presentation will be an opportunity to capture the particularities of this supply chain compared to other settings. This presentation will focus on the logistical needs of the hospital, which is the main focus of this supply chain research [21], [24]. The second part will offer a definition of the concept of digitalization in the context of the supply chain. This subsection will develop an analytical framework to analyze possible solutions to digitalize the medical supply chain of home care.

A. Characteristics of the Healthcare Supply Chain

Fig. 1 provides a general view of the supply chain for medical supplies. To meet its medical supply needs, a hospital may deal with manufacturers, but more generally with distributors who often play an integrator role in order to simplify the distribution network [25]. A healthcare facility may purchase 8000 to 10 000 different medical supplies [26].

The delivery of medical supplies to the healthcare facility does not complete the distribution circuit, as this stock should be transported within the hospital to the care unit, or the final point of consumption. Each care unit has a stockroom that may contain from 200 to 400 different types of medical supplies [27]. A hospital will have about 30 main service points. Major hospitals generally have a warehouse, a distribution center, or a central storeroom (in the latter case, in the hospital building) that interfaces between supplier deliveries and distribution to the care units. This central storeroom receives and stores large quantities of products in bulk. Depending on expressed needs, logistics staff at this central storeroom will unpack received products to pick different supplies in smaller volumes that better meet the needs of the care units [28]. The frequency of replenishment of a care unit varies according to its activity, from once a week to every day. The volume of supplies restocked can range from a dozen, to 40 product codes [27]. In addition to this official stock, the hospital may contain unofficial inventory containing materials that will only be known to a few people [29]. Over the past 40 years, there has been a trend toward minimizing the intervention of health care staff in the internal distribution process, and a shift to logistics staff [30].

With its large volumes of transport and different storage points, this chain has the characteristics of make-to-stock supply chains [31]. In response to clinical home care services, distributors have developed more personalized services to be able to make deliveries right to the patient's home. These distributors have adapted their picking areas for smaller quantities and their transport network. Such a service also requires new skills for monitoring patient needs [32]. The latter chain has more of the characteristics of an assemble-to-order supply chain [31]. According to our observations, there is very little research dealing with this specific healthcare supply chain.

Still, surveys highlight that healthcare supply chain costs are among the highest compared to other sectors [8]. In fact, studies confirm stagnation in improving practices and performance [33]. A recent survey shows that in North America, the costs of this supply chain could not be compressed over the last 20 years [34]. For Beaulieu and Bentahar [21], Snowdon et al. [35], and Srivastava et al. [36], one of the causes of this underperformance is a delay in adapting advanced information technologies and proactively exploiting the mass of information associated with product use. In this sense, a shift toward the digitalization of this supply chain could be an avenue for improvement.

B. Ramifications of the Concept of Digitalization

For Harold et al. [37], the concept of supply chain digitalization has its origins in previous waves of technological developments in the field of information technology: electronic data interchange (EDI) or the automation of certain warehousing activities in the 1960s and 1970s, the emergence of enterprise

resource planning (ERP) and warehouse management system (WMS) from the 1970s to the mid-2000s, and more recently, big data or the Internet of Things. This transition is also taking place in organizations where processes are moving from manual logic to more advanced automation [38]. In addition to the technologies mentioned previously, some authors add cloud computing, artificial intelligence, blockchain, augmented reality, social media, 3-D printing, advanced robotics, and drones as manifestations of digitalization [39], [40].

All these developments could translate the concept of supply chain digitalization into a simple collection of disparate technologies. To this end, we take up the words of Queiroz et al. [15 p. 1764] who consider the contours of the digital supply chain still unclear, but who derive this definition: "an intelligent best-fit technological system that is based on the capability of massive data disposal and excellent cooperation and communication for digital hardware, software, and networks to support and synchronize interaction between organizations by making services more valuable, accessible and affordable with consistent, agile and effective outcomes." This definition has many implications. It refers to technologies to harness a mass of data, but as Teubner and Stockhinger [16] discuss, digitalization goes beyond information technology, there is the ability for the organization to harness this data to support its daily operations or to evolve it. Following this logic, Han et al. [41] talk about technology solutions, features that will enable data acquisition, data fusion, and decision support. For Han et al. [41], these three functionalities should be deployed sequentially, after all, the lack of information sharing becomes a barrier to digitalization. Thus, data acquisition aims to collect information that will feed the different systems. Data fusion aims at integrating information from different sources in order to get more value out of it. Finally, the data-driven decision making functionality aims to extract information that will improve the various dimensions of the supply chain performance. These three functionalities further push the foundations of the supply chain management, which are based on an integration of the information flow associated with the movement of products [12], [13], [42]. The definition offered speaks of agility, it would be embodied on two axes: releasing organizational flexibility in order to respond to the volatility of the environment [40], [41], and the personalization of customer service [43], [44].

Since technology is embedded in an environment, there may be different barriers to digitizing the supply chain. In this sense, Molinillo and Japutra [47] evoke institutional theory as a framework to understand digitalization projects. The organization has its own history, which is composed of rules and norms that may create paradoxical tensions [48]. The institutional theory would have two implications [49]: first, this social fabric can create a form of organizational inertia that will limit the adaptation of the structure. Second, it can lead a function to imitate the actions taken by another organization.

