Information Technology (IT) and shortage risk in drug supply chain: Case of the hospital pharmacy of University Hospital Center (U.H.C) Tlemcen "TEDJANNI Damerdji"

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Abstract:

In this work, multi-modality approaches were used to generate the benefits of digitizing the drug supply chain. A review of the theoretical literature was conducted to capture the key concepts and interactions between them, also interviewing and analyzing the staff of Tlemcen University Hospital pharmacies to determine the various causes of drug shortages. Focusing on the role of the "EPIPHARM" and "G-PHARM" software in the hospital pharmacy. A set of results were reached, including:

IT can modernize the pharmaceutical supply chain in a way that can also serve the common goals of the economy by reducing costs and improving the quality of care provided.

Keywords: Drug Supply Chain, Shortage Risk, Information Technology (IT), Supply Chain Risk Management (SCRM), Hospital Pharmacy.

JEL Classification Codes : D73, L86, I18.

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1. INTRODUCTION

Nowadays, the supply chain is one of the most main support activities. It is a fact that if the supply chain is not functioning properly so that the drugs do not reach the patients in the hospital, the core business of a

hospital, which is to provide health care, cannot be developed. About 50 years ago, some hospitals began to invest heavily in researching new supply change management models. What they were looking for were more efficient ways to get drugs from providers to patients. Managing the process of drug flow to achieve public health and sustainable development goals is an important issue. Each country must have a national drug policy as one of the main concerns of its health policy to ensure the provision of effective, safe, qualified and affordable medicines for the government and the population (A. Fattahzadeh, 2006). The correction of pharmaceutical policies in developing countries is a major concern in the health sector, and the World Bank and the World Health Organization (WHO) agree on the need to reorganize it (WHO, 2002). In developing countries, most imported drugs are expensive, which increases the exchange rate allocated to drug imports and raises costs. In addition, the resources available in health centers are often misused, and in most cases, due to lack of different resources gathered, there is squandering and waste of resources (Reza Shakori, 2016 Dec).

Medicines are essential components of health care, and access to medicines is a basic human right and one of the central objectives of health systems (H. Hogerzeil, 2006). The pharmaceutical supply chain must provide drugs in the right quantity, with acceptable quality, to the right place and patients, at the right time and at an optimal cost to be compatible with the objectives of the health system, and it must make a profit for its shareholders (Kaufmann L, 2005). Any risk to the pharmaceutical supply chain can not only waste resources, but also threaten patients' lives by impeding access to medicines (Schneider JL, 2010). Risk management is not only important in the pharmaceutical supply chain but also plays a major part in other aspects of pharmaceuticals, such as drug prescribing and use (Rodriguez-Monguio R, 2013; JC. Schommer et al, 2006). The assessment and implementation of risk management strategies in the pharmaceutical supply chain is crucial in health systems (Craighead CW et al, 2007). The importance of risk management becomes more vital because drugs are highly regulated products, which are under the strict control and limits of public regulatory authorities (Koh R, 2003). In addition, the supply

of medicines as strategic goods in developing countries with high levels of economic, social, and political instability faces more uncertainties and vulnerabilities (Enyinda CI, 2010; AM, 2013).

Drug shortages are a complex global challenge. There are several signs of the growing importance of this issue for the health care system (Videau, 2019). Drug shortages have remained a problem throughout history until today. The first time a drug shortage was recorded was during the insulin shortage in the early 1920s. Since then, drug shortages have become more common around the world (Zwaida, 2019). In addition, the COVID-19 pandemic has highlighted vulnerabilities and gaps in the global healthcare supply chain (Tukamuhabwa, 2021).

1.1 The problem :

As cited above the medicines are the most therapeutic instrument performing in health currently that their unique character by a health report confers on them a special status. Besides, they account for a large portion of costs in the healthcare industry due to the significant costs of these products and their storage and control requirements. The drug supply chain faces various risks. Disruptions due to these risks can be costly, and hospitals seek to minimize these risks. Among these risks, we have the drug shortages that have become increasingly frequent and severe over the past decade. In addition, the reported shortages are longer-term and have had a greater impact on patient care. The causes of drug shortages are multifactorial. For effective management of these risks, hospitals are using digital technologies to identify and prevent barriers to drug access, such as drug availability and affordability, stock-outs, shortages, diversion, and falsified drugs. This drives us to look deep into this subject and ask this main problem: *What is the use of IT tools to reduce the risks of the drug supply chain, especially the shortage risk in the pharmacy of public hospitals in Algeria?*

