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Research Article

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Big Data Analytics in Heart Attack Prediction

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Abstract

Introduction: Acute myocardial infarction (heart attack) is one of the deadliest diseases patients face. The key to cardiovascular disease management is to evaluate large scores of datasets, compare and mine for information that can be used to predict, prevent, manage and treat chronic diseases such as heart attacks. Big Data analytics, known in the corporate world for its valuable use in controlling, contrasting and managing large datasets can be applied with much success to the prediction, prevention, management and treatment of cardiovascular disease. Data mining, visualization and Hadoop are technologies or tools of big data in mining the voluminous datasets for information.

Aim: The aim of this literature review was to identify usage of Big Data analytics in heart attack prediction and prevention, the use of technologies applicable to big data, privacy concerns for the patient, and challenges and future trends as well as suggestions for further use of these technologies.

Methods: The national and international databases were examined to identify studies conducted about big data analytics in healthcare, heart attack prediction and prevention, technologies used in big data, and privacy concerns. A total of 31 studies that fit these criteria were assessed.

Results: Per the studies analyzed, Big Data analytics is useful in predicting heart attack, and the technologies used in Big Data are extremely vital to the management and tailoring of treatment for cardiovascular disease. And as the use of Big Data in healthcare increases, more useful personalized medicine will be available to individual patients.

Conclusion: This review offers the latest information on Big Data analytics in healthcare, predicting heart attack, and tailoring medical treatment to the individual. The results will guide providers, healthcare organizations, nurses, and other treatment providers in using Big Data technologies to predict and manage heart attack as well as what privacy concerns face the use of Big Data analytics in healthcare. Effective and tailored medical treatment can be developed using these technologies.

Keywords: Big data; Big Data analytics; Heart attack; Nursing; Health care; Personalized patient care; Privacy; Data mining; Machine learning; Internet of things (IoT); Telecardiology

Introduction

Acute Myocardial infarction (AMI), commonly referred to as a heart attack, is among one of the deadliest of cardiovascular diseases. AMI happens as circulation or blood flow to heart muscle is interrupted, causing the heart muscle to damage or die (become necrotic) [1]. The primary reason for most heart attacks is a blockage which causes blood flow to one of the coronary arteries, vital channels through which blood travels to the heart muscle, to become reduced or obstructed. When blood flow is obstructed or reduced, the heart muscle is rapidly deprived of red blood cells which carry the necessary oxygen essential for sustaining life and consciousness in the human body. It takes as few as six to eight minutes without oxygen to cause the heart muscle to arrest, leading to the individual's death [2]. The cause of most heart attacks is plaque, a hard substance which builds up over time in the coronary arteries. Plaque, a substance made up of numerous cells and cholesterol (fat), draws platelets, which increase over time, causing a blockage large enough to diminish or block blood flow to heart muscle. Some individuals have a build-up of plaque in the arteries over many years and this is known as atherosclerosis. Examining the cause and etiology of atherosclerosis, it can be described as a chronic inflammation. And when examining AMI, it also could be described as acute inflammation. White blood cell production in the bone marrow is increased due to signaling via the sympathetic nervous system after the AMI as well as in the spleen. This increase in white blood cell production migrate to the heart and vessel wall and can be recruited into other atherosclerotic plaques, causing more inflammation and likely subsequent ischemic events such as reinfarction or stroke [3].

There are generally two phases of wound healing when it comes to monocytes and macrophages. Initially there is an early inflammatory phase and afterwards, a reparative phase begins. However, both phases are necessary for proper wound healing; but if either of these phases is stalled or if the inflammation continues too long, resolution of the inflammation never happens and it leads to heart failure [3]. On the other hand, a more unusual type of heart attack strikes when there is an acute spasm or constriction of one of the coronary arteries. The spasm then cuts off blood flow to the heart causing oxygen deprivation. These spasms can appear in coronary arteries without any signs of atherosclerosis. As far as symptoms, men are significantly more likely to experience chest pain than women. Furthermore, women are far more likely to experience a heart attack if their pain lasts more than one hour, while men are more like to experience pain durations of less than one hour when having a heart attack [2]. AMI occurs within the entire physiological system; it does not just happen to the heart, but changes happen everywhere, including remote organs such as the spleen and bone marrow [3].

The old way of handling data included small and expensive methods. Input data from clinical trials were too small and too costly; data was limited so the modelling effort was small. However, in today's market, the electronic health record (EHR) has revolutionized data management. Data has become cheaper, larger, and there is a broader patient population to be included. Data has become noisy, heterogeneous, diverse in scale and longitudinal in the EHR. In addition, Medicare now penalizes hospitals with high rates of readmissions amid patients with Heart failure, Heart attack, and Pneumonia [4]. Care plans and outcomes-based discharge measures have been established by Medicare so that hospitals must conform to Medicare admission and discharge regulations for these diseases for reimbursement. Outcomes measures have become the primary mode of evaluating patients for discharge and reimbursement since the establishment of the Health Insurance Portability and Accountability Act of 1996. Some examples of different outcome in health care include: binary outcomes (death or adverse events), continuous outcomes (length of stay or visual analogue score), ordinal outcomes (quality of life, grade of tumor, number of heart attacks), survival outcomes (cancer survival or clinical trials) [4]. Big data, a concept now several years old, is becoming the primary method to harness data as more and more health care organizations discover opportunities to better understand and predict customer behaviors and interests. Big data is the data that exceeds the processing capacity of conventional database systems. The data is too big, moves too fast, or doesn't fit the strictures of conventional database architectures [5]. Big data characteristics can be described by "6Vs". They are: Volume, Velocity, Variety, Value, Variability and Veracity [5-14].

