A Meta-Analysis of Healthcare Supply Chain Performance for Patient Safety

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***Abstract*— The coronavirus (COVID-19) pandemic has had a huge impact all over the world. Healthcare industry is one that has been greatly affected by Global supply chain disruption, including shortages of critical medical equipment and drugs, insufficiency of diagnostic, and inadequacy of medical personnel. The aforementioned problems directly affect human health in the dimension of "patient safety" which may cause life-threatening situations. Therefore, it is important to learn how to strengthen the healthcare supply chain (HSC) and increase safety, particularly for patients. There are various researchers who studied HSC performance in developed countries but the research in developing countries especially southeast Asia countries e.g., Cambodia is scarce. Therefore, this research aims to identify and synthesize HSC performance for patient safety and provide a novel model of HSC performance in developing countries' healthcare settings. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) was conducted using a patient safety definition from WHO, International Patient Safety Goals from Joint Commission International (JCI), and the Hospital Accreditation institute (HA) from Thailand. The HSC performances are categorized under the easily recognizable heading SIMPLE (stands for patient safety goals in 6 domains as follows: Safe surgery, Infection Prevention & Control, Medication safety, Patient care process, Laboratory & blood product safety, and Emergency preparedness and response). The novel model of HSC performance for patient safety is provided to demonstrate the factors that can enhance the performance of HSC management in developing countries. Moreover, this study contributes to the meta-analysis by analyzing existing research and proposing new future research opportunities in HSC performance for patient safety that leads to social sustainability.**

Keywords*— *healthcare supply chain, supply chain performance, patient safety, COVID-19

I. INTRODUCTION

Severe Acute Respiratory Syndrome Coronavirus2 (SAR-CoV-2) has first been identified from an outbreak in Wuhan city. The World Health Organization (WHO) announced SAR-CoV-2 as Public Health Emergency of an International Concern on January 30, 2020,[1] and later renamed it as COVID-19. The rapid outbreak of COVID-19 became a global threat and aroused worldwide concern over the disruption of the global supply chain [2]. The COVID-19 pandemic has had a huge impact all over the world. The Healthcare industry is one that has been greatly affected by supply chain disruption, including shortages of critical medical equipment and drugs, insufficiency of diagnostic, and inadequacy of medical personnel [3]. WHO reported that the pandemic has resulted in the shortage of global medical supplies such as Personal Protective Equipment (PPE), N95 masks, sanitizers, and diagnostic test kits, as the low numbers are the result of the rising competition, panic purchasing, and goods hoarding among people as well as the countries [4]. The situation has disrupted the HSC, affecting active pharmaceutical ingredients, shipping, procurement, finished healthcare products, and more [3]. It is a significant challenge to global and national health systems. HSC is now under huge pressure from suppliers to both the receivers and beneficiaries [5].

The HSC is comprised of various players involved in the process. The process of HSC is illustrated in Figure 1. HSC management involves managing resources and supplies, as well as delivering medical products and services to care providers and patients. The completeness of the process consists of medical products and services in the form of physical goods and information going through various stakeholders. The stakeholders for HSC include suppliers, manufacturers/importers, hospitals/clinics, healthcare providers, group purchasing organizations, and regulatory agencies [6].

In Cambodia during the first phase of the pandemic, there were a variety of strategies from the Ministry of Health to mitigate the spreading of the virus in a timely response [7]. With the help of WHO and partner countries, Cambodia can strengthen its healthcare system to support the emergency plan to fight against the pandemic. However, the situation of COVID-19 globally affected the production of medicine and vaccine which plays an essential role to fight against the virus [8]. Many of these vital medicines, vaccines, and medical supplies began to show signs of scarcity. Especially for the vital components such as PPE – N95 masks that prevent healthcare workers from infection, for example, India faced this in its worst crisis [9]. In Southeast Asia, Thailand is also one of the countries facing a shortage of negative pressure rooms and PPE. Not only medicine, medical supplies, and devices are inadequate. But many countries, almost all over the world, are also facing a shortage of medical personnel. During the height of the COVID-19 outbreak, mobilizing the surge capacity of special healthcare workers in a short time is very difficult, especially for the critical care specialist and Intensive Care Unit (ICU) nurses [10].

