STUDIES IN HEALTH TECHNOLOGY AND INFORMATICS 274

Health Information Management: Empowering Public Health

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HEALTH INFORMATION MANAGEMENT: EMPOWERING PUBLIC HEALTH

Studies in Health Technology and Informatics

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Preface

Effective and efficient management of health institutions is a key prerequisite to enabling the dynamic and sustainable development of national health systems. In an increasingly digital society, the human capacity for knowledge and skills in health information management becomes the primary factor in ensuring the sustainable development of healthcare institutions. Therefore, health institutions are showing great interest in hiring experts in the field of health information management. According to a prediction by the U.S. Bureau of Labor Statistics "*students with a master's degree in health information management, will have good perspective with 18% growing employment* between 2018 and 2028*"*. Employment in European healthcare systems is projected to grow in all healthcare occupations, but especially in those related to information management such as applied informatics professional, public health informatics professional, and chief medical information officer.

The main goal of the *Health Information Management: Empowering Public Health* is to provide a comprehensive introduction to the study and development of health information management in a clear and understandable manner. The textbook is designed to be used by university and vocational school programs to train allied health professionals. Furthermore, it can be used as an in-service training tool for new healthcare-facility personnel, government healthcare institutions, independent billing and health assurance services, or individually by health information specialists. Students and professionals can learn more about what health information management is and how it merges the fields of healthcare and information technology before pursuing a degree in the field. Readers will learn how to organize and analyze healthcare data; accurately record, store and assess health data; use an electronic patient record system; provide statistical analysis and interpret the results; as well as logical thinking, communications, and organizational processes in healthcare institutions.

This textbook has been produced within the Erasmus+ project "Enhancement of study programs in Public Health Law, Health Management, Health Economics and Health Informatics in Montenegro (PH-ELIM)", Ref.No: 573997-EPP-1-2016-1-ME-EPPKA2-CBHE-JP, funded with support from the European Commission. This publication reflects the views of the authors only, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

The Editors would like thank the authors and co-authors for their efforts in providing their chapter contributions in their fields of expertise in a didactic and pedagogical manner, with exercises and problems fostering and challenging the knowledge and skills of the readers to pursue further and fathom the field of Health Information Management.

Finally, we would like to thank both Arie Hasman and John Mantas for their diligent reviewing of the entire book and for providing advice to the authors. We are also thankful to Dr. Emmanouil Zoulias and Ms. Marianna Isaakidou, colleagues at the Health Informatics Laboratory of the National and Kapodistrian University of Athens, for their additional editing in refining each chapter according to the template.

The Editors
August 2020

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Prologue

Health Information Management, the topic of this textbook, is very much connected with Health Informatics. On the one hand, Health Informatics is the discipline that studies the informational and computational pre-requisites for an optimal information provision in healthcare, and on the other hand, it is the discipline that develops methods, techniques and systems on the basis of these discovered informational and computational requirements with which an optimal information provision can be established.

The information with regard to what actions have been performed by physicians, nurses, and administrators; the outcomes of investigations; and what decisions have been made based on what information is recorded. For the physician and nurse, the record functions as an aide-memoire, and other physicians and nurses involved in the diagnosis or treatment of a patient are informed by the record about the state of the patient.

The recording of patient data is supported by information systems like EPR (electronic patient record) systems. Since information about the same patient can be stored in different systems, the exchange of patient information between these systems is also important. Decision support systems (DSSs) contain formalized knowledge about a given subject, and when offered patient data can, for example, deduce the diagnosis. In certain cases, DSSs can obtain the necessary patient data by downloading them from relevant EPR systems. Interoperability between EPR systems or between EPR systems and DSSs is therefore necessary, but only possible if the terminology used in these systems is standardized, the data values in the systems are stored with the same format, and the same protocols are used for the technical exchange of the data. Also, the messages that are exchanged should have a standardized content. Only in this way can the receiving system correctly interpret the message it receives, store the data correctly, and use them in the right way. All these aspects have to be considered, and are among the topics dealt with by information management. The handling of data and information is as important as the capability to build good information systems, a terrain usually covered by health informaticians.

In addition to the earlier mentioned health informatics professionals, there are health information management professionals who focus on all aspects of information management. Health information management (HIM) is the part of health informatics that primarily focuses on the process of managing health data. HIM is concerned with the creation of health records and on standardized classifications and communication standards that allow uniform data storage and data exchange so that data can easily be used for further analysis and research.

The *Health Information Management: Empowering Public Health* covers the above-mentioned issues. But health information managers also need to have knowledge of related subjects, for example, Public Health and healthcare organizations, privacy issues, law, economics, etc. The textbook therefore consists of several blocks of chapters, each of which deals with a specific theme.

The first chapters introduce the reader to the basic aspects of Public Health. These are chapters on health and health determinants (including concepts from

epidemiology), health law, and the mission and structure of health services (including organizational ethics and ethical leadership). The COVID-19 pandemic has shown that conflicts may occur between public health and civil liberties/individual rights. How should governments deal with these conflicts? This question is among others treated in the chapter on health law.

A second block of chapters focuses on healthcare organizations. The structure of healthcare organizations and the planning and development of health services are also discussed. In addition, the way in which organizations should communicate with internal and external stakeholders (via advertising and PR activities) is explained. The characteristics of the healthcare systems of a number of countries are also compared.

Radical changes have occurred in the healthcare market in recent decades: increasing numbers of sick people, double-digit inflation, economic stagnation, and more competition. How can a healthcare organization survive and compete with other health institutions? The third block therefore contains chapters on Health Economics, financial management, management accounting and management and marketing in health institutions. HIM professionals should have some insight into all these subjects.

When these more general subjects (for HIM professionals) have been dealt with, the emphasis in the fourth block is on an important aspect of information management. What knowledge do HIM professionals need to be able to analyze patient data? The disciplines of biomedical statistics and healthcare data analytics are introduced. Healthcare data analytics is a relatively new discipline by means of which knowledge can be discovered from Big data repositories.

Finally, the fifth block introduces the information systems that either store or produce information. To that end, a chapter is first presented about information technology and information management in healthcare: the bread and butter of HIM professionals. In recent years, health information has become a core asset for effectively managing healthcare organizations, resulting in improved quality of care. A second chapter introduces hospital information systems as socio-technical systems: both technical components and humans play an important role in the acceptance and use of these systems. This chapter is followed by a chapter on e-health and clinical documentation. In this chapter the three levels of interoperability (technical, semantic and process interoperability) for exchanging data between systems are also discussed. A third chapter discusses the increased role of artificial intelligence in healthcare, with the presentation of a few application areas. The last chapter covers IT-assisted process management in healthcare. It is argued that the relevant clinical processes need to be well understood before a new health IT tool for supporting these processes can be developed. This chapter discusses methods for analyzing and modeling clinical processes.

The textbook pays attention to all the topics of importance for HIM professionals. It does so by focusing on five areas: public health, healthcare organizations, the healthcare market, data analysis, and information systems in healthcare. The book is of interest for all who want to get a better insight into what health information management is all about and for those beginning a study of health information management. I read the textbook with pleasure and I am sure that the readers will agree.

Arie Hasman
July 2020

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SECTION 1

Public Health

Preamble

These are chapters on health and health determinants (including concepts from epidemiology), health law and the mission and structure of health services (including organizational ethics and ethical leadership). The COVID-19 pandemic has shown that conflicts between public health and civil liberties/individual rights can occur. How should governments deal with this conflict? This question is among others treated in the chapter on health law.

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Health and Health Determinants

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Abstract. This chapter aims at providing the student with a general overview of the Health and Health Determinants basic concepts. More precisely, this chapter provides a definition and explanation of health and health determinants and presents an overview of measures in epidemiology.

Keywords. Health, health determinants, disease burden, Epidemiology

1. Introduction

Public health, in general, is referring to all the collective attempts for ameliorating populations' health and the wellness of their communities [1]. Efforts targeted to improving people's wellbeing include the promotion of healthy lifestyles, detection, prevention and monitoring of infectious diseases [2]. "The study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the control of health problems" is defined as Epidemiology [3]. It implements a set of measures and can be used as a tool for improving public health. This chapter aims at providing the student with a definition of Health and Health Determinants and an overview of measures in epidemiology.

2. Learning Objectives

The students will be able to:

- Demonstrate knowledge about health and health determinants.
- Understand measures that describe the occurrence of the illness.
- Express the relevant mathematical formulas.

3. Health Definition

Health is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [1] according to World Health Organization (WHO) in 1948. However, it is generally believed that perfect well-being for everyone at all times is not likely to exist [4] Epidemiologists tend to use simplified definitions such as "absence of disease" [1].

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4. Health Determinants

A number of different factors and their relations play a crucial part in people's wellbeing. Staying healthy or not depends on various factors such as inherent characteristics like genetics and the environment which is framed by the settings, healthcare facilities and accessibility to them, climate and all types of relationships and interactions with others [6]. The factors that act as health determinants are presented below.

- The socioeconomic and political conditions [6] are for example: how and where people are born, grow, live, work, what is their financial status and which are the resources that affect their decisions or are responsible for any inequalities in health [9]. Accessibility and availability of health services are crucial determinants that may affect health [6]. High salary and good social status are linked with improved health [6]. According to the WHO the socioeconomic environment can merely define the risk of illness. More precisely, employment, income, stress, social exclusion/inclusion, working conditions, and social support are examples of the social health determinants whilst laws and legislation form the political factors that influence health [9].
- The physical environment [6]. Access to clean water and clear air, safe workplaces, houses and public infrastructure are linked with better health [6]. Other important factors are the fertile soil for crops to grow and materials to construct shelter.
- The individual characteristics and attitudes [6]. For example, genetics and gender can also contribute to the expression of an illness. As long as attitude is concerned, diet, exercise, smoking habits can all have an impact on health [6].
- Cultural Determinants of Health include customs, traditions, and beliefs. These factors can affect health by influencing self-determination, defining discriminating behaviours, providing protection from removal/relocation or not and supporting and cultivating the respect for human rights [7].
- Commercial Determinants of Health are about companies' strategies used to promote products that can affect health. Strategies include promotion and accessibility of unhealthy products and commodities and the legal ages for consumption (e.g. legal alcohol drinking age). Finally, extensive supply chains can boost the company's influence worldwide and promote further the products [9].

These determinants include not only the factors mentioned above but also many others such as:

- Education – It is believed that people who drop out of school have a worse physical and psychological health [6].
- Relationships – interaction with others is linked to better health [6].

5. Epidemiology

Epidemiologists study the health determinants and the distribution of diseases by applying certain methods, measures and models [3]. Epidemiology as a scientific field records and monitors the rate of ill people in a specific place and time, determine the risk factors for the disease and deploy appropriate methods for preventing the disease [5].

Epidemiology clusters individuals in specific groups to facilitate the study of disease in specific populations. Thus, epidemiology studies and measures the existence of an illness occurring in groups as well as the disease outcomes in relation to a population at risk by counting the cases that are healthy or sick and healthy cases can be redefined as sick cases if they develop an illness. For epidemiologists, a target population is important to be defined as the conclusions to be drawn will represent this group. Usually, the members of the study population share common attributes such as place of living, occupation, diagnosis etc. [1]. Epidemiologists consider a few issues when investigating a disease appearing into a population. Firstly, it is important to record how many people have contracted the illness out of the population from which the cases were derived. Finally, the time period should be also taken into account. All the issues mentioned above can give an insight regarding the impact on the population. In epidemiology, mathematical formulas are used to measure disease frequency, association and potential impact. Commonly, three types of calculations are used to express disease occurrence: ratio, proportion, and rate which is a type of ratio.

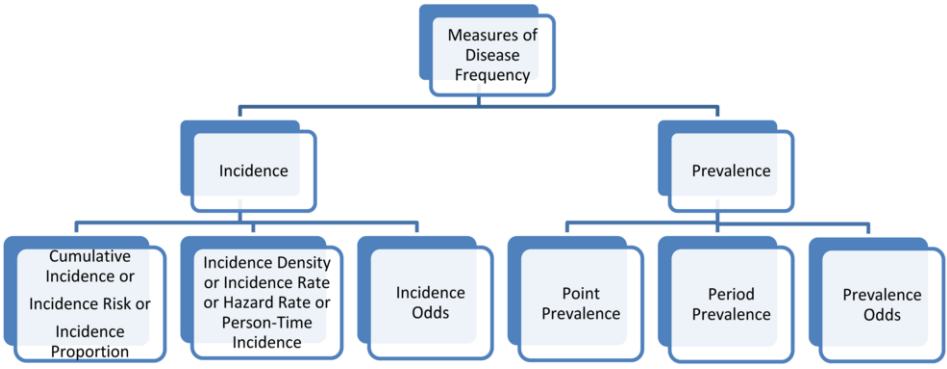

Figure 1. Measures of Disease Frequency [11]

6. Measures of disease frequency and disease burden

Incidence and prevalence are measuring disease frequency. The prevalence measure shows the people having an illness and incidence indicates the new cases with this illness [8]. In the mathematical representation of every measure of disease frequency it is important to precisely define the denominator in order to achieve accuracy [1]. The candidate population is comprised of all the people being at risk of getting a certain disease and people who already have the disease or who are immune should be excluded [1]. In the other case, when people not at risk are included in the risk population then the result will be an underestimation of the reality [9].

6.1. Prevalence

The prevalence is the proportion of all people of a population that have an illness and thus measures the existing cases of an illness [8]. The following equation represents the prevalence.

$$Prevalence = \frac{Number\ of\ subjects\ having\ the\ disease\ at\ a\ time\ point}{Total\ number\ of\ subjects\ in\ the\ population} \quad (1)$$

6.1.1. Point Prevalence

The point prevalence can be represented as a fraction with the nominator describing how many (both new and preexisting) current cases there are at a point in time, and the denominator the whole population at that time [10].

6.1.2. Period prevalence

The period prevalence can be expressed as a fraction with the nominator how many both new and preexisting cases exist during a specified time period. The average interval population is used as a denominator [10].

6.2. Incidence

A risk or incidence rate expresses the incidence. Incidence measures new cases of an illness happening in a given period of time and indicates new disease events. (Table 1). For illnesses that can appear many times, the first occurrence of the illness is estimated. New cases are estimated in a group at risk of catching a disease. It is important to highlight that incidence takes into consideration the duration in which *a group of* people is observed until they express the illness [8].

Table 1: Incidence types and characteristics

Measure	Type	Uses
Cumulative	Proportion	Research, Prevention, Treatment, Policy
Incidence rate	Rate	Research on causes, Prevention, Treatment

6.2.1. Cumulative Incidence

Cumulative incidence concerns a candidate population that develops an illness during a given period of time, expressed in the formula below. Cumulative incidence is the average risk of developing an illness during a specified timeframe and can be used in a population with minor follow-up losses [8].

$$Risk = \frac{Number\ of\ subjects\ developing\ the\ disease\ over\ a\ time\ period}{Total\ number\ of\ subjects\ followed\ over\ that\ time\ period} \quad (2)$$

6.2.2. Incidence Rate

To calculate incidence rate, the number of people getting an illness is divided by the total time all subjects were at risk of getting an illness. Thus, the incidence rate can give an instant overview of how many people get and express an illness. [8].

$$Incidence\ rate = \frac{Number\ of\ subjects\ developing\ the\ disease}{Total\ time\ at\ risk\ for\ the\ disease\ for\ all\ subjects\ followed} \quad (3)$$

6.3. Other commonly used measures in epidemiology

Years of potential life lost: It estimates how many years a subject could have lived if she/he had not passed away due to an illness. For example, if teenagers suffer from a disease which ends up in death then teenagers will have more life lost (in years) than the elderly.

Livebirth rate is the total number of pregnancies that results in a living child per 1000 population per year.

Infant mortality rate can be described as how many less-than-one-year old infants die (often divided in neonatal and post neonatal) during a year out of 1000 pregnancies that results in a living child in that same year.

Crude mortality (or death) rate is calculated as the total number of deaths from all causes per 100,000 population per year.

Cause-specific mortality rate expresses the number of deaths from a specific reason per 100,000 population per year.

Age-specific mortality rate can be applied to individuals of a common age category and expresses the total number of deaths from all causes among that group per 100,000 population per year.

Morbidity is the number of current or new cases of a specific illness per 100 population.

Case fatality rate represents the number of deaths among disease cases and it is important to take into consideration and state the specific duration of the observation. Survival rate describes how many people out of the total number of cases having a disease remain alive [9].

7. Conclusions

In epidemiology, the overall health of a population and the risk of contracting a disease are defined by applying certain methods and measures. However, it is observed that a population's health cannot be always monitored [12]–[14], thus inadequate and incomplete information remains a challenge for epidemiologists. Epidemiological monitoring of the diseases has prevented outbreaks to occur or has mitigated the effect of contagious diseases and has promoted people's wellbeing. Epidemiologic findings can be key drivers in implementing or changing policies that may affect public health.

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Further Reading

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Exercises

1. Which are the measures of disease frequency in epidemiology? Explain why such measures are important.

2. Which are the determinants of health?

3. Which is the relationship between prevalence and incidence?

Answers to the Exercises

1. Prevalence and incidence are important measures. The prevalence indicates the proportion of people in a population having a disease at a specific moment. While the prevalence represents the existing cases having an illness, the incidence indicates the number of new cases of people having an illness within a certain period.

2. Socioeconomic conditions, the physical environment, commercial determinants and inherent factors and attitudes. These determinants are consisted of factors such as: Income and social status, Age, Genetics, Gender, etc.

3. Prevalence can be defined as the proportion of the people that have an illness at a point in time whereas incidence is described as occurrence of new illness onset during a certain period in time. Prevalence is linked with incidence rate as well as depends on duration. For example, terminal fatal illnesses have small prevalence, but other terminal incurable and non-fatal illnesses can have high prevalence.

Problems/Challenges

- Why is prevalence a useful measure of frequency regarding the type 2 diabetes in different populations?

- The relative risk of lung cancer associated with passive smoking is low, but the attributable populations risk is considerable. Please comment.

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Introduction to Health Law

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Abstract. In early February of 2020, attention was drawn to the increased number of deaths and the new cases of coronavirus infection. The epicentre of the outbreak was Wuhan in the People's Republic of China. In order to control the outbreak, Chinese leaders called on the city authorities in Wuhan to set up mass quarantine centres for infected people. The Chinese government took this step to protect the public against infectious disease. This is an example of the conflicts between public health and civil liberties/individual rights. Government authority is the pillar of the public health law. The government retains the power to achieve and maintain common good by restricting -- within solid international and national limits -- individual rights concerning autonomy, privacy, association, and liberty. Public health agencies have the right to collect, use, and disclose a considerable amount of personal health information and to enforce certain vaccinations, medical examinations, and treatments. In addition to the power to isolate individuals to protect the public against the spread of infectious disease, their powers can be used to control businesses and professions. There are several legal interventions to prevent injury and disease and promote the public's health. Among these tools are taxing policies, which encourage engaging in beneficial behaviour (fruit consumption) and disincentives to engage in high-risk activities (smoking).

Keywords. Public health law, international health law, medical law, health law, health law in the European Union

1. Introduction

In early February of 2020 when this book chapter was written, attention was drawn to the increase in deaths and new cases due to coronavirus infection. The epicentre of the outbreak was the capital city of Hubei province, Wuhan in China. In order to control the outbreak Chinese leaders instructed local authorities in Wuhan to set up mass quarantine centres for people suspected to have been infected with the coronavirus.

You may wonder how such obvious tension between public health interests (e.g. public safety) and individual rights is balanced. The goal of this chapter is to provide an introduction to public health law, covering law related tools to improve the health of the public.

Laws are rules that govern behaviour, while regulation, in the domain of public health, is the use of instruments of various types to implement these socioeconomic policies or laws [1]. The law is fundamental to achieve health goals of population health, e.g. reducing the burden of cancer by reducing its prevalence in a country.

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Legal regulation is used to establish public health agencies, delegate their core functions, allocate funding, and to set the limits with respect to their actions to protect the rights of individuals. Public health organizations are authorized to collect information, monitor, and regulate dangerous activities. Social debates of public health are translated into legal frameworks—legislatures, courts, and administrative agencies—and into the law's language of duties, rights, and justice. Law is essential for making changes in society, and policymakers need to be accustomed to all the legal instruments at their disposal. The law also limits the actions of public policy. Policy makers will face difficult legal, social, and ethical issues concerning potential public health initiatives. Individual interests and public health interests must be balanced.

2. Learning Objectives

The students will be able to:

- Demonstrate knowledge on the relation between health and law.
- Understand the difference between health law, medical law, public health law, international law, and global health law.
- Understand how the European Union contributes to the healthcare of its member states.
- Discuss different types of justice.

3. Health Law

3.1. Definitions

The following definitions apply in relation to health and legislation: health law, health care law, medical law, international health law and public health law.

- **Health law**, according to the World Health Organization (WHO), as a broad category, is the "area of law concerned with the health of individuals and populations, the provision of health care and the operation of the health care system." Health law includes the national, federal, state, and local law, rules, regulations, and other jurisprudence. Health laws cover policies about e.g. managing, governing and financing a country's health system; regulating the safety and efficacy of medicines and medical devices, or protect patient rights.[2]
- **Health care law** covers national, federal, state, and local law, rules, regulations on who/when/how can receive healthcare, and who should pay for it.
- **Medical law** addresses the rights and duties of the medical profession and the rights of the patients.[3]
- **Public health law** focuses on the mission of the government to improve population health. It also covers legal issues in public health practice and the public health effects of legal practice.[4]

Government authority is the pillar of the public health law. To achieve and maintain common good, a state holds the power to restrict, within solid international and national

limits, individual rights concerning privacy, autonomy, association, and liberty, and also regarding economic interests of freedom to contract and use of property.

Public health agencies have the right to collect, disclose, and use a substantial amount of personal health information. Public health agencies also have the capability to enforce certain vaccinations, medical examinations, and treatments. In addition to having the authority to isolate individuals to protect the public against the spread of infectious disease, public health officials have the powers to control businesses and professions, including licensing and inspections.

The importance of national health law cannot be overemphasized in the field of public health, not only because it sets the rules for the national health planning process but because it also serves as a tool for translating policy objectives into actions (implementations). The epidemics that affect one nation state are often left to that nation state to deal with. Communicable diseases do not respect borders as seen in different outbreaks throughout history. Noncommunicable diseases (NCDs) have also reached pandemic proportions in the last few decades. This is supposed to be a result of the relative ease with which humans and goods can be transported between nations, highlighting the need for a transnational approach to health system governance and legislation -- hence, international health law.

International health law is based on rules governing relations between nation-states. On the other hand, **Global health law** goes beyond the pure collection of nation-states, and emphasizes an international structure based on the world as a community.[5] A good example of how global health law has played a coordinating role between nations, especially in international health and trade can be drawn from the several cholera epidemics since the middle ages. Ships sailing from the Middle East brought the contagion to Europe. Before the invention of steam-driven ships, the voyage was long enough for the infected to die during voyage, but as travelling became faster, humans became vectors for the disease. To respond to this problem in the past, disease outbreak control was based on quarantines or trade embargoes. [6] Quarantine and isolation, although considered draconian or old-school, can be an effective method for controlling a disease that needs close contact or requires short distances to spread. For example, quarantines and travel restrictions were employed in an attempt to contain the spread of the coronavirus infection in Wuhan, a city with a population of about 11 million.

As knowledge was acquired on the microbial cause of the disease in the early 20th century, sanitation became an important aspect of public health management. These factors led to the formation of the International Sanitary Conference, which has since evolved into the International Health Regulations (IHR) of 2005. The IHR puts in place warning surveillance systems for certain diseases, including cholera, yellow fever and the plague, which remain till today notifiable. The IHR also delineates verification procedures for new outbreaks and outlines essential medicines. In the same vein, it outlines guidelines for trade between countries.[7]

The importance of strengthening the implementation of the International Health Regulation became more evident following the Ebola crisis of 2013 - 2016 affecting three low income West African countries: Sierra Leone, Guinea, and Liberia. This deadly virus left an economic dent in all 3 countries.

The Ebola epidemic is estimated to have reduced Gross domestic product's (GDP) growth by 2.3 percent in Guinea, 2.2 percent in Liberia, and 1.7 percent in Sierra Leone. [8] According to the study by the United Nations Development Programme, the health systems of these countries also experienced some strain as resources were redistributed

to deal with the epidemic. This highlights the importance of implementing the IHR as a precautionary measure.

In trade, some of the stakes for health can be food safety, drug acquisition/vaccines or any kind of biotechnology in general. Indeed, as the world becomes more globalized, more integrated, there appears more and more interaction between trade and health. Countries have the right to restrict imports or exports of goods when the health of humans or animals are threatened. However, the key is to exercise this right in an evidence-based fashion.

3.2. Global health governance institutions

As mentioned in the preceding section, trade is inextricably linked to international health. One of the key mediators in trade and international health is the World Trade Organization (WTO), which was established as a successor to the General Agreement on Tariffs and Trade (GATT) in 1995. The basic principle of the WTO is non-discrimination against trading partners and the procedure for settling disputes between trading partners is emphasized. The WTO, unlike its predecessor, GATT, is not only concerned with the trade in goods, but also with the trade in services and intellectual property. There are several WTO Agreements which focus on health and health policies, for example the Agreements on Technical Barriers to Trade (TBT), Sanitary and Phytosanitary Measures (SPS), Trade-Related Intellectual Property Rights (TRIPS), and Trade in Services (GATS). In the report published jointly by the WHO and WTO, eight health issues and their link to trade are elucidated. [9]

The WHO's role in international health law does not need to be explained. The International Health Regulations are monitored and driven by the WHO through its National IHR Focal Points and WHO Contact Points and regional offices, while the World Health Assembly is the decision-making body of WHO, where issues related to communicable diseases of transnational impact are decided on. The WHO Director-General holds the powers to declare whether or not an outbreak is a Public Health Emergency of International Concern (PHEIC) and to leverage resources to address the outbreak as a global health issue.

3.3. European Health Law

The European health law with its focus on the European Union member states is a special subtype of the international health law. "There's no European Union health system, but there is an EU health policy." as stated in a publication from the health policy series of the European Observatory on Health Systems and Policies [10]. The EU influences the health of consumers in many ways that cannot always be directly ascribed to it. The influence of the EU on health has often been through soft laws, rather than hard laws (i.e. binding legislation). [11] This is expected, since the limited powers of the EU are allocated to it by founding treaties, hence, by the Member States.

In the 2019 edition of the Health Policy publication, "Everything You Wanted to Know About the European Union, but Were Too Afraid to Ask", Greer et al explain that health policy in the EU has 3 faces.

- **Firstly**, the EU has explicit health policies justified by Article 168 of the Treaty for the Foundation of the European Union (Lisbon, 2007). It states that *"*a high level of human health protection shall be ensured in the definition and

implementation of all Union policies and activities." This provision of the treaty allows the EU to exercise hard powers in certain areas, such as blood products regulation. The article also clearly states that the EU's work shall be restricted to helpful coordinating measures, whereas organizing and financing healthcare shall remain a member state power.

- **Secondly**, one of the EU's core powers lies in the regulation of its internal market against discrimination between member states. For example, in 2011 the aim of the patient mobility adopted directive was to make publicly financed healthcare systems compatible with the law of the internal market. This directive gave freedom of movement for patients to access healthcare in any member state and shaped the EU health policy in accordance with the guiding principles of the internal market. This directive ensured the patients' rights to get safe high-quality treatments as they are at home. In addition, the establishment EU internal market the free movement of labour including health workforce.
- **Thirdly**, another face of EU health policy is fiscal governance. This means that the EU monitors the Member state monetary policies including taxes, expenditure and policies that affect the Member state's financial future. If Member State policies, for whatever sector, are viewed to be short-sighted, they run a risk of being punished. This power of the EU is continuously and quickly evolving. However, it rests to be determined if it is effective for better health.

A few topics, which have already gained ground in the public health discourse in the European region include cross-border health, food safety, health information and data sharing, injury prevention and safety, obesity prevention, and tobacco control. Three of them will be discussed in more detail in the session that follows.

3.3.1. Food safety

Food safety concerns every aspect of the food chain from production to consumption ('farm-to-table'). The EU food safety rules and policies have emerged because of food-related public health concerns, such as the bovine spongiform encephalopathy (BSE), commonly recognized as 'mad cow disease' in the 1980s and other food crises. These crises led to strong legislative steps that resulted in the adoption of the General Food Law Regulation in 2002 and resulted in the founding of the European Food Safety Authority (EFSA) the same year. The EFSA is tasked with providing scientific advice and communication on existing and emerging food related risks to protect European consumers. In truth, the EU's approach to food regulation is criticised as being too traditional, focusing on "hazards" that can be injurious to health, i.e. noxious substances such as chemicals or microbes. These critics state that this approach leaves gaps in the food law regime. For example, more recent concerns such as obesity, nutrition-related diseases and the use of antibiotics in food production cannot be addressed or interpreted by the current laws at the disposal of the EU. [12] Notwithstanding, the General Food Law Regulation emphasizes the importance of the protection of human health.

Lack of physical activity and poor nutrition are identified as key risk factors for non-communicable diseases, which are a major health threat in the European Union. Food safety, investment in infrastructure, agricultural and climate change policy, as well as trade have an influence on diet and physical activity (**social determinants of health**). These are areas where the EU can contribute to the prevention of NCDs.

3.3.2 Tobacco policy

Ironically, the EU's first *tobacco policy* provided subsidies to tobacco growers from 1970 onwards, but since the 1980s, EU policy-makers have adopted diverse tobacco control measures such as monitoring of smoking prevalence, restriction on advertising and labelling of tobacco products with health warnings and most especially making cigarettes less affordable. These efforts are all aimed at curbing the tobacco epidemic posing severe morbidity and mortality threats. [13] The current tobacco regulation in the EU is embodied in the Tobacco Products Directive adopted in 2014, which aims to regulate the manufacture, presentation, and sale of tobacco products.

Advocacy measures against tobacco have not gone unhampered. Legislative efforts have met with intense lobbying, making progress in this policy area slow. Moreover, one of the biggest inefficacies of the system is the new tobacco products that are introduced to the market before any scientific evidence of their potential long-term harm. [10]

3.3.3. Crossborder healthcare

Cross-border healthcare is one of the most important achievement of the European Union. One of the central elements of EU principles and values is the free movement of people from one member state to another (the four freedoms, TFEU). This has two easily identifiable effects. For one, this extends to the movement of the healthcare workforce within Europe – in sum, labour that can be capitalized and needs to be equitably distributed. Hence, in 2012, the European Commission released an Action Plan for the EU Health Workforce to propose concrete actions for predicting workforce needs, improving workforce planning and sharing best practices on strategies of recruiting and retaining health professionals. [14] The second effect of the free movement of people within the region is patient mobility, which is under the social security law. This means that if an individual moves to another country temporarily or permanently (for work, study, or holiday) and falls ill, his social security provisions in his own country move with him. The legislation surrounding this social security coordination produced the European Health Insurance Card (Regulation (EC) No 883/2004), which allows the holder to be treated under the same terms as the persons insured under the social security system of the Member state of stay. The Directive 2011/24/EU on patients' rights in cross-border healthcare provides patients the right to seek treatments in any member states under a set of conditions and to be reimbursed for care abroad by their home country. [15]

European integration (free movement of people and goods) bears an inherent risk of infectious disease crossing borders, or the worst case scenario of bioterrorism, for which the EU has complementary legislative power, to coordinate responses by member states.[16] The EU through the European Centre for Disease Control and Prevention coordinates surveillance and monitoring of communicable disease, as well as research and capacity building. However, it has no legal powers to intervene in the event of urgent situations and domestic pressures.

For example, in 2009, EU Member states mutually competed during the swine flu pandemic when buying influenza vaccines and antiviral medications and declined to share. The response to this problem was the joint procurement of pandemic influenza vaccines (EU Joint Procurement Agreement).

Furthermore, with rising vaccination scepticism across the region, EU institutions would need to take innovative actions, in order to protect public health.

4. The moral background of public health law: social justice

4.1. What is justice?

The principle of justice is complex. It means "fair, equitable, and appropriate treatment in light of what is due or owed to individuals and groups".[17]

4.2. What is social justice?

"Social justice is a concept of fair and just relations between the individual and society, as measured by the distribution of wealth, opportunities for personal activity, and social privileges."[5] Social justice is a core element in the mission of public health.

For clarity, justice does not mean universally equivalent treatment, but it does require that people at the same level should be treated equally. Thus, justice means that equals are treated the same and non-equals might be treated differently.

4.3. What are the justice features?

Justice has special relevance to public health due to its three important features: non-discrimination, natural justice and distributive justice.

Firstly, non-discrimination means that "treating people equitably based on their individual characteristics rather than membership in a socially distinct group such as race, ethnicity, sex, religion, or disability". [18]

Natural justice, the second important feature, refers to providing procedural fairness to individuals when a burden or a withheld benefit has been imposed. It has to be guaranteed that the use of legal procedures is according to constituted rules and principles for the protection and enforcement of individual rights. Natural justice requires, for example, that public health officials provide procedural safeguards to affected individuals when compulsory actions are applied such as isolation or quarantine.

The third feature is distributive justice which is based on unbiased disbursement of common goods and the sharing of common burdens. Distributive justice involves the fair distribution of public health welfare such as vaccines and burdens e.g. limitation in access to health care services. This principle may have significance during a flu outbreak when antiviral medications are allocated. Public health actions must be obviously fair. For example, there was a public outcry in China as a result of the local government's decision to provide the most effective face masks to politicians and not to healthcare workers during the coronavirus outbreak. [19]

5. Conclusions

Laws in the health field are governors of the public's health. These laws are diverse in their applications and are not only accountable for health regulations but work in tandem with common socioeconomic environments and their regulations. Governments enforce these laws on national levels and are monitored by international regulations. Health is not bound to borders and global efforts still have to be emphasized and polished with the respective social justice and human rights to eliminate international crises.

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Students with special interests in public health law are recommended to visit the following sites:

- https://libguides.law.gsu.edu/PublicHealthLaw
- https://biotech.law.lsu.edu/map/index.htm

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Exercises

1. Find examples of public health law tools in this chapter!

2. What is meant by justice in public health?

3. Select the tree types of justice discussed in this chapter!

Answers to the Exercises

1. e.g. laws (Directive 2011/24/EU on patients' rights in cross-border healthcare), taxation policies (tobacco taxes are the most effective tobacco control tools), policy disincentives (higher insurance premiums for smokers).

2. Justice is public health means fair, equitable, and appropriate treatment in light of what is due or owed to individuals and groups.

3. Social-, natural-, and distributive justice.

Problems/Challenges

➢ What objectives are set by Article 168 of the Treaty on the functioning of the European Union?

➢ Find a contemporary public health issue which is being managed by legal tools in your country!

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Mission and Structure of Health Services

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Abstract. This chapter aims at providing the student with a general overview of the appropriate structure and ethics healthcare organizations are based on, the concept of ethical leadership, the importance of having clear statements of mission, vision and value in healthcare organizations and the Health Promotion Charters implemented in a Globalized World.

Keywords. Health services, mission, vision, value, ethical organization

1. Introduction

Organizational ethics is a field in healthcare management focusing on decisions made by managers and board members. Health care organizations face challenges regarding limited resources and there are no simple solutions to prioritize resource allocation fairly [1]. Literature suggests that clearly defined vision, values and mission statement are linked with good organizational performance regardless of the limited resources of the organization [2].

2. Learning Objectives

The students will be able to:

- Demonstrate knowledge about ethical organizations.
- Understand the difference between mission, vision and value in healthcare organizations.
- Understand the importance of ethical leadership.
- Discuss about the Health Promotion Charters applied in a Globalized World.

3. Ethical Leadership

Leaders' attitudes and decisions are crucial in creating, maintaining, and shifting the culture in an organization and are linked with ethics quality at the level of an organization's environment. It is important that leaders show certain behaviors that cultivate an ethical environment that effectively integrates ethics into the overall

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organizational culture [3]. Managers and board directors must abide by and implement the institutional rules by identifying and setting clear risk boundaries, standards, and protocols in order to provide their employees with guidelines to support them with making the right decisions. It is also important that they provide employees with adequate information about the organization, its values and what it represents. Employees need to know the organizational values from the very beginning and implement these values into their everyday practices in order to be rewarded and promoted. Leaders should support the organization's long-term reputation and sustainability and should regularly perform assessments and monitoring visits to understand whether the organization's operations and employees' actions follow the organization's values. Leaders must lead by example and must be transparent and accountable, open and honest. They should update employees about performance and achievements, keep their promises and commitments, accept responsibility for adverse events, and reward benevolent attitudes. Developing and maintaining an ethical organization can be supported with relevant training programs run by ethical leaders in order to instill an ethical culture in the organization. Healthcare leaders may face a number of demands and issues and are required to take decisions based on ethics. To ensure the sustainability of an organization, the ethical leadership must be based on values [4]. Ethics in the healthcare is based on five core values. First, healthcare providers must respect their patients' autonomy and self-determination. Secondly, beneficence is important as the healthcare provider should act on patient's best interests. Third, the healthcare provider must not cause any harm when delivering services. Fourth, healthcare providers must be fair and correct as much as possible. Fifth, patients should be treated with respect and dignity [5].

4. Differences among Mission, Vision and Value Statements

Mission, vision and value statements of an organization have become a part of corporate strategy and they describe the reason of the organization's existence, what it is trying to achieve and with what means. These statements are created no matter the industry, size, or profit status. US business statements have increased the last years, although it is observed that there can be a misalignment between a company's message and its actions [4]. Thus, it is important that statements reflect mission, vision, and value of organizations effectively and correctly. Mission statements are strategic in nature and are used in internal and external communication and for motivation. They are often described as identity statements as they present the identity of an organization, often explaining why such an organization exists and what it is trying to achieve. Other definitions are: imperative statements, purpose statements or mission statements. Formalized Organizational Statements is the general term used for vision, mission, values, purpose, and principles statements. These statements offer landmarks along the way. Organizations may improve productivity levels by providing a clear perception of who they are, what they do, where they are going, and how [6]. It is important to note here that health care organizations must take into consideration the fact that implementing ethical practices in only one unit is inadequate and the organization needs ethical identity as a body. It is important to foster into all levels of an organization (with a different skill-mix and background) a capacity and concern for ethical analysis. To achieve that, the institution must take into consideration three components: the development of relationships and responsibilities allocation, both within their own personnel hierarchy

and with other organizations, the identification of organizational values and the identification of future goals and aspirations [7]. Many organizations use the terms "Vision", "Values", and "Mission" interchangeably, using each of them in various ways. This confusion may be demotivating and may cause leaders' hesitancy to use strong formalized organizational statements [8].

4.1. Mission

Today an increasing number of healthcare institutions create mission statements and a few organizations use the mission statement to define present actions. Embedded in these statements are indications of beliefs and values [7]. The results of recent studies stress the importance of mission statements for productivity and success of an organization. Mission statements are preferred by a number of institutions in order to disseminate the purpose and the foundational reason of the organization. For example, it was found that almost 1/4 of institutions included in a survey had mission statements that reflected the reality [8].

4.2. Vision

The term vision is used to express the future image of an organization that would depend on the support of the stakeholders [9]. The vision, in order to be effective, needs to be easily communicated in order to gain the commitment of the stakeholders and incorporate it in the personal values of the participants. In addition, several qualities must be incorporated in an organization's vision to be successful. First of all, it has to propose a future goal which can be readily visualized by skilled individuals. In addition, it should deliver an important service to the community and people, giving a powerful motivational message based on supporters' personal values. Even though there are numerous articles describing how to create and promote such statements, few analyze the content and structure of these central pieces of organizational philosophy [8]. It is important to mention though that many articles highlight the positive impact of such statements.

4.3. Values

Values define the ethical environment of an organization. Three considerations can be helpful in identifying the healthcare organizations. First, a sector of an organization already implementing its values in everyday tasks can instill those values in other parts of the organization. As a result, knowledge gained from ethical explorations in the clinical areas in an organization can be transmitted to its nonclinical segments. Second, objectives of healthcare organizations such as the responsibility of an organization towards a community, the relationships between the private and public sector, the attempts to protect the vulnerable internal and external populations whom the organization serves can be the drivers for the creation of the values statements. Therefore, certain values emerge such as: humaneness, trust, reciprocal benefit, compassion, fairness, dignity, teamwork, and service. However, these values are linked with two factors: the cooperation among employees setting aside indifferences and the turnover of individuals in a vulnerable status seeking aid from unfamiliar environments and personnel. The do no harm, compassion and reciprocal benefit values bind the practitioners and the organizations of health care to a common standard concern for the

person. Only an environment that is based on the best qualities such as kindness, compassion and consideration, may give patients the courage to trust the organization [7].

5. Health promotion

5.1. The Ottawa Charter for Health Promotion (1986)

The Ottawa Charter was focused on the needs and conditions that determine wellbeing in industrialized countries, a number of which are: peace, shelter, education, food, income, a stable environment, sustainable resources, social justice, and equity. It is prudent to say that wellbeing needs the following core requirements.

- **Advocate**: Health drives socioeconomic and personal development. Political, economic, social, and environmental determinants as well as biological factors can define peoples' wellbeing. Advocacy for wellbeing is concerned with making those factors widely known with health promotion programs.
- **Enable**: Healthcare equity must also be a priority regardless of gender, nationality, status etc. Health promotion actions aim at reducing healthcare and health inequalities. This includes support with accessing healthcare services, and provision of adequate information.
- **Mediate:** Wellbeing promotion perceived because of joint efforts is important and demands liaison with governments, health authorities, public and private sectors, communities, nongovernmental organization, as well as other stakeholders.

Health promotion plans and actions should be implemented in various social, cultural and economic systems.

5.2. Public Policy for Health promotion

Wellbeing promotion needs prioritization by policy makers who need to make decisions and implement legislations, taxation, and reforms in order to promote health.

5.3. Create Supportive Environments

Health cannot be viewed as an aspect separate from other goals. Many scholars mention a socioecological approach to health and consider the protection of resources of paramount importance in wellbeing promotion.

5.4. Enhance Community Actions

Community development improves self-help and social support and develops flexible systems for public participation in health issues. This needs access to information, learning initiatives for health, and funding.

5.5. Invest in People's Skills

Wellbeing promotion and educational programs can provide all the health-related information for health to encourage people to make their own decisions about their health. As a result, people can lead a proactive lifestyle and cope better with illnesses.

5.6. Reorient Health Services

Individuals, groups, health workers, institutions, other authorities, and Nongovernmental organizations (NGOs) are responsible for wellbeing promotion. All their efforts are directed to the pursuit of health. Health services need to abide their responsibility for respecting different cultural and health needs.

5.7. Moving into the Future

Health is maintained by solidarity, self-responsibility, governmental strategies and policies based on care, holism and ecology as well as scientific initiatives. Society has to create the right conditions for maintaining people's health. [10]

5.8. The Bangkok Charter for Health Promotion in a Globalized World (2005)

The Bangkok Charter includes health promotion guidelines and actions to tackle the health determinants in a globalized world. In order to implement these plans, all sectors must:

- **respect** human rights and solidarity
- **invest** in policies, programs, and infrastructure
- **build capacity** for policy and leadership, health promotion practice, knowledge transfer and research, and informed people
- **legislate** to keep patient and people health safety and equity in healthcare
- **build alliances** with all actors and stakeholders to create sustainable actions.

In addition, there are four key commitments for promoting wellbeing:

5.8.1. Central to the global development agenda

Authorities and other responsible bodies both nationally and internationally, must reassure equity in healthcare and prioritize health promotion. This requires cooperation among nations, the public and private sector.

5.8.2. Core responsibility for all of governments

Investments targeting wellbeing promotion should be enhanced as wellbeing is a determinant of social, political and financial development and can enhance productivity.

5.8.3. Key focus of communities and civil society

Opportunities for capacity building are of paramount importance. Well organized and empowered communities and groups (e.g. patient's groups, women groups etc.) can

make their own decisions regarding health issues. Additionally, public as well as private sector are responsible for implementing strategies to improve wellbeing.

5.8.4. Good corporate sector practices

The corporate sector influences wealth distribution, culture and environment. The private sector must comply with national and international regulations and is responsible to ensure an ergonomic workplace, and to maintain their employees' well-being. Ethical organizations and fair trade should also be supported by consumers and by government's incentives along with legislations [11].

6. Conclusions

Organizational ethics and ethical leadership is an emerging field in healthcare. Literature suggests that effective use of Formalized Organizational Statements have been linked with better organizational performance [13]-[18]. Leaders' attitudes and decisions are paramount in developing, sustaining, and shifting their institutions' culture. Thus, the managers' responsibility for ethical leadership is pivotal. The Health promotion Charters include strategies, commitments and actions directed at health determinants. A healthier world requires ethical decision making by authorities, strong participation, and advocacy.

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Exercises

1. It is stated that ethics in healthcare incorporates five basic values: Respect for autonomy, Beneficence, No malfeasance, Justice, and Dignity. Please, explain in a few sentences the five basic values.

2. Which of the following statements represent vision, mission and values?
- The X Hospital provides high-quality, patient-centred and cost-effective services in order to enhance the wellbeing of our community maintaining personal and business integrity.
- In Y Clinic we respect Quality, Compassion, Teamwork, Community Relationships, and Trust.
- The B Hospital is an institution offering high quality care. We strive towards clinical excellence, patient safety and we are committed to equity in health.
- F Hospital intends to be the leading healthcare provider within two Counties.
- The Z Clinic with respect to the patient needs is dedicated to providing high quality care. As a primary health care provider, we remain focused to maintain community health by providing health care of high standards and delivering educational and preventive programs.
- W Clinic holds these fundamental values: People, Involvement and teamwork, Service Excellence, Responsibility, Quality, Communication, and Innovation.

3. How managers can create an ethical culture?

4. What is a healthcare system?

Answers to the Exercises

1. Five basic values define ethics in healthcare. First, respect for patients' autonomy and self-determination. Secondly, healthcare providers should act upon patient's best interests. Third, harm during health care provision should not occur. Fourth, healthcare providers have to be just. Fifth, patients should be treated with respect and dignity.

2. Answers
- The X Hospital provides high-quality, patient-centred and cost-effective services in order to enhance the wellbeing of our community maintaining personal and business integrity. MISSION.
- In Y Clinic we respect Quality, Compassion, Teamwork, Community Relationships, and Trust. VALUES.
- The B Hospital is an institution offering high quality care. We strive towards clinical excellence, patient safety and we are committed to equity in health. VISION.
- F Hospital intends to be the leading healthcare provider within two regions. VISION.
- The Z Clinic with respect to the patient needs is dedicated to providing high quality care. As a primary health care provider, we remain focused to maintain community health by providing health care of high standards and deliver educational and preventive programs. MISSION.

• W Clinic holds these fundamental values: People, Involvement and teamwork, Service Excellence, Responsibility, Quality, Communication, and Innovation. VALUES.

3. Answers

• Managers and board directors must abide by and implement the institution's rules by implementing certain risk boundaries, standards as well as protocols in order to provide their employees with guidelines to support them with making the right decisions.

• Give employees adequate information about the organization, its values and what represents. Employees need to know the organization values from the beginning and implement these values into their everyday practices in order to be rewarded and promoted.

• Leaders should contend that the institution's long-term sustainability is crucial.

• Leaders should assess and monitor in order to understand whether the organization's operations and employees' actions follow the organization's values.

• Leaders must lead by example and must be transparent and accountable, open and honest. They should update employees about performance and achievements, keep their promises and commitments, accept responsibility for adverse events, and reward benevolent attitudes.

• Training programs run by ethical leaders can also help install an ethical culture.

4.The World Health Organization defines a health system as all organizations, people and actions whose primary intent is to promote, restore or maintain health. Health systems are as varied as there are societies, but it only got to its modern form in the past century. The primary, unquestionable function of a health system is to provide health service. Yet, in performing this function, other questions arise. For example, how can the necessities involved in providing health be financed? Or how can resources be best allocated to allow for an equitable distribution of resources? These are questions each health system must answer, and hence, the function of investing in health to grant accessibility to the consumers comes to light as well as the function of setting/regulating the prices for the services in a fair way, so consumers regardless of financial background can afford it, a kind of universalism. In its framework for action on health systems, WHO identifies six building blocks of a health system [12], namely: Service delivery, Information and Evidence, Medical Products and Technology, Health workforce, Health financing, and Leadership and governance. If we can delineate functions of the health system and outline its objectives (good health, fair financial contribution and responsiveness), automatically, we should able to determine what is achieved with respect to its objectives (attainment) and compare these attainments with it should be able to achieve given its resources (performance). Health system research and performance assessments allow governments to make evidence-based decisions about the distribution of resources (however scarce or abundant) and also to be held accountable as stewards of the health system.

Problems/Challenges

➢ As a manager of the local public health department you are asked to develop a program that focuses on ethics in the public health workplace to assure that all employees understand their roles and responsibilities.

➢ What are the differences between the Ottawa Charter for Health Promotion and the Bangkok Charter for Health Promotion in a Globalized World?

SECTION 2

Healthcare Organisation

Preamble

The structure of healthcare organizations and the planning and development of health services are among others discussed. Also, it is explained how organizations should communicate to internal and external stakeholders (via advertising and public relations-PR activities). Also, the characteristics of healthcare systems of a number of countries are compared.

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Health Organization Development and Design

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Abstract. This chapter aims at providing the student with a general overview of the Health Organization Development and Design basic concepts. More precisely, this chapter outlines the origins and the future of Health services planning and development and the structure of health organizations. The typology of different international healthcare systems implemented in United Kingdom, United States of America, Greece, Serbia and Germany is also presented.

Keywords. Health development, organizational design, health system

1. Introduction

Over the past century health care has undergone a lot of significant transformations. Doctors were used to practice autonomously and were considered to be the ones responsible for the treatment of their patients as they were perceived to master all the relevant medical knowledge. Nowadays, a multidisciplinary team of healthcare professionals who practice in various settings constitutes a network that shares responsibility for patient care [1],[2].Early implementation of certain elements of Health organization development and design such as strategy, structures, processes, and people can positively contribute to care quality which is *"the extent to which health care services provided to individuals and patient populations improve desired health outcomes. In order to achieve this, health care must be safe, effective, timely, efficient, equitable and people-centred"* [3]. Organization design is a decision-making process which includes a number of steps and considers alternative options. An early decision can exclude later options, eliminate alternatives, and thus can lead to a final form of the organization which may require great effort to change it in the future. Taking right decisions at this first stage requires a solid theoretical background to support the rationale for selecting an option[4].Despite the fact that several managers, decision makers and other leaders make organization design decisions based on their practical experience, explicit tools such as SWOT analysis [5], cost-benefit analyses [6], process mapping [7], and LEAN-Six Sigma [8] can provide a wide spectrum of benefits. In addition, a framework for decision-making can be used as a common language for debating about choices and reasoning why one alternative outweighs another. It also incorporates decisions into a longer-term strategy instead of being based on individuals' preferences and politics. A standard framework can also provide a justification of making a decision, an explanation of the results and the consequences of implementing those choices over

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other alternatives. Last, but not least, it allows stakeholders to evaluate outcomes, perceive root causes of phenomena, and make appropriate alterations if needed [9].

2. Learning Objectives

The students will be able to:

- Demonstrate knowledge about health organization development and design.
- Understand health organization structure and be able to compare the different structures.
- Enhance decision making skills.
- Perceive the different typologies of international healthcare systems and be able to discuss about the most prominent healthcare systems.

3. A healthcare system's model

The healthcare system can be defined as the connection of separate parts for serving a purpose which consists of individuals, groups of professionals, institutions as well as external environmental and socioeconomic conditions. The first stage of the model refers to the patient's needs. Patients' health needs define the individualized services delivered by the provider, especially during the last years when the patients from passive recipients of care became active participants in their healthcare delivery [10].

The second stage is related to a group of employees working in healthcare, next of kins and other carers whose main efforts are aimed at improving patients care. It is important that the care team has access to clinical data and is able to use appropriate tools to store, manage and analyze those data in order to provide optimal care. Moreover, to deliver evidence-based care, the healthcare professionals have to be skilled and educated to act as patients advocates, encouraging the patients to make decisions regarding their healthcare plans. [10].

The third stage refers to the institution that offers the relevant infrastructure to support the care delivery. The organization incorporates decision-making systems, technology, infrastructure, and processes all aligned to assist care teams with their clinical duties. The limited staff and monetary resources make health care organizations unable to respond to their vision especially during serious crises and force patients to pay for their healthcare [10].

The next and last stage is related to the external conditions that are determined by political, financial and regulatory factors which are crucial in defining the structure, the quality and level of safety of care provided by the institutions.[10].

4. Past and Future of the Health Services Planning and Development

In 1998 Chow mentioned that: "In many western countries, hospitals cope with economical, technological and social pressures. The current environment for a health care organization contains many forces demanding unprecedented levels of change. These forces include changing demographics, increased expectations, increased competition and intensified governmental pressures".

