Health Information Systems 4

4.1 Introduction

An information system was previously defined as the socio-technical subsystem of an institution, which comprises all information processing as well as the associated human or technical actors in their respective information processing roles. Health information systems (HIS) are dealing with processing data, information, and knowledge in health care environments. Especially with regard to chronic diseases, it becomes more and more important to organize health care in a patient-centric way, such that all participating in- or outpatient care institutions cooperate very closely. This is also denoted as integrated care. In integrated care it is necessary to provide relevant information not only within a single institution, but wherever and whenever it is needed. This includes medical practices, rehabilitation centers, nursing centers, and even the home of the patient. We therefore differentiate institutional and transinstitutional health information systems. In the following, we will introduce hospital information systems, which are the most complex instances of institutional information systems, and transinstitutional information systems. Throughout the book we will use the term health information system and the abbreviation HIS if we discuss aspects concerning both hospital information systems and transinstitutional information systems. If we deal with properties being unique for one of these, we will use the terms hospital information system and transinstitutional information system, respectively. After reading this chapter, you should be able to answer the following questions:

- What are hospital information systems?
- What are transinstitutional health information systems?
- What are the challenges for health information systems?
- What are electronic health records?

4.2 Hospital Information Systems

With the definition of information systems in mind, a hospital information system can be easily defined. A hospital information system is the socio-technical subsystem of a hospital, which comprises all information processing as well as the associated human or technical

A. Winter et al., *Health Information Systems*,
DOI: 10.1007/978-1-84996-441-8_4, © Springer-Verlag London Limited 2011

actors in their respective information processing roles. Typical components of hospital information systems are enterprise functions, business processes, application components, and physical data processing systems (see Sect. 3.3.3). For the sake of simplicity, we will refer to enterprise functions of a hospital as hospital functions.

As a consequence of this definition, a hospital has a hospital information system from the beginning of its existence. Therefore, the question is not whether a hospital should be equipped with a hospital information system, but rather how its performance can be enhanced, for example, by using state-of-the-art information processing tools, or by systematically managing it.

All groups of people and all areas of a hospital must be considered when looking at information processing. The sensible integration of the different information processing tools in a hospital information system is important.

Hospital staff can be seen as part of the hospital information system. For example, when working in the department of patient records or as an operator in a department for information and communication technology, staff members directly contribute to information processing. However, in their role as user of the hospital information system, they use information processing tools (e.g., a nurse may use a telephone or a computer). Each employee may continuously switch between these two roles.

The goal of a hospital information system is to sufficiently enable the adequate execution of hospital functions for *patient care*, including *patient administration*, taking into account economic *hospital management* as well as legal and other requirements. Legal requirements concern, for example, data protection or reimbursement aspects. Other requirements can be, for example, the decision of a hospital executive board on how to store patient records.

To support *patient care* and the associated administration, the tasks of hospital information systems are:

- To make information, primarily about patients, available: current information should be provided on time, at the right location, to authorized staff, in an appropriate and usable form. For this purpose, data must be correctly collected, stored, processed, and systematically documented to ensure that correct, pertinent, and up-to-date patient information can be supplied, for instance, to the physician or a nurse (Fig. 4.1).
- To make knowledge, for example, about diseases, side effects, and interactions of medications available to support diagnostics and therapy.
- To make information about the quality of *patient care* and the performance and cost situation within the hospital available.

In addition to *patient care*, university medical centers undertake research and education to gain medical knowledge and to teach students.

When hospital information systems make available

- the right information and knowledge
- at the right time
- at the right place
- to the right people
- in the right form,

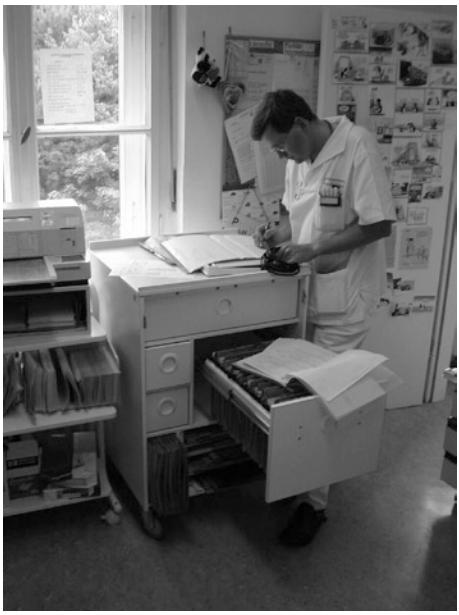

Fig. 4.1 A health care professional accessing patient information

so that these people can make the right decisions, this is also described as information and knowledge logistics.