Volume: It means data size such as terabytes (TB: approximately 10^{12} bytes), petabytes (PB: approximately 10^{15} bytes) and zettabytes (ZB: approximately ^{21} bytes), etc.

Velocity: Data is generated at a high speed.

Variety: Data can be structured, semi-structured, or unstructured.

Value: It refers to the value that the data adds to creating knowledge.

Variability: It refers to data changes during processing and lifecycle.

Veracity: It includes two aspects: data consistency (or certainty) and data trustworthiness.

Big data fosters newer opportunities to predict and/or more rapidly respond to critical clinical events, generating better health outcomes and more efficient cost management. Oracle, an international technology firm, proposes that big data often has low value density if data is received in its original form. Intelligent electronic devices - used by some individuals while both at home and while traveling about their day - now capture and transmit data for analysis in the management of chronic diseases and conditions providing more frequent data about the heart, the breathing process, blood sugar or blood pressure - as the patient goes about daily life - and significantly increases a provider's ability to make appropriate clinical decisions. A cardiologist can receive data daily about each ambulatory - roughly one hundred times more often than possible with quarterly office visits - thereby occasionally giving the provider an early warning of problems, which could prevent a heart attack. Data compiled by these medical devices is quite frequently voluminous and rapidly increasing; this necessitates intensive and complex analysis to both augment clinical decisions and guide research on improved practices, thus improving outcomes [15].

But big data is not only about size, there is also the insight it derives from complex, noisy, heterogeneous, longitudinal, and voluminous data. Challenges, however, include capturing, storing, searching, sharing and analyzing. And social communication in varied digital forms is on the increase [16]. Already established as a novel field, data mining is now a primary method for discovering knowledge in buried patterns among the big datasets. In the health care industry, this uncharted knowledge can be utilized in different application domains, for example heart attack prediction. Data mining techniques and machine learning can be used to develop new software to assist providers and others in the health care industry to make decisions about heart attacks in the early stages [17,18]. Big Data is created by a growing plurality of resources, including Internet clicks, mobile transactions, user-generated content, and social media, and currently, genomics data, as well as purposefully generated content through sensor networks or corporate transactions. Currently, the most vital advances include the use of genomic data in drug discovery, the sharing of clinical-trial data, the use of EHRs, and the growing availability of data from mHealth applications such as telemedicine, patient registries, and social media [19]. Medication data vary in EHR systems and can be in both structured and unstructured formats. The availability and completeness of medication data vary while inpatient medication data may be complete, but outpatient medication data may not be. Prescription records may be incomplete as data is usually only stored as prescriptions but we cannot be sure whether patients filled those prescriptions. Clinical notes also hold rich and various sources of information, most of which is unstructured [16]. The new generation of information about the efficacy of treatments and the prediction of outcomes are the most fundamental applications of big health care data. Big Data varies from traditional decision support tools as it fosters collection and analysis of real-time patient data [19]. It is extremely vital to patient care and reducing both mortality and morbidity associated with heart attacks that providers can utilize big data applications to improve or establish a heart attack prediction program. Predicting heart attacks will not only save numerous lives but will assist providers in establishing personalized medicine, one of the many applications of big data in health care currently available..

Aim

The aim of this comprehensive literature review is to examine current standards, methods, and uses for big data to develop a heart attack prediction system to assist providers in establishing higher standards of care and a more personalized medical care plan for the patient.

Literature Review Questions

- What is Big Data Analytics and how is it used in health care?

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- Can using Big Data Analytics be used to predict heart attacks?
- What is the role of nursing in the application of Big Data?
- What are some of the challenges of using Big Data Analytics in health care?
- What are the future trends associated with Big Data, heart attack prediction and personalized medicine?
- Will society punish violations before they occur based solely on investigative predictions of future behaviors?

Methods

Search strategy

A systematic review of the literature concerning Big Data Analytics in Health Care, Big Data Analytics, Big Data in Heart Attack Prediction, Big Data and telemedicine, visualization, and The Internet of Things in all countries was conducted in December of 2016. Studies published between 2011 and 2016 were examined using the following search engines per the search criteria: Google Scholar, EBSCOhost Online Research Databases, Medline/PubMed, Mississippi State University Library Database, and the University of Phoenix e-campus library databases. The search strategy included all English language peer reviewed articles and all types of trials and studies. The selected titles were from appropriate articles also hand-searched to detect further relevant papers.