A number of Health systems studies that were carried out around the globe suggests that there are many different organizational arrangements. Health systems are formed by complex networks consisting of different actors. Governments influence wellbeing by introducing various regulations and other reforms. In recent years, there has been a division of responsibility regarding the financing, the provision of services, the planning and monitoring of services ranging from local governments or authorities to other agencies. [11].

The priorities in health for 2020 are to ameliorate health outcomes minimizing health inequalities simultaneously. For this reason, health services must align with scientific evidence. More precisely, provision of care has to become evidence based, comprehensive as well as patient centered rather than one-fits-all. This reform agenda can be further changed due to research, education and proper management. For example, technology and ICT, like e-health applications and other devices, have made individualized, cost effective and efficient care possible. Nevertheless, there is still a huge gap between organizations that underwent transformation to fulfill patient's and populations' health demands and to replace outdated models that could not adopt successfully the advancements of the 21st century. With limited resources allocated to the healthcare sector, services have to be prioritized in order to meet population needs in the most cost-efficient way providing high quality evidence-based care. In addition to deciding about the provided services, systems must determine a pathway for these services and establish relevant protocols and processes. In case clearly defined models of care are not available, challenges such as poor care, inadequate compliance with protocols and processes or episodic care with no continuity may occur [12].

The efforts of organizations should be focused on ensuring the sustainability of systems and processes and on connecting with other providers in order to promote continuity of care. Patients may be treated in various facilities and different settings. A patient can seek healthcare in primary, secondary, and tertiary care facilities. Through such a journey, the patient may undergo diagnostic tests, receive prescribed drugs, be treated and cared by a multidisciplinary team. It is essential that the organization coordinates all these interventions well [12].

To support individualized care by well-coordinated groups of healthcare professionals, institutions must bring together employees and leaders of all levels and invest in new technologies, tools, and valuable data. Patient-centered, team-based care requires resources, support at all levels, and systems that can store and share information securely. The transition from the current state of autonomous units towards a unique entity needs all parts to function together and get influenced at the same time by all other parts. Each unit must not only work independently aiming for productivity but must also be in touch with various departments so that the sustainability of the whole entity be enhanced [13].

5. Health Organization

Organization is the connection of separate parts to create an entity in which authority, control and coordination may be used to serve a certain purpose. The proper organizational design integrates: strategy, structures, processes, systems and people [14]. The structure of a healthcare organization can be visualized with an organogram (or organization chart) which is the skeleton of an institution. An Organizational Structure of an institution depicts the existing levels of authority, enabling successful hospital

departments' coordination. The Organizational structure varies among organizations. It is observed that large hospitals have advanced organizational structures while middle sized or smaller hospitals have less complex organizational structures.

5.1. Degree of centralization and decentralization

Centralization implies standardization, uniformity, and central authority which ensures efficient decision making and coordination. Although this type is based on strict control and can be proved cost-effective, it requires strong administrative skills and leadership. Decentralization refers to a reduced central authority. It requires lower-level employees' participation in decision making and enhances a multi-departmental approach. The manager's experience, leadership attributes and teamwork skills should also be taken into account. In more depth, the degree of decentralization should match organization objectives, manager characteristics and be related to the policy framework of each organization [15],[16].

5.2. Vertical, Horizontal Organizations and Integrated Delivery Systems

Organizations can be divided in Vertical, Horizontal and Integrated Systems. Vertical Organizations are defined by Hierarchical authority, low levels of autonomy, fragmentation and multiple silos while in the Horizontal Organizations all hospital departments are incorporated into a process. In Horizontal Organizations, the whole system is created in order to meet the patient's needs and it involves managers with a lower authority level to participate in a process from the beginning to the end. Integrated Delivery Systems (IDS) involve horizontal IDS in which the planned activities across operating units belong to the same stage in the process of delivering services, thus grouping organizations that provide a similar level of care under one management umbrella. As a result, institution's resources will be prioritized with the aim of enhancing efficiency and reducing unnecessary cost. The Vertical IDS has to do with the coordination of services among operating units that are at different stages of the process of delivering patient services and thus has to do with grouping institutions that provide different levels of care under one management umbrella, resulting in increasing efficiency, reduction of expenses and continuity of care [17].

5.3. Functional, Divisional and Matrix Organizations

In the Functional Organizational Structure, similar tasks undertaken by different employees are clustered based on expertise. This model is likely to be used in different small or medium-sized organizations and in most healthcare organizations. The perks of this structure are the rapid decision making, the good communication and knowledge exchange, the strict division of job tasks and the clear guidelines on reporting incidence. For instance, a nurse can always approach the senior nurse or manager or another colleague to gain information about a patients' condition. The drawback of such structures is the inadequate liaison within departments. As a result, no one can be completely aware of others' roles and responsibilities in the hospital. For instance, human resources who deal with patient discharges may be unaware of social worker's job in ensuring a safe patient transition from hospital to another facility. In the Divisional Organizational Structure, products or projects targeted to specific customers define the groups of professionals working together. This structure differs from a functional

organizational structure, because of the fact that the professionals have different job tasks, but they all work closely. For example, doctors and nurses are placed in different divisions/departments like Oncology department, Surgical, Psychiatry etc. The Matrix Organizational Structure is a combination of the aforementioned models. More precisely, people into functional departments of specialization are grouped and allocated into divisional projects and products. Employees work autonomously and are responsible for the produced outputs to a high degree. However, it requires good planning skills in order to be deployed in large organizations [18].

5.4. P-design, G-design, and matrix design oriented organization

"P-design", where P means product or service has two types of outputs: diseases and patient groups. This design separates organizational activities based on disease or pathology or based on patient groups as for example women, diabetic patients etc. "G-designs" means geography-based and it is related to a population or a specific area. This design can be defined as a divisional model, quite innovative in the healthcare sector, which puts the relevance of specialization below integration needs. Additionally, line manager with different background and expertise usually supervise specialized employees. The G-design opens a window of opportunities in achieving continuity of care and a multidisciplinary cooperation when dealing with serious illnesses. The use of common resources such as staff, infrastructure, and devices in order to promote district populations' quality healthcare can be also facilitated. The matrix design model is a dual authority form which can be based on disciplines–products–clients as well as market responsibilities.

5.5. Rationale of Grouping Hospital Departments

The purpose of grouping hospital departments is to promote efficiency based on common tasks and duties. A typical grouping of departments consists of various services such as the Administration, the Informational Services, the Therapeutic Services, the Diagnostic Services, and the Support Services. The Administration refers to CEOs, Vice President(s), Executive Assistants, and Department Heads. Their main duties and responsibilities are to supervise operation of departments, monitor budget, and define hospital policies. Informational Services include EHRs, Imaging and ICT. The Therapeutic Services consist of the Respiratory Therapy where patients are treated usually with oxygen, the Social Services, and the Pharmacy where medications are stored and dispensed. In addition, the Dietary service defines the diet and daily nutrition needs of the patients and the Nursing is responsible for performing nursing interventions to patients. The Diagnostic Services include the Medical Laboratory for body tissues examinations and the Medical Imaging consists of CT scans, radiography, or other diagnostic imaging. Furthermore, the Emergency Medicine offers urgent response to people in need. Finally, the Support Services which include ordering, receiving, and stocking supplies and the Biomedical Technology is responsible for technology and other devices needs as well as repairs. Finally, Housekeeping & Maintenance maintains a safe and clean environment.

6. International health systems

A healthcare system is formed by many actors and their connections ranging from patients with their next of kins to decision makers, authorities, health organizations, insurers, pharmaceutical companies, financing bodies, and other institutions and providers. These actors outlined above perform various actions such as: supervision (e.g. regulations), delivery of care services (e.g. providers), administration, and allocation of resources [19].

6.1. Healthcare System Typology

State dominance is the main attribute of the National Health Service, which is implemented in North and Central European countries, Iberian Countries and in the United Kingdom. Similar attributes can be found in the National Health Insurance System, which relies on employees' contributions. Few countries such as Australia, Canada, Ireland as well as Italy have adopted this model. Austria, Germany, Luxembourg, and Switzerland have implemented the Bismarck's model which is characterized by a regulatory dimension dominated by societal actors. A Private System is merely adopted by United States of America. The Etatist Social Health Insurance system combines state regulation, societal financing and private delivery of services. This type is adopted by Estonia, Japan, Czech, Hungary and many more [20], [29].

6.2. United Kingdom's healthcare system-The NHS

A large share of financing the NHS derives from common tax, national insurance, copayments, donations and a few other minor sources. Settled residents in Britain and people coming from countries outside UK with an EU Insurance Identity can be treated by the NHS. Nevertheless, non-EU guests can only get certain types of free emergency care. The available services are: immunization programs, in-hospital and outpatient care, drugs received at hospital, access to eye clinics, mental care, care for terminally-ill patients, rehabilitation and community-based care. People have to register with their local GP. Primary care is carried out basically by general practitioners (GPs), who control hospital admissions (gatekeeping) by referring patients to secondary care only if the patients' health condition has to be treated in a hospital setting. Most GPs are private. However, due to a high patients turn up, there are limited available GP's and patients turn up to walk-in points of care. As far as hospitals are concerned, there are NHS trusts and foundation trusts using Diagnosis-related group (DRG) rates. Up until now there is no established law regarding the charges to private patients by private providers. NHS challenges include long waiting lists, and few unavailable services (treatments not covered by NHS) [21].

6.3. The Bismarck's model applied in Germany

Germany has developed a publicly financed health insurance system with funding stemming from general tax–financed spending on "insurance-extraneous" offered by Social Health Insurance which includes treatment and prevention programs. All employed and pensioners earning less than a certain amount per year and their dependents are mandatorily covered by SHI. Other options for individuals with higher income are either to stay in public insurance or pay for public insurance. SHI also offers

in-hospital and other basic services such as eye care, drug prescriptions, medical aids, rehabilitation, and care for terminally ill patients. In this country, there is no gatekeeping and individuals can choose freely among GPs and secondary settings. In Germany, 50% of the total hospital beds belong to the public sector whilst another 33% belongs to private not-for-profit and almost 17% is covered by private for profit institutions [22].

6.4. The Healthcare System of USA

The Affordable Care Act's (ACA) expansions regarding health coverage as well as the programs Medicare and Medicaid increased the number of people whose health needs where covered and who were eligible for insurance. Most Americans obtain health insurance and significant subsidies are granted to vulnerable individuals as well as the implementation of Medicaid in many states. The services covered are decided by each state independently. ACA demands that all health plans are targeted to cover specific services such as: ambulatory services, emergency care, hospitalization, maternity care, drug prescriptions, rehabilitation, medical devices, laboratory services, and preventive programs. [23],[28].

6.5. The Healthcare System of Greece

A National Health System (NHS) combined with social insurance and private insurance along with out of pocket payments exists. The entire population is covered by the NHS and social insurance funds. It is reported that one out of seven people applies for additional private insurance or just pays to get the services needed. The resources allocated to healthcare facilities are decided by the Ministry of Finance every year. Primary care is provided through local clinics and surgeries, as well as outpatient units. The private sector also offers primary care, with freelance physicians or physicians in the private sector and other diagnostic and outpatients' facilities. Secondary and tertiary care is offered by public or private hospitals, general as well as specialized depending on the services that they provide. [24].

6.6. The Healthcare System of Serbia

Serbia's healthcare system offers health coverage from the National Health Insurance Fund. Citizens with a certain income can get insured by paying their part directly whilst citizens who have a lower income are insured thanks to the contributions of employees. Private health insurance is usually a supplementary form, used for easier and faster accessibility to services. Nevertheless, there are no exact data on the amount of out of pocket payment by people. The primary care in Serbia is mainly provided in primary clinics by a physician, occupational medicine specialist, paediatrics, or gynaecology specialist, and a dentist. Patients can be referred to secondary care facilities if necessary. Each patient can get the required treatment in one of the 77 secondary health institutions in Serbia. It might be outpatient or inpatient treatment [25].

7. Conclusions

Organizational design and development require appropriate tools and a framework to support decision making as well as training and educational activities to improve managers leadership skills [26]-[29]. The Organization Design should match the health demands of the people, align with the organization's vision and strategy, and consider a multitude of factors which will determine the success of the effort such as regulations, synergies, financial support, technologies, relevant policies and other resources [30]-[35]. Consideration of all the aforementioned aspects and the early engagement of stakeholders will result in successful implementation. As mentioned, health organization development and design are affected also by politics and financing. Leaders should prioritize the creation of robust healthcare systems with the aim of delivering optimal care which in turn can have a positive impact on education, productivity, demographics and future investments.

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Exercises

1. Which are the elements that create a healthcare system?

2. What is the matrix model and how is connected to the functional and divisional models?

3. What is Centralization and Decentralization?

Answers to the Exercises

1. Healthcare system can be defined as the connection of separate parts for serving a purpose which is consisted of the individual, the care team, the institution as well as the environment.

2. The Matrix Organizational Structure incorporates attributes of the functional and divisional models into one structure. In the matrix model employees with a specialization are grouped and then allocated into divisional projects and products. In this model, employees work autonomously and be responsible for their work. However, this structure needs good planning in order to be deployed in large organizations effectively.

3. Centralization implies standardization, uniformity, and central authority while ensures efficient decision making and coordination. This type although is based on strict control and can be proved cost-effective, it requires strong administrative skills and leadership. Decentralization refers to the reduced central authority. It requires lower-level employees' participation in decision making and enhances multi-departmental approach. The manager's experience, leadership attributes and teamwork skills should also be taken into account. The degree of decentralization should match organization objectives, manager characteristics and be related to policy framework of each organization

Problems/Challenges

- In your opinion which were the priorities set for health in 2020 and how these were meant to be achieved? Can you identify any success in your country so far?

- Which departments are crucial for a secondary health organization and how would you choose to design one?

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Communication and Public Relations in Healthcare

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Abstract. This chapter is written in order to provide the student with a general overview of communication and public relations in healthcare. All healthcare institutions have a need for adequate and successful communication with their external and internal stakeholders. Every contact of a particular healthcare organization with the public represents a unique interface, as an important part of the communication strategy. Therefore, it is very important to create strategic consistency among all the messages that stakeholders need to receive. The chapter will discuss the relationships between the various components of integrated marketing communications in healthcare, crisis management in the communications sphere and ethics and social responsibility issues.

Keywords. Integrated marketing communications, advertising and PR, stakeholders (external and internal), media, crisis management, ethics, social responsibility

1. Introduction

Communication among people is a very complex phenomenon. From the point of view of the communications and linguistics sciences, the act of communication is possible only if its participants use the same code, i.e. a system of signs and symbols on the basis of which messages are composed. [1] The exchange of verbal and non-verbal messages among people is based on continuous coding and decoding of content which is being sent by messages. That is why synchronizing different aspects of communication always poses a great challenge.

Synchronization of communication processes in the healthcare field is done on several different levels, which also need to become intertwined.

All healthcare institutions have a need for adequate and successful communication with their stakeholders: patients, government, NGOs etc.; but also with internal stakeholders, such as employees and managers. The importance of healthcare organizations for a functioning society is invaluable; therefore, communication in this sector is a matter of significant public interest. A proper communication strategy is necessary in order for a healthcare institution to prosper and achieve its objectives.

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2. Learning Outcomes

By the end of this course, participants will be able to:

- demonstrate knowledge about communication by healthcare organizations;
- create and implement a communication strategy;
- have a clear knowledge about the importance of internal and external stakeholders in the context of communication;
- understand the relation between communication activities and the organization's values, vision and role in society;
- understand the role of IMC, especially of advertising and PR in healthcare;
- being able to deal with communication issues in "real-life" situations;
- understand challenges and obstacles concerning communication and PR in healthcare;
- enhance their communication skills and understand the importance of team work and creative problem-solving;
- develop more sensitivity for ethical issues and dilemmas in the field of communication and PR.

3. IMC & Communication Strategy in Healthcare

Integrated Marketing Communications (IMC) present a practice of unifying all tools used in marketing communications, in order to send a consistent and persuasive message that will promote the goals of a particular institution in the healthcare field. [2] All people that are in some way related to the brand have their role in the integrated communication and they all appropriately participate in the production and implementation of the communication strategy of a healthcare institution.

As we have already mentioned, we are talking about external and internal stakeholders and publics. These two types of stakeholders/publics can be separated only in principle, because their roles and positions can be sometimes interpreted in more than one way.

The term external stakeholders mostly covers individuals, groups or organizations that are active outside of a healthcare institution, i.e. those who are not employed by it, such as: patients (direct users of the services) and their close ones, governmental regulatory bodies (ministries and special government bodies in charge of the adequate functioning of a healthcare system in the wider social domain); professional community (individuals, associations, institutions and other organizations in the healthcare field and in medicine generally), suppliers (companies from which healthcare institutions purchases equipment and consumables), the non-governmental sector, media and society at large.

The category of internal stakeholders consists of the already mentioned employees and managers, and also other individuals and groups who are active within the healthcare institution and have an interest in it, including the owners.

Having in mind that the division between internal and external public has already been characterized as approximate, because their roles and positions can sometimes be interpreted in different ways, examples of this ambiguity can easily be noticed.

In order to illustrate this phenomenon of ambiguity we can take the example of communication with stakeholders of a private general hospital.

Many segments of the professional public (individuals, organizations, institutions and other organizations in the field of healthcare and medicine), who are regarded as external stakeholders, also often have tight relations and certain interests within private hospital institutions, which automatically characterizes them as internal public. Namely, within many national healthcare systems it is regulated that "primary healthcare in the service of general medicine is being realized by the chosen doctor who works in a team with a medical nurse or technician". [3]

It is clear that in this case so-called chosen doctors have an important role in making decisions about the institution their patients choose when hospital treatment is needed. They often have a significant position of opinion makers among their patients, and, in this context, it is natural for the management of a private hospital to tend to have a good professional communication with chosen doctors, taking into account the ethical norms that must be respected in these situations (see subsection 6). Having this in mind, hospital management and its marketing and PR department will dedicate special attention to this target group and it will use similar communication activities as for internal stakeholders. The basic goal of these activities will be primarily to create an environment of mutual trust through the continuous exchange of updated information about current medical services offered by the hospital and the advantages that this institution has compared to the competition. Communication channels in these cases are primarily personal contacts with chosen doctors (during individual and group conversations and presentations), and also an intensive online communication, as well as a constant distribution of adequate printed materials etc.

To a certain extent, there is a similar situation with regard to some other external stakeholders, such as suppliers (when cobranding certain products and offers in the interest of final beneficiaries), governmental and non-governmental organizations (when it is needed to conduct mutual activities for preventing certain types of medical conditions) etc.

On the other hand, within the ownership structure (in the internal stakeholders domain), there are often investors, e.g. individuals, interest groups, companies, governmental and non-governmental institutions which invest money in the development of a healthcare institution and thus obviously have clear interest when it comes to its work and success, but are not tightly connected to its activities in practice, so we can regard them as external publics from a communication point of view.

It is clear that in all these and similar cases, during the process of exchanging information to certain stakeholder groups, different communication techniques and tools should be utilized, with the main goal of creating an appropriate communication synergy and strategic consistency among all messages that different stakeholders and the overall public are receiving. Exactly this reflects the essential value of any good communication strategy, which is supposed to efficiently present core values of a healthcare institution, as well as its vision and the importance of its role in society.

A good communication strategy is based on an adequately established planning cycle which is supposed to clearly determine its directions and focus. For communication to be effective, objectives must be precisely determined and it should be directed to a correct target group. Then, adequate communication channels (media) must be chosen, so that synergistically organized messages would be able to reach targeted recipients in the most efficient way.

We have already noted that the IMC exactly represents a practice of unifying all tools which are used in marketing communications with the aim of sending a consistent and persuasive message that will promote the goals of a particular institution in the

healthcare field. All people that are in some way connected to the brand have their role in integrated communication. Every contact of a particular healthcare organization with the public represents a unique interface, as an important part of communication strategy.

If we again take the example of a private hospital, it is clear that everybody is included in the IMC sector: individuals who directly communicate with service users (medical and administrative staff) and with representatives of external publics, space designers or people who care about organizing patient transport, specialized bodies within and outside the institution who are in charge of all kinds of communication activities with the stakeholders... In this sense, there are two key spheres of complex organizational activities that should get special attention: advertising and public relations.

4. Advertising, Public Relations and Media Relations in Health care

Advertising is usually defined as "a paid form of persuasive communication[2] that uses mass and interactive media to reach broad audiences in order to connect an identified sponsor with buyers (a target audience), provide information about products (goods, services, and ideas), and interpret the product features in terms of the customer's needs and wants". [2]

In traditional advertising, the message (mostly non-personal) is transmitted through various types of mass media. This means that the classic advertising message realized in this type of media (such as - broadcasting media: television, radio, cinema and video advertising; out-of-home media: billboards, bus shelters, vehicles, transit areas etc.; print media: newspapers, magazines, brochures, flyers, directory advertising and so on) still and most often is not precisely targeted at a specific person. However, the situation in this sense is changing every day due to the use of new digital technologies and numerous alternative and interactive media (internet, video games, wireless communication, guerilla marketing, etc.).

Public relations (PR), on the other hand, are a type of communication that tends to make different contacts with specific target groups. Specifically, people working in the PR sector produce different content (press conferences, press releases, different kinds of events and pitches, etc.) that attract media attention. In this case, people employed by the media, in accordance with the nature of their business, convey information about certain products or services within their media space.

So, the basic formal difference is the following. When applying advertising methods, the advertiser pays the media and clearly signs the message he sends to the public. This does not happen with public relations techniques, because the media have to convey a message that they consider relevant to the audience, and it is signed by their journalists or other associates, without any financial compensation.

However, it is clear that these two different but also complementary methods of communication have various techniques and approaches for specific target groups, but are also intertwined in practice. In any case, the ultimate goal of any well-organized

[2] Of course, the "paid form of persuasive communication" does not have to refer to some type of social advertising, such as *social marketing*, in which some services of professionals in the field of communications or use of the media may be free of charge, because this type of marketing promotes goals that are considered to be *a common good*.

communication strategy is to create strategic consistency among all the messages their stakeholders need to receive.

A special and extremely useful communication tool, especially in areas such as healthcare, is the so-called *word of mouth (WOM)* or *buzz*. This term represents a method of direct voice communication that refers to the promotion of a product/service and that is orally transmitted from one person to another. Over the last fifteen years, the principles of this type of communication have also been widely transposed into the digital sphere due to the rapid development of wireless communication and social networks.

Similar to the previous subsection, we will return to the example of promoting services and activities related to specific stakeholders that could be implemented by a private hospital. Namely, we have already mentioned a larger number of external and internal stakeholders when it comes to the communication activities in healthcare. If a proper communication strategy is put in place, they can all be covered by different advertising and public relations activities.

The majority of stakeholders will receive messages regarding the general promotion of an institution, which is usually performed during so-called *launch campaigns* conducted with the aim of informing the public that a new healthcare facility has appeared on the market. Advertising messages will be released by numerous mass media, and public relations activities will be intensified with the aim of raising awareness in the general public and establishing its proper image.

However, in the context of a communication strategy, the use of specific tools for specific target groups should be envisaged. For example, when it comes to advertising tools, special print materials (brochures) and posts on social networks should be created in addition to relate to employees (internal stakeholders), but also to some types of external stakeholders, such as chosen doctors. From a PR point of view, events should be organized for both target groups in order to create the already mentioned environment of mutual trust through continuous exchange of updated information in regard to current medical services offered by the hospital and the advantages that this institution has compared to the competition. Events like those will generate an adequate *buzz* and the information that hospital management wants to release will continue to be disseminated to the public.

In the healthcare institutions that are using an effective IMC mix, marketing and PR professionals (together with specialized agencies in this field and the experts they will hire) should coordinate messages in order to create appropriate and strong communication synergies.

One of the most important activities that the PR sector within the healthcare facility needs to implement is working with employees to enhance their communication skills and capacity for team work and creative problem-solving, which can be achieved by organizing appropriate training and constant monitoring of their progress in the work.

5. Crisis communication

A crisis is an event that can cause significant negative consequences for the organization and its reputation. Time plays a very important role in crisis communication, as an adequate response in the first hours is crucial for public perception and further development of the situation. Healthcare crises generally lead to an especially high degree of public attention and risk of social panic.

It is recommended that healthcare organizations estimate their systemic weaknesses and consequential risks in advance, in order to take actions that will primarily prevent issues in the future. Brainstorming is a technique that can help with predicting potential incidents.

Healthcare crises can be classified in the following manner:

- Public health crises: epidemics, tainted medication, mass-casualty incidents (bioterrorism, mass-transportation accidents, natural disasters) etc.
- Legal crises: professional malpractice (medical or administrative), confidential data exposure, allegations of law violations, lawsuits, losing medical license etc.
- Staff crises: inappropriate behavior, felonies, misconduct allegations, falsified credentials etc.
- Administrative crises: collective layoff, poor finances, administrative policy changes etc.
- Patient care crises: missing patients, abductions, suicides, assaults, hostage situations etc.
- Facility crises: structural damage caused by accidents, natural disasters, terrorism etc.
- Cybersecurity crises: significant malware attack, espionage etc. [4]

Pre-crisis preparation entails creating a crisis communication plan. The plan establishes a crisis communication team (consisting of people from different organization areas), one trained spokesperson, a contact person, and core messages for the public that will address the crisis. It is recommended to consult communication experts. Chain of command and means of internal communication in crisis situations should be clearly stated.

The crisis communication team determines key types of audiences who are directly or indirectly involved in the issue and creates appropriate messages for addressing the concerns of each sub-group. If legal experts are involved, the communication team and legal team should coordinate their messages beforehand. It is necessary to be aware of different communication channels and use them appropriately, without neglecting the rapidly growing influence of digital media and social networks, which can be of great help for informing relevant stakeholders. Traditional media are an economical pathway for communicating with mass audience, while new (online) media are suitable for reaching narrow, "niche" audiences as well. It should be noted, however, that crisis communication is not synonymous with media relations, and it does not involve only external public, but internal public as well, such as doctors, nurses, administrative staff, managers, board members etc.

During the crisis, communication experts suggest taking responsibility for solving the problem as soon as possible, putting the public interest first, displaying honesty and transparency, constantly informing the public about the situation, being accessible, and not refusing to answer any of the questions and concerns of the media. Deception, ambiguity, disingenuous responses and duplicity are shown to carry a great risk of making the crisis worse. It is very important to protect the patients' private information during the whole process of crisis communication.

If the crisis is the result of the healthcare organization's mistake, the representative of the organization should: apologize, admit fault, explain what happened, explain how this type of error will be prevented in the future and offer fair compensation.

Healthcare crises almost always involve strong emotional responses. Feelings of involved parties and the public must be acknowledged and adequately addressed with empathy and care. The creators of communication strategy should be especially mindful of the emotional impact of their messages. A message should consist both of presented information and the feeling tone it carries. The healthcare organization should not display a defensive tone or be primarily focused on itself. Rapid positive action will be more effective than evading responsibility or shifting blame. A professional and calming tone is preferable. The core messages should be presented in the simplest and most clear way possible. Over-complicated messages filled with professional jargon are not advised.

Spokespersons or other individuals designated for making public appearances (at conferences, interviews etc.) and writing press releases should be skillful and experienced in these types of communication, also when it comes to non-verbal communication. Poor delivery can greatly reduce the effectiveness of the message, or even make the opposite effect.

After the crisis, a post-crisis evaluation should be conducted. It analyses all internal and external factors that were involved in the situation, in order to prevent future crises and implement optimal communication strategies if they occur. The evaluation should be accompanied by a remediation plan, aimed at rehabilitating the reputation of the healthcare organization, with respect to long-term negative consequences caused by the crisis.

In some cases, the professional and ethical conduct of the healthcare organization during the crisis may lead to achieving a better reputation after the crisis than before. Especially a successful and responsible reaction to the crisis can improve the public image and strengthen the trust of the audiences.

Crisis communication expert, W. Timothy Coombs, identifies five post-crisis best practices:

- "Deliver all information promised to stakeholders as soon as that information is available.
- Keep stakeholders updated on the progression of recovery efforts including any corrective measures being taken and the progress of investigations.
- Analyze the crisis management's efforts for lessons and integrate those lessons into the organization's crisis management system.
- Scan the Internet channels for online memorials.
- Consult with victims and their families to determine the organization's role in any anniversary events or memorials." [5].

6. Ethics, social responsibility and Communications in Healthcare

Ethics is a crucial element of responsible communications and PR practice, as a set of moral principles that guides human behavior. This is especially the case when it comes to healthcare communication.

Philip Kotler and his associates believe that "today's customers want marketers to treat them as whole human beings and acknowledge that their needs extend beyond pure consumerism. Successful marketing is thus distinguished by its human or emotional element." [6]

The Global Alliance for Public Relations and Communication Management, representing around 280,000 practitioners and academics around the world, has asked

PR and communication professionals to demonstrate societal responsibility by applying the following guidelines:

- "Creating and maintaining transparent - open, honest and accessible - processes and credible communication that balance public interests with organizational needs.
- Supporting the sustainability strategies of the communities from which the organization obtains resources and its license to operate.
- Ensuring that communication on behalf of employers, clients and brands does not overstate the value of products and services, which would distort the expectations of consumers and other stakeholders.
- Defining accountability metrics against which contributions to society should be measured and improved." [7]

TARES Test of Ethical Advertising is a simple but helpful tool for advertising and public relations professionals, which determines whether the content is ethical by asking five questions: is it truthful to its audience (T), authentic in representations (A), respectful in its persuasion (R), equitable to all recipients (E) and socially responsible (S). [7]

Healthcare marketing is an especially sensitive topic in relation to ethical concerns. Potential clients of health services, particularly individuals suffering from serious conditions, belong to a category vulnerable to emotional manipulation and are easily influenced by exaggerated promises.

Historically, controversies related to medical marketing can be traced back two centuries, when traveling salesman sold "miracle elixirs". During the post WWII period, before the establishment of legal marketing regulations in this field, paid medical doctors used to endorse products such as cigarettes, claiming that the particular brand is healthier than the competitive one.

Healthcare marketing does not have the same creative and artistic liberties as most other forms of marketing. Hyperbolic and ambiguous phrases must be avoided, as well as promising results that cannot be consistently achieved. Using unprovable, subjective, superlative and unsubstantiated statements is not acceptable ("best in the world", "most trusted" etc.). Also, it is considered unethical to promote a healthcare organization by using a negative campaign against other healthcare providers (unfair competition). Paid advertising should be identified as such. A healthcare organization should be mindful of all relevant marketing guidelines and laws, on a local, national and international level.

Marketing communication cannot present information in a misleading manner or display discrimination. Limitations of marketing space and time can be challenging in regard to presenting a detailed objective description of the health services that are being offered, which increases the risk of ethical dubiosities. That is why a health advertiser should consider what media form is the most ethically suitable in every individual case. It is ethically problematic to hire paid actors who will falsely present themselves as medical professionals, or to implicitly or explicitly state incorrect credentials of a physician (subspecialty training, type of medical degree etc.). [8]

Particular caution is advised when advertising alternative, experimental or controversial medical services that are not a subject of professional consensus. When it comes to special offers (free services, discounts etc.), it is deceptive to avoid mentioning any "hidden costs". Healthcare advertisers are strictly forbidden to disclose any private patients' information without their formal consent.

There are many other ethically problematic practices used in healthcare marketing, such as: fear mongering, presenting only the positive sides of a procedure or medication

(without mentioning risks and side-effects), altering videos and images digitally in a deceptive manner ("before & after photos") and many other possible manipulations.

The healthcare industry has the right to present its services to the public through all legal channels, including advertising. However, healthcare advertisers have to consider the ethical norms and the long-term public interest. A healthcare provider has the responsibility to be aware of the advertisement's impact on the public perception of the medical profession and its dignity.

7. Conclusions

Communication activities in the field of healthcare are a complex phenomenon and they may heading in various directions.

In this chapter, we have considered the relationship between the different actors involved in this process and analyzed the various communication activities targeted at specific individuals and groups.

All healthcare institutions have a need for adequate and successful communication with their external and internal stakeholders. Every contact of a particular healthcare organization with the public represents a unique interface, as an important part of the communication strategy. Therefore, it is very important to create strategic consistency among all the messages that stakeholders need to receive. That is why we have paid special attention to the role that integrated marketing communications as a whole play in the field of healthcare, as well as issues related to sensitive topics of crisis communication, proper respect for ethical standards and attitudes towards social responsibility.

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Exercises

1. What is the purpose of *integrated marketing communications (IMC)*?

2. What are the two types of *stakeholders*?

3. What are the most important formal differences between *advertising* and *PR*?

Answers to the Exercises

1. Integrated Marketing Communications (IMC) present a practice of unifying all tools used in marketing communications, in order to send a consistent and persuasive message that will promote the goals of a particular institution.

2. Internal and external.

3. The basic formal difference is that, when applying advertising methods, the use of the media is paid and the advertiser clearly signs the message he sends to the public; while this does not happen with public relations techniques, because the media have to convey a message that they consider relevant to the audience, and it is signed by their journalists or other associates, without any financial compensation.

Problems/Challenges

➢ One of the physicians at your healthcare organization has been accused of medical malpractice: misdiagnosing the patient's condition and allegedly trying to hide the mistake. How should the organization react, when it comes to communication strategy?

➢ Here is a hypothetical advisement for a particular dental procedure: "At our clinic, we offer the procedure X, performed by top doctors in Europe. If you don't schedule the appointment right now, you are at risk of developing serious tooth disorders!" Rewrite this advertisement copy by following recommended ethical guidelines.

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SECTION 3

Healthcare Management and Economics

Preamble

In the last decades radical changes in the health care market have occurred: increasing number of sick people, double digit inflation, economic stagnation and more competition. How can a healthcare organization survive and compete with other health institutions? The third block therefore contains chapters on Health Economics, Financial management, Management Accounting and Management and marketing in health institutions. HIM professionals should have some insight in these subjects.

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Fundamentals of Health Economics

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Abstract. Application of economics in the healthcare area is relatively new. Until recently, the public health scene has not understood the importance that the application of well-established economic concepts could have in this field. Fortunately, it is now well recognized that the introduction of economics in health (health economics) is of great importance. While other disciplines contribute to the understanding of factors that determine the health of an individual, health economics contributes to a better understanding of an individual's behavior that would ultimately have a strong influence on his health condition. A health economist explains individual behavior as a process in which an individual makes decisions by comparing current health condition, time and financial costs on one side and future health contributions such as a decrease of the probability of getting a disease or death, on the other side. Clarification of this issue, as well as numerous other issues concerning health economics applications are the central challenges for this field of research.

Keywords. Health, health economics, health care, efficiency

1. Introduction

There are several disciplines like biology, medicine, epidemiology, public health, psychology, and sociology that deal with research about determinants of (good) health. We have listed only those disciplines that have a long history in this field. Economics is relatively new in this field. In the public health scene, we consider economics as a way of calculating costs (if considered at all), and answers to the challenges of high disease costs have been left to the disciplines that have traditionally dealt with this field. [1] However, health economics can offer much more. Other disciplines can contribute to understanding which factors are important, and which sociological or biological mechanisms can explain the role of these factors. On the other hand, the contribution of health economics consists mainly in a better understanding of the causes of differences in health behavior of individuals. An economist explains the behavior of an individual as a process in which an individual makes a choice between his or her current state of health, time, and financial costs, on the one hand and future health benefits, in the form of a reduction in the likelihood of illness and death on the other.

Although an individual's state of health is determined by the genetic inheritance that an individual receives at birth, the risks of the environment to which an individual is

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exposed during his or her life, accidental events such as accidents, and the development of technology, his or her state of health is primarily determined by the individual's behavior. This is where health economics comes in, with its microeconomic analysis in particular. Individual behavior and behavioral changes in response to changes in the alternatives at his or her disposal often have long-term effects on an individual's health. [1]

For example, many individuals are consuming narcotic drugs that are very dangerous to health. Can economic theory, which insists on “rational behavior”, explain why individuals engage in such activities, even though they are aware of the risk that they are involved in? This and other issues of application of microeconomics in the field of health will be the subject of this chapter.

2. Learning Outcomes

- Acquiring knowledge on the specific economic characteristics of the health system and the healthcare market;
- Understand the concept of production function in the domain of health and health care;
- Interpret economic rational behavior and understand the economic reasons that lead to weaknesses and failures in healthcare markets;
- Understand and interpret the decisions of health care providers;
- Understand and interpret the economic reasons behind trends in the health system.

3. Health, Health Care and Health Economics

Health is a word we all very often use and hear in everyday conversations. But what exactly is health? It is defined by the World Health Organization (WHO) as "a state of complete physical, mental and social well-being". For most people, health is simply the absence of illness and weakness. However, this definition is problematic given that health conditions and general conditions differ among more or less developed countries. Thus, diseases such as infection with intestinal parasites or the first stage of malnutrition, considered diseases in countries with high health standards, may be such a normal occurrence in any developing country that no one even considers them abnormal.

Healthcare is a set of services, products, institutions, regulations and people. Although the health sector has many characteristics in common with other areas of economics, the set of unusual economic characteristics that exist in the health market is quite large. Some of these features are:

- The degree of government involvement;
- The dominant presence of uncertainty at all levels of health care, starting with the variability of individual illnesses up to understanding how well medical treatment works and for whom;
- Asymmetric information: a large difference in knowledge between doctors (and other providers) and their patients, users of medical services. This asymmetry leads to moral hazard issues.

- Externalities - behavior of individuals that creates costs or benefits to others.

Each of these characteristics is also present in other areas of economics, but rarely anywhere, as much as in healthcare, and nowhere in such a wide combination. There is uncertainty everywhere. Uncertain events govern the behavior of individuals and the health market. The presence of uncertainty leads to the development of health insurance, which, in fact, controls and directs the use of resources in economy. The presence of various forms of uncertainty is largely responsible for a strong government involvement in this area.

3.1. The history of a health economics

Health has become a very significant economic and political issue in the world in the last forty years, when countries began to make rapid increases in health care costs.

After the Second World War, the health sector began to develop rapidly. A few years later the definition of health, as presented in the introduction to this chapter, emerged. With this definition, health gained its social dimension. Since then, healthcare has begun to revolutionize, with a significant increase in knowledge about diagnosing and treating diseases. Fifty-sixty years ago, doctors did little more than diagnose: "They could identify the disease, observe it further, and patients would receive some basic instructions for the duration of the disease." [2] Now, there are very sophisticated solutions in this area for very complex problems, such as: kidney dialysis, organ transplantation, various types of vaccines, CT scanners, nuclear magnetic resonance imaging, artificial insemination. What this says is that health care is evolving: for example, heart transplants were completely unknown 15 years ago, while they are widely applied today.

The rapid development of healthcare has also influenced the development of a new branch of economics, the health care economics. How and when was the need for health economics born? In his works, 1929-1936, Milton Friedman dealt with issues relating to differences in income among professions such as physicians or dentists, due to the highly pronounced individualization of services and differences in quality. However, he was mostly concerned with statistical issues in his research. It was not until the late 1950s and early 1960s that economics began to attach importance to health problems. One of the first authors to define health economics was Selma Mushkin in her 1958 work, “Towards the Definition of Health Economics”. [3] In her paper, she emphasized that it is wrong to identify health care economics with money issues in the health field, and defined it as a broad science that “analyzes the optimal use of scarce resources to care for the sick people and improve health, considering the possible alternative uses of these resources.“ Later, in her 1962 work, “Health as an Investment”, she states that individuals develop themselves by investing in health and education, and the future income they receive. [4] A similar argument was made by Grossman in his work in 1972, but he was much more academically recognized. By this time, the idea of individuals investing in themselves has begun to be accepted, and the formal Grossman model refers to viewing health as an amount of good, so if we want to maintain it above the minimum (death) level, we must invest in it (which was Mushkin's attitude as well) by buying market goods, such as medicines, food, etc., and investing our own time. The model looks at depletion of health funds over time, as well as at the demand for health for different income and education levels. When we talk about the development of health economics, we need to mention two more authors. They are: Mark Pauly and Kenneth Arrow.

So, health economics, as a branch of economics, came into being in the 1960s, in America. There are many reasons why this area originated in America, but certainly the most important one is the Cold War, after which financial and intellectual resources became available that could answer empirical questions, among which health problems became a priority. Furthermore, health economics is divided into two branches. The first is health economics, officially started by Grossman, which is more concerned with theoretical issues and treating health as an investment, as explained earlier. The second branch is health care economics, which is more based on empirical findings, relies heavily on econometric methods, and was created precisely in response to the demand for empirical health studies. The pioneer of this branch is Arrow.

3.2. The role of the economists in the health sector

Why do economists work in the field of health at all? Healthcare, usually, is not an area we associate with economists. However, they did not enter this area without reason. Economists look at making choices and using existing resources to the best of their ability. When economists began to apply economic methods in the field of health, a new area of economics emerged: health economics. Many questions addressed by economists are also the subject of other sciences (eg: how can we improve the quality of life or how can we increase the availability of healthcare), but economists view these questions from a different perspective and provide different techniques to answer these and similar questions.

In all sectors, economists observe resource allocation. Demand is assumed to be unlimited, as it is thought that there is no end to customer desires. On the other hand, resources (such as labor, raw materials, production equipment, land) are limited. Therefore, the scarcity of resources (here we mean the scarcity of resources in relation to the quantity demanded) becomes a fundamental problem that economists deal with. In the field of health, this scarcity affects all those who work in it, as well as those who need health services. The question that arises is why the consumption of health care resources has increased significantly in recent decades. Also, why is it that no matter how many doctors and nurses are employed, and how many new technologies are being implemented, even rich countries are unable to provide the best healthcare for their citizens? Is it due to investing in the wrong kind of health care services? Are they investing in technologies that have a low health output compared to alternative investments?

All countries have to make decisions on how to allocate resources, whatever they have, for the production of health care, as well as on how to distribute produced health care to those in need. Economics in general, and health economics in particular, has two sides: a positive one, which deals with explaining how selections are actually made, and a normative one, which deals with what choices should be made. Furthermore, there are two ways in which a country can make choices about the allocation of resources for health care production and its further distribution. A country can leave these decisions to the market, allowing supply, demand and prices to determine resource allocation, or they can plan, usually obliging governments to collect resources from citizens, allocate them for defined activities, and distribute the services produced to citizens. Debates over which approach has been better were going on in the last century and influenced the formation of numerous political parties, groups and alliances. Countries around the world have taken different positions on this issue and created a significant number of market

and planning combinations in resource allocation, production and distribution of healthcare. Depending on which model countries chose, economists had different roles.

In countries where a model that relies more on planning is selected, the role of economists is reduced to an economic evaluation, that is, an assessment of whether appropriate services are accepted in the health sector, or whether there are technologies and services that would better meet the goals of the health system, such as improving the general health of the population or increasing the availability of health care. In terms of dividing the economics mentioned above, this would fit the normative economics.

On the other hand, in those countries that have given more importance to the market, economists are dealing more with analyzing the impact of particular measures, such as various forms of regulation, subsidies, or the introduction of new activities. Understanding the market involves understanding the demand (how health care users express their preferences through their ability and willingness to pay), supply (the state of the input market, costs, and how service delivery is organized), and their interactions. This is, in essence, a positive activity: explaining what is happening and predicting the effects of introducing change. But it can also be normative, if it was decided that a measure was desirable, such an analysis would be used to determine whether a change should be introduced.

As the health sector has grown rapidly in recent decades, it resulted in a higher number of different market-planning combinations. In those countries that have traditionally been oriented towards planning of the health sector, market elements have been introduced. On the other hand, in health sectors that were more reliant on the market, more planning was introduced, for example through public regulation, or the introduction of new payment methods, such as paying a fee to the provider on a yearly rather than per service basis, which increased the risk for the service providers and therefore a planning function was introduced, usually carried out by a public body.

The two approaches can be compared by observing the health sector outputs in Western Europe, Australia and New Zealand (where health sectors are regulated) and the US (where the market plays a much larger role).

Understanding the limits of economic modelling is crucial before using it as an important input in decision making regarding health care policies. Of course, it is clear that economics cannot provide a solution to all the problems in the field of health care. But it can create a framework for studying the impact of individual decision-making, as well as help define the available alternative mechanisms for resource allocation. When it comes to healthcare economics, we must not be extreme, for example to say that economics matters most, or that the economics has nothing to do with health care issues. Economists do not consider themselves to have the "last word" in this area but believe that they can make a significant contribution.

3.3. Economists, health politics and equality

Economic analysis in the field of health and health care often helps governments and other competent authorities to achieve the goals of their health policies. In order for this to be possible, economists need to know what those goals are. These goals are usually dominated by two aspects: improving the health of the population and fairness or equity. Thus, economists have focused on how to maximize the impact on health and equity. Economics has made it known that selections must be made, and that we cannot get everything we want. While some measures may simultaneously have the effect of

improving health and equity, some require choosing between improving health and equality.

Justice and equity are very demanding goals, and there is a significant body of literature that deals only with defining them. As ideas, both justice and equality have a strong moral connotation. It is almost impossible for anyone, at least publicly, to say that she/he is against fairness. Equality is a slightly different concept, but, again, it is hard to say that one is in favor of widening the health gap between rich and poor. There is no clear definition of fairness or equality, so when it comes to these goals, they must be clearly defined. There are numerous reasons why health and access to health care are unequal. Some people are born with a disease or handicap, some with a predisposition to become ill. Those who do not work or do not have a home can live in risky and unhealthy conditions. Some people, simply, enter risky situations themselves: they smoke, drink or engage in extreme sports. In the end, some people would be better off if they could afford a medical examination. Even when markets are functioning well, poor people are poor, and without help, have limited access to health care.

When it comes to the availability of health care, it is very important to distinguish between the situation that the health system itself leads to unequal access or that the system does not work as planned.

3.4. The relevance of microeconomics in health

After a brief history of health care economics, as well as a discussion of the role of economists in this sector, we will move on to the use of specific economic methods in the field of health, as well as to the economic aspects of health care.

Economics is a way of organizing our thinking, with the goal of solving our everyday problems. The value of economics is precisely that it can be used to solve many complex economic and social problems, including problems in health care. Today, healthcare decision makers need to understand not only medicine, biology, chemistry and similar disciplines, but also statistics, ethics, decision-making analysis, and, of course, economics.

Economics, more precisely microeconomics, is just one of the social sciences that tries to explain and predict the behavior of individuals. But it is unique among the social sciences in introducing the concepts of scarcity and uncertainty. That is, economics observes how scarce resources are allocated to meet unlimited human needs. Furthermore, there is a need for economic efficiency because there are never enough resources to provide all the goods and services desired by individuals in one society. Using resources for one activity prevents them from being used for another activity. When funds are spent on health care, they may not be available in other areas, such as education, defense, etc. The next concept is cost because all resources have alternative uses. The term opportunity cost is defined as the cost of a missed alternative, that is, the benefit we would have had if we had invested the resources in another activity. Part of the budget spent on health care for the elderly cannot be invested in youth education. Money spent on substance abuse programs cannot be spent on assistance programs for pregnant women, etc. Accepting the concept of cost-effectiveness means that choices should be made to maximize the overall utility of existing resources.

Beyond these concepts, it is important to state the basic premise in microeconomics: the rational behavior of decision makers. This assumption creates a consistent framework for individual decision making. Self-directed decision makers respond to the incentives they face. Individuals will always choose the option that is best for them, that is, they

will look for the best way to achieve their goals. Because it is often expensive to obtain and process information, individuals practice rational ignorance, that is, they choose between alternatives with incomplete information.

We will now take a closer look at how these concepts and terms are used in the healthcare field.

When more options are available, the optimal choice most closely matches the goals stated by the decision maker. So, optimization is nothing more than discovering the best possible action to achieve the goals of the decision maker. Conditional optimization takes into account the cost and availability of resources. For example, is it better for a hospital to hire a cleaning company, or is it better to do it on its own? Or, will a small clinic doctor hire an ambulance manager, another nurse or both because of the increased number of patients?

Health care choices must be made at two levels. First, physicians must decide which therapy to prescribe to the patient, and second, policymakers must decide, or plan for, the availability of health care services. Here we have the application of the first of the above concepts, namely scarcity and choice. The provision of health care at any level must answer the following questions: who to treat, when to start treatment, where to treat, and how to treat? While there are multiple ways to choose the best solution, following the above concepts, the best solution will be selected by applying the cost-effectiveness principle.

As we have already mentioned, we assume the rational behavior of all decision makers. Firms seek to maximize profits by taking into account existing technology and the cost of resources that are available. Consumers strive to maximize utility with the disposable income they own and the prices of the goods they buy. Furthermore, decision makers on both demand and supply side think on margin: they must understand the cost as well as benefit of the additional, or marginal, unit. So, assuming rational behavior, which choice is considered optimal? Looking at the figure 1.1. and using aforementioned economic logic, we can say that the consumer will buy goods and services as long as the marginal utility of consumption (MU) exceeds the marginal cost (MC). As marginal utility decreases and marginal costs increase, with the increase in consumption of a good, it will at some point equalize. We can notice that exactly at that point (point B on graph), the difference between total utility (TU) and total costs (TC) is maximized. Applied in the field of health care, the total utility (TU) we receive from medical treatment increases with increasing healthcare, but at a declining rate. For both practical and ethical reasons, physicians are increasing the amount of healthcare as long as there are positive effects. After point A (Figure 1), additional health care would be useless, that is, marginal utility is not worth the medical risk (the concept of opportunity cost).

From an economic point of view, harnessing all possible positive medical effects consumes scarce resources. In fact, any treatment provided after point B is useless - the marginal utility of additional health care is smaller than the marginal cost of obtaining it. In line with the economic principles we have already outlined, costs measure the benefit of missed opportunities, so the resources used to obtain excess healthcare could be used for some other activity.

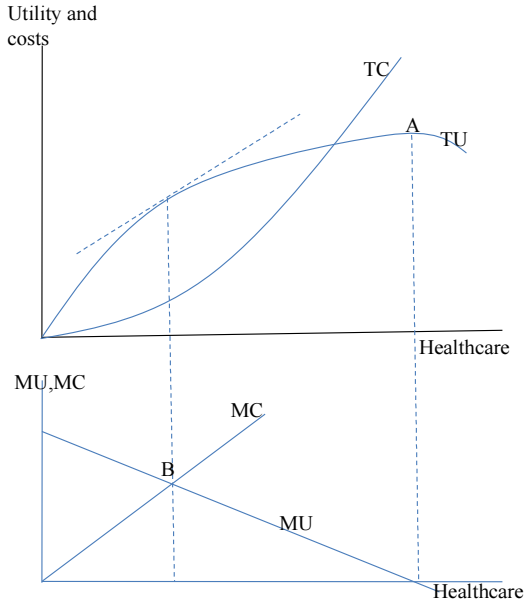

Figure 1 Economic optimization

3.5. Economic aspects of the healthcare

The first question that "comes to mind" when we are thinking about health from an economic perspective is whether or not health is an economic good. Can anyone say that surgery or tooth extraction is "good" in the traditional sense? We think that we cannot think of these or any of the other services provided by health care as good in the traditional sense: they hurt, they cause discomfort, they have undesirable side effects. However, we should think of them in terms of increasing utility. According to the traditional economic understanding, a good increases one's utility, and with a budget constraint, each individual will strive to maximize utility. Thus, we can view health as an economic good given that it makes the individual happy (individual satisfaction) and increases utility. Further, we can view it as a lasting good. Each individual is born with his or her own “fund” of health. Preterm infants or neonates with heart failure, or blind, have a very small initial health fund. Almost every action we take in our lives affects this fund.

Let us define the utility function of an individual. If we denote a health fund by H and a set of other goods and services by X, the utility function will be:

$$\text{Utility} = U(X,H)^{3}$$

According to traditional economics, "more is better", which in this case means that more health creates greater benefits. However, there is something unique about health

[3] We use standard methodology, as in Phelps, Henderson, Goodman and Stano [6], [7], [8], [9]

since the satisfaction we get from using other products and services (X) can increase if health improves. It's much more enjoyable to go to a basketball game if you don't have a headache, for example.

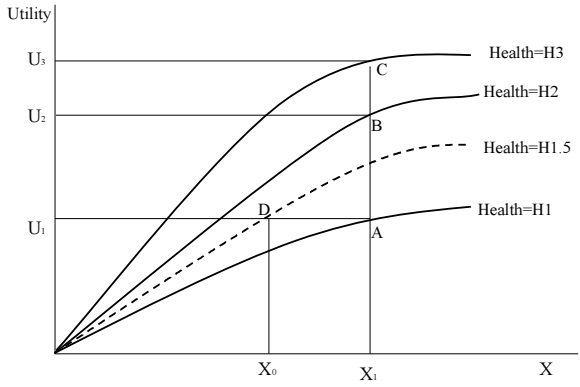

Figure 2. Increasing utility as a function of increasing consumption

Further, we can use standard microeconomic tools to analyze the effects of changing X or H on utility. From the following Figures we can see that utility increases with the increase of X or H. Figure 2 shows that an increase in health, with unchanged consumption of other goods and services, will result in greater utility.

