Unit 4 - Medical Information Systems

1.1 Objective of medical information systems

Medical information systems support processes in the healthcare sector with specific software modules that support the requirements for process implementation. The systems are composed of various logical modules that can differ depending on the type of system; Please check Figure 1.

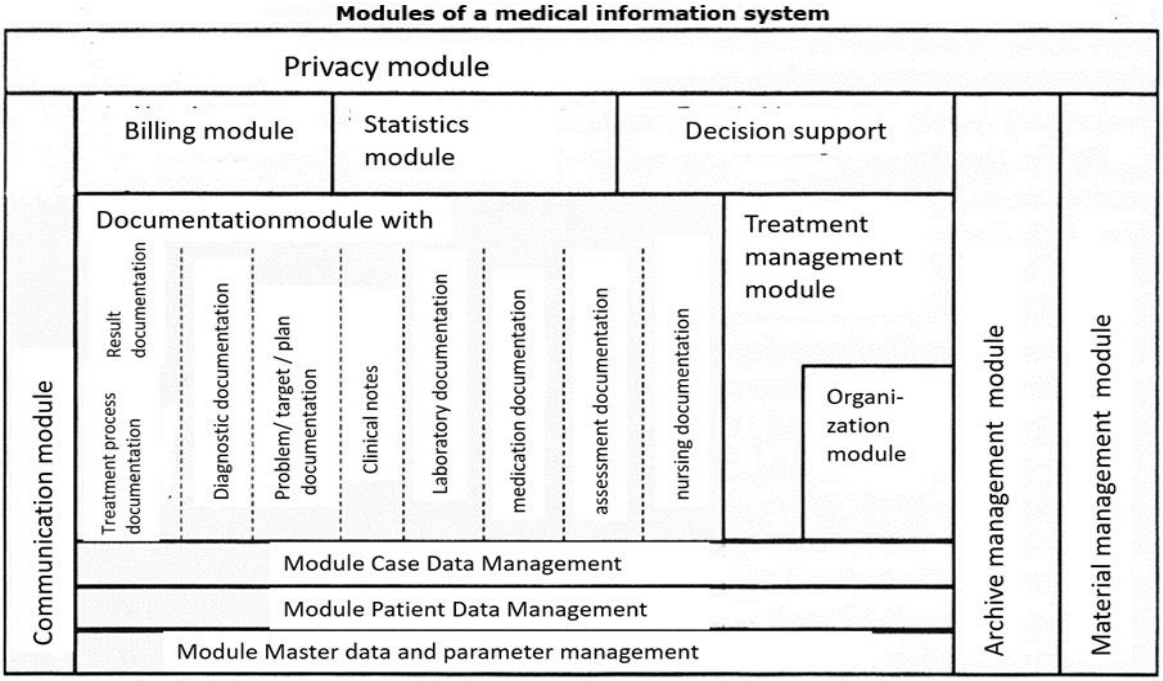

Figure 1: Modules of a medical information system[1]

The functional competence of medical information systems can be described on the basis of five different support dimensions, which are different depending on the type of information system:

Documentation support

Medical documentation is a mandatory obligation of the physician towards the patient. Failure of a practitioner to comply with the documentation requirement results in a reversal of the burden of proof. In other words, in the event of a dispute, it is not the patient who must prove that a treatment was deficient, but rather the practitioner who must prove that it was not. Therefore, ensuring medical documentation is in the physician's own best interest.

Medical information systems support the documentation and improve it through increased completeness (mandatory fields) and improved readability

[1] Source: H.AAS, 2005

(Handwriting vs. IT), by supporting storage and archiving and improved evaluation and research. It is also possible to add multimedia data such as images, videos or sound documents to the digital documentation.

Documentation are modular components of practice management software (PVS) and hospital information systems (HIS). However, some of these systems also contain specialized documentation modules for the OR, anesthesia or nursing areas. Software systems specialized in documentation are used, for example, in tumor registers or health authorities.

Communication Support

Medical information systems (IS) support communication within medical facilities, for example between functional units, such as operating rooms or radiology departments, and medical departments. They enable the exchange of all types of digitized documents. Communication partners can be individuals or information systems. The prerequisite for communication is integration into local and national networks. Outside of medical institutions, such systems communicate with external bodies, such as hospitals, physician offices or pharmacies, health insurance companies or associations of statutory health insurance physicians in the outpatient sector. Examples of internal communication are the transmission of laboratory results from the laboratory information system to the medical documentation module of the HIS.

Processing Support

The requirements for the evaluation of medical documentation, for example in hospitals, require an information system. Some examples of the usefulness of medical IS include:

- Reports to tumor registries
- Quality assurance in outpatient and inpatient surgery
- Mandatory statistics that must be transmitted to external bodies on a quarterly basis
- the semi-automated creation of physician letters and reports

They support data processing in a variety of ways.

Organizational support

Medical IS can support the organization within medical institutions. This concerns, for example, the management of schedules in functional units (operating room, radiology department, endoscopy department, etc.) and the booking of the corresponding resources, including staff. Work lists and the surgical plan are examples where the coordination process can be significantly simplified. The provision of clinical procedure trajectories with automated reminder and booking functions can also enhance the efficiency of treatment processes.

Decision support

Knowledge-based systems generate diagnosis and therapy proposals through the interaction of medical knowledge (e.g. from treatment guidelines) and patient data. Medical IS can also provide case-specific medical knowledge automatically or on demand at the point of care, in other words at the patient.

1.2 Primary systems

Hospital information systems (HIS)

Hospital information systems (HIS) are multifunctional and, depending on the level of expansion, can also support most of the administrative processes in clinic operations. In addition to the modules for the medical field, they also contain administrative modules.