These barriers seem to be more significant in the case of logistics activities in a healthcare institution. Su et al. [71] have underlined the difficulty faced by healthcare establishments in implementing logistics innovations despite these changes' having improved performance in other sectors of activity. This situation explains the delay of many hospitals in applying best logistics practices [72] or in implementing advanced information technologies to manage the supply chain [21]. Zheng et al. [73] have shown that the top management of the hospital has other organizational priorities that do not allow them to appreciate all of the benefits resulting from technological investments in logistics activities. Other studies have highlighted hospital senior management's general lack of interest in logistics activities [74]. This conflict of priorities between clinical and logistical operations was also highlighted in the study of Kwon and Kim. [75]. Adebanjo et al. [76] have demonstrated that the implementation of logistics initiatives in hospitals would be facilitated if the needs of clinical clients were integrated into these efforts. On this point, Mandal [77] has specified that the benefits for the patient should be addressed in logistics projects.

Furthermore, the digitalization of healthcare can be constrained by the cost approaches of technological projects [78] and the lack of behavioral and technological-related competencies [51]. Contingency factors can also influence the adoption of healthcare supply chain digitization technologies. For this purpose, the study by Tortorella et al. [79] demonstrated how hospitals ownership, age, size, and functionalities affects the adoption of healthcare 4.0 technologies. The findings in their study highlight, for example, that teaching's hospitals are less favorable for healthcare digitalization.

Based on the aforementioned, in Fig. 2, we propose a model that links the technology, information, and organizational components. This model is inspired by the work of Queiroz et al. [15] whose initial model had two components: basic supply chain capabilities and enabler technologies. We have enriched this model by different constructs. Indeed, the basic capabilities of the supply chain can be consolidated by some functionalities proposed by Han et al. [41]. We, therefore, see these functionalities at the interface between digital supply chain capabilities and enabler technologies. Finally, the institutional theory, includes not only technological enablers, but also organizational enablers that we have integrated in the proposed model.

Zekhnini et al. [17] have found that the concept of the digital supply chain lacked a roadmap for its implementation. A roadmap becomes a guide to support the success of such digitalization initiatives Chae et al. [50], Kim and Lee [21], while moving towards a digital supply chain may imply a deep transformation of the organization's processes [44]. There is, therefore, a twofold research opportunity. First, the home care supply chain, which has been the subject of little research work, is an opportunity to diversify the traditional contexts for studying supply chain digitalization [17], which are often industrial sectors [43]. Second, such a study would explore the application of the proposed model and answer the research question: how can the medical supply chain of home care activities be digitalized?

III. Methodology

Since the concept of digitalization is still in its early stages of development [15], [51], it is relevant to use an in-depth case study as the main research methodology [19]. Furthermore, given the nature of the research question, which centers on

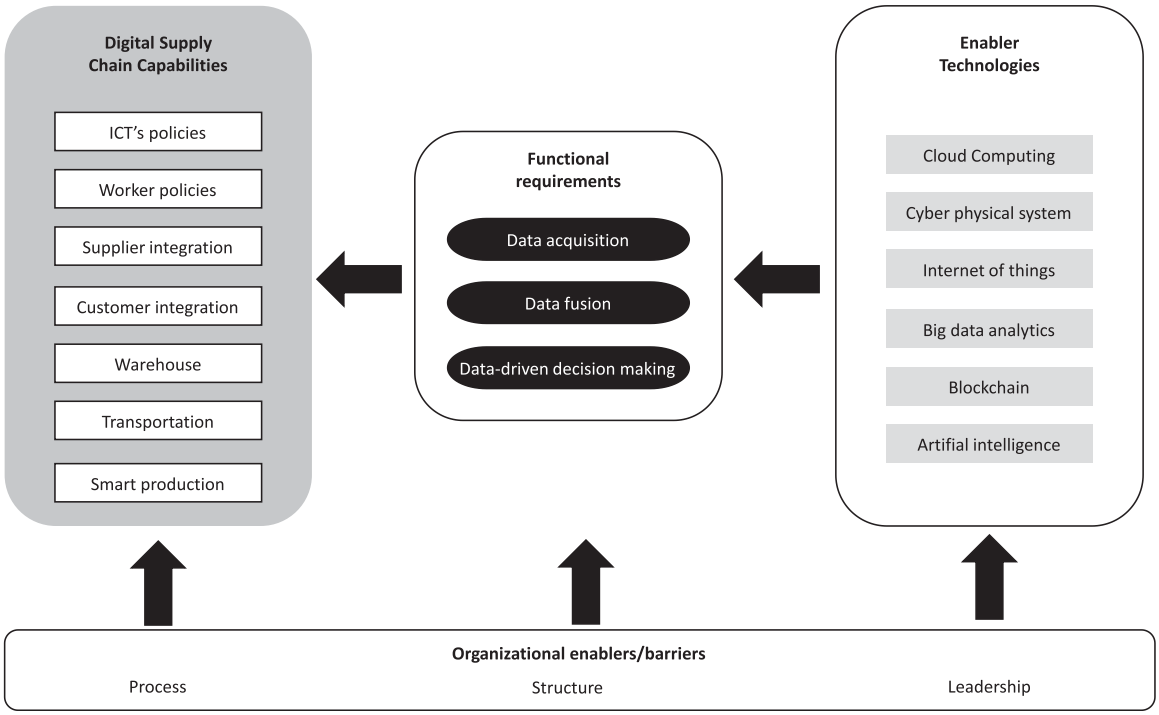

Fig. 2. Analysis model for digital supply chain initiatives.

understanding a phenomenon, the case study is an appropriate research methodology [22].

