I. KISIM - PART I

TIP BİLİŞİMİ VE YAPAY ZEKÂ

MEDICAL INFORMATICS AND ARTIFICIAL INTELLIGENCE

CHAPTER 1 / BÖLÜM 1

BIG DATA IN HEALTH AND KNOWLEDGE MANAGEMENT

BÜYÜK SAĞLIK VERİSİ VE BİLGİ YÖNETİMİ

Eda ÇEVİK*, Sevinç GÜLSEÇEN**

*Ph.D. Candidate, İstanbul University, Graduate School of Natural and Applied Sciences, İstanbul, Türkiye
E-mail: eda.cevik@deu.edu.tr

**Prof. Dr., İstanbul University, Department of Informatics, İstanbul, Türkiye
E-mail: gulsecen@istanbul.edu.tr

DOI: 10.26650/B/ET07.2023.005.01

ABSTRACT

Since the first day of humanity, technology has been an important concept that separates the history of the Earth into periods and has been mentioned with energy or raw materials such as stone, metal, earth, steam, electricity. In the age of Industry 4.0, which its birth is witnessed, Big Data Technologies and data play key roles. Many technologies developed to meet the needs of disciplines such as health sciences, astronomy, computational biology and high energy physics have been the subject of research under the name of Big Data Technologies. The technologies required for storing, capturing, improving, searching, sharing, transferring, analyzing and visualizing big data with qualities such as volume, speed and diversity, called Big Data Ecosystem, have the potential to transform every field in which it is applied. These technologies are behind the birth of the field of Precision Medicine, which aims to plan personalized treatment such as gene therapy, which is the hope for the treatment of hereditary diseases and to examine the relationship of infectious diseases that threaten public health. Just as it is necessary to manage the process of obtaining products from raw materials in production enterprises, in the same way, information production must be managed in order to create a health system that focuses on information. The beginning of keeping patient records electronically, the digitalization of the outputs of imaging devices such as x-rays, developments in the field of genetics and even social media have created a data explosion and increased the need for Information Management. And it has led to the development of the applied discipline of Health Information Management, which deals with the collection, analysis and dissemination of information flowing from medical practice, medical education, medical research activities.In this study, Knowledge Management, Big Data theoretical fields and Big Health Data, Health Knowledge Management applied disciplines are tried to be explained.

Keywords: Knowledge management, big data, big data in health, health knowledge management

ÖZ

Teknoloji insanlığın ilk gününden beri Dünya tarihini dönemlere ayıran önemli kavram olmuştur ve her dönem taş, metal, toprak, buhar, elektrik gibi bir enerji ya da hammadde ile birlikte anılmıştır. Doğumuna şahit olduğumuz Endüstri 4.0 çağında ise Büyük Veri Teknolojileri ve veri kilit rol oynamaktadırlar. Sağlık bilimleri, astronomi, hesaplamalı biyoloji, yüksek enerji fiziği gibi disiplinlerin ihtiyaçlarını karşılaşmak için geliştirilen birçok teknoloji Büyük Veri Teknolojileri adıyla araştırmalara konu olmuştur. Büyük Veri Ekosistemi olarak adlandırılan, hacim, hız, çeşitlilik gibi vasıflara sahip büyük verinin depolanması, yakalanması, iyileştirilmesi, aranması, paylaşılması, aktarılması, analizi ve görselleştirilmesi için gerekli teknolojiler uygulandığı her alanı dönüştürme potansiyeline sahiptir. Bu teknolojiler, kalıtsal hastalıkların tedavisine umut olan gen tedavisi gibi kişiye özel tedavi planlamayı ve halk sağlığını tehdit eden bulaşıcı hastalıkların ilişkisini incelemeyi amaçlayan Hassas Tıp alanının doğuşunun arkasındadır. Nasıl ki üretim işletmelerinde ham maddeden ürün elde etme sürecinin yönetilmesi gerekiyorsa, aynı şekilde bilgiyi merkezine alan bir sağlık sistemi oluşturmak için bilgi üretiminin de yönetilmesi gerekmektedir. Hasta kayıtlarının elektronik ortamda tutulmaya başlanması, röntgen gibi görüntüleme cihazlarının çıktılarının dijitalleşmesi, genetik alanındaki gelişmeler ve hatta sosyal medya veri patlaması yaratmış ve Bilgi Yönetimi alanına olan ihtiyacı arttırarak, tıbbi uygulama, tıp eğitimi, tıbbi araştırma faaliyetlerinden akan bilgilerin toplanması, analiz edilmesi ve yayılmasını konu edinen Sağlık Bilgi Yönetimi uygulamalı disiplininin gelişmesine sebep olmuştur. Bu çalışmada Bilgi Yönetimi, Büyük Veri teorik alanları ve Büyük Sağlık Verisi, Sağlık Bilgi Yönetimi uygulamalı disiplinleri açıklanmaya çalışılmıştır.

Anahtar Kelimeler: Bilgi yönetimi, büyük veri, büyük sağlık verisi, sağlık bilgi yönetimi

1. Big Health Data and Knowledge Management

The fourth industrial revolution, which focuses on the use of data as a raw material, whose volume is increasing and its structure is complex, has paved the way for a radical change in the business models of all sectors, including health services. This paradigm shift has accelerated the use of data-based solutions in the health sector and introduced new concepts such as big data into our lives. Big health data includes electronic health records, radiology and satellite images, laboratory tests, epicrisis reports, genome sequences, wearable technologies, biomedical devices, insurance records, even social media shares and more. The added value obtained by keeping, storing, transforming, processing, sharing information or knowledge briefly managing large health data, which has a very complex structure, can be used in problems such as the delivery of health services, cost reduction, and drug development.

Information, which appears as a product, is a value that must be carefully managed during the production and consumption stages. The studies carried out in order to obtain the highest efficiency from the information that plays a role in the evolution of the health sector to the concept of Health 4.0 are examined under the branch of Information Management. The application of knowledge management methodology in the field of health gives rise to the discipline of health information management.

In this chapter, before the term big data is processed, the explanation of basic concepts such as data, information and knowledge serves as a step towards understanding the subject. In this chapter, before the term big data is processed, the explanation of basic concepts such as data, information and knowledge serves as a step towards understanding the subject. Then, what big data is, its features, structure and big health data will be explained. After the basic concepts of information management, which is another important topic of the subject, are given, health information management, which is an applied discipline, will be tried to be explained.

1.1. Data Hierarchy and Role of Information Systems in Data Transformation

Linguists, philosophers and naturalists have tried to generate many definitions that can be used interchangeably for the concepts of data, information and knowledge, which are frequently encountered not only in the field of information and communication technologies, but also in different disciplines. In order to make these efforts more understandable, a hierarchy called knowledge hierarchy (Figure 1) has been developed and the hierarchy elements can be defined as follows (Ackoff, 1989; Bibri, 2018; Bellinger, et al., 2004; Rowley, 2007; Ming, et al., 2015; Gökçen, 2011):

- Data is defined as observation values or symbols representing properties of objects, events and environments, and must be transformed into information to be usable.
- Information can be defined as the answers to questions such as 'who?', 'what?', 'when?', 'where?', 'how much?' by inferring from the data.
- Knowledge is experience or expertise that translates information into instructions. As a result of processing data and information it is the answer to the question "how?" .
- Wisdom, on the other hand, is cognitive processes that add value and require the mental function called judgment about determining the value of the results obtained. Ina nutshell, it is the ability to answer the question 'What should be done?'.
- Understanding deals with the "why" of questions such as "who?", "what?", "where?", "when?", "how?".

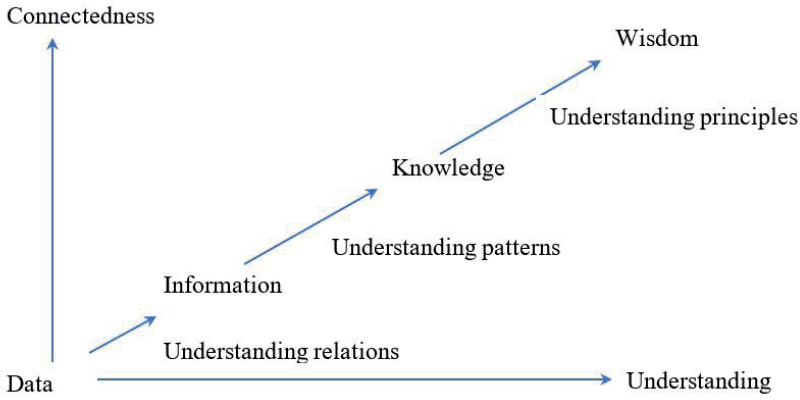


Figure 1: Hierarchy of DIKW (Bellinger, op. cit.; Saadatdoost vd., 2018; Ghuman & Aswathappa, 2010)

The illustration of the knowledge hierarchy has placed knowledge on the basis of information systems, knowledge management and information management (Rowley, op. cit.; Baskarada & Korinos, 2013). In the past, while the journey from data to information was an action that took place in the mind of the person, advanced technologies have based the transformation of complex and high-volume data into information on methodology. Computer-based information systems contain many tools for decision makers such as data filtering, mathematical modeling, statistical analysis, data mining and machine learning, optimization in order to transform between the steps of the DIKW hierarchy (Jifa & Lingling, 2014; Mondal, 2016; Gu & Zhang, 2014).