Search terms

Specific search terms were utilized in this study. Some of the search terms applied to the selected databases include: Big Data Analytics, Big Data Analytics in Health Care, Heart Attack Prediction, Heart Attack Prevention, Visualization and Big Data, Telecardiology, Sensors and Big Data applications. All the search terms were applied in English only. Each keyword was combined using "or" then combining it with "and."

Review procedure

Most of these studies were conducted either in the US, United Kingdom or Australia, using different definitions, various methods to collect the data, and both qualitative and quantitative study types. We did not however, try to analyze this data statistically, but results were summarized through Big Data Analytics in Health Care, Big Data and Heart Attack Prediction, The Internet of Things, Visualization and Telecardiology. Challenges and future trends as well as the conclusion are original research.

Article selection criteria

Inclusion/exclusion criteria

This article encompasses various types of studies, for example, randomized controlled trials, non-randomized controlled trials, longitudinal studies, cohort or case-control studies and descriptive and qualitative studies. Full-text peer reviewed articles that included Big Data in Health Care, Big Data and Heart Attack Prediction, The Internet of Things, Visualization, and Telecardiology were selected to comprise a sample group. However, studies related to Big Data Analytics in other fields, general studies on heart attack, and studies conducted unrelated to heart attack and Big Data were excluded from the sample. Conference papers, reports, and Power Point presentation material was considered when relevant to the primary sample.

Results

Features of the studies

A total of 1,224 studies were screened per title and 568 titles were excluded because the topic was not related to our research, or that they were editorials or letters. That left 142 peer reviewed article abstracts to be judged and after the title evaluation, 67 articles were examined for full text fitness and 36 articles were excluded due to the relevancy to our topic. Considering the evaluation, only 31 articles were deemed appropriate for this paper based on topic and relevancy.

Big data analytics in health care

The general process of data analytics can be comprised of two phases which are illustrated in Figure 1 [20]. Big Data analytics is changing the way we experience, provide, and receive health care. Providers are using big data more frequently than ever before to achieve a more personalized approach to their health care. As more and more data becomes available, through the EHR, medication refill records, insurance reports, genomics, telemedicine, and more currently, sensor data, we assume that innovators will design even more exciting ideas for using big data—nearly all of which that would help considerably diminish the soaring cost of health care in the US. The health care system must make a significant transformation for stakeholders to take full advantage of big data. The old levers for capturing value—chiefly cost-reduction efforts, most notably unit price discounts dependent upon contracting and negotiating power, or the rejection of redundant treatments—do not take full advantage of the insights that big data provides and therefore need to be enhanced or substituted for other methods linked to the new value pathways created by big data. Finally, traditional fee-for-service payment structures must be exchanged for a new system that bases reimbursement on gainful insights offered by big data [21].

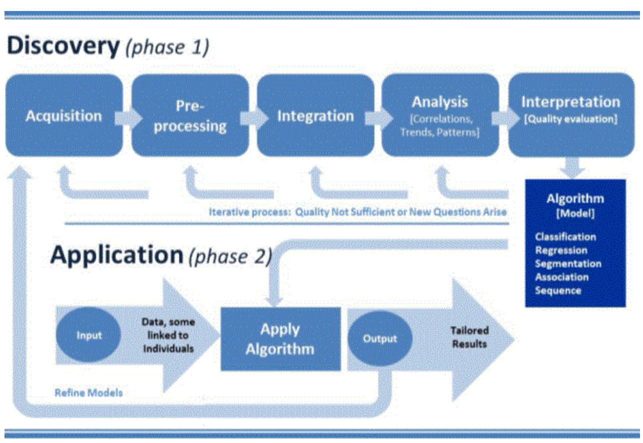

Figure 1: The general process of data analytics.

Structured data, for example, tables of numbers, do not reveal everything understood about a medication or biological process and most of the current knowledge about living organisms exists in unstructured formats [16]. Primary data pools are at the heart of the big-data revolution in healthcare. Integration of data pools is required for major opportunities. Table 1 [16] explains the primary data pools:

Primary Data Pools	**Description**
Clinical data	· Owners: providers
	· Example datasets: medical images, electronic medical records (EMR)
Activity (claims) and cost data	· Owners: providers, payors
	· Example datasets: utilization of care, cost estimates
Pharmaceutical R&D data	· Owner: academia, pharmaceutical companies
	· Example datasets: clinical trials, high-throughput-screening libraries
Patient behavior and sentiment data	· Owners: consumers and stakeholders outside health care (e.g., apparel, retail)
	· Example datasets: retail purchase history, patient behaviors and preferences, exercise data captured in running shoes

Table 1: Primary data pools of the big-data revolution in health care.