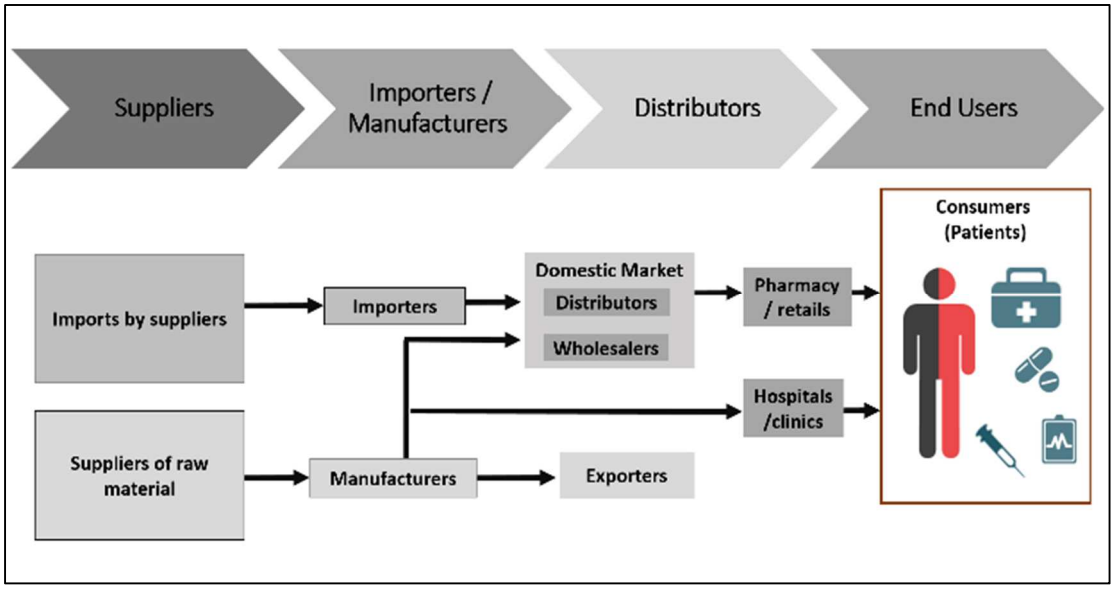

Figure 1: Healthcare supply chain process [6], [11], [12], [13]

Over a decade, the World Health Organization (WHO), its global partners, and its members have pushed a lot of effort to enhance the accessibility to health services for all the people of the world. Maintaining the awareness to detect the risks and address the sources of potential harm to patients are always challenges for all healthcare systems and health service organizations [14]. The aforementioned problems directly affect patient safety [15] which may cause life-threatening situations. Therefore, it is important to learn how to strengthen the HSC and increase resilience to prepare ourselves for future crises such as epidemics, wars, and natural disasters. The study of HSC performance correlating with patient safety is crucial due to the supply chain is the backbone of the healthcare industry, and the development of HSC performance can lead to the highest standards of patient safety.

II. Key Research Objectives

1. To identify HSC performances for the patient safety domain under the context of HSC process in developing countries
2. To illustrate the novel model of HSC performance integrating with HSC stakeholders for patient safety.

III. Research Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) was conducted in this study by searching the research in databases published over the past 20 years (from 2002 to 2022) i.e., ScienceDirect, ResearchGate, IEEE, Emerald Insight, and Springer. The search terms used were "Healthcare, Supply Chain Performance", "Patient Safety" and "COVID-19". Figure 2 shows the PRISMA diagram of the articles included in this review.