Meanwhile information systems are defined as structures that collect, organize, store, process, display and distribute all forms of information (raw data, compiled data, knowledge and expertise) and formats (text, video, audio, photographs, etc.) (Sofroniou, 2012), system elements consist of hardware, software, data, people and processes (Shelly & Rosenblatt, 2009). When these concepts are examined in the context of health, health information systems can be thought of as structures containing procedures and devices used to collect, organize, store, analyze and disseminate health care data (Gunnar, 2007). The word "devices" in this definition includes not only computers, switches, routers, modems, and printers but also devices, which can be classified as hardware, such as an ambulance or organ transplant vehicle with a global positioning system, computerized tomography, electrocardiogram.

The wealth of hardware tools has brought with it rich data structures. Today, besides electronic patient records, laboratory devices such as sedimentation test mixer, DNA sequence machines, imaging devices for example ultrasound, mammogram, fluoroscope, magnetic resonance, computed tomography, angiography, electrical potential measurement devices like electrocardiography, electroencephalography, electromyography, ophthalmoscope, diagnostic devices for instance ophthalmoscope, tonometer, spirometer, biomicroscope, audiometry and also wearable technologies produce data in different formats waiting to be transformed into information or knowledge. Due to the increasing diversity of data with complexity and volume, the healthcare industry has been confronted with the concept of big data.

1.2. Big Data

Today, there is a data explosion that causes very serious problems, thanks to events such as the personal use of computers, the discovery of the internet, the rise of mobile technologies, the transfer of archives to digital media, the development of satellite systems, the transformation of classical technologies like clocks, air conditioners, refrigerators which communicate with each other on the internet. In order to cope with such intense data bombardment, new data storage systems, analysis tools, visualization methods have been developed and continue to be developed.

According to the Data Never Sleeps 9.0 (Domo, 2022) report, in 2021 for 1 minute

- 4,500,000 people watched Youtube videos,
- 511,200 users tweeted,
- 390,030 applications downloaded,
- 18,100,000 messages sent,

- 4,497,420 Google searches were made,
- 1,389 AIRBNB reservations were made,
- 55,140 photos shared on Instagram,
- 188,000,000 e-mail correspondence has been received,
- And 694,444 hours of Netflix video streamed.

In addition to the amount of data generated by the digital process that takes place in just 1 minute in the above-mentioned technologies, satellite systems, telescopes, embedded systems, wearable technologies, internet of things, sensors and many more also generate data. This brings up the problems of storing, processing and transforming information and information, sharing together with the complexity of the data. These problems, which cannot be solved by classical databases and analysis tools, are examined under big data technologies.

In order for a dataset to be classified as big data, Berman (2013) identified the following 10 differences between big data and small data:

1. Objectives: While small data is designed to seek an answer to a specific question, in big data the purpose is flexible and the questions asked are variable.
2. Location: While small data is usually kept in a single institution, computer and sometimes even in a single file, big data is kept on distributed systems anywhere in the world,
3. Data structure and content: In small data, data is usually in the form of regular records in a sequential spreadsheet and is directed to a single discipline. On the other hand, big data that includes complex data such as text files, photographs, motion pictures, can be associated with more than one discipline.
4. Data preparation: While small data is mostly prepared by the user for their own purposes, big data is prepared by many different people/institutions and the user is rarely the person who prepared the data.
5. Longevity: When the small data project ends, the data is stored for a limited time and can be destroyed later, while big data projects often contain data that needs to be stored permanently.
6. Measurements: In small data measurements are made using an experimental protocol, while in big data it can be obtained with many different protocols.

7. Reproducibility: In small data projects, if there is an issue with the quality of the data, the reproducibility, or the validity of the conclusions drawn from the data while the entire project can be repeated by obtaining a new data set. It is rarely possible to repeat the big data project.
8. Budget: While the failure of small data projects is tolerable within the organization, big data projects can be so costly that they can lead the organization to bankruptcy.
9. Introspection: Small data is defined by row and column positions, and if the row/column headers are known, all the data points it contains can be found. Yet in big data, the content and organization of the source may be incomprehensible even to data managers, so full access to data, information about data values, and organization of data information is obtained through a technique called introspection.
10. Analysis: In small data project, in most cases, all data can be analyzed together and simultaneously, while in big data projects, analysis is performed step by step, with few exceptions such as supercomputers or operations performed in parallel on multiple computers.

First, in 1997, Michael Cox and David Ellsworth used the concept of big data to describe multidimensional and high-volume data in their study on the difficulties experienced during the visualization of high-dimensional data (Wang et al., 2018; Cox & Ellsworth, 1997a; Cox & Ellsworth, 1997b). In Gartner Glossary (2020); It has been defined as a high-volume, high-speed, and/or diverse information structure that requires innovative information computing processes to provide enhanced foresight, decision-making, and process automation. The expressions “volume”, “velocity”, “variety” in the definition represent the features of big data known as 3V, and their numbers have increased over time, such as 4V, 7V, 10V, 42V.

1.2.1. Features of Big Data

The characteristics known as the 3V of big data, which were defined in the article first published by Laney in 2001, When different experts have tried to redefine them, have been come up with different numbers over the years. In 2017, a chronology of increasing V’s was created by Shafer and the existence of 42V was mentioned. Although there are many different characteristics in the literature, 10 characteristics in a big data project are listed below (Arora & Agarwal, 2018; Agrahari & Rao, 2017; Duda et al., 2018; Atalay & Çelik, 2017; Akay, 2018).

- *Volume* specifies the amount of data.

- ***Velocity*** refers to the speed at which huge amounts of data are generated, collected and analyzed.
- ***Variety*** refers to the diversity of data sources and formats.
- ***Value*** expresses the transformation of big data into benefit.
- ***Variability*** refers to the irregular changes in the data.
- ***Veracity*** is a qualitative data collection indicator that characterizes the accuracy, quality, reliability, uncertainty, integrity, and compliance of data collection processes with analytical processes.
- ***Validity*** refers to the relevance of data in the context of the method used for the analytical study or process.
- ***Vulnerability***, that is one of the biggest challenges in data generated from multiple sources with an unstable speed, can be identified security flaw.
- ***Volatility*** refers to how long the data will be valid, valuable and reliable.
- ***Visualization*** refers to the graphical representation of multidimensional and complex data.

The characteristics listed above point out those that are expected to exist when creating a big data project. In addition, other characteristics not expressed with V can be encountered in the literature. The concept of "complexity" (Kaisler et al., 2013) can be given as an example to demonstrate the degree of interdependence and dependence in big data structures.

1.2.2. Structure of Big Data

The variety in the definition of big data and its characteristics can be explained that the data comes from different sources and in different formats. For example, when the movement data created by sensors to understand the skeletal structure and, the laboratory test results data that will help in the diagnosis of thyroid diseases are compared, they differ from each other from the way they are obtained to the methods of storage, analysis and visualization. These differences arise from the structural features of the data and are the basis for their classification. Big data has four structures: structured, semi-structured, quasi-structured and unstructured data (Figure 2) (Manikandan & Abirami, 2017).

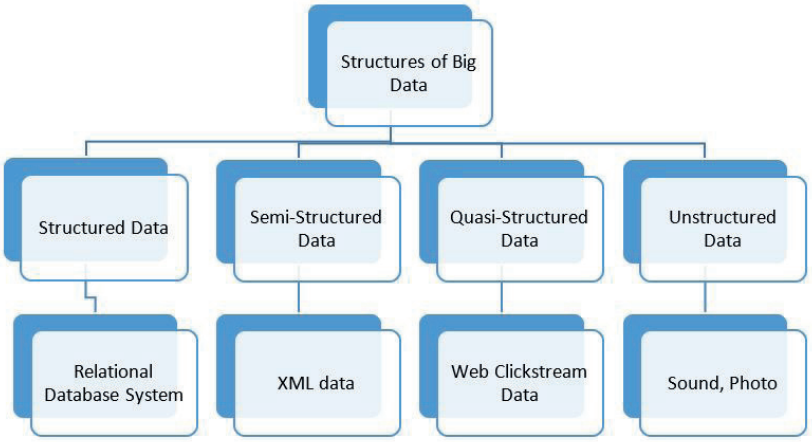


Figure 2: Big Data Classification by Structures (Chitra&MCA, 2018)

Structured data predicates regular data stored in relational databases, while unstructured data refers to irregular data structures such as photos and videos. Semi-structured data, on the other hand, are data with a structure that can be irregular or incomplete and can change quickly or unpredictably (Sultana, 2018). Quasi structured data consists of textual data with irregular data formats, located between unstructured and semi-structured data, and can be formatted with special technology. The term "quasi" means "as if" or "almost" in Latin (Shen et al., 2014). Unlike regular data, other data structures are kept in special databases called NoSQL and NewSQL.

