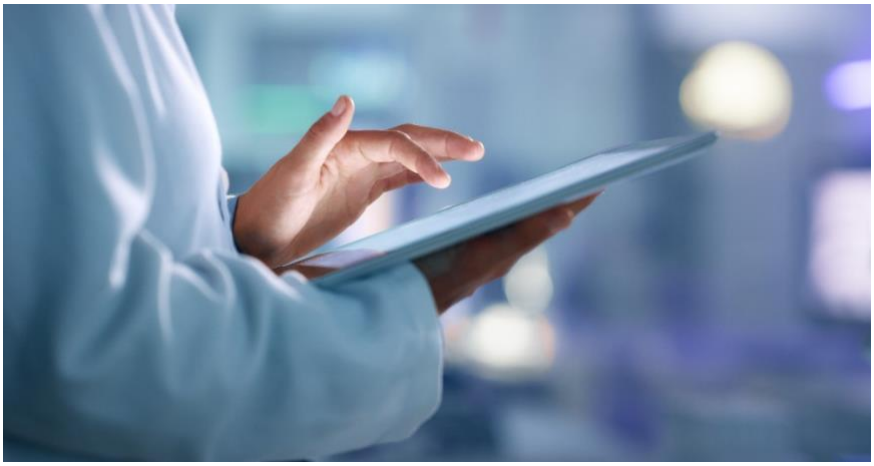
Electronic Medical Record

Basic concepts
Basic architecture

A guide for solution design



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1 Introduction

1.1 General information

The author has co-developed a total of seven medical information systems as a solution designer, product manager, and product owner. This document presents the essential basic concepts and fundamental architecture for the development or evaluation of an electronic medical record (EMR).

1.2 Methodology

The explanations are based on the two established methods of medical documentation: the problem-oriented medical record (POMR) according to Weed and the episode-oriented medical record according to Solon.[1]

1.3 Purpose of the document

This document serves as a guideline for designing an electronic medical record within a medical information system. The most essential aspects are presented as basic concepts, and a basic architecture is derived from them.

1.4 Results

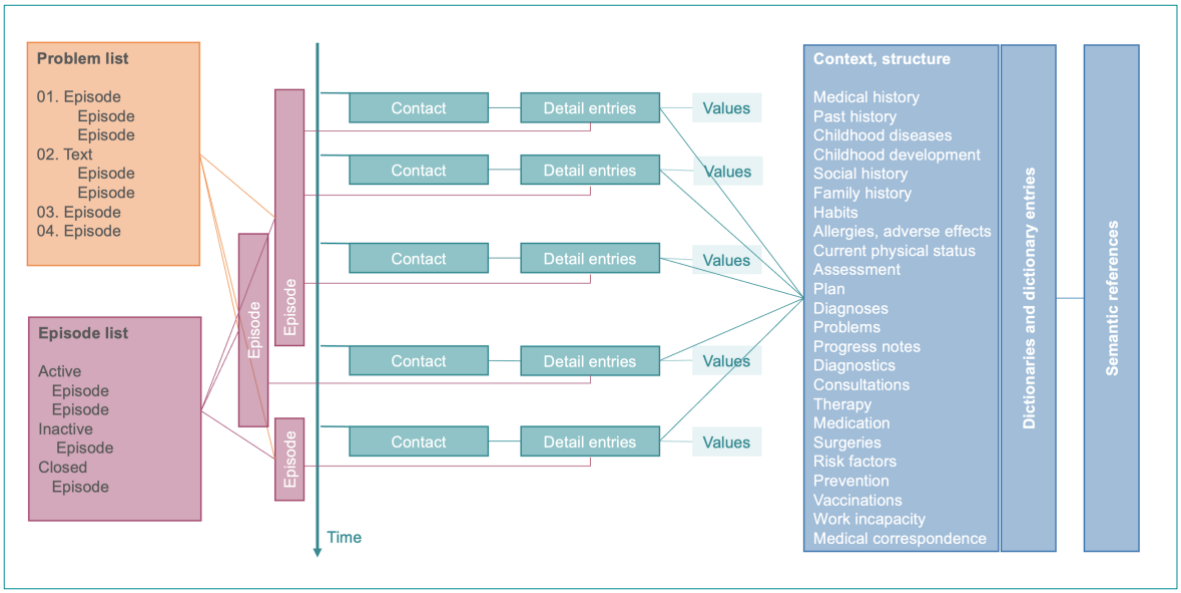


Figure 1 - Logical basic architecture of the electronic medical record

The logical architecture of the electronic medical record is created by integrating the various basic concepts: the entries in the medical record are structured as encounters or *contacts* along the time axis including the recording of time, location, doctor, and patient information. The *detail entries*, which contain the medical findings of the contacts, are recorded in a highly structured manner, linked with semantic references and documented with measured or collected values. Each detail entry is linked to a contact and an *episode of care*.

[1] The two methods of medical documentation mentioned are explained later in this document

Each episode of care represents a clearly defined health problem or diagnosis including the date of the first and last contact. The episodes are arranged linearly in the episode list, and hierarchically in the diagnosis and problem list — in descending order of importance for the patient, and grouped according to medical aspects.

2 Medical record

2.1 Terminology

In German-speaking countries, the term "*Krankengeschichte*" is used as a synonym for the complete medical documentation of a patient. In this medical record, the healthcare professional describes the patient's current and previous state of health and analyzes their illness in diagnostic and prognostic terms. In successive entries, they record the course of the illness, the opinions of the consultants, the results of diagnostic measures, the therapeutic measures, the further course of action, and the patient's response to treatment. This information is essential for all those who are currently caring for the patient and will do so in the future. The entries should be factual, provide accurate descriptions, and contain no moral judgments.[2]

The computerized method of documenting medical issues by healthcare professionals is called the electronic medical record (EMR). The electronic medical record not only includes the actual entries made by the healthcare professionals but also serves as a chronological record and archive of all medical and clinical information about a patient, collected by healthcare professionals in their primary system.

The electronic medical record of healthcare professionals must be distinguished from the *personal health record* (PHR), which contains health data collected by the patient, and the electronic health record (EHR), which is a secondary system in the form of a data repository containing data shared between patients and healthcare professionals.[3]

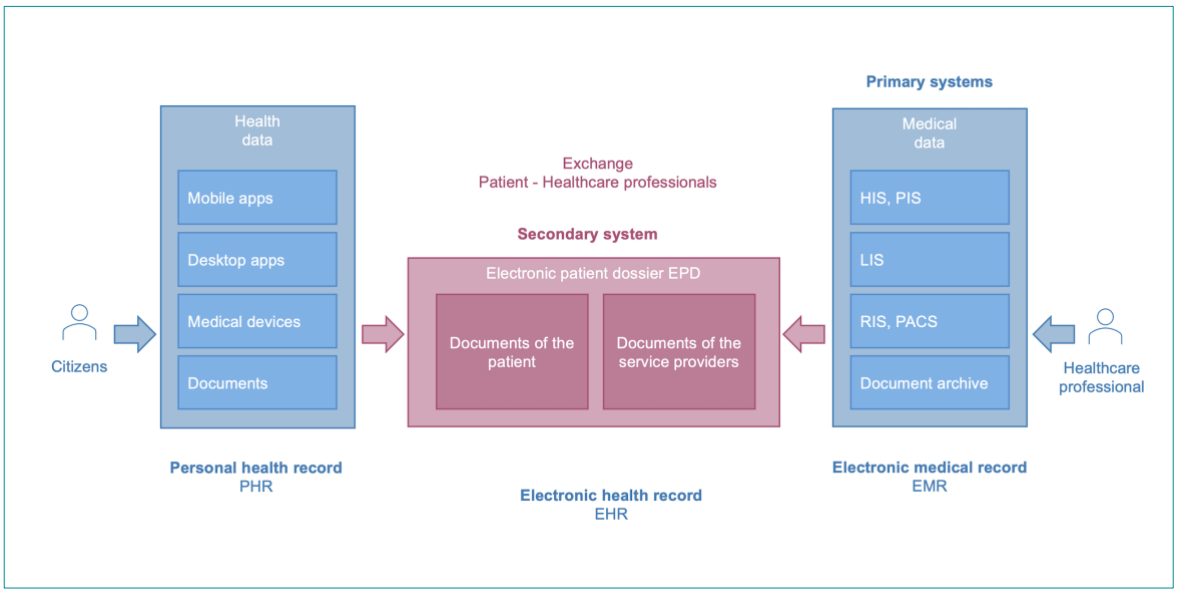


Figure 2 - Electronic medical record for healthcare professional data

[2] MORGAN, William L. *Der klinische Zugang zum Patienten*. Bern, Stuttgart, Wien: Hans Huber, 1977
[3] https://www.e-health-suisse.ch/upload/documents/Factsheet_Unterschied_eKrankengeschichte_EPD.pdf

The electronic medical record is part of the *medical information system,* which includes not only the medical and clinical data of patients, but also administrative and financial information and supports the efficiency of healthcare facilities through process automation via workflow management.

2.2 Conceptual model

The European Society for Quality and Safety in Family Practice (EQuiP) has published a *comprehensive set of quality indicators for improving the medical history*. They describe the medical record as follows:

"The medical record is a cumulative reservoir of information that should be organized in a way which enables the health care providers to insert and retrieve information easily. The medical record should reflect the bio-psycho-social state of the patient – present, past (history) and working plan for the future".[4]

This results in a conceptual model that allows an overarching view of data collection for and the use of the electronic medical record. This model forms the basis for the appropriate implementation of an electronic medical record for the recording, organization, structuring, referencing, and presentation of information.[5]

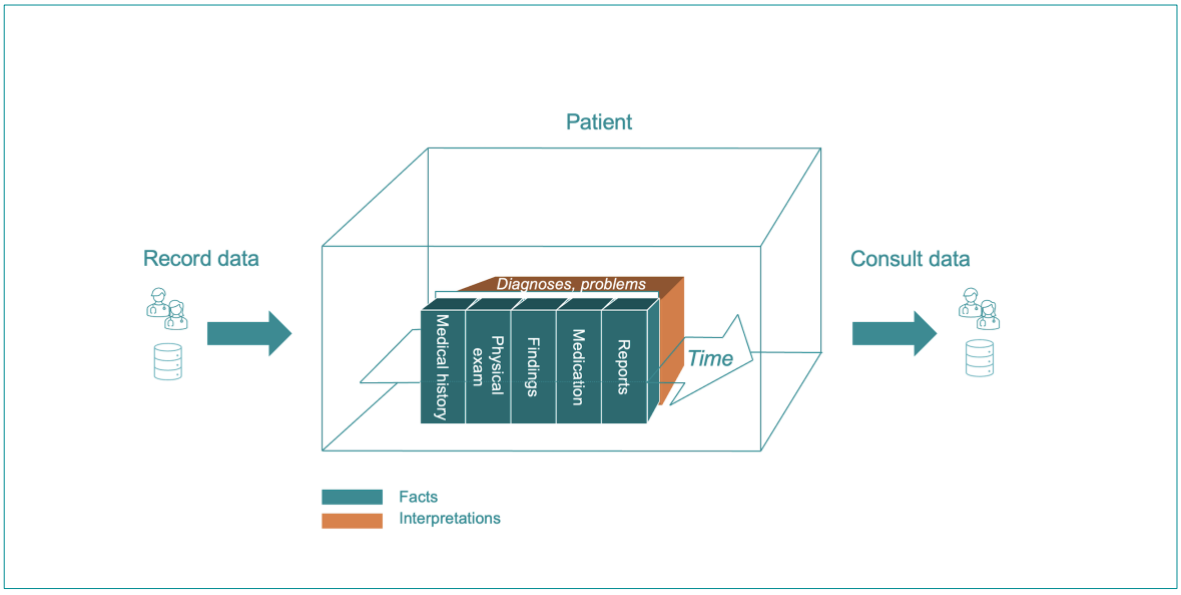


Figure 3 - Conceptual model of the electronic medical record

The cube in the middle represents the medical record and symbolizes three important aspects of the structure of the electronic medical record:

1. The building blocks within the cube represent the data categories of the entries
2. The horizontal level represents the temporal organization of the data
3. The vertical level represents the separation between observations and interpretations

The box surrounding the cube describes the data model and the interfaces that enable patient data to be recorded, queried, and displayed. Data is entered into the medical record from

[4] https://www.qualityfamilymedicine.eu

[5] VAN GINNEKEN, Astrid M., 1995. The Structure of Data in Medical Records. Yearbook of Medical Informatics. pp. 61-69

various sources, such as healthcare professionals and interfaces of third-party systems. It must be possible to retrieve this data easily and display it in a suitable form. The data is added cumulatively and is not deleted within the statutory retention period; changes are continuously historized.

2.3 Characteristics

According to EQuiP, the medical record has the following characteristics:[4] legible, explicit, standardized, continuously updated, easy to search and query, confidential, secure, organized (chronologically, problem-oriented, structured for defined aims), continuously prioritized, referenced, built for a coding system.

2.4 Functions

According to EQuiP, the medical record has the following functions:[4] documentation, communication within and outside the organization, quality improvement (audit, evaluation of processes and outcomes, analysis of clinical activity, analysis of clinical decisions, peer review), statistics, epidemiology, research, legal aspects, evaluation of the health needs of the population and for the management and planning of health policy.

3 Basic concepts

3.1 Patient centricity

Within a healthcare organization, a patient's medical record is maintained collectively by healthcare professionals across all organizational units, locations, and departments. Each patient is created exactly once in the information system and has a single medical record that contains all the medical information about that patient. Different units within the organization are accommodated by using different views of the medical data and access permissions.

Administrative data, such as treatment cases or allocation to accounting clients, can be recorded and processed per organizational unit, location, department, other units, or even across the board.

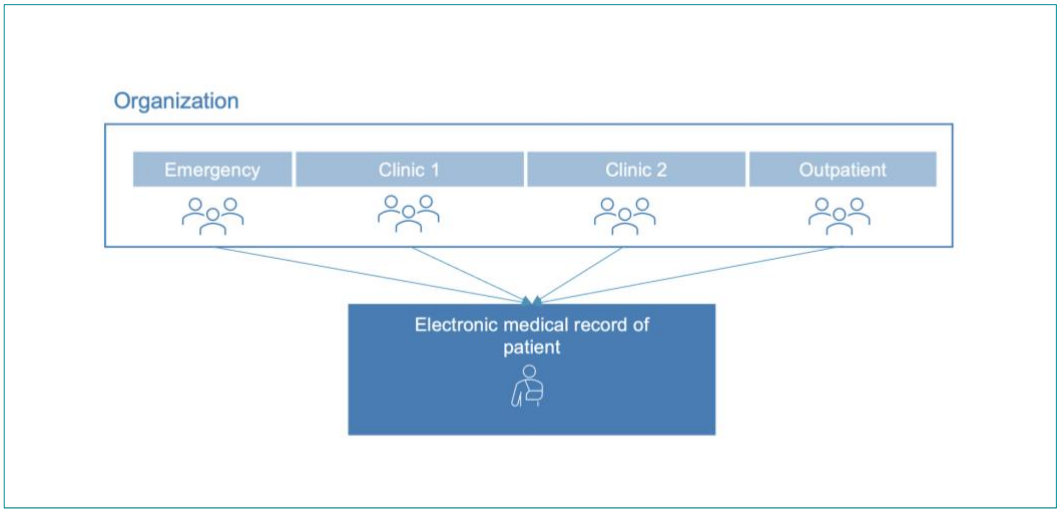


Figure 4 - Patient-centric across all organizational units

3.2 Structuring and referencing

3.2.1 Overview

A key feature of the electronic medical record is the structuring and referencing of the recorded data.

