IJISCS (International Journal of Information System and Computer Science)
IJISCS, Volume 7, Number 2, August 2023
E ISSN: 2598-246X; P ISSN: 2598-0793, pp. 89-103
Accredited SINTA 4 Number 79/E/KPT/2023
https://jurnal.ftikomibn.ac.id/index.php/ijiscs

APPLICATION OF DATA MINING IN HEALTHCARE OF BANGLADESH

Nafis Md. Zawad
Department of Computer Science and Engineering,
American International University
Dhaka 408/1, Kuratoli, Dhaka, Bangladesh

*Corresponding author
nafis.zawad96@gmail.com

Article history:
Received March 9, 2023
Revised May 14, 2023
Accepted August 28, 2023

Keywords:
Data Mining;
Healthcare;
Bangladesh;
Challenges;
Prospects.

Abstract
The paper intends to discuss the status of data mining applications in the normal and critical healthcare system of Bangladesh. The paper also focuses on the data mining strategies and processes in the current healthcare system in Bangladesh. This is a secondary source-based review paper. The methodology chosen for the study is a literature review and document analysis. The literature review was done through the analysis of book chapters, research-based articles, review-based journal articles, organizational reports, and conference papers. The key findings of the study indicate that as Bangladesh is not a developed country and is a developing one, the country's healthcare system is not up to the required standard, and the application of data mining techniques is very limited in most cases, it is at the policy level. The implementation and practice of data-mining techniques is available in internationally recognized organizations and institutions. In these circumstances, the country's healthcare policymakers and administrators should employ experts in data mining in healthcare services and facilities and standard technologies should be included in their administering the data mining in healthcare facilities. Besides, data mining should be incorporated with other related concepts and strategies to make the highest outcomes in health care systems.

1.0 INTRODUCTION

Data mining is not a new concept in the world. Many developed countries are using data mining and big data analysis in their healthcare systems and healthcare services. Currently, data mining is one of the most advancing field of study which entails finding that bears useful and meaningful detailed information from a large data (Kolling et al., 2021; Ogundele et al., 2018; Razzak et al., 2020; Trang, 2020). Health-related data requires analytical methodology (Raghupathi & Raghupathi, 2014) for the identification of vital information that to be used for decision-making (Trang, 2020). Some of the important functions of data mining are detection, prevention, and management of diseases including fraud (Joudaki et al., 2015; Rawte & Anuradha, 2015; Sowah et al., 2019) in health insurance reducing expenditure on the solution of medical and health areas (Kolling et al., 2021; Kumaraswamy et al., 2022; Ogundele et al., 2018; Trang, 2020). For the increasing use of the various technology-enhanced and technology based educational assessment, data mining methods have been explored to analyze the data and processing data in log files from such assessments (Qiao & Jiao, 2018; Richters et al., 2023). Data Mining is a newly emerging and one of the progressive areas in the healthcare system (Alhajaj & Moonesar, 2023; Doguc et al., 2022). Health data is essential in analytical

methodology for identifying and locating vital information for decision-making process (Z. Ahmed et al., 2020; Joudaki et al., 2015; Miah et al., 2020; Raghupathi & Raghupathi, 2014; Trang, 2020; World Health Organization, 2023). As an emerging technique data mining is vital and essential for the healthcare sector in the process of identification and detection of various diseases (Ogundele et al., 2018; Raghupathi & Raghupathi, 2014; Santos-Pereira et al., 2022). Data mining is also helping researchers to make effective healthcare policies, and to develop recommendation systems as well as health profiles for the patients (Cifci & Hussain, 2018; Kumaraswamy et al., 2022; Ogundele et al., 2018; Raghupathi & Raghupathi, 2014; Santos-Pereira et al., 2022; Trang, 2020; Ushasri et al., 2018). Bangladesh has a traditional/conventional and pluralistic healthcare system (Joarder et al., 2019) that has not changed since its independence in 1971(Mahdy, 2009). Bangladesh's government and other authorities are trying to digitalize the country but data mining and related concepts like big data analytics, and machine learning in healthcare are neglected for decades.

2.0 METHODOLOGY AND OBJECTIVES OF THE STUDY

2.1. Methodology

The paper is based on the secondary literature and the methodology chosen for the study is a literature review and document analysis. The literature review was done through the analysis of book chapters, research-based articles, review-based journal articles, organizational reports, and conference papers. Moreover, personal observations and perceptions are also applied to search for the truth about data mining in the health care system.

2.2. Objective

The objective of the study is to get a better understanding of the applications of data mining in healthcare sector in Bangladesh. Basically, this study intends to know about the existing challenges and prospects of data mining in healthcare areas in Bangladesh.

3.0 DEFINITION AND CONCEPT OF DATA MINING

Data mining as a concept has become popular in information technology industries (Coomans et al., 2009). It refers to extracting or mining knowledge from large amounts of data (Baker, 2010b). The term data mining is aptly named "Knowledge discovery in database- KDD" (Baker, 2010b) "Knowledge mining from data" (Bharati & Ramageri, 2010), "Knowledge mining technology"(Kaufman & Michalski, 2005) or "Knowledge mining"(N. Jain & Srivastava, 2013; Kaufman & Michalski, 2005; McClean, 2003; Rui et al., 2022). According to Osman, (2019), "*Data mining defines as the practice of examining a large pre-existing database in order to generate new information*" (Osman, 2019, p. 1). In simple words, data mining is the process of exploration and analysis of the data (Berry & Linoff, 2004; Kumar Grover & Mehra, 2008; Mukerji, 2022). Data mining is done through the automatic or semiautomatic means, of large quantities of data so that meaningful patterns and rules can be discovered (Berry & Linoff, 2004; N. Jain & Srivastava, 2013; Kumar Grover & Mehra, 2008). According to Nisbet *et el*. (2018), "*Data mining is the use of machine-learning algorithms to find faint patterns of relationship between data elements in large, noisy, and messy data sets, which can lead to actions to increase benefit in some form (diagnosis, profit, detection, etc.)"*(Nisbet et al., 2018, pp. 21–37).

The goals of data mining are as follows:

- To build or to help in building a suitable and appropriate database for creating the modeling of data sets smoothly (Nisbet et al., 2009).
- To develop and deploy a model for generating the significant and noteworthy value (Nisbet et al., 2009).
- To build a knowledge-base of modeling named "learnings" as to influence in the future to do a better job in data mining for making the work easier, faster, and also cheaper (Nisbet et al., 2009).