1.2 Methodology:

A mixed-methods approach was used to generate the benefits of digitizing the drug supply chain. A systematic literature review was conducted to capture the key concept interaction section of supply chain

risk management and information technology in the drug supply chain, and interviews with hospital pharmacy staff were collected and analyzed to identify the different causes of drug shortages. In addition, the role of supply chain risk management (SCRM) and information technology (IT) in reducing and minimizing this risk by installing "EPIPHARM" and "G-PHARM" software in the hospital pharmacy of UHC Tlemcen “TEDJANNI Damerdji”. This allows us to understand the different exogenous and endogenous reasons for drug shortages and to show how the installation of software can minimize the risk of shortages and help the hospital pharmacy to make improvements to the drug supply chain.

2. LITERATURE REVIEW

The supply chain is a set of actors, processes, information and resources that transform raw materials and components into finished products or services and deliver them to customers (N. Shah, 2005). It includes suppliers, intermediaries, third-party service providers and customers (Secchi R, 2006). It also includes all the logistics activities, manufacturing operations and activities with and between marketing, sales, product design, finance and information technology (Pedroso MC, 2009). Supply chain management (SCM) is defined as the integration of key business processes across the supply chain to create value for customers and stakeholders (Rossetti CL, 2011). There are several aspects of supply chain optimization; eliminating bottlenecks, balancing the lowest cost of materials and transportation, optimizing manufacturing flow, maintaining the right mix and location of plants and warehouses, analyzing vehicle routing, dynamic scheduling, and efficient use of capacity, inventory, and workers are the main aspects of supply chain optimization (Jaberidoost et al, 2013).

Supply chain risk management (SCRM) is a crucial and indivisible part of supply chain management to achieve the mentioned objectives (Liz Breen , 2008). SCRM attempts to minimize supply chain the vulnerability and uncertainties of the supply chain through mitigation plans (Vanany I, 2009). Therefore, it is essential to identify, assess and prioritize all risks to reduce and control the likelihood and impacts of unfortunate events (Jaberidoost M, 2012). It aims to manage risks in a compound and dynamic supply and demand network (Manuj I, 2008). SCRM has been defined in

several ways. For example, Tang described SCRM as the management of supply chain risk through coordination or collaboration among supply chain partners to ensure profitability and continuity (Tang, 2006). Ho et al. defined SCRM as "the implementation of strategies to manage day-to-day and exceptional risks along the supply chain, based on continuous risk assessment, to reduce vulnerability and ensure continuity" (Ho. W et al, 2015). Supply chain risk management is one of the most important aspects of the current supply piece, and according to (Sodhi, 2012; Tang, 2006) there are two classes of risks in the supply chain, operational risk, and disruptive risk. According to (Manotas-Duque, 2018), the SCRM consists of four stages: risk identification, risk prioritization, and risk management.

2.1 Medicines Supply Chain:

Healthcare supply chains are a special segment because their primary focus is on saving lives rather than making profits. Healthcare providers (clinics or hospitals) are the facilities that treat patients and trigger demand throughout the healthcare supply chain. Whether public or private, health care providers need to be profitable for two main reasons: (1) private health care providers need to be profitable to ensure business continuity and the proper use of funds. To manage risk and generate supply chain resilience (SCRes), it is crucial to identify the key characteristics of the supply chain (Li, 2020). Looking at the upstream healthcare supply chain, constructs that generate resilience include total quality management (TQM) and total productive maintenance (Sharma, 2020). Using SCRM in a case study of a hospital's pharmaceutical supply chain, achieved improvements in five dimensions: (1) budget consistency, (2) reliability, (3) drug flow, (4) improved flexibility, and (5) control of the bullwhip effect; where the bullwhip effect, for example, can be particularly detrimental in areas that face the challenge of managing a wide variety of items (Elleuch, 2013).