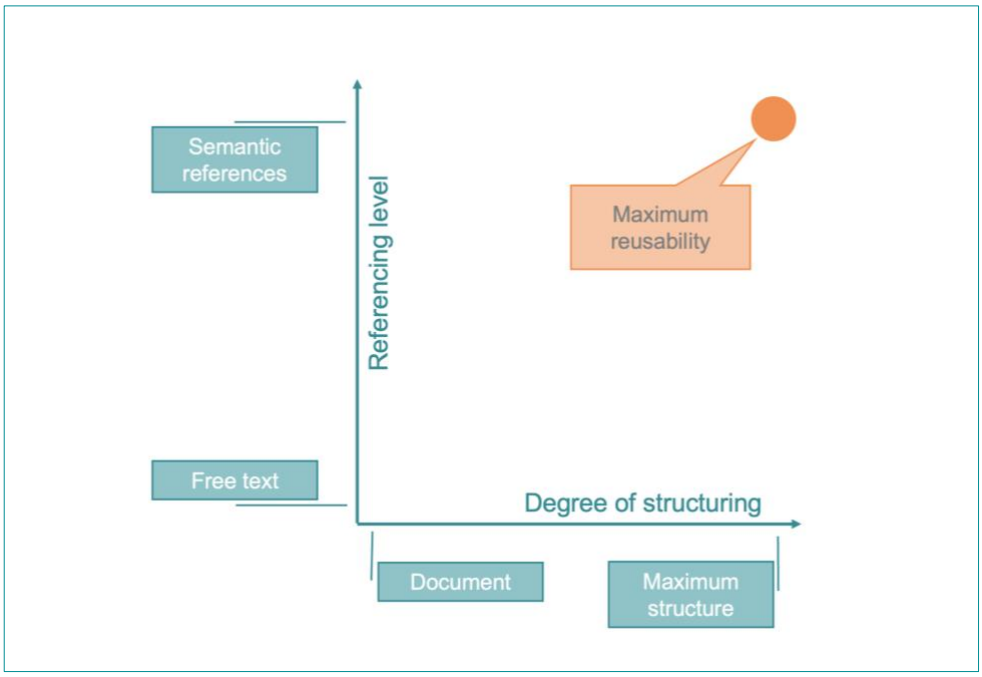


Figure 5 - Assessment of an EMR based on the degree of structuring and referencing

Structuring refers to the storage of medical data in various suitable data categories such as medical history, status, family history, vital signs, laboratory findings.

Referencing refers to the linking of recorded medical data to semantic references. Semantic referencing uses standardized terminologies, nomenclatures, classifications, and ontologies that provide medical information and data with a uniform and machine-interpretable meaning.

The more highly structured and semantically referenced the medical data is, the greater the reusability and the possibilities for multiple uses of the data.

Accordingly, it is possible to design an electronic medical record that is fully structured, but in which the medical information within the structure is recorded as free text. Conversely, an electronic medical record can have all medical information semantically referenced without recognizable structuring of the data into different categories. Neither approach is suitable on its own for the required characteristics and functions of the medical record.

3.2.2 Structuring

A patient's medical record is divided into different data categories or information units, regardless of the recording system. In information technology terms, this is referred to as *entities*, i.e. the grouping of information into logical and content-related units. The level of detail of these information units determines the degree of structure of the medical record. This ensures that all information about a patient can be correctly recorded, stored, and displayed according to logical and medical content aspects. An example of a typical medical record structure is summarized in the appendix.

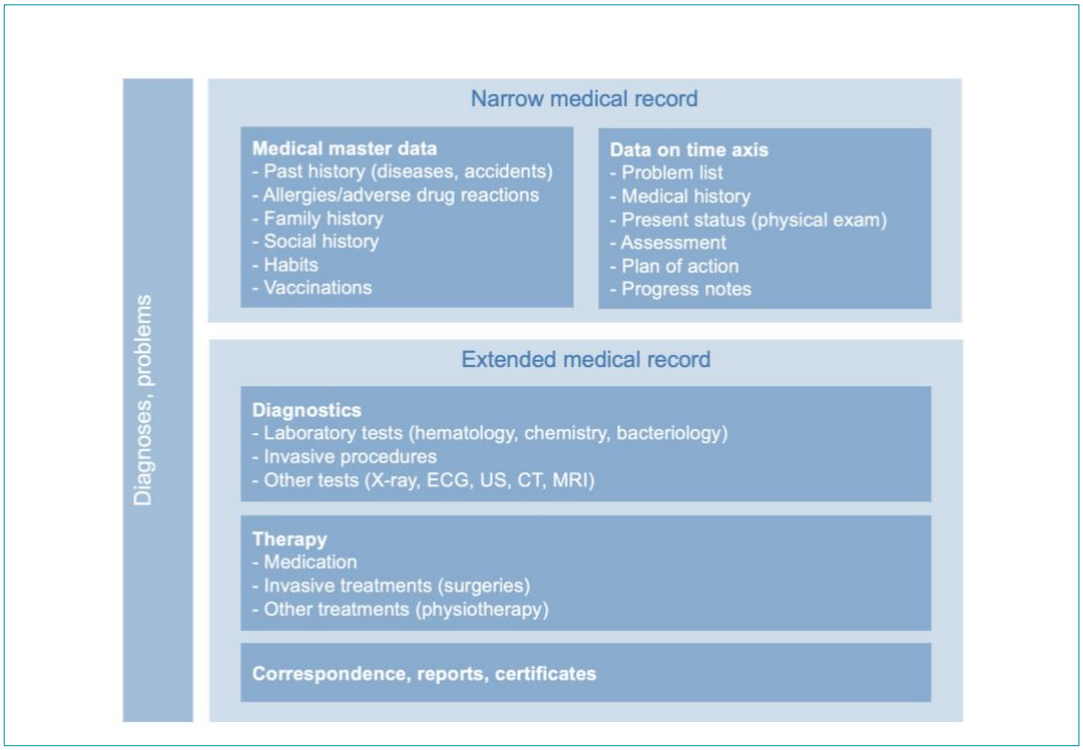


Figure 6 - Structure of the medical record

The data categories can be divided into a medical record in the narrower sense and an extended medical record. The medical record in the narrower sense is mainly maintained by the doctor. The extended medical record, which includes diagnostics, therapy, and correspondence, is maintained by all healthcare professionals and employees of the organization or is imported from third-party systems via interfaces.

Within the medical record in the narrower sense, the various data categories can be divided into data with long-term or perpetual validity and data that frequently changes during care. The first category represents the patient's *medical master data* that does not change or changes only rarely. The second category consists of medical data that changes very frequently or constantly along the time axis.

With the structured electronic medical record, various views and compilations can be created generically, such as dashboards with clinical information relevant to care, lifetime medical history, or emergency data records.

3.2.3 Referencing

The electronic medical record is based on semantic references for all medical facts (details/data/issues) and terms. All entries in the medical record for a patient can be linked to these semantic references.

A medical fact and its semantic reference are always in the context of a data category. For example, the term *fever* has a different quality if the patient reports a fever with a temperature of 38.0°C or the doctor measures a fever with a temperature of 38.2°C in the physical examination. The semantic references are managed accordingly for each context of a data category.

In simplified terms, there are *dictionaries* per data category whose dictionary entries are arranged hierarchically. For each *dictionary entry,* the facts collected, observed, or measured at a specific point in time are recorded from a selection list, as a value or as free text.

In addition to the dictionary entries, there are various medical facts with generally valid *descriptors* that can be used with different dictionary entries. Some examples:

- Localization (left, right, both sides)
- Severity (mild, moderate, severe)
- Duration (since): hours, days, weeks
- Past time: X days ago, X weeks ago
- Trend (unchanged, increasing, decreasing)
- Frequency

In everyday clinical practice, it is not feasible to have a fully referenced medical record. Therefore, it must also be possible to use free text. Special *'free text'* dictionary entries are created within the dictionaries, with at least one dictionary entry per context of the data categories. For example, the dictionary *anamnesis* with the dictionary entry *'free text'* is available for recording the *current complaint*. This means that the free text entered at a point in time for the *current complaint* is automatically assigned to the *anamnesis* data category.

The dictionaries, dictionary entries, and descriptors are used for medical forms, checklists, questionnaires, display masks, and other elements. Different attributes are required for each dictionary entry for optimal use in the various forms of presentation and data entry. A selection of attributes is listed in the appendix.

For the detail entry, it is not the name of the dictionary entry itself that is saved, but the corresponding key field. Depending on the dictionary entry or its selection list of findings, it may be useful to have a display text and output text in prose for this reference in addition to the name. For example, the abbreviation *Hb* is usually preferred for the laboratory test *hemoglobin*, depending on the use case; for physical examination, the finding *general condition: reduced* with the output text *reduced general condition* is displayed when creating reports.

The elements listed above result in a three-layer structure in the electronic medical record:

- The middle layer contains the dictionaries with the dictionary entries in the respective context of the data categories and the descriptors
- The dictionary entries are referenced to the lowest layer with the standardized nomenclatures, terminologies, or classifications
- The user interface as the top layer uses different views or references to the dictionary entries of the middle layer in a freely selectable composition

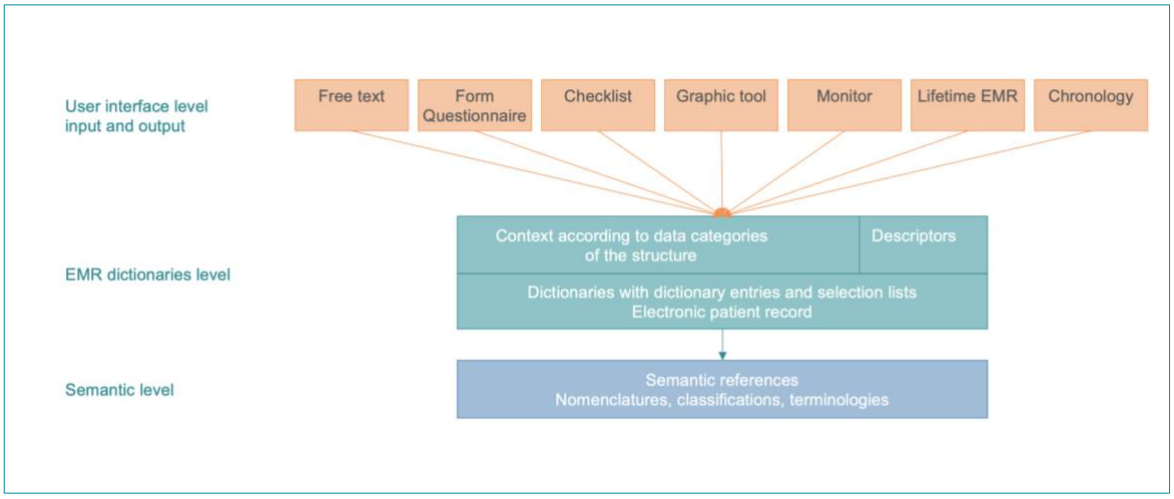


Figure 7 - Layered model of semantic referencing

The advantages of this layer model are explained in more detail using an example. In the dictionary in the context of the *physical examination* data category, the medical fact *bowel sounds* is stored as a dictionary entry and linked to a semantic reference. Various *physical examination forms* are configured in the electronic medical record, each of which contains the information *bowel sounds* by linking the dictionary entry to the respective form. At a certain point in time, the user records the pathological finding of *hyperactive bowel sounds* on a physical examination form for the patient. It does not matter on which physical examination form the entry is made. It is also possible to switch to a different physical examination form while recording data; findings that have already been recorded are carried over. The medical fact *physical examination - bowel sounds* with the finding *hyperactive* is saved in the patient's medical record at the time of recording. This information can be displayed on various forms, dashboards, chronological views, and other displays.

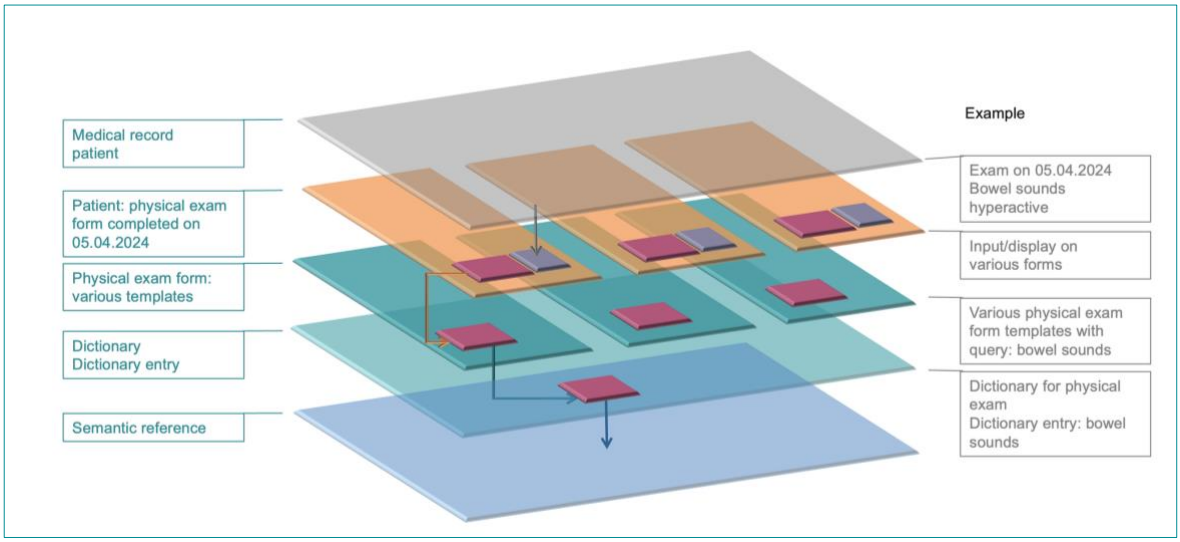


Figure 8 - In-depth representation of layer model semantic referencing with example

Thanks to the multilingualism of the dictionaries and dictionary entries, medical facts can be recorded in the language suitable for the user and displayed or output in another language.

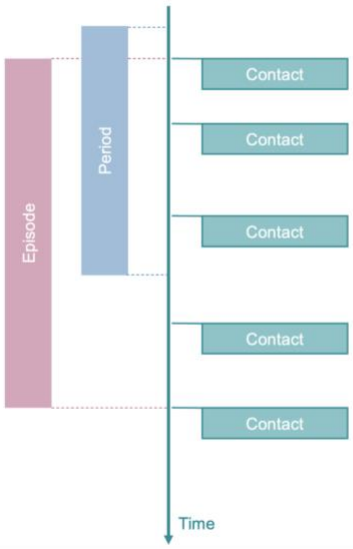
3.3 Treatment units

For storing medical data in the electronic medical record, the question arises as to what represents the smallest logical unit with which this data can be meaningfully recorded and displayed.

3.3.1 Overview

The care of a patient by the service providers comprises various treatment units, depending on how the boundaries are defined. Organizationally, contact takes place between a patient and a service provider. In terms of time, care covers a specific period such as a day, week, month, or year. In terms of content, an episode comprises one or more contacts by the patient with one or more healthcare providers in relation to a particular health problem.[6]

[6] https://fischer-zim.ch/auszuege-pcs-buch/Strukturierung-von-Behandlungsverlaeufen-9701.htm



Boundary setting	Treatment unit	Description
Organizational	Contact	Individual contact with a service provider, categorized by type of stay: outpatient / day patient / inpatient
Temporal	Period	All treatments within a certain period: day / week / year
Content-related	Episode	Multiple contacts with one or more healthcare providers for the treatment of a health problem
	Treatment section	Sections in the course of care with different care goals: - Initial contact - Prevention - Acute treatment - Rehabilitation - Care / nursing - Treatment break
	Treatment phase	Elements of a treatment section (with different care methodologies): - Diagnostics - Therapy (invasive, conservative, ICU stay) - Follow-up care - Waiting period

Figure 9 - Treatment units for patient care[7]

The electronic medical record is built according to the listed organizational, temporal, and content-related treatment units. The smallest unit for documentation is a contact between a patient and a service provider. The services provided are invoiced periodically based on time aspects. The medical documentation is structured according to episodes.

3.3.2 Contact

An encounter or *contact* is the smallest logical unit useful on the timeline for documenting medical data when treating patients. The contact contains the documentation of an event between the service provider and patient that takes place at a specific time and place.

Contact	**Remarks**
Same patient	Patient-centered medical record
Same service provider	Healthcare professional like a doctor
Same event	Office visit, hospital visit, telephone, surgery
Same point in time	Date, time, duration
Same organization	Healthcare facility like hospital, doctor's office
Same place	Clinic, department, outpatient clinic, medical practice
Same type of stay	Outpatient, inpatient, day patient

Table 1 - Key attributes of contact

A contact is based on an *event* that takes place physically or virtually, such as a consultation, home visit, hospital visit, doctor's round, telephone consultation, telephone information, telephone third-party, file review, dispensing of medication, documentation of diagnostic or therapeutic measures, among others.