Administrative modules are:

- Bookkeeping
- Accounting (creation and dispatch of invoices)
- Management of Materials and Equipment
- Management of Archives
- Statistics
- Human Resources

Treatment-related modules are:

- Documentation module
    - Treatment process documentation (including operating theater, anesthesia and functional units documentation)
    - Documentation of results (medical examination results)
    - Diagnostic documentation
    - Documentation of medical condition, objective and treatment plan
    - Clinical Notes
    - Documentation of laboratory results (received from LIS)
    - Medication documentation
    - Assessment documentation (review of therapy success)
    - Care documentation
- Decision support module
- Treatment management module
- Organization module
- Billing module (to determine the case rate)
- Case data management
- Patient data management

Not treatment-related modules are

- Master data and parameter management
- Communication module and
- Data protection module.

The individual modules can be part of a uniform, non-separable overall system or they can be provided and integrated from systems from different providers.

Practice management systems (PMS)

Practice management systems (PMS) support the processes in the practice of the general practitioner or specialist. The system is similar modular structure, but does not have all the modules of a HIS. Many modules are also only available in a less distinct form. The documentation module, for example, is often limited to the digitized version of the previously common index card.

Depending on the focus of the practice, special modules (e.g. endoscopy documentation, PACS) can also be connected if the provider provides them or supports the connection of third-party products. PVS are offered in specialized versions, for example for general practitioners, specialists, dentists and psychotherapists.

Picture Archiving and Communication Systems (PACS)

RIS and PACS are often confused with one another. PACS - Picture Archiving and Communication Systems are used to store radiological and other image data (archiving) and make them available for external systems (communication). They are used in medical facilities in which large numbers of image data are created. Typically, these are radiology clinics and radiological departments in hospitals. PACS servers communicate with imaging devices through local or inter-facility networks based on the DICOM protocol (Digital Imaging and Communications in Medicine). Communication of image data with third-party systems, e.g. HIS or PVS, also takes place via this protocol. When non-radiological devices, such as ultrasound equipment or endoscopy devices, support DICOM as well, the storage of these image data is also available in DICOM format.

RIS - Radiology Information Systems - do not serve to store image data, but do communicate with the PACS in order to provide them with patient information, which is then stored in the DICOM container.

RIS are responsible for the organization and documentation in radiological departments and perform the following functions:

- Administration of patient master data
- Scheduling of radiological examinations
- Provision of a DICOM interface to digital imaging devices (such as CT, magnetic resonance imaging), which can be used to transmit patient data (= DICOM worklist).
- Image retrieval control in the PACS; the examination to be diagnosed is selected in the RIS and the image data from the PACS is loaded simultaneously via an interface.
- Documentation of medical data in compliance with the requirements of the German X-ray Ordinance
- Documentation of billing-relevant services
- Preparation of radiological reports

[2] for explanation: DICOM defines both the storage and the communication of image data in medicine

Patient data management systems (PDMS)

PDMS are patient data management systems and are usually an integral part of both the HIS and the PMS. Responsibilities consist of managing and processing patient data in processes such as admissions, transfers, and discharges, as well as generating patient identification labels for both forms and specimens. PDMS communicate with most patient-related modules of a HIS and other special systems such as RIS or LIS.

Especially in view of the increasing digitalization of the health system, PDMS are becoming more and more important.

PDMS support medical and nursing staff by digitally documenting large amounts of patient data, for example as part of intensive medical care. In addition, not only patient data, but also equipment data can be recorded.

The main advantages of PDMS are:

- High quality of documentation
- Prevention of documentation errors due to incorrect manual data entry
- Transparency
- Easing the workload of documentation requirements

Laboratory Information Systems (LIS)

LIS (laboratory information systems) are used in analytical laboratories by specialists in laboratory medicine and in hospitals. They control the workflow from the reception of the order to the transmission of the diagnostic results to the client. LIS control automated analyzers and support quality assurance on their behalf. LIS document analyses and assign patient data to these analyses, which they receive from the HIS or PVS. Special modules, such as a blood bank, can be part of the LIS. LIS communicate in hospitals with the HIS via the HL7 or LDT interface.

[3] Source: Wikipedia.de
[4] http://www.e-health-com.eu/fileadmin/user_upload/daten/Branchenfuehrer_Healthcare_IT/BF_2014_PDMS.pdf

1.3 Electronic file and information systems

Electronic health record (EHR)

The electronic health record is[5] a digital collection of a patient's medical data (medical history, treatment data, medication, allergies, etc.) that can be stored for the patient's entire life, regardless of time and place (across sectors and cases, uniformly throughout the country), which enables the data to be retrieved centrally. Contrary to the ePR, it is also possible to integrate non-medical information (wellness information, diets, physiotherapeutic advice, etc.), whereby the patient alone decides what is stored and what is not. An Internet-based client application can be used to grant or deny access to the information to physicians or institutions such as hospitals in agreement with a complex security concept.

Electronic patient record (EPR)

An electronic patient file contains "data on findings, diagnoses, therapeutic measures, treatment reports and vaccinations for documentation about the patient across all cases and institutions" (Section 291a, Paragraph 3, Clause 1, No. 4 SGB V / GMG).

In principle, the electronic patient record (EPR) is intended to help improve future medical treatment. In a database (whether managed centrally or decentralized):

- Medical History,
- Treatment data,
- Medication,
- Allergies
- Other health data (surgeries, progression of illnesses,

etc.) can be saved across sectors and cases.

[5] The English version is the "electronic health record" (EHR).
[6] In principle, the electronic health card should be used to access the electronic health card, ie the electronic health card becomes the access key for the electronic health card.
[7] Some people are hypersensitive to certain ingredients in the drug. After the I.NSTITUT FOR M.EDICAL D.IAGNOSTICS B.ERLIN-POTSDAM show "8% of outpatients treated and 20% of hospitalized patients [...] have adverse drug reactions. In 80% of the cases, it is not about allergies but about undesirable "side" effects of the active substance. Nevertheless, the proportion of real drug allergies is still considerable at 20% "Source:http: //www.imd- berlin.de/fileadmin/user_upload/Diag_Info/ 108_Medikamentenunvertraeglichkeit.pdf.
[8] An EPR can help in the run-up to a (planned) operation by providing extensive information about previous medical Procedures are available. "Especially the fact that patients often do not or only very imprecisely

This way, incompatibilities with regard to medications/ingredients can be prevented as effectively as possible, planned operations can be better scheduled with information regarding possible (pre-existing) medical conditions, or important information can be stored for subsequent (differential) diagnoses.