According to (Romero, 2013), supply chain management in the healthcare system is characterized "by the information, assets, and money essential to purchase and transfer goods and services from the provider to the end user to control costs (Eugene S. Schneller et al, 2006). In terms of

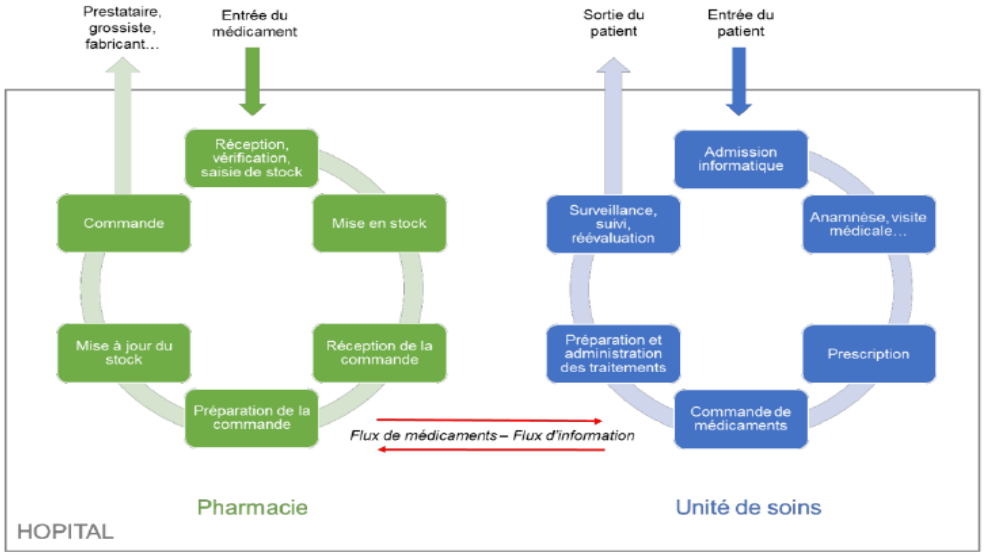
projection, healthcare supply chain management is still valued at hundreds of millions of dollars annually (Ontario Buys & Healthcare Supply Network, 2007), suggesting that hospitals' financial primacies must be redefined. Healthcare supply chains are more composite and less formed than those in other industries (Eugene S. Schneller et al, 2006). This can be explained for a number of reasons. First, supply chain management affects human health, requiring adequate and accurate medical supplies that are consistent with patient needs (Beier, 1995). If medical supplies are out of stock, distributed to the wrong patient, or prepared improperly, patients can suffer adverse effects and, in some cases, die.

In recent years, SCM has received particular attention in the healthcare sector, as it has an important impact on hospital performance in terms of reducing waste, preventing medical errors, improving the quality of care and services, and increasing operational efficiency (Sang M. Lee, 2011). SCM in hospitals includes the internal chain (e.g. patient care unit, hospital storage, patient, etc.) and the external chain (e.g. vendors, manufacturers, distributors, etc.) (Rivard-Royer, 2002). A hospital receives products and services from suppliers, and then stores and distributes them to each care unit based on the hospital’s operation processes. Therefore, SCM includes business activities (e.g., purchasing, distribution, vendor management) and operations that integrate a seamless and continuous flow of materials and services for the delivery of healthcare.

2.2 Medicines management cycle:

The drug circuit in a hospital is composed of a series of successive steps performed by different professionals. In addition, this circuit is linked with the hospital information system and logistics. The drug circuit is defined as the process of therapeutic drug management of a patient, whether he or she is hospitalized in a health care institution, a resident in a social institution or an outpatient. This interdisciplinary process includes the stages of prescribing, dispensing, administration and therapeutic follow-up, and includes information processing (E. SCHMITT et al, 2006).

Fig.1. Schematic view of the logistical (green) and clinical (blue) circuits in the hospital according to François O.



Source: (François O., 2016)**.**

The success of the drug management cycle will depend on the ability to reliably and consistently supply standard quality medicines at affordable prices to health care facilities at all levels of the health system. Pharmaceutical supply chains are different because they typically have large and extensive global pipelines requiring high levels of product availability with high uncertainty in supply and demand. To sustain and expand successful interventions, these supply chains must be made more robust and flexible through better management and increased investment of resources to achieve supply chain optimization (M.J. Iqbal, 2017).

2.3 Drug shortages:

Drug shortages continue to mark healthcare services worldwide (Clark, 2020). The World Health Organization (WHO) has identified drug shortages as a complex global (Gray A, 2012). Both developing and developed countries are affected by drug shortage issues (Beerten E, 2011), which seem to be getting worse in recent years. The American Society of Health-system Pharmacists defines shortage as "a supply problem that affects how the pharmacy prepares or dispenses a drug or how patient care

is affected when prescribers must use alternative products (Omer S, 2021). While, according to the U.S. Food and Drug Administration, shortage means "a time when the demand or estimated demand for the drug exceeds the supply of the drug" (Holcombe, 2018). Healthcare professionals are often troubled by the stress caused by the shortage and for patients; this can lead to compromised care (McBride, 2013).