The case study has been conducted as part of a collaborative approach between researchers and practitioners. Indeed, the research team has been invited in the spring of 2021 by the logistics department of a healthcare institution to support their efforts to improve the material management processes associated with the institution's home care service. In the second half of the 2010s, the logistics department of the institution responsible for preparing personalized packages for home support carried out an initial process reengineering by redesigning the medical supply pick-up area. The managers agreed that a new important round of improvement was necessary.

Furthermore, the exchanges and cooperation between the research team, the logistics managers or the clinical managers allowed iterative analytical process and created feedback loops that helped refine the data collection methodology and the analysis of the results [52], [85]. Table I details the interviewees involved in the case study. The reader can observe that there are three managers with whom we had many hours of exchanges that took place throughout the study. The study would focus on home care activities involving nurses and medical supplies. The case study becomes the appropriate vehicle for presenting the results of this collaborative research, allowing to capture the complexity of the research process [53].

A. Case Selection

The choice of a unit of analysis is a major issue in case studies [54]. Although Paschou et al [43] consider that there would be a lack of multiple case studies in digitization, Ellram [55, p. 100] states that a single case study "is suitable when the case represents […] an extreme or unique case, or a case which reveals a previously inaccessible phenomenon." Eisenhardt and Graebner [56] point out that a single case does not have to be representative of a population, but it must have theoretical representativeness to properly illustrate the relationships between concepts. Thus, it was in conducting this collaborative research that the research object became apparent: the adaptation of the supply chain for home care activities. In this sense, the research object stems from an opportunistic procedure [57] and it fits perfectly into the *research-based phenomenon* philosophy, described by Von Krogh et al. [58], whereby the researcher's presence in the field allows him or her to discern phenomena that would otherwise have remained latent to the attention of the academic community.

B. Data Collection

The research exploited the flexibility of the case study by combining different data collection strategies [22]. The first component consisted of consulting artifacts (reports, press clippings, government policies) that provide a general context for home care activities in the setting studied.

The second component involved the analysis of the production of medical supply packages for individual patients at home. A database was created by entering 1192 queries over 14 weeks of activity between December 7, 2020 and March 12, 2021. The database totaled 6 947 rows of transactions. It should be noted that the shared data were on paper and that the research team had to invest time to computerize the data in order to build a database for analysis.

TABLE I
CATEGORIES OF INFORMANTS INTERVIEWED

Work position	Interview time
Staff at the partner health facility	
Head of *home care service*	60 min
Clinical nurse	50 min
Auxiliary nurse	50 min
Nurse care planning	40 min
Nurse DI-TSA-DP	60 min
Clinical nurse	45 min
Clinical nurse	40 min
Clinical nurse - autonomy support for the elderly (ASE)	55 min
Nurse ASE	40 min
Palliative care nurse	55 min
Nurse ASE	40 min
Administrative manager ASE	270 mi
Administrative manager DI-TSA-DP	180 mi
Logistics services coordinator	400 mi
Storekeeper	60 min
Staff of benchmarking healthcare facilities	
Institution 1 : Head of Program Administration - Interdisciplinary Team Home and Community Services Department	60 min
Institution 2 : Deputy Director - Home Care Support and Intermediate Resources - Department of Support for the Autonomy of the Elderly (SAPA)	50 min
Institution 3 : Deputy Director, Local Services and Adapted Approach	60 min
Institution 4 : Head of logistics Department (warehousing, distribution and loan of equipment)	45 min
Institution 5 : Logistics coordinator	20 min
Institution 5 : Head of living environment program	45 min

The third component took the form of semistructured interviews with logistics staff and care staff. With regard to logistics personnel, the objective of the interviews was to understand how inventory management activities work in the context of home care activities. Table I outlines the different stakeholders interviewed in the case study. These interviews were coupled with visits to the places where these activities are carried out in order to fully understand the work environment. Interviews with home care nurses were conducted to understand how demand is manifested: recurrence, visibility of needs, transportation issues, and storage of information about the patient and their needs. Information was collected using an interview guide as a flexible data collection tool. Depending on the nature of the answers offered by the respondent, we could move on to another question than the one directly provided for in the guide, in order to maintain a more regular flow in the exchanges. Also, the guide allowed us to dig into specific answers for which questions had not been initially envisaged. This formula thus became a script offering the necessary flexibility to adjust interview protocol according to the nature of informant responses [59], [86].

With regard to logistics staff, interviews were conducted with three different stakeholders. As for the nursing staff, interviews were conducted with 11 nurses accounting for approximately 10% of the nursing staff. Each interview lasted between 40 and 60 min with an average of 50 min. The interviews took place in the fall of 2021.

Data collection included a final step for the external validation phase to assess whether the observations made within the establishment studied were representative of the reality of other healthcare institutions in the province of Quebec. Data were collected from other institutions in the province of Quebec. Seven institutions were identified according to a reasoned choice [80]: the similarity of geographical characteristics with those of the institution partner or the presence of distinctive practices. Finally, five institutions were able to participate in the study. This number represents one quarter of the main healthcare institutions in the province of Quebec. Thus, interviews were conducted with clinical or logistical managers of home care services in these other healthcare institutions in the province of Quebec. This data collection also took the form of semistructured interviews that covered the same themes as those discussed during the interviews with the partners' nurses. In total, eight interviews were conducted; in some institutions more than one interview was necessary to cover all of the topics that were discussed. As these interviews were intended to capture the presence of certain phenomena, they lasted from 15 to 45 min.