The aim is to ensure that physicians (including dentists), pharmacists and nursing staff can retrieve important data without any great loss of time and thus (quickly) treat the patient according to his needs. Simultaneously, however, the patient should be able to decide whether data are stored in the ePR at all, and if so, which data. Because of the voluntary nature of the provision of electronic data, it is difficult to establish a specific storage location. Therefore, both centralized and decentralized implementation variants are discussed.

This graphic depicts how electronic health records (EHRs) have impacted physician practices across the U.S. in 2018. It showed that 28.6 percent of physicians surveyed, reported that EHRs have increased/improved the quality care in their practices.

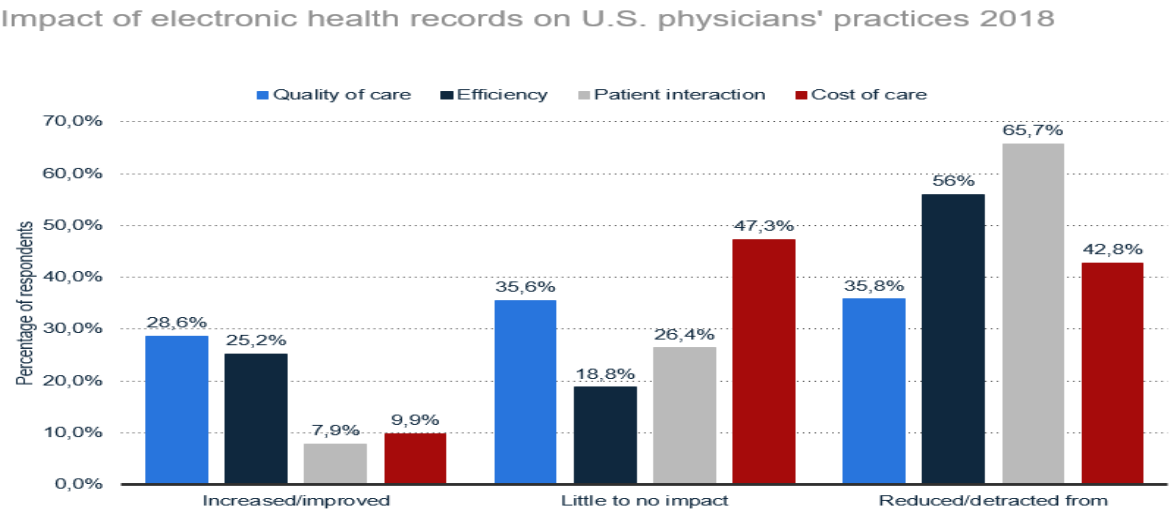

Figure 2: How electronic information health records (HER) have affected physicians' practices[12]

Being able to provide information about pre-treatments and their previous history often makes it difficult to act adequately in a timely manner "(ZTG-AK EPA / EFA, p. 10)

[9] ZTG-AK EPA / EFA, p. 9

[10] Restriction: as the data is under patient sovereignty, it is possible that the data in the EPR does not show a complete image of the medical documentation; see B.EYER ET AL., 2013, p. 133

[11] see B.ALES ET AL., 2007

[12] Source: https://www.statista.com/statistics/614068/us-physicans-electronic-health-record-practice-impact/, accessed on March 12, 2021

1.4 Medical data formats / terminology

The use of modern information and communication technologies (ICT) has improved the quality of medical care. In addition, significant economic benefits have been achieved.

Demographic change in society and the associated mounting pressure on the cost of healthcare are having an impact on ICT. At the same time, the use of ICT in healthcare also opens up opportunities for people in developing countries. Overall, it can be said that progress in ICT has changed medicine, the healthcare system and society itself.

In order to ensure better comparability of treatments and to facilitate statistics in the healthcare sector, various encoding systems and system classifications have been introduced over the last few years. The primary goal here is to make appropriate medical documentation available to authorized persons. According to LEINER ET AL . the medical documentation must be:

- Complete
- Time sensitive
- in the right place
- in the necessary format

Various challenges have to be mastered here, such as the creation and implementation of data formats in international standards that can nevertheless take national differences into account. Consequently, the most important data formats are explained in the following.

[13] I.NTERNATIONAL M.EDICAL I.NFORMATICS A.SSOCIATION; B.ATES ET AL., 2001
[14] KUNTALP, 2004
[15] BALLES, 2001; KULIKOWSKI, 2002
[16] see H.AUX, 2002; HAUX ET AL., 2002; OADVISER, O.J .; L.ONE ET AL., 2003
[17] LONE ET AL., 2003

This diagram shows the most important communication and documentation standards in healthcare.