Drug shortages influenced all stakeholders in the supply chain, particularly patients and hospitals, leading to public concern. Drug shortages for patients can lead to suboptimal care and delays or cancellation of treatments or surgeries (Kaiser J., 2011; Rosoff PM., 2012). Patients may also experience medication errors, adverse outcomes, and increased healthcare costs (L. Kux, 2011). At the hospital level, considerable time, effort, and personnel were required to respond to drug shortages (Baumer AM et al, 2004). Four types of actions were typically taken to manage drug shortages : 1) monitor and move stock to avoid a shortage; 2) anticipate the extent of shortages and identify therapeutic alternatives; 3) modify distribution practices or allocate remaining inventory and 4) communicate with other organizations (wholesalers, manufacturers, or hospitals) or contract with new suppliers to obtain back-up sources of drugs (Fox ER et al, Guidelines on Managing Drug Product Shortages in Hospitals and Health Systems., 2009).

Drug shortages represent a notable danger to public health, affecting any category of drugs (generic, pediatric, orphan, biologic, radiopharmaceutical, etc.) (Bocquet. F et al, 2017). Drug shortages impact all stakeholders (De Weerdt. E et al, 2017). Drug shortages have generated significant barriers to healthcare and its consequences involve therapeutic differences, safety issues (compromised outcomes, medication errors, deaths, etc.), and financial ramifications (higher hospital expenses, increased labor costs, increased patient cost, etc.) (Fox ER et al, 2009; McLaughlin M, 2013). In addition, wholesalers, distributors, and producers may experience reduced profits, wicked reputation, and unhealthy relationships with customers and authorities (Haninger K, 2011; De Weerdt. E et al, 2017). The causes of drug shortages are multiple and diverse. The main contributors to a disruption in drug availability, summarized in WHO

and ASHP reports, include manufacturing and regulatory issues, voluntary recalls, raw material or bulk supply issues, changes in product formulation or manufacturer, production limited drug supply and distribution, industry consolidations, manufacturer decisions and economics, natural disasters, demand fragmentation and changes in clinical practice, the gray market, poor inventory control, nontraditional distributors, and restricted drug distribution and allocation (Fox ER, 2018; Atif M et al, 2019). Drug shortages occur due to non-compliance with predetermined supply schedule (Zarei et al. , 2020). At the time of shortage, immediate action by the health system is essential to prevent disruptions in patient care (Kaakeh R, 2011); hence, activities associated with drug shortage management should be prioritized over other tasks to ensure the supply of an essential drug or its alternative (CL., 2011). Numerous studies point out that drug shortage have increased over the past few decades (De Weerdt E et al, 2015), posing an ongoing challenge to health systems (Zarei et al. , 2020). Furthermore, there is no unified theory or framework defined to manage thes issues (Chadist, 2012).

3. RESULTS AND DISCUSSION

3.1 IT and supply chain performance in the hospital pharmacy of UHC Tlemcen:

Supply chain performance refers to the activities of the extended supply chain to meet end-customer requirements, including product availability, on-time delivery, and all necessary inventory and capabilities in the supply chain to provide this performance in a responsive manner. Supply chain performance crosses functional lines and corporate boundaries. Supply chain performance could be improved by continuously building the capacity of staff who manage essential drug stocks in warehouses (Parmar, 2016). These capacity building programs would enable staff to acquire the appropriate skills to properly manage essential drug stocks. The pharmaceutical supply chain is organized around four main activities, namely selection, procurement, storage, and distribution and use. Management support systems include planning and administration,

organization, financing, information technology, and human resources (Feston Kaupa and Micheline Juliana Naude, 2021).