1.2.3. Big Data Architecture, Ecosystem and Technologies

For big data, which is a fairly new field of study, management architecture proposals that can be alternative to each other are come up from both the private sector and the academic community. In order to create a consensus, The National Institute of Standards and Technology Big Data Public Working Group conducts various studies and proposes a management architecture based on the seven elements listed below as a reference (NIST, 2015; Samsudin, 2017).

- The System Orchestrator defines the required data application activities and integrates them into the operational system.
- The Data Provider is responsible for generating, collecting and transmitting data or information for the Big Data system through various communication protocols or network technologies.

- The Big Data Application Provider is responsible for executing the data lifecycle (eg, data collection, preparation, analysis, visualization, access, etc.) that meets the requirements and security defined by the System Orchestrator.
- The Big Data Framework Provider is responsible for the infrastructure, data platform and processes underlying various networking, storage and data processing technologies while maintaining the confidentiality and integrity of data.
- The System Administrator is responsible for managing the Big Data architecture, which includes configuration, package management, software management, backup management, capacity management, resource management, and performance management to support Big Data environments.
- Security and Privacy Manager keeps the big data lifecycle up to date with new security policy and regulations.
- The Data Consumer is a person, legal entity or other system that uses big data products.

The combined representation of technologies and infrastructures, that are required for storing, capturing, improving, searching, sharing, transferring, analyzing and visualizing, with big data characteristic such as volume, speed, diversity is called Big Data Ecosystem (Demchenko et al., 2013; Demchenko et al., 2014; Sharma, 2016).

Looking at the elements of this ecosystem, it can be seen that physical elements such as big data technologies coexist with abstract elements like the conceptual foundations of big data. While making use of technical fields such as sensor, computing network, data storage, cluster computing system, cloud computing facilities, artificial intelligence and data visualization, big data technologies perform sensing, retrieval, storage, analysis and visualization functions (Figure 3) (Yang, 2016).

As big data technologies can be functional such as analyzing data, some technologies such as Hadoop can fulfill many functions by providing an integrated service. Some of the popular big data technologies are briefly described below.

- Big Data Analytics: Analytical tools such as optimization techniques, data mining, statistical analysis, data visualization, natural language processing, text mining, artificial intelligence, mathematical models in the big data toolbox are used to transform the data into information or knowledge according to the user's needs.

- Hadoop Ecosystem: Hadoop distributed file system consists of four modules: MapReduce data processing engine, YARN ("Yet Another Resource Negotiator"), Common. These modules support a 3-tier architecture: storage layer, processing layer and management layer (Landset, et al., 2015).
- Fast Data: It refers to the application of big data analytics to smaller datasets in near real or real time to solve a specific problem. Its purpose is to quickly collect and process structured and unstructured data (Miloslavskaya & Tolstoy, ibid.).
- Map Reduce: It is a data processing programming paradigm that performs data reduction on maps obtained after mapping on distributed data sets.
- NewSQL: They are hybrid database systems that combine the strengths of NoSQL and Relational databases.
- NoSQL: It is a database technology developed for storing unstructured data that cannot be retained by relational databases. There are four types based on different data models: Key-Value based (Key-Value Pair-Based), Document-based (Document-Based), Column-Based and Graph-Based (Han et al., 2011).

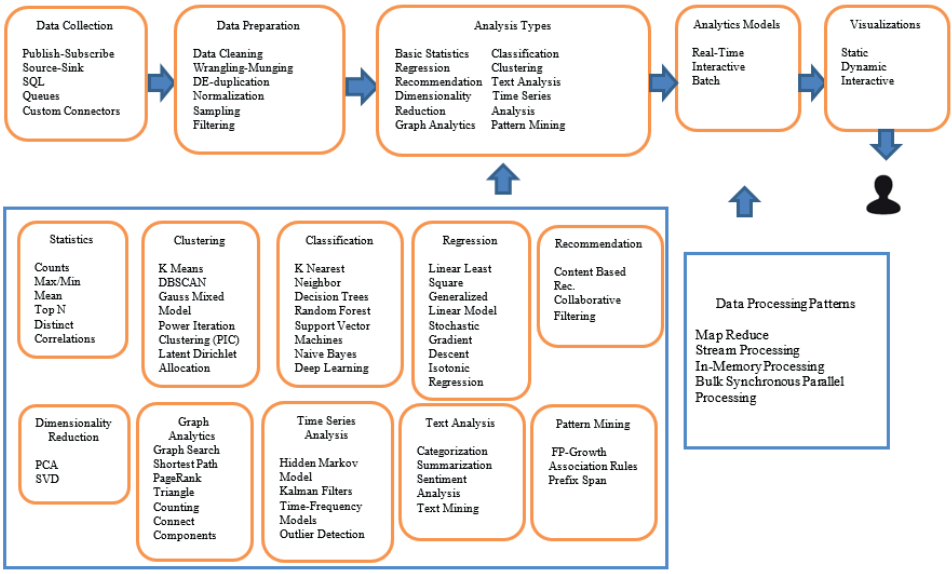


Figure 3: Big Data Flow (Bahga & Madisetti, 2019

- Data Lake: Unlike data warehouses, a data lake, which is a data storage technology, is created to process high volumes and rapidly incoming, unstructured data. While static analysis is performed in data warehouses, it uses dynamic analytical applications in lakes. While data changes slowly in data warehouses, data in the lake is accessed as soon as it is created (Miloslavskaya & Tolstoy, 2016).

In addition to the ones explained, the combination of other technologies such as cloud computing, internet of things, internet of services, and cyber physical systems with big data has radically changed the production and service business models by giving birth to the concept of Industry 4.0. Public services have also been affected by this change, and information-supported service delivery such as smart cities and smart hospitals has become popular.

1.3. Health Data and Its Relation to Big Data

Health data by the Washington Office of Technology Evaluation in 1979,

- Health status of individuals
- Individuals' use of medical care services and resources
- The cost and source of financing for the health service received
- Health effects of the environment and workplace conditions

- Indicators of diseases, health problems and health conditions
- Knowledge and attitude of the public
- Perceived health needs
- Behaviors developed against health practices (eg anti-vaccine)

defined as observations involving subjects.

As it can be understood from the definition above, health data encompasses a large ecosystem that includes not only laboratory results, radiology images, anamnesis records, but also air or water quality, values produced by mobile health monitoring systems, genetic code of a person, or any occurrence that may affect health (Figure 4).

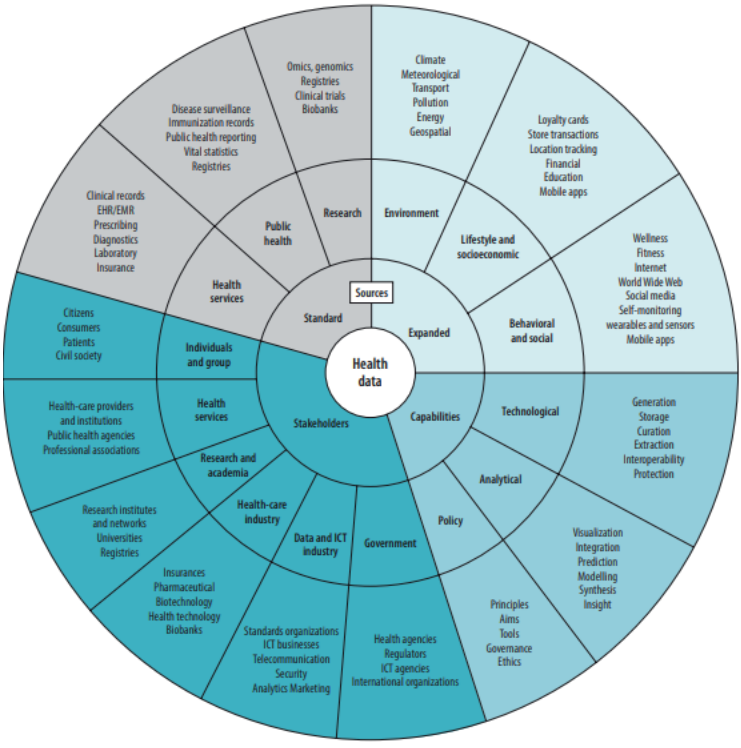
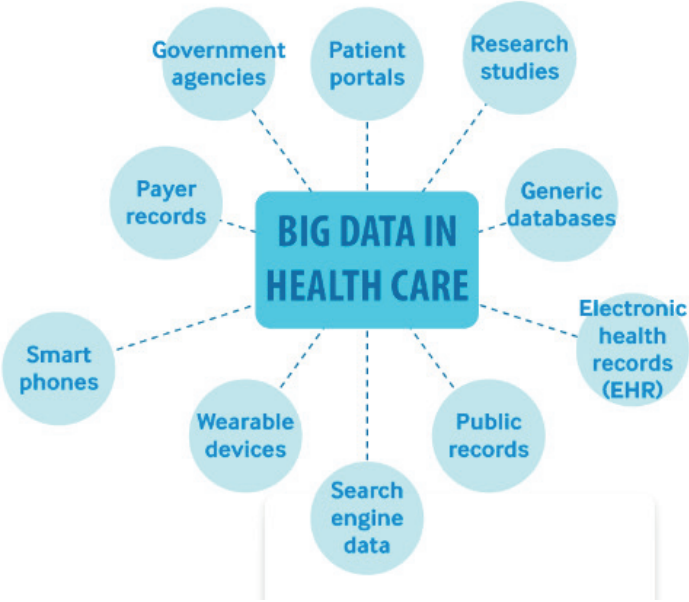


Figure 4: Health Data Ecosystem (Vayena et al., 2018; eHealth, 2016)

It is not always easy to record a patient's condition. Some of the reasons why the observed data cannot be recorded as structured are given below (Wager et al., 2005).