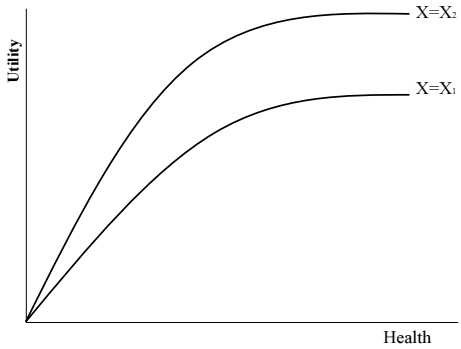

Figure 3. Increasing utility as a function of increasing health fund

Similarly, increasing consumption of other goods and services will, in the case of unchanged health, also increase the utility for the individual (Figure 3). Finally, we can combine the two figures and present in the new figure (Figure 4) different combinations of X and H. So, we come to indifference curves - curves that represent a set of different combinations of X and H that give the same level of utility to the consumer. Indifference curves are convex, downward sloping, cannot intersect and higher indifference curves are preferred to lower ones since they represent higher level of utility. Indifference curves are a very powerful microeconomic tool in describing the many economic phenomena that create / affect health care.

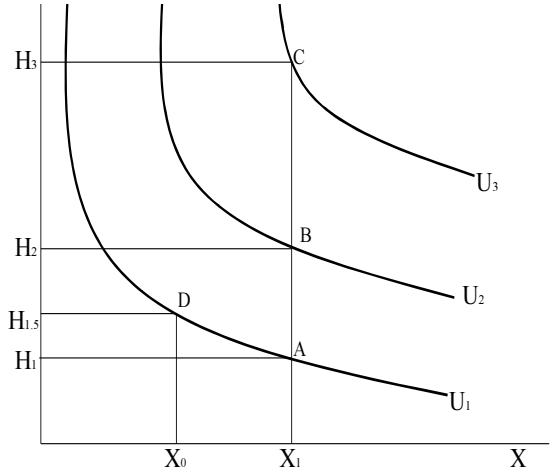

Figure 4. The same level of utility produced by different combinations of X and H

3.6. Brief review of the application of economics in the field of health

Economists dealing with the application of economics in the health field are often criticized for being redundant in this field. Those who make these criticisms believe that healthcare should be viewed solely as a technical issue for medicine as a science, that is, medical experts. The logic is: when one gets sick, he goes to a doctor who prescribes him the proper treatment.

However, in general, the claim that the economics is inapplicable in the health care field is unfounded. If economics is a science that studies how scarce resources are used to produce goods and services, and then observes how goods and services produced are distributed, then economics is certainly applicable in the field of health. Why? It is evident that health care resources are scarce. Moreover, their cost is what worries most people. It is precisely health economics that should answer how much of scarce recourses should society allocate to health and health care. Here, too, the concept of opportunity cost that we described earlier becomes relevant. Given that resources are scarce, if we choose to use them in a particular way, there is a chance that we have missed benefits that we would have obtained if we had used the resources otherwise. Further, of course health care is produced and distributed. Therefore, criticisms that there is no place for economics in the field of health care are unfounded.

One of the criticisms often addressed to economists is the use of the concept of rationality. Let us look at a situation where, say, someone close to us got a heart attack. In that situation, will we consider which option is the most cost-effective, that is, will you consider the cost of emergency services? Of course, we won't. But these are just extreme examples, and most health care does not fall under the "emergency" picture. A significant part of healthcare is optional, which means that the patient chooses whether and when to have an examination. Moreover, a part of health care becomes routine. For example, most people, when they have problems with upper respiratory infections, already have previous experience with this, and do not go to the doctor at all, but decide to treat themselves according to earlier experience.

The specificity of the health services and product markets just makes studying economics challenging! To whom will the heart be transplanted? Why are operations expensive? How many people have been vaccinated against flu? Will the insurance cover the cost of some treatment? These are just some of the issues that are being discussed on a daily basis in hospitals, doctors' offices and our homes. All these issues are addressed by health economics, along with much simpler questions that may have a major impact on our health, such as: what and how much to eat, how much to exercise, whether to rest well or to study until the early hours of the morning, and similar ones.

3.7. Systematic analysis of health care

By now, we have already come to terms with the justification of the existence of health economics as a discipline and have presented a micro and macro view of health and health care. Now, to conclude this introduction, we will use the simplified systematic analysis of health care developed by P. Zweifel and F. Breyer [5], which is shown in figure 5.

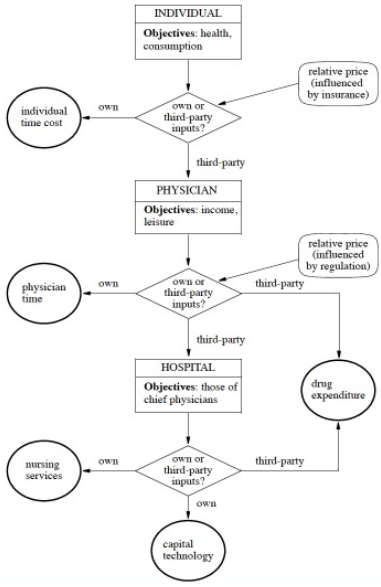

Figure 5. Systematic analysis of health care

The diagram begins with the individual and his goals, including the goal of living as healthy as possible while consuming as much as possible. How individuals behave regarding their health depends on many factors, which will be addressed in Chapters 4 and 5. Health insurance is one of these factors.

However, the state of health is not completely under the control of the individual. The extent to which an individual's behavior affects his/her health care expenditures is largely dependent on the physician. He/she, located just below the individual in Figure 5, plays the role of “gate keeper” at the entrance to the healthcare world. His choice of treatment in or outside the hospital has a significant impact on the costs that will be incurred.

Finally, physicians and hospitals largely determine the patients' demand for drugs. The circles in Figure 5, indicate the inputs generated by healthcare. If there is an intention to engage individuals to replace doctors' time and hospital services with their own time to improve their health, this is possible to a certain level, after which they simply do not have enough knowledge, so their readiness to invest their own time cannot help either.

4. Conclusions

To conclude this chapter briefly. The basic idea we have developed is that the study of health care and health contains essential elements that require quality economic analysis. Many of these elements exist in other fields as well, but nowhere as much as in the field of health. The most important of these issues are: Government intervention, uncertainty, asymmetric information and externalities. We also looked at the history of health economics, as well as the specifics of the micro and macro perspectives on health and healthcare. Finally, we have seen that basic economic principles are also applicable in the field of health.

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Exercises

Please mark the correct answer. Only one answer is correct.

1. Which of the following will lead to equitable access to social, political and economic resources?
a) Legal barriers
b) Health efficiency
c) Health equity
d) Social justice.

2. Health costs are rapidly growing due to:
a) Development of medical technology
b) Increase in knowledge regarding health
c) Increase in importance of the private sector

d) a and b
e) All of the above

3. "A state of having limited knowledge where the future outcome is unknown" best describes:
a) Asymmetric information
b) Utilization
c) Uncertainty
d) Scarcity
e) Choice

Answers to the exercises

1. Correct answer is c.

2. Correct answer is d.

3. Correct answer is c.

Problems/Challenges

- What do economists mean by scarcity and how does it apply to the health system?

- Consider the health system of your country. Do you think that medical spending accounts for a great part of GDP, and if yes, what are the main reasons?

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Financial Management

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Abstract. This chapter deals with financial management in healthcare institutions. Topics which will be covered in this chapter include the function of financial management in a company and elements of financial management. We also discuss types of ownership and related organizational forms of healthcare institutions, which influence financial functions. We are trying to identify the general role and objectives of financial management in healthcare institutions. Having in mind the fact that financial management is based on the information provided through company's accounting we will give an overview of basic accounting concepts. They influence financial reporting, which is also covered in the chapter through a presentation of different types of financial statements and their content.

Keywords. Financial management, accounting, financial reports, decision-making in finance

1. Introduction

Finance is a very broad and dynamic field of science, which is a part of company economics. The term finance as defined by John J. Hampton is the management of the flows of money through an organization, whether it will be a corporation, school, bank or government agency. [1] Managing the finance of a company or an institution is what we call financial management.

In this chapter we will focus on the general principles of financial management and discuss some special features of financial management in entities which provide healthcare services.

2. Learning Objectives

After reading this chapter students will be able to:

- Understand and apply general principles, methods and tools of financial management and types of recording and reporting models.
- Use basic theoretical knowledge of corporate finance for describing and analyzing the financial situation of a healthcare company and its financial performance.
- Understand legal, organizational and financial principles of undertaking and running a (healthcare) business.

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- Analyze suggested solutions to the problems related to financial management within the healthcare area and infer appropriate conclusions.

3. Financial Management and its function in the company

Financial management can be understood as a decision science. From that perspective, financial management is closely related to the accounting function in a company. Accounting is providing information for decision makers in a company, and financial management provides the theoretical framework, concepts and principles in order to make better financial decisions.

Financial managers of a company make three types of decisions [2]:

- Investment decisions;
- Financial decisions;
- Asset management decisions;

Investment decisions are related to capital budgeting i.e. making decisions related to investing assets aimed to provide growth and development of a company business. Investment decisions are related to the strategic financial planning of the company and determine the direction of company development. They are usually prepared by senior financial managers or the Chief Financial Officer and presented to the company Board (representative of owners) which makes final decisions.

Financial decisions concern the day-to-day management of financial assets of the company. These decisions are the responsibility of middle-level financial managers who are responsible to provide funds for daily operations, for example how to raise funds to pay suppliers. These decisions imply making a choice between the use of debt or equity capital, using internal or external funds, or using short-term or long-term bank loans.

After assets of the company have been acquired through proper financial instruments, it has to be managed in order to use them efficiently. The responsibility of financial managers is related more to current assets than to fixed assets. Fixed assets and its efficient use is managed by operational managers who are using it.

The main purpose of financial management is to maintain the financial health of a company and from that point of view its role cannot be overestimated. Of all areas of business, none has a greater responsibility for ensuring a constant focus on the creation of value in an organization. This is very important in today's era of global competition, rapid technology changes and uncertainty of global markets and imposes a need for financial managers to manage company finances from a new perspective.

There are four key elements of financial management [3]:

- Planning;
- Control;
- Organizing and directing;
- Decision making;

Planning implies the responsibility of the financial manager to identify steps which should be taken in order to achieve the goals of his organization. This means that financial managers have to understand the objectives of their organization.

Controlling encompasses the responsibility of financial management to observe whether all parts of the organization are following the plans that are established.

Organizing and directing is related to making decisions how to use available resources in the most efficient way to carry out the plans. Financial managers have to monitor day-to-day operations and check whether efficient use of resources is made.

Decision-making is related to the planning, controlling and organizing and directing because financial managers have to make choices among available alternatives based on the information they have.

4. Financial management in healthcare institutions

Financial management in healthcare institutions is somewhat different than in other types of service providing companies. This issue is primarily related to the ownership structure and organizational type of a healthcare institution. According to the Audit and Accounting Guide for Healthcare Organizations there are three types of healthcare institutions:

- Private non-profit institutions – which are charging services in order to enable self-sustainability and making profit is not their primary goal. Usually these are voluntary organizations related to churches, foundations and NGO-s;
- Private for-profit institutions – investor's owned companies which provide healthcare services and charge it in order to make profits;
- Government (non-profit) institutions – public healthcare institutions which are financed by the state or local government. These institutions provide healthcare services free of charge or against prices lower than costs and are financed from state or local taxes and contributions. [4]

If we speak about three types of decisions which are made by the financial management of healthcare institutions, then we can say that financial managers of private for-profit healthcare institutions are making investment decisions, financial decisions and asset management decisions based on the principles which are similar to service-providing companies from other sectors. However, financial management decision making in government and private non-profit healthcare institutions is somewhat different. The decisions of financial management are limited by the budget provided through contributions from government or private donors. This gives the financial and non-financial managers of these institutions an additional role as they are responsible not only for providing high quality healthcare service, but also for negotiating with financiers to get a higher budget. Budget limits sometimes result in a limited quality of healthcare services.

Different ownership types also imply differences in tax treatment and differences in the organization of these institutions [3].

Having in mind the features of a healthcare organization Michael Nowicki [5] identified six major objectives of healthcare financial management [4], in addition to the accounting and reporting functions, as follows:

- To generate income;
- To respond to regulations;
- To facilitate relationships with third-party payers;
- To influence method and amount of payment;
- To monitor physicians;
- To protect the organization's tax status.

The role of the financial management in healthcare institutions can be looked at from two perspectives. Financial management implies periodical financial reporting; however, the essence of financial management is that financial departments provide information for making proper financial decisions at the right time. We need to emphasize the difference between raw data and information, as information gives context to the data enabling the managers to understand the situation and choose the best alternative.

5. Financial reporting and financial statements

All companies which are legal entities, regardless their organizational structure, industry type or ownership status have a legal obligation to publish financial statements. In addition to the fact that the preparation and publication of financial statements is a legal obligation, it is also a very useful instrument for controlling internal and external financial operations. Business partners, potential business partners, customers, suppliers, and potential creditors are very interested in the financial health of a company. Financial statements give the basic information about the quality of financial operations. Financial statements for all business types and organizations have similar forms and usually follow international standards and basic accounting concepts.

There are different classifications of basic accounting concepts. Different authors attribute different importance to each of the principles, depending on the industry. Principles which are considered important in healthcare are as follows [6] [4]:

- The economic entity principle means that all records and activities of a company or other business organization (legal entity) have to be treated separately from records and activities of its owners, or any related business entity;
- The transaction principle means that all activities and transactions of a company or business entity have to be included and recorded in its accounting records and financial reports;
- Double-entry principle, probably the oldest accounting principle from the 15th century means that every transaction should be double-recorded in accounting: as a change in the form of assets and a change in the source of financing (liability);
- The cost valuation principle means that companies and business entities should record the value of assets, investments and liabilities at their historical cost, which is the actual price they paid to acquire it. Although there is a tendency to replace the principle of the real cost paid by the current market price, or cost of replacement, “historic” cost, or real price paid is convenient as this value is verifiable, determinable and objective to some extent;
- The accrual principle means that in accounting transactions are recorded in the periods they really occurred, not in the period when the corresponding payment (flow of money which follows exchange) was made. Thus, the financial statement related to certain period or certain moment shows whether a transaction happened (for example: when a patient gets the health service) not whether he really paid for it.
- The matching principle is related to the accrual concept and means that accountants should record revenues and all expenses related to generating that revenue at the same time (in the same period). If you record revenue on an

accrual basis, you record all real expenses which resulted from the production of goods or services which are sold in the same period. If the base of the accounting is cash, then revenues and related cost do not necessarily have to be linked to the same moment and period, which can result in problems for financial analysis.

However, the following principles are also very important for healthcare institutions:

- The revenue recognition principle in accrual accounting means that revenues will be recorded at the moment an invoice for the goods or services provided is issued, not when the money is received from the customer.
- The full disclosure principle is important as it provides information behind the financial reports which is important for making decisions for all stakeholders.
- The going-concern assumption means that accounting information is based on the assumption that the company will continue operating.
- The monetary unit assumption means that all transactions of a company or entity are expressed through monetary units.
- The time period assumption means that company life can be divided in shorter time periods such as months and years.

As in all other legal entities healthcare institutions have to publish five main financial statements:

- The balance sheet is also known as the statement of the financial condition of a company at a single point in time. In a nutshell this financial statement presents different forms of assets and the sources for financing those assets (liabilities and equity).
- The income statement gives a summary of revenues and expenses and the resulting profit or loss of a company for a certain period of time. In Europe it is also known as Statement of financial performance, while in US it is known as Statement of operation [7];
- The cash-flow report summarizes cash inflows and outflows that occurred in a certain period of time due to the operating, investing and financing activities of a company;
- The report on changes in equity summarizes the changes in equity that occurred from the beginning to the end of the reporting period;
- Notes to the financial statements or footnotes give additional information related to company's operation and financial position and are an integral part of financial statements. Companies are required to publish this financial report in order to follow the full disclosure principle.

Non-profit healthcare institutions (private and government owned) do not publish the Report on changes in equity but instead the Report on Changes in Unrestricted Net Assets which summarizes the financial elements which caused the changes in net assets of the healthcare institution.

In the following part of the chapter we will present elements of balance sheet, income statement and cash flow statements.

5.1. Balance sheet

A balance sheet is a statement of assets, liabilities and capital of a company or business entity in a single period of time (usually the end of the previous and beginning of the next reporting period). It is a financial report which presents the financial position at a particular point in time – usually the end of the reporting period [8].

The heading of the balance sheet gives information about the name of the entity and the date of the balance sheet. The main difference between the balance sheet of an investor's owned and not-for-profit healthcare organization is in the owner's equity section. In an investor's owned entity it presents the shareholders' equity in corporations or the owners' equity in other organization forms of business, while in the non-for-profit healthcare organizations this section is named net assets, in order to emphasize that it doesn't belong to any person. Net asset is classified into three categories – non-restricted, temporarily restricted and permanently restricted, depending on the level of limitation (restriction) imposed by the donor. The structure of balance sheet of investor's owned and non-for profit healthcare institutions are presented in the Table 1.

Table 1. Balance sheet structure for investor owned and non-for-profit health institutions

	Name of entity Balance sheet DATE		
	Investor's Owned Entity	***Non-for Profit Entity***	
	ASSETS	**ASSETS**	
1.	Current assets	Current assets	1.
2.	Non-current assets	Non-current assets	2.
I)	**Total assets (1+2)**	**Total assets (1+2)**	**I)**
	LIABILITIES	**LIABILITIES**	
3.	Current liabilities	Current liabilities	3.
4.	Non-current liabilities	Non-current liabilities	4.
II	**Total liabilities (3+4)**	**Total liabilities (3+4)**	**II.**
	SHAREHOLDER'S EQUITY	**NET ASSETS**	
5.	Common shares	Unrestricted	5.
6.	Retained earnings	Temporarily restricted	6.
		Permanently restricted	7.
III	**Total Shareholder's Equity (5+6)**	**Total Net Assets (5+6+7)**	**III**
	TOTAL LIABILITIES AND SHAREHOLDER'S EQUITY (II+III)	**TOTAL LIABILITIES AND NET ASSETS (I+II+II)**	

In addition, the balance sheet includes key pertinent information on shareholder's equity/net assets which include account policies, payment arrangements with third parties, asset restrictions, property and equipment, long-term debt and pension obligations.

Assets represent a resource with economic value whose use is controlled by the owner (individual, group, or state). Its use should provide benefits in future and/or increase the value of the firm. Assets are recorded by their actual costs if not donated. Donated resources are recorded at fair value at the moment of donation. Assets are classified as non-current (long-term) assets and current assets. Non-current (long-term assets) are resources to be used during a period of time which is longer than one year, whereas current assets are resources used or consumed within a year. Current assets may include cash and cash equivalents, investments, patients account receivables, receivables from 3rd party payers, inventories, assets held for sale, prepaid expenses. In non-for-profit health-care entities there can be also current assets whose use is limited or restricted by the donor's requirements. Non-current assets may include capital equipment, long-term facilities such as buildings, property, equipment, long-lasting goods, machinery, trucks,

transport vehicles. There are also items such as self-insurance, benefit plans, goodwill, net accumulated depreciation.

Liabilities represent the company's financial debt, or other financial obligations of a company to its creditors. There are two types of liabilities: if they are due within a year – current liabilities; if they are due within a period longer than a year – non-current (long-term) liabilities. Current liabilities may include accounts payable, accrued expenses (expenses are recorded when incurred, not when payed), non-paid salaries and wages, payables for third parties, non-paid taxes, commercial papers, short-term debt. Non-current liabilities may include long-term debt, retiree health costs and accrued pensions.

Investors' owned healthcare entities have shareholder's (owner's) equity which consist of common stock (initial investment) and retained earnings (profit which is reinvested during the years of operation). Net assets in non-for-profit health entities is the difference between the total value of assets and its liabilities. There are three classes of net assets: non-restricted, temporarily restricted and permanently restricted net assets. Net assets may also include non-controlling ownership interests in subsidiaries. Unrestricted net assets are part, but not all, of what would be left if all liabilities of a health-care entity were satisfied today. This part of net assets can be used in any way an entity or its management see proper. Its use is not limited by law, regulation, shareholders or donors. Restricted assets cannot be used in the manner which an entity considers as proper. Its use is restricted by the donor, shareholders, or sometimes by the law and regulation. The restriction can be put on the quantity of money which can be used / spent during a certain period of time. There is also a possibility to define how money can be used – what could an entity buy for a certain amount of money. There are two types of restrictions which are imposed to assets: permanent – when restrictions are attached to a certain portion of assets perpetually; temporarily – when the restriction is imposed for a certain period of time.

Table 2. Example Balance Sheet of a Non-For-Profit Healthcare Organization

Hospital "HERA", Montenegro Balance sheet (in EUR) December 31st, 2018.			
CURRENT ASSETS		***CURRENT LIABILITIES***	
Cash and cash equivalents	152,000	Account payables	140,000
Commercial papers	44,000	Accrued expenses	95,000
Account receivables	162,000	Short-term debt	54,000
Inventories	332,000	***Total current liabilities***	***289,000***
		Long-term debt	***350,000***
TOTAL CURRENT ASSETS	***690,000***	***TOTAL LIABILITIES***	***639,000***
LONG-TERM ASSETS		***NET ASSETS***	
Gross Plant, Property&Equipment	930,000	Permanently restricted net assets	171,000
Less Accumulated Depreciation	210,000	Unrestricted net assets	600.000
Net Plant, Property and Equipment	***720,000***	***TOTAL NET ASSETS***	***771.000***
TOTAL ASSETS	**1,410,000**	**TOTAL LIABILITIES AND NET ASSETS**	**1,410,000**

Note: Data in example are imaginary

5.2. Income statement

An income statement, also known as Statement of Financial Performance or Statement of Operations, summarizes revenues and expenses of a healthcare entity over a certain period of time. Unlike a balance sheet which represents a stock (snapshot) of assets and

liabilities at a certain point in time, an income statement refers to flows over a period of time. An income statement is based on the accrual accounting principle, which means that revenues and expenses are recorded when they occur, not when cash payment is made.

This financial statement provides information about the value a healthcare institution earned, which is the difference between the value of revenues and expenses over a certain period of time. It can be positive – profits, or negative – loss, because of which this statement is also known as a profit and loss account. However, as non-for-profit institutions are common in the healthcare business, this name is not appropriate to be used in healthcare.

There are four types [5] of revenues in healthcare institutions. ***Net patient revenue*** is the difference between the ***gross revenue*** which is generated from patients and the estimated amount of money which will not be collected as the result of different contractual allowances and discounts a healthcare institution offers to clients, and the expenses of charity care. Despite the assumption that charity activities will not result in a cash inflow, a financial statement must contain information on the amount of charity care provided based on actual revenues and costs and this has to be part of the notes to the financial statements. ***Premium revenue*** is earned through capitation arrangements and is reported separately because it is revenue collected according to the contract through which a healthcare institution agreed to provide care, no matter whether the service is delivered or not. Other revenues are collected from non-health services which can be provided by a healthcare institution: renting space or equipment, selling supplies, providing catering, café or restaurant services, etc. For non-for-profit institutions there is also an item net asset released from restrictions, an asset which was previously restricted by donors and became available in the meantime.

Expenses of healthcare institutions can be classified in five categories. **Operating expenses** include costs of operations which result in generating revenues: wages and benefits for employees, medical and pharmacy supplies, etc. **Depreciation and amortization** is the cost of non-current assets which is "losing" its value due to their use. Healthcare institutions which have short-term or long-term debts have to pay **interest** to their creditors. **Provisions for bad debt** is an estimate of the amount of money which a healthcare institution cannot collect from its clients as a result of their bad financial position. This amount must be reported in financial statements and the estimate should be based on charges. Unlike provisions for charity which was never intended to result in revenues for a healthcare institution, provisions for bad debt refer to activities which were intended to generate revenue. **Other expenses** include different costs which cannot be reported as some of the previously defined types, such as electricity, utilities, travel, office supplies, etc.

The difference between revenues and costs is generally known as profit, or net income, however in non-for-profit institution we speak about excess of revenues over expenses. In investor's owned healthcare entities and non-for-profit institutions we can speak about operating income calculated as the difference between operating revenues (net patient revenues + *net assets released from restriction in non-for profit institutions*) and operating expenses. After interest is deducted from the net operating income at investor's owned entities, we get net income from continuing operation. [8] The following item of an Income statement is Income (or) Loss from Discontinued Operations. It is an after-tax gain or loss on sale of a segment of the healthcare institution. It is distinguished from the income from continuing operations in order to provide information that the healthcare institution sold assets and generated this income during

this reporting period and that only income from continuing operations should be expected during next reporting period. Summing up net income from continuing and net income from discontinuing operation gives us the net income of an entity. At non-for-profit institutions we speak about excess of revenues above expenses which is a performance indicator for such entities. In order to get the final amount of net income attributable to an entity the amount of net income is corrected for the amount of net income attributable to net controlling interests which is related to the entity's ownership in subsidiaries. Excess of revenues above expenses is indeed the increase of non-restricted assets for the subsequent statement of operations. Table 3 gives an example of the Income statement i.e. the Statement of operations for a non-for-profit healthcare institution.

Table 3. Example of Statement of operation for a non-for-profit healthcare institution

Hospital "HERA", Montenegro Statement of operations (in EUR) *For the year ending December 31st, 2019.*	
Unrestricted revenues	
Net patient revenues (net of contractual allowances)	1,005,000
Provision for bad debts	95,000
Net patient revenues less provision for bad debts	910,000
Net assets released from restrictions	120,000
TOTAL REVENUES	**1,030,000**
Operating expenses	
Wages and contributions	433,000
Hospital supplies	120,000
Depreciation expense	185,000
Total operating expenses	**738,000**
Interest expenses	**85,000**
Other expenses	**115,000**
TOTAL EXPENSES	**938,000**
EXCESS OF REVENUES OVER EXPENSES	**92,000**
INCREASE IN NON-RESTRICTED NET ASSETS	**92,000**

Note: Data in example are imaginary

5.3. The Statement of Cash Flow

The statement of cash flows [8] is a financial report which presents cash receipts and their sources, and cash disbursements and their use in the same time period as the income statement. Thus, it starts from accrual based financial reports which present revenues and expenditures at the time they occurred and converts it into a financial report which presents the actual flows of cash. Cash flows are classified into three categories: cash flow from operating activities, cash flows from investing activities and cash flows from financing activities. Summing net cash flows from operating, investing and financing activities gives us information on the net increase or decrease of cash and cash equivalents in a healthcare entity, which is the difference between cash and cash equivalents at the beginning and end of the year (this is an item in the balance sheet).

An overview of potential cash inflows and outflows from operating, investing and financing activities, which can be recorded in the Cash flow statement, is given in table 4, while Table 5 shows an example of Cash flow statement for a healthcare institution. Table 6 shows the relationship between Cash flow statement and Balance sheet items.

Some investing and financing transactions of healthcare entities do not affect cash flows, and thus are not included in Cash Flow Statements. However, such activities have

to be disclosed separately in addition to the Cash flow statement. They include for example leasing assets through capital leasing transactions, closing debt by issuing equity securities, conversion of common to preferred stocks, etc.

Table 4. Cash flows from operating, investment and financing activities

	OPERATING ACTIVITIES	INVESTING ACTIVITIES	FINANCING ACTIVITIES
CASH INFLOWS	Receipts from customers Cash dividends received Interests paid by borrowers Other	Selling fixed assets Selling equipment Selling marketable securities Other	Issuing securities Issuing bonds and notes Issuing short-term and long-term liabilities Taking loans from banks
CASH OUTFLOWS	Wages and contributions Paying suppliers Paying taxes Interest paid to lenders Other	Paying for fixed assets Paying for equipment Purchasing debt investments Other	Purchasing treasury stocks Paying dividends Paying cash loans Paying owners' withdrawals
Net cash flow for reporting period	= **Net cash flow from operating activities**	+ **Net cash flow from investing activities**	+ **Net cash flow from financing activities**
= **cash and cash equivalents at the beginning of reporting period**		- **cash and cash equivalents at the beginning of reporting period**	

Table 5. Example of Cash flow statement for a non-for-profit healthcare institution

Hospital "HERA", Montenegro Cash flow statement (in EUR) *For the year ending December 31st, 2019.*		
CASH FLOWS FROM OPERATING ACTIVITIES		
Changes in net assets	*9,500*	*1*
Adjustments to reconcile changes in net assets to net cash flow from operating activities		
Depreciation	8,600	2
(Increase) decrease in current assets		
Increase (decrease) in current liabilities		
Increase in net account receivables	(45,000)	3
Increase in inventories	(5,000)	4
Decrease in prepaid expenses	7,000	5
Increase in accounts payable	35,000	6
Increase in accrued expenses	8,000	7
Decrease in other current liabilities	(2,000)	8
NET CASH FLOW FROM OPERATING ACTIVITIES	**16,100**	**I = 1+2+3+4+5+6+7+8**
CASH FLOWS FROM INVESTING ACTIVITIES		
Purchase (payment) of fixed assets	(90,000)	9
Sale of old equipment	68,500	10
NET CASH FLOW FROM INVESTING ACTIVITIES	**(21,500)**	**II = 9+10**
CASH FLOWS FROM FINANCING ACTIVITIES		
Payment of long-term debt	(62,000)	11
Increase of long-term debt (taking new loan)	80,000	12
NET CASH FLOW FROM FINANCING ACTIVITIES	**18,000**	**III = 11+12**
NET INCREASE (DECREASE) IN CASH AND CASH EQUIVALENTS	**12,600**	**Net change in cash = I + II + II**

Note: Data in example are imaginary, data among parenthesis are negative

Table 6. Relationship between Cash flow statement and Balance sheet

Hospital "HERA", Montenegro Selected items from the Cash flow statement and Balance sheet (in EUR) *For the year ending December 31st*		
Net increase (decrease) in cash and cash equivalents (*Cash flow statement*)	**12,600**	**Net change in cash = I + II + II**
Cash and cash equivalents at the beginning of year (*Balance Sheet*)	**152,000**	**A**
Cash and cash equivalents at the end of year (*Balance Sheet*)	**164,600**	**B = A + Net change in cash**

Note: Data in example are imaginary, data among parenthesis are negative

6. Financial indicators and financial performance

Information from financial statements are used in financial analysis with the aim to assess the financial performance of a company or organization, in our case the financial performance of a healthcare entity. Financial performance of an entity is analyzed through horizontal and vertical analysis of financial statements, and through the so called ratio analysis.

Horizontal analysis of financial statements is the analysis of trends in the value of a certain item from the financial statement which gives us information about its percentage change over time (for example changes in net patient revenue, or net income, etc.). Vertical analysis evaluates the internal structure of a financial statement. One of the items from the financial statement is considered as the base value and values of all other items is expressed as a percentage of the base. For example, vertical analysis of the balance sheet could express current assets as a percentage of total assets, or net income as percentage of total revenues of a healthcare entity.

Ratio analysis is very important for assessing the financial performance by calculating different financial indicators. Financial indicators are calculated as ratios between different items from financial statements. Ratio analysis enables investors, creditors, clients and other stakeholders of an organization to evaluate the financial health of the organization. Financial performance is analyzed in four important dimensions:

- Liquidity;
- Activity – asset efficiency;
- Capital structure – financial leverage;
- Profitability.

In the limited space we have in this textbook, we will not go into a detailed analysis of financial indicators which represent each dimension of financial performance, but will explain what each of them means.

Liquidity is the ability of an entity to pay short-term obligations before they are due. It can also be understood as availability of liquid assets, i.e. cash or cash equivalents needed to pay current liabilities. Liquidity indicators show how quickly current assets can be converted to cash. The most important liquidity indicators are current ratio, quick ratio, cash ratio, average collection period, average payment period, etc.

Asset efficiency is evaluated through so called **activity ratios.** They are calculated as the relationship (ratio) between revenues and the value of assets, i.e. they measure how efficient the use of assets is for generating revenues. Important activity ratios are

total asset turnover, fixed asset turnover, inventories' turnover, current asset turnover, etc.

Capital structure is analyzed through assessment of the relation between equity and debt capital. Capital structure indicators are used to evaluate indebtedness of a company or entity and is commonly used by banks or creditors in order to see whether an entity can take new loans. The general rule to determine the optimal debt to equity structure says that a company or an entity can increase indebtedness if an investment from a new debt will generate a growth in revenues which will be higher than the repayment annuity i.e. which will increase the company's profit or entity's excess of revenues over expenses. The most important capital structure indicators are share of net assets to total assets, i.e. share of owner's equity to total assets, long term debt to net assets (owner's equity), debt service coverage, etc.

Although profit is not the main goal of healthcare entities, it is important to speak about **profitability** not only for investor's owned but also for non-for-profit entities, despite the fact that high profitability of healthcare entities can bring criticism of the general public. Excess of revenues over costs is important in order to invest for better service quality, in order to provide funds for patients who are not able to pay, to invest in research and better technologies, in order to replace and buy new buildings and equipment. Profitability is measured as the ratio of revenues and expenses. The most important profitability indicator is the so-called profitability margin calculated as the ratio between operating profit (operating margin) or excess of revenues over expenses and total revenues. Besides, profitability is expressed through so called rates of return on assets which measures the relation between return and investment, i.e. excess of revenues over expenses and value of net assets.

7. Conclusions

In this chapter we focused on the importance of finance and financial management in healthcare institutions.

Starting from the general importance of financial management and its function in a company we discussed the importance of the financial function in healthcare institutions. Then we explained the purpose of financial reports, and gave an overview of the main financial statements, with examples from the healthcare industry. At the end, we discussed financial indicators calculated to assess the financial performance of entities, with an emphasis on healthcare entities.

Financial management of healthcare institution is a very broad and deep area which would require much more space to be elaborated in detail. However, this chapter covered its founding principles and keystones and we believe readers will be able to understand its importance and achieve the learning outcomes listed in the introduction.

8. Definition of keywords

- Financial Management is in a nutshell managing the finances of a company or an institution, through planning, control, organizing and directing financial resources, and decision making on how they are used.

- Accounting – the process of recording and storing financial transactions in a company or institution to provide information for decision makers.
- Financial Reports – formal records which summarize the financial activities of a company, person or entity and express the financial position in a single point of time and the financial performance over a period of time.
- Decision-making in finance – making choices among available alternatives on the use of financial resources, based on the information provided through accounting and financial reports.

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Exercises

1. How a healthcare institution records the value of its assets in accounting and financial reports?

2. What can we say about a healthcare institution that does not have enough cash to pay its short-term obligation before they are due? How that problem can be overcome?

3. Define the term **net patient revenue.**

Answers to the exercises

1. A healthcare institution records the value of assets at its historical costs – the cost valuation principle.

2. A healthcare institution can be described as non-liquid. The problem can be solved if an institution does not have more serious problems (if it is profitable). An institution should either collect cash from its clients or take a short term loan to overcome an obstacle.

3. Net patient revenue is the difference between the gross revenue generated from patients and the estimated amount of money which will not be collected as the result of different contractual allowances and discounts a healthcare institution offers to clients, and the expenses of charity care.

Problems/Challenges

➢ Assemble the balance sheet at the end of 2019 and calculate the value of net assets of a non-for-profit healthcare institution with the following information provided: Property & Equipment - €300.000; Cash and cash equivalents – €115.000; Gross Plant, Accumulated Depreciation - €50.000; Account payables – €120.000; inventories - €250.000; Short-term debt – €30.000; Commercial papers - €65.000; Long-term debt – 150.000; Unrestricted net assets is 80% of total net assets.

➢ Say where each of these transactions would be recorded in a cash flow report: a) Hospital care receipts paid by patients; b) Selling (and being paid for) hospital building; c) Selling old emergency room equipment; d) Taking loan from bank for new equipment; e) Paying wages and contributions for hospital staff; f) Signing contract, and buying for new supplies (payment is still not made); g) Paying for new equipment.

Solutions to the Problems/Challenges

➢ Balance Sheet of Non-For-Profit Healthcare Organization is given below:

Balance sheet (in EUR) December 31st, 2020.				Calculation
CURRENT ASSETS		***CURRENT LIABILITIES***		***NET ASSETS = TOTAL ASSETS – TOTAL LIABILITIES***
Cash and cash equivalents	115.000	Account payables	120.000	
Commercial papers	65.000	Short-term debt	30.000	
Inventories	250.000	***Total current liabilities***	***150.000***	***NET ASSETS = 680.000-300.000***
		Long-term debt	***150.000***	
TOTAL CURRENT ASSETS	***430.000***	***TOTAL LIABILITIES***	***300.000***	
LONG-TERM ASSETS		***NET ASSETS***		
Gross Plant. Property&Equipment	300.000	Permanently restricted net assets	76.000	380.000 x 20%
Less Accumulated Depreciation	50.000	Unrestricted net assets	304.000	380.000 x 80%
Net Plant. Property and Equipment	***250.000***	***TOTAL NET ASSETS***	***380.000***	***680.000-300.000***
TOTAL ASSETS	**680.000**	**TOTAL LIABILITIES AND NET ASSETS**	**1.410.000**	

➢ a) Hospital care receipts paid by patients– cash inflow – operating activity;
b) Selling (and being paid for) hospital building – cash inflow – investing activity;
c) Selling old emergency room equipment – cash inflow – investing activity;
d) Taking loan from bank for new equipment – cash inflow – financing activity;
e) Paying wages and contributions for hospital staff – cash outflow – operating activity;
f) Signing contract, and buying for new supplies (payment is still not made) – would not be recorded as there is no cash outflow from this operating activity yet;
g) Paying for new equipment – cash outflow – investing activity.

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Management Accounting

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Abstract. Healthcare institutions are business systems that provide different medical products and services to improve the health and quality of life of users of products and services. First of all, this is reflected in the differing complexities of the business, but also of the products and services they offer, as well as the different costs they cause. Thus, some products or services cause high indirect costs, while others require higher direct costs. For health care managers to make the right business decisions, they must continually have timely, quality and truthful information at their disposal. This information is provided by the management accounting of the institutions. This paper aims to present management accounting activities that enable the acquisition of information necessary for decision making.

Keywords. Management accounting, costs, cost price, cost drivers, budget, variance analysis

1. Introduction

This chapter will set out management accounting frameworks. Their tasks and the differences with respect to financial accounting will be presented. It will outline what activities are being implemented within management accounting with the aim of preparing reports for the management.

First of all, one of the significant activities in management accounting is calculation of costs and calculation of cost price of products or services. Calculation of costs includes all activities related to the monitoring of costs and their allocation to cost centers that may be individual parts of the company or individual tasks or activities. Calculation of cost price provides information on which costs an institution makes to produce a product or to do a service. Based on these activities, the management of the institution has information on what amount of costs each product or service has incurred. These data form the basis for future business decisions, as well as whether any changes to the business need to be made. Another significant activity of management accounting is budgeting. The budget is the plan of the institution's business for a certain period in the future. In fact, the budget is a guide that shows how an institution should operate in the future. In this regard, budgeting is an important dimension in the processes of planning, controlling and evaluating the outcomes of an institution's operations [1].

Thus, management accounting plays an important role in managing institutions. It enables one to look at the business of institutions in the past and to mark the causes of bad and good business. On the other hand, on the basis of this and future business

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guidelines, management accounting provides the basis for realizing the current and strategic goals of the institution.

2. Determinants of Management Accounting

Management accounting is implemented within the institution itself and provides information that enables management to monitor and control the business and make business decisions[1]. For this reason, management accounting is considered internally focused, and the term ***internal accounting*** is often used.

Information that is prepared under management accounting is included in internal financial statements or management accounting reports. These reports should contain all the information needed by the institution's management for decision-making, planning and control. They are significantly different from the external financial statements prepared in the context of financial accounting. This kind of accounting records, classifies and summarizes the data on which the external financial statements are prepared. In this regard, financial accounting provides historical data on assets, capital, liabilities, expenses, revenues and financial results that are relevant to internal and external users. Therefore, the external financial statements are prepared for the needs of the institution, but also for the needs of external users such as: shareholders, creditors, tax authorities, government institutions, regulatory bodies, the public, etc. These statements include predefined information grouped in standardized forms to meet regulatory requirements. Internal statements, on the other hand, have a flexible content and form and are prepared according to the requirements of management, both in terms of the information they need and how often reports are urgently required [1], [2]. In addition, the main features that differentiate these two types of reports are:

- detail in reporting
- frequency
- timeliness
- orientation towards the past or the future

Internal reports are more detailed than external financial statements and can be summarized to the extent necessary. Also, they occur as often as required by the management of the institution and the reporting is not strictly related to a specific period of time. External reports, on the other hand, contain information that is grouped into appropriate categories and are compiled for a specified period of time defined by their users. Usually this period covers the previous year. External reports are not characterized by the timeliness of reporting, because there is a significant delay period between the period to which it relates and its publication. Internal reports, however, can be prepared with minimal delay, when the institution's accounting has an appropriate accounting system in place that will enable this. Regarding the characteristic of the reporting orientation towards the past or the future, external reports present information relating to activities of the institution in the past. They are not future oriented. Internal reports can be focused on the past or the future depending on what kind of information the management of the institution requires. In other words, these internal reports are characterized by the use of information about past events, but are also geared towards activities that should be carried out by the institution in some future period. Thus,

management accounting allows management to consider, for example, the following issues:

- What should be done to reduce some of the costs in order to reduce the price of a particular health service by 10%?
- The institution needs a new health service delivery machine. Should it buy or rent the machine?
- How much does it cost to operate a part of an institution?
- What is the cost price of a health care service and can it be reduced?

Management accounting uses information obtained within the framework of financial accounting. The task of financial accounting is to record all business transactions (consequence of business activities in the institution) that have occurred in a given period in an institution. These transactions are recorded through bookkeeping accounts, through the diary, general ledger and individual analytical records. Based on this information, the external financial statements are published. They include the following statements: balance sheet, income statement, statement of cash flows, statement of changes in equity, etc. All of this information is further processed and used for management reporting purposes within management accounting. Thus, management accounting uses detailed information about the institution's revenues and expenses for further processing to support planning and control purposes. Activities that are carried out within the framework of management accounting, with the aim of preparing reports for the management, can be grouped into the following:

- costs calculation and cost price calculation
- budget preparation
- control

3. Calculation of Costs and Cost price

The most important segment of management accounting is the calculation of operating costs, which is why the term accounting of costs is often used for ***cost accounting***.[2] Costing involves the use of an appropriate method of calculation that allows for the tracking of costs and their allocation to cost drivers, for the purpose of calculating the cost price of the products or services. The choice and application of methods of calculation is not conditioned by legislation and the institution adapts the method to the nature of its activity, the specifics of its business and the requirements of management. The implemented method of cost calculation will provide the content and amount of information, as well as their periodicity according to the needs of the institution and its managers. Institutions implement the calculation method that will allow the most accurate allocation of operating costs to their cost drivers (products or services). **Cost drivers** can represent any activity, business, or organizational part of an institution, that caused the cost to occur [2]. However, **the ultimate cost drivers are the final products or services** that incur the costs in an institution and why some institution exists**.** Thus, cost drivers are the cause or "culprits" of the incurring costs. In this regard, cost

[2]In some institutions, management accounting is separate from cost accounting and forms one of the three components of accounting (financial, cost accounting, and management accounting), while in other institutions, management and cost accounting carry out the same activities.

calculation is the activity that obtains information about what costs were made to what extent by each of the cost drivers, as products or services. Cost calculation provides the determination of *responsibility* for costs incurred, the *profitability* of certain activities or parts of the institutions, as well as the *cost price* of each product and service when all costs are eventually allocated to the products and services for which they were incurred.

An adequate method of cost calculation should allow the allocation of *indirect costs.* Unlike *direct costs,* these costs cannot be directly linked to the cost drivers (products or services) who caused them. The problem is to determine which cost drivers have to what extent caused indirect costs. The cost calculation methods allocate business costs through different phases. First, costs are allocated to cost centers. A **cost center** is the place where costs are incurred for performing an activity or function**.** It can be any process (production, procurement, sale, administration) that takes place at a specific place in an institution and causes costs to arise. A cost center can be considered a segment of an institution that creates costs but does not directly generate revenue [3]. The cost center can be a spatially or functionally bounded unit within the institution. Four criteria are used to define the cost center: according to the functional principle, the spatial principle, the responsibility for the occurrence of costs and the possibility of allocating costs to cost drivers. Direct costs are incurred at cost centers that are related to the production activity of the institution. As mentioned above, these costs are simply allocated to the products or services that caused them. Indirect costs cannot be allocated directly products or services. In order to allocate indirect costs to products or services, it is first necessary to allocate the cost centers at which they are incurred to the cost center of production. This is because other cost centers are in function of cost centers of production. Also, all indirect costs are ultimately due to the products or services that are produced within the cost centers of production. This is simple when the institution has only one cost center of production. However, institutions are usually organized to have more cost centers. For example, one clinic has multiple departments that provide different services. Each department represents a separate cost center of production. Indirect costs incurred at other cost centers (administration, procurement, finance, human resource, maintenance, IT services, etc.) are allocated to each department of the clinic. Cost allocation keys are used to determine the amount of an indirect cost that will be allocated to each department.

After allocating costs to cost centers, the next step is allocating costs to products or services, as final cost drivers. Indirect costs allocated to cost centers of production are common to all products or services that arise in them. In this connection, it is necessary to determine what amount of indirect cost should be allocated to each of the products or services. In this case, as in the previous step, allocation keys are used. **Allocation keys** are used when some cost was caused by more than one cost center or more than one cost driver (product or service). So, when it is not known which amount of the cost relates to some cost center or to one of the products or services, the choice of allocation key is conditioned by the principle of causation, that is, there is a causal relationship between the key used for allocation and the costs to be allocated. For example, the cost of building maintaining should be allocated to each product department of the clinic. This cost is to be allocated to departments based on their relative floor space occupation, as a allocation key. For example, if one production department occupies 25% of the total floor space, 25% of the indirect costs of building maintaining will be allocated to its cost center. Similarly, administration management labor cost, as an indirect cost, is allocated based on a reasonable estimate of the time (work hours) spent on operations for each production cost centre. Thus, if management spent 20% of their working hours on activities for one production department, 20% of the administration management labor cost (indirect cost)

will be allocated to the cost center of that department. For both types of indirect costs, the allocation key is determined on the basis of the principle of causation. As can be seen from the example of these two types of indirect costs, the allocation keys are determined as percentages or rates of participation of the selected allocation criterion (floor space occupation or work hours) in the total amount of costs allocated. The indirect costs allocated to each production department are allocated to the different products or services of each department according to the allocation key: the participation in total production of that department. For example, previously the building maintaining cost of the clinic was allocated to each product department, after which this cost should be allocated to all products or services of each department of the clinic. To realize this, an allocation key is determined for each product or service. This key represents the participation of the production of a product or service in the total production of the department in which it is produced.

The following table shows the example allocation of costs for one clinic to production cost centers, that is, the departments that produce products and services. Any direct costs were directly allocated to the departments that caused them. Indirect costs are allocated using the appropriate allocation keys, in the following ways:

- Administration management labor cost - allocated based on a reasonable estimate of the time (work hours) spent on operations for each production cost centre. According to the documentation, management spent 50% of their working hours on activities for Department I, 20% working hours for Department II and 30% working hours for Department II. The percentages given are the allocation keys to allocate the total cost of € 120,000 to each of the departments.
- General building maintenance costs - allocated based on their relative floor space occupation. Department I occupies 45% of the total floor space of the Clinic, Department II occupies 25% and Department III occupies 30%. The percentages given are the allocation keys to allocate the total cost of € 40,000 to each of the departments.
- Staff transportation costs - allocated according to the relative number of equivalent full time staff in each department. In the given time period the number of full time staff in each department was: Department I - 20; Department II - 14; Department III - 6, which is in total 40. The key to allocation is the participation of the number of staff of each department in the total number of staff, that is, the following percentages: 50%, 35%, 15%. The percentages given are the allocation keys to allocate the total cost of € 10,000 to each of the departments.
- Other costs of non-production cost centers3 - are allocated on the basis of participation in each department's production for the total amount of clinic products (services). Department I participation with 40%, Department II: 35% and Department III: 25%. The percentages given are the allocation keys to allocate the total cost of € 120,000 to each of the departments.

[3] These are other costs that are allocated to the non-productive cost centers at which they are incurred and that must be allocated to the cost centers of production in order to ultimately be allocated to the products or services.

Table 1. An example of cost allocation to production cost centers

Costs of the Clinic for a period of three months allocated to production cost centers

Types of costs	Department I	Department II	Department II	Total
Direct material costs	65,000	12,000	7,000	84,000
Labor costs	210,000	45,000	25,000	280,000
Other direct costs	15,000	1,500	1,900	18,400
Total direct costs	*290,000*	*58,500*	*33,900*	*382,400*
Administration management labor cost	60,000	24,000	36,000	120,000
General building maintenance costs	18,000	10,000	12,000	40,000
Staff transportation costs	5,000	3,500	1,500	10,000
Other costs of non-production cost centers	40,000	35,000	25,000	100,000
Total indirect costs	*123,000*	*72,500*	*74,500*	*270,000*

Table 2. shows the allocation costs of Department I to the products (services) produced there (A, B, C and D). Any direct costs were directly allocated to the cost drivers (products/services) that caused them. Total indirect costs previously allocated to this Department (€ 123,000) are allocated using the appropriate allocation key. This key is determined as a percentage of the participation of each product (service) in the total products (services) of this Department. A total of 2,000 products (services) were produced in this Department, of which 800 were product (service) A, 300 product (service) B, 550 product (service) C and 350 product (service) D. That is, the following percentages of participation: A - 40%, B - 15%, C - 27,5% and D - 17,5%. The percentages given are the allocation keys to allocate the total indirect costs of this Department to each of the products (service). Table 2 shows that the total costs for each product (service) are determined by summing all costs (direct and indirect) allocated for each of the products (service). These amounts represent the total cost price of the total quantity of product (service) A, or B, C or D. The cost price of one piece of each product (service) is determined when the amounts given are divided by the quantities produced of each product (service). And these are the amounts presented in the last row of Table 2.

Table 2. An example of cost allocation to the products (services)

Costs of *Department I* allocated to the products (services) produced there

Types of costs	Product (service) A	Product (service) B	Product (service) C	Product (service) D	Total
Direct material costs	30,000	5,000	20,000	10,000	65,000
Labor costs	95,000	30,000	60,000	25,000	210,000
Other direct costs	8,000	500	3,500	3,000	15,000
Total direct costs	*133,000*	*35,500*	*83,500*	*38,000*	*290,000*
Total indirect costs for Department I	*49,200*	*18,450*	*33,825*	*21,525*	123,000
Total cost of the product (service)	*182,200*	*53,950*	*117,325*	*59,525*	*413,000*
Quantity of product (service)	800	300	550	350	2,000
Cost price of product (service)	***228***	***180***	***213***	***170***	

3.1. Traditional calculation methods

Traditional calculation methods emerged in the aftermath of the Industrial Revolution, with the development of the first industries and the need for control and management in new factories. These methods achieved the greatest development during the mass production period. Applying an appropriate method of cost and cost price calculation will depend on the type of production, i.e. the activity of the institution. That is, depending on the type of final cost drivers, products and services. In this regard, calculation methods consist of two categories: *calculation cost price for product mass* and *calculation cost price for individual orders*. Within these methods there are different methods depending on the product type and the type of industry. Each of the methods is based on the phases presented above for calculation costs and cost price:

- *cost recording and allocation to cost centers at which they are incurred*[4]*;*
- *allocation of direct costs to the cost drivers (products or services) and indirect cost to the cost centers that caused them;*
- *allocation of indirect costs to the cost drivers (products or services) - the cost price calculation.*

The application of traditional calculation methods in the business conditions created by the IT revolution and globalization shows their weaknesses and shortcomings. The new conditions have influenced changes in the way institutions are organized, changes in production methods and changes in the structures and duration of production processes. This has also resulted in changes in the cost structure, that is, a higher proportion of indirect costs in total costs, which was not the case earlier.

[4] This part is the task of financial accounting, after which the data obtained is used in cost accounting to realize the next phases of the calculation.

3.2. Activity Based Costing (ABC) method

This method emerged in the 1980s as one of the most widely accepted alternatives to traditional methods and it is set up to remedy the shortcomings and weaknesses of traditional billing methods as discussed above. First of all, they were unable to respond to the demands of management in the new conditions. Doing business in uncertain conditions requires quick decision making. In this regard, management must have accurate and timely information provided to it by cost accounting. Given that the problem of the traditional calculation method is the allocation of indirect costs to products or services, their application becomes debatable in a business that is characterized by a greater participation of indirect costs in the structure of total institutional costs[4][5].