[7] https://fischer-zim.ch/auszuege-pcs-buch/Strukturierung-von-Behandlungsverlaeufen-9701.htm

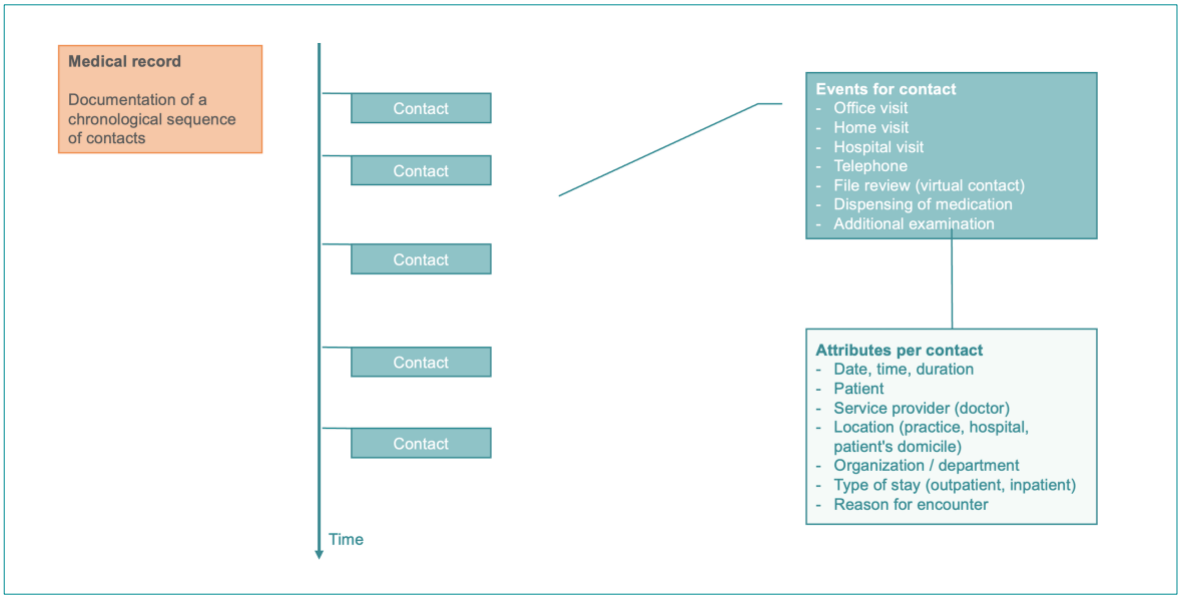


Figure 10 - Medical record - documentation as a chronological sequence of contacts

The electronic medical record is the electronic documentation of the chronological sequence of contacts. These contacts collectively result in the primary, chronological sequence of entries in the electronic medical record based on the contact date.

3.3.3 Detail entry

During a contact, various actions take place, such as taking a medical history, performing a physical examination, or measuring laboratory values. The results of these actions are documented in detail in the electronic medical record. These detail entries are linked to an information unit from the determined structure and the corresponding semantic reference. The findings or values measured during the contact are saved in the detail entry.

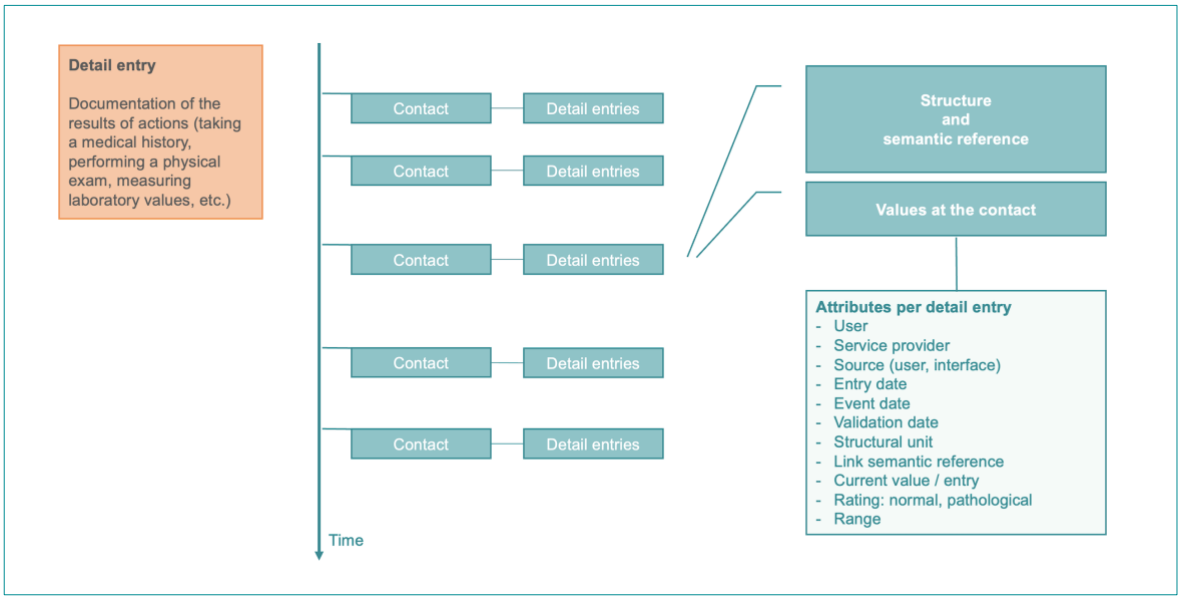


Figure 11 - Detail entry for contact

The detail entry captures a medical fact that is recorded, has occurred, was observed, or measured at a specific point in time, is known to the doctor from a specific point in time, and originates from a single source.

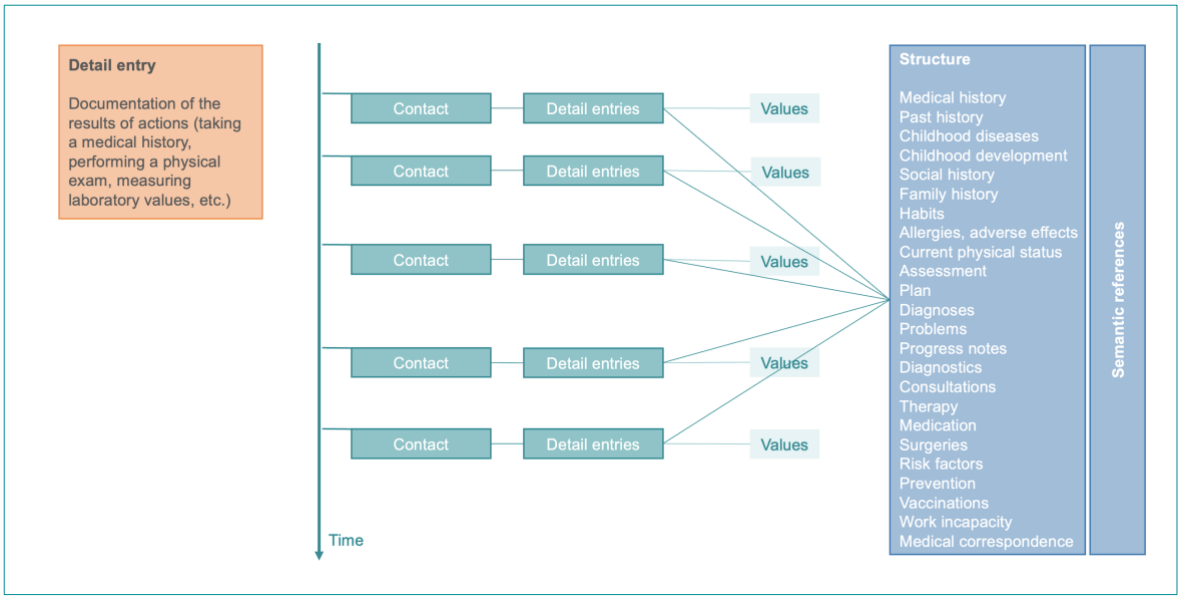


Figure 12 - Detail entries with link to structure and semantic reference

Grouping all detail entries according to the assigned data category results in a primary, generic structure of the electronic medical record. Additionally, the detail entries can also be grouped according to contacts, resulting in a generic, chronological, and structured presentation of the patient's medical data. The detail entries can also be filtered according to other attributes of the contact, such as service provider or organizational unit, allowing a healthcare professional to consult only their entries or display only entries from a specific specialist department.

3.4 Problems and diagnoses

3.4.1 Problem resolution

The relationship between patient and doctor is asymmetrical, with each having their own role. The patient has one or more health problems and seeks the medical professional's help in the hope that they will be resolved, leading to recovery.

The doctor's first task is to recognize and structure the patient's problems. The doctor then forms working hypotheses based on their knowledge, makes diagnostic or therapeutic decisions and carries them out. Finally, the doctor follows the progress, forms new hypotheses if necessary and makes new decisions. This process is iterative and imperfect, without ultimate certainty as long as the patient is alive. The patient is therefore a 'problem bearer' and their doctor the 'problem solver' — to the best of their ability.[8]

[8] Arthur Uehlinger, former head physician at Schaffhausen Cantonal Hospital

3.4.2 Diagnoses, problems

All patient information is summarized in terms of patterns into problems in the sense of health problems. During the diagnostic process, this information is refined into actual diagnoses, while other issues remain categorized as problems.[8]

Diagnoses and problems are not the same. At the beginning of the diagnostic process, the problem might be simple patient information, such as a cough for three weeks or a fever of 39°, or a surprising finding like a radiological lung shadow or a sonographic liver focus, or an uninterpreted laboratory finding such as hypercalcemia or hyperbilirubinemia. During the diagnostic process, these findings are refined into actual diagnoses, while others remain as problems.[8]

Medical diagnoses classify pathological processes into scientific terms. In Switzerland, the International Classification of Diseases (ICD) of the World Health Organization (WHO) is commonly used. Additional information is required for a diagnosis and in some cases for problems, as summarized in the following table:

Clarification	**Values**
Localization	• left • right • on both sides • anatomical term
Condition	• Suspected diagnosis • Confirmed diagnosis • Recurrent diagnosis • Excluded diagnosis
Security level	• Anamnestically secured • Clinically proven • Radiologically confirmed • Histologically confirmed
Timing information	• Acute • Chronic • Complication • Recurrence • Status on (with date)
Time indication	• Date of diagnosis, also called initial diagnosis
Status	• Active (problem or diagnosis requires diagnostic or therapeutic intervention) • Inactive (problem or diagnosis is not being processed and is dormant) • Completed
Objective	• Treatment goal agreed between doctor and patient • Period for achieving the target

Table 2 - Additional information on diagnoses

The name and type of a patient's health problem changes along the time axis during the patient's care. The problem is recorded and can be renamed or specified based on the progression. During the diagnostic process, the doctor makes a suspected diagnosis and reformulates the problem accordingly. If a suspected diagnosis is confirmed, it is renamed as a diagnosis. Based on the therapy carried out, the health problem is solved, and the diagnosis is closed. Important completed diagnoses are added to the *past medical history*.

For example, a patient with abdominal pain that develops into an acute abdomen might lead the doctor to suspect appendicitis. The patient is operated on, and the final diagnosis is confirmed

as appendicitis. The health problem is resolved and closed. As this is an important closed diagnosis, it is included in the past medical history as *status post appendectomy.*

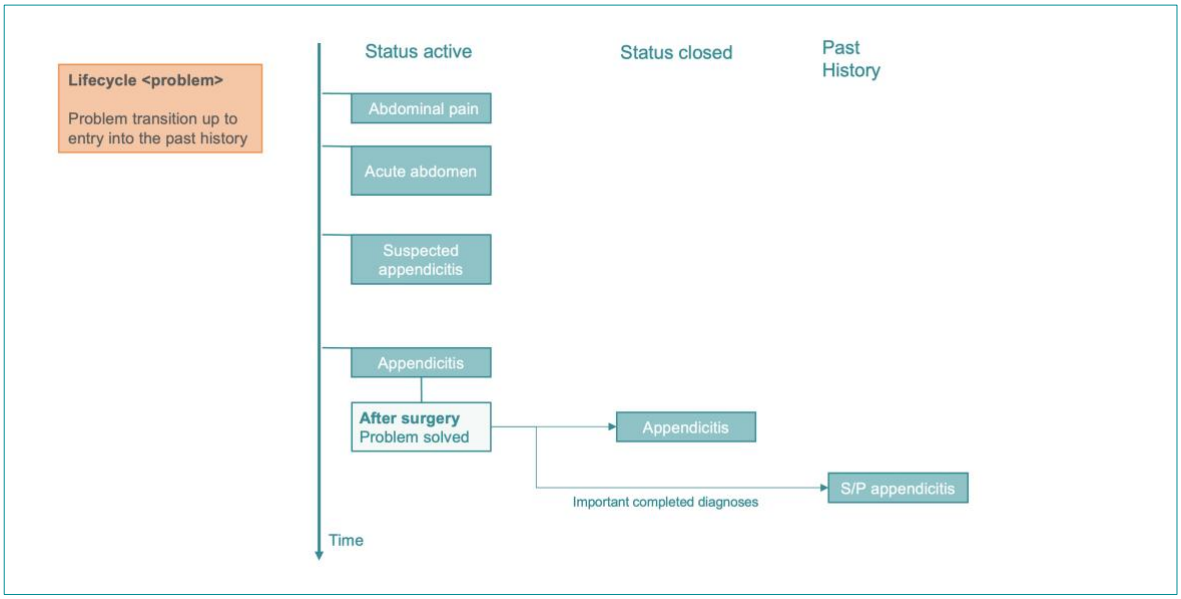


Figure 13 - Lifecycle of a health problem from the problem to the past history

3.4.3 Problem list

In 1968, the physician Lawrence Leonard Weed published an article in *The New England Journal of Medicine* introducing his methodology for improving the medical record.[9] He replaced the structuring of the medical record according to various sources such as X-ray findings, laboratory results, and doctor's notes with a structure that focused on a defined list of a patient's medical problems. The organization of patient information based on specific problems aims to improve the overview, clinical decision-making, and medical education.

The central element of Weed's problem-oriented medical record (POMR) is the so-called *problem list*. The patient's current and past diagnoses and problems are arranged hierarchically in a list in descending order of importance for the patient.

In everyday practice, problems and diagnoses are often linked or interconnected in complex ways. Therefore, diagnoses and problems are organized and numbered hierarchically according to their significance for the patient. The grouping is based on medical aspects with a main diagnosis or superordinate term and the associated problems and diagnoses indented.

Additionally, substantiating *primary data* can be added to the hierarchical problem list for each diagnosis or problem. The substantiating primary data include relevant anamnestic, clinical, or additional information with corresponding keywords, measured values, and links to other entries from the structured medical record.

The hierarchical, consecutively numbered problem list of all the patient's current and past health problems represents a clear index of the patient's medical record. Today, Weed's *problem list* is popularly called the *diagnosis and problem list*.

[9] WEED, L. L. Medical records that guide and teach. The New England Journal of Medicine, 1968, vol. 278, no. 11, pp. 593-600.

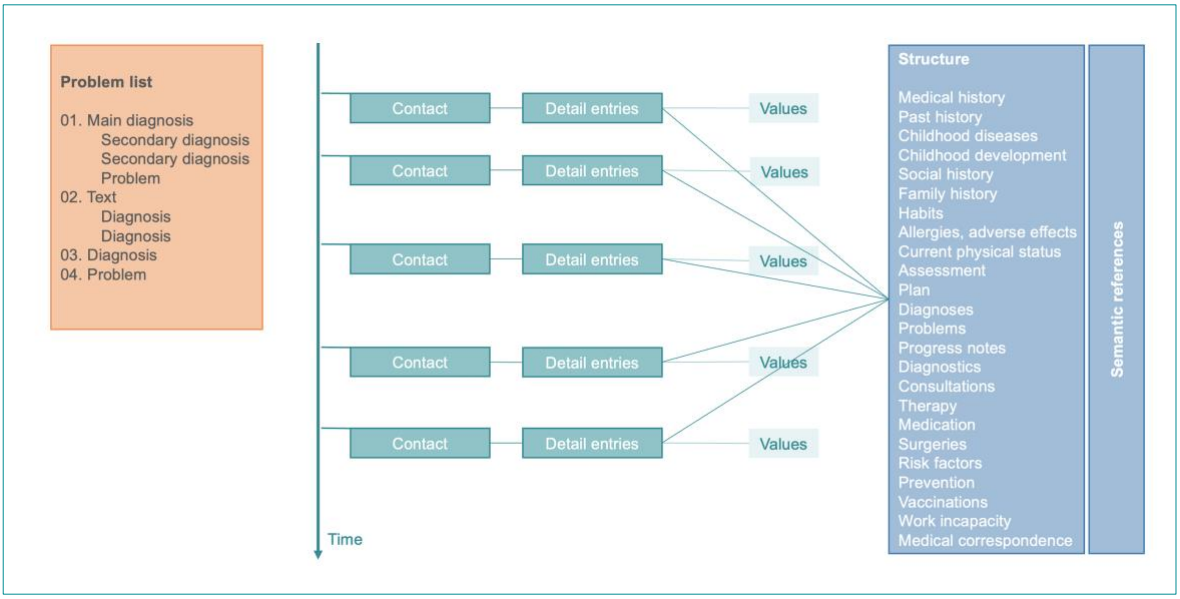


Figure 14 - Problem list as a table of contents for the medical record

Example diagnosis and problem list

1. Urinary tract infection (22.03.2024)
2. Coronary heart disease with/without
   - Arterial hypertension (ED 2009)
   - Heart failure
   - S/P myocardial infarction (2015)
3. Diabetes mellitus type 2 (ED 2007)
   - Polyneuropathy (ED 2014)
   - Nephropathy (ED 2017)
   - HbA1c 23.02.2024: 6.4%
4. Obesity WHO grade II
   - BMI initial 35.9 kg/m2
   - Start therapy with liraglutide 03.04.2022
   - BMI 16.05.2024: 31.3. kg/m2
5. Husband in need of care
6. S/P cholecystectomy (1988)
7. S/P appendectomy (1965)

3.4.4 Progress notes - SOAP principle

For each contact, the doctor writes progress notes for the active problems and diagnoses that are addressed during this contact. This documents the progress of changes in subjective symptoms and objective signs of illness as well as changes in the doctor's assessment and planning. According to Weed, a separate progress note is created for each problem or diagnosis in the problem-oriented medical record. This allows all progress notes to be displayed chronologically for a specific problem or diagnosis. In everyday practice, one single progress note is often created for several selected problems or diagnoses.