C. Data Analysis

Concerning the analysis of the database, descriptive statistics were produced in order to specify the volume of material preparation activities, the stability of demand over time and the diversity of needs.

Retaining, the qualitative data analysis strategy of [60], the interviews were coded (see Table II). The information was classified into two groups: information that allowed the reproduction of the activity circuit. For this purpose, a process mapping was performed in order to translate the collected information into a visual diagram. The second group of information concerns the process failures that the respondents may raise. These failures are grouped into coherent sets.

The case study allows for triangulation of the information collected [55], [61]. Thus, some of the information collected in the interviews could be cross checked with information from other interviews or with data from the packages production.

TABLE II
CODING AND CONTENT ANALYSIS

Themes	Subthemes	Codes
Preparation of personalized packages	Supervisor of the activity	SUP_AC
	Formulation of requirements	FO_REQ
	Dedicated resources	DED_RES
	Activity performance	ACT_PER
Allocation of patients	New patient	NP_ALL
	Patient of the day	DAY_ALL
Storage of supply lists by patient		DATA_LIS
Inventory management of medical supplies	Supervisor of the activity	SUP_AC_INV
	Formulation of requirements	FO_REQ_INV
	Dedicated resources	DRD_RES_INV
	Activity performance	ACT_PER_INV
Volumetry of personalized packages		VOL_PP

Finally, collaborative research can mean that the partner can be an active player in the research process [62]. In these circumstances, the researchers presented results to the managers of the logistics department and also to the clinical executives managing the home care service. These exchanges were opportunities to validate the observations made, but above all to identify new avenues to explore to ensure the best possible understanding of the process [52]. The exercise led us to collect new information beyond the home care service itself, integrating services that generate potential clients for the home care.

IV. CASE STUDY

The presentation of the case consists of four subsections. The first presents the general context of the case. The home care activities are carried out in a public health institution in the province of Quebec, Canada. This section explains the general structure of the public health network and the governmental orientations concerning home care. The second subsection specifies the flow of information surrounding the request for medical supplies for home care activities. The third section presents the supply chain for the preparation of medical supplies. Finally, the last subsection offers dysfunctions highlighted by the interviews.

A. General Context of the Health Sector

Quebec is one of Canada's ten provinces. With a population of 8.5 million, Quebec accounts for just under a quarter of Canada's total population. The administration of health care falls under the jurisdiction of the provinces, which must, however, comply with guidelines issued by the federal government.

As early as 2003, the government of the province of Quebec (Canada) supported a gradual shift from the traditional mode of care, from a long-term care facility, to support in the patients' living environment. Such services can reach two main customers: first, elderly people and then people with physical or mental disabilities.

In this context, home care takes various forms, the first of which is professional care and services (medical, nursing, etc.) offered in the home. This service takes the form of a nurse who visits the patient's home to monitor the patient's recovery phase or condition. At that time, she may perform medical follow-up, such as changing a patient's dressing or replenishing medical supplies needed between now and the next visit.

In the fall of 2020, the Quebec Ministry of Health and Social Services announced an additional investment of $100 million to increase the supply of homecare services. In 2020, 400 000 people in Quebec received home care services, 38 000 more than the previous year. Despite these increased budgets, the fact remains that "more than 41 000 Quebecers are waiting for homecare services, a number that has jumped by 20% in three years" [63]. These results are not surprising given that "the age pyramid is changing in favor of seniors. After Japan and South Korea, the province of Quebec is among the societies that are aging most rapidly" (INSPQ, 2021). Also, the pandemic has put pressure on the nursing resources of the Quebec health network, leading to resignations and early retirements for a certain number of them. Thus, despite the fact that in the fall of 2020, the number of nurses entitled to practice had never been so high, several health institutions are still having difficulty recruiting.

The home care service studied is integrated into a health care institution that offers the entire spectrum of health and social services in the same organizational logic as an integrated delivery network (IDN) found in the United States [64]. This institution operates with a budget of $1.2 billion and has just over 9 500 employees. In 2020, the institution offered its services in a region with just under 450 000 inhabitants spread over a territory of 247 km^2. The home care service is offered from three main clinics spread over the territory to which nurses are attached.

B. Demand Information Flow

The demand for medical supplies is naturally related to the number of patients to whom the service is offered. This demand first arises when a liaison nurse, the one in direct contact with the patient, completes a request for her "client" to receive home care services if she considers that this should be the case. This liaison nurse may work in the operating room, the hospital emergency room, or the oncology department, each of which is a distinct department from which a patient may be prescribed clinical follow-up at home. This request is forwarded to the "front line service" of the health care institution, which assesses whether the request meets the criteria set out by the Ministry of Health for obtaining such a service. If the answer is positive, the request will be forwarded to the right care program (the one for the elderly or the one for people with physical or mental disabilities). Up to