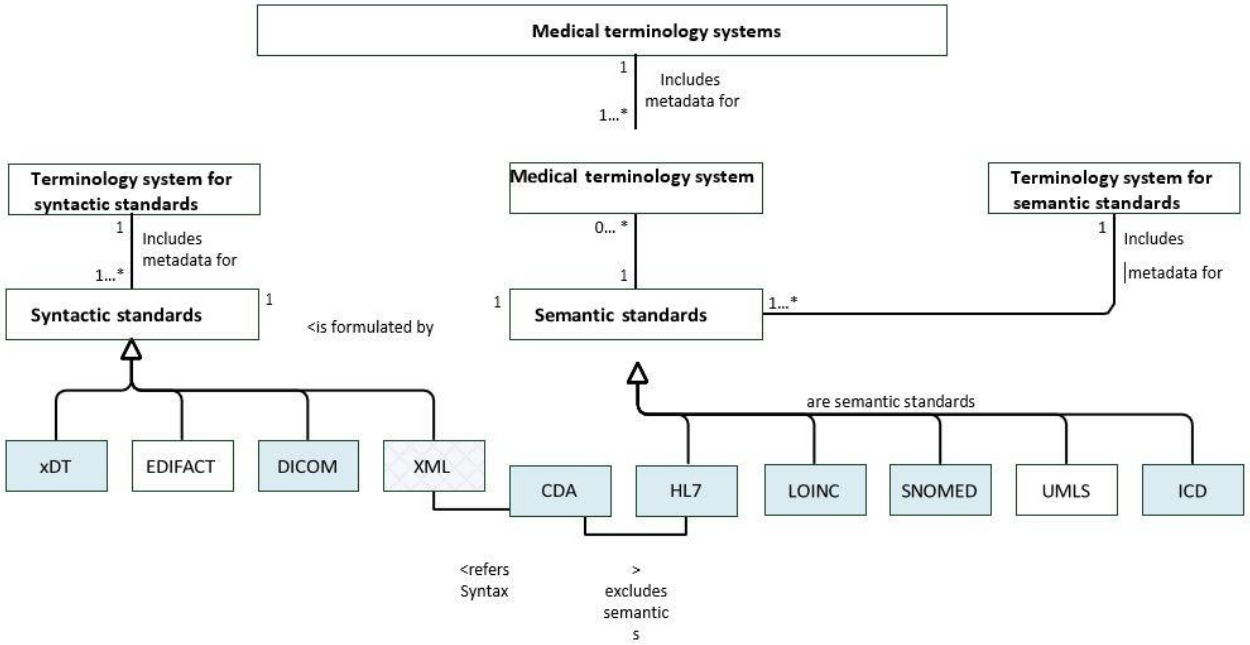

Figure 3: Communication and documentation standards in healthcare[18]

Clinical Document Architecture (CDA)

The Clinical Document Architecture (CDA) is an XML-based standard for the electronic creation, storage and exchange of clinically relevant content that has been continuously developed and further developed by the HL7 Group. XML has a number of properties (eg structured syntax) that predestine it for use for these purposes.

In principle, the CDA is an internationally applicable architecture plan. This plan describes the structural design, content and semantics of documents, as well as their electronic interchange. The German adaptation has become known under the name SCIPHOX. CDA is an ISO standard (ISO 10781) .[19]

The forerunners CDA Release 1 (November 2000) and CDA Release 2 (May 2005) are the first official standards in healthcare based on XML.

[18] Source: modified from PUNYAEV ET AL., 2014, p. 225

Clinical / medical documents

The purpose of clinical or medical documents (e.g., doctor's letter, report of findings) is to be able to reuse them in an automated and flexible manner and to exchange them electronically between different institutions of the healthcare system in the sense of cooperative patient care. In contrast to a patient file, however, the documents are not consolidated. According to PROCHAZKOVA, a clinical document has the following six characteristics: [20]

- durability**:** it should remain in an unchanged state for a certain period of time, the time segment being defined by the local requirements.
- maintenance: it is maintained by an organization entrusted with its care.
- Possibility of authentication: it is an accumulation of information that needs to be authenticated.
- context: it creates a standardized context for its content. This means that the parts are interrelated, and the document is considered as a single entity. completeness: the authentication is only applied to the entire document and not to its individual parts.
- Readability: it is easy to read for a human.

The CDA specification is very expressive and flexible. For the constraints[26] of a generic CDA specification, templates[27] can be used at the following levels:

- *Document level:* the structure of the entire document is specified.
- *Section level*: the structure of parts of a document is specified.
- *Entry level*: the structure of a specific record is defined

[19] http://www.hl7.de/ (de) or http://www.hl7.org/ (en)
[20] XML = Extensible Markup Language. XML structures data in a hierarchical form and is platform-independent. Please referhttp://www.w3.org/XML/(en) or http://www.w3.org/XML/1999/XML-in-10-points; http://de.selfhtml.org/xml/ (de)
[21] In the context of computer science, the term> system architecture <is also used for this, cf. http://de.wikipedia.org/wiki/Softwarearchitektur
[22] SCIPHOX = Standardized Communication of Information Systems in Physician Offices and Hospitals using XML; see also Noelle & Heitmann, 2001
[23]. http://wiki.hl7.de/index.php/Clinical_Document_Architecture_%28CDA%29
[24] see OADVISER, no year
[25] PROCHAZKOVA, 2006, p. 29

CDA structure

Fundamental rules apply to the structure and content of a CDA document, which can be classified into three different levels[28]:

- *Classes* - Data structures that describe objects and their relationships. Objects have a "lifecycle", so they can change over time. The properties of a class are determined by the values of its attributes. Objects represent:
    - Actions (Act) - all medical documentation is connected to "activity"
    - Entities that are related to an activity (Entity)
    - the roles in which the entities appear or are used in the context of the activity
    - the participation of the entity (in its respective role) in an activity
- *Data types* - Data structures for the values of attributes. Data types represent the value of an attribute. Such a representation can in turn be structured in itself, that is, it can have further attributes. An attribute can change and assume a different value - but the value itself has no "lifecycle" or changeable status.
- *Vocabulary and identifiers* - Certain rules are defined for values that occur in coded form. The concepts represented by codes can in turn have complex relationships with other concepts (these relationships then lie outside the formal model described here).

CDA composition

The focus is always on communication between people (person-to-person interoperability), this means documentation is always in text format. In addition, readable text can be supplemented with information blocks that can also be used by computer applications (application interoperability). In principle, a CDA document always consists of two parts:

- *CDA header* with information about the document and the documented event as well as information about the patient and the healthcare professionals involved, etc.
- *CDA body* with actual clinical content such as clinical questions, observations, diagnoses, medication, therapies, information on follow-up visits, proposed appointments etc.

