

Forecasting of Supply Chain Management for Non-Communicable Diseases

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Abstract — This paper investigates the usefulness of forecasting modelling to Non-Communicable diseases (NCDs) in supply chain management, which includes the appropriate methods to collect and analyse the important data. An alternative method has been proposed to forecast both vertical and horizontal supply chain relationships in healthcare using machine learning and numerical forecasting models. In future, this proposed method shall be considered to further developments on NCD requirements using at least 30 years' historical data to obtain more specific and reliable information that require to predict the supply and demands.

Keywords — supply chain management, Non-Communicable Diseases (NCDs), forecasting, healthcare, numerical models, machine learning

I. INTRODUCTION

The supply chain is an infrastructure that is required to provide products or services to the customers. Healthcare supply chain management is considered to provide medical supplies, resources, services to patients and healthcare providers. The healthcare items and information on medical products and services typically go through a variety of different parties including; suppliers, insurance firms, hospitals, distributors, buying associations, and a range of regulatory agencies [1].

The healthcare supply chain begins at the manufacturer of the medical products, i.e. prescriptions drugs, gloves, masks, surgery instruments, and sent to a distribution centre. The distribution centres are responsible for supplying all the necessary items to the healthcare organisations to deliver to providers and patients. Hence, there is a high demand for medical products from almost all healthcare organisations. Thus, they purchase medical products in bulk from the suppliers to increase their profits and to ensure the providers and patients do not lack the essential medical supplies.

The healthcare suppliers shall overcome many challenges to deliver their products and services to their providers and patients. Apart from many other challenges, provider satisfaction is considered to be the most challenging task. To achieve the best provider and patient satisfaction, the supplier shall boost its services and performances by cost reduction and improving the quality of products. There are few other concerns which the provider needs to be addressed to boost their performance, such as overnight shipping, hidden costs, storage facilities, physician preference and many more [2]. However, the complexity of the healthcare supply chain

increased every day due to the economic pressure, trade disagreements, and environmental changes, which may cause a highly significant risk to both medical organisations and patients [3].

Due to the health care cost and lost economic productivity, Non-Communicable Diseases (NCDs) face a huge economic effect. The world economic forum stated that between 2011 and 2030, the world will suffer a cumulative output loss of around \$30 trillion due to NCDs [4]. Moreover, NCDs dominate this 21st century, globally; by its public health challenges and high mortality rate. Cardiovascular disease, chronic respiratory disease, cancer, and diabetes are the major NCDs which cause a higher death rate worldwide [5]. Among these NCDs, one-half of the global deaths are attributed by cardiovascular disease, and 80% of deaths are due to cardiovascular disease happening in low and middle-wage countries [6]. Tobacco and alcohol consumption, improper diet, insufficient physical activity, environmental pollution and increased metabolic risk factors including blood pressure, blood glucose level and obesity may lead to NCDs [5]. It is well-recognised that a healthy lifestyle is essential to the proper maintenance and functioning of the human body. According to the World Health Organization (WHO) 2018 report [7], half of the globally accepted guidelines for cardiovascular disease, which are widely used, are less than a quarter for low-income countries. The WHO further elaborated that only one third (35%) of countries had all necessary NCD medicines and technologies. Thus, it shows an appropriate supply chain management system is important to handle the demand of the healthcare sector to manage the needs of the medical products to treat the patients with NCD.

Recently, the outbreak of the novel COVID-19 shows the vulnerabilities of the supply chain of medical resources where the manufacturers are not able to meet the buyer's needs on time and the required quantity. In the healthcare sector, the forecasting of supply chain relies on both consumer and distributor, rather than on an individual basis. Thus, forecasting offers the visibility of the supply and demand to help the organisation to improve its performance in optimising the inventory level, operations, and to lessen the inventory cost.

The layout of this paper is organised as follows: Section II introduces the main objectives of this study. Section III presents the related works of forecasting model integration in healthcare applications, and the provision of primary healthcare facilities based on demand in managing and



treating the NCDs. Section IV describes the proposed methodology of supply chain management for NCDs data. Finally, Section V concludes the paper and delivers possible future directions that may require to improve the proposed methodology.

II. OBJECTIVES

The objectives of this study are to define the usefulness of the supply chain management system as well as the forecasting models to support NCDs prediction and contrast successful ways of collecting and analysing the supply and demand data. Hence, the aim is to provide a general idea of using the forecasting models in NCDs data analysis to boost healthcare supply chain management. This study proposes different types of methods for data collection, analysis, and prediction to forecast risky medical events, which may be useful in the healthcare supply chain that involves retailers, distributors, producers and suppliers.

III. RELATED WORKS

As the world population grows, healthcare services have increased. This results in more prone to disruption in the supply chain management in the healthcare sector, such as the shortages of medicines and the necessary equipment to diagnose patients. Most researchers focused on the individual analysis of the supply chain management across the organisation (horizontal information sharing), but not, with the organisation's suppliers or vice versa. For example, Sharma et al. [8] addressed the implications of the Internet of Things (IoT) for monitoring the pharmaceutical stocks in the warehouse and its movement. Hence, this will increase the interoperability of the stocks in the warehouse. Most researchers tend to focus on individual analysis on either its supply or demand. Xu et al. [9] addressed the forecasting model of demand for a medical device with the aid of online big data in China, which is Baidu Index. However, the lack of information sharing capability might result in less accuracy of the forecasting model. It has been proven that the information-sharing capability between customer and supplier gives a positive result [10]. Nevertheless, this study will only focus on the combination of both supply and demand forecasting models to increase the accuracy of forecastings of supply chain management for NCDs.