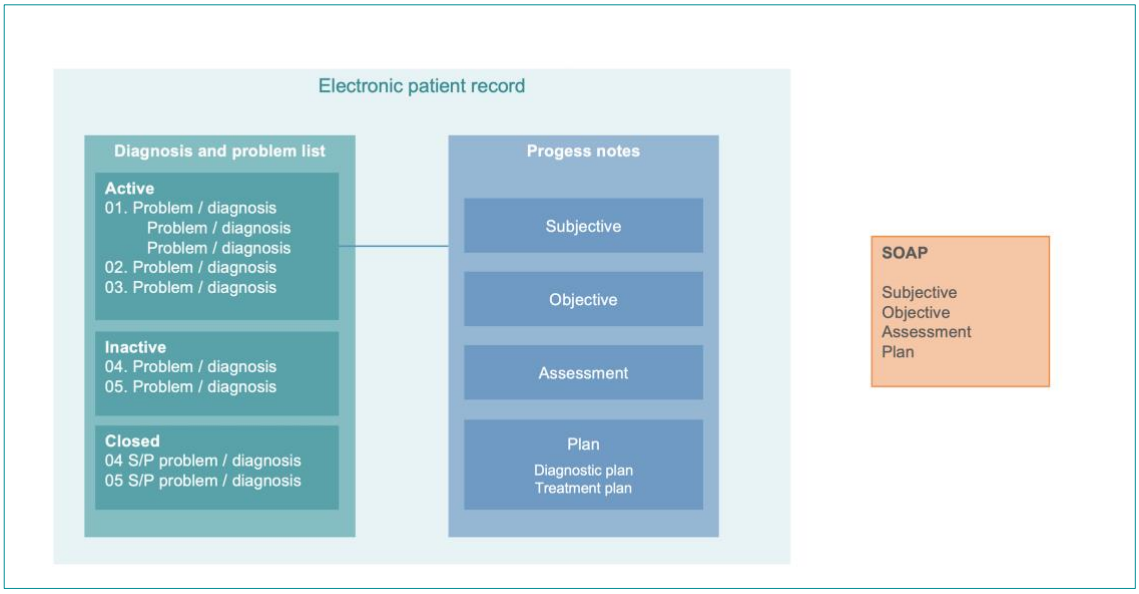


Figure 15 – Progress notes according to the SOAP principle

The progress notes for a patient's problem or diagnosis are divided into subjective information from the patient, objective findings, assessment and interpretation, and planning of the next steps for clarification and treatment. This type of entry is also known as SOAP and comprises a four-part structure: *Subjective, Objective, Assessment, Plan*. This separates the facts and interpretations. Progress notes are primarily created for active problems and diagnoses. If a progress note is made for an inactive or closed problem or diagnosis, it is active again.

3.5 Episode of care

3.5.1 Concept

The problem-oriented management of medical records according to Weed reaches its limits in certain areas. With long medical records, the user loses the overview, and the requirements of managed care can only be unsatisfactorily mapped. For comparable analyses of patient treatments regarding costs and quality, it must be possible to completely structure the data in the electronic medical record in terms of organization, time, and content. It must also be possible to differentiate between treatment cases in terms of commercial aspects within the practice, and the episode of illness as it occurs in the patient from the beginning to the healing of a health problem.

The *episode of care* has been proposed by health researchers as a suitable unit for measuring cost-effectiveness and quality. The theoretical concept behind *episodes of care* was published by Jerry A. Solon and his colleagues in the American Journal of Public Health in 1967.[10]

The episode of care is the time period of the duration of a health problem, measured from the first to the last contact between patient and healthcare provider. An episode contains all information on a single health problem that is recorded in the medical record over a defined period of time for all contacts. An episode of care covers a patient's health problem over the entire period of time from its origin to its resolution. The documentation within the individual contact takes place per episode according to the SOAP principle. Exacerbations and complications of an episode are presented in separate episodes.

[10] SOLON, Jerry A., FEENEY, John J., JONES, Sarah H., RIGG, Robert D. and SHEPS, Cecil G. Delineating episodes of medical care. American Journal of Public Health and the Nation's Health. [online]. 1967, 57(3), 401-408.

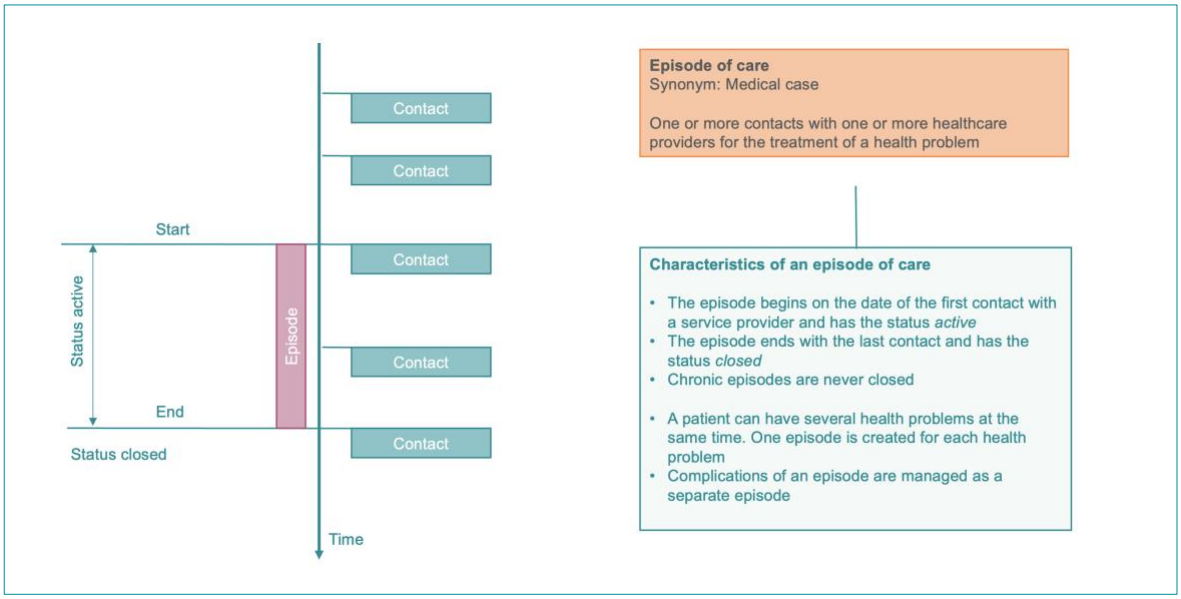


Figure 16 - Definition 'episode of care'

3.5.2 Name of the episode

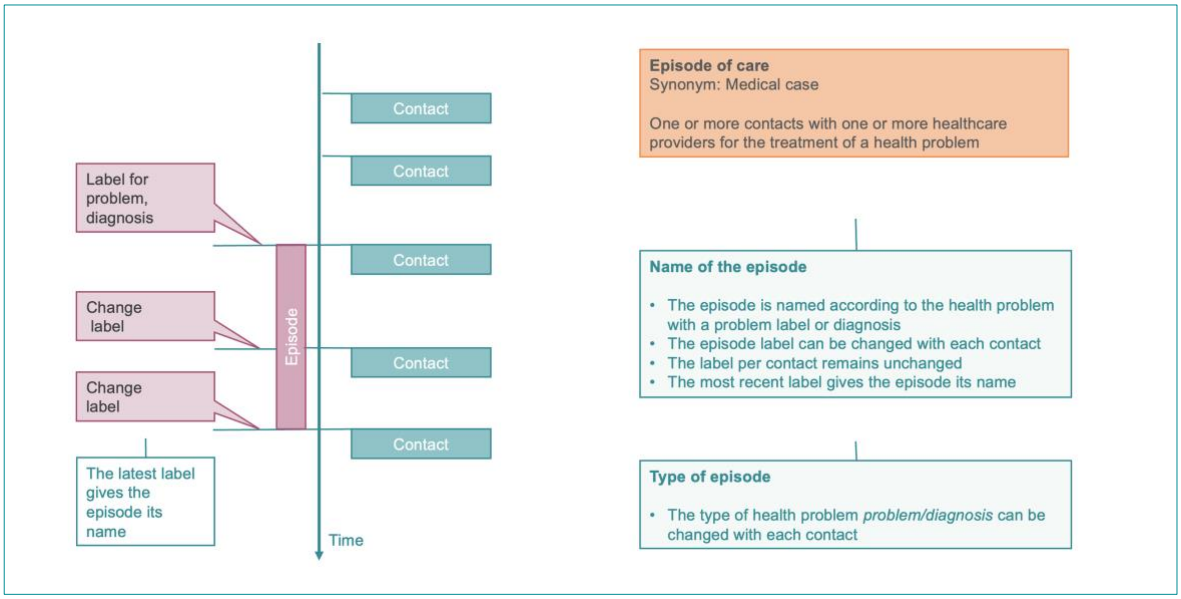


Figure 17 - Naming of an episode of care

When a new health problem arises, an episode of care is created at the corresponding contact with a problem or diagnosis as its name. With each subsequent contact, the episode can be renamed based on the diagnostic or therapeutic process. The label entered for each contact must be retained so that the chronological display of contacts always shows the name valid at that time. In this way, you can see the progress and transitions from contact to contact. The episode of care as outlined by the World Organization of Family Doctors (WONCA) is shown below with an example:

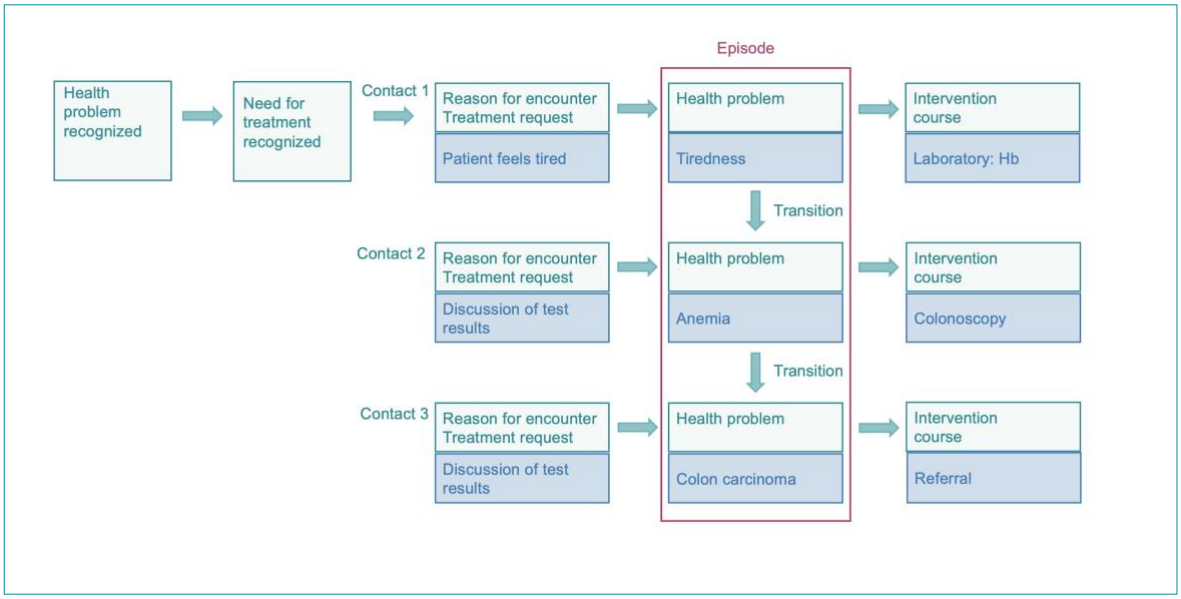


Figure 18 - WONCA - episode of care with example

3.5.3 Detail entry

All medical record data and progress notes are mandatorily assigned to an episode. Each detail entry of a contact is linked to the corresponding or matching episode. If a detail entry matches several episodes, it is assigned to the most appropriate one according to Solon's theory. In practice, it has been shown that an assignment to a 'main episode' and further 'secondary episodes' is more practical. The distinction between a main episode and secondary episodes is important for extended requirements for the medical record, such as comparison of costs and quality.

3.5.4 Progress notes

As with the problem-oriented medical record according to Weed, the episode-oriented medical record documents the progress notes per episode of care according to the SOAP principle (Subjective, Objective, Assessment, Plan). The progress note represents a special detail entry and is linked to both a contact and an episode.

3.5.5 Partial contact

Many contacts deal with more than just one health problem. The concept of *partial contact* was created to take this into account.

A *partial contact* is the part of a contact that deals with a specific health problem. So, if a patient presents two health problems during an encounter, this contact consists of two *partial contacts*. Each partial contact refers explicitly to a single health problem, whether it is a problem or a diagnosis. Each detail entry is linked to a partial contact.

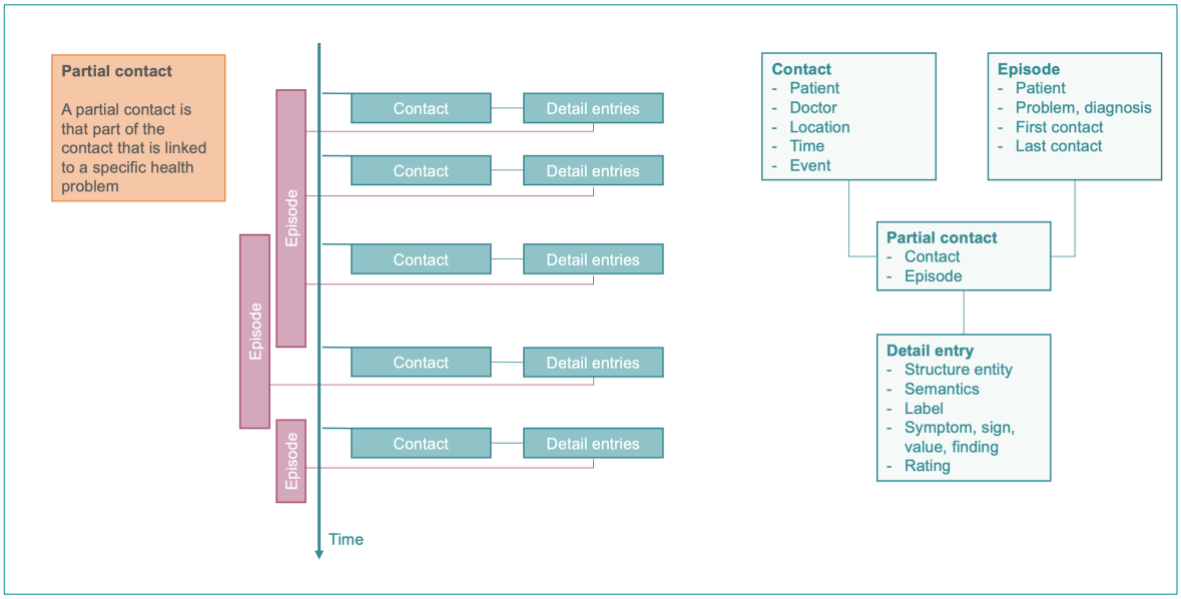


Figure 19 - Partial contact in the episode concept

If all *partial contacts* for a single health problem are linked over the time axis, the *episode of care is* generated.