Activity Based Costing method was first developed in companies and institutions in Western countries, which caused significant progress and improvement of management accounting performance. In addition to product manufacturing companies, this method is also used in service companies as well as in the public sector. With regard to the field of health, the ABC method of calculation was first applied in UK institutions. Thus, as an example of good practice, especially when it comes to the public sector in this area, the implementation of ABC methods at the Blood Transfusion Institute, part of the National Health Organization of Great Britain, can be highlighted [1].

The activity-based calculation method assumes that the costs incurred in the production of a product or in the operation of services are caused by different activities taking place in the company. That is, in order to create products and services, it is necessary to carry out certain activities, and to perform these activities it is necessary to spend adequate resources. In essence, the ABC method is basically based on traditional calculation methods. The difference with the traditional methods is that with the ABC method indirect costs are allocated to activities. Activities are considered to be any individual activity or task that is accomplished within an institution, as well as any part of a business process that is responsible for costs in the final output (products and services). That is, for the ABC method, costs are not generally allocated to particular parts of the institution (production, procurement, sales, administration, etc.), as in the traditional method. For the ABC method, costs are allocated to individual activities within these parts of the institution, for which each expense is incurred. This method allows to determine how much an institution costs for each activity in the production process, that is, to determine the cost price of each activity. Allocating costs to individual activities allows for a more accurate correlation of costs with products or services, as the ultimate cost drivers. This is because it is easier to determine which product or service has occurred in an activity. On the contrary, in the traditional method, indirect costs incurred over a period of time are allocated to production cost centers (one or more, depending on how the institution is organized), which consist of a number of activities that cause these costs and are realized during that period. For example, as shown above, in the traditional method, the indirect cost of building maintenance of a clinic is allocated to the product departments of the clinic and then to the individual products or services of each department, using the appropriate allocation keys. On the other hand, in the case of an ABC method, building maintenance cost is allocated to activities of the departments. These are the different activities that departments carry out which are involved in the production processes of products or services. So, in the example of this clinic, the ABC method does not allocate indirect costs to three departments but to individual activities within each department. After indirect costs are allocated to individual activities, they

are allocated to the products or services that are produced. Thus, the ABC method enables a more precise allocation of indirect costs to an institution's products or services. This is because indirect costs are allocated to more activities within the production part of the institution (one or more) and thus are "closer" to the products or services. This is not the case when these costs are allocated to the production part as a whole. All this contributes to a more accurate cost price calculation than in the case of traditional calculation methods. These methods often overlook the details of many activities that actually take place, especially when production processes are more complex [1]. The following table shows the costs flow for traditional methods and ABC method.

Table 3. Costs flow in traditional methods and ABC methods

Traditional methods	*Direct cots*		***Cost drivers (products or services)***
	Indirect costs	*Cost centers*	
ABC methods	*Direct costs*		***Cost drivers (products or services)***
	Indirect costs	*Activities*	

An Activity Based Costing method allows cost allocation to cost drivers (products or services) in two phases. In the first phase, the operating expenses incurred are allocated to the respective activities that caused the expenditures. Thus, allocation is made in accordance with the principle of causality, that is, the incurred expenditures of certain resources are linked to the activities that caused them. When allocating costs at this stage, the question to be answered is: *what activity caused some resources to be spent?* Direct costs are allocated similarly to traditional calculation methods, except that they are not allocated to the production cost center but are allocated to specific activities that take place within that cost center. As these activities are directly involved in the creation of products or services, their consumption of resources can be directly linked to each product or service, based on appropriate documentation of the spending of each activity. On the other hand, activities that are not directly involved in the production of products or services indirectly cause the consumption of resources. These activities occur in the parts of the institution that indirectly participate in the creation of products or services.

In the second phase of this calculation, the costs related to the respective activities are allocated to the final products or services, as the cost drivers of those activities. This allocation is also made in accordance with the principle of causation, that is, the costs of the activity are related to the products and services that caused them. At this stage of allocation, the question is: *what products or services caused the costs of the activity?* Thus, the costs incurred are allocated based on the fact that for the production of products or the provision of services, it is necessary to carry out certain activities, and that to carry out these activities the consumption of adequate resources is required. For activities that are directly related to the creation of final products or services, the costs allocated to each of them are simply allocated to the relevant products or services, because it is easy to determine which product or service was going through a particular activity. For example, in a dental office within the prosthetics business, when taking a preliminary imprint, one knows exactly what product, a prosthesis, caused this activity. All costs incurred to

realize the activity are allocated to the prosthesis, as a final product. Other activities, which are not directly involved in creating the final products or services, cause costs of an indirect or general nature. These activities also determine which final effects caused the cost of the activity, which is more complicated because each of the activities are involved in more products or services. This allocation is easy only if one product or service is realized. For example, in a dental office, the costs associated with the storage activity of a raw material are caused by more products or services, which use the given raw material. As mentioned above, as with traditional methods, it is necessary to specify an allocation key based on which costs allocated to particular activities will be allocated to the appropriate product or service. The method for defining allocation keys is the same as for traditional methods. The difference is that in this method the cost is related to the relevant activity as soon as it is incurred, which allows the choice of a more adequate and precise allocation key, and thus a more accurate calculation of the cost price of the products or services.

Considering that all the costs of individual activities are allocated to the appropriate products or services, it is possible to determine the cost of each of them. The total amount of costs allocated to a particular type of product or service represents the cost price of the total amount of product or service produced. The cost price of one product or service, as was the case with the traditional calculation methods, is obtained by dividing the total costs by the amount of products or services produced.

The implementation and use of this calculation method requires high costs. This is because the application of this method is the introduction of appropriate software that will allow detailed cost allocation. This is because the ABC method, as presented above, means monitoring and recording every step in the production of a product or service. It is the monitoring and recording of each transaction, which is a consequence of the steps taken, or activities in the institution.

4. Budgeting

An important segment of management accounting is the preparation of the institution's budget. The preparation of the budget or budgeting, together with cost accounting, is an important component of internal reporting for management purposes. The ***budget*** is a financial plan for operations of an institution for a certain period in the future [1][6]. The role of the budget in the institution's business can be viewed according to three aspects:

- guidelines for the business in the future;
- control of the realization of business goals;
- allocating responsibility for incurred variances from budget values.

Creating a budget is done on the basis of planned or standard values to be achieved in the institution during a future period. The budgeting period depends on whether the budget is being prepared for the adoption of a strategic plan of the institution's business or whether it is operational planning. In the first case, the time period for which the budget is being prepared is longer than one year, while in the second case it is up to a year or less. The budget is prepared for the whole institution, but based on the budget prepared for individual organizational parts. These parts are defined as centers of responsibility and each is responsible for the realization of the objectives of the institution. Their managers are responsible for preparing the budget of each section. The

budget of each responsibility center is a guide for organizing and realizing the goals in the time period for which the budget is prepared. The activities implemented during a given period are controlled by determining deviations from the budgeted values at the level of the entire institution, as well as for each responsibility center. Then the responsibility for the occurred variances is determined. Responsibility is tied to individual parts of the institution, as centers of responsibility, or to the individual responsible for the occurrence of these variances. In this regard, the basis of budgeting is the principle of responsibility accounting.

The starting point for budgeting are the activities or output that an institution plans to carry out or produce over a period of time. Outputs relate to the planned sale of products or services during the budgeting period. For example, in the case of a Dental clinic, budgeting is based on how many products or services you plan to sell in a given period. The value of the *sales budget* is determined on the basis of the planned quantity and the selling price. This budget is defined for the individual parts of the clinic, defined as centers of responsibility, but also for the clinic as a whole. The value of sales of individual centers and of the entire clinic directs the realization of other activities in the clinic. After that, a *production budget* is prepared, with all the details related to the costs that will be incurred, corresponding to the planned sales volume. The result is a budget for direct material costs, direct labor costs, and overheads, as parts of the production budget. Then follows a budget for indirect activities within the clinic: a budget for indirect costs. The following figure shows the sequence in which budget activities are prepared.

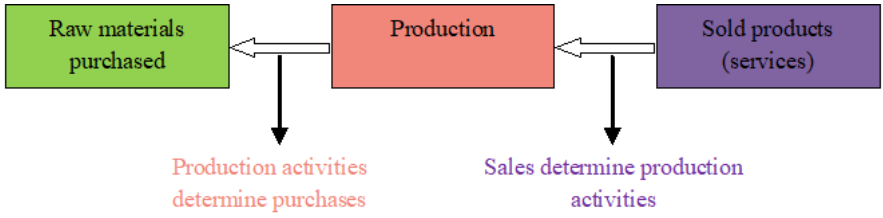

Figure 1. The sequence in which budget activities are prepared

Budget preparation can be detailed to the extent that is required by the management of the institution or by the managers of the different centers of responsibility. The detailed budgets of each responsibility center are summarized to give the overall budget of the institution. If budgeting is done, for example, for a period of one year, the budget is presented for each month separately. The end of each month will be the checkpoint for the implementation of the set budget. The reports provided are the basis that will assist management in making current and strategic business decisions. By summarizing individual items that were elaborated in the budgeting process, projected financial statements for a specific period can be produced. The projected income statement will show the planned amounts of revenues, expenses and financial results for the budgeted period. On the other hand, the projected balance sheet will show the planned balance of assets, liabilities and capital on the day when the budget period ends.

Variance analysis enables the management to identify the reasons why real values vary from those planned in the budget [6]. The following table shows the income statement of a department dealing with prosthetics within a Dental clinic. The balance

sheet contains the actual values that occurred in the third quarter of 2019 (01 July - 30 September 2019), as well as the values that were budgeted for this period. The last column shows the amounts of deviations (variances), which can be positive or negative. Positive variances from the budgeted value occur when the revenues and financial results are higher than budgeted, as well as when the actual costs are lower than those provided for in the budget. Negative variances arise in the opposite case.

Table 3. An example of the income statement of a some department of the Dental Clinic.

The Dental Clinic ***Department for prosthetics*** **Financial performance report** **01 July - 30 September 2019**			
	Actual (€)	**Budget (€)**	**Variance (€)**
Revenue (sold dentures)	22,200	20,000	2,200
Variable Costs:			
Labor	7,450	6,500	-950
Basic raw material for dentures	4,220	4,400	180
Contribution Margin	10,530	9,100	1,430
Fixed Costs	6,530	6,000	-530
Operating Profit	***4,000***	***3,100***	***900***

The table shows that part of the clinic that specializes in prosthetics in the third quarter of 2019 had a positive variance of income from the sale of dentures and positive variances in the costs of basic raw material for making dentures. On the other hand a negative variance is achieved for the labor cost, because the actual costs were higher than budgeted. Variance analysis will help management to uncover reasons for the occurrence of deviations. In case of variance in the sales revenue, the analysis will show whether the variance was due to the fact that a larger number of dentures was sold or that the planned quantity was sold at a higher selling price than the one planned in the budget. So, the variance may be affected by quantity or price. For the labor costs the analysis will show whether the fact that the actual costs were higher than budgeted was due to inefficient use of labor, because employees worked more hours than planned or whether the variance was the result of an increase in the price of working hours. With respect to the cost of raw materials, variance analysis will show whether the positive variance occurred because a lower amount of raw materials was spent or because the raw materials were purchased at a lower price than planned. The variance analysis for the costs of raw material for dentures is shown in the following figure.

Calculate the basic raw material for dentures price and efficiency variances		
Actual amount of raw material	**Actual amount of raw material**	**Budgeted amount of raw material**
x	**x**	**x**
Actual price	**Budgeted price**	**Budgeted price**
10,550	10,550	8,800
x	x	x
€ 0.40	€ 0.50	€ 0.50
€ 4,220	€ 5,275	€ 4,400
€ 1,055		**-€ 875**
Raw material favourable price variance		**Raw material unfavourable efficiency variance**
	€ 180	
Raw material favourable flexible budget variance		

Figure 2. An example of the variance analysis for the costs of raw material

The first column shows the value of the actual cost of the raw material for dentures, which is obtained by multiplying the amount of raw material actually consumed and the price at which it was purchased. The central column represents a flexible budget which is obtained by multiplying the actual quantity of consumed raw materials and the purchase price provided for in the budget.[5]The variance of €1,055 represents a positive variance resulting from the consumption of raw materials purchased at a lower price than indicated in the budget. The third column presents the cost of raw materials predicted by the static budget and is obtained by multiplying the budgeted quantity and the cost of raw materials. Since the variance between flexible and static budgets is due to the amount of raw materials consumed, the variance of the cost values is caused by the quantity. As can be seen, the negative variance of € 875 is caused by the consumption of more raw materials than budgeted. In sum, a positive variance of € 1,055 and a negative of € 875 gives a positive variance of € 180, which is presented in the income statement as a deviation from the actual budgeted cost of the raw material costs required to make dentures. Variance analysis showed that the higher amount of raw material costs actually incurred compared to the budget value is a consequence of consuming more raw materials rather than purchasing raw materials at a higher purchase price.

[5] A ***flexible budget*** is a dynamic or variable budget and is set so that items can be adjusted to changes in activity over the planned range. This budget is set for different levels of activity of the institution, which are variable, while the fixed ones remain the same. A flexible budget is usually prepared for shorter periods, such as a month, and accompanies a static budget.

5. Conclusions

This chapter outlines the role of management accounting, which provides information as an important component of decision making in healthcare institutions. Information obtained from calculations of costs and cost prices is the content of internal reports prepared within management accounting for the needs of healthcare institutions management. This information shows how much the institution has cost in the previous period, what the structure of costs is, and the cost price of each product or service produced in the previous period, as well as the amount of revenue generated. Also, if a healthcare institution consists of several departments or outpatient clinics, management accounting information will show the amount of cost of each of them, the cost price of products or services of each department, how many products or services they have sold, and how much profit each part has generated. Based on this, management will have information on whether some of the parts of the healthcare institution are causing higher costs and why. Also, whether a product or service is profitable or not. All this gives grounds for management to consider whether and how to act in the domain of particular parts of the institution or of the particular products or services offered. For example, if management accounting reports show that a healthcare institution's product or service has a high cost price, management will consider how to act on the costs of that product or service, in case it is not appropriate to increase the sales price. Certainly, changes in cost should not compromise the quality of the health care product or service.

Management accounting, on the other hand, prepares a financial plan for the health care institution for some future period. Budgeting will depend on the strategy being pursued in the future. In this regard, on the basis of management guidelines, management accounting prepares a budget that, once adopted by the management, will be a benchmark for business for a certain period in the future.

The content and quality of internal reports depend on the methods used in management accounting, both for the preparation of previous business information and for the preparation of a plan for the future. Considering the fact that in modern business for the survival of a healthcare institution it is important to make quality decisions that must be timely, quality and timely, information is needed. Modern trends in increasing the performance of business systems are primarily related to cost management. In this regard, health institutions should be focused on setting up quality management accounting systems that will be provided with the right conditions and resources for accurate calculations.

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Exercises

1. What is management accounting?

2. What is the difference between management accounting and financial accounting?

3. What is the task of calculating the cost and cost price of products or services?

4. What are allocation keys?

5. What is the sequence of preparation of budget activities?

Answers to the Exercises

1. Management accounting is implemented within the institution itself and provides information that enables management to monitor and control the business and make business decisions. Information that is prepared under management accounting is included in internal financial statements or management accounting reports.

2. Financial accounting records, classifies and summarizes the data on which the external financial statements are prepared. In this regard, financial accounting provides historical data on assets, capital, liabilities, expenses, revenues and financial results that are relevant to internal and external users. External financial statements include predefined information grouped in standardized forms to meet regulatory requirements. Management accounting, on the other hand, prepares internal statements. These statements have a flexible content and form and are prepared according to the requirements of management, both in terms of the information they need and how often reports are urgently required

3. Calculation of costs includes all activities related to the monitoring of costs and their allocation to cost centers that may be individual parts of the company or individual tasks or activities. Calculation of cost price provides information on how much an institution has cost to produce a product or to do a service.

4. Allocation keys are used when some cost was caused by more than one cost center or more than one cost driver (product or service).So, when it is not known which amount of the cost relates to some cost center or to one of the products or services the choice of allocation key is conditioned by the principle of causation, that is, there is a causal relationship between the key used for allocation and the costs to be allocated.

5. The sequence of preparation of budget activities:
- preparing a sales budget;
- preparing a production budget - the preparation of this budget is influenced by the sales budget;
- preparation of the procurement budget - the preparation of this budget is influenced by the production budget.

Problems/Challenges

➢ One private infirmary provides two types of services (A and B). During the previous month, it provided 110 services A and 154 services B.
In order to realize all services A, the following direct costs were incurred: raw material costs €16,500, direct labour costs €4,400 and other direct costs € 1,100.
In order to realize all services B, the following direct costs were incurred: raw material costs € 38,500, direct labour costs €24,600 and other direct costs € 1,500.
Total costs incurred in connection with other, indirect, activities amounted to € 105,600.
a) Calculate the cost price of service A and cost price of service B using the traditional method of calculation.
b) Calculate the cost price of service A and cost price of service B using the ABC method of calculation, if the ambulance has 13 activities performed for the realization of its services (5 for service A and 8 for service B).
c) Explain why there were different cost prices

➢ The budgeted direct cost of labour in the Dental clinic was based on the anticipated € 12 per hour wage rate and the expectation that each sold service will generate 30 minutes of work, 3,000 services are planned to be sold. On the other side, the accounting records indicate that in previous month labour consisted of 1,600 working hours at a rate of € 14 per hour.
Prepare direct labour variance: calculation of the labour rate and efficiency variances.

Solutions to the Problems/Challenges

➢ a) *Calculate the cost price of services using the traditional method*

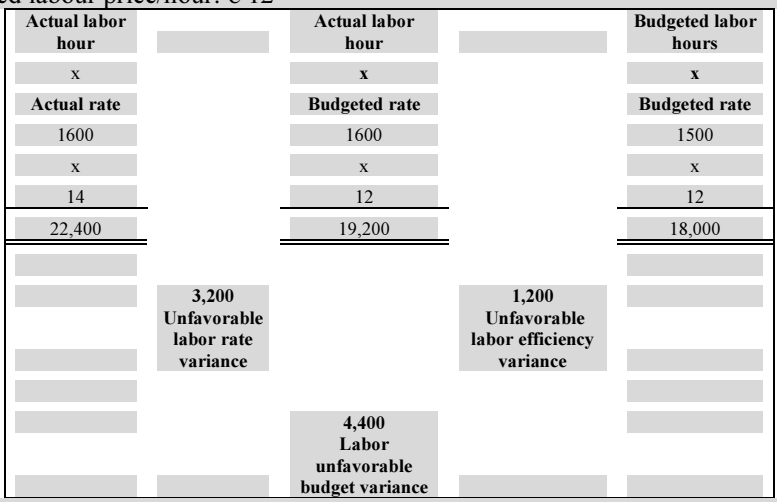
	Service A	Service A	Total
Number	*110*	*154*	*264*
Direct material costs	16,500	38,500	55,000
Labor costs	4,400	24,600	29,000
Other direct costs	1,100	2,500	3,600
Allocation key for indirect costs:			
participation in the total number of services	41.67%	58.33%	100.00%
Indirect costs	44,000	61,600	105,600
Total costs	*66,000*	*127,200*	*193,200*
Cost price of service (Total costs/Number)	***600.00***	***825.97***	

b) *Calculate the cost price of services using the ABC method*

	Service A	Service A	Total
Number	*110*	*154*	*264*
Direct material costs	16,500	38,500	55,000
Labor costs	4,400	24,600	29,000
Other direct costs	1,100	2,500	3,600
Number of activities	*5*	*8*	*13*
Indirect cost per activity (TIC/TotalNoActivities)	*8,123.08*		
Indirect costs (NoActivities*IC per activity)	40,615	64,985	105,600
Total costs	*62,615*	*130,585*	*193,200*
Cost price of service	***569.23***	***847.95***	
(Total costs/Number)			

c) *The application of the traditional method calculated a higher cost price for service A than the ABC method and a lower cost price for Service B. This is because the allocation of indirect costs in the traditional method unrealistically burdens the cost of service A. Realization of service B requires more activities than service A, so allocation of indirect costs to activities results in a more realistic cost price.*

➢ *Calculate the direct labour price and efficiency variances:*
Actual labour hours: 1600
Actual labour price/hour: € 14
Budgeted labour hours: 1500 (*budgeted sold/budgeted work hours= 3.000/0,5*)
Budgeted labour price/hour: € 12



After the calculation, it is concluded that the actual labour costs were € 4,400 higher than the budget projected. This was unfavorably affected by the higher cost of labour per hour (€ 3,200), as well as the increased number of hours worked (€ 1,200). Managers should do an additional analysis of the unfavorable impact of the number of hours worked in order to determine whether this resulted in the sale of a larger number of services than the budgeted amount or ineffective use of labour.

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Management and Marketing in Health Institutions

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Abstract. In the last decades radical changes in the health care market have happened. Customers continuously require a higher level of quality of service and they become more careful and demanding in the decision process, market intelligence is continuously growing, competition and quality of services are dramatically increasing, as well as the external influences of various lobbyists in many parts of the world. Also, it is important to mention the fact that there are many initiatives for change in many branches of health care delivery, as well as many innovative models for providing health services that change the traditional role of healthcare institutions. In these conditions in order to be competitive on the global market and to create satisfied and loyal consumers of health services, health institutions need to introduce a marketing management concept which is completely in accordance with actual trends on the global market as well as needs and demands of services consumers.

Keywords. Strategic management, marketing strategies, marketing mix, branding

1. Introduction

In the last decades radical changes in the health care market have happened. Most of the changes appeared because of certain events that influenced healthcare institutions all around the world in the 1970s. Some of the changes that have been drastically reflected in overall health trends are: the increase of the number of sick people, double digit inflation, economic stagnation and the strengthening of competition. Most healthcare institutions could no longer rely solely on simple projections of the planning of the development and growth of health services and profits. On one side, customers/patients continuously require a higher level of quality of services and they become more careful, sophisticated and demanding in the decision process and market intelligence is continuously growing while on the other side the influence of competition and quality of services is dramatically increasing.

All these things made it necessary to introduce many innovative models for providing health services as well as to implement the concept of marketing-management which is not considered any more to be an added value but a necessity which will help the health institution to survive and gain competitive advantage on the market.

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2. Learning Outcomes

After this chapter, the reader will be able to:

- Analyze, compare and implement the main phases of strategic management in health institutions
- Create and implement different marketing strategies for health institutions
- Identify and analyze the elements of a marketing mix and implement them successfully in a health institution
- Use different strategies and tools in order to brand the health institution

3. Strategic Management in health institutions

The strategic management process in health care institutions includes several phases. These are:

- Strategic analysis;
- Predicting the future;
- Definition of mission and strategic goals;
- Formulation and selection of a strategy;
- Implementation of a strategy;
- Control of the implementation of the strategy.

Strategic analysis - In general terms, strategic analysis includes an external or environmental analysis and an analysis within a health institution itself. In fact, it refers to understanding the strategic position of a healthcare institution. The analysis of the environment includes the analysis of competition, market structure, socio-cultural determinants, science and technology, economic policy of the country, special development policy in that area, legislation, ecology etc., while the analysis within the healthcare institution deals with the assessment of the company's ability to adapt to changes in the environment, and includes an analysis of human resources, organizational, technical-technological, research and development, financial, etc.

Predicting the future – Since strategic planning is closely related to the future, it would be necessary, as far as it is possible, to predict future trends and perspectives. This would relate to all the assumptions from the previous paragraph, but mostly to the special development policy in the field of the health care institution's business, or more precisely, to any individual service of its business.

Definition of mission and strategic goals – The mission usually refers to the reason or purpose of the existence of a health institution. The mission is a statement that expresses the current and future business of the institution itself, that provides broader indicators for the direction of actions and last but not less important, it is strongly related to the market and users of services. The information that should be included in the formulation of the mission are: the basic definition of health services, the definition of users and the market, technology, growth and profitability, the philosophy of the health institution, its responsibility towards society, public image, etc.

The strategic goal of each healthcare institution is to provide the services that the market is looking for and to launch them on the market maximizing the expected profit at the same time.

Formulation and selection of the strategy - After strategic analysis and the determination of the strategic goals that a healthcare institution wants to achieve in the coming period, it is necessary to formulate different strategies and choose the most appropriate one. Strategic planning is a long-term planning, during which the health institution should establish the basic purpose of its existence, determine its goals and strategies and develop detailed plans for their realization. It is important to say that this is not a static, but a continuous process, in which the environment permanently affects the health institution itself, but at the same time the health institution also has an influence on the environment in which it exists and is being adopted.

According to Kotler, strategic planning is a guiding process of developing and maintaining a possible harmony between the goals and potentials of the healthcare institution and the opportunities provided by its environment. The main purpose of strategic planning is to enable healthcare institutions to design a sufficient number of health activities, which will keep it functioning even when one of the activities does not go very well.

There are different types and sub-types of strategies. Some authors divide them into: strategies of growth, neutral strategy, recovery strategy and reduction strategy. According to Ansoff (1987), there are three basic strategies for a health institution: business, administrative and operational. However, most of the authors discern the following business strategies: Strategy of Consolidation and Minor Improvements; Market Development Strategy; Service Development strategy; Strategy of Growth; Diversification strategy; Expansion strategy etc.

Implementation of the strategy - Even the best-defined and chosen strategy may turn out to be inappropriate if it is not implemented in the right way. Implementation of the strategy involves the realization of all defined ideas and activities. At this stage, as part of the global strategic management process, it is possible to apply different approaches. It is interesting to mention that a project approach is extremely interesting. According to this approach, any strategy or part of the strategy can be treated as a separately specifically planned and realized project, which requires time, resources and financial funds for its realization, and which is monitored and controlled in order to achieve defined goals.

Strategic control - In order to complete this process of strategic management, it is necessary to control the implementation and realization of the chosen strategy. This phase is necessary for the efficient implementation of the entire process. If the control system does not function, it is almost certain that the strategy will not be satisfactorily implemented (Jovanović, 1999). The process of controlling the implementation of the strategy encompasses the following activities: planning of the results that the strategy seeks to achieve, the measurement of the achieved results and determining deviations from the plan, the analysis of results and deviations, proposing corrective actions, conducting corrective actions etc.

4. Marketing in health institutions

The role of marketing is extremely important for positioning the health care institutions on the market.

Marketing strategies of health care institutions include analysis, planning, implementation, and control processes that are designed to meet the needs and demands of customers.

4.1. Phases in the creation of marketing strategies for health institutions

The creation of marketing strategies for health care institutions includes several phases. These are:

- Market analysis
- Development of a strategy
- Creation of a market-oriented program
- Implementation and control

Market analysis. Every marketing strategy for health care institutions should be based on an analysis of the market in which the health service is offered, on competition analysis and by continuously studying markets. These analyses help in the selection of an appropriate marketing strategy.

The market should be clearly defined in order to be able to analyze the users of health services and competitors, while market analysis and forecasting of trends and perspectives of the market is crucial for business and marketing planning. In that sense, it is extremely important to identify key target groups, understand their needs and demands, estimate the size and degree of market growth and discover which healthcare institutions and services appear as competitors on the market. It is also extremely important to define, based on high-quality market analysis, which new services should be introduced, which ones should be eliminated, and which ones should be further improved.

When talking about market analysis, it is important to realize that competitors also analyze and continuously study the markets, because this is one of the essential conditions of survival on the modern market. Managers employed in market-oriented health institutions should be aware of all trends on the market, as well as develop business and marketing strategies that take advantage of all the opportunities offered, that overcome obstacles and predict how the market will look like in future.

Development of a strategy represents the second phase in this process. It includes: determining the target strategy and strategy of positioning, establishing market links and developing and introducing new services.

The purpose of determining the target strategy is to select people or institutions that are the key target group on the health care market. When the needs of patients vary, the target strategy focuses on one or more segments of the health care market. When the most important segments are determined, the target strategy is selected. The goal is to find the ideal combination of the requirements in each segment and the specific features of the institution concerned.

Creation of a market-oriented program represents the third phase of creating a marketing strategy. In order to implement the defined positioning strategy successfully, it is necessary to develop a particular set of marketing activities regarding services, distribution, price and promotion. The goal is to achieve the best results by making the most appropriate combination of these elements.

Implementation and control represent the last phase of the process. Implementation and control include: preparation of the marketing plan and budget, implementation of the plan, use of the plan in managing and controlling the strategy in the future.

4.2. The implementation of a "marketing mix" in health institutions

The implementation of marketing strategies is extremely important for health organizations because it enables them to provide added value to customers, improve the quality of services, respond rapidly to diversity and changes on the market, recognize global trends and perspectives on the global market, gain competitive advantage on the market, create a brand, etc. In order to achieve this it is extremely important to use an adequate set of marketing tools which is well known as a "marketing mix".

Instruments of a marketing mix are tools which are used in order to achieve the goals of healthcare organizations, like positioning the organization on the market, improvement of the quality of services, creation of a good reputation among specified target groups, establishment of an emotional connection with customers, raising awareness of the existence of the institution on the market, creation of a brand of public health institution, etc.

Healthcare organizations get a competitive advantage on the market by offering high-quality healthcare products (services), asking an appropriate price for healthcare services, having a successful promotion mix (public relations, direct marketing, special events and improving the added value for customers of services etc.), offering an appropriate place for services (atmosphere). This concept is known as "4P". In health care institutions, the important elements of a marketing mix additionally consist of the process of healthcare services, physical evidence and the people who work in healthcare organization (a concept known as "7P"). It should also mention: customization, control and rational use of resources and conservation (caring about the ecological environment).

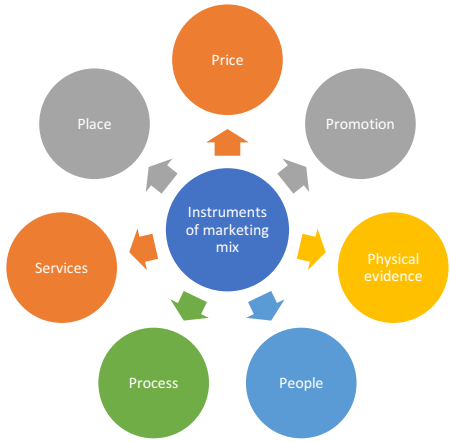

Diagram 1: Main elements of marketing mix

In health care institutions people represent one of the key instruments of the marketing mix because of the specific kind of relation and connection between staff and patients. The trust of patients in a healthcare organization depends on the employee's professionalism, communication skills, and his/her caring about the patient's situation. Patients need to believe in their healthcare professionals. This can be achieved only by good quality healthcare services and good communications based on trust.

In the digital era, it is extremely important to use all advantages of new age media, especially social networks, like Facebook, Twitter, LinkedIn, etc., in order to establish

direct communication with customers. Today, patients are more sophisticated, and they ask questions not only in real, but in virtual places as well. They often look for opinions, experiences, ideas etc. on the Internet by simple searches or by joining some of the healthcare support groups which provide much information about healthcare conditions. People create forums on specific healthcare topics, support each other in the groups, share their experiences etc., while social networks give people the opportunity to connect and discuss some healthcare problems, exchange information and data etc. In that sense, it is extremely important to use all advantages of the new media and build on-line connections by creating attractive web presentations which include all important data about the institution itself and the services it provides, about the human and facility resources, the experiences of patients, etc., by creating high quality interactive profiles on social networks and by active participation in chats, forums, social groups, etc. in order to reach different target groups and promote the health care institution and its services.

4.3. Branding of health institutions

The brand identity includes a combination of the name, logo, slogan, design, color, brand performance, etc. that aims to stimulate a sense of reliability in order to provoke positive feelings and emotions of closeness. [3] Branding represents a unique idea and concept that enables health organizations to enter into the consciousness of consumers and public.

The main goal of the branding process is to send a positive message to specific target groups and make loyal, satisfied consumers. In that process, the media play one of the most crucial roles to achieve positive publicity and to realize a strong, emotional closeness with consumers of the messages. By recognizing the importance of this approach many health institutions put in a great effort in the branding process and it is sure that this approach will be even more important in future.

But, the brand of a healthcare organization is much more than name, logo or slogan. It is the idea that targets every segment of public health institution and its business, the perception of not only the management and staff of public health institutions, but of every patient and the public as well, an idea carried out by all people participating in the realization of a pretty complex health care system, etc. More than in any other sector or business, it is people who create the brand of public health institutions: they represent the organizational culture, reflect the organization's vision and mission, as well as its main strategic goals.

A good branding strategy of a healthcare organization includes: assessment and design of a healthcare organization; change management planning and its communication within the healthcare organization; human resource strategy alignment; the process of redesigning healthcare services; technological systems implementation; talent acquisition and assessment; improving the communication skills of employees; improving the feeling of belonging to an healthcare organization; telling the organization story, day by day etc.

5. The example of good practice-The Mayo Clinic

The Mayo Clinic is an academic medical center based in the USA which represents one of the leading institution in this field not only in the USA, but in the whole world. The clinic employs more than 55000 staff, as well as more than 4500 scientists- experts from

different fields. The clinic is focused not only on clinical practice, but on research, innovations and education as well. Every year more than 1.3 milion patients with different ilnesses and diseases use the services of the Mayo Clinic.

Apart from having famous experts and an extraordinary medical staff, some of the best clinical practices, a high-quality infrastructure and equipment, in this sense it is also extremely important to point out a successful marketing approach which is based on some key elements such as:

- **Digital marketing**. The clinic uses the advantages of digital marketing for many years- they registered their domain name in 1997 and continuously improve their on-line campaign. More of the two thirds of marketing budget is dedicated to digital marketing in order to target, reach and attract particular target groups at specific moments of need. By a simple google search it is possible to find many different articles published by scientists and doctors employed at Mayo Clinic as well as to read more about experiences of satisfied patients.
- **Social media**. The fact that the Mayo Clinic has more than 1.28 million of Twitter followers as well as 867 000 likes on Facebook is the best indicator of their successful promotion on social networks. The clinic uses all advantages of social networks in order to share information quickly, answer the questions, share patients' stories and experience and raise awareness of people about the strengths of the brand. They often realise different campaigns like #StrongArmSelfie campaign in which thousands of people took and shared pictures of themselves flexing their biceps in order to raise awareness about the importance of colorectal cancer screenings.
- **Patients communities**. The Mayo Clinic puts great efforts to build patient communities and create places for them to share their stories. For these purposes they created the Sharing Mayo Clinic blog on which patients, their family members, etc. may find different contents from wide range of articles and stories on different topics in order to improve the level of knowledge and self-confidence of patience.
- **Bringing different marketing tactics together**. When analyzing the marketing approach of the Maya Clinic it is almost impossible to define where one campaign ends, and another begins. All strategies, techniques, tactics and activities are integrated, and they represent a part of a whole. They present the same idea in many different forms- in the form of articles on the web, in the form of patient experience on social media platforms, in the form of a video on YouTube etc. By using different forms and channels they have the opportunity to reach wider audience of potential consumers.
- **Constant innovations**. The Mayo Clinic is continuously innovating. Some of the innovations are mobile applications for smart phones. It is interesting to mention The Patient app which enables patients to access health information and schedule appointments, Pregnancy app which helps women to prepare for pregnancy and motherhood etc. It is also interesting to mention Surgeries on YouTube in which videos of different medical procedures are uploaded on YouTube as well as Virtual Q&A with doctors by which it is possible to get answers by doctors without appointments and visiting the clinic.

6. Conclusions

Having in mind the rapid drastic changes in the health market in the last decades, the fact that patients are more demanding than ever before and that the market intelligence is constantly growing, it is clear that health institutions all around the world have put a lot of efforts not only in the continuous improvement of the quality of services, but also in adequately positioning the institution in the market. To achieve that it is necessary that health institutions implement a marketing management approach focused on an excellent understanding of patients and their needs and demands, on actual trends and perspectives of the global market as well as on the competition and its actions. Only that approach may create loyal and satisfied consumers of services and create a high quality, competitive health institution/organization with a recognizable image on the global market.

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Exercises

1. Identify main phases in the strategic management process in health institutions
(Strategic analysis; Predicting the future; Definition of mission and strategic goals; Formulation and selection of strategy; Implementation of strategy and Control of the implementation of the strategy)

2. Identify and explain main phases in the creation of marketing strategies in health institutions
(Market analyze- analysis of market, competitors, trends and perspectives, etc.; Development of strategy -determination of strategy and strategy of positioning, establishment of market links and development and introduction of new services; Creation of market-oriented program- development of a particular set of marketing activities regarding services, distribution, price and promotion; Implementation and control- preparation of the marketing plan and budget, use of the plan in managing and controlling the strategy in future)

3. Identify and explain the main elements of "marketing mix" for a health institution? *(Apart from main four elements of "marketing mix" which are: Product (Service), Price, Place, Promotion, extremely important elements for health institutions are: Process of health care services; Physical evidence and People who work in public health institution. Additionally, it should also mention: Customization; Control and Conservation- caring about the ecological environment)*.

Problems/Challenges

➢ Study the example of Mayo Clinic (more at: https://www.mayoclinic.org) and try to identify its main management strategies which positioned this clinic as one of the most prestigious academic medical centers in the world.

➢ On the same example, try to identify the main element of marketing strategies which significantly contributed to its successful positioning on global health market.

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SECTION 4

Health Analytics and Biostatistics

Preamble

When these more general subjects (for HIM professionals) have been dealt with the emphasis in the fourth block changes to an important aspect of information management. What knowledge do HIM professionals need to be able to analyse patient data? The disciplines of biomedical statistics and healthcare data analytics are introduced. Healthcare data analytics is a relatively new discipline with which knowledge can be discovered from big data repositories.

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Fundamentals of Biomedical Statistics

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Abstract. This chapter is written in order to give students general summary of basic statistical methods, techniques, indicators and procedures. However emphasis is on the application of those that are frequently used in biomedical research. Statistics is science about data, but data that represent numbers with their context. Therefore, in this chapter the topics of population, samples, types of variables, descriptive statistics and statistical inference will be briefly covered. At the end, correlation and regression analysis will be briefly presented. The aim of this chapter is to give a very short overview of the main principles; techniques and procedures that should be used in order to obtain and understand analyzed biomedical data.

Keywords. Statistics, population, correlation, regression analysis

1. Introduction

The aim of statistics as a science is to provide insight by means of numbers. It uses data in order to gain insight about a certain activity and appearance we are interested to research, but also to draw conclusions from that. "Statistics is not only a discipline in its own right, but it is also a fundamental tool for investigation in all biological and medical sciences. As such, any serious investigator in these fields must have a grasp of the basic principles. With modern computer facilities there is little need for familiarity with the technical details of statistical calculations. However, a health care professional should understand when such calculations are valid, when they are not and how they should be interpreted".[1]

"America is world leader in biomedicine and its application on patients. She is also leader in the quantity and quality of medical research, and medical education." [2] In order to be able to read, understand and conduct research it is necessary to know how data is collected, analyzed and produced.

Data production and data analysis use methods and strategies in order to collect, organize and describe data using different graphs and numerical summaries. Those will be briefly presented and also some of the simplest statistical inference techniques used to draw certain conclusions.

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2. Learning Objective

Objective of the course: At the end of the course and by studying this chapter the student will be able to understand and carry out certain groups of statistical research methods, both theoretically and applied with the SPSS program.

Learning outcomes:

- Identify different methods of research, which correspond to a particular category of data and/or subject of research.
- Apply knowledge of descriptive data analysis.
- Compare two or more means, theoretically and with an SPSS application.
- Design and summarize results of simple and multiple regression models.
- Assess the reliability of the research results obtained by a certain method.

3. Population and Sample

A population presents group of all measurements in which researcher is interested. However, working with a population often requires a lot of money and time, sometimes it destroys the observed object, so it is better and more reasonable to investigate only samples. Samples are parts of a population from which we collect information. Data from those samples is often used to make inference about the population, from which the sample was taken. Numbers that describe a population are often called parameters, while numbers calculated from the sample are named: statistic.

The sample is supposed to be representative of the population we are interested in. "Ideally we should aim for a random sample. A list of all individuals from the population is drawn up (the sampling frame), and individuals are selected randomly from this list, that is, every possible sample of a given size in the population has an equal chance of being chosen. Sometimes, it may be difficult to construct this list or we may have to 'make-do' with those subjects who happen to be available, what is termed a convenience sample. Essentially if we take a random sample then we obtain an unbiased estimate of the corresponding population parameter, whereas a convenience sample may provide a biased estimate but by how much we will not know." [1]

4. Types of variables

A variable is data that presents the outcome or result of a study. Variables could be divided in qualitative or quantitative, dependent or independent, etc. and they will be shortly described below.

4.1. Qualitative and Quantitative Variables

Variables that are qualitative are also called categorical. Qualitative variables are those having values that one could name and place into one of the different categories. Those variables could only be counted by the number of repetitions. Those qualitative variables are usually divided into two groups: nominal and ordinal. Nominal variables have different categories but there is no ranking among them. Examples for those are hair color, sex, eye color, etc. Ordinal variables are variables that have very obvious

ordering. Example from the biomedical field would be the degree of change in the patient's health after certain treatment. It could be: huge improvement, reasonable improvement, no change, reasonable degradation, and huge degradation/death.

Variables that are quantitative are also called numeric, since they can be numerically expressed. Those quantitative variables can be divided into: continuous and discrete. First one is a variable that could take any point on a line segment. For example: height, weight, blood pressure, etc. Discrete variables are those that can take only a finite number as an outcome. Example for that variable is number of previous myocardial infarctions.

4.2. Dependent and Independent Variables

Statistics is often used in order to compare outcomes among certain groups of subjects. The dependent variable is variable we want to explain by one or more independent variables. An independent variable is a variable that is used as an explanatory one, and it is often called predictor.

5. Categorical data

Categorical or qualitative data put an individual into one of categories. Example for those could be gender (male or female), location (urban or rural), eye color (blue, brown, green), etc. Those data could be summarized and presented by displaying and describing them in certain way.

5.1. Displaying categorical data

Very often, graph or figure is used to summarize and present the result of a study in a very brief way. Pie charts and histograms are often used to display categorical variables. Pie charts display how a whole (population or sample) is divided into parts. The circle represents the whole population or sample, while wedges within the circle represent the parts. Histogram and bar chart are used when we want to compare certain groups by comparing the heights of the bars.

5.2. Summarizing categorical data

The simplest summary of categorical data is just to count the different categories. If we express the counts as a proportion, it becomes more useful. "Proportions are ratios of counts where the numerator (the top number) is a subset of the denominator (the bottom number). Thus, when in a study of 50 patients, 30 are depressed, the proportion is 30/50 or 0.6." [1]

The simplest type of data, also of qualitative data, is binary data. Binary variables are variables which have two categories such as: Dead or Alive, Masculine or Feminine, Pregnant or Not pregnant.

6. Quantitative data

In order to present a certain set of numerical data, we can choose how to display and to summarize them.

6.1. Displaying quantitative data

The purpose of the graph is to help the one who analyzes it to understand the data behind the graph. In order to present quantitative data, we can use: histograms, lines, box-plots, stem plots, etc. Depending of the type of data we have to choose an appropriate graph. For example, if we want to show how a certain quantitative variable changed over time, we probably would use a line graph in a way that we would put time (years, months, days, etc.) on a horizontal scale, while values of the variable would be on the vertical scale. The most commonly used graph for the distribution of quantitative data is the histogram.

6.2. Summarizing quantitative data

In order to describe quantitative data we can use different measures, but mostly we use: mean, mode and median. The mean is computed as arithmetic average of all observations in the population or in the sample. In order to find the mean of N observations from the population, we should sum all values of observations and divide them by N (number of observations).

$$\mu = \frac{\sum X}{N} \tag{1}$$

In a similar way we could compute the mean of the sample- adding all values of the n observations and dividing them by n.

$$\bar{X} = \frac{\Sigma X}{n} \tag{2}$$

Main characteristics of the arithmetic mean are: it requires an interval or ratio level of measurement, it is a unique value, all observations are required for its calculation and the sum of all distances of observations from their mean is equal 0.

The mode is the measurement that has the highest number of repetitions. The median represents the mid-point of a distribution, for which half the measurements have a higher value, and half the measurements have a smaller value. In order to find the median these steps should be followed:

- All observations should be arranged in order of size, from the smallest to the highest number;
- If we have an odd number of observations, our median is the central observation that could be found by counting (n+1)/2 observations, starting from smallest number;
- If there is an even number of observations, the median is calculated as average of the two observations that are placed in the center of the ordered list (starting from smallest number).

Beside above-mentioned measures of location, researchers are very interested into measured of dispersions, especially variance and standard deviation. The variance presents the squared distance of each observation from the mean of the population, than those distances are summed and then divided by the number of observations of the population.

In order to determine the variance of the population we should follow these steps:

- Find the distance of each observation from the mean of the population
- Square each distance previously calculated
- Sum all squares and divide it by the number of observations in the population.

Equation for the variance of the population is:

$$\sigma^2 = \frac{\sum(X-\mu)^2}{N} \quad (3)$$

The standard deviation of the population is calculated as the square root of the previously computed variance (equation 3). The standard deviation measures the average distance of each observation from their arithmetic mean.

However, sample standard deviation is calculated in a similar way, but in this case, we divide the sum of squared distances of each observation from the mean, by the total number of observations from sample minus 1, that is (n-1), as described in equation 4:

$$s = \sqrt{\frac{\sum(X-\overline{X})^2}{n-1}} \quad (4)$$

In the medical literature, SD usually abbreviates standard deviation.

7. Probability

"Probability is used to measure the 'likelihood' or 'chances' of certain events (prespecified outcomes) of an experiment" [3]. Probability could be understood as an estimation of certainty of the event. The probability of a certain event could be described as a: frequency, model-based and subjective approach. An outcome with probability 0 means that it will never occur, while an outcome with probability 1 means that it will occur in every repetition.

The joint probability is defined as the probability of occurrence of two or more events together. "We first define two events A and B, with probabilities P(A) and P(B), respectively. The intersection of events A and B is the event that both A and B occur, the notation being AB (sometimes written $A \cap B$). The union of events A and B is the event that either A or B occur, the notation being $A \cup B$. The complement of event A is the event that A does not occur, the notation being $\bar{A}$." [3]

8. Statistical Inference- Hypothesis Testing

Sample statistics are often used to estimate the values of the population parameters. Therefore, researchers who analyze biomedical data often use statistical methods in

order to make conclusions about certain statements, especially about the relation between data that are collected. For example: "Twenty-year-old men have a different cholesterol level than twenty-year-old women", "Rich people spend more money on health care that do poor people", … Although all these statements can sound logical or not, they should not be accepted or rejected without statistical validation. In order to determine whether these statements are correct, "…we state clearly both the hypothesis we wish to disprove (the null hypothesis) as well as the hypothesis the theory suggests to be the case (the alternative hypothesis). The null hypothesis, H0, presently is:

Men's levels (c_m) equal women's levels (c_w), or:

$$H0: cm = cw,$$

against the alternative hypothesis H1, that cm does not equal cw:

$$H1: cm \neq cw.\text{" [2]}$$

In order to prove that the level of cholesterol of twenty-year-old men is different from twenty-year-old women we have to prove that cm and cw are different.

The previously described hypotheses were designed with the purpose to test the equality of two (or more) parameters. However, in the second statement that states that rich people tend to spend more money on health care than poor people, the hypotheses would be stated differently. For example, if Er were the expenditure of the rich people, and Ep the expenditure of poor people the hypotheses would be:

$$H0: Er \leq Ep \quad \text{and} \quad H1: Er > Ep\ .$$

The goal of the "statistical inference in the form of hypothesis testing is to make decisions concerning an unknown population based on observed sample data". [3]

9. Correlation and linear regression

Very often while analyzing quantitative data, we would like to find out if analyzed variables are in a certain way linearly correlated. That could be analyzed by measuring correlation, but also by doing regression analysis (simple regression or multiple regression). This chapter will give only a short overview of estimation and inference for the regression model, without intention to present it in detail.

9.1. Correlation

Correlation could be described as indicator of the strength of association between two selected variables. It could be described by a scatter plot or by computing the coefficient of correlation. A scatter plot presents a chart that depicts the relation between two selected variables, often given as x and y.

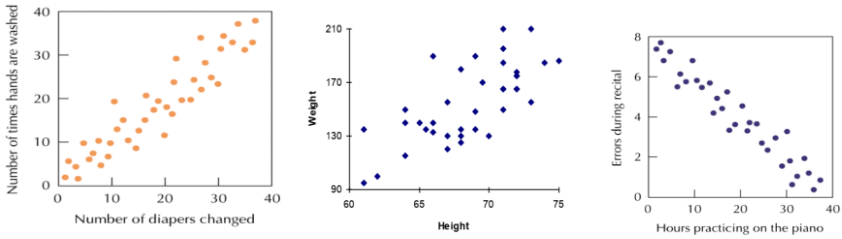

Figure 1. Examples of the different scatter plots

Previously presented examples of different scatter plots in figure 1 show examples of a strong positive relationship, weak positive relationship and a strong negative relationship. However, these relations should be additionally analyzed by the coefficient of correlation.

The correlation coefficient could be computed using equation 5:

$$r = \frac{n(\sum XY) - (\sum X)(\sum Y)}{\sqrt{[n(\sum X^2) - (\sum X)^2][n(\sum Y^2) - (\sum Y)^2]}} \quad (5)$$

Terms $\sum Y$ and $\sum X$ present sums of all observations for the dependent variable Y and for the independent variable X, respectively, while term n presents number of observations (size of the sample). The association between two variables could have two aspects: direction (positive or negative) and strength (from -1 to +1). A correlation coefficient 0 or close to 0 is a sign that between variables x and y there is no or there is very little association. However, a coefficient close to +1 and -1 imply that among variables x and y there exists a strong positive or negative association. Therefore, if r is close to +1 we could conclude that y will also increase if x increases, while r close to -1 shows that y would decrease when x increases. However, it is important to stress that the coefficient of correlation does not imply that x causes y or the opposite.

9.2. Linear regression

Linear regression presents other way to analyze the relation between two or more variables. Simple regression analysis is used if we want to predict the value of the dependent variable *(Y)* based on the value of single independent variable *(X)*. The estimate is written as $\widehat{Y}$.

Simple linear regression could be presented as in equation 6:

$$\widehat{Y} = a + bX \quad (6)$$

Coefficient *a* could be understood as an estimated value of the dependent variable *Y* when independent variable equals 0, that is *X=0*. Coefficient *b* presents the change (either positive or negative) of the estimated value of dependent variable *Y* caused by the one unit change of variable *X*. Coefficient *b* is often described as the slope of the regression line.

Coefficients *a* and *b* could be computed by following equation 7:

$$b = \frac{n(\sum XY) - (\sum X)(\sum Y)}{n(\sum X^2) - (\sum X)^2} \quad (7)$$

$$a = \frac{\sum Y}{n} - b\frac{\sum X}{n} \quad (8)$$

Term $\sum Y$ presents sum of all values of the dependent variable, while $\sum X$ is sum of all values for the independent variable. The size of sample or total number of observation is presented with the n. Those coefficients are computed using the least square principle. The computed coefficient of determination can take the following values:

$$0 \leq R^2 \leq 1$$

A higher coefficient of determination means that the variable that is used as explanatory variable is important for the explanation of f the dependent variable and it's variation. However, a smaller value of the coefficient could be a sign of a wrong specification of the model, in other words that there exist factors not included in the model.

In order to describe relationship between two or more independent variables and the dependent variable we would need to use a multiple regression model, which could be generally presented as in equation 8:

$$\hat{Y} = a + b_1X_1 + b_2X_2 + \cdots + b_nX_n \quad (9)$$

Coefficient a could be understood as a value of dependent variable Y, when all independent variables X_1, X_2, X_3,…,X_n are equal 0. Coefficient b_1 could be understood as the net change in dependent variable Y for each unit change in X_1 while all other independent variables X_2, X_3,…,X_n are constant.

"In order to have a correct model it is necessary to get the following results of testing and estimation:

- Regression is statistically significant (according to the F-test)
- All estimated parameters are statistically significant (according to the t-test) and their signs are suitable
- There is no autocorrelation in the model
- There is no heteroscedasticity in the model
- Residuals have a normal distribution
- There is no indication of a wrong specification of model" [4]

Since estimation of the coefficients b_1, b_2, ...b_n is not very exciting; there are number of computer software packages that could be used in order to find these parameters. Most often used packages are: IBM SPSS, E Views, etc.

10. Conclusions

The above described statistical ideas and reasoning was presented without the aim to turn the students into biomedical statisticians. They were presented with the aim to help biomedical students to interpret the published scientific literature, but also to know how to design research and analyze data received from that research.