3.1. Techniques of Data Mining in Health Domain

Data mining is a process and used many techniques as classification, clustering, association, regression in the healthcare domain (Ahmad et al., 2015, pp. 38–50). According to Osman, (2019), there are various techniques of data mining are being developed and regularly used in data mining projects such as association, classification, clustering, decision tree, prediction, Neural Networks, and so on (Jahankhani, 2023). The techniques of data mining are shown in the Figure 1:

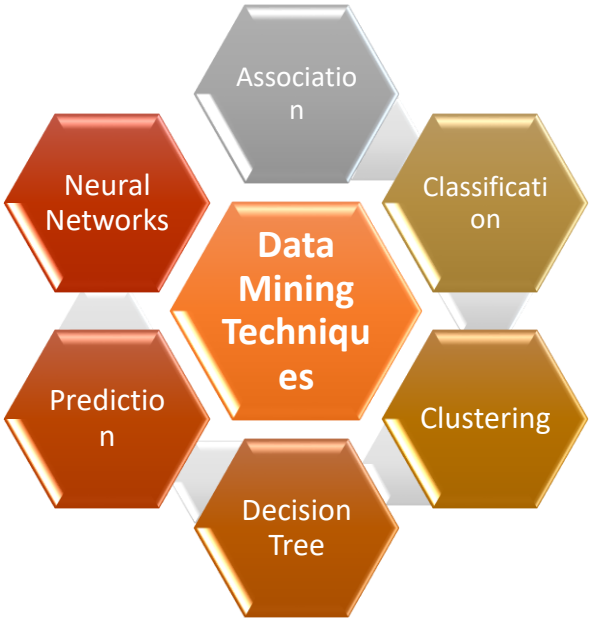

Figure 1: Techniques of Data Mining

3.2. Strategies for Data Mining

Data mining incorporates a large variety of analytical techniques, process and methods, and data mining tools. These techniques, process and other tools largely replicate the diversity in the field (A. Jain et al., 2016; Warschauer et al., 2019). A significant issue is that a large number of database merchants and vendors are seen moving from providing a separate and stand-alone service through the data-mining workbenches. Rather, the vendors are embedding the data mining algorithms directly in the database system. This process is simply known as "in-place data mining" (Ozcan & Esnaf, 2016) as well as it also enables data management and processing tasks in a more efficient way (M. K. Obenshain, 2004). The primary goal of data mining is simply to learn from data (Nisbet et al., 2009; Yang, 2019). M. K. Obenshain, (2004) and Swarnalatha & Sireesha, (2018) opined that there are two broad categories of data mining strategies Supervised Learning Strategies and Unsupervised Learning Strategies.

1. **Supervised Learning Strategies**
   Supervised learning methods/strategies are "*deployed (or strategically put into service in an information technology context) when values of variables (inputs) are used to make predictions about another variable (target) with known values*" (M. K. Obenshain, 2004, p. 691). Finding out the attributes and distinguishing fraudulent claim by using predictive modeling in health care can be an example of a supervised method. Thus, the models and attributes are generally known as supervised learning strategies (Muriithi, 2014). This strategy is employed in the cases of data predicting and discovering the information (M. K. Obenshain, 2004, p. 691;Namoun & Alshanqiti, 2020; Walid et al., 2022).
2. **Unsupervised Learning Strategies**
   Unsupervised learning methods/strategies can be used in the situations where supervised learning strategies are applied. These strategies are more frequently deployed or used on data in cases a target with known values does not exist (Ozcan & Esnaf, 2016; A. Jain et al., 2016; Warschauer et al., 2019). The application of unsupervised modeling is that the attributes and models of fraud are not known. But these can reveal the patterns and clusters of data uncovered by data mining. It can lead to various discoveries (Obenshain, 2004, p. 691;Namoun & Alshanqiti, 2020; Walid et al., 2022).

Table 1: Purposes/Objectives Modeling and Techniques of Data Mining

Objectives	Supervised Techniques	Unsupervised Techniques
Prediction	a) Ordinary least squares regression b) Logistic regression c) Neural networks d) Decision trees e) Memory-based reasoning f) Support vector machines	**Not Feasible**

	g) Multi-adaptive regression splines (Muriithi, 2014)	
Classification	a) Decision Trees b) Neural Networks c) Discriminant Analysis d) Bagging and Boosting Ensembles e) Native Bayes Classifiers(Muriithi, 2014)	**a) Clustering (eg, K means),** **b) Kohonen Networks** **c) Self-Organizing Maps**
Exploration	Decision Trees (Muriithi, 2014)	**a) Principal components** **b) Clustering (eg, K means)** **c) Link Analysis (Muriithi, 2014)**
Affinity		**a) Associations** **b) Sequences** **c) Factor Analysis (Muriithi, 2014)**

Source: (M. K. Obenshain, 2004, p. 691); Muriithi, (2014)

The functions of data mining strategies from both structured and unstructured strategies are discussed in the following table-2:

Table 2: Functions of Data Mining Strategies

Objectives of Modeling	Functions
(1) Prediction	The functions of this algorithm is to determine models or rules for predicting the continuous target or discrete target values in a given input data (Namoun & Alshanqiti, 2020; M. K. Obenshain, 2004; Ozcan & Esnaf, 2016; Walid et al., 2022).
(2) Classification	The functions of Classification algorithms are to determine the models for predicting the discrete values in each set of input data (Namoun & Alshanqiti, 2020; M. K. Obenshain, 2004; Ozcan & Esnaf, 2016; Walid et al., 2022).
(3) Exploration	The functions of exploration is to uncover the dimensionality in each set of input data (M. K. Obenshain, 2004).
(4) Affinity	The function of affinity analysis is to determine the events which are likely to occur in related to one another. (Ozcan & Esnaf, 2016; A. Jain et al., 2016; Warschauer et al., 2019;M. K. Obenshain, 2004)

3.3. Process of Data Mining

Data mining process includes the preparation of data collection, data collection, data pre-processing, and data transformation but does not include knowledge extraction and evaluation steps (Kolling et al., 2021; Ogundele et al., 2018; Razzak et al., 2020; Trang, 2020) (Ogundele et al., 2018). According to M. K. Obenshain, (2004), data mining is a process rather than a set of tools (p.691). The acronym of this process is "SEMMA" which refers to a methodology that clarifies the data mining process **(Fernandez, 2003; Joseph & Karthiga, 2014).** It is primarily divided into five (5) stages according to the SEMMA method (Fernandez, 2010; Ogundele et al., 2018). "SEMMA "is a cycle, and, the steps can be performed iteratively as needed **(Ozcan & Esnaf, 2016; A. Jain et al., 2016; Warschauer et al., 2019;**(M. K. Obenshain, 2004). Figure 2 shows the process as follows:

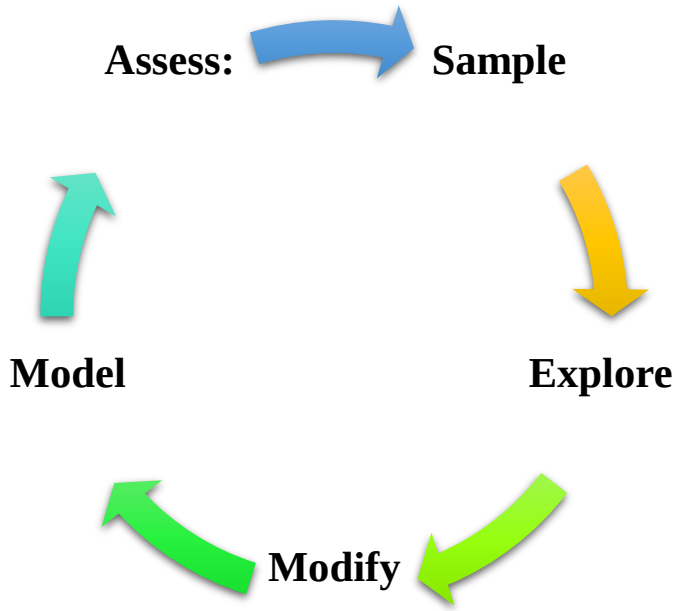

Figure 2: SEMMA data mining process. Source: M. K. Obenshain, (2004), p. 692; Muriithi, (2014);Joseph & Karthiga, (2014).