- A coding system has not yet been developed for cases such as the patient's admission record history and physical condition.
- The coding of the disease is complicated because the explanations of each patient with the same complaint will be different from each other. There can be multifactorial and temporal relationships between data pieces. This complexity naturally tangles the development of codes for medical data.
- The entry of encoded data is cumbersome and restrictive compared to ordinary text usage.
- There is no single way to organize health data; therefore the relational database model does not serve the medical field particularly well.

Hu et al. (2014) counted health sciences among the branches of science that were influential in the birth of big data such as astronomy, computational biology, and high energy physics. According to Zillner & Neururer (2016), health data is a kind of "big data" not only because of its large volume but also because of its complexity and diversity. It can be seen that big data features such as complex unstructured data, high data volume, data accumulation rate, security sensitivity, diverse and variable data source (Figure 5) are carried by health data. In summary, health data can be defined as big data by nature.



Şekil 5: Big Data In Healthcare (Catalyst, N. E. J. M., 2018)

Big health data obtained from the above-mentioned sources can be analyzed through analytics and used in the development of new and personalized health services, as well as in areas such as drug discovery, formulation of public health policies, and determination of disease-related conditions. In Table 1, examples of the usage areas of big health data are given.

Table 1. Big Health Data Application Fields

Application Field	**Explanation**
Diagnostics	Data mining and analysis to identify causes of illness
Preventative Medicine	Predictive analytics and data analysis of genetic, lifestyle, and social circumstances to disease
Precision Medicine	Leveraging aggregate to drive hyper-personalized care
Medical Research	Data-driven medical pharmacological to cure disease and discover new treatments and medicines
Reduction of Adverse Medication Events	Harnessing of big data to spot medication errors and flag potential adverse rections
Cost Reduction	Identification of value that drives better patient outcomes for longterm savings
Population Health	Monitor big data to identify disease trends and health strategies based demographics, geography and socio-economics.

Reference: Catalyst, N. E. J. M. (ibid.)

Behind the development of big data technologies is not only the advancement of internet technologies such as social media, but also the leaps in other branches of science such as space sciences, physics, biology and health sciences. While technologies such as microscopes, telescopes and laboratory equipment have developed, the amount and speed of recording observed events has increased. Especially in the field of health, not only scientific studies but also legal obligations are the driving force in the development of the concept of big health data, so big health data also played a role in the evolution of health services to Health 4.0.

1.3.1. Health 4.0

The application of Industry 4.0 standards in the field of health through technologies such as cloud computing, internet of things, wireless internet forms, 5G technologies, cryptography, semantic database, augmented reality and content-based image access system emerges as the concept of Health 4.0. (Estrela et al., 2018).

The focus of Industry 4.0, which aims to make products, processes and services more "smart" by using big data management (Elhoseny et al., 2018), is to achieve more efficiency and more personalized products with less human resources as a result of increasing automation in production by virtualizing physical reality. Likewise, the focus of Health 4.0 is to provide personalized treatment services by analyzing snapshots of the physical world in real time.

For Health 4.0 to achieve its purpose, the Internet of Everything, the cyber-physical system, cloud computing, things, services and people, evolving mobile communication technologies (for example, 5G, Wimax), standards and big data analytics must be used together (Thuemmler & Bai, 2017). After using the data of the physical world to create a model by simulation techniques, the model which is obtained can be produce a big dataset. This dataset can be operated for finding solutions to personalized treatment/precision medicine problems with big data techniques. In summary, big data can be a raw material that feeds the components of Health 4.0, as well as the product of components such as the internet of things and cyber-physical systems.

1.3.2. Big Health Data Technologies

In terms of content, big health data includes data such as insurance records, invoicing that support administrative processes, and medical data that supports health service delivery. Big health data technologies, on the other hand, can monitor resource usage, identify high-risk patients, and allow proactive patient care by collecting and analyzing health data from different sources such as clinical, financial and administrative data (Zillner et al., 2014). While the previously described technologies are used in the storage, analysis and sharing of big health data, field-specific technologies are used in its production. Listed below are several technologies that are major sources of health data, with a simple explanation.

- Wearable Technologies (Sensors): Accelerometer, Carbon Dioxide Meter, Electrocardiogram Sensor, Moisture Meter, Blood Monitoring Sensor (Oxygen saturation), Stress Sensor (measuring changes in pressure on the underside of the foot), Respiratory Monitoring Sensor, Temperature Sensor, Imaging Sensor (motion, length, location and area), Blood Pressure Monitoring Sensor, Heart Rate Monitoring Sensor, Blood Glucose Monitoring Sensor (Manogaran et al., 2017)
- Wireless Body Area Network or Body Area Network: It is a network consisting of a series of sensor nodes placed on or around the human body, such as wearable technologies, collecting data and sending it to the access point via various wireless technologies (Chen, 2014).
- Image Storage and Communication Systems (PACS): These are systems that work in integration with the hospital information system in the digital storage and management of images recorded by imaging devices such as tomography, mammography, ultrasonography (Kayaaltı & Kara, 2007).

- Hospital Information System (HIS): A HIS can extract data from different systems such as the Central Population Management System (Mernis), which keeps the demographic information of the patient, MEDULA affiliated to the Social Security Institution, electrocardiograph, electroencephalograph. In general, a HIS is formed by the integration of sub-systems such as laboratory information system, radiology information system and pharmacy information system (Bahga & Madisetti, 2013) and has the ability to exchange data with different sources.
- Content-Based Image Access System: Images are indexed according to their visual content such as color, texture, shapes (Liu et al., 2007), and by using these features, it is possible to search images can be listed (Tyagi, 2017). It can work integrated with the radiology information system or HIS.
- Gene Data Banks: Data pools created by research centers such as GenBank and Protein Data Bank can be counted among the technologies that produce large health data.
- Biobanks: They are systems that hold health and environmental data as well as data of biological materials such as genetic data, biopsy molecules, blood, plasma, serum, eye, brain, nail tissues (Baker, 2012; Mitchell & Waldby, 2010).
- MEDULA: It is an information system where billing transactions are made for examinations, analyzes, outpatient and inpatient treatments by health service providers such as pharmacies, hospitals, clinics, rehabilitation centers contracted with the Republic of Türkiye Social Security Institution (Köse, 2008), which was named MEDULA as a result of the abbreviation of "Medikal Ulak- Medical Messenger". (Güvercin et al., 2016).
- Data exchange systems: It provides insurance and demographic data to be added to health data.

1.4. Knowledge Management

Knowledge management is the deliberate and systematic coordination of an organization's people, technology, processes and organizational structure to add value through innovation (Dalkir, 2011). While defining knowledge management as an interdisciplinary field that systematically examines the creation, sharing and use of knowledge in order for individuals, teams or organizations to achieve their strategic and operational goals, its tasks and purposes can be listed as follows (North & Kumta, 2018):

- Obtaining information: To ensure that the necessary information and knowledge for business development and business processes are available.

- Knowledge creation: Ensuring that knowledge is developed in the most appropriate place (inside or outside the organization) and leads to innovation.
- Sharing and using knowledge: To ensure the dissemination, learning and optimum use of knowledge.
- Learning: Ensuring that the organization and employees learn and reflect on what has been learned.
- Protection of information: Updating and protecting the value of information, which is an asset, with the contributions of people.

A correct infrastructure must be created in order to manage the information flowing through business processes and which people use in their minds while making decisions. The elements of the knowledge management infrastructure include institutional structuring, information technologies and the physical environment. An understanding of human resources that supports information sharing, well-designed information and communication systems, office design that people can communicate with are important components for information management, which turns into value. (Kandaloosi et al., 2014; Hajir et al., 2015).

1.4.1. Knowledge Classification

Different knowledge classifications can be found in the literature because of that knowledge, which is accepted as a production factor such as capital, human, raw material and therefore essential to manage, is tried to be defined by different disciplines such as philosophy, cognitive sciences, informatics, psychology. Although Kalpič and Bernus (2006) state that there are two basic classes in the knowledge management literature as implicit and explicit knowledge, categorizations as explicit/implicit, procedural/essential and general/private knowledge are frequently encountered (Table 2).

