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A Comprehensive Study on Prediction Providing Medicines Using Machine Learning

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ABSTRACT

Providing medicines in the required quantities is a very influential point for healthcare institutions and the pharmaceutical industry. The challenge in the pharmaceutical sector is that some medicines can disappear due to side effects, while others appear as they were invented. Some medicines can also be improved, and the use of some medicines increases according to the season. These reasons combined make the prediction process complex. The current article reviews the importance of drug production management (predicting the required quantities with high accuracy), and the most important algorithms that have been employed in this field are also addressed, with a focus on improving accuracy and reducing the error value. Machine learning algorithms can play an influential role in the pharmaceutical industry and management. Improving accuracy depends largely on the availability of a data set specific to this field, which is a challenge as there is no link between diseases and their medicines, and there are some medicines that are used to treat more than one disease. The current article reviews the most important challenges facing researchers when working in this field.

Background:

The availability of medicines and medical supplies is a critical issue in healthcare institutions. This study highlights the importance of using artificial intelligence and machine learning to predict the quantities of medicines required to ensure accurate and appropriate supply. Deep learning algorithms can also be used to improve prediction accuracy.

Materials and Methods:

This study included collecting and analyzing previous studies on the use of artificial intelligence and machine learning techniques and conducting a comprehensive study on the impact of using machine learning algorithms in predicting drug quantities and their impact on providing appropriate quantities.

Results:

After compiling and analyzing related works on predicting drug availability using artificial intelligence and machine learning techniques, the study concluded with a set of challenges facing this problem and how to address them.

Conclusion:

The field of pharmacy is currently considered an important field due to the rapid development of the pharmaceutical industry. The production and supply of medicines require large amounts of money. Therefore, with the rapid increase in medicine usage data, a set of references was reviewed that used data mining techniques and artificial intelligence algorithms that were trained on medicine and pharmaceutical industry data, where the focus was on improving accuracy and reducing the error value. Also, employing the capabilities of artificial intelligence and machine learning leads to improving medicine production in terms of providing accurate quantities. The increase in production leads to the product reaching its expiration date, while the decrease in production leads to the inability of pharmacies to provide the required treatments, and in both cases, it leads to harm to human life. Future work may be to determine the side effects of medicines through patient experiences, and the effectiveness of medicines can be evaluated through clinical trials and patient ratings of medicines.

Keywords: Pharmaceutical industry, machine learning, medicine providing, medicine consumption forecasting.

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INTRODUCTION

In the pharmaceuticals industry, there are many uncommon characteristics that concern the manufacturing of pharmaceuticals. These characteristics make this industry very different from any other type of industry, and they, in fact, influence the process of finding new medicines for patients. Forming a new medicine takes a very long time, is very expensive and highly risky, and the chances of a successful result are very small. The big pharma firms are research-based organizations[1] and today technology is significantly used to assist the pharmaceutical companies to manage their stocking and to find new products and services. The administration of the pharma industry has begun to recognize the important relationship between the definition of medicines and products and management information[2]. In the unrest between costs, care-outcome and customer satisfaction, a high balance is necessary and should be established by developing information and communication technology. There is a realization that the pharmaceutical industry depends heavily on information regulation and process; every day the automated systems are used in these firms as a tool that focuses on the registration of the production process. In these systems, all the operational data that are used to keep the organization running are saved[3]. The development of healthcare and the medicinal industry most importantly resulted in the availability of data. Therefore, this field is considered to be a rich environment for different research carried out scientifically. It carries several differences when compared to other sectors, as it is linked to the life of hthatuman beings. As well, it has a relatively higher priority because it is supposed to be within a high level of health services with no regard towards its of cost, and therefore consumes a bigger amount of the specified budget for each country. Pharmaceuticals is probably one of the more influential fields of healthcare. Its industry depends on quantitative analyses of clinical studies and medicine marketing.

Data mining represents a logical process of extracting useful information from bigger data sets. It aims to discover patterns that have not been pointed out yet within the big data. These found patterns can be used to help companies develop their business through improved decision-making. Data mining involves three important stages: Exploration, Pattern Identification and pattern deployment in decision-making. In addition, as stated by several researchers (i.e., [4], [5]) learning can be put into use in the analysis of the medical dataset in order to extract data from it. Several fields within the healthcare sector used deep learning in solving problems successfully: IBM applied this method in constructing Dr. Watson's application.