[26] German: "restriction"; to be understood as a "condition" in the sense of a computer language
[27] German "templates"; In the sense of a computer language, parts of the source code (= generic template) can be specified.
[28] http://wiki.hl7.de/index.php/CDA_und_HL7_V3

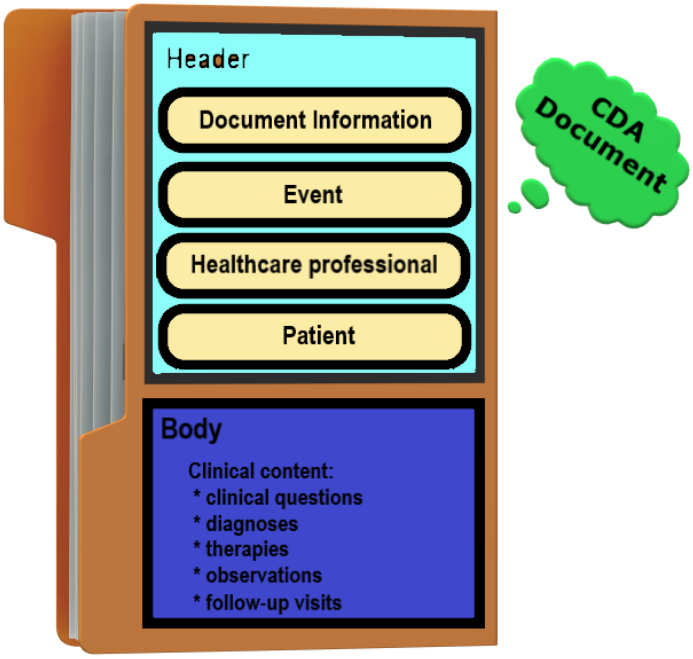

Figure 4: Schematic composition of the CDA document[29]

The documentation can be divided into sections. Text formatting functions such as lists and tables are available.

The specification distinguishes between three levels that build on one another and differ in the degree of structuring of the document content:

- *CDA level 1*: Representation of existing clinical documents in XML, focus on layout and basic formatting of free text (sections, highlighting, tables). Only allows limited interoperability because the content is not machine-readable. This means that documents can be properly displayed by different systems, but they cannot be processed further by machine. The individual laboratory results contained in a CDA Level 1 document, for example, cannot be automatically entered into a central laboratory report table.

  CDA level 2: In addition to level 1, value is placed on interoperability, whereby the free text content of level 1 is retained. Level 2 adds a uniform, structured description and structure of the content (type of document, sections, subsections). The individual components are classified by means of standardized codes and code systems (SNOMED - cf. Subitem 0, LOINC - cf. Subitem 0).

[29] Source: NOELLE & HEITMANN, 2001, p. 4

- *CDA level 3*: In addition, machine-readable information is added in order to automatically enter transmitted laboratory results into the laboratory value table of the recipient, as an example. The structures used in the process are based on the HL7 RIM, which means that they use the same data types and structures as other HL7-based communication processes, such as for the transmission of laboratory results.

For all three levels, however, the primacy of the information contained as free text (narrative block) applies; the machine-readable data and structures only ever serve as supplements and may facilitate and support the processing of the information.

International Classification of Diseases (ICD)

Under current German guidelines, medical care measures must be designated in accordance with a specified classification. The WHO develops national and international classifications together with the respective countries.

Two of these encoding systems are explained in the following subsections.

ICD

The acronym> ICD <stands for International Statistical Classification of Diseases and Related Health Problems. This is the internationally recognized and world's most important diagnostic classification of diseases. The ICD is published by the World Health Organization (WHO) and is used to encode diagnostic data for research into morbidity and mortality rates according to an internationally uniform standard. The currently internationally valid version of the ICD is called ICD-1032. The 11th version of ICD is scheduled to be launched in 2022.

The ICD code (2015) consists of 22 chapters, starting with A00 (cholera) up to [currently] U85! (HIV with resistance to antivirals or proteinase inhibitors); U99 are key numbers that have not yet been assigned. [30]

[30] ICD: International Statistical Classification of Diseases and Related Health Problems
[31] http://www.medfuehrer.de/
[32] ICD-10 means ICD, 10th revision (German: edition). This currently valid version was released in 2012.
[33] http://www.dimdi.de/static/de/klassi/icd-10-gm/kodesuche

In Germany, an appended letter code may be added to the ICD-10 code in an outpatient setting:

Security:

- A = exclusion of a disease or condition
- G = confirmed diagnosis
- V = suspicion of
- Z = symptom-free final state after illness

- Localization:
  - R = right
  - L = left
  - B = on both sides

Together with the OPS coding, the ICD codes form the foundation of the G-DRG system for hospitals, which was introduced in Germany as early as 2003 as the method for determining inpatient service payments (so-called case rates).

Systematized nomenclature of medicine (SNOMED)

The abbreviation SNOMED is a medical classification system and stands for "Systematized nomenclature of medicine". SNOMED is based on the principle of SNOP, Systematized Nomenclature of Pathology, and has been continuously expanded since 1974. According to CIMINO & ZHU, it is one of the most important nomenclatures in human and veterinary medicine. The aim of the universal and multi-axis nomenclature is to record and display medical facts in such a way that the content-related elements of a statement are fully captured. A search query should achieve a high "recall" (completeness) and a high "precision" (relevance). There are various cross-connections to reference databases and scientific collections.

By merging with the so-called read codes (also called clinical terms) of the National Health Service (NHS), the nomenclature was expanded again in 2002 to form SNOMED-CT (clinical terms).

"The structure of the SNOMED categories is hierarchical with alphanumeric codes of up to six digits. Due to its multiaxial structure, this nomenclature is suitable, for example, for scientific evaluations. As a nomenclature, SNOMED also records linguistic variants such as suffixes, prefixes or synonyms and particularly points out homonyms."

[34] German Diagnosis Related Groups
[35] https://www.dimdi.de/static/de/klassi/icd-10-gm/anendung/ Zweck/g-drg/

- Example for the description logic in SNOMED-CT; "Pulmonary Tularemia" (ICD-10: A21.2):

  Pulmonary tularemia ≡ Tularemia ∩
  Pneumonia due to aerobic bacteria ∩
  ∃ Pathogen. Fancisella tularensis ∩
  ∃ Accompanying morphology. Compacted consistency∩
  ∃Accompanying Morphology. Inflammation ∩
  ∃ Findings. Structure of interstitial
  tissue of the lungs

Logical Observation Identifiers Names and Codes (LOINC)

LOINC (Logical Observation Identifiers Names and Codes) is a universal code system for the unique encryption of medical examinations, especially laboratory examinations. LOINC is a nomenclature of globally unique identifiers for medical examination results. Originally developed for laboratory tests, LOINC has been expanded to include clinical and medical-technical tests, medical document types and other medical parameters. The aim is to facilitate electronic data exchange when transmitting medical examination results and diagnostic data.