3.5.6 Episode list

All episodes of a patient can be displayed generically as a list. The most recent episode name is displayed on the episode list. Each episode has an active, inactive, or closed status. Depending on the use case, the inactive and closed episodes can be hidden. This provides the service provider with the list of active episodes, serving as agenda items for the planned encounter.

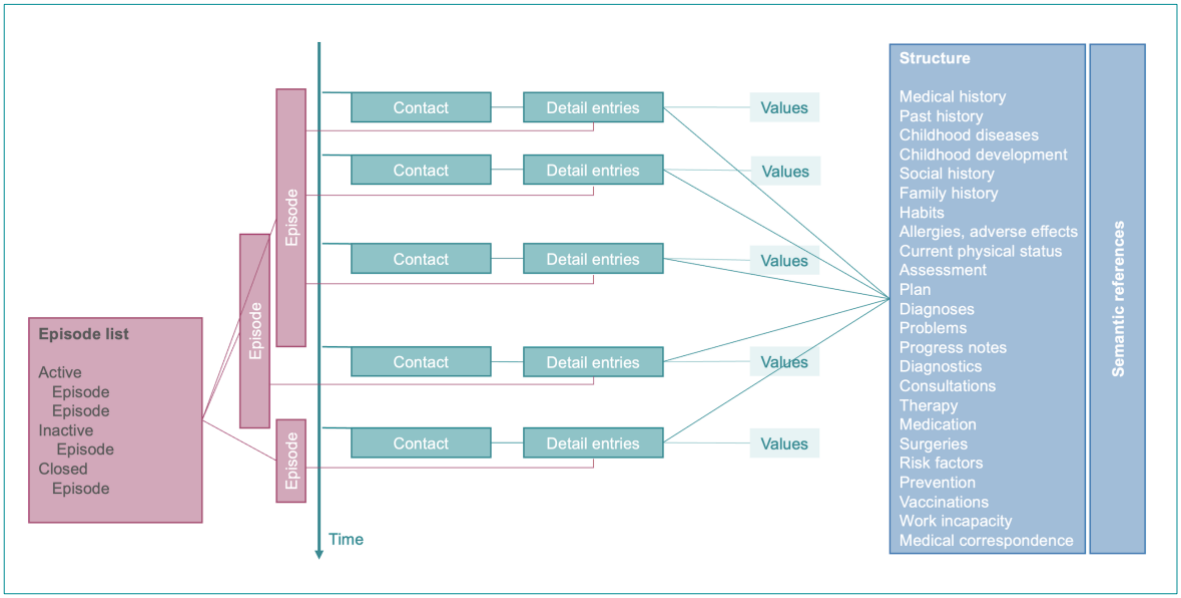


Figure 20 - Linear, generic episode list

3.5.7 Problem list and episode list

By definition, a single episode comprises a single health problem or diagnosis of a patient. However, there are often obvious and clinical connections between the different episodes. The different health problems and diagnoses of the episodes also have varying significance for the patient. This makes the linear presentation of the episode list less than ideal. The episodes are also grouped differently in the *diagnosis and problem list*, analogous to the problem-oriented medical record.

In the diagnosis and problem list, related health problems of the various episodes are grouped hierarchically and presented together. The hierarchical grouping is numbered at the top level according to their significance for the patient in descending order. Inactive and closed episodes as well as entries from the past medical history, follow at the bottom and/or in a separate list. The list of diagnoses and problems can also include the patient's important risk factors, allergies, and the underlying primary data. The diagnosis and problem list is adapted and revised as the diagnosis progresses and the disease evolves.

The most recent name of the episode is always displayed in the diagnosis and problem list. This is in contrast to the contact, where the name valid at the time of the contact is displayed.

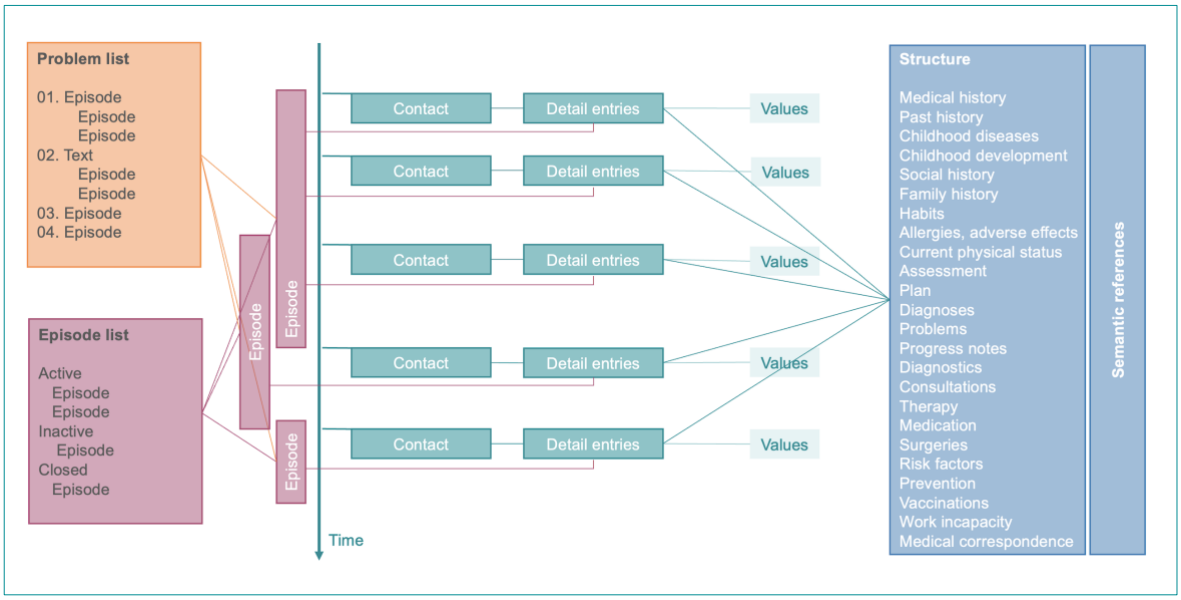


Figure 21 - Relationship between episode list and problem list according to Weed

The episode list is created generically in linear form, divided into active, inactive, and closed episodes. In the diagnosis and problem list, the episodes are linked to the hierarchical structure, and the most recent name of the episode is displayed in each case. The informative value of the two lists is different, as the following two examples of coronary heart disease (CHD) and urinary tract infection (UTI) show.

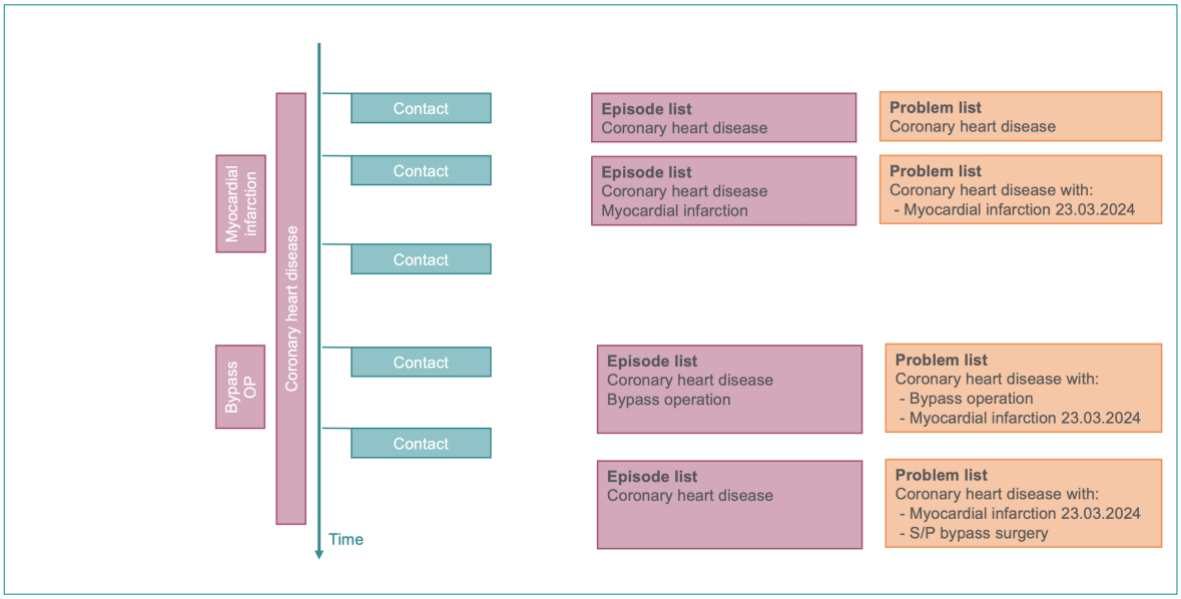


Figure 22 - Example CHD - Relationship between episode list and problem list according to Weed

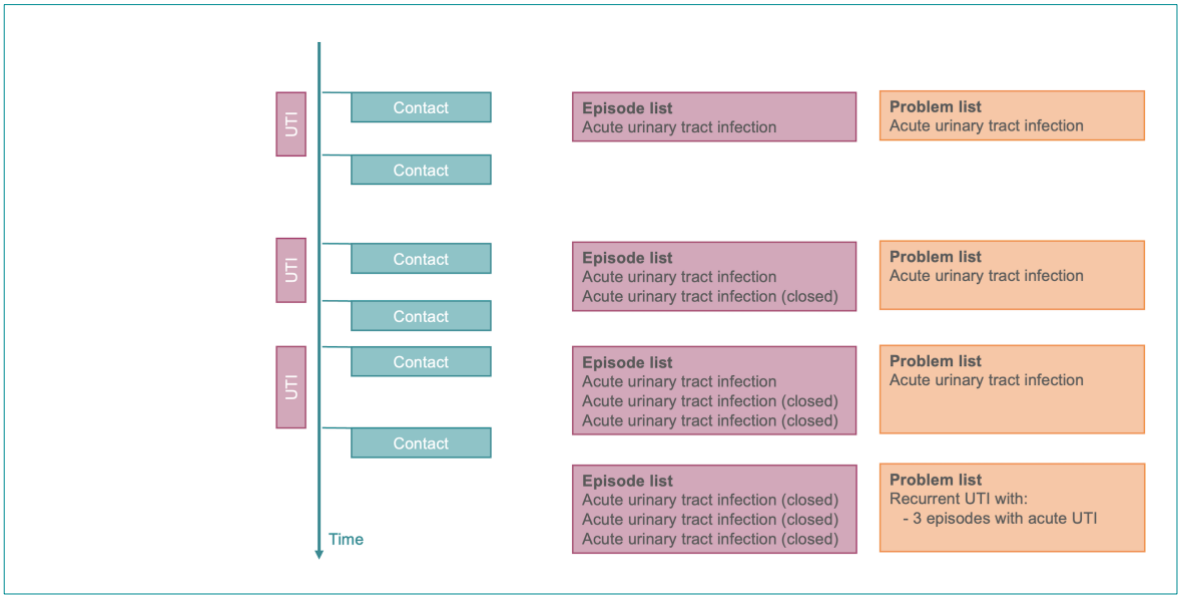


Figure 23 - Example UTI - Relationship between episode list and problem list according to Weed

In the problem-oriented medical record according to Weed, the urinary tract infection (UTI) is recorded once as a diagnosis and the progress notes are documented. In the episode list, each urinary tract infection, linked to the contact, automatically has a start date and end date. This allows the doctor to quickly see that the patient has recurrent urinary tract infections, which clinically suggests a more serious cause and requires more in-depth clarification.

3.6 Historization

The question arises as to the extent to which the entries in the electronic medical record may be changed or deleted. From the author's point of view, a correct and legible medical record is essential for the quality of patient care. Preventing corrections or indicating that corrections have been made by crossing them out is not expedient in this sense.

All entries in the medical record can be modified and deleted by users according to an authorization framework. Every change – creation, correction, deletion – is fully historized with details of the date, time, user, and changes made. This corresponds to a transaction log. The current version of the entry is always displayed, and the transaction log can be viewed at any time by authorized users.

Every modified or deleted entry must be submitted to the author for validation and sign-off, see the basic concept for *validation/sign-off.*

3.7 Delete versus remove

A detail entry can be deleted for two different reasons:

- The user has made an incorrect entry and wants to delete the detail entry
- A medical issue no longer applies and should be removed

For example, if it is noted in the habits that the patient is a smoker, and the patient stops smoking, the service provider will want to delete this habit. In this case, the detail entry should not simply be deleted, but instead must be marked as *removed* and no longer displayed. Otherwise, the information about the period as a smoker will be lost.

In the electronic medical record, a distinction must be made between *incorrect entry* and *removal* when deleting a detail entry. If possible, a validity with start and end date of the medical facts is preferable to removal. This allows different time periods to be entered for a detail entry in which a medical condition applies. Depending on the use case, only the most recent detail entry or all detail entries can be displayed chronologically.

Deletion in terms of removal or period of validity is particularly important for data on the timeline of the medical record in the narrower sense and for the extended medical record. Medical master data naturally tends to be subject to deletion rather than to incorrect entry.

3.8 Access log

Every read access by a user to the electronic medical record is stored in as much detail as possible in an access log. This means that all internal and inter-company accesses can be viewed. If required, the patient can see who has accessed their electronic medical record. Together with historization, this provides a complete picture of all read and write access to a patient's medical record.

3.9 Source orientation

The various sources are documented for each detail entry:

- User
- Executing service provider, or commissioning or responsible service provider, also known as the primarily responsible service provider
- Data source such as manual entry, voice recognition, interface, migration

The detail entries are usually made by the service provider themselves or they document circumstances that were commissioned by the service provider. Accordingly, the performing, ordering or primarily responsible doctor is recorded for each detail entry.

It is important to document the data source so that the consulting user can classify it correctly. The data can be entered manually at the workstation, or transferred automatically via an interface from a third-party system or from a data migration.

3.10 Responsible service providers

As a rule, one or more service providers within an organization or organizational unit are responsible for the work of other service providers regarding patient care, e.g. the senior physician for the work of the assistant physician or the medical director in a group practice for the employed physicians.

For each detail entry, the service providers responsible for the activity of the executing service provider are also recorded.

3.11 Validation and sign-off

It must be ensured that the service providers responsible for the patient take note of all medical information available in the electronic medical record. This applies to all newly recorded, changed, or deleted medical data.

Every detail entry that is not documented by the executing, commissioning, or responsible service provider must be submitted to this service provider for review. This review is documented via sign-off by the service provider and timestamped in the detail entry.

Depending on the organization, certain service providers are responsible for the medical activities involved in patient care. These responsible service providers should be able to view all medical information for which they are responsible in order to validate and verify it. Accordingly, hierarchical validation and sign-off of the detail entries is required. The executing service provider signs-off first, followed by the responsible service providers in a predetermined order.

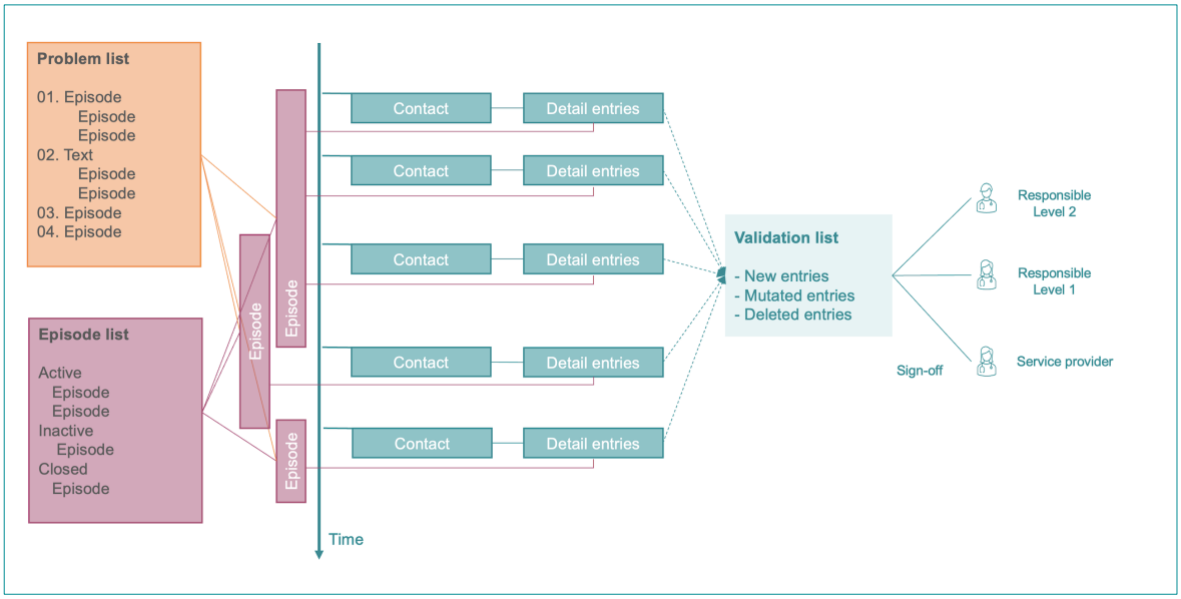


Figure 24 - Hierarchical validation of detail entries

3.12 Timestamps

The detail entry is the documentation of an action such as taking a medical history, taking a status report, or diagnosing an X-ray image. Three date/time stamps are recorded in the electronic medical record for each detail entry: recording time, event time, availability time.