Table 2. Categories of Knowledge

Categories	Definition
Explicit/Implicit Knowledge	While information that has been transformed into expression such as guides, drawings, audio and video tapes, computer programs, patents, coded data is explicit information, information such as understanding, intuition and thought that is in the mind of the person and not expressed and not transferred to any source is tacit knowledge.
Declarative/ Prosedural Knowledge	While declarative knowledge can be expressed in the form of propositions, expected correlations, or formulas represented by variables, procedural knowledge specifies sequences of steps or actions.
General/Domain Specific Knowledge	While many people have general knowledge that can be easily transferred between individuals, a limited number of people have specific knowledge that is difficult to convey in the absence of skill or education.

Reference: It was created by the authors using the study of Fernandez & Sabherwal (2010).

When Table 2 is examined, it cannot be evaluated in a single class while determining the category of information. For example, a recipe that has been passed down from generation to generation in the family for years is explicit because it is written in the notebook, it is procedural because it includes steps and action sequences, and it is private information because it is known by a certain group.

1.4.2. Knowledge Management Processes and Tools

Resources need to be optimally coordinated, in other words managed. Each of the factors of production such as capital, people and raw materials has its own specific management steps. Of course, the management steps of machine park which is kind of capital and the sales team will be different and specific to the subject. So the management of information also consists of subject-specific sub-processes. Since knowledge management researchers and institutions that want to gain value through knowledge management define their own processes, It can't be said that there is consensus on steps of knowledge management process. In Table 3, the processes that can be encountered in the academic environment and the private sector are exemplified.

Table 3. Knowledge Management Frameworks

References	**Frameworks**
Marquardt, 1996	(1) Acquisition (2) Creation (3) Transfer and Utilization (4) Storage
Ruggles, 1997	(1) Generation (2) Codification and (3) Transfer
Van der Spek & de Hoog, 1998	(1) Conceptualize (2) Reflect (3) Act (4) Review
Ernst & Young, 1999	(1) Knowledge Generation (2) Knowledge Representation (3) Knowledge Codification (4) Knowledge Application
Liebowitz, 2000	(1) Transform Information into Knowledge (2) Identify and Verify Knowledge (3) Capture and Secure Knowledge (4) Organize Knowledge (5) Retrieve and Apply Knowledge (6) Combine Knowledge (7) Learn Knowledge (8) Create Knowledge loop back to 3 and (9) Distribute

Source: Rubenstein-Montano et al. (2001) abridged from their work.

As can be seen from Table 3, three basic steps, which are production, sharing and implementation, exist for the information management process. These mentioned steps can include the digitization of tacit knowledge by making it explicit, or sometimes the production of new knowledge from digitally held explicit knowledge. These two examples require the use of different techniques, tools or technologies. In particular, the transformation of tacit knowledge requires a very special effort. Figure 5 shows the SECI model (Socialization - Externalization - Combination - Internalization) created by Nonaka et al. (1998) for the transfer of tacit knowledge.

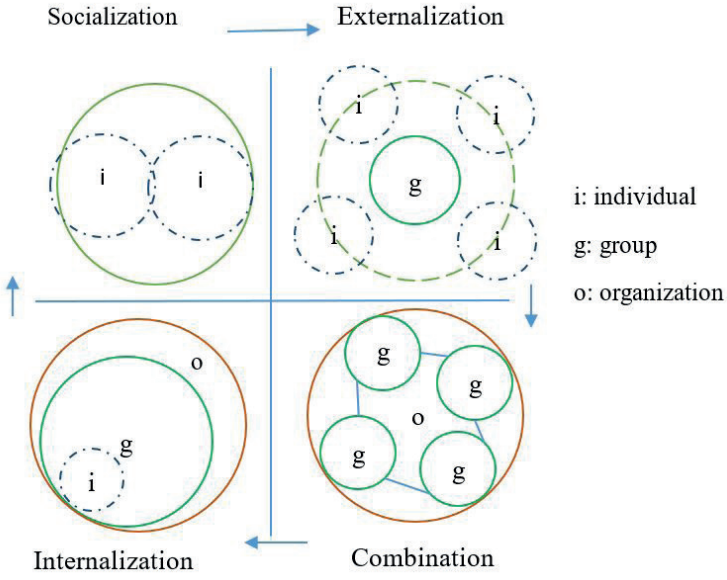


Figure 6: SECI (Nonaka, I., & Konno, N., 1998)

The steps of the SECI Model are Socialization, which means that the person with knowledge does activities or spends time with those who do not have information, Externalization which represents the creation of a report as a result of a meeting, Combination which represents the synthesis of coded information, and internalization which represents learning.

When the categories of knowledge, knowledge management processes and toolbox are examined, it can be said that the concept of knowledge management consists of a structure in which people, technology and processes are intertwined (Bhatt, 2000). Chatti et al. (2007) emphasized that Web 2.0 technologies are fully compatible in performing the sub-processes on the SECI model. In Table 4, examples of technologies that can be used in knowledge management sub-processes and SECI model steps are given.

Table 4. Knowledge Management Techniques, Tools and Technologies

Knowledge creation and codification phase	**Knowledge sharing and dissemination phase**	**Knowledge acquisition and application phase**
Content creation Authoring tools Templates Annotations Data mining Expertise profiling Blogs Mashups Content management Taxonomies Folksonomies Metadata tagging Classification Archiving Personal KM	Communication and collaboration technologies Telephone/Internet telephone/Fax Videoconferencing Chat rooms/instant messaging/iwitter E-mail/discussion forums/ wikis Groupware Workflow management Folksonomies Social networking Web 2.0/KM 2.0 Networking technologies Intranets Extranets Web servers, browsers Knowledge repository Portal	E-learning technologies CBT WBT EPSS Emerging technologies Folksonomies Metadata Artifi cial intelligence technologies Expert systems DSS Customization/personalization Push/pull technologies Recommender systems Visualization Knowledge maps Intelligent agents Automated taxonomy systems Text analysis — summarization

Reference: Dalkir (a.g.e.)

While technologies such as authoring tools or content management systems, blogs are used to reveal the private and/or tacit knowledge in minds in knowledge creation and coding sub-process, data mining technologies are used to produce knowledge from coded data and information. However, a technology can't be considered as belonging to a single subprocess. For example, the WordPress Content Management System is a knowledge creation and coding sub-process technology for the system administrator, and also it is a technology that represents the knowledge acquisition and learning sub-process for those who read the information shared through this system. A person, who has the knowledge, can share and deliver the text she/he has produced through the content management system to the people who do not have that knowledge, again through the same technology. As the knowledge management tools are examined in this context, we can see that there are no definite boundaries between the distinctions made on the basis of sub-processes.

1.4.3. Health Knowledge Management and Types of Health Knowledge

Health Knowledge Management, which emerged with the establishment of the knowledge economy (the economic era in which intellectual capital is the main source of wealth and power) (Sheffield, 2008), is a broad field that plays a role in the execution of processes related to finance, management, insurance companies and the state in the field of health, apart from

being concerned with how the information flowing from activities related to medical practice, medical education, medical research is perceived, processed and transmitted (Dwivedi et al., 2007).

Health Knowledge Management is recognized as a discipline in the world and universities train Health Knowledge Managers as a result of a four-year training program (Sasnett & Ross, 2007). In addition, American Health Information Management Association (AHIMA) and Canadian Health Information Management Association (CHIMA) organizations, which aim to organize trainings on health knowledge management, share health information among professionals, and establish standards, put forth their efforts for the development of this discipline.

Health knowledge management in health services, which includes patients, doctors, nurses, caregivers, hospital administrators, laboratories and many other stakeholders, can provide the necessary tools to create a health system that centers information. Health Knowledge Management involves the systematic creation, modeling, sharing, operation and transformation of health care information, where and when healthcare professionals (and even patients and individuals) need it to help them make high-quality and cost-effective patient care decisions (Abidi, 2007).

In general, three sources can be mentioned to reach health information. These can be classified as the information of those who assume the role of service delivery such as doctors, nurses, unit chiefs, that is, provider information, patient information including the description of the symptoms of the disease and the last one is organizational information which can be found in medical diagnosis systems, text-based materials or associations formed by other medical professionals with expertise (Chen, 2013). When these resources are evaluated within the framework of knowledge management, they can also be considered as explicit and implicit information. Provider information can be considered as implicit and proprietary information, and text-based materials included in corporate information can be considered as explicit information.

When we look at the practices of institutions in the production or service sector, it can be seen that the Knowledge Management discipline defines its functions in the focus of objectives that are suitable for their field of study. It may not be the right way to adopt a general definition, which includes other business field, for health institutions that aim to improve the health status of people and protect their well-being. For this reason, Abidi (ibid.) made an effort to determine the functions of health knowledge management specifically for health institutions and suggested the following list.

- To create a comprehensive, validated and accessible source of health knowledge.
- Capture, represent, model, organize and synthesize different types of health knowledge.
- Making available, sharing and disseminating information available to health care stakeholders.
- Decision support systems can be defined as systems that aim to functionalize and use clinical information flows and health care information to provide pragmatic patient care services at the point of care and need.