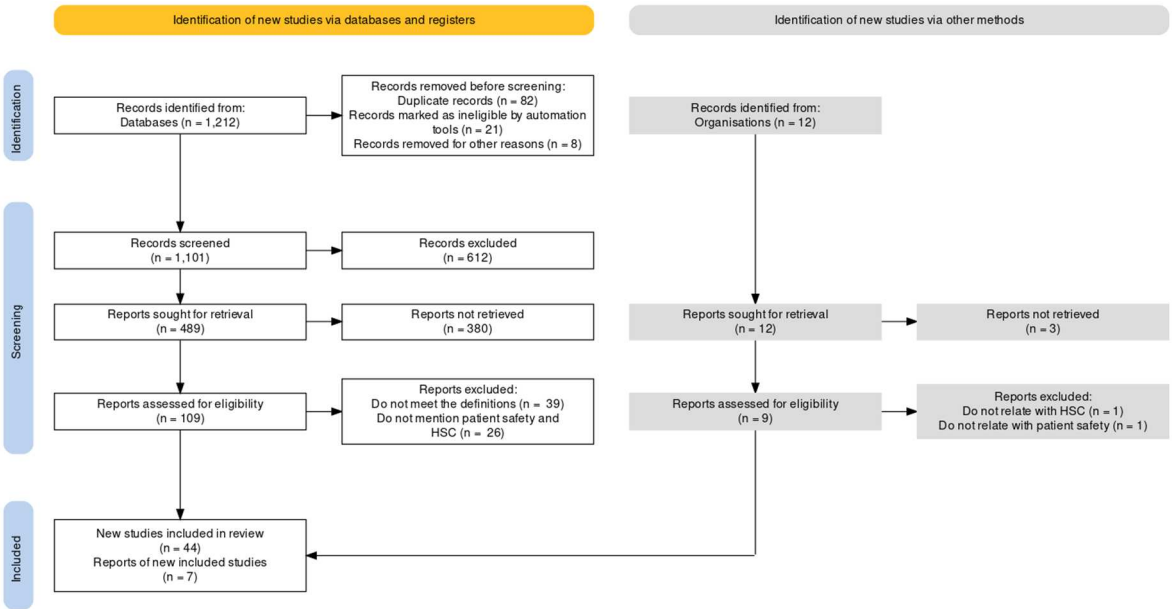

Figure 2: PRISMA 2020 flow diagram for the systematic review of HSC performance for patient safety

IV. Research Results

The exploratory search using the terms "Healthcare supply chain", "supply chain performance", "Patient Safety" and "COVID-19" were conducted. The Meta-analysis is conducted using a PRISMA flow diagram [16]. A patient safety definition from WHO, International Patient Safety Goals from JCI, and Hospital Accreditation institute (HA) from Thailand were used in the identification of new studies via other methods in PRISMA. 1,212 articles and 12 organization papers were discovered under the 5 databases. After eliminating non-English articles and duplicates, the screening process for the abstract review was conducted. The articles were excluded (n = 612) if they are not relevant to supply chain and patient safety. The screening stage was conducted accordingly with the remaining articles (n = 109). In the full-text review, the articles retained 44 items from articles and 7 items from organization papers. With the Meta-analysis, the 12 factors HSC performances are extracted and categorized under the safety domain with the easily recognizable heading SIMPLE stands for patient safety goals in 6 domains as follows: Safe surgery, Infection Prevention & Control, Medication safety, Patient care process, Laboratory & blood product safety, and Emergency preparedness and responses which is adopted from the patient safety goals by JCI and HA of Thailand [17], [18]. The analysis is displayed in Table 1 below.