Furthermore, Bui et al. [11] summarised different forecasting models that have been used in the healthcare industry, exclusively on cardiovascular diseases, and using time series data to predict future trends. Thus, there are still more supply chain problems that need to be addressed for these specific diseases such as chronic respiratory diseases, cardiovascular diseases, diabetes, and cancers.

Enhancing the availability of primary healthcare services based on the needs and demand will help to control and treat the NCD patients. Especially, using measuring devices such as thermometer, stethoscope, sphygmomanometers, measurement tape, weighing machine, peak flow meter, and glucometers. However, test strips, i.e. blood glucose test strips, urine protein test strips, urine ketones test strips, troponin test strips, urine microalbuminuria test strips, are also highly demandable medical products in the primary healthcare services. In addition, assay kits including blood cholesterol assay, lipid profile, serum creatinine assay and other devices including nebuliser, pulse oximeter, electrocardiograph, defibrillator and spacers for inhalers are some equipment listed under primary healthcare services [12].

IV. PROPOSED METHODOLOGY

The discovery of information from the NCD dataset is a useful tool for extracting the most important information. This collected information can then be filtered to eliminate redundant information and provide the required predictions using the appropriate forecasting models. Incorporation of the collected NCD data analysis with a forecasting model provides a mechanism for the supply chain management to achieve a useful understanding of the results in the healthcare system. The proposed supply chain management system to NCDs data is shown in Fig 1.

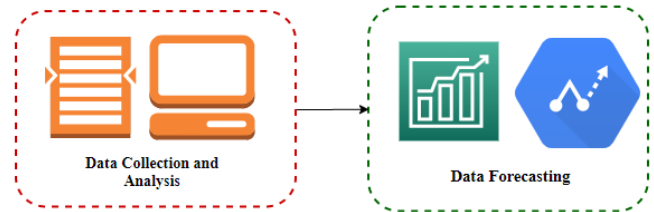


Fig. 1. Proposed supply chain management methodology for NCDs data

A. Data collection and analysis

Data collection in the healthcare field is mainly used to analyse important information and provide insights to support in medical decision makings, especially in analysing the clinical data, pharmaceutical, patient's information, and medical cost. Thus, forecasting will be the most appropriate solution to predict the supply as per the demand of the healthcare field. Most importantly, the WHO has provided up-to-date statistical data that is more relevant to different types of diseases, specifically for NCDs. As of the WHO 2018 report [7], it can be confirmed that the demand for medical supplies is increasing each year rapidly. Therefore, the suppliers shall be able to predict the requirements such as medical product transporting and storing, before ahead. However, providers and patients (customers) should be concerned about many essential factors such as manufacturing quality, durability, and the cost, before demanding products from the supplier.

The collected supply and demand data shall be further analysed to choose the most relevant information. Data engineering may be a useful method to find the trends of the dataset and develop many types of algorithms to make the raw data as useful informatics. Most possibly, the data cleaning process and statistical evaluations can build pipelines to transform the data into the forecasting models to discover their patterns and knowledge to create machine language algorithms to make requisite early predictions.

B. Data forecasting

Forecasting requires historical data for mathematical modelling to work in order to project future outcomes or trends. Hence, forecasting modelling is essential to improve the supply according to the demand. Thus, it may enhance profits and reduce inventory cost. The numerical models such as Naïve method (NM), Cumulative mean (CM), Moving Average (MA), Exponential smoothing (ES), Auto-Regressive Integrated Moving Average (ARIMA), and Linear Regression (LR) can be considered as the best solution to address the healthcare supply chain to estimate the budgets and plans as of the demand from the providers and patients (customers).

Moreover, machine learning is another method that is commonly used to forecast the supply chain in healthcare. The key advantage of machine learning is its ability to handle big data without human interference [13]. Thus, it can provide



an unprecedented consumer with insights into demand. Xu Shuojing et al. [9] approached Support Vector Machine (SVM) machine learning method to forecast the demand of medical devices with the aid of online big data, whilst Chae S. et al. [14] applied both numerical and machine learning methods; LSTM and Deep Neural Network (DNN) to get an early advantage to anticipate infectious diseases based on the short-term forecast.

As aforementioned, the forecasted results can be utilised to predict the amount of demand (patient) for that particular type of disease in the near future. Hence, with that information, the organisation management can place an order on time, resulting in the reduced delay time of machine to arrive, queue time in the healthcare facilities and reduce overburden of the physicians, in case of the surplus amount of patients coming in.

V. CONCLUSIONS AND FUTURE DIRECTIONS

Healthcare supply chain relationships have paid particular attention to work more closely with partners, including customers, vendors, and different logistics vendors to achieve collaboration and alignment across supply chain relationships, i.e. vertical relationships and horizontal relationships. Most of the healthcare supply chains are lacking in information sharing between the healthcare organization and the suppliers. In future, the provision of healthcare requires a complicated undertakings and trade between quality and cost. Thus, it is essential to create a transparent and a closer connection between supplier and customer, whilst keeping a strong bond between the other organisations, i.e. supplier to another supplier, disturber to another distributor, to work together to improve their priorities and activities to achieve long-term goals, objectives and target strategies by integrating the forecast modelling.

The proposed NCDs data forecasting model confirms that it is essential to gather the most reliable data and analyse them using suitable tools before transporting them to a forecasting model. It has been noted that the machine learning models yield better results in forecasting the NCDs data into various categories. Also, there are several studies which conducted forecasting via deep learning methods and obtained promising results. In addition, the combination of traditional forecasting methods and deep learning models, i.e. Recurrent Neural Network (RNN) or Long-Short Term Memory (LSTM) may be beneficial to the healthcare supply chain

management to obtain more accurate forecasting results from NCDs data.

Moreover, computer-based applications can be developed to broadly extend the proposed method to forecast the risk level of all types of NCD patients. This can be done further by emphasising the relevant vitals and their interpretation to provide expert consultations.

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