When each of these functions is examined one by one, it would not be wrong to think that they are listed by a perspective centered on information systems. Because the current era replaces paper-based systems with systems that use information and communication technologies, information systems play a complementary role rather than supportive.

1.4.4. Health Information Systems

Information systems are used to create, store, share and use/reuse information in the discipline of health information management, which provides methods for producing solutions to specific challenges such as system complexity, reduction of medical errors, significant increase in data in the field of medicine, and increased health care cost (El Morr & Subercaze, 2010). The discipline of "Biomedical Informatics" hosts applications including medicine, dentistry, nursing, pharmacy, medical imaging, veterinary and public health informatics (Hoyt & Bernstam, 2014) (Figure 7).

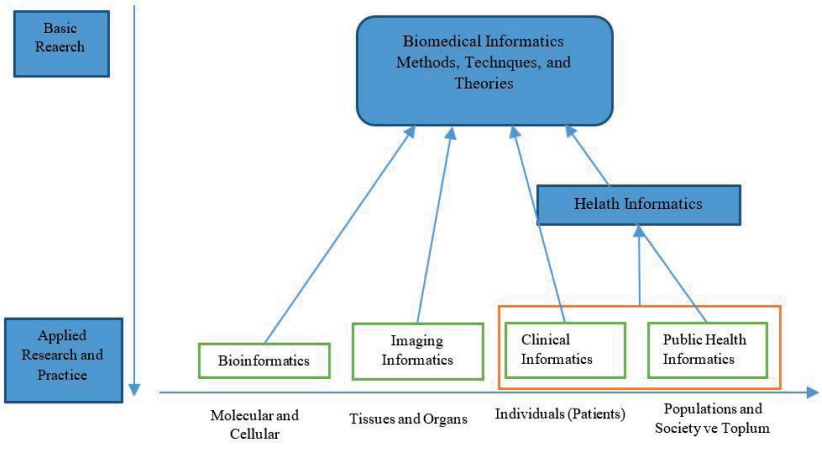


Figure 7: Biomedical Informatics (Hoyt & Bernstam, ibid.)

Biomedical informatics examines the theory and applications of information and communication systems at all levels, from the molecule to the population. Health information systems, on the other hand, provide the production of information that supports both administrative processes and health service delivery and is examined under the umbrella of Health Informatics (U.S. Congress, 1995).

Health information systems consist of technologies and procedures that integrate the collection, processing, reporting and use of data necessary to improve the effectiveness and efficiency of health care through better management at all levels of health care (Sauerborn & Lippeveld, 2000). Examples of the purposes of using information systems in health information management can be listed as below (Mahmood et al., 2012)

- To improve access to information and information at all levels (physicians, hospital administrators and staff, insurers, healthcare consumers, pharmacies and health insurance companies) to increase efficiency and reduce costs.
- To transform the various members of the healthcare industry (care recipients, service providers physicians, nurses, therapists, pharmacists, suppliers) into a knowledge network/community of practice.
- Enabling evidence-based decision-making to promote self-care and improve the quality of healthcare by providing easy access to relevant information.

Whilst a health information system is a system consisting of computer-based components used by healthcare professionals or patients to enter, store, process, communicate and present information about health or patients, its applications in hospitals are called Hospital Information System (Mehdipour & Zerehkafi, 2013). While health information systems cover all the steps and stakeholders of the health system, extending from the health center to the ministry of health, hospital information systems can be considered as an information management system used by institutions that are in contact with the patient.

Hospitals are complex systems that contain both patient and disease-specific units and units that are expected to perform management functions. Considering the elements of this structure, the modules of a hospital information system may consist of the following subsystems (Winter et al., 2011):

- Patient Management System,
- Medical Documentation System,

- Nursing Management and Documentation System,
- Outpatient Treatment System,
- Supplier or Physician Order Entry System,
- Patient Data Management System,
- Operations Management System,
- Radiology Information System,
- Picture Archiving and Communication System (PACS),
- Laboratory Information System,
- Enterprise Resource Planning System,
- Data Warehouse System,
- Document Archiving System,
- Pharmacy Information System
- Special components such as the Cardiovascular Information System or the Dialysis Information System, depending on the hospital's expertise

A health information system or hospital information system actually has two basic categories, administrative and clinical. Clinical information systems can also be called Electronic Health Records System (EHRS) if they are designed to collect all data related to patient care (Wager, ibid.). Data that are expected to contribute to the bigger picture, such as the formulation of public health policies, come from electronic health records (Figure 8).

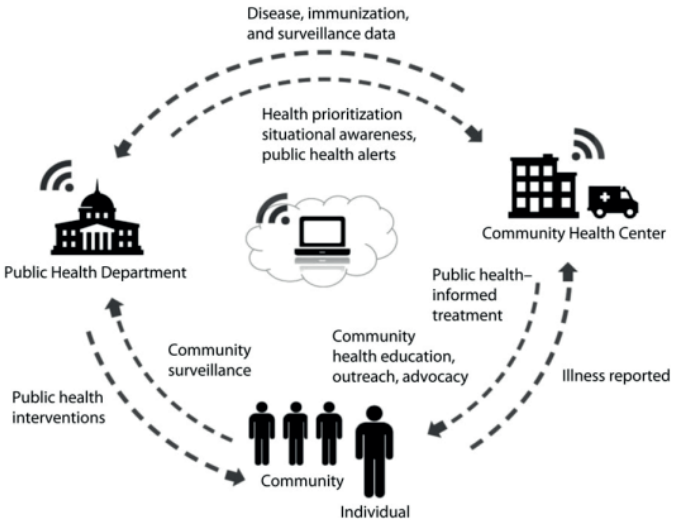


Figure 8: Exchange of Health Data (Calman vd., 2012)

Meanwhile EHRS records are used to create public health policies, public health units that use EHRS data as inputs provide data to a global organization such as the World Health Organization. Therefore, when it comes to health information systems, the exchange and sharing of data is as important as storing and processing the data.

1.5. The Role of Big Data and Information Systems in Health Information Management

Abidi, in his study published in 2001, stated that healthcare establishments are considered 'data rich' because they produce large amounts of data such as electronic health records, clinical trial data, hospital records, administrative reports, benchmarking findings, and so on. However, he found that 'information is insufficient' as health data rarely turns into a strategic decision support source. The evolving discipline of health information management can provide a theoretical foundation and practice for deciding what data is necessary for the organization to operate efficiently and effectively, how this data should be analyzed to provide the most useful information for organizational processes and decision making (Pauleen & Wang, 2017). Especially with the inclusion of big data technologies in the information management toolbox, semi-structured and unstructured health data is waiting to turn into a great treasure.

While information systems perform functions such as producing, sharing and recording information, they also benefit from big data technologies. Whilst health information management deals with the transformation of information into benefits, information systems provide the necessary infrastructure, including big data technologies.

Health centers often have a large amount of information available. In particular, the introduction of the hospital information system into clinical practice has led to the storage of a large number of data generated from daily activities and the reporting of employee experiences (Montani & Bellazzi, 2002). Meanwhile the hospital information system represents an implicit source of information, both administrators and policy makers seek ways to turn this implicit information source into benefit. For this reason, efforts are being made to produce information from large health data at an increasing rate in the world, and to turn this produced information into a product.

2. Conclusion

With the introduction of computer technology into the health sector in the 1960s, medical records evolved into the "Electronic Health Records System" (Jacques, 2010), whose history can be traced back to the papyri written in Ancient Egypt in 1820 BC (David, 2008) or the works of Hippocrates in 400 BC in Ancient Ionia, formed a basis not only for storage but also for analysis.

After a few decades, these electronic records have expanded and played a role in the birth of a concept called big data. Developing information technologies, growing and complex health data and their management problems have paved the way for the existence of new disciplines such as Health Information Management and Biomedical Informatics. According to needs, these branches of science have focused on methods and techniques such as Cloud Computing, Virtualization, Database Technologies, Artificial Intelligence, Statistics, Optimization, Simulation and Big Data in order to capture, organize, store, analyze, share health data. In addition, the "Data Science" discipline, which has focused on all data-related technologies and methods, has also started to rise.

We can benefit more from the products of concepts such as Health 4.0, Big Data, Internet of Everything, thanks to the managers who prepare the health policies and the people who have technical knowledge in the provision of health services such as physicians, nurses, biologists, chemists, geneticists, also the professionals who can understand and analyze the problems of the service recipients such as patients and their relatives and respond to these problems by using information technologies. These products can be used to combat chronic diseases that affect the quality of life, epidemics that shake the world both economically and psychologically, or to maintain a healthy state.

References / Kaynakça

Abidi, S. S. R. (2001). Knowledge management in healthcare: towards 'knowledge-driven'decision-support services. International journal of medical informatics, 63(1-2), 5-18.

Abidi, S. S. R. (2007, July). Healthcare knowledge management: The art of the possible. In AIME Workshop on Knowledge Management for Health Care Procedures (pp. 1-20). Springer, Berlin, Heidelberg.Ackoff, R. L. (1989). From data to wisdom. Journal of applied systems analysis, 16(1), 3-9.