The LOINC terminology is published as a database by the Regenstrief Institute (Indianapolis, USA), and is regularly updated and expanded. In Germany, the introduction of LOINC was funded by DIMDI, the German Institute for Medical Documentation and Information. The institute provides the Regenstrief LOINC Mapping Assistant (RELMA®) to access the database content. The German translations of LOINC entries are also accessible.

The LOINC database consists of two parts (see DIMIDI):

- The part on laboratory tests contains the common categories of clinical chemistry, hematology, serology, microbiology (including parasitology and virology) and toxicology.
  There are categories for medication, drugs, allergens and for cell counts as they appear in a blood count or CSF cytology. Laboratory regulations for antibiotic sensitivity are in a separate category.

- [36] Systematized Nomenclature of Pathology. SNOP is a four-digit nomenclature for pathology with the dimensions topography (Txxxx), morphology (Mxxxx), etiology (Exxxx) and function (Fxxxx)

[37] CIMINO & ZHU, 2006
[38] National Health Service, UK National Health Service
[39] GEARBAND ref. D.UGAS, 2003
[40] http://loinc.org/
[41] http://www.dimdi.de/static/de/klassi/loinc/index.htm

- The clinical examinations section of the LOINC database contains entries on vital signs, hemodynamic determination, fluid balancing, EKG, ultrasound in obstetrics, echocardiography, imaging in urology, endoscopic examinations in gastroenterology, ventilation and other clinical examinations.

#	Bedeutung/Unterbezeichnungen	Beispiele
0	Nummerischer Code	3257-3
1	Komponente	
	Bezeichnung der Komponente	GLUCOSE
	Belastungstest-Informationen (Menge, Darreichungsform, Zeitangaben)	2H POST 100G GLUCOSE PO
	zusätzlichen Adjustierungen / Bedingungen	PH ADJUSTED TO 7.4
	spezielle Angaben zur Unterscheidung zwischen Probe und Patient	**PAT** (Patient), **DON** (Spender), **FET** (Fetus), **CONT** (Kontrolle)
2	Messgröße, Art des gemessenen oder beobachteten Merkmals	**MCNC** (Massenkonzentration) **SCNC** (Substanzkonzentration)
3	Zeitangaben zum gemessenen / beobachteten Merkmal / Beobachtungsdauer	**PT** (Zeitpunkt) **1H**, **24H** (Stunden), **3D** (Tage)
4	System / Untersuchungsmaterial	**SER** (Serum), **PLAS** (Plasma)
5	Skalentyp des gemessenen oder beobachteten Merkmals	**QN** (quantitativ), **SQ** (semiquantitativ), **QL** (qualitativ)
6	benutzte Methodik zur Erlangung des gemessenen / beobachteten Merkmals	**AGGL** (Agglutination) **US** (Ultraschall) **EIA** (Enzymimmunoassay)

Figure 5: The formal components of the LOINC code (extracts)[42]

- The following six fields are used to specify a LOINC expression (cf. Figure 6):
  - Component - e.g. potassium, sodium, ...
  - Measured variable - e.g. substance concentration, enzyme activity (catalysis rate)
  - Time specification - either a one-time examination at a specific point in time or an examination within a certain period of time
  - System (type of sample) - e.g. urine, whole blood, plasma
  - Scaling - e.g. quantitative (dimensional accuracy), ordinal (with graduated alternatives), nominal or as a text representation
  - If required, the method by which the result was obtained or other observations made are given

The preceding numeric code (ex: 3257-3 from Figure 5) references the six fields.

[42] Source: MC.D.ONALD ET AL., 2000

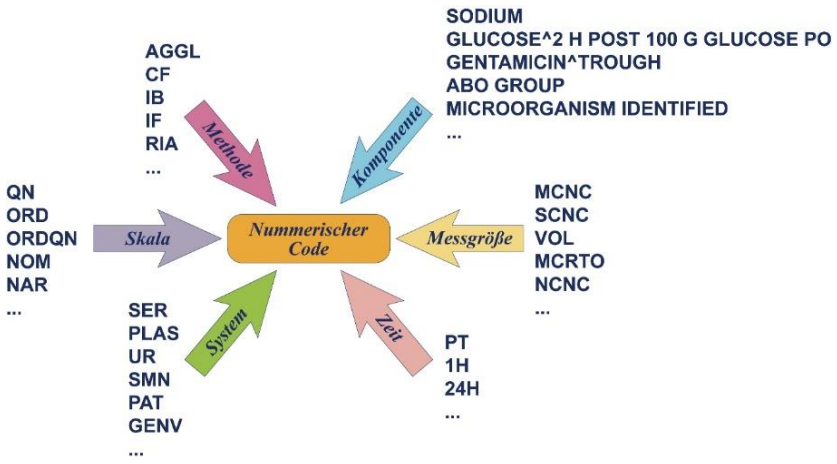

Figure 6: The six axes of LOINC[43]

The LOINC coding system can use XML for the structured electronic transfer of information (syntax). The following example describes the laboratory value terminology
"Complete blood count" [LOINC code: 24317-2] in XML:

```
<code code = "24317-2" codeSystem = "2.16.840.1.113883.6.1"
      codeSystemName = "LOINC" displayName = "Complete blood count" />
<statusCode code = "completed" />
<effectiveTime value = "200609241025" />
```

1.5 Medical communication formats

Health Level 7 (HL7)

Health Level 7 (HL7) is an international standard for the exchange of data between organizations and computer systems in the healthcare sector. The number 7 of the name HL7 refers to layer 7 of the ISO / OSI reference model for communication (ISO7498-1) and expresses that communication is described here on the application level. Although HL7 is a name for an organization, in the context of communication formats it is a specification. The best-known specification is version 2.x of the HL7 messaging format, which is predominantly used in hospitals in Germany. In contrast, HL7 is used rather rarely for exchanges between hospitals and physicians in private practice.