Table I: The factors of HSC in patient safety domain categorized as SIMPLE

Safety Domain	Factors	Description	Source
Safe surgery and invasive procedure	Availability	The availability is the key factor to ensure the stakeholders in HSC can monitor and track product availability to increase the timely delivery of supplies, especially in life-saving procedures	[19], [20], [21]
	Innovative Technology	The potential of innovation always lights up expectations of less invasive and more accurate healthcare outcomes in the future, with lesser complications, faster recovery time, and better quality of life	[22]
	Reliability	When illicit products are supplied via illicit routes to hospitals and be used in surgical procedures, risks are present and harm to patients can occur. It is very essential to build and evaluate the strengths and weaknesses in every step of HSC in order to ensure the safety and effective care provided to all patients	[23], [24]
	Skill, Knowledge, and Experience	Skills, knowledge, and experience are the most critical resources. Healthcare personnel, for instance, an operating team including surgeons, anesthetists, nurses, and others, a team must work effectively together to provide safe treatment and avoid life-threatening complications that may occur to patients.	[25], [26],[27]
Infection Prevention and Control	Safety	The safety of medical products, supplies, and medicines is always the most concerning issue. The COVID-19 situation made emerging new supplies, new tests, new medicine, new work process, and new normal in society to ensure patient safety and reduce the rates of infection during the pandemic.	[28], [29].
	Quality	The pandemic aroused awareness about the quality of medical products. To respond to uncertain situations effectively, health supply systems should be designed to rapidly and reliably source and deliver essential health products including vaccines, medicines, medical supplies, medical devices, and PPE for healthcare workers	[28], [30], [31], [32]
Medication Safety	Forecasting and Planning	The requirements of medicine are very necessary to be determined regularly especially vital medicine for patients. The effective tools that are able to quantify the essential medicine and medical supplies supporting COVID-19 patients' needs, especially in developing countries and able to effectively plan for the next uncertainties is very essential	[33],[34],[35] [36]
	Safety	The safety of medicine and vaccine product is the most concerning issue during the pandemic. It pertains to critical safety and efficacy assessment. Special importance should be placed on assessing a patient for imminent safety concerns	[28], [37] [29].

Table I: The factors of HSC in patient safety domain categorized as SIMPLE (Cont.)

Safety Domain	Factors	Description	Source
Patient Care Process	Communication	An emerging trend in the healthcare system nowadays is using electronic medical records and technologies as tools for better communication. For instance, the tracking system of implant devices in Electronic Medical Record (EMR) can enhance patient safety throughout the chain from upstream to downstream	[38],[39]. [40], [41]
Laboratory and blood product safety	Awareness	The awareness of safety measures opined that safety factors such as sufficient training, reviewed and updated protocols, working practice policies, and Standard Operating procedures (SOP) are very important. Awareness is one of the crucial factors for HSC performance that the stakeholders require to focus on	[42] ,[43], [44], [45], [46]
	Integrity	During the COVID-19 pandemic, the guidance from FDA was also issued and provided to assuring the safety of medical product trials, compliance with good clinical practice, and minimizing risks.	[37], [47].
Emergency preparedness and response	Assessment	The best assessment practice comprised of various topics: forecasting and quantification, procurement, storage and inventory management, governance and capabilities, financing, and data management. The assessment addressed should be reviewed and revised regularly to cover the areas relevant to the emergency supply chain.	[45], [48], [49].
	Partnership	During a health emergency, partnerships, and the use of digital tools to track and measure the impact of the crisis are imperative. It can help facilitate the movement of supplies and healthcare personnel to meet urgent demands and inform strategic decision-making during crises.	[7], [50], [51], [52]
	Communication	The strategies to enhance communication are not just only for the clinical part but also include non-clinical activities. The supply chain is a critical and essential component to improve patient safety in healthcare settings.	[53], [38],[39]. [40], [41]
	Innovative Technology	With the cutting-edge technology of AI and machine learning, it is able to ultimately increase the efficiency and accuracy of forecasting to support real-time decision-making for changes in unprecedented demands	[54], [55], [56]

From the analysis of HSC performance, the identified factors were found relevant to patient safety in 6 domains. The researcher then conducted a literature review involving stakeholders in the HSC process and performance under the context of developing countries i.e., Thailand and Cambodia. The stakeholders in the HSC process consisted of supplier, manufacturer/importer, distributor, and hospitals/clinics. Each player has an important role to support the HSC process to achieve the goal of safety. Therefore, the factors from patient safety are integrated with HSC players as shown in Table 2.