Ackoff, R. L. (1989). From data to wisdom. Journal of applied systems analysis, 16(1), 3-9.

Agrahari, A., & Rao, D. (2017). A review paper on Big Data: technologies, tools and trends. Int Res J Eng Technol, 4(10), 10.

Akay, E. Ç. (2018). Ekonometride Yeni Bir Ufuk: Büyük Veri ve Makine Öğrenmesi. Sosyal Bilimler Araştırma Dergisi, 7(2), 41-53.

Antalya: 2. E- Sağlık Kongresi

Arora, S., & Agarwal, M. (2018). Empowerment through big data: issues & challenges. Int J Sci Res Comput Sci Eng Inf Technol, 3, 1-9.

Atalay, M., & Çelik, E. (2017). Büyük Veri Analizinde Yapay Zekâ Ve Makine Öğrenmesi Uygulamalari-Artificial Intelligence and Machine Learning Applications in Big Data Analysis. Mehmet Akif Ersoy Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 9(22), 155-172.

Bahga, A., & Madisetti, V. K. (2013). A cloud-based approach for interoperable electronic health records (EHRs). *IEEE Journal of Biomedical and Health Informatics*, 17(5), 894-906.

Bahga, A., & Madisetti, V. K. (2019). Big Data Science & Analytics: A Hands-On Approach. ISBN: 978-1-949978-00-1

Baker, M. (2012). Building better biobanks. Nature, 486(7401), 141-146.

Baskarada, S., & Koronios, A. (2013). Data, information, knowledge, wisdom (DIKW): a semiotic theoretical and empirical exploration of the hierarchy and its quality dimension. *Australasian Journal of Information Systems*, 18(1).

Bellinger, G., Castro, D.,&Mills, A. (2004). Data, information, knowledge, and wisdom. https://homepages.dcc.ufmg.br/~amendes/SistemasInformacaoTP/TextosBasicos/Data-Information-Knowledge.pdf Access: February, 2020

Berman, J. J. (2013). *Principles of big data : preparing, sharing, and analyzing complex information*. ABD: Elsevier

Bhatt, D. (2000). EFQM excellence model and knowledge management implications. Published by EFQM Organization, 8.

Bibri, S. E. (2018). *Smart Sustainable Cities of the Future: The Untapped Potential of Big Data Analytics and Context-Aware Computing for Advancing Sustainability*. Switzerland: Springer

Calman, N., Hauser, D., Lurio, J., Wu, W. Y., & Pichardo, M. (2012). Strengthening public health and primary care collaboration through electronic health records. American journal of public health, 102(11), e13-e18.

Catalyst, N. E. J. M. (2018). Healthcare big data and the promise of value-based care. NEJM Catalyst, 4(1). [https://catalyst.nejm.org/doi/full/10.1056/CAT.18.0290] Access: May, 2020

Chatti, M. A., Klamma, R., Jarke, M., & Naeve, A. (2007, July). The Web 2.0 driven SECI model based learning process. In Seventh IEEE International Conference on Advanced Learning Technologies (ICALT 2007) (pp. 780-782). IEEE.

Chen, E. T. (2013). An observation of healthcare knowledge management. Communications of the IIMA, 13(3), 7.

Chen, M. (2014). NDNC-BAN: supporting rich media healthcare services via named data networking in cloud-assisted wireless body area networks. Information Sciences, 284, 142-156.

Chitra, M. K., & MCA, M. (2018). Hurdles of Big Data in Business Application. International Conference on Data Analytics & Visualization Edıtors Of Specıal Issue Journal, 8.

Cox, M., & Ellsworth, D. (1997a). Application-controlled demand paging for out-of-core visualization. In Proceedings. Visualization'97 (Cat. No. 97CB36155) (pp. 235-244). IEEE.

Cox, M., & Ellsworth, D. (1997b). Managing big data for scientific visualization. In ACM Siggraph 97, pp. 21-38.

Dalkir, K. (2011). Knowledge Management in Theory and Practice. 2. Baskı. ABD: The MIT Press

David, R. (2008). The art of healing in ancient Egypt: a scientific reappraisal. The Lancet, 372(9652), 1802-1803.

Demchenko, Y., De Laat, C., & Membrey, P. (2014, May). Defining architecture components of the Big Data Ecosystem. In 2014 International Conference on Collaboration Technologies and Systems (CTS) (pp. 104-112). IEEE.

Demchenko, Y., Ngo, C., & Membrey, P. (2013). Architecture framework and components for the big data ecosystem. Journal of System and Network Engineering, 4(7), 1-31.

Domo. Data Never Sleeps Infographics. [https://www.domo.com/learn/data-never-sleeps-7] Access: February, 2020

Duda, O. M., Kunanets, N. E., Matsiuk, O. V., Pasichnyk, V. V., & Rzheuskyi, A. V. (2018). Fog computing and Big data in projects of class smart city. ECONTECHMOD: An International Quarterly Journal on Economics of Technology and Modelling Processes, 7.

Dwivedi, A. N., Bali, R. K., & Naguib, R. N. (2007). Building new healthcare management paradigms: A case for healthcare knowledge management. In Healthcare Knowledge Management (pp. 3-10). Springer, New York, NY

eHealth. The health data ecosystem and big data [Internet]. Geneva: World Health Organization; 2016. [http://www.who.int/ehealth/resources/ecosystem/en/] Access: May, 2020

El Morr, C., & Subercaze, J. (2010). Knowledge management in healthcare. In Handbook of research on developments in e-health and telemedicine: Technological and social perspectives (pp. 490-510). IGI Global

Elhoseny, M., Abdelaziz, A., Salama, A. S., Riad, A. M., Muhammad, K., & Sangaiah, A. K. (2018). A hybrid model of internet of things and cloud computing to manage big data in health services applications. Future generation computer systems, 86, 1383-1394.

Ernst & Young (1999) http: //www.ey.com/consulting/kbb/k2 work.asp

Estrela, V. V., Monteiro, A. C. B., França, R. P., Iano, Y., Khelassi, A., & Razmjooy, N. (2018). Health 4.0: applications, management, technologies and review. Medical Technologies Journal, 2(4), 262-27.

Fernandez, I. B. & Sabherwal, R. (2010) Knowledge Management Systems And Processes. İngiltere: M.E. Sharpe, Inc.

Gartner Glossary. [https://www.gartner.com/en/information-technology/glossary/big-data] Access: February, 2020

Ghuman, K. & Aswathappa, K. (2010). *Management: Concepts, Practice & Cases*. Hindistan: Tata McGraw Hill

Gökçen, H. (2011) .*Yönetim/Bilgi Bilişim Sistemleri: Analiz veTasarım*. 2.Edition. Ankara: Afşar Matbaacılık

Gu, J., & Zhang, L. (2014). Some comments on big data and data science. *Annals of data science*, 1(3-4), 283-291.

Gunnar, A. (2007). *Healthcare Politics, Policy and Services: A Social Justice Analysis*. Amerika: Springer Publishing Company

Güvercin, A., Mil, H. İ., & Tarım, B. (2016). Sağlık hizmetlerinin finansmanı ve sosyal güvenlik kurumu (SGK). Bartın Üniversitesi İİ BF Dergisi, 7(13), 80-94.

Hajir, J., Obeidat, B. Y., Al-dalahmeh, M. A., & Masa'deh, R. (2015). The role of knowledge management infrastructure in enhancing innovation at mobile telecommunication companies in Jordan. European Journal of Social Sciences, 50(3), 313-330

Han, J., Haihong, E., Le, G., & Du, J. (2011, October). Survey on NoSQL database. In 2011 6th international conference on pervasive computing and applications (pp. 363-366). IEEE.

Hoyt, E. R. Bernstam, E. V. (2014). Overview of Health Informatics. In: Health Informatics: Practical Guide for Healthcar and Information Technology Professionals. Ed: Hoyt, E. R. USA: Informatics Education

Hu, H., Wen, Y., Chua, T. S., & Li, X. (2014). Toward scalable systems for big data analytics: A technology tutorial. IEEE access, 2, 652-687.

Jacques, L. B. (2010). Electronic health records and respect for patient privacy: a prescription for compatibility. Vand. J. Ent. & Tech. L., 13, 441.

Jifa, G., & Lingling, Z. (2014). Data, DIKW, Big data and Data science. *Procedia Computer Science*, 31, 814-821.

Kaisler, S., Armour, F., Espinosa, J. A., & Money, W. (2013, January). Big data: Issues and challenges moving forward. In 2013 46th Hawaii International Conference on System Sciences (pp. 995-1004). IEEE.

Kalpič, B., & Bernus, P. (2006). Business process modeling through the knowledge management perspective. Journal of knowledge management.

Kandaloosi, A. S., Lhazaei, K., & Khanjani, T. (2014). Examining infrastructural obstacles against knowledge management in high education centers in free west zone of Mazandarn Province. European Online Journal of Natural and Social Sciences: Proceedings, 2(3 (s)), pp-3052.