3.4. Purposes and Functions of Data Mining

The usefulness of data mining is to stipulate the sorts of patterns that are generally found during data mining (Joseph & Karthiga, 2014). Among the types of data mining tasks descriptive and predictive are main (N. Jain & Srivastava, 2013). The descriptive data mining tasks generally characterize the general properties and forms of data in the database but the predictive data mining tasks finish implication or reasoning of current data to make predictions (N. Jain & Srivastava, 2013).

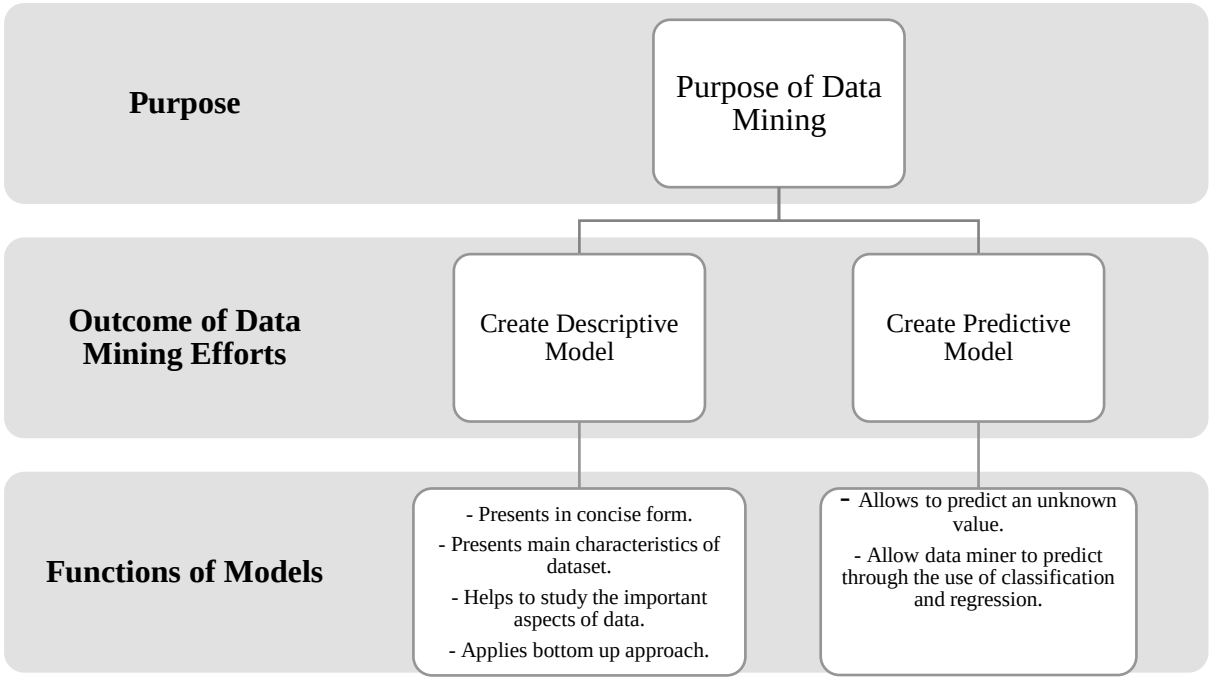

Figure 3: Purpose of Data Mining (N. Jain & Srivastava, 2013).

3.5. Elements of Data Mining

Data mining consists of several elements. The five major elements of data mining are:

- Extracting, transforming, and load transaction of data into warehouse system.
- Storing and managing data into the systems.

- Providing data access to the stakeholders.
- Analyzing the data.
- Presenting data into a useful format (Jain & Srivastava, 2013, p.116-119).

4.0 DATA MINING APPLICATIONS IN DIFFERENT FIELDS

Data mining is presently being employed in a varied number of fields. It is an advantage of data mining techniques is their applicability to massive data in a fully automated way (M. K. Obenshain, 2004). On the other hand, old-style statistical methods that are employed in epidemiology take the convention work by professionals. As the traditional methods necessitate a fixed number of variables which are predefined (Muriithi, 2014). But, data mining techniques can include updated variables and can generate a huge number of different variables (M. K. Obenshain, 2004); (Muriithi, 2014). A review by Liao et al., (2012) from 2000 to 2011 on data mining techniques and applications suggests that multiple social science discipline methodologies like social psychology, cognitive and behavior science, and human behavior science can employ data mining techniques. These techniques can be implemented as an substitute to the methodologies that are currently in use (Liao et al., 2012). For revealing the useful information regarding the students three data-mining techniques are employed. These techniques are such as cluster analysis (CA), decision tree (DT), and artificial neural network (Gobert et al., 2012); (Qiao & Jiao, 2018). Data mining, also known as "Knowledge Discovery in Databases (KDD)"(Hicham et al., 2020), in the arena of finding innovative, unique, new, and possibly valuable data from a large volume of data. Data mining is also used in various fields such as sales, bio-informatics, counter-terrorism and so on (Baker, 2010a; Hicham et al., 2020). This application may play a implausible role and great potential in the industry of healthcare (Ogundele et al., 2018). Apart from these, Ghorbian, (2019) discussed 14 areas where data mining can be applied. These areas are:

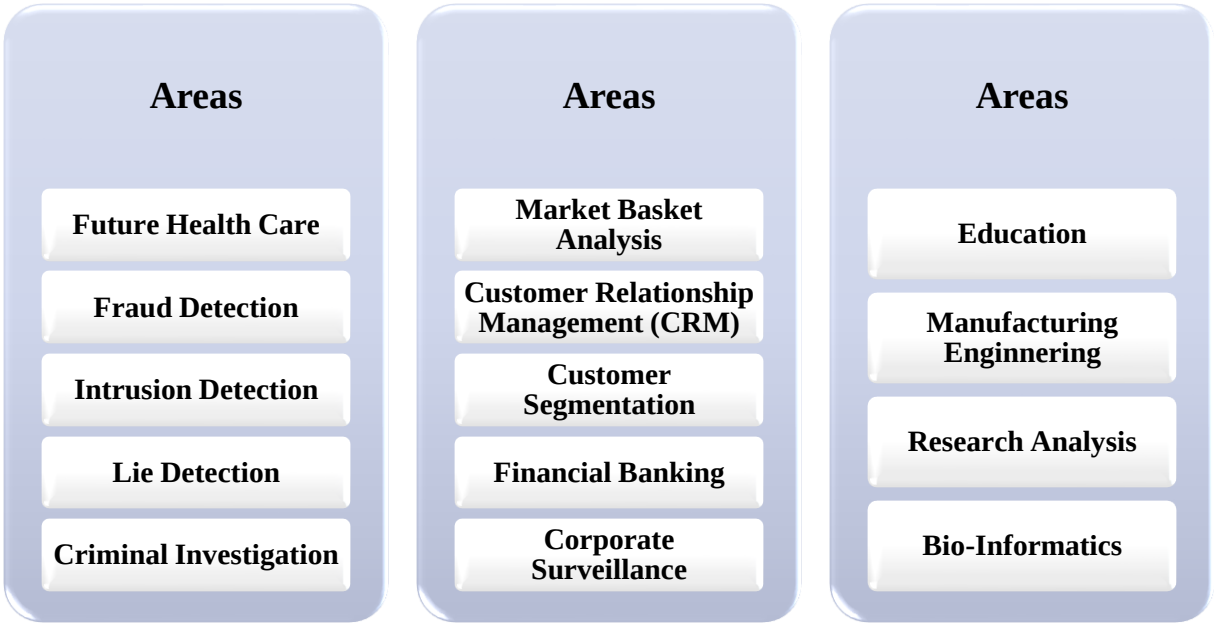

Figure 4: Fields of Data Mining

4.1. Trends in Data Mining Techniques

Liao et al., (2012) in their study showed the trends in data mining techniques from 2000 to 2011. The trend of DMT was shown by some keywords such as (1) Data mining (DM), (2) Decision tree (DT), (3) Artificial Neural Network (ANN), (4) Clustering, (5) Association Rule, (6) Artificial intelligence, (7) Bio-informatics, (8) Customer relationship and (9) Fuzzy logic (Liao et al., 2012) are presented in Table 3.

Table 3: Trends of Data Mining Techniques from 2000-2011

Keyword	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Data mining	1	0	6	5	8	8	12	16	10	16	16	16	114
Decision tree	0	0	1	0	0	2	0	1	2	4	3	4	17
Artificial neural network	1	1	2	1	2	2	2	0	2	4	2	3	22
Clustering	0	0	1	0	0	3	0	1	0	2	1	1	9
Association rule	0	0	0	1	0	0	0	2	1	3	0	1	8
Artificial intelligence	0	0	0	0	0	0	1	0	1	1	2	1	6
Bioinformatics	0	0	0	0	0	0	0	3	0	1	0	0	4
Customer relationship management	0	0	0	1	0	0	0	0	0	0	3	0	4
Fuzzy logic	0	0	0	1	1	0	0	1	0	1	0	0	4
Total	2	1	10	9	11	15	15	24	16	32	27	26	188

Source: Liao et al., (2012), p.11304

This trend shows that among 188 times of use of various data mining techniques in various reviewed journal articles, data mining as a concept was used 114 times.

4.2. Data Mining Tools Used in Medical Science

Generally, data mining tools help analyzing the volumes of complex data on the basis of dataset characteristics that users specify in determining trends of occurrences (Altalhi et al., 2017). The software can be used for diagnoses, prediction, and management of diseases to extract knowledge and make decisions (Cifci & Hussain, 2018; Kumaraswamy et al., 2022; Ogundele et al., 2018; Raghupathi & Raghupathi, 2014; Santos-Pereira et al., 2022; Soni et al., 2011; Trang, 2020; Ushasri et al., 2018). Due to the availability of various software tools used, the choice of choosing appropriate software to solve a particular problem becomes difficult (Hosseini & Sardo, 2021; Mikut & Reischl, 2011; Ogundele et al., 2018; R. Pallavi Reddy, 2020). The most common data mining tools are:

- WEKA (Waikato Environment for Knowledge Analysis);
- KEEL (Knowledge Extraction based on Evolutionary Learning;
- R (an open-source program);
- KNIME (Konstanz Information Miner);
- RAPIDMINER;
- Tanagra
- ORANGE (Hosseini & Sardo, 2021; Mikut & Reischl, 2011; Ogundele et al., 2018; R. Pallavi Reddy, 2020).

5.0 DATA MINING IN HEALTH CARE IN BANGLADESH

After the liberation of Bangladesh, the healthcare facilities and system of the country never reached to a remarkable improvement in proportion to a large number of populations. The country's government tried to its best to ensure quality in healthcare system but never got the success at a large scale (Akter et al., 2019).

Some common scenario in the health care system in Bangladesh are as follows:

1. The country does not have substantial number of medical professionals such as specialist doctors, nurses (Akter et al., 2019).
2. Defective and insufficient treatments, inadequate care, losing belief to the health care system is also another vital issue in this sector (Akter et al., 2019).
3. Higher work load, suffering and distress from psychological point of view, lack of trained personnel and absence of coordination during pandemic is another alarming situation in the country (Razu et al., 2021).
4. Situational, environmental and organizational factors are also playing negative role in healthcare system (Razu et al., 2021).
5. Shortage of patient's information, lack of updated medical equipment, shortage of properly trained healthcare service providers, insufficient information about the diseases and symptoms are also creating great challenge to the healthcare system in Bangladesh (Mahdy, 2009);(Akter et al., 2019).

But a hope is arising from the use of data mining applications in healthcare facilities and systems that the DM techniques can be effective in several areas such as primary detection of diseases like cancer and other difficult diseases, detection and identification of fraudulent activities in care system, properly manage the information regarding the detection of abuse of drugs and so on (Kolling et al., 2021; Ogundele et al., 2018; Razzak et al., 2020; Trang, 2020). According to Mahdy (2009), "*widespread dissatisfaction exists in the population and amongst doctors about healthcare delivery*"(Mahdy, 2009, pp. 411–416). Data mining in healthcare in Bangladesh can be discussed in the following stages:

5.1. Clinical Care and Clinical Service

The application of DM techniques can be used in the sector of clinical care and clinical service. The general concept of prescribing any medicine to a patient should be on the basis of the past medical records and documents. But it is a matter of sorrow that the physicians of Bangladesh prescribe medicines without going through the previous medical histories due to the lack of properly developed database system. A "centralized electronic patient record database system (CEPRDS)" (Akter et al., 2019; Raghupathi, 2010) could be effective for proper diagnosis and treatment of the patients. Besides, the "Electronic Health Record Systems (EHRs)" are used in developed countries, and it could produce a benefit in healthcare system in Bangladesh (R. Pallavi Reddy, 2020). A "clinical decision support system (CDSS)" is a new innovation in healthcare system, but it is a sorrow that in Bangladesh there is no use of this system (Akter et al., 2019; Raghupathi, 2010). The working process of CDSS is shown in the Figure 5:

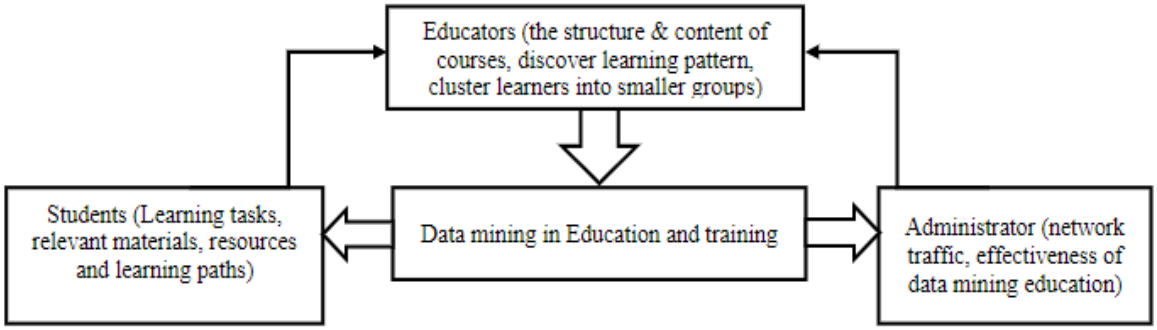

Figure 5: Working Process of Clinical Decision Support System. Source: Akter et al., (2019).