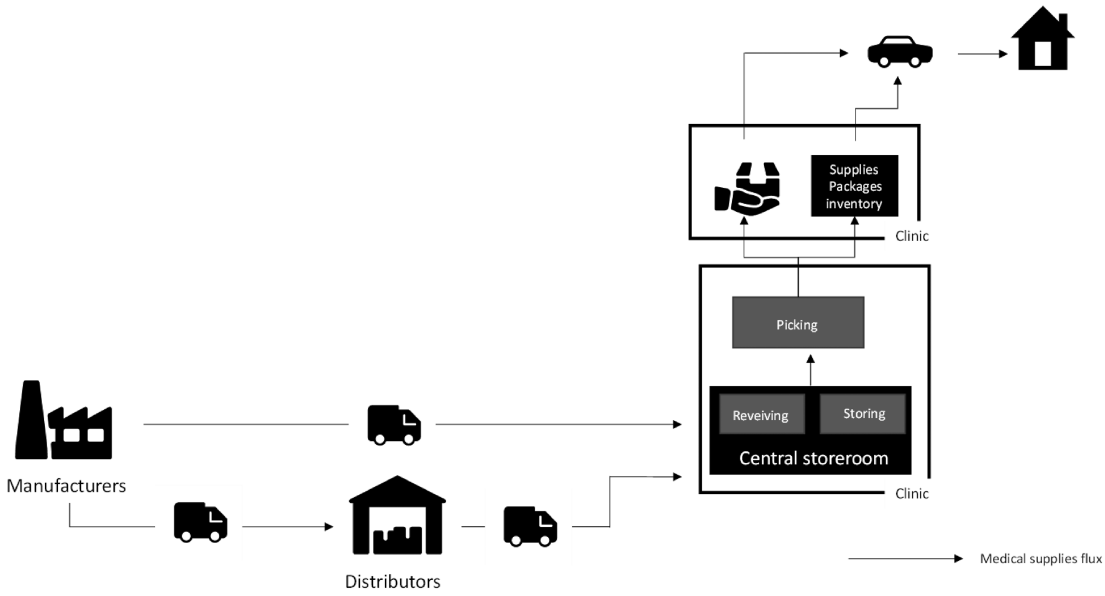

Fig. 3. Home care supply chain.

now, the exchanges are done through PDF forms sent by email or fax.

An administrative assistant associated with either program will open an electronic file on behalf of the patient in the centralized provincial home care system. This record will contain the assessment sheet, the care plan, and possibly medical equipment that could be loaned to the patient (therapy surface, lift, etc.). This software allows the Ministry of Health to produce provincial statistics on the demand for home care. At the same time, the complete patient record will be on another database. There is common information between these two systems. In addition, there is a paper file that is kept.

Once these steps have been completed, and depending on the priority of the file, the new patient will be assigned to a nurse for a first visit with the patient on the same day or within 24 h. In the interviews conducted at the other five institutions, the 24-h period is the norm. However, in only one institution, it is 48 h. This new appointment fits naturally into those scheduled with patients already receiving home care services. For the health care institution studied, in one case, the appointments are entered into an electronic spreadsheet that can be consulted at any time in order to find out the schedule for these same appointments for the coming week. When appointments are renewed, the nurses assigned to these patients enter the information. Depending on the medical condition, appointments can be scheduled every week, on the same day, at the same time.

The three clinics become the nurses' home base. From there, the nurses perform their administrative duties, receive their assignments and pick up any supplies they may need for their visits. These visits are conducted seven days a week on two shifts during the week. The procedure for scheduling appointments is not uniform in the three sites that offer home care services. In one of the sites, the planning of work schedules is simply done manually in a notebook. This disparity in practices is also observable in the five other establishments studied.

C. Supply Chain of Home Care

For a first visit, the nurse goes to the patient with a generic package of medical supplies according to the nature of the medical follow-up to be provided (wound care, chemotherapy, urinary care, etc.). Nurses prefer to order a personalized bag for this first visit, judging that the generic packages do not contain all the necessary material. Following the first visit, the nurse will complete a request to obtain a personalized package of supplies according to the patient's specific condition. Up-to-date information regarding supplies for a patient is located in the patient's paper chart, in the care plan or simply in the nurse's memory, or in more than one of these sources. The validation phase with the five other establishments reveals a similar situation.

These supplies are assembled by the logistics team. Fig. 3 provides a simplified representation of the distribution network for these personalized packages. One of the three clinics assigned to home care activities has a central storeroom where medical supplies are stored. This store receives deliveries directly from suppliers. The purpose of this store is to stock medical supplies located in the three clinics. Adjacent to this store is an area for the preparation of personalized packages. This area is supplied with medical supplies from the adjacent store. These packages fall into two categories: there are six generic packages that are kept in stock in each of the three clinics. As stated previously, these packages are used for the first visit to the patient at home. It should be noted that the preparation of these packages of medical supplies by a logistics team is a minority practice in the Quebec healthcare network. The validation phase with five other institutions revealed that only one of them has a similar organization. In the four other institutions, this activity is achieved by nursing staff or clinical management staff. The logistics employees may support the nursing staff in this activity.

Analysis of the 14 weeks of data shows that requests are almost evenly distributed among the three sites. Around 85

personalized packages are produced per week; of this number, 25 to 30 packages are intended for new patients. The production of packages containing 4 to 8 items accounts for 59% of all volume. It should be noted, however, that 16% of the requests contained only one or two items. The 1 192 queries analyzed identified 323 different product codes. The other health institutions, adopting a similar strategy of preparing personalized packages of medical supplies, manage 180 different supplies. Each of these other institutions was unable to share precise data concerning the volume of activities.