Kayaaltı Ö, Kara S, (2007). Erciyes Üniversitesi Hastaneleri Radyoloji Servisi PACS Sisteminin İncelenmesi.

Köse, İ. (2008). Sağlık bilişimi ile SGK sağlıkta tek aktör olmaya doğru ilerliyor. Sağlık Düşüncesi ve Tıp Kültürü Platformu. [http://www.sdplatform.com/Dergi/138/Saglik-bilisimi-ile-SGK-saglikta-tek-aktor-olmaya-dogru-ilerliyor.aspx] Access: May, 2020

Landset, S., Khoshgoftaar, T. M., Richter, A. N., & Hasanin, T. (2015). A survey of open source tools for machine learning with big data in the Hadoop ecosystem. Journal of Big Data, 2(1), 24.

Laney, D. (2001). 3D data management: Controlling data volume, velocity and variety. META group research note, 6(70), 1.[https://blogs.gartner.com/doug-laney/files/2012/01/ad949-3D-Data-Management-Controlling-Data-Volume-Velocity-and-Variety.pdf] Access: February, 2020

Liebowitz, J. (2000) Building Organizational Intelligence: A Knowledge Management Primer, CRC Press, Boca Raton

Liu, Y., Zhang, D., Lu, G., & Ma, W.Y. (2007). A survey of content-based image retrieval with high-level semantics. Pattern recognition, 40(1), 262-280.

Mahmood, N., Burney, A., Abbas, Z., & Rizwan, K. (2012). Data and knowledge management in designing healthcare information systems. International Journal of Computer Applications, 50(2), 34-39.

Manikandan, G., & Abirami, S. (2017). Big Data Layers and Analytics: A Survey. In Computer Communication, Networking and Internet Security (pp. 383-393). Springer, Singapore.

Manogaran, G., Thota, C., Lopez, D., Vijayakumar, V., Abbas, K. M., & Sundarsekar, R. (2017). Big data knowledge system in healthcare. In Internet of things and big data technologies for next generation healthcare (pp. 133-157). Springer, Cham.

Marquardt, M. (1996) Building the Learning Organization: A Systems Approach to Quantum Improvement and Global Success, McGraw-Hill, New York.

Mehdipour, Y., & Zerehkafi, H. (2013). Hospital Information System (HIS): At a Glance. Asian Journal of Computer and Information Systems (ISSN: 2321–5658), 1(02).

Miloslavskaya, N., & Tolstoy, A. (2016). Big data, fast data and data lake concepts. Procedia Computer Science, 88(300-305), 63.

Ming, H., Chang, C. K., & Yang, J. (2015, July). Dimensional situation analytics: from data to wisdom. *In 2015 IEEE 39th Annual Computer Software and Applications Conference* (Vol. 1, pp. 50-59). IEEE.

Mitchell, R., & Waldby, C. (2010). National biobanks: clinical labor, risk production, and the creation of biovalue. Science, Technology, & Human Values, 35(3), 33.

Mondal, K. (2016). Application design and analysis of different hybrid intelligent techniques. *International Journal of Hybrid Intelligent Systems*, 13(3-4), 173-181.

Montani, S., & Bellazzi, R. (2002). Supporting decisions in medical applications: the knowledge management perspective. International journal of medical informatics, 68(1-3), 79-90

NIST (2015) Big Data Interoperability Framework: Volume 6, Reference Architecture. https://bigdatawg.nist.gov/_uploadfiles/NIST.SP.1500-6.pdf Access: February, 2020.

Nonaka, I., & Konno, N. (1998). The concept of "Ba": Building a foundation for knowledge creation. California management review, 40(3), 40-54.

North, K. & Kumta, G. (2018). Knowledge Management: Value Creation Through Organizational Learning. 2. Edition. Switzerland: Springer.

Pauleen, D. J., & Wang, W. Y. (2017). Does big data mean big knowledge? KM perspectives on big data and analytics. *Journal of Knowledge Management*.

Rowley, J. (2007). The wisdom hierarchy: representations of the DIKW hierarchy. *Journal of information science*, 33(2), 163-180.

Rubenstein-Montano, B., Liebowitz, J., Buchwalter, J., McCaw, D., Newman, B., Rebeck, K., & Team, T. K. M. M. (2001). A systems thinking framework for knowledge management. Decision support systems, 31(1), 5-16.

Ruggles, R. (1997) Tools for Knowledge Management: An Introduction Knowledge Management Tools, Butterworth-Heinemann, Boston.

Saadatdoost, R. Sim, A. T. H. Jafakarimi, H. Hee, J. M. (2018) Knowledge Discovery for Large Databases in Education Institutes, In: *Information Retrival and Management: Concepts, Methodologies, Tools and Applications* Editör: Management Association, Information Resources USA: IGI Global.

Samsudin, A. Big data: Related technologies, security challenges, and research opportunities. 2017-6-22]. http://repository. nauss. edu. sa/bitstream/handle/123456789/64343/002.pdf Access: February, 2020

Sasnett, B., & Ross, T. (2007). Leadership frames and perceptions of effectiveness among health information management program directors. Perspectives in health information management/AHIMA, American Health Information Management Association, 4.

Sauerborn, R. & Lippeveld, T. (2000) Introduction In: Design and implementation of health information systems. Ed: Sauerborn, R. Lippeveld, T.& Bodart, C. World Health Organization.

Shafer, T. (2017). The 42 V's of Big Data and Data Science. [https://www.kdnuggets.com/2017/04/42-vs-bigdata-data-science.html] Access: February, 2020

Sharma, S. (2016). Expanded cloud plumes hiding Big Data ecosystem. Future Generation Computer Systems, 59, 63-92

Sheffield, J. (2008). Inquiry in health knowledge management. Journal of Knowledge Management. Vol. 12 No. 4 2008, Pp. 160-172.

Shelly, G. B. & Rosenblatt, H. J. (2009). *Systems Analysis and Design.* 8. Baskı Kanada: Course Technology, Cengage Learning

Shen, Y., Li, Y., Wu, L., Liu, S., & Wen, Q. (2014). Big data overview. In Enabling the new era of cloud computing: Data security, transfer, and management (pp. 156-184). IGI Global.

Sofroniou, A. (2012). Computing, A Précis On Systems, Software And Hardware. [https://books.google.com.tr/books?id=I5boAwAAQBAJ&pg=PA39&dq=%27information+system%27+software+hardware+database&hl=tr&sa=X&ved=0ahUKEwiOzpP6ournAhVfRhUIHby4A90Q6AEIVTAE#v=onepage&q='information%20system'%20software%20hardware%20database&f=false] Access: February, 2020

Sultana, A. (2018). Unraveling the Data Structures of Big Data, the HDFS Architecture and Importance of Data Replication in HDFS. International Research Journal of Engineering and Technology (IRJET), 5(01).

Thuemmler, C., & Bai, C. (2017). Health 4.0: Application of industry 4.0 design principles in future asthma management. In Health 4.0: How virtualization and big data are revolutionizing healthcare (pp. 23-37). Springer, Cham.

Tyagi, V. (2017). Content-Based Image Retrieval: Ideas, Influences, and Current Trends. Singapore: Springer Nature.

U.S. Congress, Office of Technology Assessment (1995). Bringing Health Care Online: The Role of Information Technologies. OTA-ITC-624. Washington, DC: U.S. Government Printing Office URL: https://ota.fas.org/reports/9507.pdf Access: May, 2020

Van der Spek, R. & de Hoog, R. (1998) Knowledge Management Network, U. of Amsterdam, The Netherlands (working paper) Boston.

Vayena E, Dzenowagis J, Brownstein JS, Sheikh A. (2018). Policy implications of big data in the health sector. *Bulletin of the World Health Organization* 96(1), 66–68. DOI: 10.2471/BLT.17.197426

Wager, K. A. Lee, F. W. & Glaser, J. P. (2005). Managing Health Care Information Systems: A Practical Approach for Health Care Executives. 4. Edition. US: John Wiley & Sons, Inc.

Wang, Y., Kung, L., & Byrd, T. A. (2018). Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. Technological Forecasting and Social Change, 126, 3-13.

Washington Office of Technology Assessment (1979). Selected Topics in Federal Health Statistics. US: Congress, Office of Technology Assessment.

Winter, A. Haux, R. Ammenwerth, E. Brigl, B. Hellrung, N. & Jahn, F. (2011) Health Information Systems: Architectures and Strategies. England, Springer.

Yang, M. (2016, July). Research Progress on Data Analysis in Big Data Technology. In 2nd International Conference on Computer Engineering, Information Science & Application Technology (ICCIA 2017). Atlantis Press.

Zillner, S., & Neururer, S. (2016). Big data in the health sector. In New Horizons for a Data-Driven Economy (pp. 179-194). Springer, Cham.

Zillner, S., Oberkampf, H., Bretschneider, C., Zaveri, A., Faix, W., & Neururer, S. (2014, August). Towards a technology roadmap for big data applications in the healthcare domain. In Proceedings of the 2014 IEEE 15th International Conference on Information Reuse and Integration (IEEE IRI 2014) (pp. 291-296). IEEE.