Biomedicalization denotes the on-going expansion of medicalization into new territory due to relatively fresh technology and scientific changes. Health care organizations, insurance agencies, pharmaceutical companies, and providers are now struggling to form new techno scientific innovations and organizational methods to meet their ever-growing needs. There has been a tremendous growth of the techno scientific nature of biomedicine in recent years, primarily due to three overlapping areas: computerization and data banking; molecularization and genericization of biomedicine and drug design; and medical technology, design, development and distribution [22]. Numerous medical characteristics combined with big data analysis based on the medical diagnostics of multiple fields rather than just by an individual provider relying on each patient's medical information [23]. Big data now plays a critical role in health care operations as data from large EHR systems, refill profiles, insurance information, genomic data and currently sensor data from both wearable and stationary nodes. Providers can utilize the data to manage many disease processes, personalize treatment to the individual, and improve outcomes through researching the database. Nursing care can also now be tailored to the individual's specific needs.

Smart Healthcare, now a current trend in health care contributing to the sources big data supports, has used multiple products such as home health care, wearable healthcare, and bio-transplant health care. For patients needing monitoring at home, home health care systems are sensors installed in the home that help manage the individual's health along with individual users and their smartphones. In the case of wearable health care, sensors are worn on the human body, providing personalized service through the measurement, transmission, and analysis of the bio-signal of the user's body in real time [23]. Sensors provide invaluable real time data to the provider.

Precise analysis in big data can lead to more certain decision-making. Apache Hadoop, an influential aspect in big data was developed by Yahoo, is an open-source software framework written in Java and is primarily for distributed processing and distributed storage of enormous datasets on computer clusters. Enormous data storage and faster processing are supported by Hadoop. Hadoop Distributed File System (HDFS) makes numerous copies of each data block and distributes them on systems to a cluster for reliable access. HDFS supports cloud computing using Hadoop, a distributed data processing platform. A distributed column oriented database—Hbase—is built on top of HDFS. It can be used when we need random access to very large datasets. HDFS provides reliable and scalable data storage. The central core of Apache Hadoop consists of a storage part—HDFS—and a processing segment, Map Reduce. Apache Mahout executes distributed or scalable machine learning and data mining algorithms [17,24]. Proposed system architecture is described in Figure 2 [17].

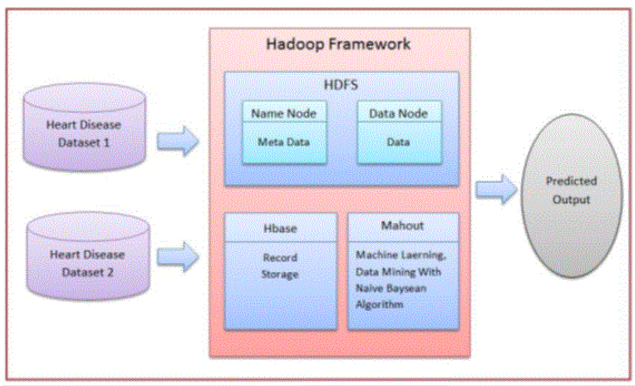

Figure 2: A system architecture dealing with big data.

This system is primarily concerned with two datasets—the original big dataset and the updated dataset. There are also two nodes: the Name Node which keeps a record of all files in the file system, and tracks the site of each file in a cluster; there is also the Data Node which warehouses data in the Hadoop File System. Any efficient file system is comprised of more than one Data Node, with data replication. Hbase is used when an engineer needs random; real time read or writes access to Big Data. The goal of Hbase is to accommodate especially large tables [17]. The Hadoop framework fractures big data into smaller parts stored on clusters of commodity hardware. Hadoop concurrently processes huge quantities of data utilizing various low cost computers for speedy results. HBase is a column-based database management system running above HDFS. It is well suited for scant datasets common in numerous big data use cases. HBase applications use a Java programming language like typical MapReduce applications. An HBase system is comprised of sets of tables. Each table holds columns and rows like a traditional database. An HBase column characterizes an attribute of each item. HBase permits several characteristics to be grouped together into column families, so that each of the elements of a column family is stored together. In HBase you must first predefine the table schema and clarify the column families. New columns can be added to families virtually any time, making the schema highly flexible. Hadoop manages huge amounts of structured as well as unstructured data much more efficiently than the traditional enterprise data warehouse. Since Hadoop is an open source framework and can run on commodity hardware, initial cost cuts are dramatic. Hadoop has a vigorous Apache community behind it which continues to subsidize its advancement. HDFS, a Java oriented file system, delivers reliable and scalable data storage [18].

Patient-customized health care and big data

Ciccone et al. conducted a feasibility study of incorporating care managers (specially trained nurses) into the healthcare system to support general practitioners (GPs) and specialists in the management of patients with cardiovascular disease (CVD), diabetes, heart failure or CVD risk. Care managers worked directly with individual patients, assisting them in making lifestyle changes, monitoring their conditions and providing the necessary information and advice to promote patient empowerment, and enhance self-management skills. This resulted in a tangible improvement in the clinical service and patients achieved better control of their disease. Ultimately, the care manager role has a positive influence on patient health and self-management, and their outcomes can be attributed to the solid "partnership" between the care manager and the patient and the collaboration between the provider and the care manager [25]. Specially trained nurses are now at the forefront of the new data revolution in healthcare. Not only do nurses provide care at the bedside, in the data-driven society we live in currently, nurses must shift their roles to assist their patients in becoming more empowered, changing their lifestyles, and improving their overall health based on the data. Never before in history has this system of personalized medicine been at the threshold of revolutionary evidence-based patient care.