5.2. Administration of Health Service Facilities

Administration is an essential part for any organization and system, and health care system of Bangladesh is not an exception in this case. Generally, administrators play the key role in health sector and healthcare system by making critical and vital decisions. A trend is observed in the developed countries that healthcare service providers and administrators are employing modern computer – based system for demarcating their needs. A modern tool like (Partially Observable Markov Decision Processes- POMDPs) can predict a moderately better wayouts in the disease outbreaks (Akter et al., 2019; Raghupathi, 2010). The system is not available in Bangladesh for some practical and cost oriented causes.

5.3. Medical Research and Innovation

Many researchers have applied data mining techniques. Data mining techniques are contributing much in healthcare system by properly making decisions, appropriately make diagnosis and better prediction of diseases (Ogundele et al., 2018; Razzak et al., 2020). Some primary areas of medical research such as cellular and molecular biology, medical genetics, immunology, neurology, neuroscience, psychology and human behavior. Data mining methods and teachniques can help researchers of Bangladesh to know the patterns of disease, cause-effect associations and relations and various patterns of medical conditions and prediction for the critical situation (Akter et al., 2019; Raghupathi, 2010).

5.4. Medical/Clinical Education and Training

Medical and clinical education and training is another crucial part of healthcare system. Modern education in medical colleges needs computer based updated system and training needs to be scientific. The use of data mining can make the process easier and reliable. The flow chart of the education and training system is shown in Figure 6:

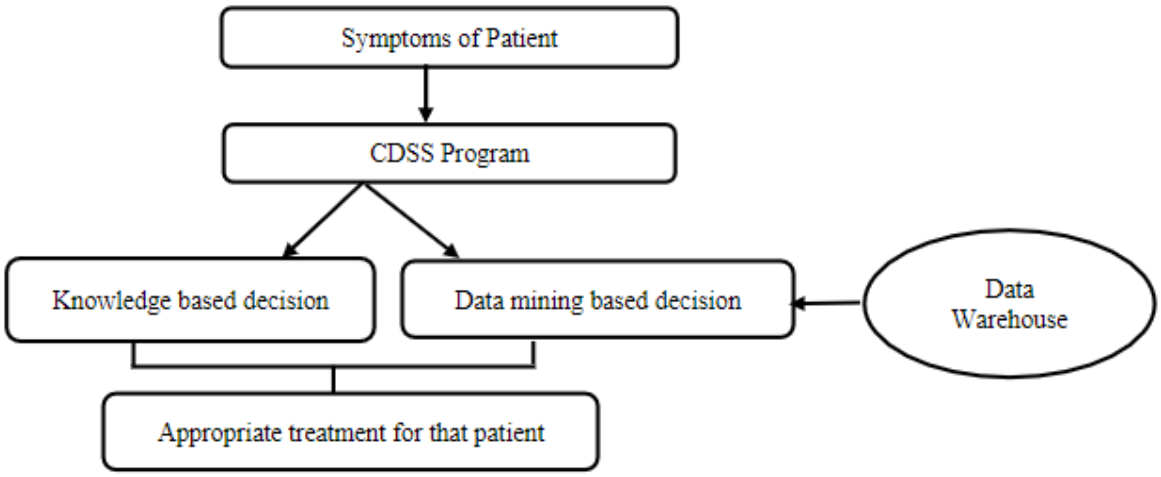

Figure 6: Education and Training System. Source: Akter et al., (2019)

As Bangladesh a developing country, the healthcare system is not Up-To-Date according to the country's need. Knowledge- based and data mining-based decisions are not accumulated in education and training facilities, so that a relatively positive outcomes cannot be regenerated (Akter et al., 2019).

5.5. Challenges of Data Mining in Healthcare in Bangladesh

Applying data mining in healthcare system in Bangladesh is a challenging task and the task is expensive and time worthy. Some of the challenges are discussed below:

- In different stages of medical treatment system such as diagnosis, prognosis, treatments and management of the diseases, medical data generally to be analyzed properly and accurately. But in Bangladesh, most of the hospitals and clinics are not doing that except some modern and famous hospitals.
- Bangladesh and its healthcare system is progressing slowly and this slow progress is also visible in information and technology sector. The difficulties in the management of huge amount of data regarding health data creating a grave challenge to employ data mining strategies in healthcare system of the country.
- Proper training and technical support is scarce in healthcare system to employ data mining in healthcare in Bangladesh.
- Discovering and locating useful data from the vast data is also a great challenge in this field.
- Electronic Health Record Systems (EHRs) for clinical data storage are not available in most government hospitals and clinics in Bangladesh. So, the medical data and clinical diagnosis history are kept in the patient's file. A centralized data management system for medical data is not so easy task for Bangladesh.
- The major limitation in Bangladesh in the case of applying data mining techniques in healthcare system is that the nature of varied and huge pertinent fresh data cannot be handled easily (R. Pallavi Reddy, 2020).
- It is a matter of regret that unfinished, half-finished, and undone data, less consistent data, and erroneous or misplaced data in the process of medical/health records or archives made the issue very challenging.
-

5.6. Prospects of Data Mining in the Healthcare of Bangladesh

Bangladesh has achieved a noteworthy advancement in digital healthcare in past years. Bangladesh has deployed the open-source District Health Information Software 2 (DHIS2). Bangladesh now has a national public sector health data warehouse for storing public health data (Khan et al., 2019; ROSA, 2019). Health sector of Bangladesh has gained progress on the following grounds:

- "Management Information System-(MIS)" of "Direactorate General of Health Services-(DGHS)" of Bangladesh is doing an excellent work. The MIS-DGHS is doing the visionary and outstanding work for an "shared health record- (SHR)" project for creating a nation-wide electronic archive of the citizens of Bangladesh (Khan et al., 2019).. The SHR will preserve

the "electronic health records-(HER)" of all citizens for life time and the health record will be accessible from any places of the country (Khan et al., 2019).

- Another improvement in this context is that currently concentrations is given to the open-source nonproprietary software (OSNS). The software is unique and that has made the software acquisition easy and affordable. The software has permitted to establish an ownlership of the system (World Health Organization (WHO), 2011); (Khan et al., 2019).
- In Bangladesh, OpenMRS system has been broadly upgraded to generate a full-bodied and wide-ranging solution for hospital computerization and automation. The another aobjective of the system is to build a nation-wide electronic hospital networking (EHN) system (World Health Organization (WHO), 2011).
- The developed version of OpenMRS is known as OpenMRS+. OpenMRS+ is a composition of various modules from OpenMRS, Odoo, OpenELIS, and dcm4chee. The OpenMRS+ system is combined into the Shared Health Record System of the country (World Health Organization (WHO), 2011); (Khan et al., 2019).
- Bangladesh initiated to address emerging challenges in health issues such as incomplete civil registration in 2012 by technical assistance from World Health Organization. Bangladesh Government is doing this work on the basis of a strategic action plan affiliated with the Commission on Information and Accountability (CoIA) recommendations (World Health Organization (WHO), 2011); (Khan et al., 2019).
- In Bangladesh e-Helath Programs are in an expansion at a speedy rate (T. Ahmed et al., 2014). It resulted to a vast amount of data that are being amassed at the central data repository of the DGHS of Bangladesh (Khan et al., 2019).
- According to Health Bulletin, 2017, the healthcare sector of Bangladesh is providing eService to the mass people through it's information technologies such as Hospital Automation Syatem, Electronic Health Record (EHR) system, Attendance Monitoring System and so on (MIS-DGHS, 2017); (Alam et al., 2020)).
- Bangladesh has made extraordinary progress in establishing a country-wide health information system (HIS) that includes a "robust routine health information system-(RHIS)" (MIS-DGHS, 2017)

Some of the progress in healthcare sector are database for health policy planning, OMR-based patient-level data collection and telemedicine (Alam et al., 2020).