The presented methods and briefly described model once again "show that the use of statistical and econometrics methods in the analysis of different phenomena has limited power. While introducing mathematical relations for the description of certain phenomena we must not forget the fact that all those phenomena are the result of social relations and activities, and that human behavior cannot be completely described by deterministic equations." [4]

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Because this chapter emerged from years of classroom and professional interaction, we would like to thank to Professor Milica Vukotic, with whom we have collaborated in a number of years as a teaching assistants for the courses: Statistics. We also would like to thank Professor Veselin Vukotic who gave us the chance to start working with students and who has always challenged our ideas and encouraged us. We also thank our students and colleagues, but special thanks to our families who were always patient and supportive for us while doing our research.

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Exercises

1. Analyze a survey of nurses' opinions about their working conditions. Define what type of variables is: a) length of service, b) age, c) staff grade, d) number of patients seen in a day, e) salary.

2. A sample of 35 women was chosen in order to analyze hemoglobin level (g/100mL). For the given data compute average, median, mode, variance and standard deviation:

10.20	13.70	10.40	14.90	11.50	12.00	11.00
13.30	12.90	12.10	9.40	13.20	10.80	11.70
10.60	10.50	13.70	11.80	14.10	10.40	13.60
12.10	12.90	11.40	12.70	10.60	11.40	11.90
9.30	13.50	14.60	11.20	11.70	10.90	10.40

3. You want to analyze the relation between size of pulmonary anatomical dead space (in ml) and height of children (in cm). The data is collected from 15 children. Present

the data in the scatter diagram, analyze the diagram and then calculate the correlation coefficient.

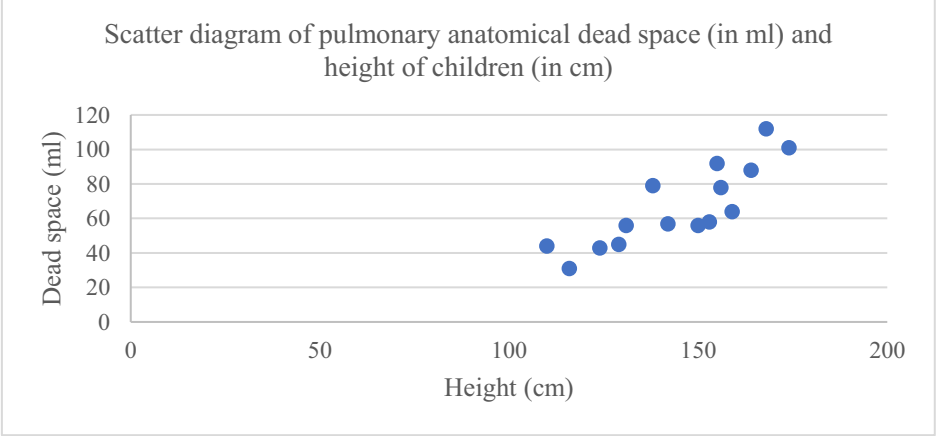
Height (cm)	Dead space (ml)
110	44
116	31
124	43
129	45
131	56
138	79
142	57
150	56
153	58
155	92
156	78
159	64
164	88
168	112
174	101

Answers to the Exercises

1. a) Quantitative, continuous, b) quantitative, continuous, c) qualitative, ordinal, d) quantitative, discrete, e) quantitative, continuous.

2. Average is 11.9, median is 11.7, mode is 10.4, variance is 2.11, standard deviation is 1.45.

3. Scatter diagram shows strong positive correlation.



Computed coefficient of correlation is 0.846.

Problems/Challenges

➢ What you can conclude about a variable if you know that it has standard deviation equal 0? Do you have an example of such a variable?

➢ The coefficient of correlation is 0.5. That means that the part of the dependent variable explained by the independent variable is: a) 1/2, b) 1/4, c) not enough information. Explain your answer.

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Healthcare Data Analytics

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Abstract. Health analytics is a branch of analysis that focuses on the analysis of complex and large amounts of health data that are characterized by high dimensionality, irregularities and rarities. Their aim is to improve and increase the efficiency of the process of healthcare providers, working with patients, managing costs and resources, improve diagnostic procedures and treatments, etc. The prime focus is investigating historical data and finding templates for different scenarios. As a final product, usually different visualisation tools are produced to support practitioners in patient care to provide better services, and to improve existing procedures.

Keywords. Health analytics, health data, machine learning, predictive modelling, phenotyping, patient similarity

1. Introduction

Health data covers large amounts of patient data, data collected during the overall care processes (from symptoms and diagnostics, to treatment and recovery monitoring) and only by using advanced processing methods it is possible to support their integration and further analysis. They are of particular importance for further decision-making by all stakeholders in the healthcare system (from patients, administrators, clinicians, to policy makers and authorities). Healthcare Analytics investigates the application of various methodologies for the statistical analysis of healthcare data, discusses the study design, and enables the interpretation of and inference from the results [1]. In essence, it combines different methods of computer science, statistics, and mathematics aimed at discovering and communicating meaningful patterns in healthcare data [2].

Broad categories of data for collection and parsing can be roughly categorized into: data about resource exploitation (including financial, human, medications, etc.), clinical data together with health population data, data about patient behaviour and sentiment. The combination of financial and administrative data can assist hospital and healthcare managers to identify areas where operations can be streamlined and increased savings with simultaneous increased quality of care and better services can be realized. Data is the basis for research to create innovative solutions and improved treatments, the effectiveness of which can be further monitored by data collection and analysis. Services that need to be improved can be identified from clinical data providing more insights in treatment effectiveness, success rates, and more. Finally, by analysing the individual patient, his or her habits and feelings, while following the progression of disease and

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recovery process, it is possible to create advanced personalized services which significantly increase the quality of care and health care services.

Topics studied in healthcare data analytics include predictive analytics, computational phenotyping and patient similarity, as described in the following sections. Since analytical executions usually require large computations with additional memory usage, analytics software solutions use the latest methods in statistics and computer science, as well as modern hardware solutions [3].

2. Predictive Modelling

Predictive modelling includes a framework for applying a series of algorithms over historical data to identify a set of predictors and create a suitable multivariate model to predict outcomes, events or behaviours [4].

The healthcare industry is strongly focused on modelling the specific market based on patient and consumer preferences, demographics, lifestyles and psychographics, and to create targeted messages to be delivered through specific channels [5]. On the other side, predictive models can contribute to improving healthcare in different ways, naming just a few:

- Increase accuracy of diagnosis- Prediction models can help doctors making increasingly precise diagnoses. For instance, by modelling symptoms and health conditions of patients, doctors can be provided a calculated probability indicating whether it is safe to send a patient home [6];
- Public health and preventive medicine - with early diagnosis and timely intervention, numerous infections can be avoided or improved;
- Support to personalised treatments of each individual patient- evidence-based medicine used for modelling of a specific disease can provide details about different treatment plans as well as identify and categorize individuals for which treatment does not work well. On the other side, by modelling the characteristics of each individual patient and cross-matching with disease treatment models, personalised treatment plan can be created.

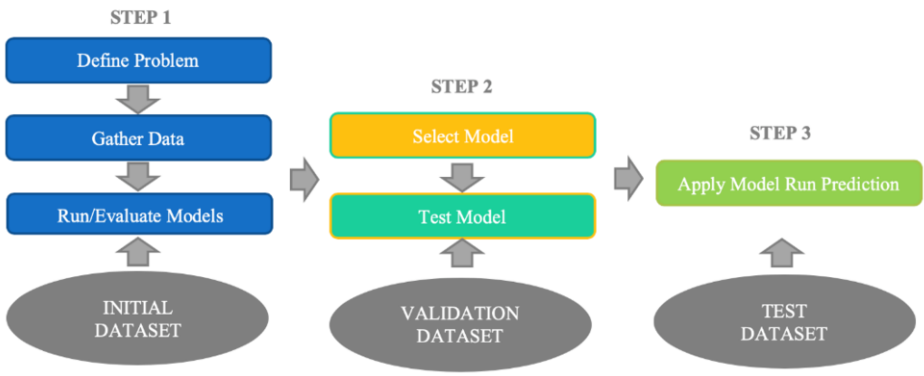

Figure 1. Three steps of predictive modelling [6]

The predictive modelling process consists of the following key steps (Figure 1):

- **Step I** - Definition of problem, event or behaviour that is going to be addressed, collection of initial data and evaluation of existing algorithms/methods/models from the perspective of what potentials they offer when applied;
- **Step II** - Selection of the best performing model and validation of the whole approach on testing data;
- **Step III** - Running the model in real settings.

Every step in this process has many different options, thus resulting in different predictive models and approaches having different predictive performances, depending on the characteristics of the analysed problem, event or behaviour.

Most common predictive models belong to one of two categories: classification problems (e.g. predicting if the patient will have a heart failure or not) and regression problems (e.g. predict the rate of spread of infection).

2.1. Classification models

Classification techniques are used to classify each object from a specific set of objects into one of a predefined set of classes or groups [8]. They have a wide potential for healthcare applications, including categorization of patients at higher risk for various diseases such as diabetes, cancer, etc., predicting the effectiveness of appropriate treatments such as radiotherapy, diagnosis of various diseases such as thyroid, heart, diabetes, cancer, etc. [9].

The most common data mining techniques that are used for classification problems in health domain are presented in the following sections, such as: neural networks, decision trees, nearest neighbour algorithms, support vector machines and Bayesian Methods.

2.2. Neural networks

Artificial neural networks (ANN) are computational paradigms based on mathematical models developed to model and simulate human brain functioning from the point of cognitive abilities, reasoning, learning and decision-making processes [10].

The key constitutive element of an ANN is called the neuron, which processes information in response to external stimuli. An artificial neuron emulates the biological neuron and the processes of the flow of information, signal integration and threshold firing. Neural networks are typically arranged in layers which represent arrays of processing neurons. Each element is stimulated by an input signal, which after reception is processed and generates an output signal by which it further stimulates the elements in the adjacent layer by passing the output signal to the neurons in that layer.

A Multilayer Perceptron (MLP) (Figure 2) is an example of artificial neural networks which is *feedforward*, i.e. a network with acyclic connections between nodes. MLP networks normally have three layers of processing elements and therefore have only one middle layer which is a so-called hidden layer. In complex models, there are more hidden layers since there is no limitations regarding their number.

The tasks assigned to each of the layers can be described as follows:

- the input layer receives information (the form of input data) and distributes it to the first hidden layer;

- the hidden layer performs an activation function (usually some predefined function) over the summed data obtained from the input level (most commonly used is a weighted sum of the input signals). The results of the activation functions are further passed to the next level (this can be the next hidden layer or the output layer);
- the output layer receives data from the hidden layer and summarizes it (most commonly used is the weighted sum of the input signals). The output is obtained by means of an activation function (usually some predefined function) over the summed signals.

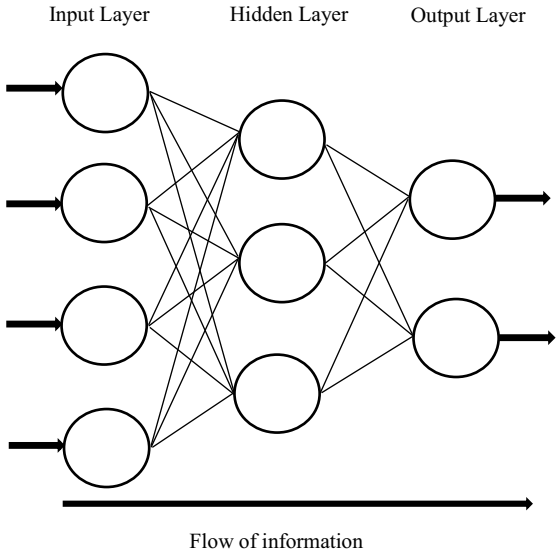

Figure 2. Multi-layered neural network [10]

There are different fields of applications in the health domain, such as: clinical diagnosis [11], x-ray image analysis [12], analysis of ECG recordings and interpretation, and drug development [13].

2.3. Decision tree

A decision tree is a knowledge representation structure which is created based on possible predictor values that characterize possible categories (classes) [14]. In this way, the affiliation of a specific object to one of the possible classes is predicted. Decision trees have a clear structure and visual interpretation in the form of a tree in which nodes represent the characteristic values of predictors, branches are conditions concerning certain predictors that need to be met, while leaves represent classes [14] [16].

Decision trees are easy to interpret (Figure 3), and very often integrated with database systems and they have comparable or better accuracy in many applications compared to other more complex algorithms, such as logistic regression, neural networks, etc. [14]. There are many Decision tree algorithms such as CART, ID3, C4.5 (a later version ID3 algorithm), SLIQ, SPRINT, etc.

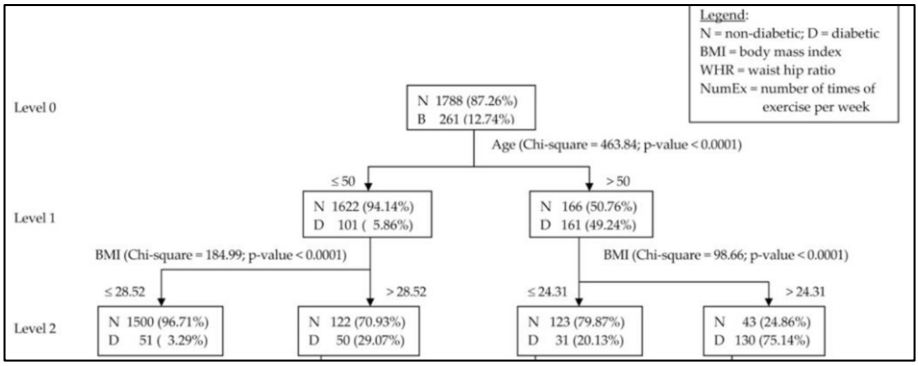

Figure 3. Example of decision tree representing association of variables (age, BMI) with diabetes [15]

2.4. Nearest neighbour algorithms

The k-nearest neighbours (k-NN) algorithm is one of the most widely used data mining techniques in classification problems [18]. It is simply based on the idea that "objects that are 'near' each other will also have similar characteristics. Thus, if you know the characteristic features of k objects, you can also predict them for their nearest neighbour", where k is a positive integer, usually a small number.

kNN is characterized by relatively fast convergence and is usually applied over variables of continuous type and can also be applied over variables of discrete type. However, the main disadvantage of this method is that it uses a lot of memory due to the need to store the entire sample, which is problematic when the sample is large and drastically increases the response time [18].

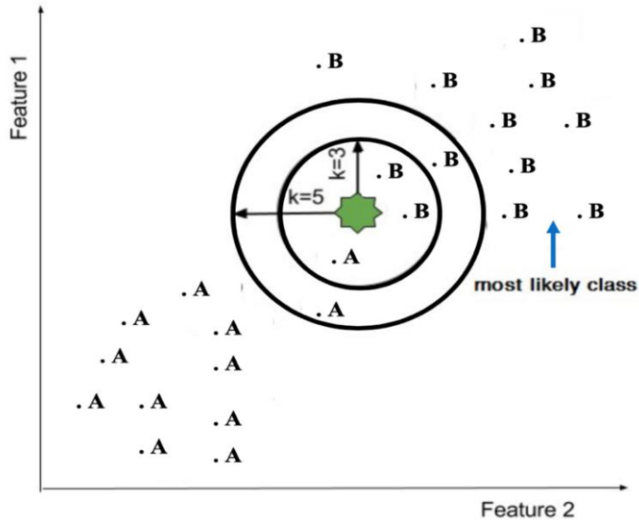

Figure 4. Example of kNN classifier for a two-class problem (i.e. dots annotated with A and B) for different values of K parameter (k=3, k=5). The green star represents a sample point for which the most likely class is needs to be determined

2.5. Support vector machine

The Support Vector Machine (SVM) is one of the most robust and accurate methods used in data mining algorithms [20]. SVM is based on determining the optimal hyperplane that separates categories in such a way that cases from one category are all on the same side of the hyperplane. Support vectors are vectors that are close to the hyperplane, and the basic goal of SVM is to maximize the distance between the separated classes (the so-called large margin) (Figure 5). Distance maximization is usually achieved via iterations over training data, thus achieving a high accuracy of classification in cases where the data. belong to the same distribution. SVM is very commonly used in medical fields: medical diagnosis [21] [22], comparative study purpose [18], etc.

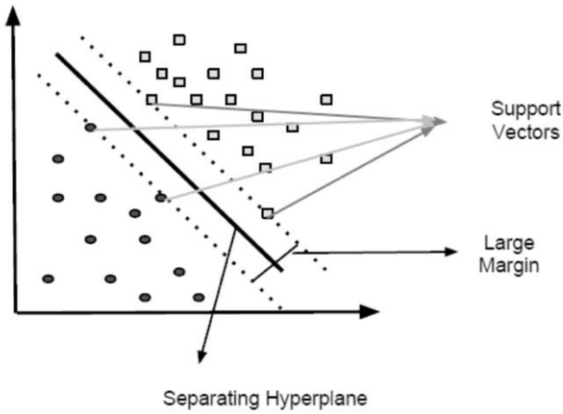

Figure 5. Illustration of a Support Vector Machine (SVM) [20]

2.6. Bayesian Methods

The Bayesian method is based on probability theory. BNs (Bayesian networks) are based on Bayes' theorem and uses a graphical representation for probability computations and reasoning under uncertainty of multiple variables [23]. Bayes' theorem is a formula for calculating the probability of a certain state of phenomena, which is analyzed depending on the probability of observing the factors that are related to the occurrence of this state. For example, if there are several different diseases that develop similar symptoms, the decision on the probability of diagnosing a particular disease comes down to summarizing the causal relationship of the disease with the patient's poor condition depending on the value of appropriate diagnostic tests, laboratory and physical examinations [23].

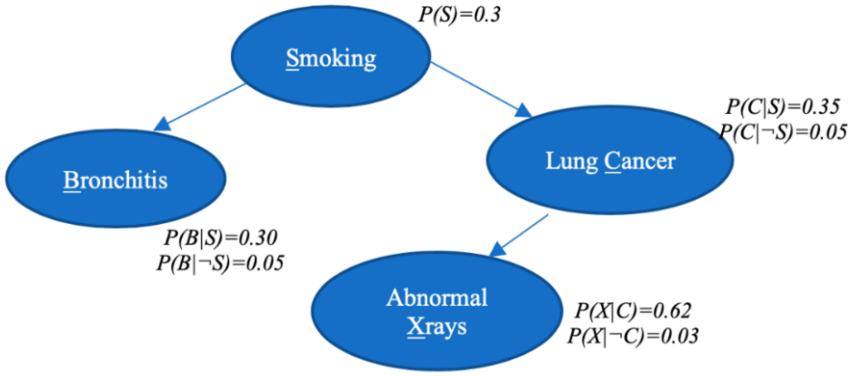

Figure 6. Example of a simplified Bayesian network for Lung Cancer Diagnosis with four variables (S- Smoking; B- Bronchitis; C- Lung Cancer; X- Abnormal X-rays) and assigned conditional probabilities [23]. For example, P(S)=0.35 represents that probability of smoking is 0.3; P(C|S)=0.35 represents that assigned probability for smokers to get lung cancer is 0.35, and P(C|¬S)=0.05 represents that assigned probability for non-smokers which is only 0.05.

Informally, a Bayesian network can be defined as a directional acyclic graph consisting of the following:

- nodes that represent variables;
- branches that connect mutually correlated variables;
- probability tables assigned to each node and define the unconditional probabilities of possible values of the variable if the node has no input branches; and the conditional probabilities of possible values of the variable depending on the value of the variables with which it is correlated (i.e. those nodes from which the input branches come).

There is no single approach how to determine variables and estimate probabilities, so the role of domain experts is very important for the determination of variables as well as the appropriate algorithms for probability estimation. However, the advantages of using the Bayesian classifier are high efficiency and low sensitivity to missing data.

2.7. Regression models

Regression analysis is a statistical method that focuses on modelling the relationship between dependent variable (main phenomena which is analysed and attempted to be understood or predicted) and a set of independent variables (the factors that are hypothesized as having an impact on dependent variable). Regression analysis produces a regression equation which represents how changes in the predictors are associated with changes in the dependent variable.

Statistical methods are generally characterized with high efficiency because the models are simple and linear weighting functions are used. However, there is a limitation- the fulfilment of the prerequisite about certain patterns in the distribution of variables in the model. In real life this is often a limiting factor and worse results are obtained with the use of these methods [25].

However, regression models are applied to many different subjects. Naming just a few: analysing costs and their determinants [26], risk score modelling to predict the presence of a certain disease during a specified time period [27], “survival analysis” to

link patients' disease progression to the time a certain outcome occurs [25] and many others.

3. Computational Phenotyping

Phenotyping involves the process of creating medical concepts (so-called phenotypes) based on raw data on patients that are generally from different sources and includes demographic data, data on diagnoses, drugs, medical procedures and treatments, laboratory findings, etc. Phenotyping consists of several steps [28].

Firstly, a domain expert is responsible for suggesting relevant features, while the final decision about feature selection is made based on results of some statistical approach (such as hypothesis testing) which identifies which of the features are significant for a specific disease and/or a specific accompanying phenomenon.

Traditional statistical methods are easier to implement and interpret, but they might have lower efficacy due to complex relations among health data and they may very often require human interventions. Some of the alternative solutions may include the creation of n-dimensional tensors as a structure capable to present an n-way interaction among variables (e.g. three dimensional ones which include patients, diagnoses in addition to procedures for representing raw input data [29]). In that case, the method will be focused on splitting the n-dimensional tensor into a bias tensor (which represents baseline characteristics common in the overall considered population) and several interaction tensors (that represent specific characteristics of interest) which capture meaningful phenotypes.

3.1. Clustering

Phenotyping implies the use of grouping algorithms, most often a patient-by-disease matrix is applied to different groups of patients. Since health data have different structures as coming from a variety of sources, researchers are forced to use two types of methods for the creation of meaningful clusters. The primary method is based on learning from robust latent representations and the application of clustering. The secondary method is based on the application of clustered probability methods over the collected health data [25].

Also, there are different examples of grouping algorithms:

- **K-Means** and **Hierarchical Clustering** are based on the principle that each data belongs to one cluster, so that they represent hard grouping algorithms.
- **Gaussian Mixture Model** implies that some data can belong to a larger number of clusters, so that it represents a soft clustering algorithm.
- All these clustering algorithms are based on solving an optimization problem, usually defined as minimizing the total distance of the observed point x in relation to corresponding center μ. The task refers to all observed points, therefore usually so-called **Expectation Maximization optimization**

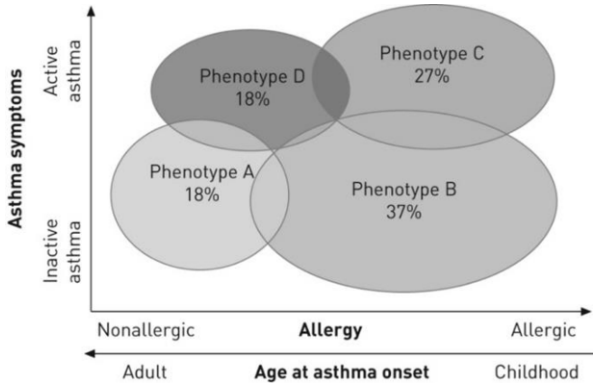

Figure 7. Example of phenotypes: Asthma phenotypes plotted based on the two most significant characteristics in classification [28]: Asthma symptoms and Allergic disorders linked with the age that it occurred. Created phenotypes: A (no or few asthma symptoms and low allergic disorders), B (no or few symptoms but presenting with atopy and allergic disorders), C (younger individuals with childhood-onset asthma, atopy and asthma symptoms), D (adult-onset asthma and asthma symptoms)

3.2. Dimensionality Reduction

The set of raw health data is very complex and usually is presented in a huge number of dimensions (thousands, even millions of dimensions). If we want to use them effectively it is necessary to reduce the dimensionality of the original data without violating their basic characteristics. We use dimension reduction methods for this purpose.

The most commonly used method of dimension reduction is Principal Component Analysis (PCA), which aims to provide a linear transformation of data into lower dimensions while preserving the characteristics of the original data. By applying this algorithm, each original data is represented by new variables, the so-called principal components. The principal components are linear combinations of the original characteristics and are placed such that the first essential component accounts for the largest variation, the second accounts for the following most-valued variance, and so on. Ideally, almost all of the variance in our data might be represented by only the leading essential components, enabling us to reject the rest of the elements without missing vital information [30].

Assumptions of linearity are not suitable to solve problems with a non-linear relation between components. Examples of nonlinear algorithms that can solve such problems are for example:

- **Locally Linear Embedding (LLE)** relies on the local symmetry of linear combinations, on the basis of which the local characteristics of high-dimensional data are transferred to a lower dimensional space that preserves local properties.
- **Kernel Principal Component Analysis (KPCA)** uses a kernel function for nonlinearly mapping data inside a more open place and complete an algorithm of Principal Component Analysis (PCA) on the more extended data.

4. Patient Similarity

Evidence-based medicine is one of the recent paradigms in healthcare where decisions are made and guidelines are used in practice based on the results of well-designed and conducted research, so-called Randomized Clinical Trials (RCT). RCTs are quantitative, comparative, controlled experiments in which two or more groups of randomly selected individuals are created, that receive different interventions of which the results are compared. The RCT is one of the simplest and most powerful tools, but expensive and time consuming to conduct.

On the other side, large datasets about patient demographics, diagnoses and treatments, examinations, with further data about patient genetics and lifestyle can be used for patient similarity algorithms which are aimed to identify groups of patients sharing similar characteristics. The process of determining patient similarity firstly involves creation of components among patient data (the component includes characteristics among which there is a small distance for different patients), then the distance between patients is defined based on the created components and groups of patients with small distances are created [32]. This approach has proven benefits on reducing costs and improving healthcare systems [32].

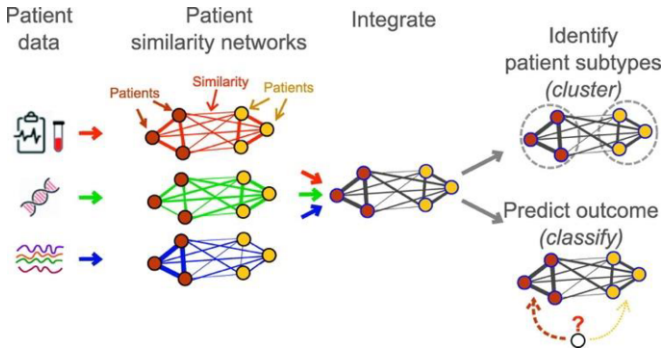

Figure 8. Patient Similarity process [36]

4.1. Distance Metric Learning

One of standard approaches relies on the creation of a Euclidean multi-dimensional feature space as follows:

- a patient can be represented by a n-dimensional vector (*n*- total number of dimensions in feature space);
- the cosine of the angle between two vectors which represent two different patients can be used as a patient similarity metric, the so-called "cosine similarity":

$$PSM\ (P_1, P_2) = \frac{P_1 \cdot P_2}{\|P_1\| \|P_2\|} = \frac{\sum_{i=1}^{n} P_{1i} P_{2i}}{\sqrt{\sum_{i=1}^{n} P_{1i}^2} \sqrt{\sum_{i=1}^{n} P_{2i}^2}},$$

where p_{1i} and p_{2i} represent the value of a single predictor variable *i* for patients 1 and 2, · represents the dot product, and || || represents the Euclidean vector magnitude;

- The minimal possible similarity will result in a PSM value -1 (i.e. the vectors are in the exact opposite directions to each other, create a 180° angle and its angle cosine is -1);
- The maximal possible similarity, i.e. two perfectly overlapping vectors, will result in a PSM value 1 (i.e. an angle of 0° between them, and its angle cosine is 1);
- All other similarity values will be in range -1 to 1.

The predictive model based on the patient similarity method consists of the following steps:

- the domain expert determines the *index patient* (usually the patient who in the best way illustrates the phenomenon that is being analysed);
- for all patients from a given set, the similarity value in relation to the index patient is calculated;
- based on the calculated similarity values, *N* most similar patients are selected and added to the index patient representing the *reference set of patients*;
- the created reference set can be used for further training of the algorithm, or for validation, prediction of a certain group affiliation (e.g. a group of patients with fatal outcome caused by disease, a group with morbidity, etc.).

As the model is based on the selection of index patients, further testing and overall validation of the model is necessary, after which it can be applied in various fields, especially in epidemiology and in clinical studies [32].

It is important to highlight that methods/approaches that incorporates data outputs from previous experience (i.e. selection of index patient etc.) are known as supervised learning. On the other side, there are unsupervised learning methods which do not need any supervised information and models are designed to train and learn about the whole phenomenon and identify referenced values/categories.

4.2. Graph-based Similarity Learning

As alternative to the previous approach of calculating the similarity with an index patient, clinical predictor variables about each patient can be used for the unsupervised clustering of patients and the creation of patient-patient networks. It is an intuitive representation where nodes and edges in the graph could be used for the presentation of patients, medical events and their relations, depending on the specific problem that is modelled. For this purpose, quantified measures of the similarity of graphs and subgraphs have been of interest, and different approaches are suggested in the literature, such as [33]:

- *Graph Edit Distance*- measuring similarity between two graphs by assessing the number of modifications necessary to transform one graph into the other. Different metrics are developed, and they are usually based on the idea that two nodes or edges are similar if their neighbours are similar;
- *NetSimile*- which calculates different node-specific values, like the number of neighbours, the clustering coefficient of a node, and others. These attributes are finally aggregated into one value using different functions, producing a measure of the similarity of two graphs.

Graph-based approaches are exploited in different directions: finding patients with similar temporal diseases, prediction of medical events such as the onset risk of heart failure, etc.

Patient similarity algorithms attract the attention of many researchers, but they are still facing certain challenges, such as network gridlocks, low hardware performance (processing power and memory), and local convergence, and different solutions are suggested for specific problems and applications.

Conclusions

Health systems have a large amount of various medical data that can provide quality parameters for evaluating the health status of patients and society. A large number of researchers have presented different possibilities of collecting, analysing and using health data to support physicians in different domains of medicine, managers of health institutions and other stakeholders of public health activities at the local, national and international levels. In this chapter, we summarized key arenas within healthcare data analytics such as predictive analytics, computational phenotyping and patient similarity, and explained widely used algorithms and methods with identified challenges and potential applications.

Modern health systems require a high level of interoperability of different health data and the ability to apply a holistic approach to data analysis to improve the quality and efficiency of health services such as timely and complete support to practitioners, more accurate prediction and treatment of diseases, improved care and treatment of patients [34].

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Exercises

1. What are the potentials of applying different methods and algorithms to healthcare data?

2. Explain the process of predictive modelling.

3. What is a phenotype? List few approaches of computational phenotyping.

4. What is the aim of patient similarity approaches?

Answers to the exercises

1. Generally speaking, use of different models and algorithms over healthcare data can contribute to improving healthcare in different ways, naming just a few: increase accuracy of diagnosis; public health and preventive medicine; support to personalised treatments of each individual patient; identification of improved treatment plans for specific groups of patients, etc.

2. The predictive modelling process consists of the following key steps:
Step I- Definition of problem, event or behaviour that is going to be addressed, collection of initial data and evaluation of existing algorithms/methods/models from the perspective of what potentials they offer when applied;
Step II- Selection of the best performing model and validation of the whole approach on testing data;
Step III- Running the model in real settings.

3. Phenotype is a medical concept which represents group of patients that share similar characteristics of interest (based on raw data on patients that are from different sources and includes demographic data, data on diagnoses, drugs, medical procedures and treatments, laboratory findings, etc.). Examples of computational phenotyping approaches: Clustering and Dimensionality Reduction.

4. Patient similarity algorithms are aimed to identify groups of patients sharing similar characteristics from the aspect of the phenomenon / disease being analyzed.

Problems/Challenges

➢ Design a framework that you would suggest to healthcare managers dealing with cost reduction in a hospital (identify data and relevant data sources, applicable analytical approaches, etc.).
➢ Design a framework that you would suggest for diabetes patients in order to design a personalised treatment plan (identify data and relevant data sources, applicable analytical approaches, etc.).

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SECTION 5

Health Informatics

Preamble

The information systems either store or produce information. The first chapter provides an excellent overview of IT and information management in healthcare. Next chapter introduces hospital information systems as socio-technical systems. This chapter is followed by a chapter on e-health and clinical documentation also presenting principles of interoperability. A third chapter discusses the increased role of artificial intelligence in healthcare with applications. The last chapter is on IT-assisted process management in healthcare discussing methods for analysing and modelling clinical processes.

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Information Technology and Information Management in Healthcare

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Abstract. Recent decades made a change in health care by putting health information as a core asset for effective management and improved quality of care. That is a reason why applications of information technology in health and healthcare attract more attention by healthcare organisations with highly skilled health information management professionals having an active role in the effective maintenance of organized and accurate electronic healthcare data. Also, widely adopted standards and principles of healthcare information governance are essential in efforts to reach a compromise of shared data, information and knowledge in the interoperable, electronic healthcare information sharing environment.

Keywords. Health information technology, health information, health information management, digital transformation

1. Introduction

In order to ensure effective planning, monitoring and risk assessment [1] during the provision of health services at all levels of health care (organizational[2], regional[3], national [4] and international [5] it is essential that modern healthcare systems are based on intensive use of information that is expected to be timely and reliable. It is therefore necessary to achieve a high degree of integration of modern information and communication technologies (ICTs) in order to ensure greater efficiency of services in the healthcare sector.

The integration of ICT into health systems has been continuously realized over the past 60 years through several key developmental stages [6] : (i) in the 1960s, the development of IS concerned the support of the work of the financial service; (ii) during the 1970s IS was developed to support clinical departments such as radiology, laboratory and pharmacy[7]; (iii) IS for cost accounting management and material management systems [8] were implemented during the 1980s; (iv) ISS to support clinical systems using electronic medical records (EMR) [9]were developed during the 1990s; (v) for the last twenty years, distributed ISs have been implemented that integrate data from different sources and are characterized by the use of AI technologies.

According to a review of the literature [10] we conclude that the development and integration of ICT solutions in healthcare is largely driven by advances in technology and, to a lesser extent, needs-driven improvements in the efficiency and management of healthcare systems. These facts significantly contributed to the inhomogeneous

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development of health information systems (HCIS) [11]during the first period of application of ICT in healthcare.

Modern lifestyles, characterized by high mobility of people, a broader market and greater availability of healthcare facilities, have imposed the principle of competitiveness on health systems, especially with regard to the quality and efficiency of health care services and care. On the other hand, the rapid technological development of ICT has enabled different approaches to the development of healthcare institutions [12] so that the focus is on improving the quality of health services and management procedures, while reducing the cost and making more efficient use of available resources [13] [14]. Therefore: development of integrated and well-orchestrated elements to support adopted processes such as health resource management[15], efficient and coordinated decision-making process support [14] , clinical and diagnostic equipment support[13], and Person-Centred-Care [16] are becoming the key requirements for development in modern healthcare IS.

2. Digital transformation of the health system

In the 21st century, challenges for the health sector become even more pronounced and demanding, involving financial, strategic, human and digital transformations: (i) Health systems are being challenged to achieve financial sustainability, which is usually implemented by reducing the cost of high quality and effective patient care; (ii) Encouraged by modern technologies development, new health care strategies are increasingly advocating preventative health care activities and person centred; (iii) Dealing with the trend of rising life expectancy of the population and the lack of experienced clinicians imposes the imperative to educate and retain skilled workers; (iv) Rapid development of digital technologies enables the development of solutions that are helpful to clinicians in delivering healthcare services while being receptive to patients and consumers [17].

The development of digital solutions in healthcare is based on the integration of data from different sources and the use of open, secure platforms which, as a result, provide the basis for development of new patient-centred care delivery models; integrated predictive, preventative and personalized aspects in the treatment of patients and diseases; all aimed on promoting treatments and therapies that are effective, high-quality and tailored to the needs of each individual patient. The following current and emerging innovations enable the digital transformation of health systems [17]:

- Cloud computing solutions create more flexible applications with richer sets of features, capable to support either individual physicians working alone or teams of professionals working in health care institutions, provide new ways of instant communication and effective sharing of available resources.
- 5G wireless technology provides massive network capacity, higher data speeds and more reliable communication between two end users. Higher performance and improved efficiency empower new user experiences and create connections with new industries.
- Interoperability provides an ability of communication and data exchange between different health information systems. Regardless the domains and fields of applications, the standards enable sharing information between healthcare providers, hospitals, pharmacies, etc.

- Artificial intelligence (AI) in medicine enables optimization of health care processes for patients with chronic disease, proposes more accurate therapies for complex diseases and advances results of clinical trials. Potential directions for further development of AI and its applications in the field of medicine in the near future could include: natural language processing as a tool for prescribing treatments instead of written sentences; creation of new radiology tools; making EHRs more effective; decreasing the risks of antibiotic resistance; offering more accurate analytics for pathology images; more effectively usage of immunotherapy for cancer treatment and so on.
- Big data analytics include advanced analytical techniques over large and diverse sets of structured, semi-structured and unstructured data obtained from different sources, all aimed on providing support to the decision-making process. Computer algorithms could be used for increasing the accuracy in interpreting digital images compared to existing manual or semi-automatic processes conducted by clinicians.
- The healthcare industry uses four Robot types to improve current standards of care: Surgical Robots – developed to help physicians in performing complex procedures in a more precise and flexible manner; Exoskeletons - designed to assist patients in the rehabilitation process of conditions leading to lower limb disorders, including spinal cord injuries and strokes; Care Robots - developed to provide care and support to elderly and disabled patients; Hospital Robots - can be used in delivering medications, laboratory specimens, or other sensitive material within a hospital environment.
- Sensors use algorithms to define the best possible treatment and AI solutions to identify and flag abnormalities in order to provide patient care in a timely manner.
- Blockchain technology is capable to transform the healthcare system with its key features, such as decentralization, anonymity, persistence, and audibility. The use of blockchain will increase the quality of healthcare, make it more transparent, highly secured, and more cost-effective.
- Learning platforms are very important for continually strengthening and educating human resources in healthcare institutions. The platforms enable interactive and flexible learning regardless the physical location either of the lecturers or trainees. Workgroup collaboration tools enable efficient information sharing, better teamwork and more effective data control in teaching, learning and research activities.
- *Internet of Medical Things* are medical devices connected to the health system network infrastructure aimed on providing services and data to patients and clinicians as end users, therefore leading to improved health processes and a more efficient provision of health services.

Although digital technologies are used to support health care delivery processes and their effective management, digital technologies are also used for effectively responding to threats and attacks in the digital environment, such as: (i) identifying threat agents or patterns of data leaks and creating appropriate protection measures using AI methods and predictive analytics; (ii) data integration and deployment of more secure cloud platforms (implemented in collaboration with major cloud solution providers and EMR and EHR providers); (iii) logistic support, financial and supply chain management, digital identity using blockchain technologies, etc. Understanding technology and

business processes is a prerequisite for successful implementation of the digital transformation process in healthcare organizations. Key challenges of digital transformation in healthcare are:

- Technologically obsolete information systems with expensive maintenance;
- Autonomous systems which prevent modifications, but improve interoperability;
- Selection of a specific technology appropriate for distributed development for a longer period of time;
- Frequent changes in business processes impose complex system modifications and furthermore make them more vulnerable;
- Full acceptance and support by healthcare professionals and business staff members for implementation of business process digitization;
- Cyber security provision with special focus on the protection of personal health data in accordance with GDPR.

3. Overview of Health Information Management

During the last two decades integration of information technology into the health system is characterized by the rapid development of health information systems and is expected to change and progress even more. The amount of healthcare data is growing exponentially, and projections indicate that we will exceed 2,314 exabytes by 2020. [18] In order to create and implement effective use of very large amounts of healthcare data, several accompanying challenges are identified: (i) effective data governance [18], (ii) integration of new devices for continuously collecting various health data, such as home monitoring systems, smart watches and fitness devices, (iii) necessity of translating generated knowledge into practice [19], (iv) enhanced predictive analytics and interoperability as key functionalities [18], etc.

Merriam-Webster [20] define big data as “an accumulation of data that is too large and complex for processing by traditional database management tools”. Big Healthcare Data has a huge potential for developing a new and innovative software solution for the health system. According to a recent review [19] over the last decade health researchers are mainly focused on big data from the next three areas: 1) disease management and epidemiology; 2) data mining and machine learning technologies and applications; and 3) health services enhanced by integration with personal health devices and electronic health records.

Health information management (HIM) is a multi-disciplinary area that is primarily focused on the entire management process of health data from both traditional sources and those digitized. HIM is vital for providing quality patient care, encompassing activities ranging from data collection, storage, analysis, interpretation and protection. Rapid development of tools and methods for data processing as well as the increasing size of data stores, format and size of data sources, led to changes in the HIM practice of managing and facilitating the secondary use of patient data. During the period of paper medical records, patient records were primarily used for administration and billing purposes. Secondary use of patient data was possible only through creation of diagnostic and procedural / coding system interventions, while nowadays the focus is put on creation of health records and standardized classifications that allow uniform data storage and ease of use in further analysis and research.

Health information includes all data related to the patient's medical history, including symptoms, diagnosis, performed procedures (laboratory results, X-rays, hospital records, interventions and surgical procedures), prescribed treatments and medications, outcomes and control data reviews. The analysis of the patient's health information can be performed for various purposes: (i) monitoring the patient's health status, monitoring the development of the disease and the rehabilitation process, (ii) analysing health indicators on a part of the population or population as a whole, (iii) analysing the effect of certain medical interventions within some studies, etc.

Health Informatics (HI) is a science focused on the engineering of computer systems that technically provide processes for the creation, recording, transmission and use of health information. It is a comprehensive discipline that integrates a variety of disciplines, from engineering (computer science and technology), management (data management, process control, data security, patient safety) to medical (healthcare and public health). Due to rapid development of technologies, health informatics is attracting more and more attention for research and innovation, as well as for the practical applications and assessment of potential impacts achievable by using modern technologies.

Health information management professionals (HIM professionals) are highly educated about procedures and business processes within healthcare institutions and healthcare system as a whole, as well as about capabilities, implementation and use of the latest information systems management applications. The role of HIM professionals is of multiple importance for health care functioning, as they are active participants in the continuous process of managing health information and electronic health records (EHRs), and are responsible for preserving the quality, integrity and credibility of patient health information. They are additionally responsible for creating and implementing classification of diseases and treatments as a basic prerequisite for the secondary use of health data.

Health information technology (HIT) includes a framework for technical implementation (hardware components, software components, and software systems) of health information management processes and their sharing among various actors in the healthcare system. To meet these requirements, HIT professionals typically have a background in information technologies with a significant knowledge about the functioning and maintenance of EHRs and other health systems.

3.1. Health Information Management Professionals

Effective health data management includes the following tasks: ensuring availability and integrity, ensuring confidentiality and data protection, providing information necessary for decision making by individuals as well as organizations and systems, timely and effective health promotion, etc. In order to respond to these tasks properly in a time of rapid technology development, HIM professionals are required to have a high level of skills and knowledge how to adapt and implement new technologies and standards for electronic data collection, storage, distribution and processing. At the same time, the application of various technological advances is possible in an interoperable environment with defined standards, and the corresponding tasks of HIM professionals are summarized in Table 1.

Table 1. Roles of HIM professionals in healthcare organizations [21]

HIM Roles		
Data Capture, Validation, Maintenance		
Chart correction analyst	Data architect	ICD-10 implementation specialist
Classification editor and exchange expert	Data capture design specialist	Information workflow designer
Clinical coding validator	Data dictionary manager	Patient identity manager
Clinical content manager	Data integrity and transition specialist/auditor	Registrar (birth, cancer, device, bone marrow, tissue)
Clinical documentation improvement specialist/supervisor	Data mapper/translator	Research coordinator/associate
Coder	Data quality manager/analyst	Research data abstractor
Coding compliance coordinator/supervisor/manager	Documentations/EHR trainer	Terminology asset manager
Computer-assisted coding validation practice leader	EHR content manager	Voice capture specialist
Privacy Officer	Enterprise patient master index, data integrity analyst	
Data/Information Analysis, Decision Support and Informatics		
Business analyst/data analyst	Data integration manager/analyst	Decision support officer
Claims data analyst	Data integrity and transactions specialist/auditor	Health data analyst/manager/ director
Clinical content analyst	Data quality manager/analyst	Health data statistician
Data abstractor/coordinator	Data repository architect/manager/analyst	Health outcomes analyst
Data architect	Decision support analyst	Health data quality engineer

3.2. Health Information Management Practices

Health information management provides support for the entire life cycle of health information and its functions can be grouped into 5 high-level groups, as presented in Figure 1. [21].

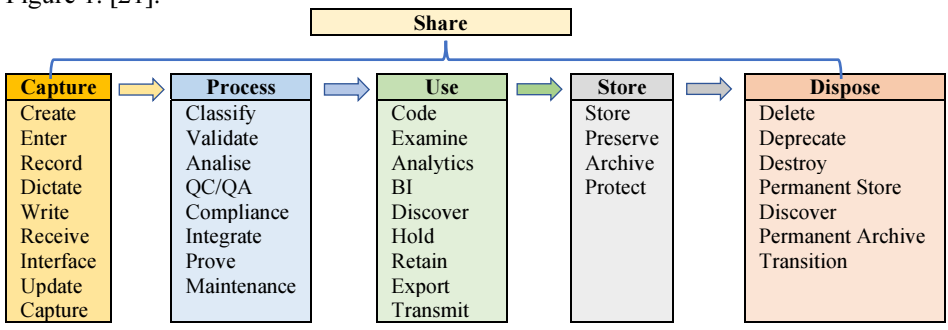

Figure 1. Health information management function Health Information

Health information should include all types of health data generated through the episode of care and integrated by all actors involved in the episode (e.g., patients, clinicians, administrators, HIM professionals, etc.). The episode of care covers various functions, of which the order and implementation approach are determined by the type of visit in accordance with the institutional organization and regulations. The functions include patient registration, triage, medical history, testing and diagnosis, treatment and care plan, follow-up of the recovery process, etc. All functions are followed by different

activities with health data, where activities may include data generation and storage (e.g., activities in the registration process), then queries and readings over existing data (e.g., activities in the medical history analysis), data generation and sharing (e.g. activities in the testing and diagnosis process), as well as combinations of all these activities (e.g., follow-up activities of the recovery process). All activities over health data need to be stored in an appropriate manner, while some actors in the care episode occasionally use paper formats to create documentation, which is also needed to be transformed into a digitized format to be adequate for further processing and use (e.g., scanning and automatic recognition of content, etc.). One example of episode care and related health data activities are presented in Table 2.

Table 2. Functions of the Episode of Care and Examples of Health Information in the Record

Episode of Care's Functions	Examples of Information in the Record
Visit Registration / Admission	Demographic characteristics of patients, consent for retaining and sharing information, created billing documentation for provided care and treatment
Triage	Triage documentation with triage tags (usually created based on vital signs and their classifications)
Assessment	Documented patient history: medical history, report of problems and medications already taken Preliminary diagnostic report with recommendations for further diagnostic procedures (if required) as well as preliminary therapy
Laboratory and Diagnostic Testing	Consent for Procedure, Test Order, Test Results, Test Reports (when applicable)
Diagnosis and Treatment Plan	Confirmed Diagnosis and Updated Treatment Plan
Prescription	Medication Order and Dispense Report
Progress assessments	Reports on repeated laboratory testing (if needed), taken interventions and procedures, documented summary of health assessment during and after treatments etc.
Summary of Care	Transfer Summary or Discharge Summary
Discharge/Transfer/Discharge (ADT)	ADT Record

In order to enable comprehensiveness and structure in the records, a hierarchical structure of records contents is created as follows:

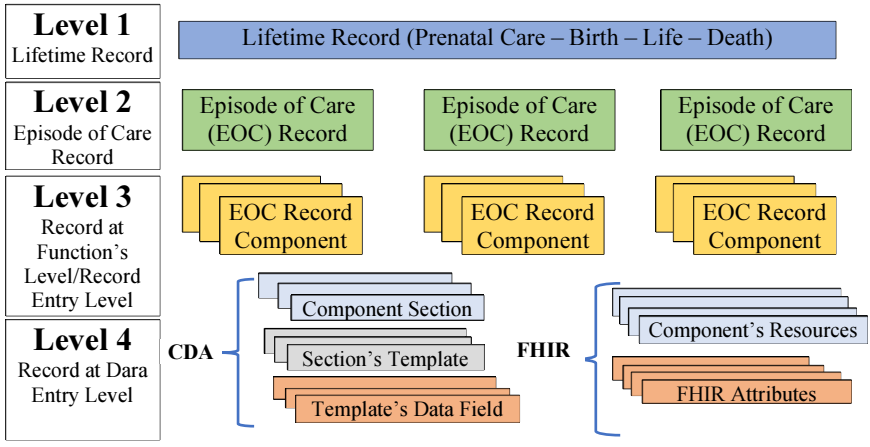

Figure 2. Record Content Hierarchy

- Level 1 - Lifetime Record - the highest level in the hierarchy that provides a comprehensive view of records from all episodes of care throughout the patient's life (from prenatal care and birth to death)

- Level 2 - Episode of Care Record - hierarchy level related to a comprehensive view of a specific care episode, generated from lower levels in the hierarchy and pertaining to specific procedures within a given care episode
- Level 3 - Function's Record Component - Specific records that have been generated within a specific episode care function (e.g., the care functions illustrated in Table 2)
- Level 4 - Data Entry Record (record at data entry level)- the lowest level in the hierarchy that includes individual data related to a specific function or parts of a function, as illustrated in Figure 4. Of particular importance for the complete hierarchy of records is the presentation of data in accordance with relevant standards: Health Level Seven (HL7) Continuity Care Document (CCD)/Clinical Document Architecture (CDA) standard [21], HL7 Fast Health Interchange Resource (FHIR) standard [22] and/or other information content standards.

Figure 3 presents the detailed views of episode of care functions and appropriate documentation for each function.

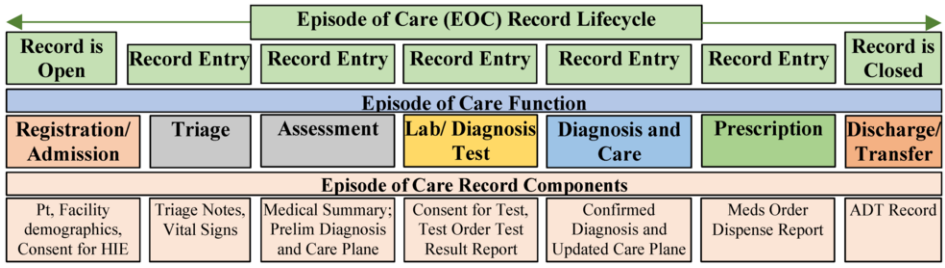

Figure 3. Examples of Episode of Care's Functions and Records/Documents

4. Information Governance

Information governance defines rules for dealing with information as objects in the process. More precisely, it can be defined as "an accountability framework that includes the processes, roles, standards, and metrics that ensure the effective and efficient use of information to enable an organization to achieve its goals" [23].

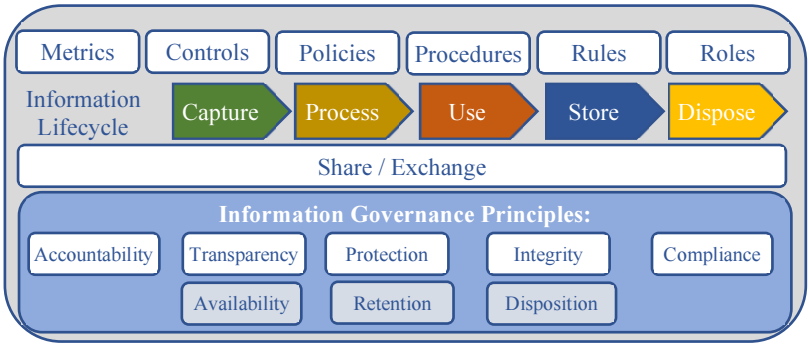

Figure 4. AHIMA Framework for Information Governance [24]

The generally accepted standard Maturity model of ARMA International (Association of Records Managers and Administrators) [25], defines the key principles for record keeping: Accountability; Transparency; Protection; Integrity; Compliance (these 5 principles represent the attributes of the record); Availability; Retention; Disposition (these 3 principles represent the states of the record lifecycle).

These Information governance principles were adopted for the healthcare domain by AHIMA (American Health Information Management Association) in 2014 and resulted in a comprehensive set of eight Information Governance Principles for Healthcare [26]. In order to build and strengthen the trust between patients, doctors and regulatory authorities, it is necessary to comprehensively implement all eight principles even when some of them are overlapping [24].

Figure 4 presents the AHIMA framework for information governance which is created in relation to the information lifecycle and thus enables organizational policies and processes to support the whole process [24].