Hospital information systems have to consider various areas of a hospital, such as

- wards,
- outpatient units,
- service units: diagnostic (e.g., laboratory department, radiology department), therapeutic (e.g., operation room), and others (e.g., pharmacy, patient records archive, library, blood bank),
- hospital administration areas (e.g., patient administration department, patient record archive, department of quality management, financial and controlling department, department of facility management, information management department, general administration department, human resources department),
- offices and writing services for (clinical) report writing.

In addition, there are the management areas, such as *hospital management*, management of clinical and non-clinical departments, administration management, and nursing management.

These areas are related to *patient care*. They could be broken down further. For university medical centers, additional areas, needed for research and education, must be added to the above list.

Obviously, the most important people in a hospital are the

- patients and, in certain respects, their
- visitors.

The most important groups of people working in a hospital are
- physicians,
- nurses,
- administrative staff,
- technical staff and
- medical informaticians and other health information management staff.

Within each group of people, different needs and demands on the hospital information system may exist, depending on the role, tasks, and responsibilities. Ward physicians, for example, require information that is different from that required by physicians working in service units or by senior physicians. Patients sometimes need similar information as physicians but in a different form.

4.3 Transinstitutional Health Information Systems

In many countries, the driving force for health care and for ICT in health care has recently been the trend toward a better coordination of care, combined with rising cost pressure. One consequence is the shift toward better integrated and shared care. This means that the focus changes from isolated procedures in one health care institution (e.g., one hospital or one general practice) to the patient-oriented care process, encompassing diagnosis and therapy, spreading over institutional boundaries (Fig. 4.2).

A group of two or more legally separated health care institutions that have temporarily and voluntarily joined together to achieve a common purpose are defined as a health care network. The information system of a health care network is called a transinstitutional health information system. Typical examples are regional health information systems, comprising the health care environment in a certain region, including, for example, hospitals, offices of general practitioners, pharmacies, rehabilitation centers, home care organizations, and even health insurances and governmental authorities.

In the United States, for example, health care institutions are merging into large integrated health care delivery systems. These are systems of health care institutions that join together to consolidate their roles, resources, and operations to deliver a coordinated range of services and to enhance effectiveness and efficiency of patient care. The situation in Europe is also changing from hospitals as centers of care delivery to decentralized networks of health care delivery institutions that are called regional networks or health care networks. Enterprise boundaries are blurring. Hospital information systems will increasingly be linked with information systems of other health care institutions.

For example, the Hannover Medical School, a large hospital with 75 departments and more than 1,400 patient beds, provides a web portal for its partners, where patient data can be shared and mutually updated by all institutions participating in patient care. Among others, a rehabilitation clinic in Fallingbostel, 50 km north of Hannover, has

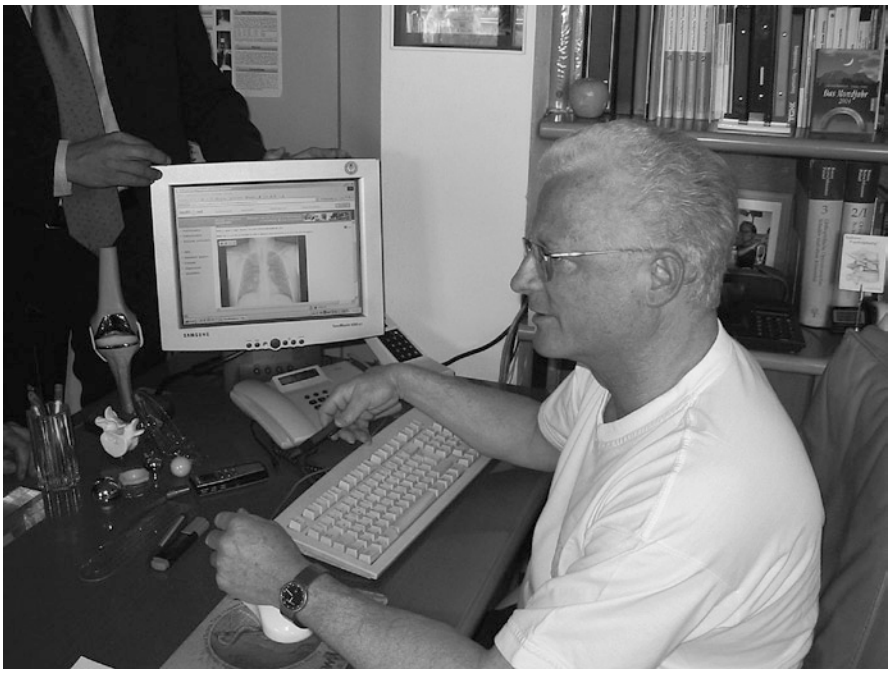

Fig. 4.2 A general practitioner accessing documents of a hospital information system

access to the data of transplant patients, who need time to recover after their operation has taken place, without the need for expensive intensive care treatment. By electronically linking both facilities, the most cost-effective treatment process and optimal time of transfer to the rehabilitation facility can be chosen without loss of quality due to information lags.