6.0 RECOMMENDATIONS AND CONCLUSIONS

6.1. Recommendations

- From the study, it can be stated that government and private healthcare organizations should consider a systematic process of storing data and creating research branches in hospitals in Bangladesh. As a result, researchers and doctors working in healthcare fields will be able to find out solutions to health-related problems.
- Time, resources, and productive efforts need to be applied as an investment with a view to promoting the quality of data mining technologies.
- The entry of healthcare data can be stored systematically and properly for further use.
- Medical education and training of healthcare personnel such as doctors, nurses, and related staff can be provided with a more pragmatic procedure. In addition, practical knowledge of data mining needs to be imparted by organizing seminars, and symposiums. If needed, an academic curriculum can be developed in such a way that can promote the standard of using data mining in healthcare.
- A central data storage system and warehouse should be developed to store the medical data so that these data can be further used by using data mining and other scientific procedures and applications.
- Skilled human resources should be get involved to store data, and data mining experts should also be employed and facilitated in this sector.
- More budget should be allocated according to the needs of ICT especially data mining software and techniques. Besides, the budget should be allocated to machine learning technologies and big data analytics in Bangladesh.
- Extensive researches need to be undertaken on data mining and machine learning in the healthcare area of Bangladesh. Also, seminars and symposiums can be arranged on data mining and big data analytics in healthcare facilities.

- The recommendations of WHO and other national and international organizations should be incorporated into the perspective plan (PP) and annual development plan (ADP) of Bangladesh.

6.2. Conclusions

Although Bangladesh is a less developed country, the country has developed ICT and digitalized services. But the country is getting slow progress in data mining and big data analytics-related policies in health care services. Although the Government of Bangladesh and MIS-DGHS has introduced Health Information System (HIS), Hospital Automation and Electronic Health Record (EHR), and OpenMRS+ system, the progress is slow. Besides, Bangladesh is a country with a huge population, the automation process needs a huge amount of budget in the health sector. Moreover, the country's infrastructure and skilled manpower related to ICT, data mining, and big data analytics are not developed enough to run the services fully. The practical application and utilization of machine learning are also not up to the mark in Bangladesh. The objective of the study was to reveal the applications of data mining in healthcare systems in a developing country like Bangladesh and the current needs. But after reviewing the documents and various studies it can be concluded that the country's progress in data mining in health care is not up to the mark. It is in an initiation process, and the end product namely 'the service in the health sector' is a far-reaching object. The study suggests that the country's manpower should be well-trained; the research should be increased and the political will and allocation of available resources/ budgets should be given the highest priority. If these can be done, the people of the country could enjoy better benefits from the health care services.

REFERENCES

[1]. Abdul, M., Khan, H., de Oliveira Cruz, V., Azad, A. K., Abul, D., & Azad, K. (2019). Bangladesh's digital health journey: reflections on a decade of quiet revolution. In *WHO South-East Asia Journal of Public Health* (Vol. 8, Issue 2).

[2]. Ahmad, P., Qamar, S., & Rizvi, S. (2015). Techniques of data mining in healthcare: a review. *International Journal of Computer Applications*, *120*(15), 38–50. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=82289448146b86c6160bf5225bd5e3cea35a8c57

[3]. Ahmed, T., Lucas, H., Khan, A. S., Islam, R., Bhuiya, A., & Iqbal, M. (2014). EHealth and mHealth initiatives in Bangladesh: A scoping study. *BMC Health Services Research*, *14*(1), 1–9. https://doi.org/10.1186/1472-6963-14-260/FIGURES/2

[4]. Ahmed, Z., Mohamed, K., Zeeshan, S., & Dong, X. Q. (2020). Artificial intelligence with multi-functional machine learning platform development for better healthcare and precision medicine. *Database: The Journal of Biological Databases and Curation*, *2020*. https://doi.org/10.1093/DATABASE/BAAA010

[5]. Akter, M., Islam, T., Trisha, K., & Ullah, M. (2019). An overview of data mining in medical informatics: Bangladesh perspective. *Asian Journal of Medical and Biological Research*, *5*(4), 258–264. https://doi.org/10.3329/ajmbr.v5i4.45262

[6]. Alam, M. Z., Hu, W., & Uddin, A. (2020). Digital Transformation in Healthcare Services Sector of Bangladesh: Current Status, Challenges and Future Direction. *Journal on Innovation and Sustainability RISUS*, *11*(1), 30–38. https://doi.org/10.23925/2179-3565.2020V11I1P30-38

[7]. Alhajaj, K. E., & Moonesar, I. A. (2023). The power of big data mining to improve the health care system in the United Arab Emirates. *Journal of Big Data 2023 10:1*, *10*(1), 1–33. https://doi.org/10.1186/S40537-022-00681-5

[8]. Altalhi, A. H., Luna, J. M., Vallejo, M. A., & Ventura, S. (2017). Evaluation and comparison of open source software suites for data mining and knowledge discovery. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, *7*(3). https://doi.org/10.1002/WIDM.1204

[9]. Baker, R. S. J. d. (2010a). Data Mining. In P. Peterson, E. Baker, & B. McGaw (Eds.), *International Encyclopedia of Education (Third Edition)* (pp. 112–118). Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-08-044894-7.01318-X

[10]. Baker, R. S. J. d. (2010b). Data Mining. *International Encyclopedia of Education*, 112–118. https://doi.org/10.1016/B978-0-08-044894-7.01318-X