[43] Source: KHeitmann (Wikipedia)
[44] See Practical Guide IT in Health Care, p. 133f.

This is partly because a plethora of data exchange formats have evolved in medical office software, with xDTs arguably being the formats with the widest distribution.

The HL7 standard nevertheless provides interoperability between hospital information systems (HIS), practice management systems (PMS), laboratory information systems (LIMS), service billing systems, and systems that function as electronic patient records.

The following example is an excerpt for use in a HIS:

- First, a patient is admitted to the hospital. The dispatch of a message is triggered for this event.
- After the admission has been entered in the hospital information system, the HIS generates a message of the type ADT ("Admission, Discharge, Transfer") and the event type A01.
- This message is used to inform the associated clinical subsystems, ensuring that the patient and his or her master data are already available there.
- HL7 messages consist of 'segments' which are divided into 'fields' which are filled with certain 'data types'.

The following example (see Figure 7, Figure 8 and Figure 9) of an HL7 message of the type ADT and the event type A01 (new recording) consists of three segments: Message Header (MSH), Patient Identification (PID) and Patient Visit (PV1).

[45] http://de.wikibooks.org/wiki/Medizinische_Informatik:_Standards (Accessed on November 23, 2020)

The MSH segment is at the beginning of every HL7 message:

Figure 7: Example structure of a message header (MSH)[46]

The field contains information on which field separators are used, which applications are communicating, the message and event type, and the HL7 version used. The control number (Message Control ID) in field 10 is unique and will be referenced in the subsystem's acknowledgement message.

The PID segment contains all of the patient's master data (name, birthday, address, health insurance number, etc.).

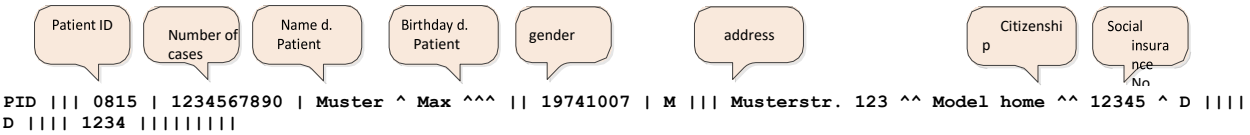

Figure 8: Sample structure of the Patient Identification (PID)[47]

The PV1 segment contains data for a specific medical case. These parameters include the admission mode, the accounting method, the patient's assigned location (ward, room, bed), and the admitting physician.

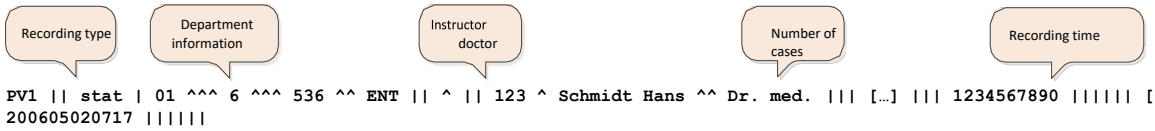

Figure 9: Example structure of a patient visit (PV1)[48]

[46] Source: after LAZAR
[47] Source: after LAZAR
[48] Source: after LAZAR

HL7 FHIR

HL7 has developed a new standard, the "FHIR" ® (Fast Healthcare Interoperability Resources) standard. The exchange of data between software systems in the healthcare sector is supported by FHIR and the advantages of the established HL7 product lines Version 2, Version 3 and CDA are combined with current web standards. There is a strong focus on ease of implementation. Patients are connected to their data regardless of location and mobile architectures are supported by FHIR. The standard provides flexibility.

Distributed data across different systems of the various aspects of a patient record can be transparently summarized and further processed by any user. Self-contained, consolidated data packages with uniform, well-defined properties, semantics, context and metadata are used. The smallest unit of the transmission are the resources. The entire spectrum of healthcare is covered by 150 specified resources. Examples are Medication, the Patient, Procedures, and Order.