One of key recommendations defined in the Framework is the establishment of an appropriate Committee which is responsible for creation and definition of information management policies and processes. Representatives of management, clinical, technology and administrative departments should be included in the Committee [25], as follows:

- Management department
  - Representative from Financial department
  - Representative from Legal and HR department
  - Depute CEO
- Clinical department
  - Representative of key clinical departments
  - Representative of support services (laboratory, pharmacy, etc.)
  - Representative of nurses
- Technology department
  - Representatives from Health information technology
  - Representatives from Medical informatics
- Administration
  - Representative of legal and administrative services

There is no unique title for this Committee (Form Management Committee, HIT Committee, etc.) since it relies on the specificities of each organisation and the different responsibilities that are assigned to the Committee. However, it is of critical importance for the Board to have the capacities to establish adequate HIM processes and documentation that are essential in efforts to compromise on shared data, information and knowledge in the interoperable, electronic healthcare sharing environment.

Three key suggested principles of information governance in healthcare, recommended as mandatory for standardization of the Committee's efforts are: Information Availability, Information Integrity and Information Protection, as follows.

4.1. Principle of Information Availability

The availability concept ensures that appropriate healthcare personnel can access health information resources in a reliable and timely manner, ensuring implementation of

security service functions. The healthcare institution is obliged to provide accurate, efficient and effective access to information for each authorized user of a health information system, all in accordance with established procedures and granted access rights. Each authorized entity should have the ability to use information and devices in an appropriate way [25].

Some authorized entities who use information are the following:

- Doctors, nurses and patients at health care institutions;
- Full and part time authorized workforce;
- Other health and government institutions entitled to access data in accordance with legal regulations;
- Institutions authorized for internal and external audit (quality assurance, payor audit, financial audit).

In order to implement the best HIM practices in line with diverse business requirements, HIT standards have been established by reputable international standardization organizations such as:

- Health Level Seven (HL7).
- International Organization for Standardization (ISO)
- American Society for Testing and Materials (ASTM) and

Table 3. HIM business requirements for Information Availability.

	Health Information: Availability Requirements	Standards Development Organizations		
		HL7	**ISO**	**ASTM**
1	Being able to harvest information accurately, and in a way that allows efficient retrieval.	EHRS FM R2	HL710781 IEEE IS11073	E1633
2	Being able to do specific actions with customized patient information regardless of the system, such as: Lookup, Identification, Fetching.		TS 14265	E2369
3	Being able to retrieve information for various systems and devices which include the ability to use queries as a tool for gathering information.			E1384
4	Being able to gather information from various electronic systems disregarding the organization's location	CDA R2		E2369
5	Being able to deliver the requested information to the right requestor for the expecting time	EHRS FM R2	HL710781 IS 136063 TS 14265	E1744 E2369 E2473
6	Being able to support various metadata services across multiple systems	EHRS FM R2	TS 17948	E1384
7	Build trust with applicants by guaranteeing the efficiency, timeliness and accuracy of information	EHRS FM R2 CDA R2	HL710781 IS 13606	E1633 E2369

4.2. Principle of Information Integrity

The concept of integrity of information can be implemented while respecting the following three principles:

- Data should not be altered by unauthorized persons or processes;
- Authorized persons or processes should not make unauthorized changes to the data;
- The data are internally and externally consistent, which means that the internal data are mutually consistent across all subfields, as well as with the real world, i.e. the external environment [27].

Table 4. HIM business requirements under Principle of Information Integrity

	Health Information: Integrity Requirements	Standards Development Organizations		
		HL7	ISO	ASTM
1	Being able to provide accurate and complete information from credible sources.	EHRS FM R2	HL710781 IEEE IS 11073	E1633
2	Being able to ensure that all implemented practices for information maintenance are safe and compliant with a legal requirement.	EHRS FM R2	HL710781	
3	Being able to ensure that all implemented practices for information maintenance are according to the organization's policies.	EHRS FM R2	HL710781 IS 22600-1	
4	Build trust with claimants by guaranteeing completeness, authenticity and accuracy of records in litigation.	EHRS FM R2	HL710781	
5	To be able to reliably control the system in a way that supports the organization's ongoing activities	EHRS FM R2	HL710781 IS 22600-1	
6	Establish reliable information integrity controls to support the implementation of the organization's ongoing activities	EHRS FM R2	HL710781 IEEE IS 11073	E1384 E2369 E2473
7	Being able to deliver reliable healthcare information in appropriate form for their further processing and use in other applications.	EHRS FM R2	HL710781 IEEE IS 11073	
8	Establish a regular audit process that will ensure the reliability and integrity of information.	EHRS FM R2	HL710781 IS 22600-1	E2147

4.3. Principle of Information Protection

Confidentiality, integrity and availability make up the so-called holy trinity of Protection. Everything related to information protection and protection mechanisms, all threats, vulnerabilities and security processes are subject to evaluation against these three criteria.

Protection of health information includes: protection against unauthorized, unpredicted or inadvertent modification of data; providing access to information only for authorized users; ensuring the availability of health data and availability of health information systems which provide services [27].

Table 5. HIM business requirements under Principle of Information Protection.

	Health Information: Protection Requirements	Standards Development Organizations		
		HL7	ISO	ASTM
1	Ability to prevent corruption and loss of classified and essential business information	EHRS FM R2	HL710781 IS 27799	
2	Ability to update information security systems throughout each phase of the information lifecycle	EHRS FM R2	HL710781 IS 27799	
3	To be able to create a protocol for audit and verification if the sensitive information is handled in accordance with the organization's security policies	EHRS FM R2	HL710781	E2147
4	To be able to manage information in compliance with law and regulated policies	EHRS FM R2	HL710781 IS 22600-1 IS 27799	
5	To be able to set up various security and disaster recovery processes which would allow unobstructed operation during periods of disruption	EHRS FM R2	HL710781	
6	Ability to establish and manage appropriate rules for information access control for each user according with their assigned roles and duties.	EHRS FM R2	HL710781 IS 17090 IS 22600-1 IS 27799	
7	To be able to develop safeguards in accordance with organizational policies that will prevent the information from being spread harmful or unauthorized regardless of the type of communication channel	EHRS FM R2	HL710781 IS 17090-1,2	

5. Health Information System

Nowadays, healthcare managers face four major challenges: (i) challenge of globalization: how to ensure business growth in a global and turbulent economic environment; (ii) strategic challenge: how to design a healthcare organization as a flexible system that will be competitive and efficient; (iii) challenge of information architecture: how to develop an information system that will optimally support business goals of the healthcare institution; (iv) challenge of control: how to provide a monitoring system for actors in the organization and control their activities with appropriate protection against unauthorized access.

From the management point of view, it is almost impossible to answer these key questions without an adequate, timely and continuous process of gathering information from the organization and environment. The health information system is not only a managing instrument for creation and monitoring of activities in the organization; furthermore, it is an interface that allows interaction between people, processes and technology all aimed on supporting more effective businesses and increased quality of healthcare services. Shortly, health information systems can be defined as systems that *process data and provide information and knowledge in healthcare environments* [28].

From the perspective of decision makers, a health information system should have four key functions: data creation, processing, analytical reasoning models and a communication reporting infrastructure. In a nutshell, the Health Information System collects and creates data from the health sector and other relevant institutions, analyses and processes data ensuring quality, relevance and timeliness, and converts them into information necessary for decision makers.

5.1. Components of a Health Information System

A health information system is required to contain the whole list of components as illustrated in Figure 5 and described in the following paragraphs, which only when mutually integrated and interconnected can enable the data storage, decision support and health promotion functions of the system.

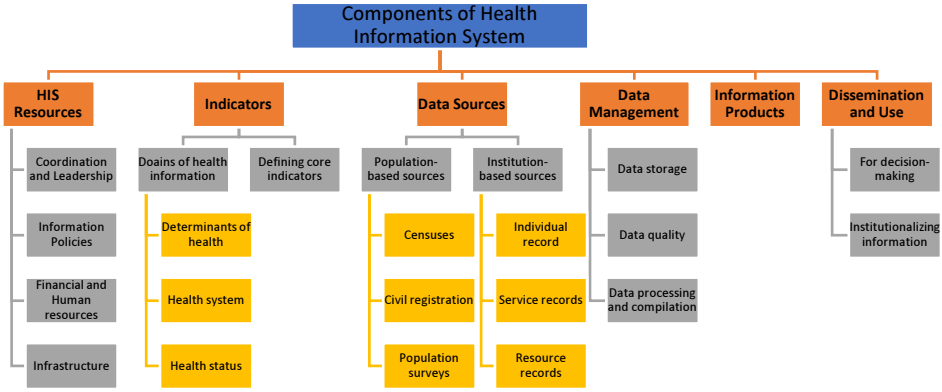

Figure 5. Components of Health Information System

Health Information System Resources - include frameworks and resources necessary for establishment and functioning of the HIS [28], such as:

- *Health Information System Coordination and Leadership* - Development and strengthening of the system requires coordination and cooperation with key actors in the health system. The actors should be identified depending on the organization of the health system, including those at institutional and national levels, such as the Ministry of Health, Institute of Public Health and others. These institutions are expected to support the provision of a framework for data collection, storage and transmission, analysis and reporting.
- *Health Information System Information Policies* - In order to develop technological support to storage and transmission of health data among various actors, it is necessary to regulate and define standards for ensuring the availability of data, data exchange and quality, as well as protection and security.
- *Financial and human resources of the health information system* - Efficient management of available resources is at the heart of the functioning of the health system, including continuous education, capacity building, optimal use of finances with simultaneous improvements of the quality of care, etc.
- *Health Information System Infrastructure* - The use of information technology provides modern resources for storing large amounts of health data, which can significantly contribute to reducing the time of data processing and transmission, as well as increasing the level of protection and data security. In addition, modern communication technologies provide benefits as increased performance of data analysis as well as higher speeds of data transmissions.

Indicators - The HIS development plan and strategy are created based on a core set of indicators and related objectives, as follows:

- *Determinants of health* - determinants that contextually determine the environment in which the health system operates, including the following: socioeconomic, environmental, behavioural, demographic and genetic determinants or risk factors.
- *Health system input indicators* – include direct inputs for the health system (human resources, financial resources, infrastructure, equipment, medicines, supplies), as well as other related inputs and processes (policy, organization, etc.).
- *Health system output indicators* - relate to the evaluation of health services and healthcare information, including their quality and availability assessments.
- *Health system outcome indicators* - relate directly to health systems, use of services and comprehensiveness of information.
- *Health status* - a set of variables describing health status which may be related to determinants of health and their potential impact on health outcomes and efficacy and coverage of health interventions. These variables include the following: mortality, morbidity, disability and well-being levels, which can be further broken down into sub-variables.

Defining basic indicators - Basic indicators of the health system should be created to allow evaluation of changes that occur over time and thus become the basis for decision making. A minimum set of indicators is usually defined at national levels, while national programs define how indicators are evaluated, collected, planned and continually monitored.

Data Sources - There are two basic principles for categorization of data sources:

- *Population-based sources* - include data relating to the entire population (e.g. census, civil registration, etc.) or to a representative sample selected to provide relevant information that can be generalized to obtain an image of the entire population (e.g. population surveys on smoking habits, etc.).
- *Institution-based resources* - data that are continuously generated during clinical service delivery (e.g. individual records with all health data, records from institutional health information systems about delivered services, etc.) and administration activities at the institution (e.g. billing records, records about use of material resources, etc.).

Each data source provide data for at least one healthcare indicator, while usually data for particular indicators can be generated from more than one source, as summarised in Table 6.

Table 6. Linking indicators and data sources

	Determinants of Health	Health system		Health status
		Inputs and outputs	Outcomes	
Censuses	+	+		+
Civil registration	+			+
Population surveys	+	+	+	+
Individual record	+	+	+	+
Service records		+	+	+
Resource records		+		

Data Management - covers the entire process of handling healthcare data, including the following:

Data storage. It is of particular importance for health information systems to store all collected data for the medium to long term. In that manner, it provides access to data

needed for comprehensive evaluations of the healthcare system, analysis of resources' exploitation, as well as trend analysis of specific diseases and health as a whole.

Data quality assurance. As in other domains, whenever quality assurance is discussed, it is necessary to develop policies and standards for its implementation, as well as continuous implementation review and self-assessments. Due to the amount of health data that is generated, one of the additionally imposed principles is the principle of minimality, i.e. reducing the amount of data required to the minimum possible while maintaining the level of information and its meaningful content.

Data processing and compilation. As data in medical information systems are coming from different sources and generated by different actors, a permanent requirement is on ensuring data consistency, integrability with prior clean-up and normalisation (when needed). Additionally, the needs and requirements of involved actors may change over time, as well as institutional and national rules, development technologies are rapidly improving and changing, and therefore it is necessary to ensure that data processing systems support the changes and ensure their relatively easy adaptation.

Information products - Raw data from the storage can be rarely useful unless it is transformed into information relevant for analysis and decision making. Many of today's systems are characterized by being "rich in data" but "poor in information" because large repositories of high-quality data are created, and they are not used for decision making and further reasoning. However, real value is obtained when high quality data from a data storage can be retrieved, synthesized and triangulated with other sources, analysed by using advanced statistical tools and deeper analysis. Therefore, a key aspect of data use is the synthesis of information and knowledge, the identification and comparison of trends, as well as decision-making on improving care and health as a whole. Figure 6 illustrates the flow of data transformation into information and evidence.

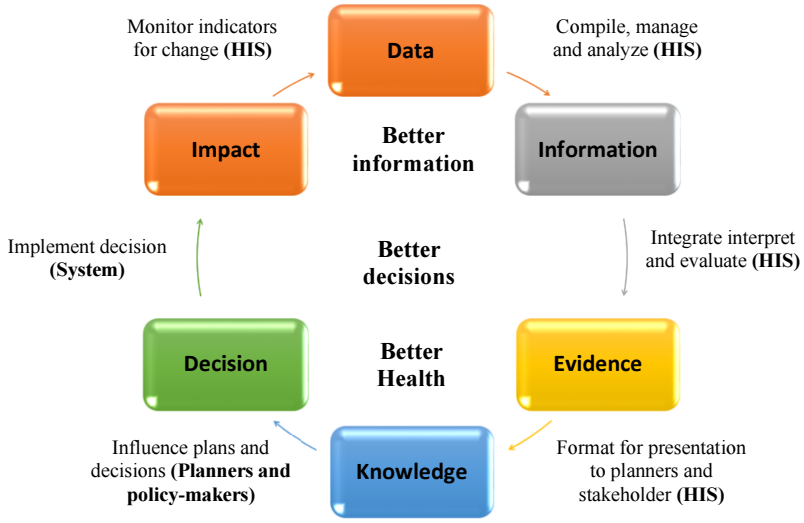

Figure 6. Transforming data into information and evidence [29]

Dissemination and use - Health data gets value only when transformed into information, and obtained information gets value only when used by decision makers at different levels of the institutional and national systems.

Use of information for decision making. For each country, the national level is a key for health system decision-making, which encompasses policy definition, planning and development, on which basis decisions are made at all institutional levels. The principle of Health Metrics Network is that country information should be an essential part of the day-to-day management of health system planning and delivery. Health system information is the basis for planning health care financing at the national level (ministries of health and finance) as well as when planning is aimed on submitting applications and use of external sources of funding (donors, loans from agencies and development banks). Also, decision-making requires involvement of various actors, from healthcare professionals, managers, to top-level executives at the governmental level and the population at large. Therefore, health information should be available and presented in an appropriate format to all actors involved.

Institutionalizing the use and demand of information. At different levels, different actors create different types of data, while as we move towards the health pyramid, the link between the decision-making process and the use of health information is increasingly sensitive. Moreover, towards the higher levels of the pyramid, additional factors are influencing the strategic goals, such as interest groups and lobbies, political interests and many others. There are different interests and decision-making needs at all other levels, such as: managers aim to help increase the efficiency and quality, policy makers want optimal use of resources and prioritized planning. Clinicians and practitioners, on the other hand, want to improve the effectiveness of care treatments as well as increase the efficiency of procedures and administrative protocols.

5.2. Expectations of a health information system

Health information systems are used by a variety of actors with different purposes, including care, evidence-based optimization and management decisions, identification of improvement requirements and creation of best-fitting mechanisms to the current situation, etc. Health information systems simultaneously integrate data from different sources used for different purposes to create information relevant to the system, as follows [28]:

- Individual level data - information about each individual patient, records of all treatments and interventions of the patient during life. Review of comprehensive patient data is of particular importance to practitioners in creating a picture of a patient's health; while poor connectivity and lack of coordination of data from different subsystems can cause problems and data overload.
- Health facility level data - A complete information about health care institution can be obtained by integrating data about care processes, patients' health indicators, corresponding administrative data as well as data about consumption of medications and other resources. By analysing data at the healthcare facility level, managers and authorities can make adequate decisions for resource management as well as appropriate measures for improvements of quality of care. In addition, if combined at the level of all institutions (public and private), these data can provide information relevant for the whole health system as well as public health as a whole.
- Population level data - data that includes not only the population who uses the healthcare services, but additionally the population who does not use them. In

that way, information about the whole population is provided, with special focus on their habits and characteristics which may be of importance in the prevention and treatment of certain diseases, as well as for understanding the expectations and existing practices of using the health care system.

- Public health - In order to identify health issues at the population level as well as to create timely adequate responses, it is necessary to bring together data at levels of all institutions as well as those related to the community as a whole. This linking of data is usually an added requirement and challenge for information systems at the level of various health care institutions, but it is of particular importance for the adoption of urgent actions and measures in the prevention of epidemics and other diseases.

Technology development and overall increase in evidence-based decision-making approaches have contributed to a significant increase of awareness and needs for development of information systems capable of generating reliable data. In many countries, health sector reforms are being implemented that require increased standardization and data quality, improved requirements for collecting of distributed data, their processing and analysing, with ongoing demands for privacy and ensuring a high level of data protection.

6. Conclusions

The rapid development of information and communication technologies has led to the development of a full range of applications and services in the field of health, which together represent Health Information Technology (HIT). HIT is primarily focused on supporting the process of collecting and storing various types of health data coming from different segments of healthcare, as well as supporting business processes in the healthcare system (from increasing the efficiency of the care process itself, administration and finance, to decision-making process and creation of policies). The results of the development and implementation of HIT are evident in reducing paperwork, increasing productivity, improving communication among various actors in the healthcare system, reducing costs and improving the quality of certain parts of care. However, the rapid development and widespread deployment of IT services requires a comprehensive impact assessment as well as an analysis of the transformation of the HIM profession in the digitalization era, which certainly requires skills development and redefining of their roles in healthcare system.

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Exercises

1. What is the main characteristic of ICT integration into health system through history?

2. What are the most important challenges for the health sector in the 21st century?

3. What kind of technical innovations are recognized as key technologies for digital transformation of health system?

4. Explain four levels of hierarchical structure of records?

5. What are the main components of Health Information System?

Answers to the Exercises

1.
- The 1960s: the development of IS concerned the support of the work of the financial service;
- The 1970s: IS was developed to support clinical departments such as radiology, laboratory and pharmacy;
- The 1980s: IS for cost accounting management and material management systems;
- The 1990s: ISS to support clinical systems using electronic medical record (EMR);
- For the last twenty years: distributed ISs have been implemented that integrate data from different sources and are characterized by the use of AI technologies.

2. There are four most important challenges for the health sector in the 21st century:
- Health systems should achieve financial sustainability;
- New health care strategies such as: preventative health care activities and person centred care;
- The education and retaining skilled workers;
- The development of technology supported solutions acceptable to patients and consumers will be helpful to clinicians in delivering healthcare services.

3. The following technologies will have a key role in digital transformation of health systems: Cloud computing; 5G technology; Interoperability; Artificial intelligence; Big data; Robots; Blockchain technology; Learning platforms; Internet of Medical Things.

4. In order to enable comprehensiveness and structure in the records, a hierarchical structure of record content is created as follows:
- Lifetime Record - the highest level in the hierarchy that provides a comprehensive view of records from all episodes of care.
- Episode of Care Record - hierarchy level related to a comprehensive view of a specific care episode, generated from lower levels in the hierarchy.
- Function's Record Component - specific records that have been generated within a specific episode care function.
- Data Entry Record - the lowest level in the hierarchy that includes individual data related to a specific function or parts of a function.

5. Health Information System are composed of: HIS Resources, Indicators, Data Sources, Data Management, Information Products and Dissemination and Use.

Problems/Challenges

➢ Existing healthcare data collections are planned to be expanded with data coming from smart health watch systems. Can you identify key issues that are needed to be addressed?

➢ Can you identify which technology can be used for implementation of person-centred care for a specific disease (e.g. brain stroke)? Which kind of health information can be generated?

➢ Re-skilling and up-skilling of health information management professionals is one of continuous issues that need to be addressed systematically. What is a set of minimum requirements for the modern health information community?

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Hospital Information Systems

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Abstract. Hospital information systems (HIS) have to be considered as socio-technical systems, which consist of technical components as well as of the human aspect like hospital staff and patients. HIS strive for the optimization of information logistics, to support tasks like patient care and administration of a hospital. To systematically manage such complex systems, HIS can be analyzed on three layers: First, tasks and entity types should be considered. Entity types represent information which is used and updated by tasks like 'Patient Admission' or 'Decision Making'. Second, application components of a HIS should be analyzed, they can be either computer-based or paper-based; both of them support tasks from the first layer. Therefore, they store and exchange information. The third layer analyzes physical data processing components of a HIS, like servers, workstations or networks. The three-layered view can be used for the systematic information management of HIS on three perspectives: strategic information management plans the development of the whole HIS for the next 5 years and longer. Measures from strategic information management are implemented as projects, coordinated by the tactical information management. The operational information management ensures a continuous and reliable operation of the HIS.

Keywords. Hospital information systems, information management, health information exchange, documentation, software

1. Introduction

Large hospitals are organized in several clinics or centers, which are specialized in certain medical fields like a clinic for surgery or a center for heart diseases. In hospitals there are typically different areas like wards with normal care, intermediate care or intensive care, operating rooms and service units, e.g. for image acquisition. Some hospitals also have outpatient departments. Typical central facilities of hospitals are:

- Pharmacy: delivering medication for all clinics
- Controlling: responsible for reimbursement and internal accounting
- Administration: responsible for employment, salaries, compliance and other administrative aspects.

All the above-mentioned parts of a hospital are called organizational units. Different organizational units have different responsibilities, e.g. the organizational unit "pathology" is responsible for analyzing samples of human material.

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Hospital information systems (HIS) support the variety of tasks which have to be carried out in a hospital. For example, the task "admission of a patient" might be supported by a "patient administration system" to record and provide the patient's master data (e.g. name, date of birth). According to Winter et al. [1] a HIS is a socio-technical system consisting not only of components like software or hardware, but also integrates the human aspect of staff working with these components or patients. It does not make sense to talk about HIS without considering both parts, the social and the technical part.

Analyzing the entirety of a HIS as a socio-technical system which supports all organizational units becomes soon very complex. This is the reason why we need special perspectives and tools that help us to systematically analyze HIS. A systematic approach is to model HIS on three different layers [2]. The first layer describes the tasks being fulfilled by organizational units of a hospital, e.g. patient admission or radiation therapy. Additionally, this layer consists of entity types representing information that might be used, created, changed or deleted. For the sake of simplicity, we only differentiate "using" and "updating" entity types; in this context "updating" means either creating new information about an entity type or changing existing information or deleting existing information about an entity type. Typical examples of entity types are patient, diagnosis and anamnesis, which all can be described by a certain set of parameters. The second layer describes application components being used in a hospital to process and store information, e.g. patient administration systems and clinical information systems. These can either be computer-based application components or paper-based application components. An important aspect of this second layer is the interaction of application components with each other using communication interfaces and communication links. The third layer is used to describe physical data processing components. These physical components can be easily identified by asking the question if a given object can be touched – the answer is typically 'yes' for things like a workstation, a server, a shelf and so on.

These three layers of HIS are used to structure this book chapter. In the first subchapter typical tasks in a hospital are introduced by showing them along with linked entity types. The second subchapter provides an overview of typical application components found in a hospital and their interaction. In the third subchapter some issues of physical data processing components are described, representing the basis for provision of application components. The last chapter introduces the topic of management of complex HIS.

2. Learning objectives

After this chapter readers shall be able to

- define a HIS as a socio-technical system
- distinguish the fundamental components of a HIS: tasks, entity types, application components and physical data processing components
- name typical tasks which must be performed in a hospital
- name typical application components for different organizational units of a hospital and their core tasks
- explain the principle of communication between application components with the help of communication interfaces and communication links
- explain fundamental concepts of HIS management.

3. Tasks and Entity Types of a HIS

In this subchapter typical tasks in a hospital are introduced by showing several functions along with entity types. As an example, a patient with acute abdominal pain can be considered. When he comes to the hospital he is admitted, and his patient master data is recorded. The reason for the pain is not clear at the beginning of the stay, but after some diagnostic procedures appendicitis is diagnosed. Based on this information a decision for a therapeutic procedure is made. After the patient has been treated, the services are billed. The mentioned concepts can be found in Figure 1.

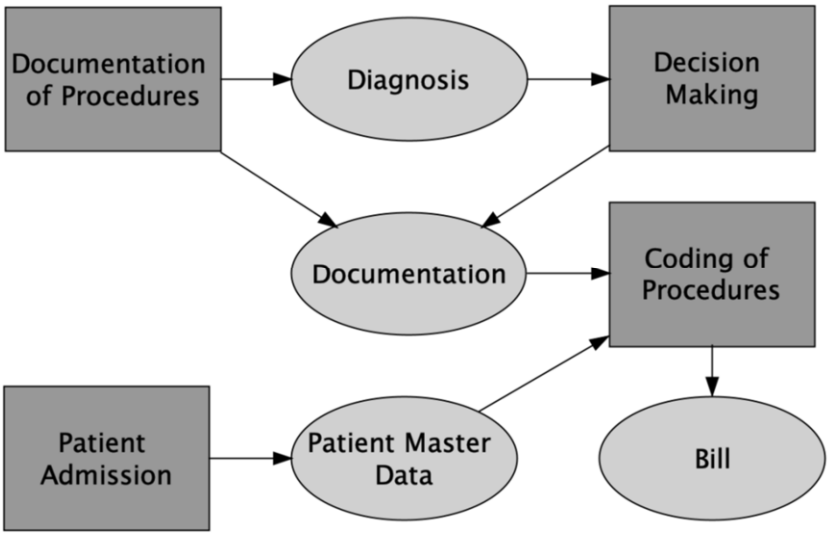

Figure 1. Tasks (rectangles) and entity types (ellipses) for a typical medical OU.

In the example 'Patient', 'Diagnosis', 'Documentation', and 'Bill' are entity types. They describe typical concepts in a hospital for which information is processed to fulfill tasks. For example, the entity type 'diagnosis' could be specified by information about the ICD-code of the diagnosis and the status if it is a 'suspected diagnosis' or a 'confirmed diagnosis'. In the above-mentioned example the ICD-code K37 for appendicitis may be used after discharge for a task like 'reimbursement'.

To formulate it more abstractly: Entity types are a formal representation of real-world objects in a hospital information system. For analyzing and processing information in a HIS it is helpful that the information about objects with the same entity types are described in the same way. That means that the same set of parameters is recorded or provided for each entity type. At the same time, this also represents a challenge: While defining entity types one has to consider all possible instances of the respective concept. For example, the entity type 'patient' must be defined in a way appropriate for all patients in a hospital independent of the way their treatment is payed (social health insurance, private health insurance, self-payer).

In a hospital, updating entity types is done by tasks. A given task updates a limited set of entity types. In the example from Figure 1 the task 'Documentation of procedures' updates the entity types 'Diagnosis' and 'Documentation'. In practice this would mean

to document the result of the diagnostic procedures (appendicitis). Tasks also interpret entity types in order to achieve their objectives. Again, considering Figure 1 the task 'Decision Making' interprets the entity type 'Diagnosis' as a basis for the medical decision for a therapy, e.g. an appendectomy.

Hübner-Bloder et al. [3] published a reference model of hospital tasks. Here we introduce some important tasks of the model in more detail:

Patient admission: This is the administrative task when a patient comes to the hospital. It includes especially the capture of patient master data (e.g. name, birthdate, gender, insurance data) and the assignment to a ward and room. A unique identifier (ID) is generated for each patient, that can be used for several hospitalizations. For different visits of a patient an unambiguous visit ID is used.

Appointment scheduling: For a planned stay of a patient in a hospital this task incorporates the coordination of physicians, nurses, rooms, equipment and further resources.

Decision making: Personnel involved in patient treatment have to make decisions on diagnostic and therapeutic procedures. For this it is crucial to have all relevant information available, which should be supported by the HIS. If the patient itself is also involved and works together with personnel, this is called "shared decision making".

Planning and organization of patient treatment: As soon as a decision for a certain kind of treatment has been made, it can be planned in detail. This includes the exact type of a therapy, a time schedule, e.g. for an operation or for nursing plans, and responsibilities like the operating physician or the nurse in charge.

Order entry: Some of the hospital's organizational units offer services like diagnostic procedures and do not have wards. To request such a service an order has to be placed. Orders update entity types, which typically contain the reason why the procedure is necessary, the detailed request as well as information about the patient being treated. For example, a physician of the ward of internal medicine could send an order to the radiology department for an x-ray of a hospitalized patient, to rule out a tumor disease at a specific organ.

Documentation of procedures: Patient care provided in the hospital has to be documented and archived. On the one hand this is often required by law. On the other hand, this documentation is very helpful to have information on earlier hospitalizations available, which can support decision making.

Coding of diagnoses and procedures: Diagnoses and procedures are often documented with the help of coding systems, in order to standardize the documentation. For example, a diagnosed heart attack could be documented with the terms "heart attack", "myocardial infarction" or even "MI". Using a coding system like ICD-10 a uniform code like "I21" would represent this diagnosis and can be used world-wide. Such a standardization is very helpful for automated analyses, which might be done for several purposes, like billing, research or resource planning. Many coding systems are well-established and define medical documentation even on an international level.

Patient discharge: After all necessary services were carried out on the patient in the hospital, the patient is discharged to home or transferred to another health care institution. For every further treatment, all relevant information must be provided with respect to administrative, medical and nursing issues.

After these important tasks of a hospital we have a closer look at typical entity types in patient care. The selection of entity types bases on Winter et al [1].

Diagnosis: A diagnosis is the result of one or more diagnostic procedures. It considers symptoms and findings observed in a patient. The entity type typically contains a written form of the diagnosis as well as a representation with the help of a coding system, like ICD-10 or SNOMED CT. The information of a diagnosis is crucial for the task of decision making, because specific therapies to handle the disease have to be selected.

Discharge summary: When a patient is discharged, a summary of important issues of the hospital stay, like information on treatment, is created and provided as a document. This document is intended for use by the referring physician and also contains recommendations for further treatment. This document is created as part of tasks related to 'documentation'.

Finding: A finding is a description of the result of a diagnostic procedure like a CT examination or a pathological examination. It is often formulated by the expert physician of the service unit.

Informed consent: Before a procedure is carried out, a document is signed by the patient, which proves that he agrees with the procedure and that he was informed about potential adverse effects.

Anamnesis documentation: After or during an anamnesis the patient's health history is summarized by a physician or a nurse.

Therapy report: A summary of all clinically relevant issues of a therapeutic procedure. For example, the chemotherapy administered over a certain period of time could be summarized by sessions and the administered infusions.

Order: The necessary information for an organizational unit, to perform a medical procedure, like diagnostic imaging. The information is created within the task 'order entry'. For example, a radiology department could receive an order for the x-ray of a specific organ for a given patient.

Patient Master Data: This entity type contains administrative data about a patient. The individual is identified by a patient ID (PID), that is unique to the patient within the hospital. Further components of patient master data are name, birthdate, address, relatives and so on.

Transfer: When the needs for patient care change, the patient is permanently transferred to another organizational unit or even another hospital. For example, a patient could be transferred from a normal ward to an intensive care unit, because he has to be intensively monitored. The entity type 'transfer' contains all necessary information like involved physicians and requested procedures.

Visit: A visit in the HIS context is the billable unit for reimbursement of a patient staying in hospital. There may be cases where one hospitalization is split into several visits or where two hospitalizations are cumulated into one visit. Typical information for a visit is a visit ID, a start and end time of the visit as well as the kind of visit (inpatient or outpatient).

4. Application Components of a HIS

This subchapter provides an overview of application components, which support tasks in a hospital. That means that we have moved to the second layer of describing HIS.

Application components are either based on software products or they are paper based, for example printed forms. After a software product of a vendor is installed and

configured it is an application component that can be used to fulfill certain tasks. Application components can be used in different scopes: Specifically, in one organizational unit or globally in the hospital. The software for a specific application component can be selected and configured considering the specific needs of the organizational unit such as data recording in the clinic for cardiology. If an application component is intended to be used globally in a hospital, requirements from many organizational units have to be considered and the software product's compatibility to other application components have to be ensured. As an example, enterprise resource planning (ERP) systems are typical globally used application components: As an example, an ERP system should be interoperable with the materials management systems in operation rooms in different organizational units for ordering consumables.

To familiarize with application components, we describe very common ones below and explain what tasks they typically support (cf. Figure 2).

Patient Administration System (PAS): The PAS is the central application component for managing administrative patient data, providing information about a patient's (administrative) state in the hospital. It is used – among others – to support the tasks 'Patient Admission', 'Patient Transfer' and 'Patient Discharge'. It manages the identities of all patients including the patient master data and the patient ID (PID).

Medical Documentation System (MDS): The MDS supports tasks related to data recording in organizational units. It is used to capture information about medical procedures like the findings resulting from cardiac catheter diagnostics. It typically offers configurable forms for specific needs of the organizational unit using the application component. These forms either capture data in a very structured way e.g. by drop-down menus, as free-text or in a semi-structured way by finely granulated free-text fields. Structured data can be processed automatically; this is relevant for further analysis e.g. by decision support systems or medical research. MDS can also help users with coding diagnoses and procedures. This is a complex task, because some classification systems are comprehensive. ICD-10 is a common system offering codes for the representation of diagnosis, it consists of more than 10.000 codes.

Physician Order Entry (CPOE) System: CPOE Systems support the task 'order entry'. They capture data from the physician who places the order and transfer it to service units. These orders for procedures can also include appointment scheduling and other supporting tasks like tracking the progress of the order. There are also CPOE systems that support the task of prescription of medicines which may contain decision support components. They can calculate medication dosage or search for contraindications or drug interactions.

Radiology Information System (RIS): Radiology departments are an example for organizational units that provide services for other organizational units. Often, they do not have any wards or only few patient beds. The RIS can receive orders via the CPOE system. The appointment planning is one task supported by the RIS. After a patient arrives, images will be acquired with the help of different modalities like Radiography, CT or MRI. These images will be assessed by radiologists. A report about the findings is sent together with selected images to the ordering organizational unit.

Document Archiving System: Software is a very dynamic product which is regularly updated and sometimes even replaced. Therefore, to store data for a long period of time document archiving systems are needed. They receive documents from many application components in a hospital and archive it with long-term integrity. This means documents can be accessed at any time (availability), without changes compared to the original

document (integrity) and only by authorized employees (confidentiality). To offer this access with ease, the document archiving system should be closely integrated with the medical documentation system e.g. to enable a view from the medical documentation system on documents in the archiving system. For the task decision making it might be helpful to know results from further treatments of a tumor disease.

Picture Archiving and Communication System (PACS): The images from the modalities in a radiology department must be archived for the same legal and medical reasons as all other data in the hospital. However, images should not be archived in the document archiving system, which is optimized for handling text-based documents. The PACS is used for handling and archiving large image files. Every workstation in the hospital, that is allowed to access the PACS can view the image files. They offer functions to manipulate images, for example to enhance contrast or rotate 3D models. RIS and PACS systems should be well-connected to support the workflow in a radiology in the best possible way. In this case it is possible, that a link in the RIS takes the user directly to the latest picture for this patient in the PACS.

Laboratory Information System (LIS): The LIS supports the whole diagnostic process in a laboratory. This mostly begins with the reception of a human specimen like blood or tissue. To keep track of the specimen while analyzing it in different laboratory analysis equipment it is typically assigned a label with a barcode. The high level of automation in modern laboratories enables a high throughput. The LIS keeps track of the position of all specimens and the progress of their analysis. After completion of the automated analyses the results have to be validated with a check for plausibility by a laboratory physician who is supported by the LIS in this task. The approved results are consolidated as structured findings in a report and sent back to the ordering unit by the LIS. This can be fulfilled by a printed document or by standardized messages via a communication interface.

Clinical Information System (CIS): The CIS integrates different application components which support medical tasks into one application component; for example, a medical documentation system and a CPOE system are often integrated in a CIS. In daily routine, this application component is often called electronic patient record. In huge hospitals like university hospitals it is rather unlikely that all medical tasks are fully supported by a CIS and it will be supplemented by specialized systems.

Enterprise Resource Planning (ERP) System: The ERP system supports tasks such as management of finances, materials and human resources. As these tasks are not domain-specific for the healthcare, ERP systems can be found in many other enterprises as well. All aforementioned application components are healthcare-specific, but hospitals also need to manage resources like employees or material and can use the same functions as other industries for these tasks. Typically, an ERP system is used in administrative organizational units, like controlling, supply management and human resource management. To support these tasks efficiently, the ERP system has to be well-connected the other application components already introduced in this subchapter.

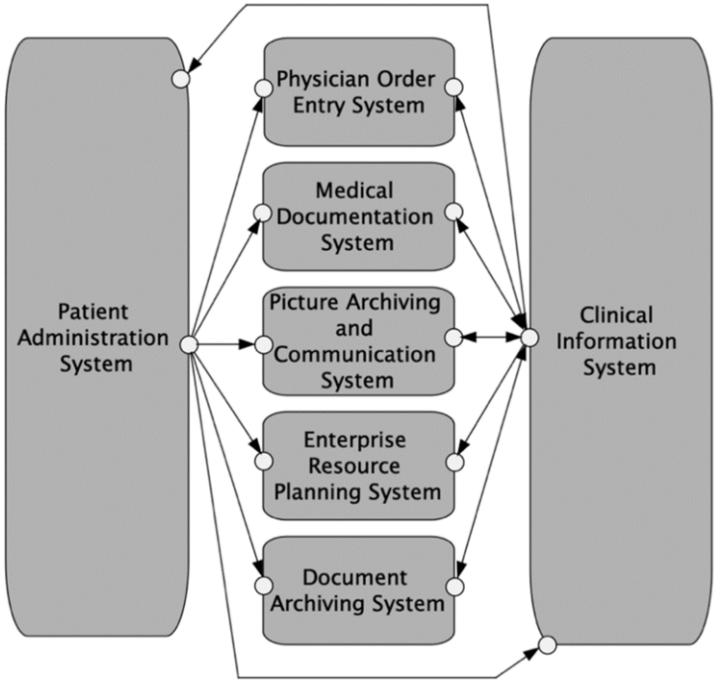

Figure 2. Typical application components (rectangles) in a hospital with communication interfaces (small circles) and communication links (arrows) for exchange of standardized messages

HIS consist of a variety of application components, many of them have their own database to store medical data. Figure 2 shows a simplified example. You may have already realized that the treatment of a single patient is supported by several application components, which work to the same extent on the same data. Nevertheless, duplicate data entry should be avoided whenever possible. To integrate data, entity types are exchanged as messages between different application components: information is encapsulated in messages, which are sent from one application component to another. For example, after the admission of a patient, the patient administration system sends a message containing his master data to the medical documentation system of the respective ward. The messages are sent through communication interfaces, which can be regarded as entry or exit point for data in application components. Communication interfaces are connected by communication links enabling the message exchange. Messages have several types, depending on the entity type they are representing. They can be based on communication standards like HL7 v2, HL7 FHIR and DICOM[2], defining the structure and content of messages. This "common language" enables application components to exchange data, even if the concerned software products are from different vendors.

[2] See Chapter 5.3 entitled E-Health and Clinical Documentation Systems in this volume

5. Physical Data Processing Components of a HIS

In this subchapter we briefly introduce aspects of physical data processing components. Software-based application components in a hospital are typically installed on servers. Servers are an example for physical data processing components, that can be reached from all workstations that need to use the application component. A personal computer in an organizational unit is an example of such a workstation and is also a physical data processing component. In modern data centers the operating system is not necessarily directly installed on a server. Data centers are rather operated with the help of virtual machines. Virtual machines are an abstraction between the hardware of a server and the software running on it. This means that one virtual machine can run on multiple servers or – vice versa – one server can run multiple virtual machines. The latter case is especially important for security and data privacy, because different application components can be separated from each other on a single server. Furthermore, virtualization is very helpful in terms of availability, because servers can be bundled as a cluster. If one of these servers drops out the others can take over and still operate the virtual machine and subsequently the regarding application component is still available.

The principles mentioned above are not different from those in other industries. However, there are data processing components of a HIS, which distinguish the physical part of a HIS from other industries. These are special medical devices, which are extensively used in hospitals, like imaging modalities, monitoring devices or laboratory devices.

Nevertheless, there are also non-computer-based physical data processing components, which have to be considered. A common example is paper-based forms and the archiving system for them, which might be a piece of furniture like a shelf.

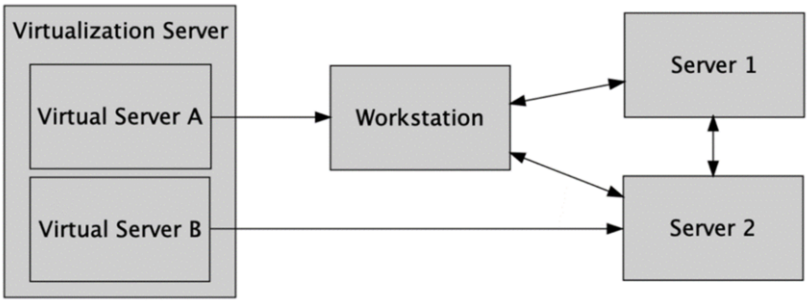

Figure 3. Example of virtualized and conventional Physical Processing Components (rectangles) and network connections (arrows).

Most physical data processing components are connected via computer networks in order to enable data exchange between software-based application components and Figure 3 shows a simplified example of such a network. Approaches like cloud-based computing and software-as-a-service (SaaS) shift physical data processing components from the hospital's data center to a centralized data center of cloud providers. In such environments the perspective on physical data processing components has to be extended from local networks to the internet. In this case the third layer of a HIS contains a reference to external providers.

6. Management of HIS

You may have realized that a HIS consists of a variety of components of different types. The structured views on three layers help us to systematically describe a HIS and to manage its complexity. If a physical data processing component drops out, you can look on the other levels which application component is influenced by this failure and which task cannot be fulfilled anymore. This is just one example for management of a HIS. The term 'management' can have two meanings. Firstly, it refers to the organizational unit of the hospital responsible for planning, monitoring and directing activities of other units and the hospital as a whole. Secondly, it can be defined as a task which incorporates all leadership activities that help to achieve the hospital's goals.

In the context of HIS, the major management interest is on information processing and is called information management. Typically, responsible managers can be found in the central IT department and often a dedicated Chief Information Officer (CIO) is responsible. Additionally, there may be local IT representatives in organizational units, who are the first contact for the users there.

Typical general tasks of information management are:

- Planning of the whole HIS and its architecture, e.g. "Which logical and physical components do we have to buy for a new PACS?"
- Directing the establishment and the operation of the HIS, e.g. "Introducing a new LIS to support next generation genome sequencing"
- Monitoring the development and operation of the HIS, e.g. "How often was the system down in the last year?"

Besides these tasks, we now introduce three management perspectives: strategic, tactical and operational information management.

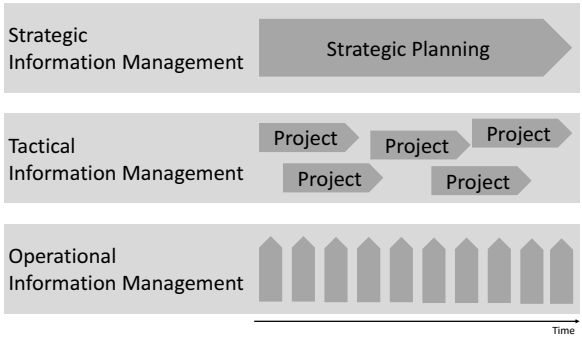

Figure 4. Three perspectives on information management (cf. [4])

Strategic information management: Key aspects of strategic information management concern changes to the HIS as a whole over the next years in order to support the strategic aims of the hospital, like unifying the communication standards used by application components or avoiding monolithic software products, which cause negative effects like vendor lock-ins. The time horizon of this management perspective is three to five years and above. An IT strategy is being developed, which contains a plan with all necessary steps and decisions to achieve the overall hospital aims. An example could be the extension of the HIS, to enable the automated receipt of patient-generated data. This example could serve the hospital aim of strengthening patient empowerment.

Necessary projects for this aim, like the introduction of application components for the external data exchange with patients, development of patient apps or the integration with the CIS are then delegated and become tasks of tactical information management. The overall implementation of such changes is managed with help of the Deming Cycle. The steps of this cycle, which is also known as PDCA-cycle, are: Plan, Do, Check, Act.

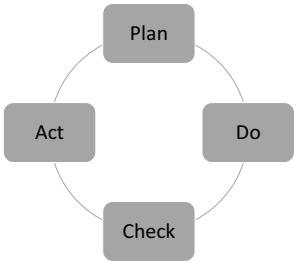

Figure 5. Deming Cycle

The work of the employees who are responsible for the task must be checked on a regular basis and the results must be compared with the IT strategy. If any deviations are detected, measures must be taken as part of the "Act" step to compensate for the deviations.

Tactical information management: The managers of this perspective are working on more particular activities. The introduction of a new application component, like a medical documentation system in the clinic of cardiology, is a typical task of tactical information management. Other tasks can be removing or changing existing application components. Activities of tactical management are typically organized as projects. This means that start and end time are defined, a measurable result is defined, and a limited amount of resources is assigned. In the field of project management there are a lot of tools available, which can help to organize work in the different project phases, shown in Figure 6. Just as with the strategic management perspective the PDCA-cycle is used to keep track of working progress.

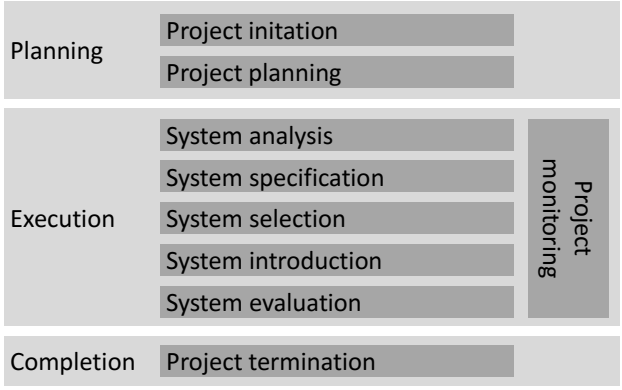

Figure 6. Project phases (c.f. [5]) divided in the three super ordinated phases “Planning”, “Execution” and “Completion”. The “Execution” sub-phases are specifically suited to selection and introduction of new application components.

An example: The update strategy of a software vendor of an application component causes many outages. Employees who are responsible for operational information

management receive many users' complaints about this, because they constantly need the application component for their work. This could lead to the initiation of a project to implement a failover mechanism, which is based on a second server that enables the users to continue their work, while the other server is updated. Other triggers for projects are the IT strategy, changes in legislation or end-of-life notices from software vendors. While initiating a project a project charter is created. It contains details on the project aims, the budget and also on the available time. This information is the input for project planning, which defines milestones. Milestones represent intermediate goals of a project, which are reached by fulfilling working packages, which are also allocated time and resources. For the definition of goals concerning milestones and working packages, the SMART criteria should be considered: Goals should be **s**pecifically defined, their accomplishment should be **m**easurable for the management and also **a**ctivating for the project staff. Of course, the goals have to be **r**easonable, because otherwise the whole project plan would be at risk to fail. Finally, goals should always be **t**ime-bound, so artifacts are ready, when they are needed for further working packages. The execution of a project covers one or more of the sub-phases shown in Figure 6. This can be shown by means of the introduction of a new application component: First, within the system analysis sub-phase the current state of the concerned part of the HIS, e.g. an application component of an organizational unit, is analyzed. The information from the analysis and the project goals are used to specify the requirements for the new application component and the software it will be based on. The identified requirements are used within the sub-phase of system selection to compare software products of different vendors and to select one of the available solutions; this is often done with the help of a public tender. The selected software is installed, configured and introduced into the organizational unit; this is part of the sub-phase system introduction. After the system was used for some time, the success of the project should be determined by a system evaluation. This can be done with methods like user-interviews or work shadowing. Finally, the project is terminated within the last phase of completion and its only sub-phase project termination. Main task of this sub-phase is project approval: the results of the project are compared with the goals via a presentation and a written report. The project ends when the strategic information management accepts the results.

When a project was successful, the operation and maintenance of application components become the tasks of the operational information management.

Operational information management: This management perspective is responsible for the trouble-free operation of the HIS. For this, reasonable resources like employees with specific competences, rooms and money have to be allocated.

A very important task of operational information management is the incident response: If a user encounters a problem, he must be able to reach a help desk which can assess the problem and either help the user or escalate the problem to a higher management perspective, e.g. the tactical information management. To prevent problems, operational information management also has to monitor the application components and the network of a HIS. By doing so it becomes possible to predict outages and to avoid them or at least soften their effects.

Combining HIS layers for the management perspectives: For a good management of a HIS all three layers of the subchapters 2 to 4 are regarded together. All objects from the layers "tasks and entity types" as well as "application components" depend on objects of other layers. To handle these complex connections between the layers all inter-layer relationships should be explicitly described. For example, the task reimbursement is supported by two application components: The patient administration system and the

clinical information system. If one of these systems is not available, the hospital might not be able to properly perform the reimbursement. Such an outage of an application component could be caused by hardware problems, e.g. a defective hard drive in a server. Dependencies from hardware are shown by connections between application components and physical data processing components, e.g. the clinical information system depends on a specific server in the data center and workstations on the ward using the application component. If one of these physical data processing components drops out, the clinical information system could become unavailable. Again, this could restrict the performance of 'Reimbursement', because it depends on the clinical information system. This example is shown in Figure 7.

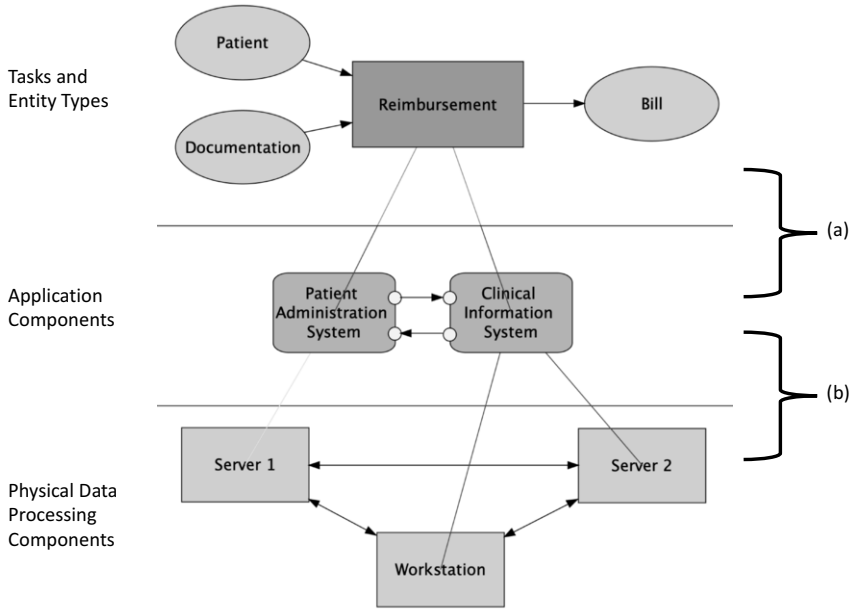

Figure 7. Inter-layer relationships between objects of different perspectives. The vertical lines show the connections (a) between tasks and application components as well as (b) between application components and physical data processing components.

The inter-layer relationships play an important role in all three management perspectives. All relationships must be strategically planned in order to create a reliable environment. Managers of the tactical perspective have to consider the relationships, e.g. while selecting new application components and physical data processing components. The operational information management has to consider all relationships e.g. for planning maintenance of components, because the maintenance might affect many objects from other perspectives.

7. Conclusion

HIS are socio-technical systems supporting good information logistics in a hospital. In daily language use of employees, the HIS is often regarded as an application component,

supporting several tasks. However, the aim of this chapter was to clearly show you that a HIS is not

- computer software sold by a vendor
- hardware e.g. a server or the entirety of workstations
- exclusively computer based.