Using Pareto logic, 13% of the product codes (41 of the product codes) take up 80% of the transaction lines, or 20% of all product codes (65 product codes) take up 87% of all transactions. There were 135 product codes that were requested only once during the 14 weeks of data analysis. The package preparation area contains 280 different items. This means that there are approximately 50 products that need to be retrieved from the clinic's central store or from other warehouses that the health care institution has in other facilities in this territory. Retrieving these items can be time consuming, delaying the shipment of the package, because as one of the warehouse workers assigned to this task states, "the goal is to ship packages with all the items."

Depending on the site, the nurses' orders for their personalized packages are done on a paper form or a PDF with a drop-down menu. In the latter case, there are six forms for the six generic packages and a seventh form for a personalized package. These orders can be sent by fax or by email. In both cases, the forms are printed, and then, become the pick-up slip in the order preparation area. Hard copies of the forms are kept for a period of time.

D. Malfunctions Expressed by the Stakeholders Associated With the Process

From the interviews with the nurses, the management of orders for personalized packages is considered a point of tension by almost all the interviewees. A common explanation is that this task is a waste of time when compared to the clinical tasks they must perform. One nurse indicated that the "supply order form does not use product names that reflect the clinical terms used." Conversely, the logistics staff associated with the preparation of the packages also have difficulty determining the products desired by the nurses: "They do not always use the name we know for the product. They do not always use the name of the product we know, so I have to contact them to validate the product they want."

"We do not get feedback from the logistics team on whether or not they received my order," said one nurse. From the logistics staff's perspective, they work in an uncertain environment, "After my shift, requests can still come into my email box." When I come back the next morning, I may have several urgent requests that I will prioritize. In fact, logistics staff say, "we know we will have busier or less busy days, but it is hard to predict which. So, if there are fewer requests to prepare, we can put together generic packages for the first few visits."

Another nurse said, "There is no coordination between the time I place the order and the time I go to my client's home thinking they have picked up the equipment needed to perform their care." Logistics staff had the same complaint, "We do not know if it is the nurse or the patient's family who will bring the materiel to their home." The logistics worker in charge of assembling the packages indicated: "I have been told that the packages can remain in the sites for a few days waiting to be picked up."

Similarly, another interviewee states, "order picking takes too long in cases of new patients who require specific care." The assembled packages leave the staging area at 11:55 A.M. for the other two home care sites. Requests that are received before 11:30 A.M. may be assembled before the transport departure. Nurses tend to forget this constraint when formulating their requests.

In these circumstances, the car of several nurses becomes a storage place to make up for the shortcomings of the preparation of the packages. One nurse said: "I have a basic stock in my car so that I can make up for shortages of supplies and be autonomous when I go to the patient's home. Another nurse said, "I prefer to keep stock in my car instead of placing an order, because the order preparation process is too long." In addition to the in-car stock, each clinic has a mini stockpile of medical supplies that serve as a replenishment point to fill in the in-car stock of supplies. This practice is also present in the five other studied institutions. However, in one of these institutions, the practice is limited to a few items (compresses, gloves, masks) that will not be affected by variations in ambient temperature (cold or heat), as opposed to those with properties that may be affected by extreme temperature variations.

Finally, the analysis concluded that nurses devote an average of 40 min per day to administrative tasks associated with the management of medical supplies for their patients at home. This may involve writing queries or retrieving medical supplies stored in their workplace to complete a generic package. This time may be devoted to related tasks such as the production of travel records.

V. Discussion

The discussion will be divided into three subsections. The first will identify the difference between the traditional healthcare supply chain and the home care supply chain. The second part will identify a series of solutions from digitalization to enhance the performance of this activity. Finally, the last part will offer solutions to the challenges involved in the digitalization of logistics activities within the context of home care activities.

A. Comparison of Supply Chains

To grasp the magnitude of the effort required to upgrade the home care supply chain, we need to compare the data from our case with the generally studied reality of the hospital medical supply chain [21], [24]. Our working hypothesis is that this first supply chain is clearly different from the second one and must have solutions of its own.

Table III compares the main characteristics of these two supply chains in the healthcare sector. The contrast between the two supply chains clearly demonstrates that the hospital supply

TABLE III
COMPARISON OF HOSPITAL AND HOME CARE SUPPLY CHAIN

	Hospital environment	Home care
Number of product codes kept in the order picking area	1 500 à 2 000	280
Frequency of point-of-service replenishment	One to seven times a week	Once a month to once a week
Average order size	15 to 25 items	4 to 8 items
Meeting the needs	From the point of service	From the patient
Presence of a safety stock at the point of service	Three to four weeks of safety stock	The order meets the current need