Time	Explanation
Recording time	Date and time on which the event was recorded in the medical record. This corresponds to the transaction date
Time of event	Date and time when the documented event took place, was observed, or measured
Time of availability	Date and time at which the information of the detail entry is available to the executing or responsible service provider, i.e. is validated and reviewed

Examples

Example 1: Past medical history

- The service provider records the patient's entry 'Myocardial infarction 1998' during a contact; this is the recording time.
- The myocardial infarction occurred in 1998; this is the time of the event.
- The responsible service provider sees this information two days later and validates it; this is the time from which the responsible service provider has this information.

Example 2: Documentation of a laboratory result

- The laboratory technician records the result of a laboratory analysis; this is the recording time.
- The blood sample was taken two days earlier, and the result is valid for this event time.
- The doctor sees the laboratory result three days later and validates it, meaning the doctor has the relevant information from this date.

3.13 Explicit versus implicit

If a medical issue is not documented in the medical record, it must not be implicitly assumed that it does not apply to the patient. A non-applicable fact must be explicitly documented as such.

For example, in the absence of any documentation on the patient's allergies, it must not be implicitly assumed that the patient has no allergies. The facts are only meaningful if there is explicit documentation of *no known allergies.* Otherwise, a note such as *allergies not recorded* should be added.

Accordingly, it must be possible to document non-applicable facts within the structure and associated semantic reference. Without this documentation, a note is issued depending on the use case.

3.14 Assessment of detail entry

A detail entry documents a medical finding. This finding can be normal, borderline, or pathological. Accordingly, it must be possible to explicitly document the assessment for a detail entry, if this makes sense for the documented facts. This means that all detail entries with pathological findings can be compiled using a filter without the documented value having to be interpreted.

For example, a resting pulse rate of 150/min in the vital signs or an enlarged liver in the examination of a patient are pathological.

Based on the considerations for explicit documentation, the assessment for each detail entry must contain at least the following: normal, physiological variant, borderline, pathological, irrelevant, not recorded.

3.15 Range

For each detail entry, the range is also saved when the medical information is recorded. The range defines the permitted access to the detail entry taking the user recording it as the zero point. The smallest range is a personal comment made by the user, to which only the user has access. Detail entries that all users or their roles have access to have the largest range. For the ranges in between, a range matrix is created and applied based on users or roles. Users from external organizations who have access to the medical record form a special role.

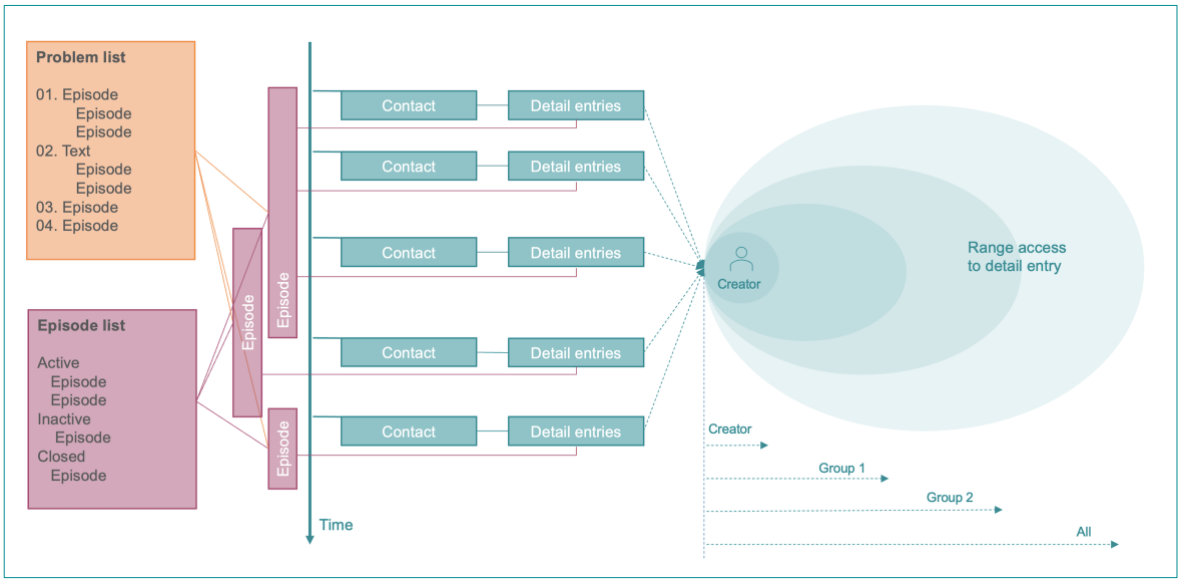


Figure 25 - Range per detail entry for access rights

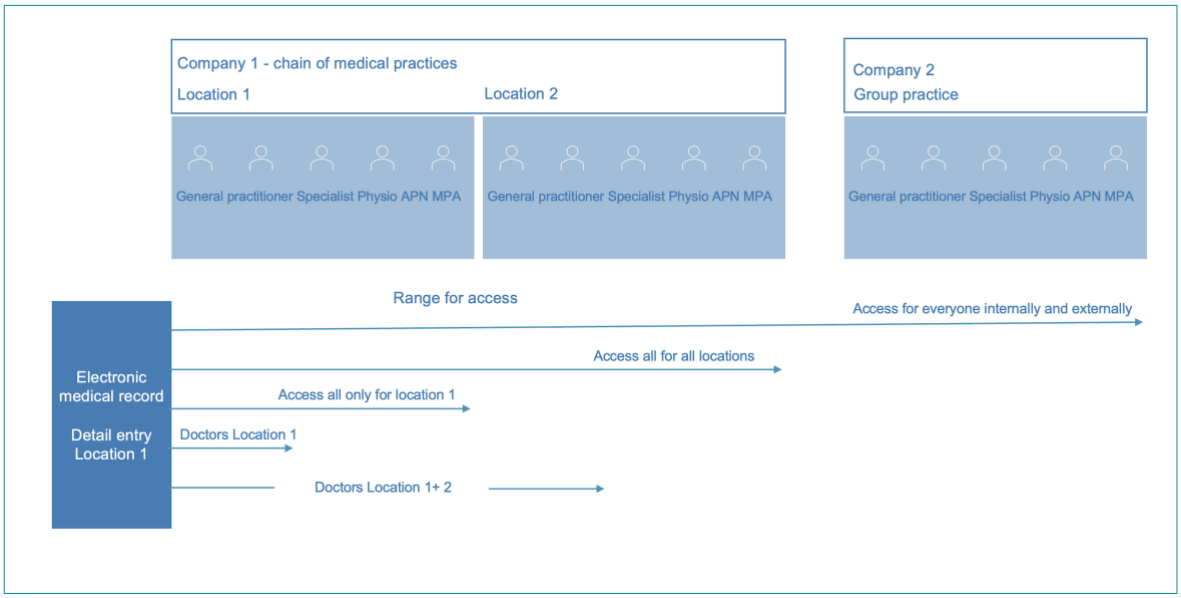


Figure 26 - Range example medical practice chain

3.16 Data protection and data security

The relevant regulatory provisions and best practices regarding data protection and data security are in place, including *privacy-by-design* and *privacy-by-default.*

With the range concept, aligned with privacy-by-default, the permissions are already defined at the level of the detail entry during data collection.

The data in the medical record belongs to the patient, who can request a copy of the entire medical record at any time or request that it be deleted. Exceptions are the user's personal notes and comments, which are not part of the medical record and do not have to be handed over to the patient.

Depending on the treatment contract between the patient and the organization, the patient gives their permission for access to their medical record. This consent can vary, so that all or only certain organizational units or only certain service providers receive the right of access from the patient. Accordingly, a distinction must be made between two levels:

- User context level: *permissions* for users to access the medical data of all patients, controlled by the organization
- Patient context level: *access right* granted by the patient, which overrides the user authorizations for this patient

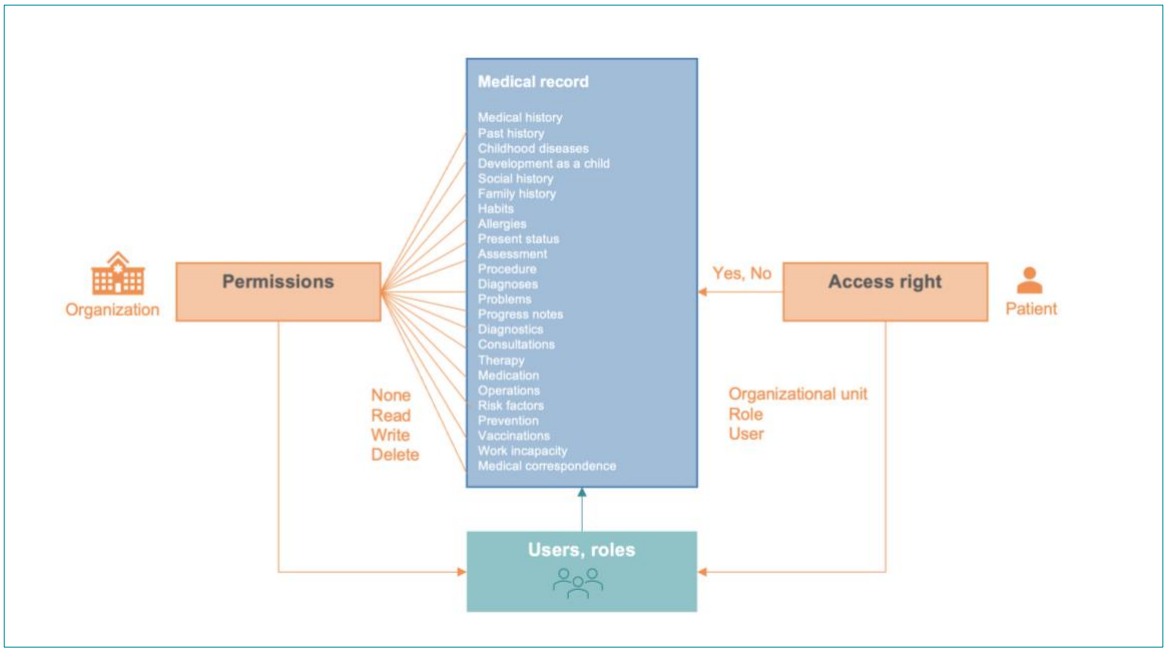


Figure 27 - Permissions and access rights

With the complete logging of access and historization of all entries and their changes, the patient can see who has had read or write access to their medical record if required. Internal guidelines and directives can be checked in the event of suspected breaches.

4 Basic architecture

4.1 Logical basic architecture

The logical architecture of the electronic medical record, and the foundation for modeling a database design, are created by combining the various basic concepts.

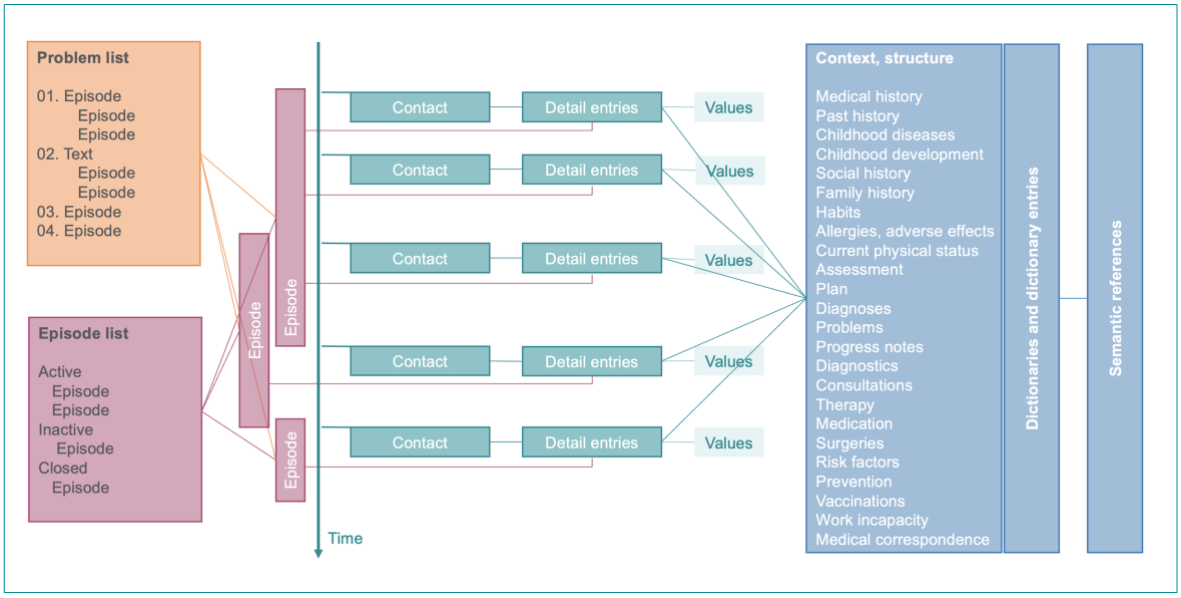


Figure 28 - Logical basic architecture of the electronic medical record

The *contact* is the smallest logical unit that makes sense on the timeline for documenting medical data in patient care. The contact between patient and service provider includes the documentation of an event that takes place at a specific time and place.

The patient's health problems are recorded as an *episode of care.* Each episode represents a clearly defined health problem or diagnosis, with the date of the first and last contact. The episodes are compiled linearly in the *episode list* on the one hand and grouped hierarchically in the *diagnosis and problem list* – according to descending importance for the patient and medical aspects – on the other.

The medical facts collected during various actions are documented as *detail entries.* Each detail entry is linked to the contact at which the medical data are documented. Each detail entry is linked to the episode that is displayed with the name of this episode valid at that time. Each detail entry contains the documentation of a medical fact by the performing service provider that was experienced, observed, or measured at a certain point in time and is known to the performing and responsible service provider from a certain point in time.

Each detail entry is linked to the dictionary and dictionary entry that reflect the medical facts in the context of the corresponding data category. Each dictionary entry is linked to a standardized semantic reference.

4.2 Data model

A conceptual data model is derived from the logical basic architecture. Only the basic tables without primary and secondary key fields are shown in the illustration. The attributes per table are only listed as far as they are useful for understanding. A more detailed list of attributes can be found in the appendix.

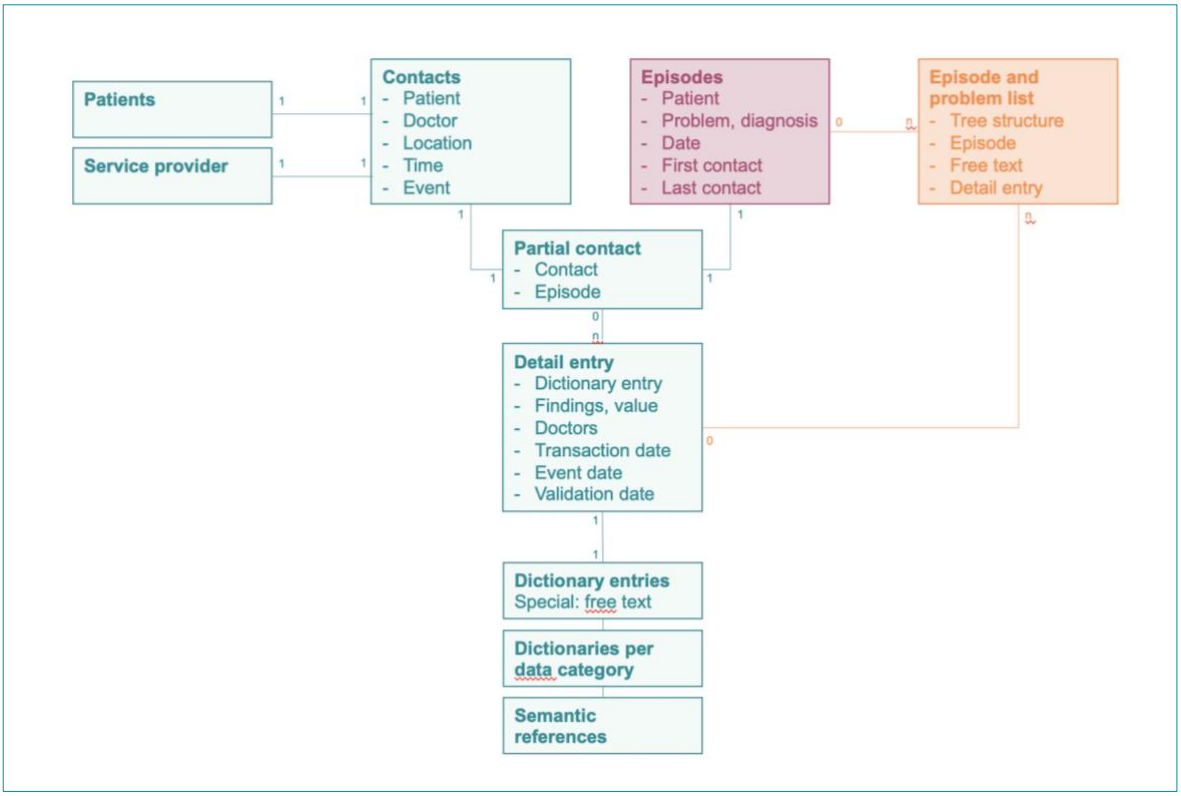


Figure 29 - Conceptual data model of the electronic medical record

5 Discussion

Some of the benefits and advantages resulting from the basic concepts, the logical architecture, and the data model are listed below.