In this study, the researcher focused on the safety of the patient who is directly affected by the vulnerability of HSC. Ineffective HSC caused by poor performance of stakeholders can lead to unsafe health care at push the patient at the most risk.

Table II: Stakeholders and supply chain performance in healthcare

Role	Factors
Supplier	Availability
	Quality
	Communication
Importer/Manufacturer	Innovative Technology
	Reliability
	Integrity
	Safety
	Communication
Distributor	Forecasting & Planning
	Partnership
	Communication
Hospital/Clinic users	Skill, knowledge & Experience
	Awareness
	Assessment
	Communication

V. Discussion

According to the result of the study, the patient safety domain is categorized into 6 items with 12 factors related to HSC performance. Moreover, the identified factors are integrated with stakeholders in the HSC process by the comprehensive literature review in the context of developing countries. Although many researchers have attempted to address the performance and process of HSC but mostly tend to focus on the performance of the suppliers, manufacturers, and distributors while only a few mentioned the HSC issues related to patient and patient safety domain. This study proposed a novel model of HSC performance for patient safety in the context of developing countries as illustrated in Figure 3.

Since the COVID-19 pandemic has shed the light and attracted many researchers on the issues of supply chain disruption. The Healthcare industry was shown that it is very essential during the pandemic situation in terms of diagnosis, treatment, and prevention. Regarding the implication, the HSC performance for patient safety model presented in this study can be used for performance improvement of the various stakeholders in supply chain processes in healthcare settings. The model can be useful in addressing HSC issues upstream and downstream for implementing strategies to improve overall performance and cope the future uncertainties.

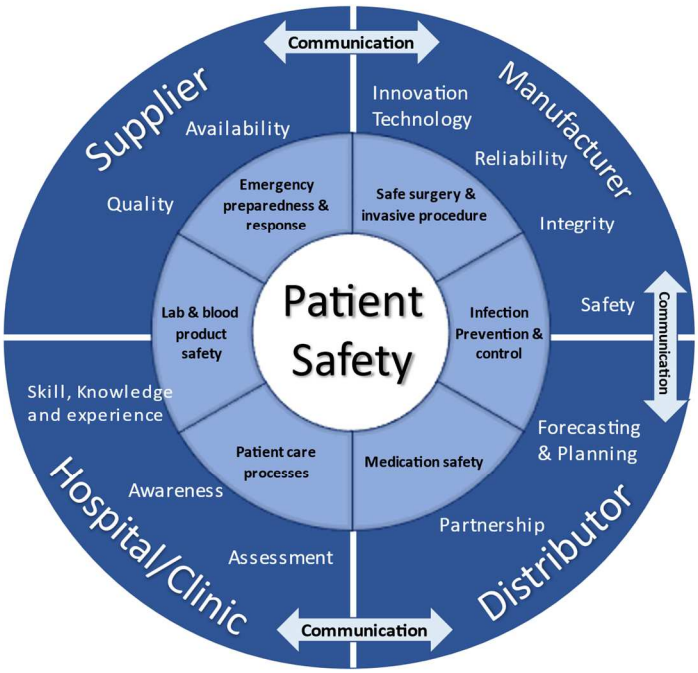

Figure 3: The novel model of HSC performance for patient safety

VI. Conclusion

Although many countries in Southeast Asia can cope well with the COVID epidemic situation. However, limited resources and difficulty to access to public health across the countries in some places i.e., Cambodia and Thailand have highlighted that healthcare system development must be accelerated especially in HSC [7], [57], [58]. This study contributes by presenting a novel model of performance related to HSC management with reference to the developing countries' context. This study shows the imperative of HSC management that can create a stronger healthcare system in developing countries and enhance the performance of HSC to mitigate the risk of medical supply chain disruption from future uncertainties. Furthermore, reducing the vulnerability of the medical supply chain can lead to the ultimate goal of patient safety. This study can lead to future research opportunities in HSC performance for patient safety and the sustainability of the HSC towards the highest patient safety for a better quality of life.

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