Recently, a Patient-customized Healthcare System based on Hadoop with Text Mining (PHSHT) was developed as a method to efficiently manage diseases and the health care system. Subsequently, the PHSHT not only supplements the glitches within the existing decision-making algorithm, which ignores the relationship among attributes, but it also produces precise disease rules. Also, the patient's status is revealed to the individual so preventing any unexpected accidents since the patient can then take immediate action. The Text Mining based Hadoop platform determines an individual's disease, predicts the disease process, and creates more precise information about any diseases by converting the patient's unstructured generated data to structured data. There are four modules in PHSHT: (a) MDCM stores big data such as a patient's health information in the Hbase, which happens within a hospital or a portable health care system. Afterward, the collected big data is separated into structured data like patient information, family history, and medical prescriptions, as well as unstructured data like clinical notes, EHR, and PACs data; (b) TMHM analyzes the amassed unstructured data with Text Mining based Hadoop and transforms it to structured data. TMHM also distributes and stores structured data in the Hbase then merges the stored structured data and stores it in Hbase again with a MapReduce Framework; (c) DRCM generates disease rules by using the disease information stored in the Hbase and CPST algorithm and stores them again in the Hbase; (d) DMPM notifies a patient or the provider of a risk index as the result of disease prediction after analyzing the patient's risk with the patient's collected information or by predicting a disease by relating the disease rules generated by DRCM with collected information [26]. The modules and flowchart of the PHSHT is illustrated in Figure 3 [26].

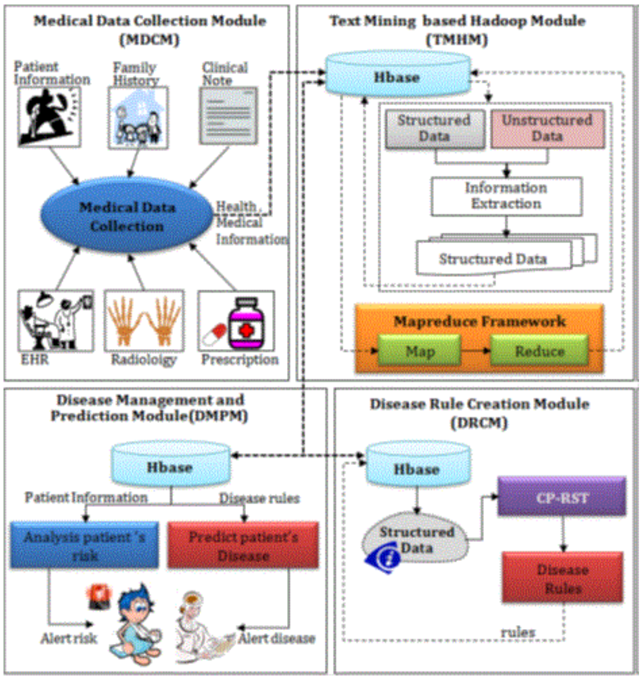

Figure 3: The modules and entire flowchart of the PHSHT.

Troponin and implanted sensors

Following medical advice about controlling risk factors plays a key role in reducing the severity and relapse, prevention, and health promotion of cardiovascular diseases. Cardiac patients who may be undergoing CABG could be the main determinant of compliance with health advice treatment outcomes and the quality of life in patients after surgery. On the other hand, the disease negatively affects their psychological well-being; usually cardiac patients have lower psychological well-being than patients without heart disease [27]. There is also solid evidence that a higher incidence of anxiety and depression follows a heart attack. Young age, heart murmur, history of implantable cardioverter defibrillator (ICD) shock and generalized anxiety all point to greater anxiety after cardiac arrest and may well be predictive for people who have had a heart attack without arrest. Problems arise not only from the onset of depression and anxiety for cardiac patients but also predict poorer recovery and a higher long term risk for complications [22]. Factors other than chest pain can predict a heart attack before it occurs. Some chemicals that the body produces in response to an AMI can be detected hours prior to the actual heart attack. An electrocardiogram (ECG) can also be a reliable method to predict heart attacks and refer patient to the hospital for rapid treatment and prevention of the disabling effects of heart attacks. It is vital to utilize every tool available to predict, manage, and treat heart disease.