The architecture of hospital information systems must take these developments into account. They must be able to provide access or to exchange patient-related and general data (e.g., about the services offered in the hospital) across its institutional boundaries.

A lot of technical and legal issues have to be solved before computer-based transinstitutional health information systems will adequately support transinstitutional patient care. For example, a general willingness to cooperate with other health care providers must exist; optimal care processes must be defined, and recent business processes be redesigned; accounting and financing issues must be regulated; questions of data security and data confidentiality must be answered, together with questions on data ownership (patient or institution) and on responsibilities for distributed patient care; issues on long-term patient records (centralized or decentralized) must be discussed; and technical means for integrated, transinstitutional information processing must be offered (telemedicine, eHealth), including general communication standards.

4.4 Electronic Health Records as a Part of Health Information Systems

The most important enterprise functions in health care are related to diagnostics and therapy. Obviously, data that are relevant to medical decision making need to be collected and presented in a patient record.

A patient record in general is composed of all data and documents generated or received during the care of a patient at a health care institution. Nowadays, many documents in the paper-based patient record are computer printouts, such as laboratory results, or discharge summaries typed into a text processing system. The portion of documents created in computer-based form will further increase. Thus, it seems natural to strive for a patient record that is partly or completely stored on electronic document carriers: the electronic health record (EHR).

The electronic health record (EHR) is the collection of medical data relating to one subject of care, i.e., the patient, that is stored in the computer-based part of a health information system. "The EHR for a subject of care might be scattered physically across multiple (discrete or interconnected) clinical systems and repositories, each of which will hold and manage a partial EHR for each of its data subjects, scoped according to the service or community settings, clinical domains and time periods of use of that system in the life of each person."[1]

Primarily, EHRs are used to support patient care by providing relevant information about a patient whenever and wherever it is needed. Furthermore, they are needed for administrative functions, such as billing and quality management.

In the past, EHR used to be provider-centric, i.e., they only contained patient information that was recorded in one institution, for example, in a hospital or in a physician's office. Those EHR are usually called electronic patient records (EPR). Hence, potentially relevant information about the medical history of a patient that was recorded in other institutions was missing or had to be recorded again. This led to quality and efficiency problems.

Although this situation can still be found in many institutions, efforts are being made today to organize EHRs patient-centric, i.e. independent of institutional boundaries. To achieve the vision of a complete and lifetime-spanning EHR which supports health care on the one hand, but respects legal and ethical issues on the other hand, different strategies can be found. These are described in Sect. 7.3.2.

4.5 Challenges for Health Information Systems

In spite of the positive general development of health information systems, challenges can be identified that have to be resolved. Evolutionary grown information systems (remember that hospitals have an information system from the beginning of their existence) consist of a variety of components and tend to be very heterogeneous. As a consequence, major challenges exist. In anticipation of concepts that are introduced later in this book, we want to sensibilize you for the following challenges:

[1] Standard ISO/Draft International Standard 18308

- **The challenge of user acceptance**. Health care professionals or hospital managers as users of heterogeneous health information systems may have the need to overview a broad variety of data. They will have difficulties or will at least have the problem of having to use a set of application components, often with different user interfaces, overlapping features, and separate user identification procedures. This is time-consuming and potentially dangerous for the patient, as important data may not be available when needed, leading to wrong diagnostic or therapeutic decisions.
- **The challenge of data redundancy**. As different health care professionals often need the same data (see Sect. 2.3), heterogeneous information systems typically lead to data duplication: Relevant data may be documented several times at different sites and or by different providers. This double-documentation is time-consuming for staff and patients and error-prone, as documented data may be inconsistent or incomplete. In addition, uncontrolled redundancy causes considerable additional maintenance costs for updating duplicated data in (redundant) databases.
- **The challenge of transcription**. In heterogeneous architectures there is a considerable amount of transcription, i.e., the transfer of data from one storage device to another (e.g., the transfer of a patient's diagnoses from the patient record to an order entry form). Media cracks, i.e. the change of the storage media during the transcription of data, are often the cause of errors. Both may decrease the quality of data and both do increase costs as well as the health care professional's time needed for recording and accessing patient data.
- **The challenge of maintaining referential integrity**. For redundant data, either as replicates or even as duplicates, it is difficult to obtain and later maintain referential integrity, i.e., the correct assignment of entities, for example the assignment of data to a certain patient (see Sect. 6.5.2.2).
- **The challenge of costs**. Too high, in particular uncontrolled redundancy causes considerable additional maintenance costs for updating replicate data in (redundant) databases.
- **The challenge of privacy and security.** Patients' health data belong to the most sensitive data about humans. For this reason, individual patient data must only be accessible to those persons previously authorized by the patient. A health information system must guarantee this claim which is called privacy of patient data. Likewise, the information system has to ensure data security which comprises availability, confidentiality and integrity of patient data.