[11]. Berry, M. J. A., & Linoff, G. S. (2004). *Data Mining Techniques for Marketing, Sales, and Customer Relationship Management* (2nd Ediction). Wiley Publishing, Inc.
[12]. Bharati, M., & Ramageri, B. M. (2010). Data mining techniques and applications. *Indian Journal of Computer Science and Engineering*, *1*(4). https://www.researchgate.net/publication/49616224_Data_mining_techniques_and_applications
[13]. Cifci, M. A., & Hussain, S. (2018). Data mining usage and applications in health services. *International Journal on Informatics Visualization*, *2*(4), 225–231. https://doi.org/10.30630/JOIV.2.4.148
[14]. Coomans, D., Smyth, C., Lee, I., Hancock, T., & Yang, J. (2009). Unsupervised Data Mining: Introduction. *Comprehensive Chemometrics*, *2*, 559–576. https://doi.org/10.1016/B978-044452701-1.00063-6
[15]. Doguc, O., Canbolat, Z. N., & Silahtaroglu, G. (2022). Recent applications of data mining in medical diagnosis and prediction. *Big Data Analytics for Healthcare: Datasets, Techniques, Life Cycles, Management, and Applications*, 95–109. https://doi.org/10.1016/B978-0-323-91907-4.00006-6
[16]. Fernandez, G. (2003). Data Mining: A Gentle Introduction. In *Data mining using SAS applications* (pp. 1–361). Chapman & Hall/CRC. https://doc.lagout.org/Others/Data%20Mining/Data%20Mining%20using%20SAS%20Applications%20%5BFernandez%202002-12-27%5D.pdf
[17]. Fernandez, G. (2010). Data Mining: A Gentle Introduction. In *Statistical data mining using SAS applications* (p. 453). CRC Press. https://www.routledge.com/Statistical-Data-Mining-Using-SAS-Applications/Fernandez/p/book/9781439810750
[18]. Ghorbian, M. (2019, July 12). *14 areas where data mining is widely used* . https://www.researchgate.net/post/2
[19]. Gobert, J. D., Pedro, M. A. S., Baker, R. S. J. d., Toto, E., & Montalvo, O. (2012). Leveraging Educational Data Mining for Real-time Performance Assessment of Scientific Inquiry Skills within Microworlds. *Journal of Educational Data Mining*, *4*(1), 111–143. https://doi.org/10.5281/ZENODO.3554645
[20]. Hicham, A., Jeghal, A., Sabri, A., & Tairi, H. (2020). A Survey on Educational Data Mining [2014-2019]. *2020 International Conference on Intelligent Systems and Computer Vision, ISCV 2020*. https://doi.org/10.1109/ISCV49265.2020.9204013
[21]. Hosseini, S., & Sardo, S. R. (2021). Data mining tools -a case study for network intrusion detection. *Multimedia Tools and Applications*, *80*(4), 4999–5019. https://doi.org/10.1007/s11042-020-09916-0
[22]. Jahankhani, H. (2023). Cybersecurity in the Age of Smart Societies. In H. Jahankhani (Ed.), *Proceedings of the 14th International Conference on Global Security, Safety and Sustainability*. Springer International Publishing. https://doi.org/10.1007/978-3-031-20160-8
[23]. Jain, A., Hautier, G., Ong, S. P., & Persson, K. (2016). New opportunities for materials informatics: Resources and data mining techniques for uncovering hidden relationships. *Journal of Materials Research*, *31*(8), 977–994. https://doi.org/10.1557/JMR.2016.80
[24]. Jain, N., & Srivastava, V. (2013). Data mining techniques: a survey paper. *International Journal of Research in Engineering and Technology*, *2*(11), 116–119. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=1c5971351969d6729e0a27715934bf771e1d833c
[25]. Joarder, T., Chaudhury, T. Z., & Mannan, I. (2019). Universal Health Coverage in Bangladesh: Activities, Challenges, and Suggestions. *Advances in Public Health*, *2019*, 1–12. https://doi.org/10.1155/2019/4954095
[26]. Joseph, R., & Karthiga, S. (2014). Data Mining Techniques Approaches in Healthcare. *International Journal of Computer Science and Information Technology Research*, *2*(2), 194–201. www.sas.com.
[27]. Joudaki, H., Rashidian, A., Minaei-Bidgoli, B., Mahmoodi, M., Geraili, B., Nasiri, M., & Arab, M. (2015). Using Data Mining to Detect Health Care Fraud and Abuse: A Review of Literature. *Global Journal of Health Science*, *7*(1), 194. https://doi.org/10.5539/GJHS.V7N1P194
[28]. Kaufman, K. A., & Michalski, R. S. (2005). From Data Mining to Knowledge Mining. *Handbook of Statistics*, *24*, 47–75. https://doi.org/10.1016/S0169-7161(04)24002-0

[29]. Khan, M. A. H., Azad, A. K., & Cruz, V. de O. (2019). Bangladesh's digital health journey: reflections on a decade of quiet revolution. *WHO South-East Asia Journal of Public Health*, *8*(2), 71–76. https://apps.who.int/iris/handle/10665/329331
[30]. Kolling, M. L., Furstenau, L. B., Sott, M. K., Rabaioli, B., Ulmi, P. H., Bragazzi, N. L., & Tedesco, L. P. C. (2021). Data Mining in Healthcare: Applying Strategic Intelligence Techniques to Depict 25 Years of Research Development. *International Journal of Environmental Research and Public Health*, *18*(6), 1–21. https://doi.org/10.3390/IJERPH18063099
[31]. Kumar Grover, L., & Mehra, R. (2008). The Lure of Statistics in Data Mining. *Journal of Statistics Education*, *16*(1). https://doi.org/10.1080/10691898.2008.11889552
[32]. Kumaraswamy, N., Markey, M. K., Ekin, T., Barner, J. C., & Rascati, K. (2022). Healthcare Fraud Data Mining Methods: A Look Back and Look Ahead. *Perspectives in Health Information Management*, *19*(1). /pmc/articles/PMC9013219/
[33]. Liao, S., Chu, P., & Hsiao, P. (2012). Data mining techniques and applications–A decade review from 2000 to 2011. *Expert Systems with Applications*, *39*, 11303–11311. https://doi.org/10.1016/j.eswa.2012.02.063
[34]. Mahdy, H. al. (2009). Reforming the Bangladesh healthcare system. *International Journal of Health Care Quality Assurance*, *22*(4), 411–416. https://doi.org/10.1108/09526860910964852
[35]. McClean, S. I. (2003). Data Mining and Knowledge Discovery. *Encyclopedia of Physical Science and Technology*, 229–246. https://doi.org/10.1016/B0-12-227410-5/00845-0
[36]. Miah, S. J., Gammack, J., & Hasan, N. (2020). Methodologies for designing healthcare analytics solutions: A literature analysis. *Health Informatics Journal*, *26*(4), 2300–2314. https://doi.org/10.1177/1460458219895386/ASSET/IMAGES/LARGE/10.1177_1460458219895386-FIG2.JPEG
[37]. Mikut, R., & Reischl, M. (2011). Data mining tools. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, *1*(5), 431–443. https://doi.org/https://doi.org/10.1002/widm.1309
[38]. MIS-DGHS. (2017). *Health Bulletin, 2016*. www.dghs.gov.bd
[39]. Mukerji, B. (2022). Modern techniques for identifying mineralization in virgin area. *Innovative Exploration Methods for Minerals, Oil, Gas, and Groundwater for Sustainable Development*, 297–309. https://doi.org/10.1016/B978-0-12-823998-8.00014-4
[40]. Muriithi, I. A. (2014). *A Data Mining approach to private healthcare services demand forecast in Nairobi County* [University of Nairobi]. https://docplayer.net/15263268-University-of-nairobi.html
[41]. Namoun, A., & Alshanqiti, A. (2020). Predicting Student Performance Using Data Mining and Learning Analytics Techniques: A Systematic Literature Review. *Applied Sciences 2021, Vol. 11, Page 237*, *11*(1), 237. https://doi.org/10.3390/APP11010237
[42]. Nisbet, R., Elder, J., & Miner, G. (2009). The Data Mining Process. In R. Nisbet, J. Elder, & G. Miner (Eds.), *Handbook of Statistical Analysis and Data Mining Applications* (pp. 33–48). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-374765-5.00003-6
[43]. Nisbet, R., Miner, G., & Yale, K. (2018). Theoretical Considerations for Data Mining. In R. Nisbet, G. Miner, & K. Yale (Eds.), *Handbook of Statistical Analysis and Data Mining Applications (Second Edition)* (pp. 21–37). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-416632-5.00002-5
[44]. Obenshain, M. (2004). Application of data mining techniques to healthcare data. *Infection Control & Hospital Epidemiology*, *25*(8), 690–695. https://www.cambridge.org/core/journals/infection-control-and-hospital-epidemiology/article/application-of-data-mining-techniques-to-healthcare-data/7EE5E7B1FA8B1C535FBC7A3881EC42E0
[45]. Obenshain, M. K. (2004). Application of Data Mining Techniques to Healthcare Data. *Infection Control & Hospital Epidemiology*, *25*(8), 690–695. https://doi.org/10.1086/502460
[46]. Ogundele, I., Popoola, O., & Oyesola, O. (2018). A review on data mining in healthcare. *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, *7*(9), 698–704. https://www.academia.edu/download/63168792/IJARCET-VOL-7-ISSUE-9-698-704202005501-106436-q3miyw.pdf
[47]. Osman, A. S. (2019). Data mining techniques: Review. *International Journal of Data Science Research*, *2*(1). http://ojs.mediu.edu.my/index.php/IJDSR/article/view/1841