Pharmaceutical companies could also benefit from healthcare Customer Relationship Management (**CRM**) and data mining. Pharmaceutical companies can specify their marketing target through following up on which practitioners give out prescriptions for what medicines and for what purposes[6]. This shows the least expensive or most effective treatment plan for a certain illness, as well as its contribution in identifying the practitioners who have practices with specific clinical

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trials like those who have a high percentage of patients that belong to a particular classification), and pictures the course of an epidemic with the aim of supporting pharmaceutical salespersons, physicians, and patients [7].

The rest of the article is organized as follows: Medicine Provision: This paragraph reviews the importance of providing medicines in pharmacies and hospitals and the impact of drug shortages on human life. Pharmaceutical Industries and Data Mining: This paragraph shows the extent to which the pharmaceutical industry benefits from data mining applications through data analysis, pattern discovery, and the use of results in developing the pharmaceutical industry sector. Related Work: This paragraph reviews articles related to drug management and provision and the impact of employing machine learning algorithms in building models that accurately predict the required quantities of medicines. Challenges and difficulties in analyzing drug data: Here are the most important challenges facing researchers when working on employing machine learning algorithms in the pharmaceutical industry.

PROVIDING MEDICINE

The medicine is an important necessity for a patient to be healthful. It is one of the major materials used by health experts or physicians in preventing disease or in therapy[8]. Therefore, hospitals and/or pharmacies should guarantee providing the necessary medicine at any times so they can be specified to patients when needed. Health care institutions face a challenge in providing required medicines and good services. As they control the provision of medicines and avoid harmful effects, inventory or stocking control is the main factor to keep the organization's competitiveness in progress [3]. Medicine quantification is a procedure used to define how much of a product or medicine is wanted for the purpose of procurement. Quantification process does not only identify quantity demands of medicines or specific item, but it also defines the financial funds required for purchasing the item. To achieve perfect medicine quantification, different information is needed, such as the Essential Medicines List (EML), consumption of the medicine, number of items, procurement cycle [9].

PHARMA INDUSTRIES AND DATAMINING

The Pharma industries depend on resolution oriented, systemic chosen models that allow the decision maker to evaluate the profit that is predicted to outcome from the implementation of a proposed choosing plan [10]. The pharmaceutical industry employs data mining applications in a variety of ways such as regression, classification, clustering, prediction and data analysis. Prediction in the pharmaceutical field partly includes employing the prescription numbers in the

history of physicians to improve predicting future behavior [11]. Data analysis in the pharmaceutical field employs inference from the data mining research to define the better path of work concerning future business resolution. By defining the prescription patterns through prediction ways, pharmaceutical firms can view which physicians write the most prescriptions and which medicines they use [12]. Marketing planning that focuses on growing incomes will be more convincing than those addressing cost-decrease[13]. These technologies will make the pharmaceutical firms improve the goals and marketing to specific customer parts and will increase the use of that technology and will open the door for projects aimed to decrease the payment and increase clinical experiment results. There are automatic systems in the firms designed to store the production data, which are used to keep the firms running. These systems are known as "legacy systems" or "traditional system." Big information is unobserved in legacy systems, and this can be easily discovered. In most situations, the discovery of data cannot directly be applied from that system since it is not designed to answer the unexpected questions [10].

RELATED WORK

In this section we will review the most recent prediction methods for medicine utilization, where some of these methods are statistical methods and others use a machine learning method. All methods are using the prediction process for one, two, or three medicines at most. Table (1) summarizes all the related works that are listed below with additional information.

1- [14] This study aims to create optimal drug clusters for utilization use a new model called useDisease_Drugs_Clustering_Deep_Nural_network (DDC_DNN), a deep neural network with four layers. The model focuses on forming primal clusters based on proximity and distance, re-forming clusters, and calculating cluster centers. Data on diabetes, leukemia, and allergy drugs were for validation, with the proposed model outperforming traditional methods like K-means according to the silhouette validity score.

2- Pharmaceutical drug provision in appropriate quantities is crucial for efficiency, as unnecessary excess can lead to prolonged storage and reduced effectiveness due to short shelf life. In [11] employed time series analysis, and using deep learning like LSTM, to predict drug requirements accurately. The method in this study based on seasonal

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prescription trends and quarterly indicators forecasts drug needs for a year with low MSE. Comparison with traditional methods like linear regression shows promising results. This approach ensures customer satisfaction and efficient drug marketing by producing the right number of drugs needed.