5.1 Basic requirements

The basic requirements for an electronic medical record are fulfilled and result in the essential features of the electronic medical record.

Concept	Basic requirement	Prerequisite
Patient-centered	All medical data is clearly assigned to a patient and can be displayed selectively for each patient	Unique patient identification
Structure-oriented	The data is divided into different data categories/information units	Standard structure of medical record
Reference-oriented	The data is stored with semantic references down to term level	Semantic references
Time-oriented	The data is organized chronologically and can be recorded and displayed according to documentation date, event date, or validation date	Contact, timestamps for detail entry
Episode-oriented	The data are assigned to episodes of care in terms of health problems and allow quality and costs to be compared	Implementation of the episode of care methodology

Problem-oriented	Problems, diagnoses, allergies, medical history, and other detail entries can be compiled in a hierarchically-grouped diagnosis and problem list	Implementation of the methodology problem-oriented medical record (POMR) according to Weed
SOAP entry	The data is divided between observations, facts, interpretations, and decisions	Implementation of the methodology problem-oriented medical record according to Weed
Source-oriented	The data is clearly assigned to a service provider and can be displayed selectively for each source	Clear identification of healthcare professionals
Validatable	The documenting service provider and the responsible physicians must be able to validate and verify the data	Validation concept
Explicitness	The data is provided with an explicit evaluation or reference to missing information, no tacit interpretation of undocumented facts	Assessment of detail entry
Traceability	The data can be recorded, changed, and deleted with historization of all transactions	Transaction log
Access rights	The data can be blocked by the patient for access in general or per service provider; emergency access must be possible	Authorization
Permissions	The data is readable, mutable, deletable, or invisible to the user according to the company's rules	Roles, user groups, users
Access log	All read and write access to the data is fully documented	Access log, transaction log
Multiple use	The medical data already collected can be reused in various areas without additional data collection	Structuring Referencing
Data protection, data security	The data is collected and processed in accordance with regulatory requirements	Privacy-by-default, access rights, permissions, access log
Availability	The data is highly available	Technology

Table 3 - Coverage of the basic requirements by the basic concepts

5.2 Extended requirements

In the author's experience, in addition to the basic requirements, all requirements stipulated by organizations and their users for the electronic medical record can be implemented without 'misuse' and 'bending' of the data model or individual data fields. The biggest challenge instead concerns user-friendly implementation to enable efficient data entry by users.

5.3 Scalability

The basic concepts and the basic architecture derived from them result in an electronic medical record that is scalable in various directions.

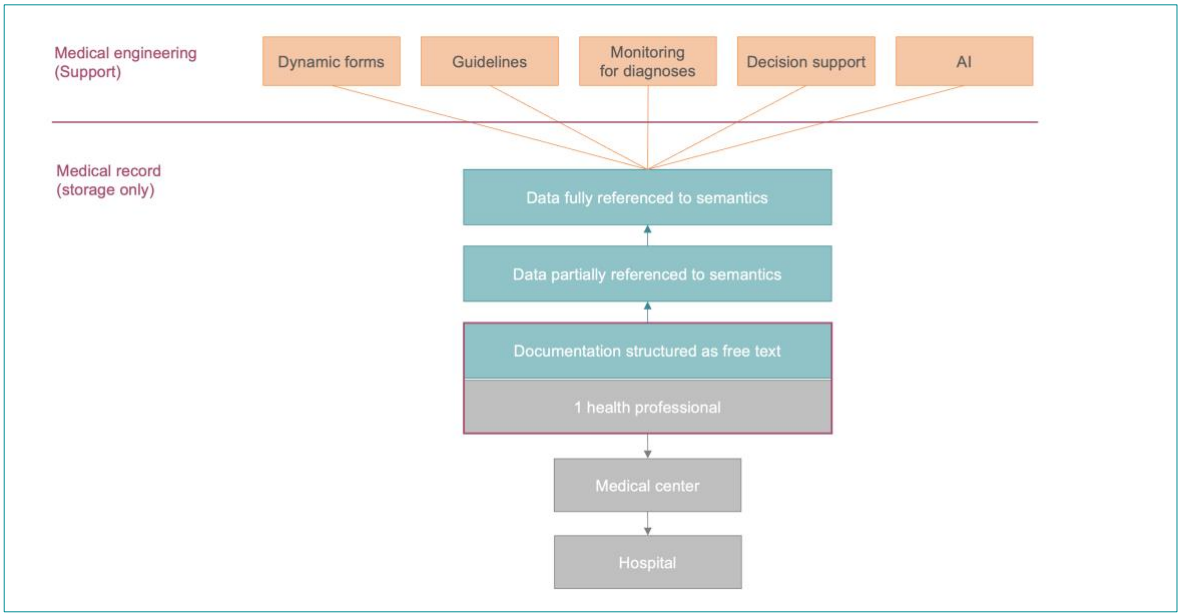


Figure 30 - Scalability of the electronic medical record

The minimum use is medical documentation as free text in a patient's structured medical record by a healthcare professional.

Regarding medical documentation, the electronic medical record gives the user the freedom to enter free text, and partially-referenced or fully-referenced data. As soon as the electronic medical record is fully structured and fully referenced, *medical engineering* is made possible in addition to the pure storage of medical data. Medical engineering is the support of the user through medical informatics IT technology, such as the integration of decision support, decision trees, the dynamic structure of guidelines, the creation of a knowledge base for expert systems, and the monitoring of chronic diseases.

Medical engineering unlocks the use of artificial intelligence. The information available as free text can be converted into structured and referenced data using suitable AI systems. For example, the AI system can create a free-text medical record entry from the recording of the doctor-patient conversation and automatically fill out a form that matches the context.

For instance, a diabetes monitoring form is used for the care of diabetes patients. This form is completed by the AI system using the free text as far as possible, and the doctor completes and validates this form. This results in high-quality and explicitly recorded data, and an overall increase in quality thanks to the form being completed in accordance with guidelines in the form of a checklist.

In terms of organizational boundaries, the electronic medical record can be scaled by multiple healthcare professionals in outpatient facilities of various sizes, from hospitals to chains of medical practices with documentation from geographically diverse locations.

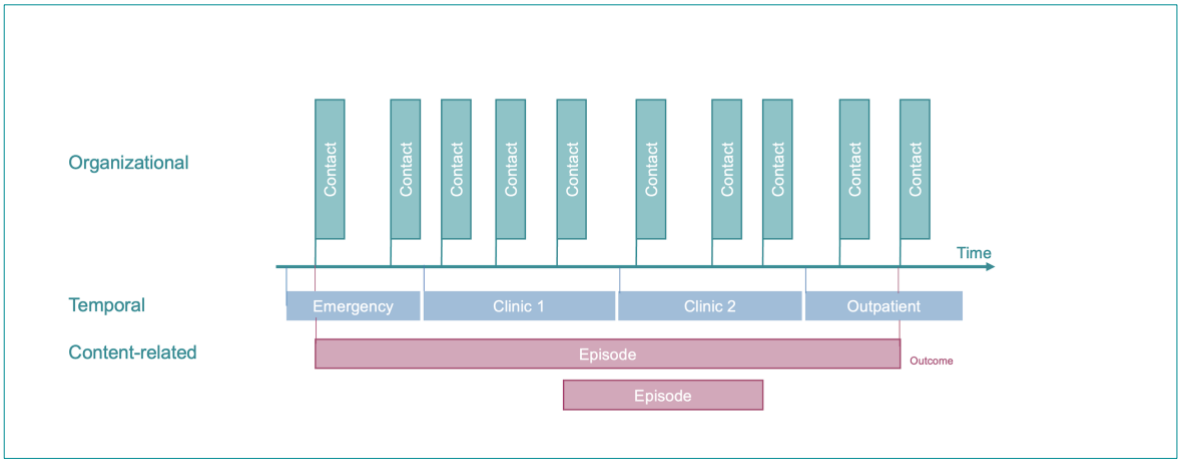


Figure 31 - Episode concept and patient-centeredness in the hospital

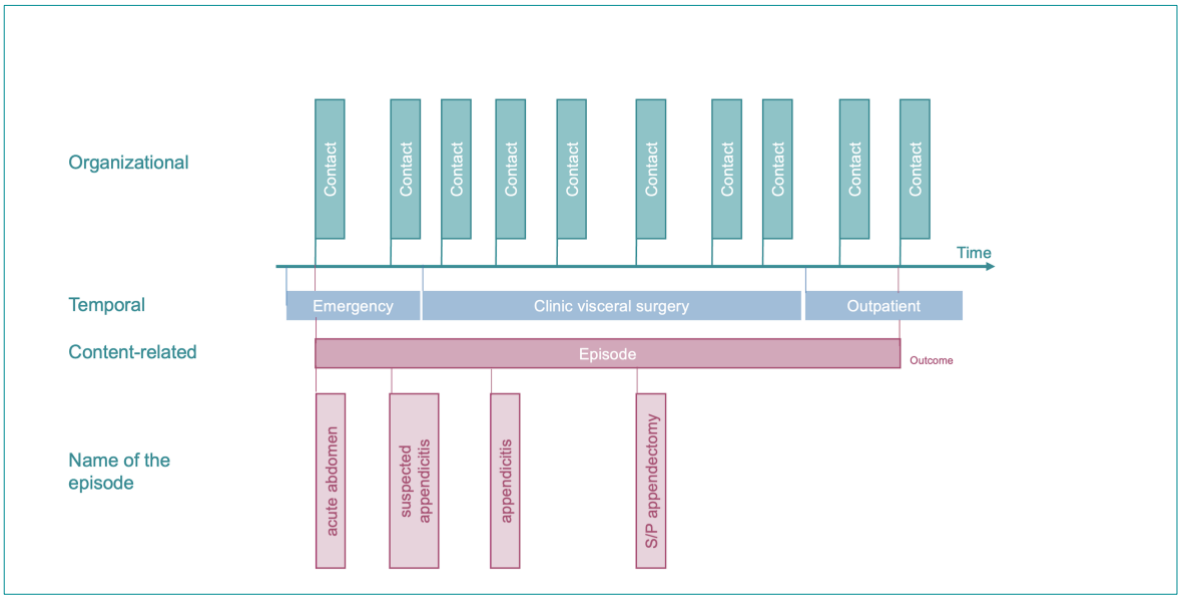


Figure 32 - Episode concept and patient-centeredness in the hospital - example

5.4 Reusability

The highly structured and dictionary-referenced storage of a patient's medical data results in a very high degree of reusability of this data:

- With the concept of dictionaries, practice-specific, doctor-specific, and clinic-specific data entry masks can be created, and a wide variety of user interfaces can be implemented, from forms to graphical tools such as status sheets, fever curves, monitoring sheets, and graphical displays. In any case, the recorded information can be merged back into the required medical information units, or information that has already been recorded can be displayed in different views.
- The forms commonly used in medicine can be displayed on the screen referenced to dictionaries.
- Graphical representations can be stored with dictionary terms. This allows prose texts to be automatically generated from graphical representations for medical records and reports.

- The user receives completely different views of the same information, such as chronological view in prose, problem-oriented view in prose, tables, cumulative representations, curves, graphs.
- Reporting can be largely automated. Report templates are used to define which information units or terms from the patient's medical record are to be inserted.
- The electronic medical record forms the basis for the implementation of decision support, guidelines, monitoring, AI tools, and other areas of medical engineering.
- Comparable analyses are possible for scientific work and studies. A wide variety of data can be combined down to the individual term for the analyses.
- The electronic medical record serves as a knowledge base for expert systems. Data recorded about the patient can be evaluated against other data on this patient, and expert systems can extract data from the electronic medical record in a targeted and reliable manner.
- The high degree of structure and referencing to dictionaries form the basis for standardized data exchange.
- For each term in the dictionary, it can be specified which services must be provided so that this term can be documented in the electronic medical record. This means that the entire service entry for billing can be automated.
- Thanks to the high level of structure and referencing to dictionaries, data can be stored independently of time. Any conversions to new technologies are easily possible.
- The individual episodes can be linked to the diagnosis and problem list. This results in the following hierarchical structure: The problem list can comprise several episodes, and each episode can have several contacts. This structure creates a very attractive model for the documentation of chronic diseases that have overlapping episodes of complications of the disease. When the problem list and episode of care are used together, this opens up new and interesting possibilities for structuring related data.

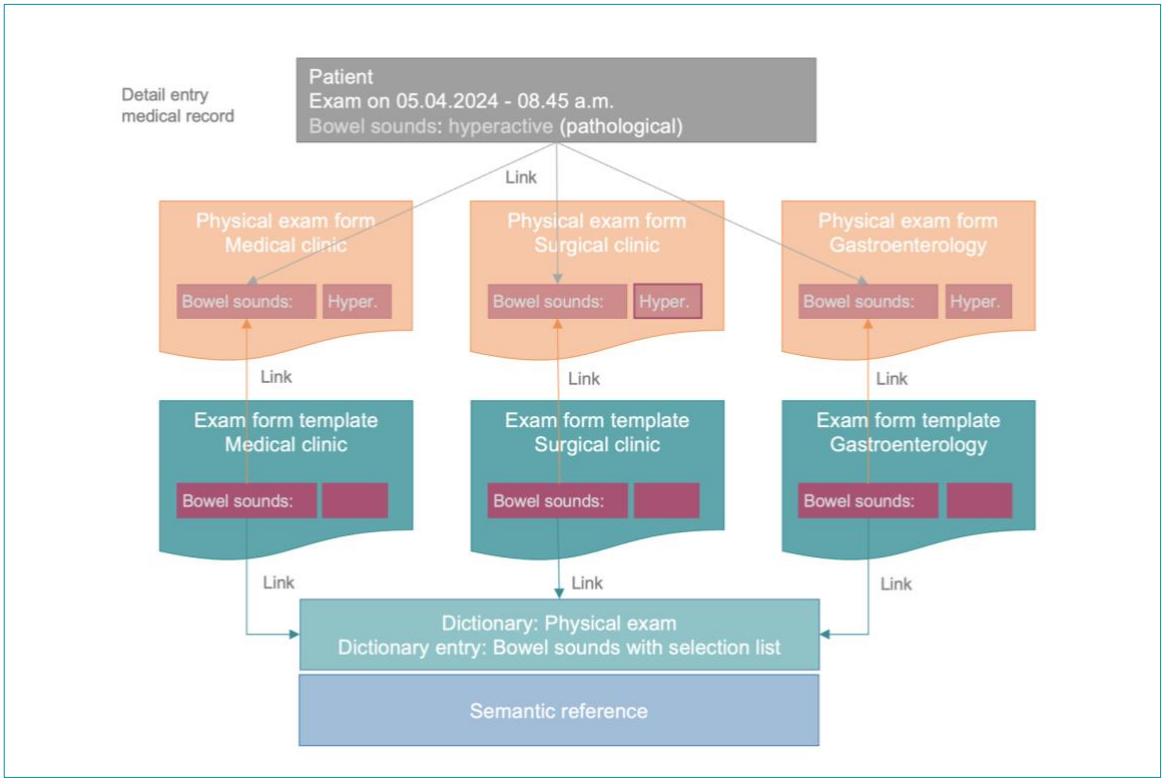


Figure 33 - Example status sheet with various templates

5.5 Quality

All structured and dictionary-referenced data can be understood and analyzed by computer systems.