Troponin levels, a chemical produced by the heart in response to ischemia, usually increase in the blood some hours before a heart attack occurs. Measuring this chemical can lead to preventive or immediate treatment for a heart attack. Measurement of troponin must be done by detecting it inside the body. Very recently, there have been some developments in various institutes to develop a mechanism to detect troponinT/I and transmit this data via a smart phone. In effect, this would be an early heart attack detection system where an implanted troponin detection sensor is attached trans receiver to a real-time monitoring center. Reports from the real-time monitoring system, individualized to the user are analyzed and the patient alarmed to the condition. Troponin I (cTnI) is more reliable test specificity than troponin T (cTnT). An electrochemical biosensor as well as a microprocessor can be utilized for the recognition of troponin levels. The biosensor is surgically implanted inside the skin of a patient so that it can be exposed to blood flow, preferably an artery. Data is received from the sensor in analogue form then it is necessary to amplify the magnitude and convert it to digital form. It is then that the processed data transmitted by the Wireless Body Network Controller (BNC) attached RF device is sent to the medical monitoring system. The EHR database, updated in real-time, is equipped with a monitoring and administration zone and fault tolerant base alarm system. Troponin levels from various users are provisioned and updated in the EHR database in real-time. The implanted sensor sends troponin related data through Bluetooth and other access networks for the monitoring center to analyze in real-time or a short periodic manner [1].

The internet of things and disease prediction

The Internet of Things (IoT) is an advanced technology which exploits several specialties such as sensor development, data acquisition, management and processing, and communication and networking where subjects (e.g. objects, people) with unique characteristics can link to a remote server and form local networks. Since the connectivity in IoT-based systems permits objects to trade and fuse data to gain more comprehensive knowledge about their functionality and qualities of the neighboring environments, it offers superior, intelligent, and well-organized services. IoT technologies offer an improved quality of life for individuals through continuous (i.e., 24/7) remote monitoring systems which is one of the primary features of this technology. Although several efforts exist to use IoT-based systems for monitoring and care of the elderly, most only target specific conditions from a too limited standpoint (e.g. health monitoring, safety monitoring, etc.). Deliberating on the importance of remote monitoring of the elderly and the complete variety of possible services available with such a system, it is difficult not to realize that the technology still lacks a user-centered study. For example, a user-centered design would use numerous resources to present a system which focuses on the proficiencies, conditions, and abilities of the users. Various literature has focused on IoT-based elderly care which provides a comprehensive review of monitoring services; that is, essentials of user-centered system design for monitoring the elderly and the development of a multipurpose system which monitors a large group of users to detect (or predict) patterns or health-related situations that may happen to elderly patients such as heart attack, stroke, or diabetes. Remote health monitoring becomes even more important in the care of elderly patients due to the increased frailty and susceptibility to various diseases (e.g. acute and chronic diseases) of old age. Not only does remote health monitoring improve the quality of life of elderly patients, detects and notifies caregivers and providers of emergencies, reduces nursing care needs and hospital stays (e.g. health care cost reduction), it can predict and track disease processes such as heart attacks [28].

Wireless detection of a heart attack

Smartphones and sensors can detect and transmit varied health data. A wrist watch has been designed as Heart Attack Detection equipment used daily to indicate heart condition, detect heart attack and to call for emergency help. Designed especially for patients with heart disease, it can not only decrease morbidity and mortality but disability as well.

The ECG is extremely valuable as a tool for detecting a heart attack. The ECG is an electrical recording of heart activity and can be utilized in the investigation of heart disease. Electrical impulses initiate heart muscle contraction, which results in the heartbeat. Notice that the spacing between each pulse measure a heart's rhythm and the height of the pulse is an indicator of pumping strength. The wrist watch contains an ECG circuitry unit which captures abnormal heart beat signals from the patient. The microcontroller on the watch then runs a heart attack algorithm and the Bluetooth emergency calling system dials medical help during the time of heart attack. There are two biosensors worn on the patient's wrist which sends the ECG signal to the analog ECG circuitry. Then the amplified and filtered analog output of the circuitry is translated from an analog to digital signal and then transmitted to the unit on the walking watch. The ECG circuitry unit, the A/D converter and the transmitter are worn on one of the patient's wrists. This watch is wireless, giving the user more freedom to move by avoiding wires between the watch and the wrist. The patient wearing the watch receives a digital ECG signal, and the microcontroller runs a heart attack algorithm to detect potential heart attack symptoms. If any symptom of a heart attack is detected, the risk level rises. Once a patient's risk level reaches the emergency mode, the Bluetooth module activates the user's mobile phone to call 911 for medical help. The latest mobile phones include a GPS function [29].

Telecardiology in heart attack prediction

Telecardiology can be defined as the monitoring or diagnosis of cardiac activities at a distance via telecommunication technology. ECG and imaging-based echocardiography (ECHO) are tools most often applied in cardiology. ECHO has become a widely-used tool in telecardiology due to its ability to physically evaluate cardiac and vascular anatomical structures and physiological functions, which can affect intervention strategies. The strongest advantage of telecardiology is that it allows timely remote diagnosis by cardiologists and for the provider to evaluate effective therapeutic strategies, especially for rurally located patients where professional cardiologists are not as accessible. Telecardiology lowers the mortality rate for patients with heart attack and can reduce the cost of transportation from the home to the emergency setting or unnecessary transfers between hospitals [30].