3- The authors in [15] used data mining techniques to forecast the inventory of medicines. Four different types of machine learning algorithms were used for the purpose of analyzing time series. Gaussian Processes, SVM Regression, MP, and LR have explored their accuracy in the forecasting results. They used data that contained product demand from 2011 to 2017, three products were chosen in this work. These products have different frequencies of demand (high demand, low demand, and randomly chosen product). Statistical features (weeks, mean, median, max, min, std, and variance) were used in the prediction process, to improve the prediction model the authors used the lag estimation variables. RMSE used as an execution measure to compare the result of various algorithms. The results showed that Gaussian Processes was the method that provided the best prediction with a lower RMSE than the rest of the applied methods, RMSE was (789551.3),(9179.5), and (146336.0) for the three products.

4- The article presented in [16] deals with predicting carbapenem resistance from monitoring antimicrobial consumption. In this article, the researchers relied on data collected through the hospital's pharmacy system. The data included antimicrobial clan, potion, mode, way of management, parcel volume, number of a set put out, trait, and infirmary location. The prediction model presented in this article was autoregressive integrated moving average (ARIMA) with meropenem utilization at lag −1 as a forecast, to evaluate the model accuracy the authors used "RMSE" and "R-squared (R2)]". The best result reached in this work was RMSE = 1.41 and R2 = 79%. However, the ARIMA model may lead to poor forecasting during the identification stage. especially if the in-sample explanatory performance of the model is maximised.

5- The sales for new medicines (new licensed and released for market) that suffering from unstable sales and no historical data available. for those reasons in [17] the forecasting model based on the sales data and another factor of influence was suggested in this article. the prediction model built by using random forest without using influence factors and it

was compared with the random forest prediction model taking into account The influence factors. these two models were evaluated by three performance metric MAE, MAPE, and RMSE. the model of a prediction that takes into account the impact factors (present season, the cost of the medicine tested, the changeful costs, selling, and training sample) reached an improved result in the forecasting (RMSE= 19183.72). however, using random forest tree to build prediction model may give different results depending on the depth of the random tree, it can suffer from under_fitting when using a little deep.

6- Deep learning has been used in [18] to perform the prediction of pharmaceutical product sales. Data of three years are arranged as weekly sales therefor the prediction model is built to predict the sales of the week. The authors selected four medical products with different behaviours for training. The data used in this work extends from 2014 to 2017. In this work, the researchers presented a model consisting of three shallow networks called Autoencoder, Precursor and Gambler. In this work, the available data is divided into three-zone. Autoencoder-precursor's job was to produce the abstract representation of the input data (the first data zone), the second data zone used to train the gamber-net, and the third data zone used as test data for predicting the future data. The best hit rate the researchers reached in their work was (86.4%).

7- The work was presented in [19] studies on trends in the utilization and cost of medicines used in tdata ishe treatment of eye tumours. To complete this study, researchers used Taiwan's National Health Insurance Research Database from 2009 to 2012, predicting the quantities and cost of medicines required until 2016. The researchers collected anti-tumour medicines in six groups. Usage data representing the number of prescriptions and cost were collected by quarter and annually for each of the six groups. In this study, the researchers used statistical analyses of time series and the ARIMA model to predict market share through the size of prescriptions and the total cost of targeted treatments among all antiretroviral agents.

8- In [20] the authors have forecasted the quantities consumed and purchases for only one medicine. The medicine is RAPILYSIN LYPDINJ 2X1.16G/VIAL (RL). These medicines are used in the management of acute myocardial infarction (AMI). The data used in this work were collected from one hospital for the period from 2009 to 2011. The authors

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presented in this work a method univariate time series analysis and forecasting, A medicine purchase model and a medicine consumption model were built and the researchers obtained the best prediction result based on the mean square error is (4.3245x106, 4.1437x107).

9- Monitoring the spread of disease by building an approved GIS map was presented in [21], In order to monitor the spread of diseases in Greece, Traditional statistical methods were used to compute Health care demand and supply GIS was also used for the purpose of spatial visualization through mapping the maps. The color density used to identify the quantities of supply and demand services that applied in the polygons map of the country provided another view for the evaluation of the health care. However, the work depended on traditional statistical methods only, the data set was not used to predict future healthcare requirements.