[48]. Ozcan, T., & Esnaf, Ş. (2016). *Swarm Intelligence Approaches to Shelf Space Allocation Problem with Linear Profit Function*. 22–41. https://doi.org/10.4018/978-1-5225-0075-9.CH002
[49]. Qiao, X., & Jiao, H. (2018). Data mining techniques in analyzing process data: A didactic. *Frontiers in Psychology*, *9*(NOV). https://doi.org/10.3389/FPSYG.2018.02231/FULL
[50]. R. Pallavi Reddy. (2020). A Review on Data Mining Techniques and Challenges in Medical Field. *International Journal of Engineering Research And*, *V9*(08). https://doi.org/10.17577/IJERTV9IS080143
[51]. Raghupathi, W. (2010). Data Mining in Healthcare. In *Healthcare Informatics: Improving Efficiency and Productivity* (1st ed., pp. 211–224). CRC Press. https://doi.org/10.1201/9781439809792-C11
[52]. Raghupathi, W., & Raghupathi, V. (2014). Big data analytics in healthcare: promise and potential. *Health Information Science and Systems*, *2*(1). https://doi.org/10.1186/2047-2501-2-3
[53]. Rawte, V., & Anuradha, G. (2015). Fraud detection in health insurance using data mining techniques. *Proceedings - 2015 International Conference on Communication, Information and Computing Technology, ICCICT 2015*. https://doi.org/10.1109/ICCICT.2015.7045689
[54]. Razu, S. R., Yasmin, T., Arif, T. B., Islam, M. S., Islam, S. M. S., Gesesew, H. A., & Ward, P. (2021). Challenges Faced by Healthcare Professionals During the COVID-19 Pandemic: A Qualitative Inquiry From Bangladesh. *Frontiers in Public Health*, *9*, 1024. https://doi.org/10.3389/FPUBH.2021.647315/BIBTEX
[55]. Razzak, M. I., Imran, M., & Xu, G. (2020). Big data analytics for preventive medicine. *Neural Computing & Applications*, *32*(9), 4417. https://doi.org/10.1007/S00521-019-04095-Y
[56]. Richters, C., Stadler, M., Radkowitsch, A., Schmidmaier, R., Fischer, M. R., & Fischer, F. (2023). Who is on the right track? Behavior-based prediction of diagnostic success in a collaborative diagnostic reasoning simulation. *Large-Scale Assessments in Education*, *11*(1), 1–24. https://doi.org/10.1186/S40536-023-00151-1/FIGURES/3
[57]. Rui, Y., Carmona, V. I. S., Pourvali, M., Xing, Y., Yi, W. W., Ruan, H. bin, & Zhang, Y. (2022). Knowledge Mining: A Cross-disciplinary Survey. *Machine Intelligence Research*, *19*(2), 89–114. https://doi.org/10.1007/S11633-022-1323-6/METRICS
[58]. Santos-Pereira, J., Gruenwald, L., & Bernardino, J. (2022). Top data mining tools for the healthcare industry. *Journal of King Saud University - Computer and Information Sciences*, *34*(8), 4968–4982. https://doi.org/10.1016/J.JKSUCI.2021.06.002
[59]. Soni, J., Ansari, U., Sharma, D., & Soni, S. (2011). Predictive Data Mining for Medical Diagnosis: An Overview of Heart Disease Prediction. *International Journal of Computer Applications*, *17*(8), 43–48. https://doi.org/10.5120/2237-2860
[60]. Sowah, R. A., Kuuboore, M., Ofoli, A., Kwofie, S., Asiedu, L., Koumadi, K. M., & Apeadu, K. O. (2019). Decision Support System (DSS) for Fraud Detection in Health Insurance Claims Using Genetic Support Vector Machines (GSVMs). *Journal of Engineering (United Kingdom)*, *2019*. https://doi.org/10.1155/2019/1432597
[61]. Swarnalatha, D. . T. ., & Sireesha, V. . (2018). Data Mining and Knowledge Discovery. *International Journal of Engineering Research & Technology*, *2*(15). https://doi.org/10.17577/IJERTCONV2IS15022
[62]. Trang, N. (2020). The application of Association Rule in data mining and building an assessment and classification system of students in Intermediate Professional Education. *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, *9*(3), 38–42. https://www.academia.edu/42899581/The_application_of_Association_Rule_in_data_mining_and_building_an_assessment_and_classification_system_of_students_in_Intermediate_Professional_Education
[63]. UNISEF Regional Office for South Asia (ROSA). (2019). *Health System Strengthening: Transforming the health information system in Bangladesh*. https://www.unicef.org/rosa/reports/health-system-strengthening-transforming-health-information-system-bangladesh
[64]. Ushasri, K., Kishore, P. J., Reddy, K., Sekar, K., & Prasad, A. R. (2018). Applications of Data Mining in Healthcare. *International Journal of Engineering Research & Technology*, *2*(15). https://doi.org/10.17577/IJERTCONV2IS15030

[65]. Walid, M. A. A., Ahmed, S. M. M., Zeyad, M., Galib, S. M. S., & Nesa, M. (2022). Analysis of machine learning strategies for prediction of passing undergraduate admission test. *International Journal of Information Management Data Insights*, *2*(2), 100111. https://doi.org/10.1016/J.JJIMEI.2022.100111

[66]. Warschauer, M., Yim, S., Lee, H., & Zheng, B. (2019). Recent Contributions of Data Mining to Language Learning Research. *Annual Review of Applied Linguistics*, *39*, 93–112. https://doi.org/10.1017/S0267190519000023

[67]. World Health Organization. (2023, March 7). *Data collection tools - WHO*. https://www.who.int/data/data-collection-tools

[68]. World Health Organization (WHO). (2011). *Keeping Promises, Measuring Results* . www.who.int

[69]. Yang, X.-S. (2019). Mathematical foundations. *Introduction to Algorithms for Data Mining and Machine Learning*, 19–43. https://doi.org/10.1016/B978-0-12-817216-2.00009-0