A critical tool for telecardiology applications is wireless telecommunication, which delivers pervasive services with less interruption errors when compared to traditional telephone lines. Therefore, thanks to this technology, individuals residing in rural areas or disparate health care areas around the world will benefit from remote. However, it is possible to achieve ECG monitoring in a home environment without Internet connections using only traditional telephone lines by recording ECG signals as audio input which is then transmitted to a hospital via a fixed phone line or mobile phone [30].

Tele-ICU, a hospital-based form of telecardiology is only conducted by qualified and experienced nurses and cardiologists, who are responsible for the 24 h continuous remote monitoring of vital signs. A second significant feature of tele-ICU technology is the real-time tele-communication and tele-consultation among the bedside paramedics, off-site professionals and ICU patients via surveillance and the 24-hour alert system [30].

Data mining in big data processing and heart attack prediction

Currently, data mining can help health care insurance organizations to detect hypocrites and misuse, health care institutions to make decisions of customer relationship management, providers to identify effective treatments and best practices and patients now receive enhanced and more economical health care services. This predictive analysis is widely used in health care. Classification is one of the data mining methods used to predict and classify the predetermined data for the specific class. There are diverse classifications procedures proposed by researchers. Different data mining techniques have been applied to predict heart disease. The accuracy of each algorithm has been verified and stated as Naïve Bayes, Decision Tree and ANN. The three-different data mining algorithms, ANN, C4.5 and Decision Trees are utilized to investigate heart related diseases using ECG signals. The analysis results clearly show the Decision Tree algorithm performs best and provides better accuracy than the C4.5 or Naïve Bayes algorithm. It requires less space when the volume of data is increased; it has a lower error rate, and minimizes the predictive error. C5.0 algorithm is the most potentially suitable algorithm for any kind of medical diagnoses. In cases of the C5.0 algorithm performs faster and provides the best accuracy with lower memory consumption [24].

Data mining techniques can be utilized for pre-processing and machine learning algorithms can be utilized for implementation; cloud computing is used for deployment. Currently, popular machine learning algorithms have already become useful in determining the heart disease risk level and in helping the doctors correctly predict it. Data Mining is a process of extracting valuable and significant knowledge from huge datasets. Data Pre-processing is an important process in data mining and machine learning. Thus, dimensionality reduction is a valuable tool for downsizing data. The most key procedures for dimensionality reduction are feature selection and feature extraction. Feature selection is the method of choosing a subset of applicable features. Feature selection techniques are a subset of the more universal field of feature extraction [31].

Technology and its tools can be utilized for visualization and investigation, to automate the progression of detecting promising ideas to foster more efficient discovery of content, and to provide the facility to track its influence after the presentation of hopeful ideas into the discourse community. There are varied types of discourse analysis, including automated content analysis, which uses natural language processing and machine learning techniques. Running the discourse through I2A using KBDeX for visualization, it was possible to classify discourse units (DUs) and their corresponding contents into distinctive idea types. First, I2A was used to detect ideas, followed by the determination of pertinent and promising ideas, then by conducting an analysis of discourse belonging to different idea types for validation purposes [32].

With Naïve Bayes' assumption, all the attributes are autonomous, significantly reducing the calculations later developed. Using Naïve Bayes assumption, the probability can be divided into a continuous product of class conditional probabilities. Each patient has the risk intensity for which the posterior probability is extreme. Using a normal distribution accounting for age, cholesterol and thalach provides an approximately excellent assumption. The general idea of the algorithm is to use a weighted average calculation for all heart disease symptoms. Providers may sometimes be unsuccessful in correctly diagnosing the severity of the disease. Inside Mapper, the function of each line from the input file is used as input to map the phase and is then fed to different map-tasks in parallel, considering a multi-node cluster. Each node follows the same procedure in parallel [31].

The issue of privacy in big data

Faulty results and seriously compromised privacy are only two concerns when algorithms and data whose quality is suspicious, yield faulty results although used appropriately. Even when the algorithms and data are appropriate for their intended purpose, privacy concerns are paramount and may seriously compromise individual rights. Big Data analytics support automated processes which arrive at decisions about an individual, health care organization, or disease, and raise important questions about self-determination, personal autonomy and fairness. Results may also yield predictions about patients which may be conceived as invasive or against patient choice. Policymakers, users of data, and data protection authorities must carefully consider how principles are honestly and effectually harnessed by analytics. Although there are risks associated with the use of big data analytics, as a society, if we fail to utilize its benefits to solve old problems in health care, research, education, and development, we deprive individuals, patients, and society of the potential benefits. Preferably, there will be thoughtful guidance which studies the realities of big data and the nature of analytic processing and will empower organizations to utilize analytics in a vigorous and accountable style to reach long-sought out solutions [20].