10- Prediction of demanding medicine presented in [22] where the researchers relied on spatial data in addition to demographic data and consumption data for the predicting the required quantities of the medicine. A model was developed to predict the required quantities of the medicine Salbutamol based on data from 2010 to 2014. Generalized Linear Models, SVM with LK and SVM with Gaussian kernel are used as a model for prediction. The algorithm that gave the lowest ratio of the line is GL Models. The authors used mean absolute error to evaluate the three models and the error was (5.78, 6.33, 17.07) for Generalized Linear Models, Support Vector Machines with linear kernel and Support Vector Machines with Gaussian kernel respectively.

11- In the article [23] Authors present a model for forecasting the quantities of medicines required based on consumption data as well as social networking data and wireless sensor data. Only three medicines were predicted. The researchers used consumption data as endogenous variables that came from time series and exogenous variables that came from topic trend analysis of Facebook, Twitter, and bloggers. Two prediction models have been tested in this article: an autoregressive model with endogenous variables only and autoregressive model with endogenous and exogenous variables. The results showed that the prediction model improved after using the topic trend obtained from social networking as exogenous variables.

12- Data mining was used in [24] to define the amount of medicine to be stored in the depot. First, the exploratory network examination was performed to define the cluster set and members of medicine that have identical sales manners. Three different types of time series of sales were used in this study, prediction models. The ARIMA model and neural network were first executed on one record of previous medicine to design a sales prediction. At the end, a neural network model was constructed utilizing zone records of each medicine along with medicines involved in a similar set of analysis methods. The proposed method presents a better result to the proposed approaches, helping to capture linear and nonlinear trends in medicine sales.

13- [25] present in this study, the Adaptive Network-Based Fuzzy Inference System (ANFIS) employed to construct a prediction model for future demand of the pharmaceutical product. only one product data was used in this study, the data was divided into four periods. four periods using as training data and the demand in the period was as the future prediction of the model. the historical sale data of the product and effective factors were used as input to the prediction model. the accuracy of the prediction model was measured by average testing error. The best result that was achieved by this model was (0,18169).

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Table 1 the summary of related work

NO.	Method name	Prediction method	Type of data	Evaluation measures
[12]	Data mining for clustring	Disease_Drugs_Clustering_Deep_Nural_network (DDC_DNN)	https://www.data.gov provides a big dataset for the UAS drugs utilization over many years.	The Silhouette Score
[10]	Deep learning for prediction the medicines consumption	LSTM	https://www.data.gov provides a big dataset for the UAS drugs utilization over many years.	RMSE
[13]	Data Mining method for storing prediction :	GP, SVMR, MP, and LR	products demand from 2011 to 2017	RMSE
[14]	Forecasting carbapenem resistance from antimicrobial consumption surveillance	the autoregressive integrated moving average (ARIMA)	data collection monthly consumption	RMSE, R^2
[15]	Model of medicines sales forecasting taking into account factors of influence	random-forest without using influence factors, random forest prediction model taking into account the influence factors	Sale data from 2014 to 2017	MSE, RMSE,MAPE
[16]	A Deep Learning Algorithm to Forecast Sales of Pharmaceutical Products	Autoencoder, Precursor and Gambler	Sale data from 2014 to 2017	hit rate

[17]	location tendency in the use of targeted medicines for the curing of malignant neoplasms of the eye	the autoregressive integrated moving average (ARIMA)	Sale data from 2009 to 2012	MSE
[18]	Forecasting the consumption and the purchase of a medicine	univariate time series analysis and forecasting	2009 to 2011	MSE
[19]	map tendency and sample in a GIS summary.	traditional statistical methods	Consumption from 1997 to 2007	MSE
[20]	Improvement of the Prediction of Medicines Demand Using Spatial Data Mining Tools	GL, SVM with LK and SVM with GK	Sale data from 010 to 2014	MAE
[21]	Demand Forecasting Models for Medicines through Wireless Sensor Networks Data and Topic Trend Analysis	an autoregressive model with endogenous variable, an autoregressive model with endogenous variable and exogenous variables	Sale data from January 2010 to August 2013	Error rate
[22]	Intelligent Sales Prediction for Pharmaceutical Distribution Companies	ARIMA model, hybrid neural network	Sale data for three years	MAE
[23]	Demand prediction in pharma manufacture Using AI and ANFIS	ANFIS	Sale data for seven years	MAE

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CHALLENGES AND DIFFICULTIES IN PHARMACEUTICAL DATA ANALYSIS

The pharmacy field is one of the interesting fields in recent times; therefore, there are several challenges to be faced to analyze the pharmacy field data.