TABLE IV
PROBLEMS AND SOLUTIONS IN PREPARING CUSTOM PACKAGES

Problem	**Solution**	**Advantage**
Managing nurses' expectations	Develop a procedure specifying cut-off times to obtain a customized package within 24 hours The information system would offer an alert on the time of delivery given the time of demand.	Such a procedure would allow nurses to better plan the second visit with the patient. The alert would enable to manage the expectations of the nurse.
Laborious search for products by nurses in the static list proposed by the PDF form or conversely difficult identification of products by storekeepers.	Data acquisition by which the nurse can add synonyms to designate products.	To more easily find the products desired by the nurse and to ensure the correspondence by the logistics staff.
No dynamic electronic request.	Through artificial intelligence technologies, electronic requests could already propose a list of products. The information system would keep the list of products associated with a specific patient.	Faster writing of the request by the nursing staff. The information system's memory would compensate for the multiplication of the databases currently being used. This memory would resolve the issue of re-entering all of the information associated with a product request.
Reduce the variety of products in personalized medical supply packages	A customer integration would allow the creation of a database directly linked to the electronic requests combined with big data analytics that would allow the realization of different consumption analyses.	Conduct more frequent standardization exercises with readily available evidence. Reducing the number of products would simplify package preparation activities, resulting in productivity gains.
To manage the capacity of the preparation of personalized packages by the logistics staff, reducing part of the uncertainty in which the logistic staff works.	A customer integration involving data fusion between the scheduling of home visit appointments and the needs of the patient could automate some of the product requests	The customer integration would be accessible by logistics staff. They would be able to discern medium or long term recurring needs from short term urgent needs and manage the capacity to prepare packages.
A lack of integration of the systems between the formulation of needs, the management by the home care service, and the management of the patient record.	An integrated system would eliminate the re-entry of information from one clinical actor to another.	Such an integrated system would enable the analysis of the demand evolution. Such a system could combine functionalities, facilitating schedule-planning or administrative follow-up tasks, such as the production of travel records.

chain is centered on volume logic and oriented for managing the complexity stemming from the diversity of its items [28]. However, this complexity is partially mitigated by the presence of large inventories both in the order picking area (storeroom) and in the wards' stockrooms [27].

Unlike hospital supply chain, the home care supply chain is less complex in terms of product diversity or volume of activity. However, this supply chain does not contain the formal buffers of the hospital supply chain: it must respond to a specific request from the patient, and the patient has no safety stock at home other than what the nurses brought to the last visit (or the material recovered by the family).

Another major difference between the two supply chains is the issue of distance. In the case of a hospital supply chain, the picking area will be right within the walls of the hospital or at least close by [26]. While in our case, the custom package preparation area has to deal with a territory of 247 km^2. While the distances are not significant, they inevitably introduce a transport delay that becomes significant in a context of stock outage. The case study's data show that this delay distorts nurses' perceptions of the low rates of logistical activities for the preparation of packages. Transport deadlines do not seem to be taken into account when requests are formulated. This is why the unofficial stock, the stockpile of material that each nurse is invited to keep

TABLE V
RESEARCH CONTRIBUTIONS

Contributions	Theoretical insights
This article shows how the supply chain of medical supplies for home care activities is different from that usually studied over the past 20 years.	Bentahar et al. [65] hinted at this new reality through their study of telemedicine cabins, which pushes the atomization of healthcare facilities even further.
The study highlights the influence of digitalization technologies not only on the improvement of logistical activities, but also of the administrative activities of care delivery. Indeed, improving administrative activities becomes a prerequisite for increasing logistics performance.	Beaulieu and Bentahar [21] have underlined in their study on the digitization of the healthcare supply chain that the enhancement of administrative practices can support logistical gains.
The results offer a deep understanding on how digitalization enables data analysis with a view to the standardization of products and the simplification of the work environment in the context of home care supply chain.	Process improvement initiatives have often been underlined as an antecedent of supply chain digitalization [44].
The study highlights the role of home care in creating new territory for hospital logistics that aligns with the evolution of care delivery.	Previous research studies have focused mainly on the hospital as a focal actor in the healthcare supply chain [70] and rarely addressed issues of home care supply chain management.

in her car, is of great importance. Unlike the unofficial stock that comes from personal initiative in the context of a hospital [29], in the case studied, it is practically an institutional policy.

These elements demonstrate the specificity of the home care supply chain and the search for solutions that correspond to its characteristics. As presented in the case, in an environment where the demand for home care services exceeds the current capacity of the Quebec health network and where there are also challenges in recruiting nurses, improving the logistical process can be an opportunity to generate productivity gains for nurses who could take on more patients.

B. *Nature of the Problems and Solutions*

The problems with the process of preparing medical supply packages for home care go beyond the inconveniences cited by nurses or logistics staff assigned to this service. These problems can be traced to an environment that is fraught with uncertainty; uncertainty concerning when the personalized package will be requested, uncertainty about the products, and uncertainty about the demand. Table IV shows these problems in a more specific way by proposing solutions associated with elements of the developed model (see Fig. 2). The problems are presented according to the technological complexity of the solution.

C. *Deployment of Digitalization Solutions*

The literature review has already highlighted the challenges involved in adopting good practices or technological solutions in a healthcare institution [21], [71], [72]. First, despite the claims, not all solutions will be technological. There is also a critical need for development of procedures and institutional perspective for process change, for example, for specifying deadlines where a request will be processed within a defined time frame. These procedures not only become a solution to a problem, they remove some organizational barriers [46]; they become norms, reducing potential conflict areas between different actors in the organization [48]. These norms also provide a more defined environment in which the envisaged technologies generate their full potential. Indeed, the adoption of digitalization in the supply chain is a social construct that depends on the institutional norms, values, and practices of different actors [13].

Second, when comparing the different technological solutions offered by supply chain digitalization (see Fig. 2) and those selected to solve many problems, very few of them have been selected. For example, there are no proposals for capabilities associated with warehousing. From our point of view, there are no issues at the moment directly related to package preparation activities, the volume of demand, and the diversity of products would not require advanced technological solutions. In this sense, as other works mention, there must be a match between the technological choices and the organization's work environment [40], [41], [45].