- The user's entries can be checked for plausibility. Possible pathologies and value ranges can be stored for each term in the dictionary.
- All necessary information is prompted with a dynamic selection of data entry options.
- The workflow management of a medical information system can be very deeply integrated with different displays of the information required for each step in the process.
- With the validation concept, no data 'disappears' unread in the electronic medical record.
- Knowledge databases can be used to check medical correlations. For example, interactions between prescribed medications can be recognized and displayed.
- The stored data of a patient can be used as a knowledge base and medical correlations can be checked. For example, an allergy check can be carried out when prescribing medication, or in the case of a pathological creatinine value in the laboratory (renal insufficiency), a proposal for reducing the dosage of a medication can be calculated.
- Quality of treatment and outcome are generically integrated and can be determined from the existing structured and referenced data.
- In the event of legal disputes, thanks to historization, the doctor can present a complete medical record with all corrections made and the respective time from which they were aware of the stored information.

5.6 Business management data

For comparable analyses of patient treatments in terms of costs and quality, the data in the medical record is structured in terms of organization, time, and content. It must be possible to distinguish treatment cases as they occur commercially within in practice from the episode of illness as it occurs in the patient from the beginning to the healing of a health problem.

In Switzerland, the TARMED tariff system is used as a catalog of individual services for outpatient billing. The smallest unit for recording TARMED tariff items is the *session*. The *contact* of the electronic medical record corresponds to the *session* according to TARMED. The *episode* or *medical case* is used for the electronic medical record, while the *administrative case* or *treatment case* is used for billing. Invoicing takes place periodically.

By storing the dictionaries and dictionary entries with the tariff items required to document the medical facts, service entry can be automated. Ideally, a neutral service catalog is created and the corresponding tariff items are stored for each service per tariff type and law. The dictionary entries can then be linked to the neutral service catalog.

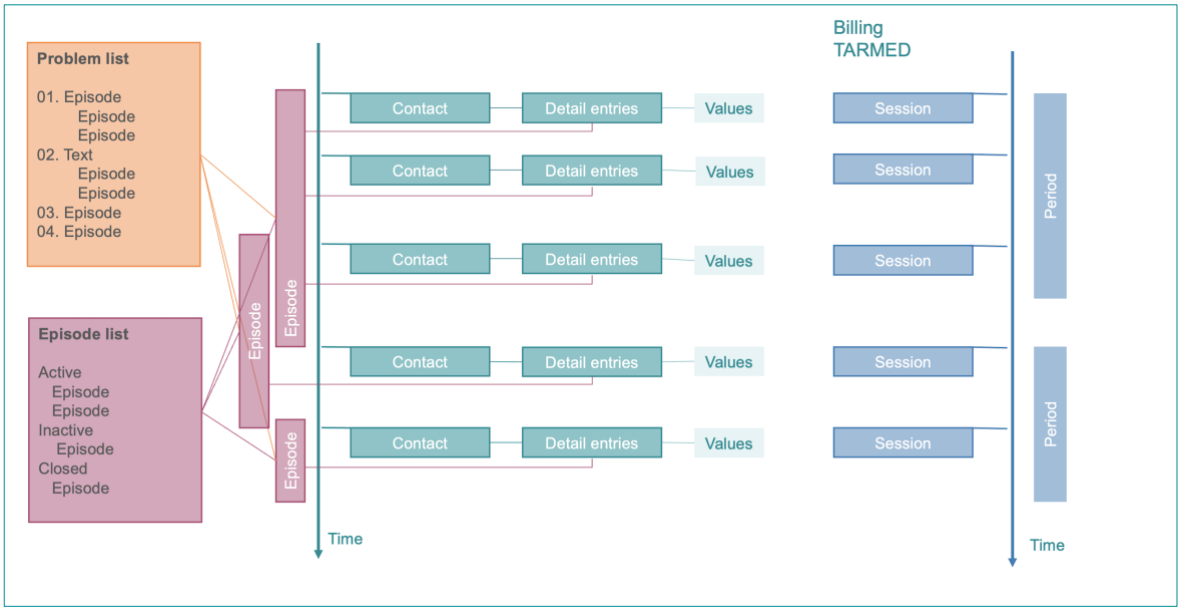


Figure 34 - Relationship between 'contact' and TARMED 'session'

With the *episodes of care* concept, medical documentation can be linked to the accounting system down to the individual service level. This allows the costs per episode to be determined and compared, creating the basis for cost unit accounting.

6 Glossary and abbreviations

6.1 Glossary

Term	Abbr.	Explanations	Source, standard
Classification		Medical classifications are used to systematically organize expert knowledge for medical documentation, information processing, and global communication and cooperation. Classified collections of information include diseases and their effects, drugs, organs, operations, and other therapeutic or diagnostic procedures (e.g. ICD-10, ICPC-2).	
Diagnosis		Medical diagnoses are the classification of pathological processes into scientific terms.	
Electronic health record	EHR	Systematized collection of electronically-stored patient and population health data in a digital format. This data can be shared across different healthcare facilities, promoting seamless communication and continuity of care.	https://en.wikipedia.org/wiki/Electronic_health_record
Electronic medical record	EMR	Electronic medical record in the outpatient or inpatient sector for recording, storing, and managing a patient's health information in the primary system.	
Episode of care	EoC	One or more contacts with one or more healthcare providers for the treatment of a health problem.	

Healthcare facility		Healthcare institution or organization that provides medical services like a hospital or doctor's office.	
Healthcare professional	HCP	Professional recognized under federal or cantonal law in Switzerland who carries out or prescribes treatments in the healthcare sector or dispenses therapeutic agents or other products in connection with a treatment.	https://www.e-health-suisse.ch/glossar
Medical record	MR	Complete medical documentation of a patient.	
Nomenclature		A nomenclature (Latin nomenclatura) is a collection of guidelines according to which the naming of objects in a specific subject area should be based. The totality of names in a subject area forms a terminology (e.g. SNOMED, LOINC).	
Ontology		An ontology is the most comprehensive structure that not only includes terms and classifications, but also defines the relationships between the terms and their properties, based on the underlying terminologies.	
Organization		See Healthcare facility	
Personal health record	PHR	Personal health records are electronic applications that allow patients to manage their health information in a private, secure, and confidential environment.	https://www.healthit.gov/faq/what-personal-health-record
Place of treatment		Place where the medical services are provided, e.g. doctor's office, outpatient clinic, hospital, patient's domicile.	
Privacy-by-design		Development of a software solution with the intention of protecting the data required for its operation in the best possible way. The issue of data protection is therefore already considered when designing the solution.	
Privacy-by-default		Data protection by default. Data protection-friendly settings have priority.	
Problem		A problem is a health issue of a patient that requires either diagnostic or therapeutic intervention.	
Semantics		Semantics is the study of the meaning of words. Semantics defines terms and assigns names to terms. In technical languages, the definition and assignment of terms and designations are referred to as terminology or nomenclature.	https://www.bfarm.de/DE/Kodiersysteme/terminologien-nomenklaturen-klassifikationen.html
Service provider	SP	Person from a healthcare facility that provides medical services for the treatment of patients, e.g. doctor.	
Session (TARMED)		A session is a limited period of time during which a service provider is utilized by a patient. In the outpatient sector, the session begins when the patient arrives at the practice and ends when the patient leaves the practice.	
Terminology		A terminology or nomenclature is a collection, a catalog of recognized technical terms for describing	https://www.bfarm.de/DE/Kodiersy

		the units, objects, states, processes, etc. of a specialist field. It must cover the subject area quantitatively and qualitatively, i.e. be as comprehensive and as specific as possible, and be able to be expanded in line with the progress of scientific knowledge.	steme/terminologien-nomenklaturen-klassifikationen.html
Thesaurus		A thesaurus is a model that attempts to precisely describe and represent a subject area. It consists of a systematically-organized collection of terms that are thematically related to each other. The thesaurus is a controlled vocabulary (attribute value range) for the attribute to be described. Primarily synonyms, but also generic and subordinate terms are managed (e.g. MeSH, UMLS).	

6.2 Abbreviations

Abbreviation	Explanation
EHR	Electronic health record
EMR	Electronic medical record
EQuiP	European Society for Quality and Safety in Family Practice
HCP	Healthcare professional
MR	Medical record
PHR	Personal health record
POMR	Problem-oriented medical record (according Weed)
SOAP	Subjective - Objective - Assessment - Plan
WONCA	World Organization of Family Doctors

7 List of figures and tables

7.1 List of figures

7.2 List of tables

8 Appendix

8.1 Structure of the medical record

The structure presented is based on the author's analysis of dozens of case histories used in everyday clinical practice and the literature.[11] A simplified structure is presented.

Data category (entity)	**Explanation**
Medical history	The medical history, also called anamnesis, is the questioning of the patient or informed third parties (relatives) by the doctor in the form of an interview. The information collected is categorized as follows: - Present illness - Past history - Family history - Childhood development - Review of systems - Allergies and adverse drug reactions - Habits
Present status	The present status is the physical examination and observation of the patient by the doctor. The performance of the examination is referred to as "recording the status", and the totality of the examination findings as "status" for short. A distinction can be made between a general status and a local status. The vital signs indicate the vital functions of the status.
Assessment	Differential diagnosis is a step in the diagnostic process. Based on the subjective complaints and objective findings, a list of possible diagnoses is drawn up, ordered according to the probability of the pathological processes and the patient's suffering. This is done by evaluating, weighing up, and differentiating the individual symptoms and signs. The individual diagnoses become more probable or less probable based on additional examinations and observations on the course of the disease, until one diagnosis becomes the most probable. The assessment comprises the doctor's considerations for identifying a disease. It serves to analyze the information gathered and forms the basis for planning further diagnostic and therapeutic clarifications as well as the care of the patient. Prognosis is about assessing the patient's condition.
Plan	Determining the next steps with regard to diagnostic and therapeutic measures: The clarification plan is derived from the considerations underlying the assessment and prognosis. Each main point of the differential diagnosis is reviewed, and a record is made of which additional examinations and procedures appear necessary to confirm or rule out the corresponding diagnosis. At the same time, suitable parameters (laboratory values etc.) are selected which can be used to monitor the course of the disease. The examination proposals are assessed regarding their urgency, the clinical condition of the patient, the risk of the examination procedure, and their informative value. A treatment plan is drawn up for each diagnosis as a broad outline with a record of the thought processes that led to the planned therapeutic approach.
Diagnosis and problem list	Depending on the methodology of medical documentation, diagnoses and problems are handled differently.
Diagnostics	Diagnostic examinations are used to confirm or rule out a diagnosis. They include the detailed commissioning, documentation of the implementation, and results of the

[11] MORGAN, William L. *The clinical approach to the patient*. Berne, Stuttgart, Vienna: Hans Huber, 1977

	examinations. As a rule, the measures are recorded in the investigation plan and then implemented according to the plan. Some examples: - Laboratory analyses - Imaging procedures (radiology, ultrasound) - Functional tests (ECG, lung function) - Invasive procedures (biopsy)
Therapy	The therapeutic measures are documented in an appropriate form depending on the type. In the case of drug therapy, the prescribed medication, dosage, and duration are noted. For surgical interventions, an operation report and anesthesia protocol are drawn up. A basic distinction is made between: - Conservative therapy (medication etc.) - Invasive therapy (surgery, minor intervention, etc.)
Progress notes	Comments on the course of the disease, both on changes in the subjective and objective signs of the disease and on changes in the doctor's assessment and planning. The progress notes are divided into subjective symptoms, important examination findings, assessment and plan (SOAP). In the problem-oriented medical record (POMR), the progress entries are kept per problem.
Risk factors and prevention	Known factors that represent an increased risk for certain diseases. These include information from various parts of the medical record, such as anamnesis (smoker), status (blood pressure), laboratory (blood lipid values), family history (genetic burden), etc. There are three types of risk factors: - Risk indicators (without direct causal significance, such as age, gender, medical history, family history, race) - Causal factors (such as occupational exposure, smoking) - Physiological parameters (early expression of a pathogenetic process such as obesity, hypertension) Prevention is concerned with prophylaxis and early detection of health disorders of all kinds. The aim is to identify people with an increased risk of illness as early as possible.
Vaccinations	Vaccinations are usually documented in a vaccination record and in the medical record. The doctor uses a vaccination history to determine all vaccinations administered.
Work incapacity	Documentation of all medically-determined incapacity for work and dispensations (school dispensations, sport dispensations, wearing dispensations, swimming dispensations). Confirmation to third parties of the patient is provided in the form of a medical certificate.
Medical correspondence	Medical correspondence mainly consists of reports and certificates. All outgoing and incoming documents are filed in the patient's medical record.

8.2 Attributes database design

Some attributes from the data model of the electronic medical record are compiled and explained in the following tables. The list is denormalized and without primary and foreign key fields.

8.2.1 Contact

Attribute	**Explanation**
Patient	Link to the patient
Service provider	Link to healthcare professional such as doctor with whom the event is primarily agreed

Event	Consultation, home visit, hospital visit, doctor's round, telephone consultation, telephone information, telephone third-party, file review
Time	Date, time
Duration	Minutes, hours
Organization	Organization like hospital, doctor's office
Location	Clinic, department, outpatient clinic, medical practice
Type of stay	Outpatient, inpatient, day patient
Reason	Reason for encounter

8.2.2 Episode

Attribute	**Explanation**
Patient	Link to the patient
Service provider	Link to the healthcare professional who recorded the problem/diagnosis
Label	Name of the health problem or diagnosis per contact, the most recent name gives the episode its name
Kind	Problem, diagnosis
Event date	Date on which the problem or diagnosis occurred
Documentation date	Date, time of documentation
Validation date	Date, time of validation by the performing and responsible service provider
Date of first contact	Date of first contact with detail entries on this health problem
Date of last contact	Date of last contact with detail entries on the health problem
Time information	- Acute - Chronic - Complication - Recurrence - Status on (with date)
Status	- Active (problem or diagnosis requires diagnostic or therapeutic intervention) - Inactive (problem or diagnosis is not being processed and is dormant) - Closed
Localization	- Left - Right - On both sides - Anatomical term
Condition	- Suspected diagnosis - Confirmed diagnosis - Recurrent diagnosis - Excluded diagnosis
Security level	- Anamnestically secured - Clinically proven - Radiologically confirmed - Histologically confirmed
Objective	- Treatment goal, agreed between doctor and patient - Period for achieving the target

8.2.3 Detail entry

Attribute	Explanation
Partial contact	Link to contact and episode
Users	User who entered the detail entry
Executing service provider	Link to service provider
Responsible service providers	Link to service provider
Dictionary	Link to the context of the data category
Dictionary entry	Link to the medical fact
Entry	Entry with value, link to selection list or free text
Rating	Normal, physiological variant, borderline, pathological
Standard range	Standard values, e.g. for numerical entries Valid at the time of the event date
Remarks	Free text
Extended entries	Depending on the data category, further specific attributes are required
Event date	Date on which the medical condition was recorded, measured, or observed
Valid until	End date of the medical issue
Documentation date	Date on which the detail entry was recorded (transaction date)
Validation date Executor	Date on which the performing service provider validated and signed off the record
Validation date Responsible	Date on which the responsible service providers validated and signed off the record
Documents	Link to documents in the document archive
Range	Default authorization for access according to the organization's policies
Tariff items	Tariff items required for the documentation of the detail entry

8.2.4 Dictionary entry

Attribute	Explanation
Data category	Context of the dictionary entry, e.g. anamnesis, status
Name	Label of the dictionary entry
Text screen	Text for display on the screen
Text prose	Prose text for report
Status	Asked, not asked
Data collection scheme	Selection list, alpha, numerical, yes/no, present/not present, angle, joint measurement zero method, temperature, etc.

Selection list	Selection list with rating (normal, pathological) for each entry in the selection list
Boundaries	Upper and lower limits for numerical values, joint measurement, zero permitted, yes/no
Rating	Normal, physiological variant, borderline, pathological
Standard values	Standard values, e.g. for numerical entries
Descriptors	Descriptor required yes/no Links to required descriptors
Chronological classification	Can be entered once (medical master data), can be entered multiple times with history
Range	According to range concept (e.g. only recording user, only primarily responsible physician, all physicians, all of the location, all of the organization)
Tariff item	Service that led to the documentation of this dictionary entry