1- Dealing with a big data set over a number of years.
2- It is not possible to have a comprehensive and specific data set that contains information about diseases and medicines used to treat them.
3- Non-stationary data: because of the development and discovery of new types of medicines as well as the development of diseases such as AIDS.
4- Confronting emergency situations: The emergence of epidemics and pandemics in recent years, especially the Corona pandemic, has forced the pharmaceutical industry to enter into trials of several new medicines and vaccines to confront emergency situations.

CONCLUSION

The field of pharmacy is currently considered an important field due to the rapid development of the pharmaceutical industry. The production and supply of medicines require large amounts of money. Therefore, with the rapid increase in medicine usage data, a set of references was reviewed that used data mining techniques and artificial intelligence algorithms that were trained on medicine and pharmaceutical industry data, where the focus was on improving accuracy and reducing the error value. Also, employing the capabilities of artificial intelligence and machine learning leads to improving medicine production in terms of providing accurate quantities. The increase in production leads to the product reaching its expiration date, while the decrease in production leads to the inability of pharmacies to provide the required treatments, and in both cases, it leads to harm to human life. Future work may be to determine the side effects of medicines through patient experiences, and the effectiveness of medicines can be evaluated through clinical trials and patient ratings of medicines.

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Conflict of interests

There are non-conflicts of interest.

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الخلاصة

يُعد توفير الأدوية بالكميات المطلوبة عاملاً حاسماً لمؤسسات الرعاية الصحية وصناعة الأدوية. يكمن التحدي في قطاع الأدوية في أن بعض الأدوية قد تختفي بسبب الآثار الجانبية، بينما تظهر أدوية أخرى كما تم اختراعها. كما يمكن تحسين بعض الأدوية، ويزداد استخدام بعضها الآخر مع تغير الفصول. هذه الأسباب مجتمعة تجعل عملية التنبؤ معقدة. تستعرض هذه المقالة أهمية إدارة إنتاج الأدوية (التنبؤ بالكميات المطلوبة بدقة عالية)، كما تتناول أهم الخوارزميات التي تم استخدامها في هذا المجال، مع التركيز على تحسين الدقة وتقليل قيمة الخطأ. يمكن لخوارزميات التعلم الآلي أن تلعب دورًا مؤثرًا في صناعة الأدوية وإدارتها. يعتمد تحسين الدقة بشكل كبير على توافر مجموعة بيانات خاصة بهذا المجال، وهو ما يمثل تحديًا نظرًا لعدم وجود صلة بين الأمراض وأدويتها، وهناك بعض الأدوية التي تُستخدم لعلاج أكثر من مرض واحد. تستعرض هذه المقالة أهم التحديات التي تواجه الباحثين عند العمل في هذا المجال.

مقدمة:

يُعدّ توافر الأدوية والمستلزمات الطبية مسألةً بالغة الأهمية في مؤسسات الرعاية الصحية. تُسلّط هذه الدراسة الضوء على أهمية استخدام الذكاء الاصطناعي والتعلم الآلي للتنبؤ بكميات الأدوية اللازمة لضمان توافرها بدقة وسرعة. كما يُمكن استخدام خوارزميات التعلم العميق لتحسين دقة التنبؤ.

طريقة العمل:

وتضمنت هذه الدراسة جمع وتحليل الدراسات السابقة حول استخدام تقنيات الذكاء الاصطناعي والتعلم الآلي، وإجراء دراسة شاملة حول تأثير استخدام خوارزميات التعلم الآلي في التنبؤ بكميات الأدوية وأثرها في توفير الكميات المناسبة.

النتائج:

وبعد تجميع وتحليل الأعمال ذات الصلة بشأن التنبؤ بتوفر الأدوية باستخدام تقنيات الذكاء الاصطناعي والتعلم الآلي، خلصت الدراسة إلى مجموعة من التحديات التي تواجه هذه المشكلة وكيفية معالجتها.

الاستنتاج:

تسلط النتائج الضوء على كيف يمكن للتعلم الآلي أن يساعد المدارس على اتخاذ القرارات بشأن دعم الطلاب وتوقع احتياجات الطلاب بشكل فعال. بالنسبة للعمل المستقبلي، سيأخذ العمل المقترح في الاعتبار مقاييس مثل بيانات السلوك والمشاركة وتحديث النماذج باستمرار لتحسين الدقة لتحسين أداء الطلاب.

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