By applying new technologies, the pharmacy has experienced a great improvement in the management of its multiple tasks by applying a computer system that allows the processing of data designed in a program called Epipharm, launched by the experienced services of the Ministry of Health and Hospital Reform. Epipharm developed in 1994, is a drug management program for Algerian hospitals proposed by the Minister of Health and Hospital Reforms to improve management (entry, exit, expenditure, stock, and inventory). In 1995, the Epipharm program, initiated by the control authority at the level of the central pharmacy UHC Dr. Tidjani Damardji was created with the aim of effective and rational management of pharmaceutical products. The Epipharm software brings several changes to the pharmacy; it took over the management of pharmaceutical products and contributed to the improvement of the movements of the pharmacy because in paper format it generates several problems of conservation and traceability of data, difficulties of deciphering, verification of the recorded information. On the other hand, the use of Epipharm software allows quick and easy access to the product's data more readable, safe and accurate information. The consultation of stocks and expiration dates of products in paper files requires a long process and a lot of time. Despite these benefits and improvements to the pharmacy, healthcare facilities need a more comprehensive tool that tracks the flow of drugs to improve the quality of care and hospital performance.

In 2014, the hospital's pharmacy, to strengthen its information system and its drug cycle, called on a private company "NALTIS" to build inventory management and supply of drugs software "G-PHARM". It helps and strengthens the monitoring of the flow of pharmaceutical products to improve the quality of products and the availability of drugs, thus minimizing the various risks (breakage, expiration, deterioration ...).

3.2 Drug Shortages in the pharmacy of the UHC Tlemcen:

Drug shortage is a serious concern in the Algerian healthcare system. It becomes increasingly common and more acute over the past decade, affecting healthcare institutions, healthcare providers, and patients. This

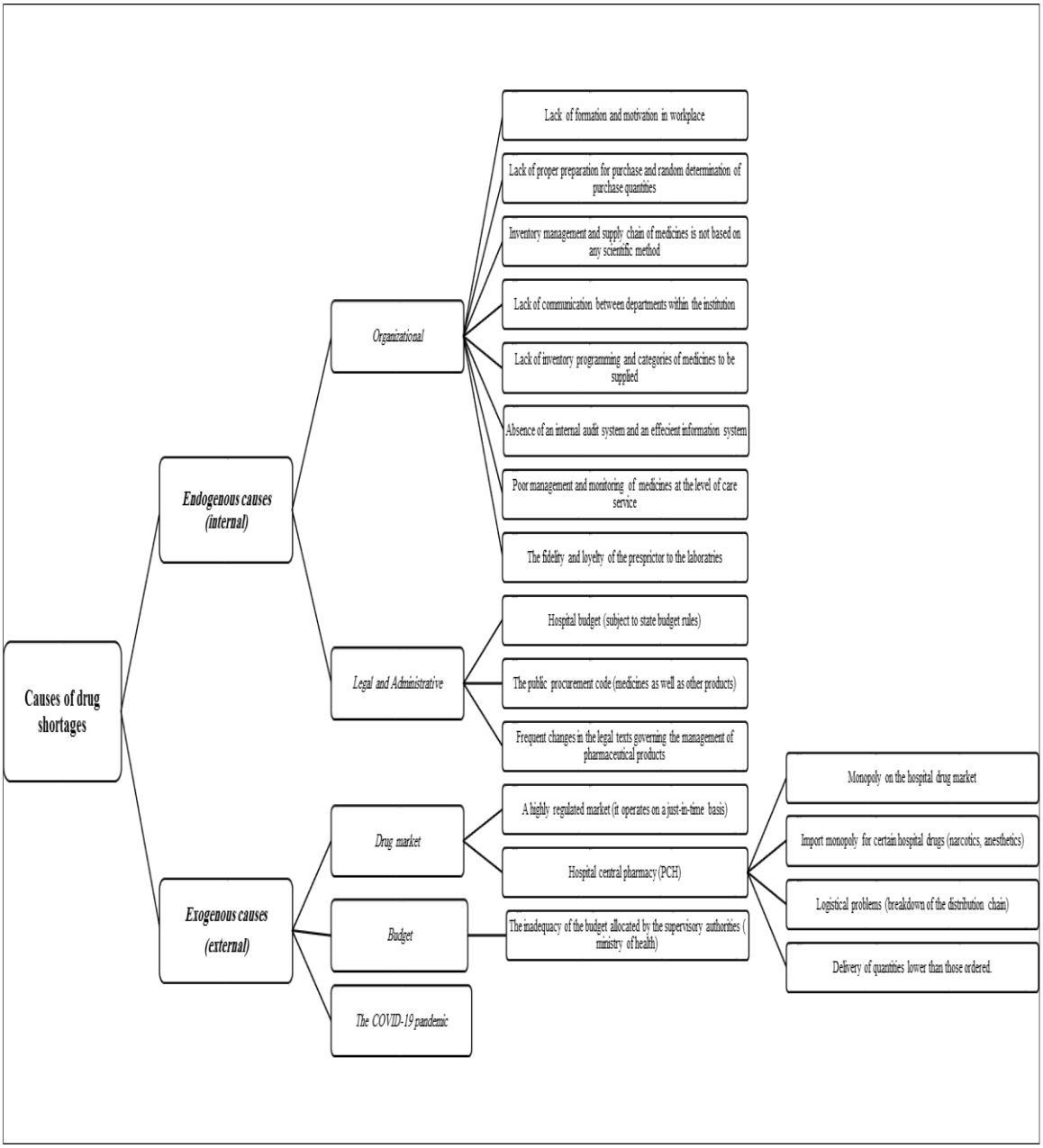
poses enormous and forbidding financial, logistical, and ethical challenges (Chen. E et al, 2021). In addition, reported shortages are longer in duration and have had a greater effect on patient care. The outbreak of the COVID-19 pandemic has only exacerbated these problems related to both supply-side challenges as well as increased demand for medications used for critically ill patients (Shuman AG, 2020).