Challenges and future trends in big data analytics

Big data in health care has many challenges including but not limited to: deducing knowledge from complex heterogeneous patient sources; leveraging the patient/data correlations in longitudinal records; understanding unstructured clinical notes in the appropriate context; competently managing huge volumes of medical imaging data and mining potentially beneficial information and biomarkers; analyzing genomic data, a computationally rigorous task and merging it with standard clinical data to increase layers of complexity; capturing the behavioral data through multiple sensors with their various social interactions and communications. Big data does have some goals, which include: taking advantage of massive amounts of information and providing the right intervention to the right patient at the right time; personalized care for the patient; potentially utilize all components of the health care system, that is, provider, payer, patient, and management. Sources and techniques for big data in health care can be structured EHR data, unstructured clinical notes or PACS data, genetic data, or research data. The biggest challenge for handling the data include ungrammatical phrases, grammar mistakes, short phrases, abbreviations, misspellings, semi-structured information which is copy-paste from other sources such as lab results and vital signs [16].

Other challenges for big data use include the structured template of some clinical notes (SOAP notes), text mining information such as extraction of the name, entity recognition, information retrieval, clinical text versus biomedical text, and medical literature (well-written medical text. Clinical text is that which is written by clinical staff in the clinical setting [16]. Other challenges of include analysis, capture, data collection, search, sharing, storage, transfer, visualization and information privacy. The term big data simply denotes the use of predictive analysis or other specific advanced methods to mine valuable information from data, and often refers to the size of dataset [17]. The size and heterogeneity of data being gathered is a significant challenge. The high volume, velocity and variety of available data collection methods is likely to drive this data-driven society to a point where sampling will not be required because the entire background of a population is available [19].

The future scope of our health care system is aimed at offering a big data infrastructure for our designed risk calculation tools, to design more sophisticated prediction models and feature extraction techniques and extend our proposed system to predict other clinical risks [17]. Some other future possibilities are for the discovery of ground-breaking pharmaceuticals, the development of more effective treatment protocols and for the development of personalized medicine [19].

Summarization of main findings

The following Table 2 is a summarization of our results based on the literature research. Each section is denoted and a summary of findings associated with the results is indicated. The results of this review were conclusive in one sense: personalized medicine is the key to the future of medicine and nurses play a key role in helping patients navigate the data-driven healthcare society that was once driven by the provider.

Sections	Main Findings
Big Data analytics in health care	Big Data analytics is a novel method of handling the numerous amounts of healthcare data that is streamed daily. It includes technologies and tools adept at navigating the massive amounts of data in any given healthcare system and mining useful information to treat patients
Patient-customized health care and big data	Big Data tools are now able to predict, prevent, and suggest the best evidence-based treatment plans for the patient based on the data from a variety of sources. Care managers, specially trained registered nurses trained to work with providers to empower and assist patients to make lifestyle changes, are essential in the data-driven society to personalize medicine.
Troponin and implanted sensors	Implanted sensors are now available to detect troponin levels in the blood prior to some heart attack and potentially alert emergency personnel to the problem and prevent mortality and morbidity associated with heart attacks.
The Internet of Things (IoT) and disease prediction	The IoT can be used to predict diseases based on monitoring of the elderly, sensors, and the data which can then be processed using Big Data analytics.
Wireless detection of a heart attack	Smartphones, wristwatches, and other human-based sensors can be used in predicting and preventing heart attacks prior to occurrence by reading the EKG which may show changes prior to heart attack and alert key personnel immediately.
Telecardiology in heart attack prediction	Telemedicine is in a key position to monitor and indicate when a person is having a heart attack in healthcare systems where cardiologists may not be available immediately. The data relayed in these eICU and eER settings are key to preventing morbidity and mortality in small rural healthcare area.
Data mining in big data processing and heart attack prediction	Data mining is a key tool of Big Data used to predict, prevent, and suggest the best treatment plan for heart attacks.
The issue of privacy in big data	Privacy is a key issue in today's data-driven healthcare society as most information is de-identified; however, it can be re-identified under certain circumstances. With the onset of Big Data uses in healthcare, it is imperative that privacy against hackers, identity theft, and the illegal uses of healthcare data is prevented.

Table 2: Gathering the main findings.

Conclusion

The analysis of voluminous, structured and unstructured data, as well as disorganized data has produced substantial discoveries. The absence of cross-border direction and technology integration demands standards to enable interoperability amid the elements of the big data value chain. Big data proposes vast promises for detecting interactions and nonlinearities in relationships among variables. Mobile devices, such as smart phones and tablets, and sensors, will continue to be the most indispensable tools available to deliver heart attack prediction and telecardiology services over wireless networks to reduce cardiovascular disease morbidity and mortality. The deployment of cloud computing has inexpensively facilitated the collaborative application of telecardiology between hospitals and has expanded services from regional to global. The most important factor, however, in the development and application of big data, telecardiology, sensor use, mobile phone or tablet use and landline use is patient privacy and to safeguard the patient's ability to direct and discover the use of his or her health care information. Care managers, specially trained nurses who are revolutionizing healthcare by empowering patients directly to change their lifestyle and habits based on evidentiary research and data are needed to assist patients in this new data-driven healthcare scene. Nurses have always been on the forefront of revolutionary medicine and in today's data-driven healthcare system, nurses are critical in assisting their patients to navigate the data landmines and empower them to change unhealthy habits and reach a more improved health status.

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