In transinstitutional health information systems, the problem of heterogeneity can be estimated even higher. Since these systems involve many originally autonomous information systems, some additional challenges can be identified:

- **The challenge of terminology**. Having data stored in different databases (and without a unique and comprehensive data model or data dictionary) at different sites, there is no immediate need for a unified terminology and semantics. When starting to communicate between these applications systems, this can, however, cause severe problems, and an agreement on terminology for communicating information on diagnoses and procedures is needed.

- **The challenge of stability**. Down times of one or more computer-based application systems with the consequence of significantly restricting care processes may be seldom, but they exist. The same holds for problems in accessing the non-computer-based record. But in a transinstitutional or even regional context, risk of instability is comparatively high.
- **The challenge of transinstitutional information management**. Nowadays, in many hospitals, the *operational, tactical*, and *strategic information management* is organized professionally (see Sect. 9.3). Dedicated, specialized staff is taking care of the information system. For information processing and storing within health care networks, there is often no specific person or group being responsible and having authority to decide and act.

4.6 Example

4.6.1 Architecture of a Hospital Information System

Here is an extract of the description of the architecture of the hospital information system of the Plötzberg Medical Center and Medical School (PMC). As mentioned, PMC is a fictitious institution, which will be used in examples and exercises in this book.

The hospital information system of PMC enables the hospital functions of *patient care* with *patient admission*, *decision making and patient information*, *medical and nursing care planning order entry*, *execution of diagnostic, therapeutic, and nursing procedures*, *coding of diagnoses and procedures*, *patient discharge and transfer to other institutions*. In addition, *supply and disposal management, scheduling and resource allocation*, *hospital administration,* and *hospital management* are supported.

Those hospital functions are supported by some bigger and over a hundred smaller application components (partly computer based, partly non-computer based). The most important application component is the patient administration system, the computer-based application component that supports *patient admission* and *patient discharge and transfer to other institutions*. In addition, several computer-based departmental application components are used for work organization and resource planning (e.g., in the radiology department, in the laboratory department, and in outpatient units). Nearly all computer-based application components are interconnected, using a communication server. Some computer-based application components are isolated systems without interfaces.

Non-computer-based application components are used for special documentation purposes (e.g., documentation in operation rooms), and for *order entry*.

The application components are installed on physical data processing systems. As computer-based physical data processing systems, approximately 40 application and database servers are operated, and over 4,000 personal computers are used. Over 1,000 printers of different types are installed. Most computer-based physical data processing systems are interconnected by a high-speed communication network.

As non-computer-based physical data processing systems, over 2,000 telephones and 800 pagers are used. About 1,500 different types of paper-based forms are used to support different tasks. More than 400,000 patient records are created and used each year, and a dozen local archives are responsible for patient record *archiving*. A paper-based mailing system allows for non-computer-based communication between departments.

4.7 Exercises

4.7.1 Hospital Information System as a System

As introduced, a system can be defined as a set of people, things, and/or events together with their relationships that forms an integrated whole. Which people, things, or events can you find when looking at a hospital information system? In what relationship do they stand to one another? To solve this exercise, take into account the components of hospital information systems as defined in Sect. 3.3.3.

4.7.2 Buying a Hospital Information System

Look at the definition of hospital information systems in Sect. 4.2. Based on this definition, is it possible to buy a hospital information system? Explain your answer. What do vendors of hospital information systems thus really sell?

4.7.3 Transinstitutional Health Information Systems

Patient-centered (not just institution-centered) care is obviously playing a major role. Mention the challenges, which transinstitutional health information systems are facing. Try to argue from your point of view, why these challenges are greater than the same ones within one hospital.

4.8 Summary

Information systems that are dealing with processing data, information, and knowledge in health care environments are called health information systems.

Health information system can be differentiated as institutional health information system, for example, hospital information systems, and transinstitutional health information systems that span the borders of two or more legally separated institutions. Transinstitutional health information systems play a vital role in supporting integrated care.

Important challenges of health information systems are:

- the challenge of user acceptance,
- the challenge of data redundancy,
- the challenge of transcription,
- the challenge of maintaining referential integrity,
- the challenge of costs,
- the challenge of privacy and security.

In transinstitutional health information systems, some additional challenges can be identified:

- the challenge of terminology,
- the challenge of stability,
- the challenge of transinstitutional information management.

The electronic health record (EHR) is the collection of medical data relating to one *patient* that is stored in the computer-based part of a health information system. EHRs are needed to support functions of *patient care* as well as for administrative functions.