In Algeria, the new Health Law 2018 does not define shortages. It only provides in a general way that the State "ensures the availability" of medicines and "guarantees access" to medicines, "especially essential ones, at any time and in any place in the Algerian territory" (art.205) (JORADP, 2018). It also states that producers and importers "must ensure the availability" of medicines (art. 219) (JORADP, 2018), without providing for penalties and sanctions in the event of non-compliance with these obligations.

Shortages cause serious health problems for patients as well as for the communities. Drugs are essential in the healing process of the patient. Shortages of care can have irreversible repercussions on the health of the patient. When discussing the causes of interruptions and shortages within the health care facility. The UHC Tlemcen has experienced a very disturbing situation, especially in the management of these drugs. When the hospital is in a situation of rupture of any drugs that directly influenced the health of patients and the operation of the institution. Therefore, it is necessary to discover the causes of this rupture because the consequences of this rupture are multiple and various.

According to the interview we carried out within the UHC Tlemcen; the drugs that are in ruptures are drugs that affect all therapeutic classes this rupture sometimes impacts some services that end up being stopped, we are going to detect in the next headings the principal causes and their consequences on the health of the patients and the establishment.

Fig.2. Cause tree of drug shortages in the pharmacy of the UHC-TLEMCEN –



Source: Prepared by the researchers.

3.3 Results of our interview in the hospital pharmacy:

We passed our internship at the of the hospital pharmacy of University Hospital Center (U.H.C) Tlemcen level because we obtained the favorable decision from the director of this establishment to spend our internship. In

addition, because of the geographical proximity of our residence given the health situation the Covid-19 pandemic.

The UHC Tlemcen Pharmacy is divided into three units as follows:

- *Unit A:* This is the unit responsible for the distribution of drugs and vaccines.
- *Unit B:* This is the unit responsible for the consumables, these products have a high rate of rotation and are generally offered daily, frequently requested, single use such as tubes, syringes, infusions, gloves, probes…
- *Unit C*: This is the unit responsible for biological and chemical reagent products such as laboratory reagent tests.

We only interested in drug pharmacy because of the nature of our study. We tried to meet all the agents who are related to the drug supply chain in the hospital pharmacy. So our study were conducted with 06 pharmacists, 03 administrative staff, 01 computer scientist, and 01 preparer 72.7% of them had more than 10 years' experience in hospital pharmacy. Where the majority of the interviewers agree that the hospital and hospital pharmacies are concerned about supply chain risk management. They had preliminary discussions with supply chain management about managing drug supply chain risks while listing the main risks of hospital supply chain risks regarding the five major risk factors (demand, supply, process, control, and environmental risks). Thus, hospital management integrates risk management into the drug supply chain program. It applies a risk management strategy in place and has mechanisms to identify and document the risks facing the supply chain.

However, in the meetings of evaluation and study of the medicines supply chains, not all the actors of the medicines chain are invited. This concerns only the pharmacists, which means that the others (administrators, computer scientists, preparatory) do not receive information on risks to the medicines supply chain periodically so they cannot be aware of the latest and the substantial risks. In addition, at the institutional level, there have been problems and incidents in the last 12 months that have led to a

disruption of the supply chain in which drug shortages are a current problem frequently.