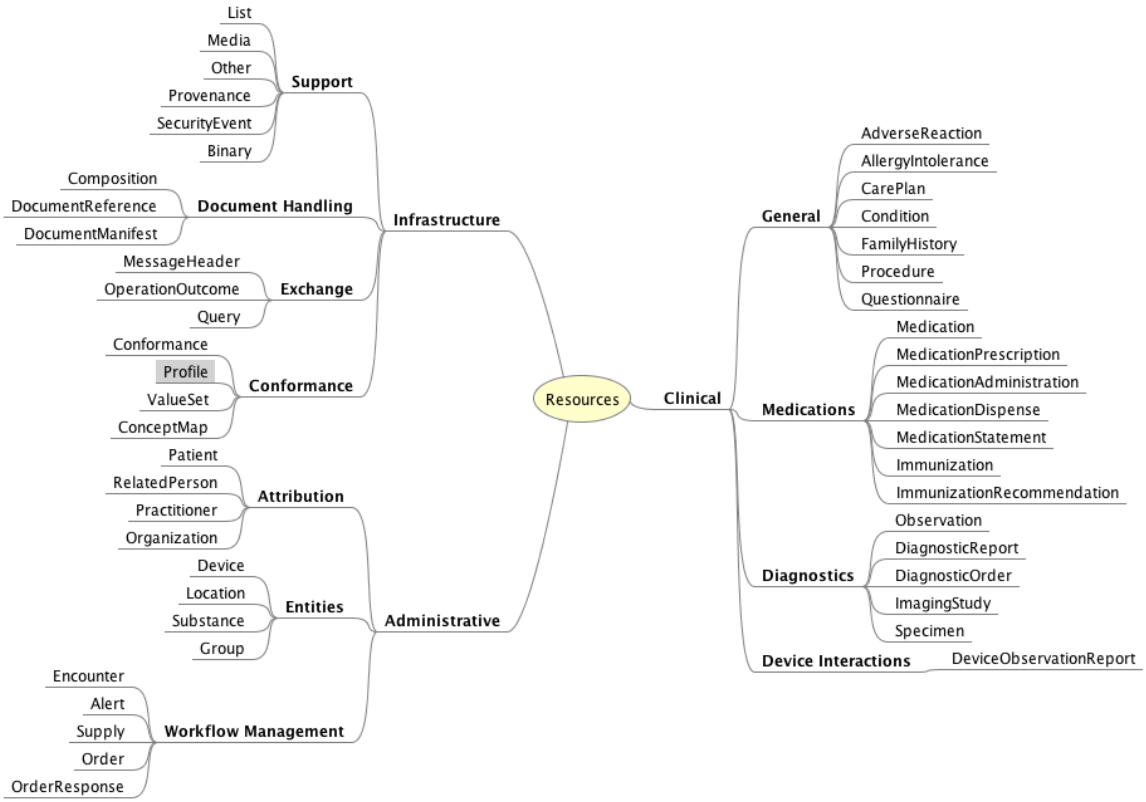

Figure 10: currently defined FHIR Resources (2014)[49]

[49] Source: https://hl7.de/themen/hl7-fhir-mobile-kommunikation-und-mehr/warum-fhir/ accessed on December 7th, 2020

Digital Imaging and Communication in Medicine (DICOM)

DICOM stands for Digital Imaging and Communication in Medicine. DICOM is the international standard for medical imaging51 and the information associated with it (DICOM is certified under ISO 12052: 2006) .52 On the one hand, it defines the formats for medical imaging, which must be of an appropriate quality for clinical use. On the other hand, it is also a communication protocol for the interchange of such data. The open and thus manufacturer-independent standard serves both the storage and the interoperability between medical device imaging and the information systems for medical image data management.

Since 1995, DICOM has been accepted as a formal standard in Europe, leading to virtually all manufacturers of medical imaging or image processing systems, such as digital X-ray, MRI, CT or sonography, implementing the DICOM standard in their devices.

Background & development

According to EICHELBERG ET AL., "since the introduction of computer tomography as the first digital imaging procedure in medicine, the importance of digital medical imaging has steadily increased. With the advent of the idea of digital archiving of images (PACS) and electronic image distribution in hospitals at the latest, the necessity arose to be able to interchange digital images between devices from different manufacturers.
On the development, the iftm writes: "In 1983, the American College of Radiology (ACR) and the National Electrical Manufactures Association (NEMA) formed a committee whose purpose was to develop a standard for medical images."

[50] German: Digital image processing and communication in medicine
[51] In this context, it is also possible to speak of “imaging procedures”, “imaging diagnostics” or “imaging” for short will.
[52] http://medical.nema.org/Dicom/about-DICOM.html
[53] http://www.iso.org/iso/catalogue_detail?csnumber=43218
[54] This means, for example, PACS (Picture Archiving and Communication System), which are used in most practices or clinics for digital image archiving.
[55] Image data management includes information on the digital images, additional information such as segmentation (usually the first step in image analysis), surface definitions and / or image registrations (in simple terms, these are image combinations that generate additional information from two or more (almost congruent) individual images).
[56] http://dicom.offis.de/dcmintro.php.de
[57] see E.ICHELBERG ET AL., O.J.
[58] iftm = Institute for Telematics in Medicine; http://www.iftm.de/index.htm
[59] see iftm

The ACR-NEMA format is considered to be the forerunner of the DICOM format, which after many revisions made it possible for various partners to communicate over a network for the first time in 1993. In addition to the image information, the hierarchically structured ACR-NEMA format could also save patient data.

Next to the support for PACS networks, a central development goal was to ensure the interoperability of DICOM-compatible devices and programs.

This is how the DICOM standard was "born" in 1993, which is currently (information from 2014) in version 3.1 2014c. It is continually developed further.

DICOM dimensions

DICOM has different dimensions / levels (also called support levels):

- The most important and primary level is the support for the image exchange between transmitter and receiver (inquiry / retrieval between devices and diagnostic workstation).
- One level provides support for connecting to a database, storing and retrieving image information, or enabling another device to find out what images have been stored, etc.
- An different level addresses the image (data) management, information for patient scheduling, image quality, storage device, security,etc.

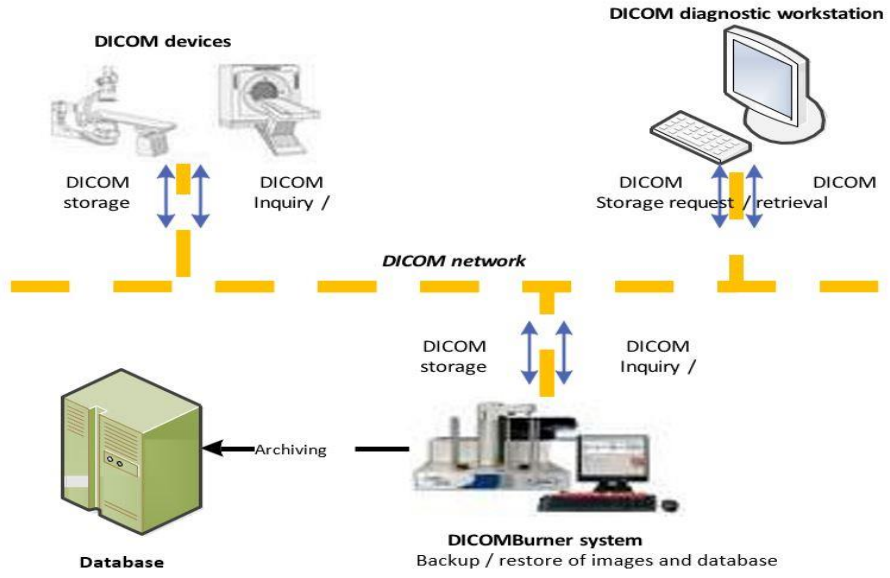

Figure 11: DICOM flowchart[61]

[60] http://medical.nema.org/standard.html
[61] Source: EHARD, O.J.

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