HIS as socio-technical systems can be described with the help of three separate layers. First, the tasks and entity types of a HIS, which describe what has to be done in organizational units and which information has to be handled for this. Second, application components, which are often installed and configured instances of software products including databases are viewed. Between these application components information is exchanged, therefore communication interfaces are used. Application components are a central aspect of information management in hospitals, because they support one or more of the tasks from the first perspective. Third, physical data processing components describe on which physical tools the application components are operated. Furthermore, the third perspective describes how information is physically exchanged. Most often computer networks are used.

This three-layered description is very helpful for managing the complexity of a HIS. Management tasks are split into three perspectives: strategic information management, tactical information management and operational information management. Strategic managers create a holistic planning for several years. The strategic plan has to be realized with the help of separate projects with limited time frames, which is part of tactical management. The application components introduced by projects have to be continuously operated and maintained. This is part of the operational information management.

All perspectives of information management are a crucial part of hospital management. It enables the hospital to perform its tasks and reach its goals by enabling good information logistics. This is a basic prerequisite for high quality decisions, optimized patient care and cost-effective operation of all organizational units.

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Exercises

1. Assign the following objects to the classes (1) tasks, (2) entity types, (3) computer-based application components, (4) paper-based application components or (5) physical data processing components.

1. Decision support system
2. Shift schedule
3. Nursing care planning
4. Calendar
5. Wi-Fi access point
6. Medication List
7. Patient app
8. Radiation therapy planning
9. Tablet computer

2. Which tasks could a CPOE system support? To which other application components does it require a communication link?

3. Assign the following aims to the perspectives of information management (1) strategic information management, (2) tactical information management or (3) operational information management.

1. Decision if a central medical documentation system should be replaced with a new application component for all wards.
2. Develop a user training concept for new employees.
3. Update workstations in the center for cardiology with minor security updates for the operating system.
4. Helping a user with a password reset.
5. Introduction of a new LIS application component.
6. Replacing a defective hard drive in the data center.

Answers to the Exercises

1. 1 → (3); 2 → (2); 3 → (1); 4 → (4); 5 → (5); 6 → (2); 7 → (3); 8 → (1); 9 → (5)
2. It supports the task order entry (e.g. by creating orders for radiology departments). It requires communication links to the patient administration system (e.g. to access patient master data) and to the medical documentation system (e.g. to access specific documentation of a patient, which is needed in the radiology department).
3. 1 → (1); 2 → (2); 3 → (3); 4 → (3); 5 → (2); 6 → (3)

Problems/Challenges

- Do you think it is possible to buy a hospital information system? Argue your answer.
- Why do some application components need more than one communication interface?
- Should a hospital have a chief information manager as a part of its executive board?

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eHealth and Clinical Documentation Systems

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Abstract. eHealth is the use of modern information and communication technology (ICT) for trans-institutional healthcare purposes. Important subtopics of eHealth are health data sharing and telemedicine. Most of the clinical documentation to be shared is collected in patient records to support patient care. More sophisticated approaches to electronic patient records are trans-institutional or (inter-)national. Other aims for clinical documentation are quality management, reimbursement, legal issues, and medical research. Basic prerequisite for eHealth is interoperability, which can be divided into technical, semantic and process interoperability. There is a variety of international standards to support interoperability. Telemedicine is a subtopic of eHealth, which bridges spatial distance by using ICT for medical (inter-)actions. We distinguish telemedicine among healthcare professionals and telemedicine between health care professionals and patients. Both have a great potential to face the challenges of aging societies, the increasing number of chronically ill patients, multimorbidity and low number of physicians in remote areas. With ongoing digitalization more and more data are available digitally. Clinical documentation is an important source for big data analysis and artificial intelligence. The patient has an important role: Telemonitoring, wearable technologies, and smart home devices provide digital health data from daily life. These are high-quality data which can be used for medical decisions.

Keywords. eHealth, medical documentation, patient records, interoperability, telemedicine.

1. Introduction

It has been reported from ancient times that Hippocrates taught his students to take notes about their patients' anamnesis, the reason for consultation and the outcome of a treatment ([1], pp. 99). This might have been the start of clinical documentation. In the early 20th century medical documentation was regarded important to advance medicine by storing and retrieving literature as well as diagnoses, clinical findings, and therapy results. In 1926 the first epidemiology tumor registry was established to improve aftercare and monitoring. At the beginning of electronic processing of clinical documentation punch cards were used. Nowadays, we are in the era of digitalization, and clinical documentation is the major prerequisite for success of the hot topics of Digital Health, Big Data, and Artificial Intelligence.

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In this chapter, we first explain the basic concepts for clinical documentation. Most of the clinical documentation is collected in patient records. With further progress of digitalization, we can characterize different approaches to electronic patient records. The more sophisticated approaches are trans-institutional or even (inter-)national and belong to the field of eHealth. We define eHealth as the use of modern information and communication technology (ICT) for trans-institutional healthcare purposes.

The basic prerequisite for eHealth is interoperability, which we describe on three levels. We provide approaches to semantic interoperability and give examples for terminology and communication standards. Another important field of eHealth is telemedicine as discussed in the final section of this chapter.

2. Learning Objectives

After reading the chapter you shall be able to:

- understand the role of medical documentation and eHealth for modern medicine
- explain different approaches to electronic patient records
- distinguish the three levels of interoperability
- describe approaches to syntactic and semantic interoperability in health care
- characterize telemedicine and other eHealth applications.

3. Background

According to Leiner "Documentation denotes the methods and activities of collecting, coding, ordering, storing, and retrieving information to fulfill specific future tasks" ([2], p 1). The next sections describe the basic concepts so that this definition is understandable in every detail.

3.1. Basic Concepts

In this section we define some basic concepts and explain how we use the corresponding terms throughout the whole chapter.

- According to the above-mentioned definition, information is the major subject of documentation. It is important to clearly distinguish between data and information: Data is the reinterpretable representation of information in a formalized manner suitable for communication, interpretation, or processing (ISO 2382-1). Data is stored and recorded in a documentation system. If the data of a patient's medical history are recorded in a foreign language you don't understand, you will not use it for decision making on the next steps of treatment. In this case the data are no information for you unless they are translated.
- An object represents a part of the perceptible or conceivable world (ISO 1087). Each single object exhibits a set of characteristics that may distinguish it from other objects or that display commonalities between the objects ([2], p. 15). Within a documentation system, an object is represented by some of these characteristics in the form of attributes. One characteristic of the patient 'Mrs.

Sunshine' could be that she is suffering from diabetes. In a clinical documentation system this is represented by the attribute type 'diagnosis' and the attribute value 'diabetes type I'. The formal notation is: attribute = attribute type + attribute value.

- In a highly structured documentation, attribute types are predefined and the user can choose an attribute value from a predefined value set. Therefore, it is possible to run analyses on the documented attributes. For example, we could count the number of patients that are recorded with the diagnosis 'diabetes type I'.
- In an unstructured approach clinical narratives are written. They are often organized in documents. We call this a document-based approach. Documents can also be scans of paper-based documents that are integrated into a clinical documentation system. A document can be indexed (labeled) by so called metadata, for example by the document type and an unambiguous identification of the patient. In this case, the metadata of the document can be automatically analyzed but not so the clinical information within the document.

3.2. Aims of clinical documentation

The definition of documentation shows that medical documentation has a specific purpose, as we want to fulfill specific future tasks by using information. The general aim of medical documentation is to contribute to good information logistics[2], i.e. to provide authorized persons with

- all relevant information (but not more than that)
- at the right time
- at the right place
- in the right form.

Good information logistics is becoming more and more important because the amount of available data is constantly increasing. Information overload can become a severe problem.

To access the information we need, we often start a retrieval. The quality of retrieval results is good when the information supplied does not contain any superfluous information (overload). This can be quantitatively described by the measures precision and recall as shown in figure 1.

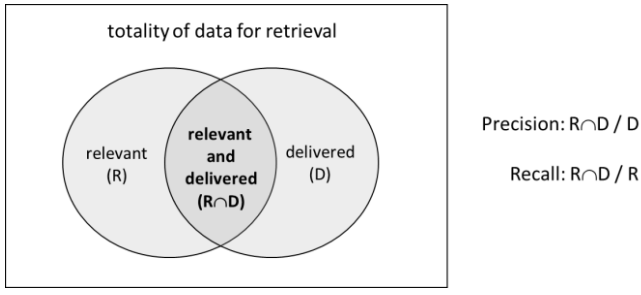

Figure 1. Quality of a retrieval measured by precision and recall

[2] See Chapter 5.2 entitled Hospital Information Systems in this volume

Besides the general aim there are more dedicated aims of medical documentation. According to Hippocrates, the major aim is to support patient care. In this context, the documentation serves as a reminder and communication aid. Since shared decision making is becoming more and more important in modern medicine, this aim is even more challenging due to regional mobility of patients, higher specialization in medicine, and increased multimorbidity.

In health care institutions providing evidence is also an important aim of medical documentation. It might be necessary to justify a medical treatment retrospectively or to analyze the reasons for errors, wrong decisions or malpractice. The burden of proof lies with the physician: The basic assumption would be that an action that has not been documented has not taken place. Therefore, there are laws which require to store documentation for a defined period of time. That means that fulfilling these laws is also a typical aim of a medical documentation. Other important aims are reimbursement, quality management, financial management or educational purposes.

Last but not least, medical documentation is the prerequisite for medical research. It can be used for the selection of study groups, generation of hypotheses and the standardized description of a study population that is analyzed with sophisticated statistical methods.

3.3. Examples for Data Management Systems and Medical Documentations

A typical documentation system in healthcare is the patient record, which is described in detail in chapter 4. It fulfills the aims of patient care and providing evidence. For other aims of medical documentation there are often very specialized documentation systems which are planned and designed to answer dedicated questions. When documentation for quality management in surgery is planned, you may want to know how many wound infections occur after a certain surgical intervention. You will plan a highly structured documentation system to record relevant attributes.

Typical documentation systems for research are clinical registries and the documentation in clinical trials. A clinical registry is a highly structured documentation about patient care and its outcome to answer a medical research question in one or more healthcare institutions. The major difference to a clinical trial is the fact that in a registry no intervention takes place and that it is most often not limited in time. In a clinical trial the effect of an intervention is measured by comparing the data about patients who receive this intervention and patients who receive the most appropriate standard therapy at this point in time. The research question is whether the outcome in the intervention group will be better than the one in the control group. Examples are trials for testing whether or not a new drug can be released to the market or whether it would be more effective for a cancer patient to have chemotherapy first and the surgery after or vice versa.

There are many aims of medical documentation and many interesting questions that can be answered by analyzing medical documentation. Additionally, there are lots of bureaucratic and legal processes that need documentation. Therefore, the daily workload of healthcare professionals for data recording is very high and it is an important part for medical informatics to support these tasks efficiently.

4. Patient Records

According to Leiner ([2], p. 176) the "patient record comprises all data and documents generated or received during the care of a patient at a health care institution. Document carriers may be conventional or electronic media." Due to continuous digitalization, electronic media are more and more common in medicine. They are the prerequisite for realizing trans-institutional patient records and health records for an integrated and continuous care. Nevertheless, paper-based documents are still widely used. Therefore, special processes within a health care institution are necessary to handle the media discontinuity.

4.1. Institutional Patient Record

Health care institutions keep patient records as an important tool to remember and communicate relevant aspects of the care for a patient. When a patient is visiting a health care institution where he has been before, information about his previous contacts is often very helpful. During a patient's stay in a hospital they are the central collection point for all stakeholders involved in the care. The institutional records contain a variety of different data and documents about personal data, anamnesis, clinical findings, lab results as well as the process and results of the treatment. A patient record in a hospital often contains 50-100 documents for each treatment case. As mentioned above, patient records have to be archived for a long time for legal purposes. The health care institution has to establish a management process for easy and secure access to the archived records. This is especially challenging if paper-based and electronic documentation exist in parallel. There are three options for an archiving strategy:

- digital and paper-based archiving: Information about a patient's case is spread into two archives.
- paper-based archiving: All documents that are available electronically have to be printed and stored in a conventional archive.
- digital archiving: All paper-based documents have to be scanned and integrated into the electronic patient record.

4.2. Trans-institutional Case Record

In modern medicine, the medical case of a patient is often not limited to one health care institution. For example, for oncological cases several disciplines may be involved in diagnosis (neurology) and therapy (radiology) or after a surgical procedure a rehabilitation in a specialized institution is necessary. For seamless high-quality care, it is necessary to exchange all relevant information. To achieve good information logistics a trans-institutional case record can be technically realized by

- electronic transmission of data and documents using standardized communication interfaces: examples are listed in chapter 4.2.
- allowing other health care institutions to access one's own documentation on the common patient.
- using a joint platform or cloud where each participating institution can upload relevant information for a patient case.

Patient participation is another aspect of modern medicine. The idea is to better involve the patient into the care process so that he or she will be able to make well-informed decisions about his or her own health. To support patient participation health care institutions can give patients electronic access to their clinical data by providing so called patient portals.

4.3. Electronic Health Record

The electronic health record (EHR) is a life-long record with health-related data and documents which is independent of certain health care institutions. Patients have the sovereignty over their own data, which means that they decide which health care professional can access which data. Early solutions were web-based applications where a patient could upload, enter and manage his health data and documents. Nowadays, there are different approaches to realize such a concept. For national approaches secure technical infrastructures have to be provided to avoid unauthorized access to health data. Often physicians are responsible to provide data and upload documents into the EHR. To achieve patient participation, it should be possible to add patient-generated data as well. We distinguish two types of patient-generated data:

- patient-reported outcome: The patients record in a structured questionnaire, symptoms, pain attacks, quality of life or other attributes at defined points in time.
- quantified data: These data are measured and collected by wearables, implanted technology or by telemonitoring applications.

5. Interoperability

Providing good information logistics is more challenging the more data are available. Trans-institutional approaches like the ones introduced in chapter 3.2 and 3.3 are typical examples for eHealth solutions. The major prerequisite for implementing them is interoperability. Interoperability generally refers to "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" [3].

The international standard development organization (SDO) HL7 has defined three levels of interoperability:

- technical interoperability → physical transmission
- semantic interoperability → unambiguous meaning for sender and receiver
- process interoperability → integration of systems into work processes

Technical interoperability describes the ability of physical transmission of data and is independent of the meaning of the data. Data can be read by the user of the receiving system. Technical interoperability is further divided into protocol interoperability and syntactic interoperability. Protocol interoperability refers to the lower six levels of the OSI model of network architecture (cf. figure 2). Syntactic interoperability is achieved by the seventh layer, which refers to applications. In healthcare, standardized messages are often sent and received by communication interfaces to reach syntactic interoperability. To give an example: In case of patient demographics, it might be defined

in a communication standard that the third field of a standardized message contains the date of birth of a patient and the fourth field contains the place of birth.

Layer	Function	Example
7 – Application	Applications	SMTP, HL7 v2
6 – Presentation	Formats / Protocols	JPG, GIF, HTTPS
5 – Session	Establish / End connections	PPTP, DOCSIS
4 – Transport	Data transfer protocol incl. error handling	TCP, UDP
3 – Network	IP adresses	Router, layer 3 switch
2 – Data Link	MAC adress	Switches
1 – Physical	Physical Wire	Cable, Hubs

Syntactic Interoperability

Protocol Interoperability

Figure 2. OSI model and its roles for interoperability

For semantic interoperability the sender and the receiver agree on the meaning of the data, so that also non-numerical data can be processed by the receiving system. Major problems occur if a certain term may have different meanings (homonyms). The term 'bank', for example, can describe a financial institution as well as a seating furniture. In a medical example for homonyms, the abbreviation MI can mean 'myocardial infarction' or 'mesenterial infection'. Therefore, it is important for semantic interoperability to agree on a common understanding of the underlying concept of the exchanged data. A low level of semantic interoperability can be reached if scanned documents are indexed by standardized metadata. A common method to reach a certain degree of semantic interoperability is the use of controlled vocabularies like the International Statistical Classification of Diseases and Health Related Problems (ICD) for coding diagnoses. More sophisticated approaches make use of medical ontologies. SNOMED CT is a highly relevant example.

Process interoperability describes the successful integration of computer-based applications into real work processes. If process interoperability cannot be reached, a new application system may be only partially used or avoided completely by the intended users. One aspect of process interoperability is the perceived interoperability at user level: The interoperability of the systems is designed in such a way that it is not perceived as disturbing. Process integration is the optimal integration of the system in existing processes and the highest level of process interoperability is reached if work processes are optimized by the application system.

There are other approaches to structure the concept of interoperability into different levels. They define for example procedural, social, organizational, or user interoperability. Nevertheless, all approaches agree that it is important to distinguish between syntactic and semantic interoperability. Therefore, typical approaches and standards for semantic and syntactic interoperability are introduced in the next two chapters.

5.1. Terminology

A terminology is an organized set of terms in a specific field together with the definitions of the concepts they denote (cf. ISO 5127). To reach semantic interoperability we describe three types of terminology systems:

- A controlled vocabulary is an organized set of authorized terms, which avoids synonyms and homonyms. It can be used to unambiguously define value sets and can therefore be regarded as a language for medical documentation and retrieval. If a definition of the underlying concepts is provided, we call it not only a vocabulary but a glossary. Controlled vocabularies are often hierarchically structured (taxonomy). If codes are used as short and formal labels, we call the vocabulary a medical coding system. Well-known medical examples are ICD 10, International Classification of Procedures in Medicine (ICPM), Logical Observation Identifiers Names and Codes (LOINC), or the TNM Classification of Malignant Tumors.
- Standardized reference data sets (SRDS) are highly structured descriptions of a consensus on attribute types, value sets and data types for structured medical documentation. They are often consented for a certain medical domain. If several application systems implement the SRDS they can share data e.g. for research purposes. For example, an European data standard for cardiology was developed and published [4]. SRDS are often provided in tables for different contexts and should define the underlying concepts of attribute types and values. Synonymous terms are ‘core dataset’, ‘data standard’, or ‘minimum basic data set’.
- Concept-oriented terminologies organize terms according to an underlying ontology. In an ontology, a domain is formally described by (i) a set of concepts, (ii) attributes, that characterize these concepts and (iii) relations between the concepts. Typically, there are not only hierarchical relations in an ontology but also associative relations like causal relations, temporal relations, or spatial relations. In a concept-oriented terminology, an authorized set of terms that label the concepts of the ontology is provided. SNOMED CT is an example that has been adopted by a variety of nations. It models more than 300.000 medical concepts and more than 1.000.000 relations between these concepts. Multilingual terms can be associated to the concepts.

Terminology Management Systems are application systems to manage large and complex terminologies. They are especially important for concept-oriented terminologies, because non-hierarchical relations most often cannot be presented in a book. A well-known example in medicine is the MeSH thesaurus, which is provided by NLM and is used for indexing the scientific literature in MedLine. MeSH is a so-called terminology-browser. If you have to organize and maintain a complex terminology, a terminology editor might be necessary where concepts, terms and relations can be added. It is important not to delete any entries during the update, because the term may have been used in a clinical documentation. Only new versions of concepts and terms can be added.

5.2. Communication Standards

To reach interoperability among a variety of application systems from different vendors, we need to use widely agreed specifications, which are usually developed, consented, and provided by an SDO. In the following section we describe briefly some important standards or initiatives for interoperability in healthcare.

HL7 – version 2: A very important SDO in healthcare is Health Level 7 (HL7), which has defined widely used communication standards to gain interoperability. One of these standards is HL7 v2 which exists since 1989. As for all older HL7 standards the specification is traded commercially, but its use in software products is free. HL7 v2 evolved to the most widely used communication standard in healthcare. The specification offers a set of formats for packaging health data about a certain event into standardized messages. One common event is the admission of a patient to a healthcare institution. This would be represented by a message of the type 'ADT (A01)', which stands for admission, discharge, transfer and contains information like the patient's master data, the admitting ward etc. However, there are limitations in HL7 v2: The meaning of attribute values is not specified, therefore semantic interoperability is not supported. Technical details like transportation of messages are not standardized either.

HL7 – version 3: HL7 v3 was published in 2005 and is a family of standards based on a common Reference Information Model (RIM). RIM provides object classes for implementing health information systems. The RIM consists of the four basic classes 'Entity', 'Role', 'Participation', and 'Act'.

The basic assumption of RIM is that everything documented in a patient record is an act, e.g. an x-ray examination. The context of an act is defined by participations like the examiner and the subject of examination. Participations are fulfilled by roles. For example, the examiner of an x-ray examination should have the role physician. Roles are taken by entities, e.g. the radiologist Dr. Doolittle. Attributes are listed for each of these four basic classes. For more specific modelling, additional classes are derived by restricting the attributes of the basic classes.

The communication standard of HL7 v3 is XML based. The most successful member of HL7 v3 standards family in terms of implementation and practical use is the Clinical Document Architecture (CDA).

Clinical Document Architecture (CDA): The CDA is a HL7 markup standard of HL7 v3 for interoperable document exchange among healthcare providers. Each CDA-document consists of a header and a body. The header contains no clinical content, but metadata about the type of document, the patient encounter, stakeholders of the document and relations to other documents. The header ensures that an exchanged document can be read and integrated into the electronic patient record system of the receiving institution. The body of a CDA document contains the clinical information, which can be structured on different levels. The first level is not structured any further besides the XML markup. On the second level, the document is structured into semantically relevant paragraphs and on the third level attribute values are coded. The three-level-concept leads to an incremental semantic interoperability. It is a major advantage that documents can be exchanged even if the application systems of sender and receiver work on different CDA levels.

HL7 FHIR: In 2014 HL7 published the first draft of FHIR (Fast Healthcare Interoperability Resources). Although HL7 integrated many success factors of its previous standards, FHIR was considered as a new beginning in the healthcare sector. By using modern web standards (REST, HTML, TLS and OAUTH2), FHIR enables the

use via mobile devices, development of vendor-independent mobile applications, use of patient-managed health records, cloud storage and much more. FHIR puts special emphasis on a fast and easy implementation of the data exchange.

The core of FHIR are the so called resources, which represent health information for typical contexts of patient care like patients, practitioners, organizations, devices or an invoice as well as more abstract concepts like tasks, goals, appointments or conditions. Resources contain a set of structured data elements as described by the definition of the resource type. A particular resource instantiates the standard specification of the resource type by storing the attribute values of the respective attribute type in the data elements. Resources can be related to other resources. An important aspect in the specification of resources is the 80/20 rule, which suggests to focus on those 80 % of attribute types that all users need (cf. Pareto principle). By this, the data model is kept lightweight which enables a fast data transport. The remaining 20 % of attribute types will vary among users and therefore HL7 allows free extension of a resource by the users.

Additionally, resources can be profiled. In doing so, the resource specification is adapted and restricted to a particular context of use like a health care institution or a research project. Rules can be set to define which attribute types of the resource are mandatory, optional or not to be used, and which additional attribute types are added that are not part of the base specification. For example, it can be predefined which genders can be selected and/or whether this information is mandatory or not. This could be helpful for carrying out a study in which only women should participate.

openEHR: openEHR is a non-profit initiative that offers a two-level modeling approach for the exchange of electronic health records (EHR) or parts of it. On the first level, openEHR provides the technical specification for a reference data model of an EHR system. This reference data model does not provide any object classes for clinical information but for EHR management. The modeling of clinical information is part of the second level, the clinical archetypes. An archetype is a standardized maximum data set for a medical concept and is provided in an archetype repository. Two openEHR systems that use the same archetypes are semantically interoperable. It is the advantage of two-level modeling that the reference model is small and flexible and that the EHR system does not need to be changed when medical knowledge changes. In this case, a new archetype can be provided and processed by any system that is based on the openEHR reference model. openEHR has strongly influenced the development of ISO 13606 on electronic health record communication.

DICOM: Digital Imaging and Communications in Medicine (DICOM) is a standard for image data formats and the transfer of digital images. DICOM is the basis for so-called picture archiving and communication systems (PACS), which together with radiology information systems (RIS) cover the entire digital radiology workflow and are used in hospitals' radiology departments and medical practices worldwide. The standardization efforts started in 1982 and were initiated by the American College of Radiology (ACR) and the National Manufacturers Association (NEMA). Today the standardization body consists of vendors of imaging systems, user organizations, public authorities and professional associations. A workflow is established using so-called DICOM Services. The most important ones are 'Storage' (sending and receiving images), 'Query/Retrieve' (querying a DICOM system for examinations and retrieving images) and 'Worklist' (getting information about service requests). DICOM Services consist of a Service Class User (SCU) and Service Class Provider (SCP) comparable to the client/server model. The DICOM standard facilitates technical interoperability and partly semantic interoperability. Vendors of DICOM components have to prepare DICOM

Conformance statements that describe which DICOM services and functionalities are supported in a fixed structure defined by the standard. This facilitates the assessment of the real-world interoperability of DICOM-enabled systems.

IHE: IHE (Integrating the Healthcare Enterprise) is a worldwide non-profit association of users and vendors which aims to improve the interoperability of healthcare application systems. IHE was founded in 1997 by the Radiological Society of North America (RSNA) and the HIMSS (Healthcare Information and Management Systems Society). IHE does not specify new standards but creates profiles based on well-established standards like CDA or FHIR. Practical requirements on interoperability aspects are collected and presented as use cases. A so-called IHE profile describes specific solutions to interoperability problems in a specific clinical domain utilizing the needed standards. Profiles for various clinical domains can be found in the technical frameworks on the IHE website. In order to understand an IHE profile two definitions are important: The role of an application system is called actor. An application system can take on different roles e.g. image viewer and archive in the radiology domain. The exchange of information between two actors is defined as transaction. A transaction could e.g. be the query of a specific image of a patient.

At regular so-called connectathons, manufacturers can test their systems with implemented IHE profiles against each other and thus prove IHE compliance.

6. Telemedicine

Telemedicine is a subtopic of eHealth that bridges spatial distance by using ICT for medical (inter-)actions. There is a variety of disciplines that benefit from telemedicine like teleradiology and telecardiology. We distinguish telemedicine that takes place (i) among health care providers and (ii) between a health care provider and a patient. Due to ongoing digitalization, information technology is increasingly used for telemedicine and the availability of mobile devices offers new potential.

6.1. Telemedicine among healthcare providers

Telemedicine among healthcare providers enables the cooperation of remote healthcare professionals to improve medical care. Examples are:

- teleconferencing for interdisciplinary treatment of a patient: e.g. in medical tumor boards physicians of several disciplines discuss the further treatment of a patient. In case of telemedicine they are supported by a video conferencing system and trans-institutional data sharing (e.g. lab results, medical images).
- telepathology: The histology of tissue samples is analyzed by a remote physician. To get a second opinion, the samples have to be digitized. The scanning process causes a loss of information, and consequently less information is transferred. Another scenario is virtual microscopy. In this case, the primary assessment is made by a remote pathologist using digital high-resolution image acquisition. The sample and the pathologist are not in the same place. The pathologist uses an application system that works like a virtual microscope.
- teleradiology provides images for a remote partner by ICT: It is often used to consult experts or to discuss a second opinion with respect to therapeutic

decisions. As a result, the patient may be transferred to the partner institution. Teleradiology is one of the first successful application fields of telemedicine.
- telemonitoring for accidents and emergencies: In an emergency, a patient's vital signs like ECG can be sent from the ambulance car to the hospital to prepare the best possible treatment.

6.2. Telemedicine between healthcare provider and patient

The application of telemedicine between healthcare providers and patients is also called telehealth. Typical approaches are:

- teleconsultation: a patient is seeking medical advice without visiting a health care institution but using ICT. This is also called an eVisit. If the local practitioner does not offer eVisits, a call center will conduct a triage and then decide whether a teleconsultation or a direct contact with a physician or a healthcare institution is necessary. eTriage is a web application that offers a symptom checker in the form of a chat-bot. In a virtual dialog the patient can enter symptoms and answer questions. As a result, information about potential diseases are offered. This may comprise a piece of advice or an offer for an immediate teleconsultation.
- Teleconsultation in the field of psychology or psychiatry is called eMental-Health. For some patients, teleconsultation means a lower hurdle to seek consultation.
- eVisits that take place by videoconferencing, offer synchronous communication for telehealth. However, teledermatology is often applied asynchronously: Digital photos of the affected skin are sent for diagnosis to a remote dermatologist either by the patient's general practitioner or directly by the patient.
- Telemonitoring is the periodic or continuous measurement and control of a patient's vital signs in daily life. It can be used to monitor risk patients, e.g. to avoid exacerbations in patients with congestive heart failure (CHF) or COPD. Patients can use the service of a telemonitoring center and send their vital signs by mobile devices. The telemonitoring center provides feedback on whether a certain risk exists for the patient or it contacts healthcare providers in the case of emergency. An additional service would be telecoaching based on the transferred data. This includes support for tasks the patient has to do in a self-reliant way, e. g. dosing insulin for diabetes patients.
- Teleinterventions summarize remote medical treatments like telesurgery, telerehabilitation or telephysiotherapy.

6.3. Potential

Telemedicine has a great potential to face the challenges of aging societies, the increasing number of chronically ill patients, multimorbidity and low number of physicians in rural and remote areas. Each of the application areas mentioned in section 6.1 and 6.2 impose requirements for adequate information technology, application systems, management processes and regulatory frameworks. Wide-spread use of telemedicine depends on the national healthcare systems, laws and the reimbursement of telemedical services. The high availability of mobile devices for patients and healthcare professionals as well as of

personal health devices at the patient's home increases the motivation and acceptance of the users. Nevertheless, the seamless technical interoperability of technical devices and application systems in health care remains a challenge. Telemedicine applications need high standards of data protection and security.

7. Conclusions – Digital Health

With ongoing digitalization more and more data are digitally available. High performance technologies enable the management and analysis of Big Data and clinical decision support by artificial intelligence. The analysis of data in medicine is more effective when highly structured data are available and – even more – if the data are semantically interoperable. Clinical documentation is an important source of data for these approaches. The quality and availability of clinical routine data strongly influences the quality of treatment outcome and medical research. eHealth with its subtopics telemedicine and trans-institutional data sharing for patient care contributes to higher availability of data and medical services.

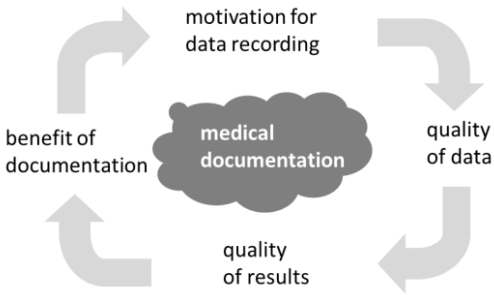

Figure 3. Vicious cycle of medical documentation.

Despite the fascinating potential of modern technology, the key to success is to take care of socio-technical aspects: The quality of the documentation depends on the motivation of the staff to record data. This leads to the vicious cycle illustrated in figure 3: The motivation of the staff depends on the benefit they expect from documentation. The benefit of documentation depends on the quality of the results, and the quality of results depends on the quality of the recorded data. This clearly shows that medical informatics is not only an issue of developing highly sophisticated algorithms and technology but also of systematic management of processes involving all stakeholders. Among these stakeholders the patients play a very important role: Telemonitoring approaches, wearable technologies, and smart home devices lead to digital health data from daily life. These are quantitative high-quality data which have to be sensitively analyzed and which can be used for medical decisions.

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Exercises

1. Clinical documentation can fulfil a variety of purposes. List some typical aims for clinical documentation. Think about some documentation systems you use at home. What is their major purpose?

2. Explain differences and commonalities between trans-institutional case records and electronic health records.

3. Why is interoperability important for eHealth and which levels of interoperability can be distinguished?

4. Describe some international approaches for syntactic and semantic interoperability.

5. Which of the above-mentioned application fields of telemedicine take place synchronously?

Answers to the Exercises

1. You can find the answer to this question in chapter 3.2. Documentation systems at home may be an address book or a shopping list. Their purpose is to be able to contact people as necessary or not to forget an important item you need for daily life.

2. You can find the answer to this question in chapter 4.2 and 4.3. The major commonality is that both types of records are trans-institutional. The major difference is, that an electronic health records covers more than just one single medical case.

3. The levels of interoperability are introduced in chapter 5. eHealth describes the use of modern information and communication technology (ICT) for trans-institutional healthcare purposes. To fulfill this purpose health information has to be exchanged among healthcare institutions. Only if interoperability is given the information can be exchanged and processed efficiently.

4. You can find the answer to this question in the chapters 5.1 and 5.2. HL7 offers several important standards in this field. Other approaches to semantic interoperability are e.g. SNOMED CT and openEHR.

5. Teleconferencing (e.g. as part of teleradiology), teleconsultation (eVisits), telesurgery

Problems/Challenges

➢ What are advantages of paper-based and electronic documentation systems? Can trans-institutional patient records be realized without electronic media?

➢ Imagine, you are responsible for the archiving of patient records in a health care institution, in which paper-based and electronic medical documents are used. Would you decide for digital or paper-based archiving?

➢ If you were a chronically ill patient what would be important features of an EHR you would like to use?

➢ If you were responsible for the introduction of a new EPR system in a hospital: How would you proceed to reach process interoperability?

➢ Analyze, whether the international standards in chapter 5.2 support technical or semantic interoperability.

➢ Which are the advantages and disadvantages of synchronous and asynchronous communication in telemedicine? Illustrate your answer by some examples.

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Artificial Intelligence in Healthcare

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Abstract. Modern technology development created significant innovations in delivery of healthcare. Artificial intelligence as "a branch of computer science dealing with the simulation of intelligent behaviour in computers" when applied in health care resulted in intelligent support to decision-making, optimised business processes, increased quality, monitoring and delivering of personalised treatment plans and many other applications. Even though the benefits are clear and numerous, there are still open issues in creating automation of healthcare processes, ensuring data protection and integrity, reduction of medical waste etc. However, due to rapid development of AI techniques, more advances and improvements are still expected.

Keywords. Artificial intelligence, machine learning, speech recognition, natural processing, expert systems

1. Introduction

Healthcare has historically focused on care based on the diagnosis and treatment of the disease after it occurred, while the focus was not on prevention. This focus is now changing significantly, and health care is being transformed into treating persons before any illness, as well as during and after medical treatment. These changes are also accompanied by a series of changes in cost reimbursement and funding, with simultaneous aim on managing the comprehensive health of the patient and out of treatment for the disease [1, 2].

When talking about technology, artificial intelligence (AI) has proven capacities to explore huge sets of medical data (collected from different sources), but in order to understand the possibilities for advancing healthcare through AI, it is necessary to know the modern circumstances and drivers of transformation in healthcare. It is not about technology; it is about using technology to treat patients as a human being and receiving all the benefits of implementing such a concept.

On one side, AI promotes the automation of the whole or parts of the diagnostic and treatment process, providing recommendations to patients, their families and relatives (who may also be involved in the treatment process), to physicians and clinical teams. Technological innovations, on the other hand, should further improve and enhance the management of profession principles such as interest, profit, productivity and income on investment [4].

However, when it comes to the use of AI in healthcare, particular attention should be paid to analysing whether and how the use of AI affects the care process itself, what are the benefits and / or potential negative impacts, as well as ethical issues surrounding

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the collection and data usage, security against potential misuse and unauthorized use of data, etc. [3] These questions are additionally disputed by society and authorities' viewpoints of health and health care, which change health care into social welfare and health care as an economic property [4].

These considerations about using modern technologies clearly impose the development of support for some well-known use cases in health care business operations, such as: lessening expenses and increasing efficiency, developing the quality of health care and treatment, setting human intervention priorities to specific processes/interventions, automation of frequently repeated tasks [5] and optimization of workflow in healthcare facilities [8], reduction of medical waste (failure to provide care, failure to coordinate care, inadequate training, failure in cost, fraud and abuse and administrative complexity); etc.

When deploying and developing these tools, it is essential to be fair and inclusive, to work on innovative applications, workflows, interventions, all aimed on supporting distributed health care delivery, provision of enhanced personalized health with ensured data availability, accuracy and privacy protection; respect for user preferences, and simultaneously avoiding historical inequality in access and outcomes [7], other adverse events and unintended consequences.

2. Overview of Artificial Intelligence

The term AI is like a hype used almost by everyone, usually having a hypothetical meaning focusing on the modern and near-future appliances and applications of AI. A precise explanation of AI originates by the Oxford English Dictionary: "The capacity of computers or other machines to exhibit or simulate intelligent behaviour; the field of study concerned with this," or Merriam-Webster online: "1: a branch of computer science dealing with the simulation of intelligent behaviour in computers, 2: the capability of a machine to imitate intelligent human behaviour."

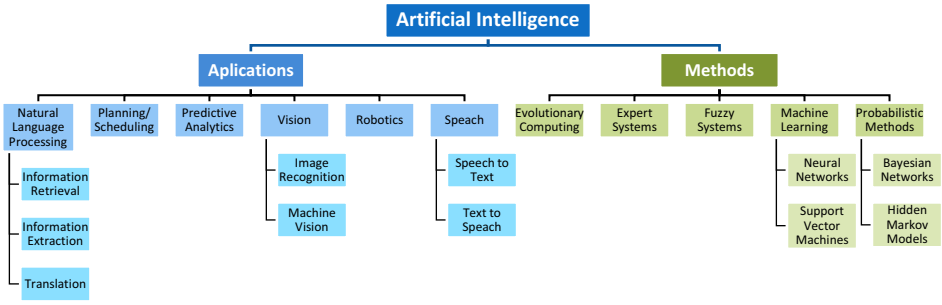

Figure 1. Hierarchical representation of AI technologies [10]

When talking about AI, we also might consider the purpose AI is striving to accomplish, including which approach is used for its achievement. Generally, AI systems range from those that are modelling humanistic thinking to explain a problem, to those that are attempting to create a model based on big data collections in order to clarify the

subject(s) of concern or even to incorporate elements of human reasoning without exactly modelling human reasoning processes.

Machine learning is a group of analytical and numerical modelling methods that uses a heterogeneity of strategies to automatically discover and enhance the prediction of a target state/phenomena [11]. Various approaches, such as artificial neural networks, Bayesian networks, deep learning and random forests, use distinct postulates and mathematical structures and ingest data and information, and learning occurs within the algorithm. In addition to the typical machine learning methods, regression analysis such as linear and logistic regression are very much used in machine learning. The term "machine learning" is universally accepted by general businesses, but "AI" is commonly accepted for marketing purposes. In most situations, "machine learning" is more suitable. There are several types of machine learning algorithms, most commonly classified in three subgroups: supervised learning, unsupervised learning, and reinforcement learning.

Natural language processing (NLP) allows machines to recognise and adopt human languages [12]. NLP requires to model humanistic logic because it acknowledges the purpose of written and spoken language in a measurable, interpretable, and reliable means. Compared to other domains of AI implementation, NLPs are much more difficult to achieve because they require significantly more information to interpret and correctly understand the meaning. NLPs are complex systems and consist of rule-based learning systems, data-driven machine learning algorithms and many interior control elements with predefined information and appropriate outputs. An example of the use of NLP may be a system for evaluating the progression of cancer, in which the effectiveness of the therapy is recognized based on radiological reports and EHR data on postoperative complications.

The fundamental objective of Speech algorithm is to transfer data recorded on tapes or other audio recording devices, into a digitized data form suitable for processing and converting to human speech. Particular complexity is reflected in the intonation, accent and emphasis of the syllable in the word/sentence, which can exceedingly change the meaning. That is why the input and output interpretation and speech generation process is a very complex operation. The applicability of neural networks in the implementation of the speech algorithm has shown very effective results [13].

An Expert system is an intelligent software program that uses knowledge and inference systems in the process of problem-solving to emulate the decision-making capacity of human specialists. The basic components of expert systems are knowledge base; inference mechanism; user interface and global database. The knowledge base is a database of facts and heuristics associated with the problem being analysed. An inference mechanism is a "brain of expert system" and provides mechanisms for reasoning over a knowledge base and drawing conclusions from it. It works by combining facts from the knowledge base with user-generated information for the purpose of drawing specific conclusions. The user interface is the part that enables the dialogue between the decision-maker and the system, accepts user input and displays data, presents possible decisions, displays information, questions, answers and discourages the user from making mistakes. A global database records current system statuses, inputs for a particular problem, and relevant elements deduced by the inference mechanism. It preserves the facts and conclusions drawn during the ongoing dialogue. There are a number of examples of implementation of expert systems in healthcare. One is a clinical decision support tool [14] developed within the Clinical Pharmacogenetics Consortium, which presents personalized advice for pharmaceutical treatment based on the results of genetic patients data [15].

For the efficient and dynamic functioning of modern healthcare institutions, Systems for automatic planning and scheduling (such as clinic scheduling) are of principal importance. These systems are usually based on the adoption of intelligent agents specially designed to automate the scheduling process [16]. These systems require large-scale calculations based on complex data on the various resources of a healthcare organisation.

Computer vision includes techniques for collecting, processing, analysing, and recognition of digital images to derive data in the form of decisions. Computer vision concentrates on how algorithms evaluate, integrate, and produce reasoning from digital images or videos. The visual system attempts to automate or implement human cognitive reasoning [17]. The scientific discipline of computer vision is concerned with the theory behind artificial systems that extract information from images. Patient mobility in the intensive care unit is a key indicator of the level of patient recovery. The application of computer vision for monitoring the progress of the recovery process is one example of their application in healthcare institutions.

Although artificial intelligence (AI) is increasingly capable of successfully analysing health data such as medical images and test results, in a situation where AI and medical professionals' come to different conclusions, human decision making is prevalent. Combining human and artificial intelligence into enhanced intelligence focuses on the supportive role of algorithms, emphasizing that these technologies are designed to enhance human processing, cognition and performance rather than replace it [19]. Therefore, the principle of Collaborative intelligence where AI systems are analysed through human intelligence is increasingly accepted.

Accuracy, completeness, and availability of Data in an appropriate form suitable for processing is a key resource for both healthcare institutions to be able to provide adequate healthcare services and AI algorithms to achieve the expected level of efficiency and effectiveness. Many health systems, although possessing a wealth of heterogeneous health data, cannot achieve satisfactory business efficiencies, mostly because the data is inappropriate for processing (in paper form) or does not provide the expected level of interoperability so that they can be understood. Various electronic devices such as electronic health records and medical devices or sensors generate huge amounts of different health data such as claim data, genetic information, patient data and radiological images. These trends impose the need for structuring health data and providing the required level of interoperability by applying the recommendations defined in the adopted standards.

3. How AI is changing Health care

Health care industry has invested for years in technology enhanced solutions in healthcare, including AI. Even though results have shown promising solutions and potentials for using AI in creating different solutions, there are several gaps and drawbacks, including: difficulties to assess their impact in the real environment based on evaluations provided in the peer-reviewed literature and, overall assessment of solutions in case of combining more specific components since they can provide better performance in synergy (e.g. the performance could be increase in combination with high-speed computer systems, using Internet of Things (IoT), etc.), but also decrease (e.g. when combining multiple predictive models, errors could also increase, etc.), which is impossible to predict.

In the following, we present the potential of AI solutions for different groups of stakeholders: patients and families, clinical care teams, public health program managers, business administrators, and researchers.

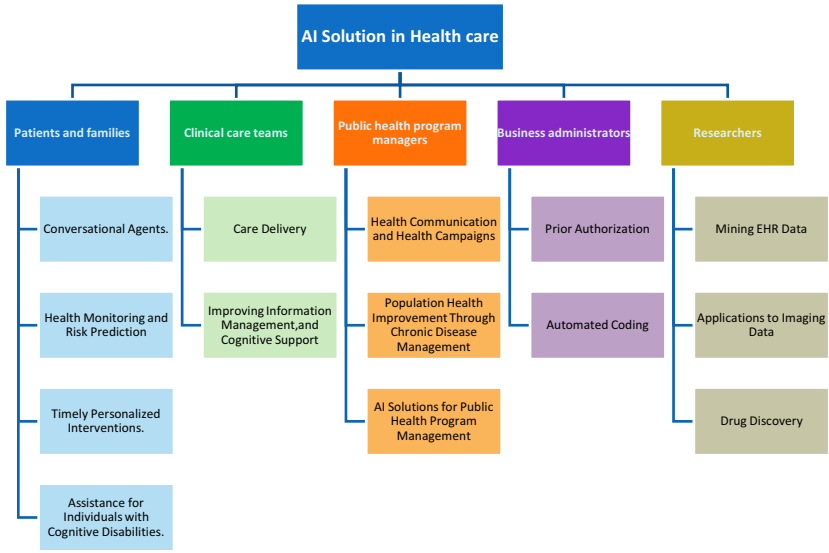

Figure 2. AI solutions for different health stakeholder groups [10]

3.1. AI Solutions for patients and families

One of the increasingly recognized needs for the use of AI techniques is support in the creation and management of a care plan that is tailored and adapted to the needs of the patients, especially in chronic diseases such as diabetes, asthma, as well as the control of chronic depression, smoking habits, etc. The support can range from assisting in taking medications, monitoring diet plans and physical activities, to wound care and delivery of injectables, with simultaneously addressing personal preferences and requirements of each individual (e.g. persons with disabilities, religious requirements, preferences over available options in a training plan, etc.) as well as specific interventions related to a specific disease. It can be grouped within the following categories: conversational agents, health monitoring and risk prediction tools, personalized adaptive interventions, and technologies for assistance of individuals with disabilities, as described below.

3.1.1. Conversational Agents

Conversational agents integrate AI algorithms for natural language processing (NLP) to automate the process of dialogue, i.e. simulation of real-world interaction and conversation based on spoken language, text-based dialogue, or a combination of both [20]. Such agents have the potential to recognize disease symptoms, life habits as well as patient's lifestyle and his/her emotional status in the interaction simulation, which is of particular importance for effective disease management. The development of agents is quite limited so far, but there are solutions for self-management of depression, smoking

cessation, asthma and diabetes, while the literature reports a growing interest of involved actors in supporting mental health care [21].

Depending on the interaction method they implement, these agents have different names: virtual agents, chatbots, or chatterbots; as well as different types of interfaces, such as:

- Agents with integrated visual identity (e.g., images of practitioners, nurses or trainers, or non-human images such as robots, etc.) to give users a richer and more convincing experience of communication. Such agents are referred to as Embodied Conversation Agents (ECAs), which may additionally have integrated and non-verbal communication components, such as e.g. hand gestures or various facial expressions.
- Agents that have only an integrated voice without any visual effects (so-called unformed voice-only agents, such as Apple's Siri, Amazon's Alec, or Microsoft's Cortana).

3.1.2. Health Monitoring and Risk Prediction

AI techniques can be used to reason over data that can be collected from smart devices, mobile healthcare applications and various integrated sensors, all aimed to identify patterns of behavior and patient habits. In this way, patients can significantly benefit by providing them a better understanding of their symptoms, their reactions to treatments and the progress of their disease. Also, physicians could benefit in receiving a more comprehensive overview of the patient's health status and relevant indicators during the periods in between physical visits and controls. Mobile health applications development as well as consumer acceptance are growing rapidly, as evidenced by the following figures: usage of wearable, smart devices in US adults was 9% in 2014, and increased to 33% in 2018, with continued growth till today; use of mobile health applications increased from 16% to 48% [21]; while the companies for development of AI solutions for healthcare based on wearable devices have invested over $ 4.3 billion in development since 2013 [22].

3.1.3. Timely Personalized Interventions

There are various challenges in the development of the Personalized Disease Management Support System, such as the potentially high workload of users in self-monitoring and recording intake (e.g. intake of each food item eaten by the patient, etc.) as well as limited self-awareness (e.g., timely blood pressure control, etc.). To overcome these, special benefits were shown by the use of sensors to replace self-reporting by the user, enabling the collection of comprehensive patient data, including internal indicators (e.g. mood, anxiety, blood pressure) as well as external (e.g., location, activity). Based on these data, as well as historical data on previous interventions, systems are developed to “learn” about the patient and make decisions about dynamic and personalized treatment. These systems are commonly known as AI-driven Adaptive Interventions, called JITAI, "just-in-time adaptive interventions" [23]. JITAI assistance is especially important in critical situations for the patient (e.g. drastic blood sugar surge and urgent insulin therapy, etc.), and additionally helps physicians to identify specific and problematic patterns of behaviour and disease development.

The sensors used in the JITAI development are increasingly diverse, with potentials for interactions with smart home systems (e.g. coupling the meter to sensors on the consumption of refrigerated foods, fluid intake based on smart home faucets, etc.).

3.1.4. Assistance for Individuals with Cognitive Disabilities

Existing systems are not developed to provide assistance and support to patients with cognitive disabilities (such as Alzheimer's disease and other forms of dementia), while in recent studies, the size of this population is increasing significantly due to general aging of the population, which is a basic predictor. Currently, there are nearly 16 million patients with cognitive disabilities in the U.S., nearly 5 million are over 65 years of age. This age category currently represents almost 9% of the global population, which is expected to double by 2050 [24]. An additional challenge for the system as a whole is the fact that these patients are often reluctant or unable to move to care facilities or a nursing home, so family members or relatives provide unpaid care and support to these patients, having thus clear social and economic consequences.

This domain shows the clear potential of deploying AI home monitoring techniques and supporting development of smart robots that will provide the necessary assistance. In addition, these systems can support the collection of data about all patient's activities at home, the time they spend in bed, the way they move and the number of possible falls, etc., which are significant inputs for creating personalized care tailored to each patient's condition.

Several types of social robots are currently being developed [26]: robots that have been developed to stimulate dementia patients and simulate the effect of social contacts (e.g., PARO, Kabochan and PePeRe), as well as robotic pets that have been shown to have significant benefits in reducing anxiety in nursing home patients with dementia [25], etc.

3.2. AI solutions for the clinician care team

There are two main areas for application of AI techniques in clinical care: (1) enhancing and optimizing care delivery and (2) improving information management, user experience, and cognitive support in electronic health records (EHRs). These areas have been progressing for decades, typically by developing applications with embedded expert knowledge and rule-based reasoning about specific clinical areas or problems. Continuous improvements of AI techniques give potentials for further improvements of already achieved performances.

3.2.1. Care Delivery

The potentials for the use of AI techniques over the increasing and diverse amount of patient data can be divided into the following three groups: diagnosis (including prevention, early detection, risk/benefit identification), surgery and personalized treatment, which has a strong impact on the overall clinical care process. Patient data includes primarily those stored in the EHR as well as those generated from a variety of sources: wearable devices, social media; consumer spending, nutritional value of grocery shopping, etc. and which are being lately generated on an increasing scale.

Diagnosis. There are various records of the benefits and potentials of using AI in diagnostics, including [27]: diagnostic imaging analysis, histopathological diagnostics,

etc. However, although rapid developments and advancements in AI results are continually growing, in the field of diagnosis they are expected to significantly reduce human error, but still keeping the necessary role of physicians in making the final diagnostic decision and treatment plan (usually radiotherapy and surgery). Diagnostic image recognition can distinguish benign from malignant melanomas, diagnose retinopathy, identify cartilage lesions within the knee joint [27], detect lesion-specific ischemia, and predict nodal status after a positive breast cancer biopsy; thus significantly contributing to prioritization of patients (consequently saves time and enable timely interventions over complex cases), correct decisions on diagnosis, treatment planning, implementation of screenings, etc. Also, since precise classification of tissues, identification of the existence of specific types of viruses, bacteria or proteins in tissues is of particular importance in histopathology, the application of AI techniques is also directed into this direction.

Surgery. The application of AI techniques is recognized in several areas of surgery, such as [28]: surgical planning and decision-making, support for surgery interventions, etc. Of particular importance for planning and decision making in surgery is the prediction of the consequences of decisions during interventions as well as of surgical interventions as a whole. To this end, deep learning models are usually created over patient data, medical history, identified risk factors, and other evidence from surgery practice. Also, these models can benefit surgeons during the intervention, make it safer and reduce the risk. During the surgery itself, the highlighted benefits of AI are due to controlled robots that can increase the sheer precision of interventions (especially in anatomical locations that are not otherwise reachable by human hands) as well as increase the practitioner's safety (when exposed to high doses of ionizing radiation). This is an area that is in rapid expansion and it is expected that in the near future, robots will be major in performing surgical interventions while the role of surgeons will be in monitoring the movement of robots.

Personalized management and treatment. AI is expected to support clinicians in creating personalized medical treatments that are tailored to each individual patient's characteristics. The following studies are particularly emphasized in this regard [29]: personalized dosing of chemotherapy with dynamically adapted plans depending on the level of progress of the patient's condition; monitoring and treatment of polyps in pathological findings with the identification of a personalized periodic treatment; the personalized combination of treatments and procedures in the treatment of complex diseases such as cancer, etc.