They have "EPIPHARM" and "G-PHARM" software as technological tool. The help of "G-PHARM" software is essential because it is a tool for sharing information about the availability of drugs and reporting drug unavailability at the pharmacy level. It displays a notification on current shortages and potential alternatives while making the list of drugs in shortage accessible to all stakeholders in the drug cycle in hospital, it makes reliable and develops information and communication between the pharmacy and services for the management of information on shortages in real-time. This software helps to prevent and to minimize the risk of drug shortages and it ensures the quality of data relating to stocks and flows of drugs for the benefit of better patient treatment. On the other hand, each of the interviewers has a preference for one software over the other. For example, one pharmacist finds the "EPIPHARM" software better for DDP tracking and the "G-PHARM" software better for supply and procurement. Another pharmacist finds that the software "EPIPHARM" is standard and meets all the tasks of drug management (inventory, stock, rupture ...) and the software "G-PHARM" needs updates to adapt to the needs of employees (it’s been 3 years since the updates were made due to insufficient budget). The computer scientist finds that the "G-PHARM" software is the best because it gives a detailed list of the movement of medicines from reception to distribution at the level of the care services.

4. CONCLUSION

The drug supply chain is the mean by which prescription drugs are delivered to patients. The supply chain is a target for multiple risks at different levels, but improving supply chain performance is also a central strategy for the continuity and survival of hospitals in a new era of competition. Assessing the supply chain process helps identify problems and opportunities. Digital technology has the potential to modernize the drug supply chain in a way that can also serve the common goals of the economy by reducing costs and improving the quality of care provided, thereby helping to improve patient outcomes in the best possible way if it deployed effectively.

With the COVID-19 outbreak, the severity of the supply chain is pushing all parts of the health system to focus on building a resilient supply chain. While evidence suggests that digital technologies and innovations in the medical supply chain are linked to:

- Product identification: introducing innovation in drug cycle management to track drugs through all the different stages to easily detect stock-outs, which influences time-based competition, as well as patient treatment and satisfaction.
- E-procurement: refers to digital information systems related to the procurement of supplies. This can play a discriminating role in the supply chain and during disruptions. It can be used as part of broader strategies to improve transparency, reduce costs and potentially prevent shortages in drug supply.
- Reverse logistics: is increasingly important in terms of supply chain sustainability.

4.1 Recommendations and suggestions:

As recommendations and findings of our work, the following components are key for a functioning and successful drug supply chain while reducing shortage risk:

- A patient-centered and holistic procurement strategy should be in place, accompanied by political backing for drug supply chain management. The strategy is expected to be specific regarding different types of medicines, and it should balance different objectives and approaches as well as the different interests and the roles of stakeholders.
- Regarding governance, it was considered important to have a dedicated entity in charge of drug supply chain management.
- It was urged to put sufficient attention into the design of the processes. They should be efficient and transparent and be based on standing operating procedures. Skilled staff should be responsible for handling the processes, and this should be supported by E-solutions.
- Monitoring was mentioned to be a key component of an effective

supply chain system. It should be supported by robust data.

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- ## 7. Appendices
  - **Entretien avec les employés de la pharmacie hospitalière de CHU Tlemcen**

- Madame, Monsieur, étudiante en doctorat à ESMT. Nous menons actuellement un travail de recherche sur *« la technologie d'information et le risque de pénurie dans la chaîne d'approvisionnement des médicaments»*.
- Présentez-vous (âge, le poste occupé, les années d'expériences)
- Est-ce que vôtre établissement est préoccupé par les risques liés à la chaîne d'approvisionnement ?
- Comment évaluez-vous la gestion des risques de la chaîne d'approvisionnement des médicaments dans votre établissement ?
- Connaissez-vous des pénuries fréquentes de médicaments dans votre hôpital ?
- D'après-vous quelles sont les causes de la pénurie des médicaments ?
- Utilisez-vous l'outil informatique dans la gestion des médicaments ?
- Si oui, qu'est ce vous utilisez comme logiciels ?
- Comment jugez-vous votre expérience dans l'utilisation de ces logiciels ?
- Qu'est-ce que vous préfère utiliser comme logiciel 'G-PHARM' ou 'EPIPHARM', et pourquoi ?