The three functional requirements [41] become a sort of technological deployment maturity scale for the process under study. The first solutions proposed are aimed precisely at acquiring data through sharing in order to build a database of the products consumed. From there, it becomes possible to use big data analytics or artificial intelligence technologies, because the organization will have a database from which to connect these tools. Finally, the last recommendation is part of data fusion logic. It is not just about automating the sharing of requests, but about giving logistics staff visibility for demand by allowing them to see upcoming appointments in addition to the demand for packages. This visibility concept have been highlighted in the extant literature as an enabler of decision making and a critical factor of supply chain performance [12], [13].

The development of an interface to automate the request process, including the scheduling of home visits, would unify information that is now dispersed in different systems. Such an environment would facilitate the sharing of information between different nurses who can take turns providing services to the same patients. Beaulieu and Bentahar [21] had rightly

pointed out that the search for clinical benefits through logistical initiatives facilitated the implementation of such projects. This proposition is consistent with the recommendations of Adebanjo et al. [76] as well as Mandal [77] that technological initiatives associated with supply chain management in the healthcare environment should formulate not only logistical benefits but also benefits for customers, including patients. In our case study, the patient—the ultimate customer—will not be directly impacted by the digitization solutions offered. However, by eliminating administrative shortcomings, logistical gains will be created, improving the quality of service for the patient.

Finally, more broadly, our study completes the actual picture of the digitization of the healthcare supply chain by integrating into the relationship between the hospital and its suppliers a missing and increasingly strategic external supply chain represented by the home care. Such an integrated design of the digital healthcare supply chain can contribute not only to enhance the performance of the supply chain but also to its resilience during disruptive events such as the COVID-19 outbreak. Indeed, during the crisis, we were able to identify the high value of home care, which mitigates the weaknesses, and vulnerability of the hospital supply chain. In this sense, we bring a complementary vision to the study of Tortorella et al. [81] that have demonstrated how the adoption of hospital digitalization technologies within the supply chain and for patients contributes to improving the management process and the resilience capacity of healthcare organizations.

VI. Conclusion

The COVID-19 pandemic had led to a growth in demand for home care services, and with the aging of the population in major industrialized countries, this trend is not likely to abate. In this sense, a new supply chain must be implemented in healthcare organizations to meet the medical supply needs of patients receiving such services. While studies on the healthcare supply chain had focused on the hospital model, to the best of our knowledge, this was the first in-depth study that offered a detailed description of this supply chain and its challenges. Table V summarized the main contributions of the study.

A. Research and Practical Implications

Previous research had explored mainly the digitalization of hospitals internal supply chain or hospitals external supply chain focusing on the management of the relationship with suppliers.

This study was an extension of previous research work conducted in the topic of supply chain digitalization by offering the analysis of another under-studied environment. In this sense, this study was an opportunity to explore an enriched model of analyzing the digitalization of supply chain [15]. The case study research is an opportunity to continue prior thoughts and discussions concerning the implementation of technological solutions associated with a healthcare institution's logistics activities.

The study offered three main implications for practice. First, the results provided logistics managers and nurses with a framework of digitization initiatives that can help them in improving the decision-making process and the management of the home care medical supply chain. Second, this article offered healthcare managers an enriched conceptual framework on the relationship between enabler technologies, functional requirements, and digital supply chain capabilities. A deep understanding of the relationship between these constructs and their application in practice will influence significantly healthcare supply chain performance. Finally, the study highlighted the opportunity for healthcare stakeholders in going beyond logistical benefits and provided solutions that may fill gaps in clinical staffs' administrative processes.

B. Limitations and Further Research

Moreover, the study ends when the recommendations were formulated. It would be appropriate to continue the study from a longitudinal perspective in order to identify the impact of certain organizational barriers such as structure or leadership in the implementation of the solutions discussed. Zheng et al. [73] had highlighted the issue related to the senior management of a healthcare institution's leadership. Our study does not cover this dimension, which we may capture in future research in the context of home care supply chain digitalization.

The diversification of research contexts would fill the gap of the case study method which focused on the public health sector in one Canadian province. For example, logistics activities were handled directly by the health care institution's logistics team. There may be other models where these services were handled by a logistics provider (third-party logistics) [32]. From a supply chain digitalization perspective, it would be interesting to see if the integration of information systems would be easier or more complex than what our case study presented.

Due to the combination of clinical and logistical information within the same database, ethical issues and questions related to the confidentiality of medical information may arise [82], [83]. It would then be relevant to explore how other digitalization technologies, such as blockchain, could be implemented to ensure the confidentiality, security, and interoperability of systems [84]. However, the blockchain remained at the stage of infancy and testing in the healthcare sector, in particular, by companies or organizations, such as VeChain, IBM Blockchain, or IEEE standards association, thus requiring future exploration of technological, organizational, and regulatory barriers.

Finally, it would be interesting to see if the lessons learned for home care supply chain could be applied to telemedicine services, which also experienced an increase in demand with the COVID-19 pandemic [67]. In this sense, the COVID-19 pandemic was decompartmentalizing the delivery of care that was very hospital centric. This study was a first step to better understand a supply chain that was expected to grow in importance with a form of decentralization of care delivery. In addition, this study can help to better deploy information technologies in an environment where this type of implementation was often difficult [68].

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