3.2.2. Improving Information Management, User Experience and Cognitive Support in EHRs

EHR systems can be enhanced by integration with specific AI techniques in different areas, such as information management (e.g., clinical documentation, information retrieval), user experience, and cognitive support, as described in the following sections. *Information management* - EHR systems and regulatory requirements have imposed to providers the responsibilities and procedures for storing and handling data that are in general extending the range of data that are necessary for patient care support. This is why AI techniques can be applied to improve the way that data are accessed and used by clinicians, such as:

- Support for voice data entry, which is already well recognized in clinical documentation and allows dictation of clinical reports that are automatically recognized and entered into the system (AI techniques for natural language recognition and processing);
- Support to clinicians in querying over patient records - similar to conversational and interactive systems used outside of the healthcare domain (e.g., Amazon's Alek, Apple's Siri), these systems can replace the clinician's efforts to reach the desired information through clicking on multiple screens with patient information. In that sense, the system can receive a voice query while the clinician will be committed to reviewing and interacting with patients. This feature is expected to significantly improve the patient-clinician relationship in the near future, by reducing the time that clinicians spend on screen viewing and becoming more devoted to talking with the patient.

Cognitive support. In addition to a direct focus on improving the decision-making process in clinical practice through clinical decision support systems (CDS), AI can be used to improve cognitive support through the creation of memory alerts, data displays and reminders, as well as interaction with clinicians and patients.

Smarter alerts and reminders from CDS. EHR systems often generate a large number of irrelevant pop-up alerts primarily due to low specificity and lack of clinical context in the generation of CDS rules, which interfere with the work of clinicians and contribute to the effect of "alert fatigue" [31]. The potentials of AI application are reflected in the ability to analyze large amounts of contextual information about patients, prioritize different types and categories of alerts, specifically integrate lifelong learning processes and upgrade systems based on previous clinician experiences (eg adjusting priorities for specific types and categories of alerts, etc.).

Improve access to the biomedical literature to support clinical decision making. The general development of AI techniques can greatly contribute to the advancement of clinical knowledge itself. Regardless of the field of science in which they are applied, machine learning algorithms are used to rank search results in the electronic search of available literature and sources. Additionally, AI has potentials to make advancements specifically related to medical knowledge, such as: transformation of patient static narrative text into medical records about health indicators during and after treatment (using AI methods: extracting information, NLP, automatic summarization and deep learning), creation of dynamically adaptive treatments for each specific patient based on continually updated clinical evidences as soon as the results of new clinical trials become available, etc.

3.3. AI solutions for population/public health program management

AI-supported software solutions have been implemented in many health systems, starting from the local level, through municipality, regional and national health systems belonging to the primary, secondary or tertiary level of health care. AI has also found applications in public health systems to monitor health indicators within the population, as well as to observe a wide range of educational, economic, social and environmental factors that are essential for good health. AI systems are used to monitor the following: physical, mental and social health of the population, health promotion and disease prevention, physical and work environment, organization and functioning of the health system as well as in crisis and emergency management.

Health care programs are realized through non-traditional partnerships between different sectors of the community: local self-government units, health services, health insurance organizations, social security systems, educational institutions, public media, companies, public companies, sports and other organizations and associations, families and citizens. The activity coordinators are public health institutes that promote healthy lifestyles, disease prevention and injury, as well as detection, prevention and respond to infectious diseases.

3.3.1. Health Communication and Health Campaigns Enabled by AI

The use of AI in the process of disease prevalence or high-risk behaviour can very effectively identify demographic or geographical locations and predict their spread and impact in the future. Through the successful application of analytical procedures and neural networks, researchers have been able to quantify the relationship between the environment and the prevalence of obesity. Using appropriate analytical models, they have shown that appropriate physical characteristics of the neighbourhood can be related to variations and incidence of obesity. By using machine learning on biomarkers and socio-marker data in paediatric asthma patients, the risks of re-examinations can be predicted and identified [33].

The presented model accurately predicted two out of three patients at risk based on socio-markers without knowing the specific characteristics that describe the symptoms of the disease. Identifying the population or region enables more effective health activity and campaigns, thus reducing the potential for interpersonal and mass influences. However, the use of machine learning techniques in these contexts also poses several problems, including (1) inability to recognize the correct application of algorithms by clinicians, (2) inability to consider the context of care in algorithms, or (3) fundamental lack of reliability of certain medical data [34]. As we can conclude, the perceived shortcomings and challenges cannot be attributed to the weaknesses of machine learning but represent the inappropriate use of modern technologies.

3.3.2. Population Health Improvement Through Chronic Disease Management

AI approaches have already been developed and are applied in a wide range of population health programs, including support for clinical decision making, prediction of epidemics and risks to the population, creation of tools to automate examination and monitoring of patients, etc. [35]. Furthermore, risk prediction models used by AI systems sometimes represent an alternative approach to standard models. For example, in the process of identifying clinically important contingencies, predictive models using machine learning algorithms may be significantly more efficient than traditional research approaches that rely on statistical hypothesis methods. Applying machine learning over EHR data and other administrative data will allow the consideration of personalized risks and benefits at the individual level, which is an analysis of significantly better quality than those obtained based on average population indicators. Models predicted based on individual-level health data, using modern ICT, allow the creation of a common model. A good example of a collaborative patient prediction model is Observational Medical Outcomes, which uses observational healthcare data [36].

The use of AI in predictive models provides not only the ability to predict risks but also the ability to assess the presence or absence of disease for a patient. An example of successful application is the memetic pattern-based algorithm for risk assessment for

coronary heart disease. Patients undergoing coronary artery disease were analysed using an AI predictive model. The result showed that the model not only predicts the likelihood of disease in the patient but successfully identifies and excludes coronary artery disease. The implementation of this model has multiple benefits. In addition to proven ability of the model to help healthcare institutions in the identification of those at increased risk of disease at an early stage of disease progression, it enables more efficient work and savings as it prevents unnecessary diagnostic procedures for patients who are not at risk of the disease.

3.3.3. AI Solutions for Public Health Program Management

Workers at health institutions are interested in ICT based support which will enable productive and practical management of programs, procedures, and assistance; exposure disease and monitoring; as well as research and innovation. Compatible AI solutions are continually being explored within many health domains.

Surveillance of diseases. A number of AI systems are used to enhance disease surveillance. For many years, researchers have been using various questionnaires to determine the factors and monitor the outbreak. One of the most common ways of realizing these systems is tracking the terms that users search on a daily basis using available search engines on the Internet. Some of these approaches rely on search terms that users type in search engines (e.g., Google Glunds Trends). When using software solutions based on this approach, it is necessary to be very careful, since the analysis of data that are not collected to serve scientific research may yield misleading results. It should also be considered that search algorithms are consensually and non-transparently changing depending on business needs.

Environmental and Occupational Health. AI systems based on modern technologies (nanotechnology, robots, sensors) are widely used in the field of environmental and occupational health. The application of AI solutions based on sensors for testing bacterial water pollution in regular water supply systems has been implemented in many cities. Water sampling at shorter intervals and their analysis significantly improve control efficiency over traditional water sampling and laboratory testing processes, with significantly reduced costs and reduced risk of contamination to an acceptable level.

3.4. AI solutions for health care business administrators

The process of coordination and payment for care is quite complex in every major healthcare system. Several different actors are involved in the whole process, in addition to the patients, there are providers, healthcare facilities, laboratories, hospitals, pharmacies, administrators, and many others. The process of administrative coordination regarding appointment, billing and payment follows the period of before, during and after the examination performed with the patient. This whole process is known as *administration of care or administrative workflow.*

The potentials of AI implementation are reflected primarily in increasing the efficiency and precision of the whole process, while eliminating the bias of the day-to-day functions of the system for administration of care. Additionally, more recent in-depth learning methods can offer solutions to automate the process of analyzing patient narratives, which are often of great importance in determining the type of intervention and treatment. The development of such systems must be supported by professionals who will provide data sets necessary for training such models, by continuously collecting

and analysing patient narratives, the results of which will train the model. However, although these models have proven power in the effectiveness of the analyses, they cannot be trusted in absolute terms (i.e., there are false positives and false negatives), and the role of practitioners and administrators cannot be completely rejected. However, these systems will be of considerable assistance to the administration in increasing the efficiency and increasing the time devoted to the patient, but continuous monitoring is necessary primarily to ensure patient safety.

In the following sections, some of key activities administration of care process are described from the perspective of AI applications.

3.4.1. Prior Authorization

In the case of more demanding health procedures and plans, prior approval of the procedure, device, laboratory and durable equipment is required. The approval process is based on patient data, physician reports, and requirements requiring approval, and upon which the appropriate professional committees make the decision.

Such procedures, besides requiring a lot of time and human involvement, are often subject to biased decisions and inconsistencies. The application of AI techniques can help to overcome these shortcomings, such as: advanced sorting of cases by the level of professionals/committees in charge (whether a decision can be made by a nurse and technician or specialized commission), advanced processing of documentation and linking of information from different documents, automation of the decision-making process based on defined process protocols, etc. This would certainly result in fewer complaints from patients, system-generated decisions would be subject to prior authorization by professionals, but the whole process could work in near real time, which is of particular importance for patients.

3.4.2. Automated Coding

ICD-10 codes, from the International Statistical Classification of Diseases and Related Health Problems, 10th Revision is a process that involves identification of EHR information necessary to apply for funding for appropriate health issues.

This process relies on experts who know the language, professional medical terminology as well as the complete narrow-professional encryption-based nursing administration process. An additional challenge of the coding process is the frequent modification of code systems, some codes are added, some are deleted, as are the assigned descriptions and interpretations themselves. This is why AI semantic technology-based methods have been used for a decade to automatically identify specific codes that completely or partially replace the manual code-filling process. Although these systems have been in use for a long time, absolute accuracy has not been ensured: false negatives can cause compensation to be denied, and false positives can unreasonably increase costs and lead to problems of breach of certain regulations and rules.

Modern AI methods can enhance administrative coding with the automated integration of meaningful information from patient notes and narratives (e.g. using Word2vec), and the application of deep learning methods to identify and integrate information of importance from issued medications, lab tests, etc.

3.5. AI Solutions for Research and Development Professionals

The application of AI technologies involves both the application of existing methods in specific areas of health and the creation of new AI techniques to ensure better performance than the application of existing techniques. This is a very broad area of presentation, and in the following sections the focus is on the application of AI techniques by research institutions with both medical training and focused on the analysis of large and multiple data warehouses (such as biobanks, DICOM systems and EHR systems).

3.5.1. Mining EHR Data

Since EHR contains large datasets with different information and data of different types (including structured data, unstructured data - usually patient narratives, images, genomic data, etc.) they serve as a basis for research aimed on providing clear benefits in advancing biomedical research and improving health care.

Extracting practical information from EHR data is an area of application of AI techniques of particular importance, since EHR data hides a wealth of information that results in "hidden" knowledge about disease characteristics, categorization of patients by risk factors, etc. This is why the following AI techniques are most commonly used: clustering, decision-making systems, data mining, etc. however, there are also major challenges in implementing these techniques precisely because of the high dimensionality and heterogeneity of the data, and often poor data quality.

Machine learning. These deep learning algorithms have the ability to identify patterns and cause-and-effect relationships that one cannot perceive, so it is often said that using them over large medical data can lead to mining "hidden knowledge about specific diseases" and the health characteristics of the population as a whole.

Deep learning. Usually, latent structures are created using these algorithms to represent a large amount of raw data, in the form of a multilayered structure of causal factors (often in the form of artificial neural networks), thereby achieving excellent predictive powers of these models. Creating a predictive structure by applying “unsupervised feature extraction” often results in models that go beyond the traditional predictive models for early detection of heart failure, various cancers, and starting and withdrawing from intensive care unit interventions.

3.5.2. Applications to Imaging Data

Analysis of radiological imaging and detecting abnormal tissue structures is a challenge for practitioners as well as for the automatic support of this process. The results so far have shown that it is not necessary to develop new modelling techniques for this purpose, but rather standard machine learning techniques can be used in combination with image analysis tools. Thus, the application of deep learning algorithms has yielded many results in this field, naming just a few illustrative:

- A model was created to predict age based on brain imaging [38];
- An analysis of multimodal image overlay was performed that resulted in identified lesions that were not made visible by any type of brain imaging (e.g., structural MRI versus functional MRI);

- Researchers at Massachusetts General Hospital in Boston have created a model to analyse brain images to identify what is normal for a developing baby brain [39];
- Models have been created for analysing electrocardiogram data to characterize types of heart failure, etc.

3.5.3. Drug Discovery

Machine learning algorithms have great potentials to support drug discovery in a fast and efficient way. The benefits of using these algorithms can be seen in the following: extracting information on cellular systems, identifying potential drug effects, analyzing large chemical databases, etc. Significant progress has been made in recent years in the development of large sets of chemical data, which are of particular benefit for the creation of new drugs through machine learning, as they enable:

- predicting synthesis,
- biological activity of new ligands,
- drug selectivity,
- pharmacokinetic and toxicological profiles,
- modelling polypharmacy side effects (due to drug–drug interactions), and
- designing de novo molecular structures and structure-activity models.

Large databases are of particular importance for the implementation of AI, and research initiatives are therefore particularly important to link EHR databases to structured data from other sources that may be relevant to the comprehensiveness of information, such as: biobanks, radiological images, families and relatives about experiences with the patient, etc.

Finally, in order to make a summary representation, Table 1 and Table 2 provide examples of the types of AI applications for different stakeholders. These examples are not exhaustive.

Table 1. Examples of AI application for stakeholder groups: patients and families, and clinician care teams

Use Case or User Group	Category	Examples of Applications	Technology
Patients and families	Benefit/risk assessment	Devices and wearables Smartphone and tablet apps, websites	Machine learning, natural language processing (NLP), speech recognition, chatbots
	Disease prevention and management	Obesity reduction Diabetes prevention and management Emotional and mental health support	Conversational AI, NLP, speech recognition, chatbots
	Medication management	Medication adherence	Robotic home telehealth
	Rehabilitation	Stroke rehabilitation using apps and robots	Robotics
Clinician care teams	Early detection, prediction, and diagnostics tools	Imaging for cardiac arrhythmia detection, retinopathy Early cancer detection (e.g., melanoma)	Machine Learning
	Surgical procedures	Remote-controlled robotic surgery AI-supported surgical roadmaps	Robotics, machine learning
	Precision medicine	Personalized chemotherapy treatment	Supervised machine learning, reinforcement learning
	Patient safety	Early detection of sepsis	Machine learning

Table 2. Examples of AI application for stakeholder groups: public health program managers, business administrators, and researchers

Use Case or User Group	Category	Examples of Applications	Technology
Public health program managers	Identification of individuals at risk	Suicide risk identification using social media	Deep learning (convolutional and recurrent neural networks)
	Population health	Eldercare monitoring	Ambient AI sensors
	Population health	Air pollution epidemiology Water microbe detection	Deep learning, geospatial pattern mining, machine earning
Business administrators	International Classification of Diseases, 10th Rev. (ICD-10) coding	Automatic coding of medical records for reimbursement	Machine learning, NLP
	Fraud detection	Health care billing fraud Detection of unlicensed providers	Machine learning, NLP
	Cybersecurity	Protection of personal health information	Machine learning, NLP
Researchers	Physician management	Assessment of physician competence	Integrated cognitive computing
	Genomics	Analysis of tumor genomics	Integrated cognitive computing
	Disease prediction	Prediction of ovarian cancer	Neural networks
	Discovery	Drug discovery and design	Machine learning, computer-assisted synthesis

4. Conclusions

AI techniques are mainly developed to simulate human intelligence and we are witnessing their continuous rapid development. When applied in healthcare, AI is powered by huge healthcare datasets and bring significant results in enhanced care treatment, increased efficiency of care process etc. Healthcare datasets mainly include EHR data linked with other data sources, such as wearable devices, clinical laboratory results and images, narratives with patients, demographics etc. and they are firstly used for "training" AI systems and then for testing and validation. Even there are impressive results in prediction accuracy, automated processing etc. human interventions of physicians, specialists and administrators cannot be fully rejected, but integration of AI systems significantly contribute to increasing effectiveness and precision, with increased safety of patients and quality of care.

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Exercises

1. Can you define the term of AI and list few AI methods?

2. Can you list examples of different AI solutions developed for different stakeholder groups?

3. What are expected benefits of using AI applications in healthcare?

Answers to the Exercises

1. A precise explanation of AI originates by the Oxford English Dictionary: "The capacity of computers or other machines to exhibit or simulate intelligent behaviour; the field of study concerned with this," or Merriam-Webster online: "1: a branch of computer science dealing with the simulation of intelligent behaviour in computers, 2: the capability of a machine to imitate intelligent human behaviour."
AI methods can be classified as follows:
- Evolutionary computing;
- Expert systems;
- Fuzzy systems;
- Machine learning- including Neural networks, and Support Vector Machines;
- Probabilistic methods – including Bayesian Networks, and Hidden Markov Models.

2. AI solutions are developed benefiting to different groups of stakeholders, as follows:
- patients and families: conversational agents, health monitoring and risk prediction, timely personalised interventions, assistance for individuals with cognitive disabilities, etc.
- clinical care teams- care delivery, improving information management and cognitive support, etc.
- public health program managers- health communication and health campaigns, chronic disease management, public health program management, etc.
- business administrators- prior authorization, automated coding, etc.
- researchers- mining EHR data, imaging, drug discovery, etc.

3. AI use in healthcare is expected to provide support for some well-known use cases in health care business operations, such as: lessening expenses and increasing efficiency, developing the quality of health care and treatment, setting human intervention priorities to specific processes/interventions, automation of frequently repeated tasks [5] and optimization of workflow in healthcare facilities [8], reduction of medical waste (failure to provide care, failure to coordinate care, inadequate training, failure in cost, fraud and abuse and administrative complexity); etc.

Problems/Challenges

➢ If you consider development of AI support to persons with seasonal allergy, what applications/tools can you identify to be of interests?

➢ Do you agree on massive integration of different AI applications developed by a wide range of developers/programmers? Why?

➢ Do you expect that full automation of processes in some specific branches of healthcare will be provided in near future? Why?

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IT-Assisted Process Management in Healthcare

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Abstract. Clinical processes need to be well understood before a new health IT tool can be introduced. Observations, interviews, surveys, or documentation analysis are carried out to systematically collect information to better understand a clinical process. To aggregate and visualize the collected information about a clinical process, use case diagrams can build a basis. Formal process models such as process chain diagrams or BPMN diagrams are well suited to model the process in detail. The objective of this chapter is to discuss these methods for analyzing and modeling clinical processes, as this is an important precondition for systematic process management in health care.

Keywords. Process management, process analysis, observations, interviews, surveys, documentation analysis, process modeling, use case, process chain, BPMN.

1. Introduction

Health information technology (health IT) can comprise many different types of tools, such as a new documentation system for nurses or a new mobile decision support app for physicians. When introducing new health IT, the clinical processes that the new health IT tool should support need to be known beforehand. Only if the processes of documentation or of decision-making are well understood, the new health IT tool can be prepared, adapted and implemented in a way that best supports these processes.

Formally, a process can be understood as a number of related activities that serve to reach a certain objective. A process is triggered by a defined starting event. It has a clear end situation. For example, the process of nursing documentation comprises several related activities such as nursing admission, assessments, care planning, documentation of tasks, and evaluation. This process of nursing documentation starts when a patient is admitted to a ward and ends when the patient is discharged. The overall objective of this process is to support nursing care by carefully collecting and analyzing all relevant patient data needed for deciding on nursing activities.

If a clinical process is not well understood, a new health IT tool may fail to support the process. For example, if the implementation team is not aware of the fact that some activities of nursing documentation are conducted directly on the patient's bedside, and thus no mobile documentation devices are provided, nurses will need to go to a stationary

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computer to review and enter their nursing data. This will take more time and may lead to documentation of lower quality – and surely to lower satisfaction of the nurses.

If a clinical process, however, is well understood, a new health IT tool will have a greater chance to be implemented in a way that it successfully supports this clinical process. For example, if the implementation team first conducts a thorough analysis of the processes of nursing documentation, it will understand that documentation is also done in mobile form. The implementation team will thus provide both stationary computers as well as a sufficient number of mobile computers for the nurses. Thus, nursing documentation will be supported efficiently and nurses will be more satisfied.

These examples show that the implementation of new health IT is not just about technology, not just about providing software and hardware, but rather and most importantly about socio-organizational issues: How are clinical processes organized? Who will use the new health IT tool, where, and when? Only when this information about the context of an IT implementation is available, an implementation project can be well prepared and will thus have a higher chance to be successful.

2. Learning objectives

The learning objectives of this chapter are thus

- to be able to select and apply methods to analyze clinical processes, and
- to be able to select and apply methods to formally model a clinical process.

Process analysis is part of process management in an organization. Process management is the discipline that aims at identifying, analyzing, modeling, improving, and automating business processes [1]. Process analysis as a sub-discipline covers the analyzing and modeling activities of process management.

In this chapter, we will discuss process analysis in more detail by concentrating on the following three steps: preparation of the process analysis, systematic collection of data, and formal modeling of the process.

3. Preparation of process analysis

When planning a process analysis, the project team should carefully discuss and clarify the following issues:

- Why is the process analysis conducted? A clear formulation of the objectives of process analysis helps to better plan the next steps. For example, is the process analysis conducted to better prepare the introduction of a specific health IT tool, including preparation of user trainings? The answers to these questions are the basis for answering the next questions.
- Which processes should be analyzed in more detail? For example, should the analysis focus only on the process of nursing documentation or should it also cover medical documentation? This decision should be based on a careful analysis of the functionality of the planned new health IT tool.
- In which organizational units should the process be analyzed? For example, should the analysis only be conducted in the cardiology unit of the hospital or

also in the surgical unit? This decision should be based on information in which organizational units the new health IT tool will be introduced.

Next, the project team should decide on the best ways of data collection. Typical methods of data collection are observations, interviews, surveys, and documentation analysis. These types of data collection have specific strengths and limitations that are summarized in Table 1. The project team should carefully consider the specific setting, the objective of process analysis, and the available time and resources and then decide on the most appropriate method.

Interviews and surveys are also called "subjective" methods, while observations are called "objective" methods. However, please note that an external observer is also "subjective" as he will (often unconsciously) decide which information is important and thus will be collected, and which not; another observer may collect other information. Thus, calling methods "subjective" or "objective" is not helpful when deciding on the best method.

To combine the strengths of the different data collection methods and to reduce the limitations, a project team may decide to combine two methods. For example, observations and interviews may be combined to have information on a given process both from the point of view of the process participants as well as from the point of view of an external observer. Both methods may thus nicely complement each other and will provide a more complete picture of the process than each method alone.

For all data collection methods, the project team then needs to decide how many observations or interviews will be conducted or how many persons will be invited to a survey. The team may decide to start with a defined (smaller) number, and then after completing those analyses decide whether they have enough information for process analysis since the data collection brought up mostly the same information in all cases, or whether they need more information. This approach is called "saturation"; you collect information until you are satisfied with the available information and confident that new information will not come up with further data collection.

All data collection needs to be carefully prepared. For interviews, interview guidelines need to be prepared with a combination of open-ended and closed questions. For surveys, the standardized survey questions and the (online or paper-based) survey form need to be prepared. For observations, an observation guideline on what and how to observe need to be prepared. It makes sense to test all these instruments with a few users and revise them before applying them. In addition, all persons who will conduct data collection, who perform observations or conduct interviews, should be carefully trained.

After all these preparations, data collection can start. Before starting, the project team needs to make sure that both the management and the staff of the unit where data collection will take place is informed and has agreed to support data collection.

Table 1. Strengths and limitations of various methods for data collection during a process analysis in health care.

Data collection methods	Example	Strengths	Limitations
Observation	A project team member observes the process of nursing documentation on the ward over two days by following the nurses. A project team member conducts a measurement of the time needed for documentation of nursing admission.	An external observer may provide an unbiased view on the whole process that is not limited to the potentially subjective point of view of the persons involved in the process.	Observations may be quite time consuming and may disturb the usual clinical routine. People may change their behavior when they know that they are observed.
Interview	A project team member conducts a two-hour interview with one nurse (or with two nurses) on the activities that are part of nursing documentation.	Persons involved in the process are the best experts for this process, directly talking to them will bring a lot of important information on the process.	Only a limited number of persons can be interviewed due to time constraints of both interviewer and staff. Each interviewed person may only be aware of a part of the process.
Survey	The project team prepares a standardized, online survey questionnaire that is sent to all nurses on the unit. The survey asks questions on the most relevant problems of nursing documentation.	Surveying persons involved in a process with standardized questions helps to collect the perspectives of all involved persons in a quantifiable way.	Only standardized questions can be asked, no dialogue is possible. If open-ended questions are used, data analysis is quite time-consuming.
Documentation analysis	The project team analyses the available guideline for nursing documentation of the hospital. The project team analyses patient records to understand which data is collected during the nursing documentation.	Already available data can be used, which is quite efficient and does not disturb clinical workflow.	It is not clear whether the analyzed information is accurate and up-to-date and really gives a complete picture of reality.

4. Systematic collection of data

We will now look at how to conduct successful observations, interviews, and surveys. For in-depth reading, you may want to consult the literature on systems analysis or business process analysis [2].

4.1. Observations

Observations allow an external view on a given process. They can be more or less standardized. Standardized observations focus on a limited set of pre-defined aspects

such as time needed for certain activities, or the number of times a computer is used for nursing documentation. Less standardized observations focus on a given situation as a whole, are not limited to pre-defined aspects, and try to understand, for example, how a process is organized in general and who is involved.

As observations are quite time consuming, in many cases, only the most important parts of a process can be observed. Observers should be quite familiar with the clinical setting where they conduct the observation and with its informal rules and jargon, to avoid disturbing the usual flow of activities and to be able to understand the context of any observation.

To document the results of an observation, the observer should document all observations either on prepared documentation sheets for more standardized observations (such as checklists) or in a (more unstructured) observation diary for less standardized observations. It is advisable to train the observers and to conduct a test observation to make sure that the observation runs smoothly.

Observations are quite intrusive from the perspective of the observed people, thus careful information beforehand and agreement of all persons that will be observed need to be guaranteed.

4.2. Interviews

Interviews collect information from persons that have some important knowledge about the analyzed process. Typically, representatives of the most important roles involved in the process are chosen for an interview. For nursing documentation, for example, the head nurses, some ward nurses, some assistant nurses and a physician may be invited for interviews.

Interviews can be conducted as single interviews (with one person) or as group interviews (with a group of persons). Group interviews have the advantage that they are more efficient and may bring up new information by fostering discussions among the participants. They have the disadvantages that one participant may dominate the discussion, or that participants may be reluctant to talk openly in the group, especially if members of different hierarchy (e.g. head nurse and ward nurses) are present.

An interview should be done in a quiet place where disturbances are limited. At the beginning of the interview, the interviewer should explain the purpose of the interview, explain how the results will be used, and answer open questions.

When interviews are conducted for the purpose of process analysis, it is helpful to use “activity cards” that show single activities that are part of the overall process. These cards can be put on a table where the participants then can try to describe the flow of activities within the process by sorting the cards. If an activity is missing, a card can easily be added. This approach is quite helpful to support a joint and visual perspective on the process. The outcome of such a workshop is a good preparation for process modeling that is further discussed below.

It is also helpful if two persons conduct the interview – one person conducts the interview, the other documents the answers. The interview can also be recorded by a tape recorder, but participants may need some time to feel at ease in the sight of a tape recorder.

4.3. Surveys

Surveys allow the standardized collection of responses from a large number of respondents. The questions need to be short, clear, without any ambiguities or

abbreviations. The survey should also contain the explanation of why the survey is conducted, how the results are used, and who is available for any questions on the survey. The overall survey should be short, to increase the response rate. It is advisable to test the survey with a smaller number of people beforehand.

Surveys can be conducted online or paper-based. Online surveys are more efficient to conduct and analyze, but require that all respondent have a valid e-mail address.

For analyzing processes in some depth, surveys are often not very helpful, as analyzing processes requires more than simple, standardized questions from a survey. However, surveys may be helpful to collect additional and standardized, quantitative information such as user satisfaction with a given process or a given health IT tool, or to rank the most urgent problems in a given process or health IT tool.

5. Formal modeling of the process

Observations, interviews, surveys and documentation analysis will bring up a lot of information on how a specific process is running, who is doing which activities, where the activities take place, in which order the activities take place, and which tools are used in each activity.

To prepare for the implementation of a new health IT tool, it is now crucial to analyze and aggregate this information into standardized process models, so that people can use this process model for further assessment and planning.

A process model is a simplified, standardized and validated visual representation of the most important elements of a clinical process. Process models support a joined understanding among all involved persons on how the process is organized now.

Creating, presenting and discussing process models with all involved roles is often the first time that people in an institution really look at this process in more detail and discuss the process from an interdisciplinary point of view. Developing process models (i.e. in group interviews) and presenting the outcome of the discussion to all staff may lead to an intensive debate on the strengths and weaknesses of the process and on ways to improve it. Therefore, process analysis itself may already foster and facilitate process change. Process analysis is thus an important part of process management in general. In addition, process models are a crucial basis for describing the planned future process, for example, to prepare the introduction of a health IT tool that will help to improve the process. Overall, process models can present both the current process as well as the planned new process.

There exist plenty of approaches to model processes, for an overview look at the list of literature given at the end of this section. In this chapter, we will now present three approaches that we see as representative for the most important types of models: Use case diagrams, process chains, and Business Process Modeling Notation (BPMN) models.

5.1. Use case diagrams

Use case diagrams give a good overview of the process and its sub-processes (the “use cases”) and the roles (the “actors”) involved in a given process. Use case diagrams present an easy-to-understand visualization of use cases and actors and through this may provide a first summary of the results of a process analysis. They give all involved persons a good overview of the process and who is involved. Use case diagrams are easy

to understand and are thus well suited to support discussion between the project team, the actors (for example, the nurses) and the management of the institution.

Figure 1 presents an example of a use case diagram for the process "nursing documentation", showing the use cases and the involved actors. For more information on use cases, consult the related literature [3].

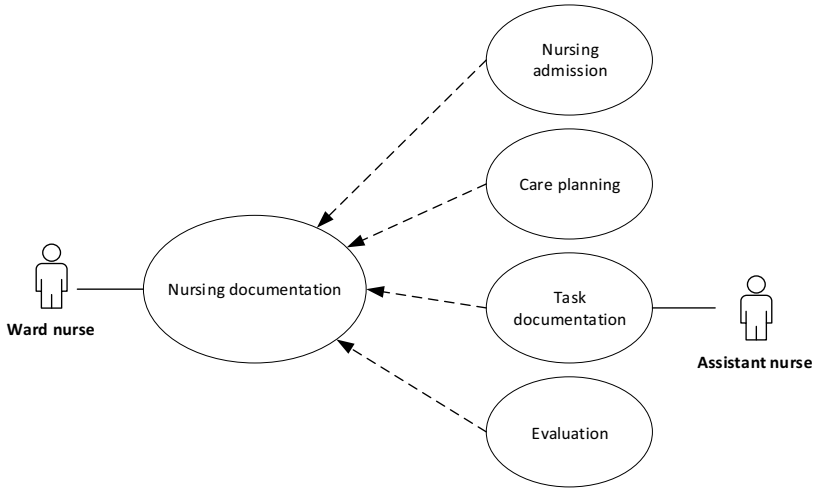

Figure 1. Use case diagram of the process "nursing documentation". The use case "nursing documentation" includes sub-processes such as nursing admission, care planning, task documentation and evaluation, as indicated by the dotted lines. The actor "ward nurse" is responsible for nursing documentation. The actor "assistant nurse" as a subordinate role is only allowed to perform task documentation.

5.2. Process chain diagrams

Process chain diagrams describe the activities and actors within a process. A process is split into those activities that are needed to reach the goal of the process. For each activity, the actors responsible for this activity are visualized. Finally, also the tools used for each activity can be added.

Process chains are an easy-to-read model of a mostly linear process. They can be used to communicate and discuss the process with the various actors and the management of the institution. More complex processes with several alternative or parallel branches can, however, not easily be modelled as process chains. For this, BPMN models - that are explained further below - are better suited.

Figure 2 presents an example of the process chain "nursing documentation" with activities, actors, and tools.

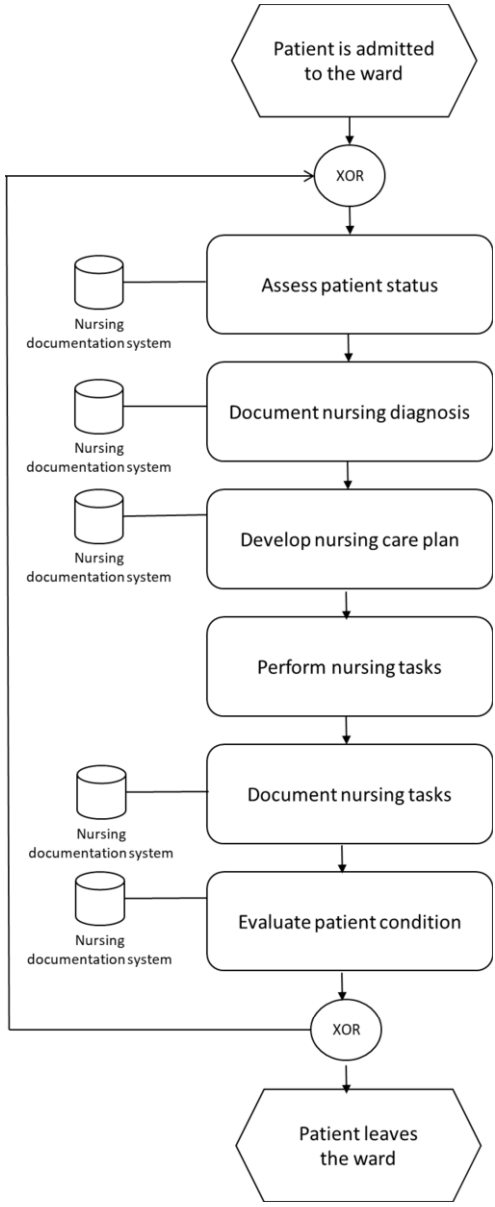

Figure 2. Process chain of the process "nursing documentation". Activities are presented in rectangles with rounded edges, actors as rectangles, starting and closing event as hexagon. The documentation tools are assigned to the related activity. Arrows denote the logical flow of activities. XOR denotes an "exclusive OR", indicating that the process either continues with re-assessment of patient status, or terminates when the patient leaves the ward.

5.3. Business Process Modeling Notation (BPMN) diagrams

The Business Process Modeling Notation (BPMN) allows to model and visualize more complex processes. Besides activities and actors, BPMN models also allow to describe

which event starts the process, which event ends the process, which activities can be done in parallel ("AND" split) and which activities are alternatives ("OR" split). In addition, BPMN offers further possibilities, e.g. to describe time triggers. In this section, we will focus only on the core elements of BPMN.

BPMN is a more complex notation that allows modeling a lot of detailed information about a given process. As a consequence, BPMN models may be quite comprehensive and difficult to understand. Therefore, BPMN models are mostly used within the project team. If BPMN models should be used for communication with clinical staff, careful training needs to be provided to help them understand the BPMN models.

Figure 3 presents an example of the BPMN model "nursing documentation" with activities, actors and tools. For more information on BPMN, consult the related literature [4].

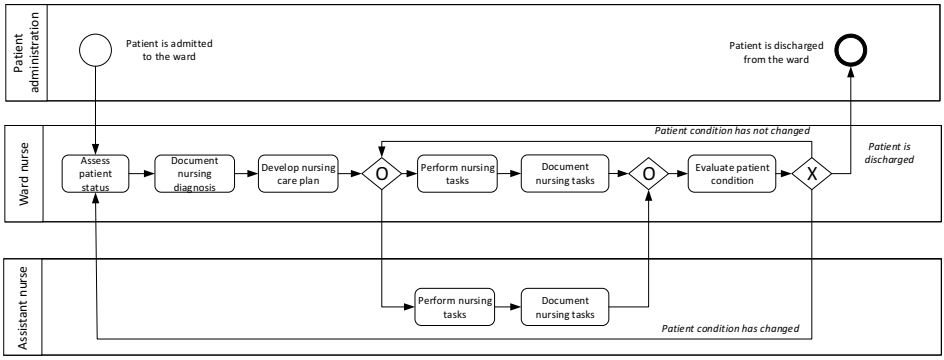

Figure 3. BPMN model of the process "nursing documentation". Activities are presented in rectangles with rounded edges, actors are shown in the swim lanes, starting and closing event are shown as circles. Arrows denote the logical flow of activities. "O" denotes an "inclusive OR" gateway, indicating that "performing nursing tasks" can either be done by the ward nurse, or by the assistant nurse, or by both actors together. "X" denotes an "exclusive OR" gateway. The specific conditions are assigned to the three arrows.

6. Conclusions

A thorough understanding of a clinical process is an important prerequisite for the successful implementation of a new health IT tool or for any other planned changes in the process. Process analysis comprises methods to analyze a given clinical process, such as observations, interviews, surveys, and documentation analysis. Such a process analysis should be well prepared.

To support communication and discussion of processes, process models are extremely helpful. Various ways to model processes exist, such as use case diagrams, process chains diagrams, or BPMN diagrams. Selecting the most appropriate model depends on which information should be communicated to which group. Those models with the maximum information in it (such as BPMN) are often not immediately suitable to be used for communication with clinical staff.

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Exercises

1. In which situation would you prefer a direct observation of a clinical process and in which situation would you prefer an interview with involved staff members? Explain your answers!

2. Compare Figure 2 (process chain diagram) with Figure 3 (BPMN diagram). Which information about the clinical process is visualized in which diagram? Which information is better visualized in the process chain diagram and which one is better visualized in the BPMN diagram?

3. Select a simple clinical process with which you are well familiar. Model this process both with a use case diagram and with a process chain diagram. Which information can you visualize in each model and which not? For which purpose would you choose use case diagrams and for which process chain diagrams?

Answers to the Exercises

1. Observations are time consuming and intrusive. I will thus only carefully use them in cases where I want to get an own impression or where I need objective information on a given process. I will use interviews when I want to better understand the perspective of various staff members on a given question. Often, I may combine both observations and interviews.

2. Process chain diagrams allow an easy visualization of the activities within a process. They can be used to model simple processes or parts of more complex processes. BPMN diagrams allow to add more information, e.g. on events or time triggers. By using swim lanes, BPMN diagrams allow structuring more complex processes. When communicating with clinical staff, process chain diagrams may be better suited. When communicating with IT staff, BPMN diagrams may be better suited.

3. Use case diagrams allow to describe which roles are involved in which process or sub-process. Use case diagrams thus show which roles should be involved in any project that will modify these processes. Process chain diagrams allow to describe which activities are performed in which logical order. They help to better understand and optimize processes.

Problems/Challenges

➢ Imagine you want to prepare the introduction of an IT-based nursing documentation system. You are planning a workshop with all nurses to inform them on this introduction project. As part of the workshop, you also want to explain the current situation of the (mostly paper-based) process to the nurses, and you want to highlight the planned changes of the process after the introduction of the new documentation system. Which type of model would you choose and why?

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Glossary

Accounting is the process of recording and storing financial transactions in a company or institution to provide information for decision makers.

Advertising and public relations (PR) are complementary communicational activities within the IMC, whose aim is to send the persuasive message to specific segmented publics. The basic formal difference is that, when applying advertising methods, the use of the media is paid and the advertiser clearly signs the message he sends to the public; while this does not happen with public relations techniques and its activities (press conferences, press releases, different kind of events, pitches etc.), because the media have to convey a message that they consider relevant to the audience, so it is signed by their journalists or other associates, without any financial compensation. Of course, these two components of IMC use different communication methods and techniques.

Application component can be either computer-based or paper-based. Examples are a computer-based patient administration system and a paper-based form for an anamnesis. Application components support tasks carried out in a hospital and interpret or update entity types.

Artificial intelligence (AI) is "1: a branch of computer science dealing with the simulation of intelligent behaviour in computers, 2: the capability of a machine to imitate intelligent human behaviour." (definition in accordance with Merriam-Webster online)

Branding is the process of creating a relationship or a connection between a company's product and emotional perception of the customer for the purpose of generating segregation among competition and building loyalty among customers. A brand is directly related to the perception and mind set of prospects and customers. It reflects the direct and indirect brand experience of what they have seen, heard, learned, thought and felt over time. A strong brand characterises itself by a strong customer base, or even better, by a sustainable base of loyal customers.

Budget is a financial plan of operations of an institution for a certain period in the future.

Business Process Modelling Notation (BPMN) is a Process model that allows to model and visualize more complex processes.

Correlation represents a measure of the strength of association between two variables. It can be described by scatter plot (graph) or by computed coefficient of the correlation. Two aspects of that association are important: direction (could be positive or negative) and strength. The correlation coefficient is a dimensionless quantity ranging from −1 to +1. A positive correlation is one in which both variables increase together. A negative correlation is one in which one variable increases as the other decreases. When variables are exactly linearly related, then the correlation coefficient equals either +1 or −1.

Cost drivers represent any activity, business, or organizational part of an institution, product, and service that caused the cost of the business to occur.

Cost price is the amount of costs necessary to produce 1 unit of product or service.

Costs are the amount of spending the resources (input) or production factors in order to produce and sell the effects of the institution (output).

Crisis management is a type of management that is aimed at dealing with and overcoming crisis situations. A crisis is an event that can cause significant negative consequences for the organization and its reputation. Crisis management also encompasses pre-crisis (preventive) and post-crisis (remediation) activities.

Data collection. As part of a process analysis, data can be collected via observation, interviews, survey, and documentation analysis.

Decision-making in finance is making choices among available alternatives on the use of financial resources, based on the information provided through accounting and financial reports.

Digital transformation is a process of the rapid development digital solutions that are helpful to clinicians in delivering healthcare services while being receptive to patients and consumers. The development of digital solutions in healthcare is based on the integration of data from different sources and the use of open, secure platforms; integrated predictive, preventative and personalized aspects in the treatment of patients and diseases; all aimed on promoting treatments and therapies that are effective, high-quality and tailored to the needs of each individual patient.

Disease burden is the impact of a health problem as measured by financial cost, mortality, morbidity, or other indicators.

Efficiency. Technical efficiency occurs when the firm produces the maximum possible sustained output from a given set of inputs.

eHealth is the: use of modern information and communication technology (ICT) for trans-institutional healthcare purposes.

Entity type. Representation of information in a hospital information system. Represents the type of information as well as all information instances of the information type.

Epidemiology is the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the control of health problems.

Ethics is a set of moral principles that guides human behaviour. It is a crucial element of responsible communications and PR practice. Ethical communication is factual, honest and respectful. Healthcare marketing is especially sensitive topic in relation to ethical concerns.

European health law with its focus on the European Union member states is a special subtype of the international health law.

Expert system is an intelligent software program that uses knowledge and inference systems in the process of problem-solving to emulate the decision-making capacity of human specialists. The basic components of expert systems are knowledge base; inference mechanism; user interface and global database.

External stakeholders mostly covers all subjects that are active outside of a healthcare institution, i.e. those who are not employed by it, such as: patients and their close ones, governmental regulatory bodies; professional community, suppliers, non-governmental sector, media and society at large.

Financial Management is in a nutshell managing the finances of a company or an institution, through planning, control, organizing and directing financial resources, and decision making on how they are used.

Financial Reports are formal records which summarize the financial activities of a company, person or entity and express the financial position in a single point of time and the financial performance over a period of time.

Global health law goes beyond the pure collection of nation-states, and emphasizes an international structure based on the world as a community.

Health Analytics is a branch of analysis that focuses on the analysis of complex and large amounts of health data that are characterized by high dimensionality, irregularities and rarities.

Health Data covers large amounts of patient data, data collected during the overall care processes (from symptoms and diagnostics, to treatment and recovery monitoring) and only by using advanced processing methods it is possible to support their integration and further analysis

Health Determinants are the range of social, ecological, political, commercial, and cultural factors that influence health status.

Health Development. The process of constant, progressive enhancement of the health status of a population. The notion of development as a managed process has been derived from work in the field of economic and social development studies and is now being applied to health systems.

Health economics is part of economics focused on evaluating scarcity in health system. All classical economic tools can be used in area of health and health systems.

Health information includes all data related to the patient's medical history, including symptoms, diagnosis, performed procedures (laboratory results, X-rays, hospital records, interventions and surgical procedures), prescribed treatments and medications, outcomes and control data reviews.

Health information management is a multi-disciplinary area that is primarily focused on the entire management process of health data from both traditional sources and those digitized, providing quality patient care, encompassing activities ranging from data collection, storage, analysis, interpretation and protection.

Health information technology includes a framework for technical implementation (hardware components, software components, and software systems) of health information management processes and their sharing among various actors in the healthcare system.

Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

Health law is concerned with the health of individuals and populations, the provision of health care and the operation of the health care system.

Health Services is the provision of medical treatment and care to the public or to a particular group.

Healthcare System. It is the organization of people, institutions, and resources that deliver health care services to meet the health needs of target populations.

Hospital information systems. Socio-technical systems consisting of technical and human parts. Their main goal is to optimize information logistics to support healthcare. They can be analysed on three layers.

Integrated Marketing Communications (IMC) present a practice of unifying all tools used in marketing communications, in order to send a consistent and persuasive message that will promote the goals of a particular institution in the healthcare field. All people that are in some way related to the brand have their role in the integrated communication and they all appropriately participate in the production and implementation of the communication strategy of a healthcare institution. Two key areas of IMC are: advertising and public relations.

Internal stakeholders are employees, managers, and other individuals and groups who are active within the healthcare institution and have an interest in it, including the owners. These two types of stakeholders/publics can be separated only in principle, because their roles and positions can be sometimes interpreted in more than one way.

International health law is based rules governing relations between nation-states.

Interoperability is the ability of two or more systems or components to exchange information and to use the information that has been exchanged.

Machine learning is a group of analytical and numerical modelling methods that uses a heterogeneity of strategies to automatically discover and enhance the prediction of a target state/phenomena. There are several types of machine learning algorithms, most commonly classified in three subgroups: supervised learning, unsupervised learning, and reinforcement learning.

Management accounting is implemented within the institution itself and provides information that enables management to monitor and control the business and make business decisions.

Marketing mix is the combination of four elements, called the "4P" (Product, Price, Promotion and Place), that every company has the option of adding, subtracting, or modifying in order to create a desired marketing strategy. Some authors proposed a model of "7P", comprising the original 4 Ps extended by *Process, People* and *Physical evidence*, as being more applicable for services marketing. Since then there have been a number of different proposals for a service marketing mix (with various numbers of Ps), most notably the 8 Ps, comprising the 7 Ps above extended by *Performance.*

Marketing strategy is the way in which the marketing function organizes its activities to achieve a profitable growth in sales at a marketing mix level. A marketing strategy may be defined as a plan (usually long term) to achieve the organisation's objectives. It consists of: identifying markets and customers' needs; planning products which will satisfy the needs of these markets and organising marketing resources, so as to match products with customers in the most efficient and effective way possible, so as to maximise customer satisfaction and the organisations' profits or sales revenue at the same time.

Media are the adequate communication channels that are chosen in order for synergistically organized marketing messages to be able to reach targeted recipients in the most efficient way. In traditional marketing communications, the message is transmitted through various types of mass media, which are mostly non-personal. This means that the classic marketing message realized in this type of media (such as - broadcasting media: television, radio, cinema and video advertising; out-of-home media: billboards, bus shelters, vehicles, transit areas etc.; print media: newspapers, magazines, brochures, flyers, directory advertising and so on) still and most often is not precisely targeted at a specific person. However, the situation in this sense is changing everyday thanks to the use of new digital technologies and numerous alternative and interactive media (internet, video games, wireless communication, guerrilla marketing, etc.).

Medical Documentation is methods and activities of collecting, coding - labelling, ordering, storing, and retrieving information to fulfil specific future tasks in medicine and health care.

Mission Statement is a short statement of why an organization exists, what its overall goal is, identifying the goal of its operations: what kind of product or service it provides, its primary customers, and its geographical region of operation.

Natural language processing (NLP) is a group of AI methods which allow machines to recognise and adopt human languages. NLPs are complex systems and consist of rule-based learning systems, data-driven machine learning algorithms and many interior control elements with predefined information and appropriate outputs.

Organization Ethics is the way an organization should respond to external environment in relation to organization ethics.

Organizational Design. The manner in which a management achieves the right combination of differentiation and integration of the organization's operations, in response to the level of uncertainty in its external environment.

Patient Records contain all data and documents generated or received during the care of a patient at a health care institution.

Patient Similarity is a group of algorithms and methods which are aimed to identify groups of patients sharing similar characteristics.

Phenotyping is the process of creating medical concepts (so-called phenotypes) based on raw data on patients that are from different sources and includes demographic data, data on diagnoses, drugs, medical procedures and treatments, laboratory findings, etc.

Physical data processing components are application components, which are realized on physical data processing components. Examples are servers in a datacentre, workstations on a ward or also paper-archives like folders in a shelf.

Population, in the statistical sense, is a theoretical concept used to describe an entire group of individuals in whom we are interested. Generally, it is costly and labour intensive to study the entire population. Therefore, we collect data on a sample of individuals from the population who we believe are representative of that population, that is, they have similar characteristics to the individuals in population.

Predictive Modelling represents a framework for applying a series of algorithms over historical data to identify a set of predictors and create a suitable multivariate model to predict outcomes, events or behaviours.

Process analysis is a sub-discipline that covers the analysing and modelling activities of process management.

Process chain diagrams. Process model that describes the activities and actors within a process. A process is split into those activities that are needed to reach the goal of the process.

Process is a number of related activities that serve to reach a certain objective.

Process management is a discipline that aims at identifying, analysing, modelling, improving, and automating business processes.

Process model is a simplified, standardized and validated visual representation of the most important elements of a clinical process.

Public health law focuses on the mission of the government to improve population health. It also covers legal issues in public health practice and the public health effects of legal practice.

Regression analysis is a method used for the prediction of the dependent variable (Y) based on one or more independent variable (X_1, X_2,… X_n). In regression we are looking for a dependence of one variable, the dependent variable, on another, the independent variable. In linear regression the dependent variable is continuous whereas in logistic regression it is binary. The relationship is summarized by a regression equation consisting of a slope and an intercept.

Social determinants of health are all the socioeconomic conditions, structures and systems in which each individual in the population exists in. They are responsible for the health outcomes of that individual.

Social responsibility is a type of responsibility that obliges an organization or an individual to act in a way that benefits the society and does not cause harm to the community. Social responsibility includes the values such as transparency, integrity, professionalism, ecological awareness, protecting human rights etc.

Speech recognition is a group of AI methods with fundamental objective to transfer data recorded on tapes or other audio recording devices, into a digitized data form suitable for processing and converting to human speech.

Stakeholders (external and internal) are all the individuals and groups who have a stake in the work and success of some healthcare institution.

Statistics is science about gathering, organization, presentation, analysis and interpretation of data in order to help decision making. As such, statistics analyses different methods and methodologies to collect, review and analyse numerical data and draw conclusions from that data. Statistics is not only a discipline in its own right, but it is also a fundamental tool for investigation in all biological and medical science.

Strategic management is one of the most prominent and relevant areas in the management field. It constitutes a set of management actions that enable company managers to keep it aligned with its environment and on the correct path of development, thereby bringing about the achievement of its objectives and its mission. It is a cross-process of formulation, implementation and evaluation of the decisions that enable organizations to define and achieve their mission and ultimately to create value.

Tasks are fulfilled by organizational units of a hospital. Examples are ‘patient admission’, ‘decision making’ and ‘therapy planning.

Telemedicine is a subtopic of eHealth, which bridges spatial distance by using ICT for medical inter-actions.

Use case diagrams. Process model that gives an overview of the process and its sub-processes (the “use cases”) and the roles (the “actors”) involved in a given process.

Value Statement is a declaration about how the organization wants to value their customers, suppliers and be valued within their own internal community. These value statements explicitly define how people will behave with each other in the organization.

Variance analysis enables management to identify the reasons why real values vary from those planned by the budget.

Vision Statement is a declaration of an organization's objectives, intended to guide its internal decision-making.

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Subject Index

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Author Index

The effective and efficient management of healthcare institutions is key to the successful development of national health systems. In an increasingly digital society, the skills involved in health information management become a primary factor in ensuring this development. Employment is projected to grow in all areas of healthcare, but especially in those related to information management, such as applied informatics, public health informatics and medical informatics.

This book, *Health Information Management: Empowering Public Health*, aims to provide a clear and comprehensive introduction to the study and development of health information management. It is designed for use by university and vocational courses to train allied health professionals. It can also be used as an in-service training tool for new healthcare-facility personnel, for those working in government healthcare institutions, independent billing and health assurance services, or individually by health information specialists. The book describes health information management, and explains how it merges the fields of health care and information technology. Readers will learn logical thinking and communication, and will be introduced to the organizational processes in healthcare institutions, as well as finding out how to organize and analyze health care data; accurately record, store and assess health data; use an electronic patient record system; and provide statistical analysis and interpret the results.

The book will be of interest to all those wishing to gain a better insight into what is involved health information management, and to all those studying the subject.

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